Department of Public Works and Highway

Infrastructure Preparation and Innovation Facility – Output 1 – Roads and Bridges

Bataan – Cavite Interlink Bridge (BCIB) Project – Environmental Impact Assessment Report

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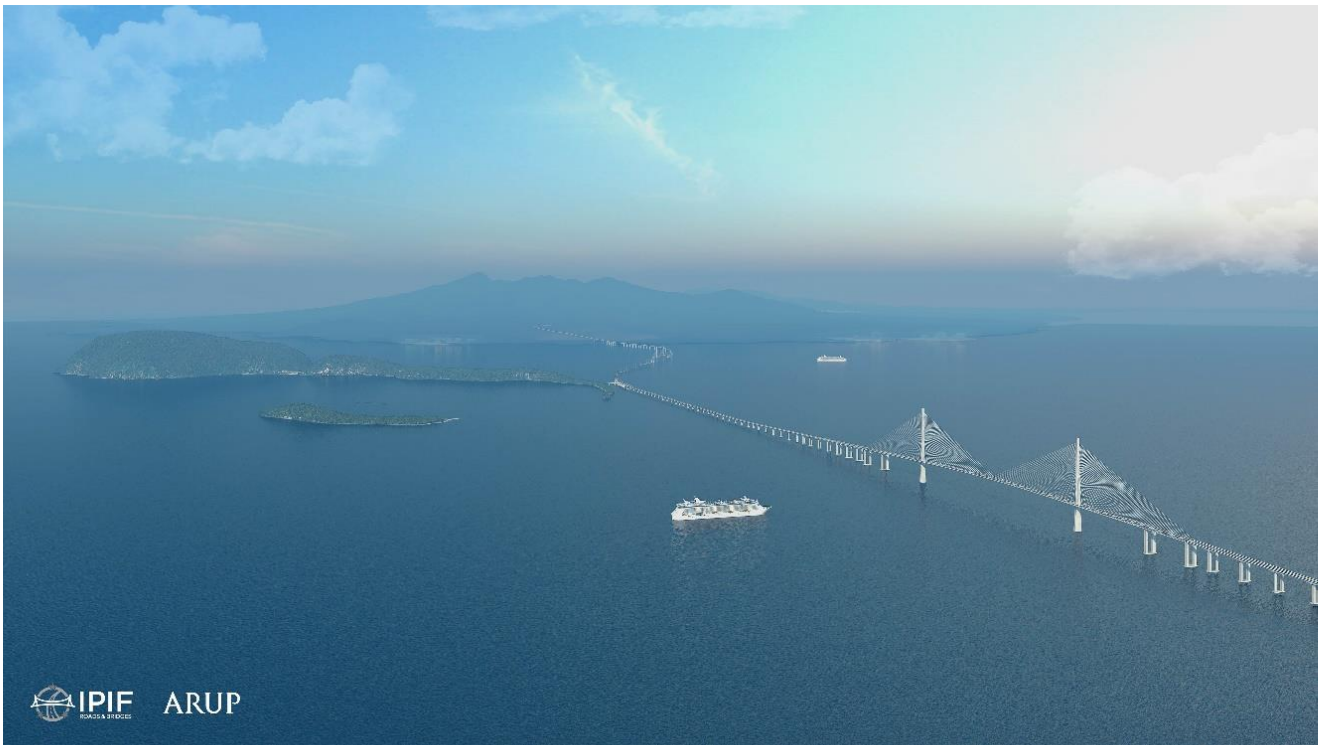

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This report has been prepared specifically for and under the instructions of the Department of Public Works and Highways (DPWH), a Philippine Government Department, under the sub-project assignment "Bataan – Cavite Interlink Bridge (BCIB) Project Feasibility Study", as part of the Infrastructure Preparation and Innovation Facility contract dated 13 February 2018.

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In preparing this report we have relied on various information supplied by others. We have relied in particular on the accuracy and completeness of such information and accept no liability for any error or omission in this report to extent the same results from errors or omissions in the information supplied by others.

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Abbreviation

A&D	Alienable & Disposable
ADB	Asian Development Bank
AoA	Area of Analysis
APHA	American Public Health Association
AQI	Air Quality Index
AR	Artificial Reef
ASP	Amnesic Shellfish Poisoning
ASRs	Air Sensitive Receivers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BCIB	Bataan-Cavite Interlink Bridge
BEPZ	Bataan Export Processing Zone
BEZ	Bataan Economic Zone
BFAR	Bureau of Fisheries and Aquatic Resources
BFAR-PFO	Bureau of Fisheries and Aquatic Resources - Provincial Fisheries Office
BFP	Bureau of Fire Protection
BMB	Biodiverstiy Management Bureau
BNS	Bataan Nearshore Sampling
BOD	Biological Oxygen Demand
BSWM	Bureau of Soils and Water Management
CAAP	Civil Aviation Authority of the Philippines
CADS	Climatology and Agrometeorology Data Section
CALAX	Cavite-Laguna Expressway
CARP	Comprehensive Agrarian Reform Program
CAVITEX	Cavite Expressway
CBMS	Community-Based Monitoring System
CCA	Climate Change Adaptation
CCC	Climate Change Commission
CCTV	Closed-Circuit Television
CDP	Comprehensive Development Plan
CEQ	Council on Environmental Quality
CFI	Corregidor Foundation Incorporation
CITES	Convention on International Trade in Endangered Species
CIWRM	Cavite Integrated Water Resource Management
CLIRAM	Climate Information Risk Analysis Matrix
CLUP	Comprehensive Land Use Plan
CNS	Cavite Nearshore Sampling
COD	Chemical Oxygen Demand
CoNS	Corregidor Nearshore Sampling
CPP	Communist Party of the Philippines
CSWDO	City Social Welfare and Development Office
CTSI	Consolidated Training Systems Incorporated
CVAA	Cold-Vapor Atomic Absorption
CWA	Clean Water Act
DA	Department of Agriculture

DAO	Department of Environment and Natural Resources Administrative Order
DBH	Diameter at Breast Height
DED	Detailed Engineering Design
DENR	Department of Environment and Natural Resources
DGAC	Dense-graded asphaltic concrete
DIC	Directly Impacted Communities
DIGITEL	Digital Telecommunication Philippines
DILG	Department of Interior and Local Government
DND	Department of National Defense
DO	Dissolved Oxygen
DOLE	Department of Labor and Employment
DOT	Department of Tourism
DPWH	Department of Public Works and Highways
DRR	Disaster Risk Reduction
DSP	Diarhetic Shellfish Poisoning
ECA	Environmental Critical Areas
ECC	Environmental Compliance Certificate
ECP	Environmentally Critical Project
EIS	Environmental Impact Statement
EMB	Environmental Management Bureau
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EN	Endangered
EPA	Environmental Protection Agency
ERA	Environmental Risk Assessment
ERDB	Ecosystems Research and Development Bureau
FAB	Freeport Area of Bataan
FARMC	Fisheries and Aquatic Resources Management Council
FGD	Focus Group Discussion
FHWA	Federal Highway Administration
GAD	Gender and Development
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GF	Guadalupe Formation
GHG	Greenhouse Gas
GI	Geographical Indication
GPS	Global Positioning System
GRM	Grievance Redress Mechanism
HAB	Harmful Algal Blooms
IBAT	Integrated Biodiversity Assessment Tool
ICP	Inductively Coupled Plasma
IEC	Information and Education Campaign
IEMP	Integrated Environmental Monitoring Program
IFC	International Finance Corporation
IHO	International Hydrographic Organization
IPNI	International Plant Names Index
IRR	Implementing Rules and Regulations
ISF	Informal Settler Family
ISPP	International Sewage Pollution Prevention

IUCN	International Union for Conservation of Nature
IV	Importance Value
LGU	Local Government Unit
LLDA	Laguna Lake Development Authority
LRFD	Load and Resistance Factor Design
MAO	Municipal Agricultural Office
MARIWAD	Mariveles Water District
MARPOL	Marine Pollution
MBCO	Manila Bay Coordinating Office
MBEMP TWG-RRA	Manila Bay Environmental Management Project Technical Working Group Refined Risk Assessment
MBR	Manila Bay Region
MBS	Marine Water Sampling
MCWMC	Metro Clark Waste Management Corporation
MENRO	Municipal Environment and Natural Resources Office
MEPCOM	Marine Environmental Protection Command
MERALCO	Manila Electric Company
MGB	Mines and Geosciences Bureau
MMDA	Metro Manila Development Authority
MOA	Mall of Asia
MPDO	Municipal Planning and Development Office
MPPMGNP	Mounts Palay-Palay-Mataas na Gulod National Park
MSL	Mean Sea Level
MWWP	Marine Wildlife Watch of the Philippines
NAAQGV	National Ambient Air Quality Guideline Values
NAAQS	National Ambient Air Quality Standards
NAMRIA	National Mapping and Resources Information Agency
NBCP	National Building Code of the Philippines
NCIP	National Commission on Indigenous Peoples
NCR	National Capital Region
NCWCD	National Commission for Wildlife Conservation and Development
NDF	National Democratic Front of the Philippines
NEDA	National Economic and Development Authority
NEPA	National Environmental Policy Act
NFRDI	National Fisheries Research and Development Institute
NFS	Naic Fish Sanctuary
NGCP	National Grid Corporation of the Philippines
NGOs	Non-Governmental Organizations
NGPT	New Generation Power Technology
NHA	National Housing Authority
NHC	National Historic Commission
NIPAS	National Integrated Potected Ares System
NOAA	National Oceanic and Atmospheric Administration
NPA	New People's Army
NPAA	Network of Protected Areas of Agriculture
NPC	National Power Corporation
NPCC	National Pollution Control Commission
NSRs	Noise Sensitive Receivers
NWRB	National Water Resources Board

O&G	Oil and Grease
OGAC	Open-Graded Asphaltic Concrete
OSHA	Occupational Safety and Health Association
OWS	Oil and Water Separator
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
PAH	Polycyclic Aromatic Hydrocarbons
PAMB	Protected Area Management Board
PAP	Project Affected Person
PAR	Philippine Area of Responsibility
PAWB	Protected Areas and Wildlife Bureau
PCCP	Portland Cement Concrete Pavement
PCG	Philippine Coast Guard
PCO	Pollution Control Officer
PCP	Pawikan Conservation Project
PEISS	Philippine Environmental Impact Statement Systems
PEM	Philippine Earthquake Model
PEMSEA	Partnerships in Environmental Management for the Sea of East Asia
PENELCO	Peninsula Electric Cooperative, Inc.
PENRO	Provincial Environment and Natural Resources Office
PESO	Public Employment Service Office
PGA	Peak Ground Acceleration
PGR	Population Growth Rate
PHIVOLCS	Philippine Institue of Volcanology and Seismology
PLDT	Philippine Long Distance Telephone Company
PM	Particulate Matter
PNA	Philippine News Agency
PNP	Philippine National Police
PNTC	Philippine Nautical and Technological College
PPE	Personal Protective Equipment
PPP	Public-Private-Partnership
PSA	Philippine Statistics Authority
PSGC	Philippine Standard Geographic Code
PSHA	Probabilistic Seismic Hazard Analysis
PSP	Paralytic Shellfish Poisoning
PSWS	Public Storm Warning Signals
PTA	Philippine Tourism Authority
PUJ	Public Utility Jeepneys
RAP	Resettlement Action Plan
RCPs	Representative Concentration Pathways
RI-KFUPM	Research Institute - King Fahd University of Petrolum and Minerals
ROW	Right of Way
SA	Spectral Acceleration
SBMA	Subic Bay Metropolitan Authority
SDP	Social Development Plan
SEC	Securities Exchange Commission
SGT-HEM	Silica Gel Treated Hexane Extractable Material
SIZ	Special Institutional Zone
SLF	Sanitary landfill

SOLAS	Safety of Life at Seas
SWM	Solid Waste Management
TCs	Tropical Cyclones
TCSS	Traffic Control and Surveillance System
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UBIV	Under Bridge Inspection Vehicles
UNDP	United Nations Development Programme
UPS	Uninterruptible Power Supply
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VFS	Valley Fault System
VOCs	Volatile Organic Carbons
VU	Vulnerable
WACS	Waste Analysis and Characterization Survey
WCPI	World Ports Climate Initiative
WEF	World Economic Forum
WGS	World Geodetic System
WSF	Water Soluble Fractions
WSRA	Water Sector Reform Act
WTP	Water Treatment Plant

Executive Summary

Project Fact Sheet

<table>
<tr><td>Name of Project</td><td colspan="2">Bataan – Cavite Interlink Bridge (BCIB) Project</td></tr>
<tr><td>Project Location</td><td colspan="2">Mariveles, Bataan: Barangays Mountain View and Alas-Asin
Cavite: Barangays Timalan-Concepcion and Timalan-Balsahan</td></tr>
<tr><td>Nature of the Project</td><td colspan="2">Bridge Construction</td></tr>
<tr><td>Project Size</td><td colspan="2">Length: 32.15km; Width: 20.92m (carriageway)</td></tr>
<tr><td>Summary of Major Components</td><td colspan="2"><table>
<tr><th>Project Component</th><th>Description / Specifications</th></tr>
<tr><td>Navigation bridge</td><td>Provide the necessary navigation clearance for ships</td></tr>
<tr><td>Marine viaducts</td><td>Viaduct structures constructed above sea water</td></tr>
<tr><td>Interchanges and viaducts on land</td><td>Viaduct structures constructed on land and provide connections to existing road networks</td></tr>
<tr><td>Approach ramps</td><td>Parts of the road that go up from existing ground level towards the approach bridge</td></tr>
</table></td></tr>
<tr><td>Project Cost</td><td colspan="2">Php. 120.79 Billion (Civil Works)
Php. 175.66 Billion (Total Project Cost)</td></tr>
<tr><td>Project Duration</td><td colspan="2">2018-2027</td></tr>
<tr><td>Operation Date</td><td colspan="2">2027</td></tr>
<tr><td>Proponent Name</td><td colspan="2">Department of Public Works and Highways (DPWH)</td></tr>
<tr><td>Proponent Authorized Representative</td><td colspan="2">Emil K. Sadain, CESO I
Undersecretary for UPMO Operations and Technical Services
Department of Public Works and Highways</td></tr>
<tr><td>Proponent Address and Contact Details</td><td colspan="2">Address: Bonifacio Drive Port Area, 652 Zone 068, Manila, 1018 Metro Manila, Philippines
Contact Number: +63 2 5304 3805 / +63 2 5304 3681</td></tr>
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</table>

Process Documentation

- **Project Categorization**

As per the Revised Procedural Manual of the Department of Environment and Natural Resources (DENR) Administrative Order No. 30 Series of 2003 (DAO 2003-30), major roads and bridges are categorized as Environmental Critical Project (ECP) under Category A and within the scope of the EIS System based on Proclamation No. 2146 (1981) and Proclamation No. 803 (1996). The proposed Bataan-Cavite Interlink Bridge (BCIB) is technically defined under an area which will traverse water bodies tapped for domestic purposes, within the controlled and/or protected areas declared by appropriate authorities and which support wildlife and fishery activities.

Based on the Environmental Management Bureau (EMB) Memorandum Circular 005 of 2014 (EMB MC 2014-005) or the Revised Gudelines for Coverage Screening and Standardized Requirments under the Philippine EIS System, the proposed project, which is 32.15km long falls under Category A. Thus, a full-blown EIS is needed to secure an Environmnetal Compliance Certificate (ECC). This EIS report will outline the current conditions of the project area and will demonstrate all potential impacts that may be found significant. Moreover, as this project falls under the President Rodrigo Duterte's Build, Build, Build Projects, streamlining this environmental impact assessment (EIA) is also considered in the process (DAO 2019-16).

- **Definition of EIA**

As defined under the DAO 2003-30, an EIA is a systematic process that involves the prediction and evaluation of significant impacts of a project, including cumulative impacts on the environment all throughout its life cycle (*construction, operation and abandonment phase*). In addition, it involves designing appropriate preventive, mitigating and enhancement measures addressing the consequences in attaining socio-economic and environmental balance.

- **Scope of the EIA Study**

The contents of this report are based on the scoping checklist of the Terms of Reference from Annex A of DAO 2019-16 (**Annex A**). Among the major and critical components of the EIS Report are the following:

1. Project Description
2. Environmnetal Impact Assessment (EIA) Summary
3. Assessment of Environmental Impacts
4. Environmental Management Plan (EMP)
5. Environmnetal Risk Assessment (ERA) and Emergency Response Policy and Guidelines
6. Social Development Plan (SDP) and Information and Education Campaign (IEC)
7. Self-Monitoring Plan, Multi-Sectoral Monitoring Framework and Environmnetal Guarantee and Monitoring Fund Commitmments
8. Decomissioning/ Abandonment/ Rehabilitation Policy, and
9. Institutional Plan for Environmental Management Plan (EMP) Implementation

- **EIA Team**

The Department of Public Works and Highways (DPWH), the main proponent of the project, is the lead engineering and construction agency of the government, tasked in ensuring and designing infrastructure developments such as national highways, bridges, flood control and other related public works.

DPWH has appointed Ove Arup and Partners Hong Kong Ltd., “Arup”, as the lead consultant for the Feasibility Study of this BCIB Project. Arup is a multi-national firm which provides engineering, design, planning, project management and consulting services for all aspects of the built environment (**Annex B**).

Ecosys Corporation was hired by Arup as its sub-consultant to collaborate in the preparation of the EIA for the project, including social aspects such as the conduct of public consultations, IECs, perception survey, among others. The EIA Team consists of the following members:

Table 1 EIA Team

Name	Role in the EIA Study	Qualification
David Rollinson	Environmental and Social Team Leader (Arup)	BSc (Hons) Environmental Biology MSc Environmental Management
Angel Salcedo	Environmental and Social Specialist (Arup)	EIA Registration No. IPCO 334 MSc Environmental Engineering B.S. Chemical Engineering
Maria Catherine Rontos	Environmental and Social Specialist (Arup)	EIA Registration No. IPCO 037 Diploma in Urban and Regional Planning B.S. Environmental Planning and Management
Frederick Esternon	Terrestrial Ecology Specialist Environmental and Social Specialist EIA Head (Ecosys Corp)	EIA Registration No. IPCO 311 Environmental Management Specialist B.S. Forestry and Natural Resources
Elenor De Leon	Environmental and Social Specialist EIA Deputy Lead (Ecosys Corp)	EIA Registration No. IPCO 425 Master in Development Management Master of Environment and Natural Resources Management (units earned)
Ruben Estudilo	Marine Ecology Specialist (Ecosys Corp)	PhD Marine Science (Units Earned) MSc Marine Science Ecology B.S. Marine Science
Armando Gillado Jr	Terrestrial Flora Specialist (Ecosys Corp Inc)	EIA Registration No. IPCO 312 B.S. Forestry and Natural Resouces
Russel Banigued	Terrestrial Fauna Specialist (Ecosys Corp Inc)	EIA Registration No. IPCO 157 Environmental Science Specialist

- **EIA Study Schedule**

Table 2 presents the timeframe of activities set by the EIA consultant for the EIA study of the BCIB project.

Table 2 EIA Study Schedule

Year	2019												2020																																															
Month	Oct				Nov				Dec				Jan				Feb				Mar				Apr				May				June				July				Aug				Sept				Oct				Nov				Dec			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activities																																																													
Reconnaissance Survey																																																												
Coordination and Communication meeting																																																												
Initial Perception Survey																																																												
IEC and FGD																																																												
Bataan																																																												
Cavite																																																												
Meeting with EMB																																																												
Fauna Assessment																																																												
Flora Assessment																																																												
Corals Assessment																																																												
Fish Assessment																																																												
Air & Noise Sampling																																																												
Water sampling and analysis																																																												
Sediment sampling and analysis																																																												
EIS report writing																																																												
Awaiting new EMB DMO																																																												
EMB Procedural Screening and EIS Draft Report Acceptance for substantive Review of REVCOM																																																												
Public Hearing																																																												

- **EIA Study Area**

The bridge will be constructed between the provinces of Bataan and Cavite. The alignment crosses over the Manila Bay – a natural harbour that is bounded by Cavite and Metro Manila on the east, Bulacan and Pampanga on the north and Bataan on the northwest. It has two navigation channels and the alignment will cross both the north and south channel on either side of Corregidor Island.

In Bataan, the alignment is situated between jurisdiction starting from the Roman Highway and then traversing the barren land area at Barangay Alas-Asin, and then skirts to the shoreline of Barangay Mountain View in Mariveles.

In Cavite, the alignment will start from the shoreline of Barangay Timalan Balsahan in Naic, then traversing through the agricultural and residential area and terminating at Antero Soriano Highway, which is in a relative flat terrain in Barangay Timalan Balsahan and Barangay Timalan Concepcion.

- **EIA Methodologies**

Table 3 Summary of EIA Methodologies

EIA Key Components	Methods
Land	
Land Use and Classification	• Review of secondary data from comprehensive land use plans and maps • Key informant interviews • Site visits
Geology/Geomorphology	• Review of secondary data • Simplified ground modelling
Geohazard Assessment	• Maps from Comprehensive Land Use Plans (CLUPs) and from the Mines and Geosciences Bureau (MGB) and the Philippines National Geophysical Data Center
Pedology	• Review of secondary data from comprehensive land use plans, and soil survey report of Bataan (2003) and Soil Survey Classification of Cavite (2002) from Bureau of Soils and Water Management (BSWM).
Terrestrial Ecology: Flora Assessment	• Transect survey • Use of quadrat sampling plots • Documentation of tracks and coordinates of sampling stations using a handheld GPS • Geo-tagging of photos
Terrestrial Ecology: Fauna Assessment	• Transect survey • Netting • Trapping • Night sampling
Water	
Hydrology/ Hydrogeology	• Review of secondary data from comprehensive land use plans, Integrated Water Resource Management Master Plan by the Provincial Government of Cavite, related hydrologic studies, and historic flood levels
Oceanography	• Review of secondary data from comprehensive land use plans, NAMRIA bathymetric maps and related studies

EIA Key Components	Methods
Water Quality	• Surface and groundwater sampling • Marine water quality sampling
Freshwater Ecology	• Review of secondary data from comprehensive land use plans
Marine Ecology	• Inter-tidal, Exposed Coastal Beach and River Estuary - Collection of primary data from on-site observation, interview and coastal characterization. • Collection and Analysis of Phytoplankton and Zooplankton • Ichthyoplankton (Fish Eggs and Fish Larvae) - Secondary data review (baseline information from a published report) • Primary Productivity (Chlorophyll-a Concentration) - Surface water sampling • Harmful Algal Blooms - Review of secondary information from published papers and articles on HAB events by several researchers • Soft Bottom Infaunal Benthos - River estuary and intertidal sediment sampling • Corals and Associated Fish Assemblages - Rapid reef survey - Review of secondary data - Fish survey • Macroinvertebrates - Visual observation • Macrophytes (Seagrasses and Macrobenthic Algae) - Review of secondary data - Interviews with local fisherfolks - Visual inspections along the exposed coastal beaches and intertidal and subtidal shallows of Alas-asin (Mariveles), Corregidor Island, and Timalan Concepcion (Naic) on the presence of seagrasses and macrobenthic algae (seaweeds). • Mangrove and Other Coastal Vegetation - Flora assessment using point sampling method - Use of the Shannon biodiversity index to measure species diversity • Fish Sanctuary and Artificial Hard Structures (Artificial Reef and Shipwreck) - Key informant interviews with the Municipal Agricultural Office (MAO), Fisheries and Aquatic Resources Management Council (FARMC), Corregidor Foundation Incorporated (CFI), and community-based Bantay Dagat (Sea Patrol) - Site visit to local marine resources - Review of map provided by CFI • Protected Marine Species (Threatened or Endangered Species) - Interviews with the staff from the MAO, FARMC, PENRO and Bantay Dagat at the project sites in Mariveles and Naic. - Actual site visits and direct observations assisted by Bantay Dagat members. - Key informant interview with Manolo Ibias, Chairman of Bantay Pawikan, Inc. in Morong, Bataan. - Interviews with the local fisherfolks and Bantay Dagat - Review of secondary data from the works of Alava and Cantos (2004), Aragones et al. (2010), Marine Wildlife Watch of the Philippines (2014) and a number of published reports, as well as from media coverage/news reports on marine mammal strandings in Manila Bay. • Fisheries Resources

EIA Key Components	Methods
	- Site inspections and actual observations - Key informant interviews - Review of secondary data from published reports and technical publications of the National Fisheries Research and Development Institute (NFRDI) and Partnerships in Environmental Management for the Sea of East Asia (PEMSEA).
Air	
Ambient Air sampling	• Ambient air sampling • Air dispersion modelling
Noise sampling	• Noise sampling • Noise modelling
People	
Scoping and Public Participation	• Preliminary desk research • Site visits • Initial consultations • Stakeholder mapping • Key informant interviews • Consultations • Household survey
Traffic Impact Assessment	• Secondary data review • Vehicle-classified count surveys • Traffic impact assessments • Travel time savings analysis
Environmental Risk Assessment	• Site assessment • Secondary data review • Key informant interviews • Consultations

Public Participation Activities

Consistent with the Guidelines on Public Participation under the Philippine Environmental Impact Statement System (PEISS) of DAO 2017-15, stakeholder's consultation has been continuously conducted for the BCIB Project. Information and Education Campaigns (IEC) were completed in Barangay Timalan Conception, Sabang and 53B in Naic and Cavite on 21 January 2020 and Barangay Mt. View and Alas-Asin in Mariveles on 22 January 2020. The complete Public Participation Reports are attached in **Annex C**.

Public scoping is not yet held due to the restrictions of the COVID-19 pandemic. DPWH sent a letter to EMB requesting for an advice for the conduct of Public Scoping and should EMB agree to waive this activity and resume the moment its safe to conduct public gatherings (**Annex D**). EMB advised to temporary hold the activity due to the restrictions of the current health situation and proceed with the preparation of this EIS Report. Hence this report initially contains the IEC and FGD issues and concerns conducted before the start of the Enhanced Community Quarantine (ECQ).

Table 4 Summary of Pre-Scoping IEC Activities and Issues

LGUs Covered by IEC	Actual IEC Schedule / Dates	Issues Raised / Suggestions Provided
Brgy. Timalan Concepcion, Naic, Cavite	21 January 2020	• Access for fishermen and boat operators. • Vehicular traffic near and along Timalan Concepcion Elementary School will increase. It will also be affected by the planned road widening in the area. • Once construction begins, roads will be busy. Who will ensure safety in the area/community? • Will tricycles be allowed to use the bridge?
Brgy. Sabang, Naic, Cavite	21 January 2020	• Consideration of community welfare by the project. • How about those who are within the project alignment? • Does the government pay those whose properties will be affected by the project? • How will Cavite benefit from the project in terms of employment?
Brgy. 53B, Cavite City, Cavite	29 January 2020	• Project alignment • Benefits to Cavite City and its residents
Brgy. Mt. View, Mariveles, Bataan	22 January 2020	• Specific areas and sitio to be traversed by the BCIB alignment. • Concern regarding the pollution that will be produced during construction of the BCIB alignment. • Responsible entity for cleaning the pollutants generated during and after the construction. • Construction of toll gates.
Brgy. Alas asin, Mariveles, Bataan	22 January 2020	• Inclusion of exit to Corregidor. • When to expect the development and traffic from the Cavite and Bataan entry points. • Concern regarding the pollution that the BCIB Project will produce. • Confirmation of rumors that fisherfolks would not be allowed to go near the bridge post. • Allowing fisherfolks to use the bridge in case their boats break down. • Participants added that fisherfolks frequently stay in Corregidor Island when their boats break down.

EIA Summary

- **Siting**

The options for the road links structural form were narrowed down to six (6). Based on initial studies and a rigorous option selection process, it was recommended that a cable stayed bridge is taken forward for both North and South Channel Bridge using the most preferable option for the BCIB project (alignment option 2c). **Table 5** shows the various structural forms considered.

Table 5 Summary of Bridge Options

Option	Structural Form
Option 2a	Immersed Tube Tunnel
Option 2b	Navigation Bridge
Option 4a	Immersed Tube Tunnel
Option 4b	Navigation Bridge
Option 5	Navigation Bridge
Option 2c	Navigation Bridge

- **Technology Selection**

Given the nature of the project, which is a bridge, there will be no alternative / special technologies, operation processes and measures to minimize waste generation. The updated designs will be determined as the study progresses whilst good site practices and standard waste collection process will be implemented in the construction and operational phase, respectively.

Integrated Summary of Impacts and Residual Effects after Mitigation

Table 6 Integrated Summary of Impacts and Residual Effects

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
Pre-Construction				
A1. Preparation of the project site for construction	Terrestrial Ecology	Cutting down of trees along the road right-of-way Displacement of animals, insects and avifauna	• Identification of site for replacement tree planting • Compliance with conditions of DENR/LGU, Tree Cutting Permit, ROW • Provide temporary fencing to vegetation that will be retained • Delineation on the ground of the areas to be cleared should be implemented to avoid and minimize unnecessary clearing.	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Water Quality	Inconsistency on DENR and LGU's current mandate to rehabilitate and improve the water quality of Manila Bay	• Integrate the Manila Bay Rehabilitation plan in the project • Regular coordination with LGUs, DENR and Manila Bay Coordinating Office (MBCO) • Regular water quality monitoring	DPWH will ensure that the project will be integrated with DENR's Manila Bay Rehabilitation plan. Impacts on water contamination will be 80-100% mitigated.
A2. Procurement and planning	Economy	Increase business opportunities due to purchase of construction materials	• Purchase from local suppliers whenever possible • Secure services of residents whenever possible	DPWH will ensure 80-100% purchase of construction materials to local suppliers and services of the locals.
A3. Land acquisition and resettlement	People	Loss of land within the project affected area; Displacement of residents and structures in the project site and within its vicinity	• Implementation of the approved Resettlement Action Plan (RAP) of the Project • Provide relocation / compensation to affected landowners, households, and owners of other establishments	Provide 100% implementation based on the final agreement between the proponent and the Project Affected Persons (PAPs).

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Regularly monitor of presence/absence of complaints from PAPs. • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism (GRM)	
Construction				
B1. Erection of temporary facilities for workers and field office, storage sheds, and workshops	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Implement appropriate operating hours • Provide noise barriers, such as site fencing, during the construction stage • Properly operate and maintain all noise sources	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site • Use covered vehicles to deliver materials that may generate dust • Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQS. • Workers will be provided with the appropriate PPEs and will practice standard occupational health and safety pursuant to BWC-	Impacts on dust re-suspension and increased vehicular emission will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			DOLE Occupational Safety and Health Standards	
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
	Water Quality	Degradation of water quality due to generation of domestic wastewater	• Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to ensure continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • Locate motor-pool area at least 500 meters away from any body of water; • The contractor will be required to comply with the Civil Works Guidelines; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment.	Impacts on generation of domestic wastewater will be 80-100% mitigated, depending on DENR accredited hauler collection, but the proponent will ensure 100% compliance with RA 9275

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Community health and safety	Increased risks to community due to increase in vehicular movement Disturbance to nearby residents and resort operators	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents • Regularly monitor of presence/absence of complaints from PAPs • Immediate action on the stakeholder complaints through the implementation of GRM	Impacts on community health and safety will be 80-100% mitigated, but the proponent will ensure 100% monitoring and coordination with the LGUs and barangays.
		Possible spread of diseases due to workers' unsanitary practices	• Observe proper sanitation practices in the construction area and workers' barracks to avoid generation and spread of diseases. • Regular conduct of health and safety awareness to all construction employees.	Impacts on health and safety will be 80-100% mitigated, considering proponent's proper sanitation practices and health and safety awareness within the construction site.
	Solid waste	Generation of solid waste from construction activities	• Implement solid waste management plan • Proper waste management and housekeeping measure • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; and • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	Waste management will be 90-100% implemented, unless there will be incidents which are uncontrolled.
		Generation of hazardous materials in land (i.e. disposal of	• Implement an organized waste storage, collection, and management system;	Impacts on generation of hazardous materials will be 90-100% mitigated depending on DENR accredited hauler collection.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility.	• Proper waste management and housekeeping measures can also prevent possible contamination in soil and water in compliance with RA 6969; • Used oil, spillages and other hazardous waste should be collected, contained and disposed by a 3rd party accredited hauler and treater; • Maintenance and proper use of construction materials and heavy vehicles; • The contractor shall be provided with training and should ensure that hazardous waste is collected on a daily basis from the site.	Proper equipment maintenance, disposal of hazardous wastes and non-recyclable wastes, and expert handling of waste oil and oil spills will translate to 80% to 100% efficiency in pollution control. Compliance to RA 6969 will be ensured.
	Local economy	Temporary employment for the locals during the construction stage Increase in economic opportunities.	• Prioritize locals when hiring laborers. Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; and • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs. • Enforcement of RA6685	Providence on equal employment for qualified workers and livelihood will 80-100% be ensured by the proponent.
B2. Mobilization of equipment and supplies to project site	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Air quality	Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	Impacts on increased vehicular emission will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Traffic	Transport of construction materials from source to casting yard	• The project will not cause congestion, however, should be necessary, traffic management plan will be prepared and implemented. • Coordination with LGUs is proposed to provide traffic enforcers for safe and organized traffic flow.	The project will ensure implementation of Traffic Management Plan, provision of traffic enforcers, and coordination with LGU's regarding traffic rerouting to provide 80% to 90% efficiency of smooth traffic flow.
	Community health and safety	Increased risks to community due to increase in vehicular movement Disturbance to nearby residents and resort operators	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents • Regularly monitor of presence/absence of complaints from PAPs • Immediate action on the stakeholder complaints through the implementation of GRM.	Impacts on community health and safety will be 80-100% mitigated, but the proponent will ensure 100% monitoring and coordination with the LGUs and barangays.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
B3. Setting up of casting yard	Terrestrial flora	Cutting down of trees within the proposed casting yard	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	Impacts will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site	
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
	Traffic	Transport of construction materials from source to casting yard	• The project will not cause congestion, however, should be necessary, traffic management plan will be prepared and implemented. • Coordination with LGUs is proposed to provide traffic enforcers for safe and organized traffic flow.	The project will ensure implementation of Traffic Management Plan, provision of traffic enforcers, and coordination with LGU's regarding traffic rerouting to provide 80% to 90% efficiency of smooth traffic flow.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Water Quality	Degradation of water quality due to oil, fuel or other lubricant agents leaks	• Locate motor-pool area at least 500 meters away from any body of water; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to ensure continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • The contractor will be required to comply with the Civil Works Guidelines; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Emergency and contingency plan in case of spills (health and safety management plan must be in place); • The contractor shall ensure that solid and hazardous waste is collected on a daily basis from the site.	Siting motor pool away from water bodies, adhering to Civil Works Guidelines, and installing oil-water separators will result in 80% to 100% efficiency in pollution control The proponent will ensure 100% compliance with emergency plans and standards and RA 6969
B4. Establishment of dry dock and works area for navigation bridge	Terrestrial flora	Cutting down of trees within the proposed dry dock and works area	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Noise	Increased noise level due to use of heavy	• Limit the use of noise-emitting machines and equipment to daytime only;	Impacts will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		equipment and other vehicles	• Provide noise barriers, such as site fencing, during the construction stage	
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site	
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
	Transportation/ Occupational Health and Safety	Sea Traffic	• Proper coordination with the Maritime, PPA, Coast Guard, LGUs and other related government offices regarding the following: -Schedule of shipping -Coordinates of alternative route of ships passing through North and south Passage • Ships/barges will be fitted with proper lighting during nighttime • Continuous coordination with the LGUs and affected barangays, PPA and other related government-offices • Assign a ship crew to assist the helmsman during nighttime steering	Risks of accidents among small fishing boats and ships/ barges will be 80-100% mitigated, by ensuring that the project coordinated the construction activities to affected fishers and vessel operators.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Designated exclusion zones should be defined and vessels not related to the construction works shall be prohibited from entering these areas in order to minimize impacts from marine traffic. Exclusion zones shall be defined and clearly marked by the contractors such that non-construction vessels navigating in the vicinity of the works area are kept clear of the area and transit at slow speed. Contractors should liaise with the PPA, PCG, LGUs and other related government offices to patrol the exclusion zone to maintain traffic order. • Flexible rules and mitigation measures should be developed by the contractor according to different working stages (i.e. special yellow marker buoys fitted with yellow lights should be laid to mark the extents of particular exclusion zone as required). • It is proposed that a Marine Liaison Group is established prior to construction to co-ordinate and expedite the construction of the BCIB while maintaining safe marine activities in Manila Bay. • The membership of the Marine Liaison Group may include representatives from: -Contractors for BCIB; -DPWH;	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			-Engineer's Representative; -Philippine Coast Guard Representative; -Philippine Port Authority Representative; -Philippine Navy Representative; -Relevant LGU's • The purpose of the Marine Liaison Group is as outlined below: -To provide a forum for the sharing of vessel activities to assist planning of construction activity. -To co-ordinate marine traffic management requirements between the Contractors, Marine Department and other relevant Government Authorities. -To review and discuss the experience of implementation measures to optimise the safety and efficiency of construction and marine activities. -To advise the Engineer with respect to the phasing of construction operations. -To agree on the precise timing and setting out of exclusion zones required for construction activities above North and South Navigational Channel. -To resolve conflicts that may arise from the implementation of the works.	
	Water Quality	Degradation of water quality due to construction, and water	• Apply appropriate siltation control measures such as well-designed	Impacts on generation of hazardous materials will be 90-100% mitigated and 100% compliance with emergency plans and standards and RA6969 is

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		contamination due to fuel, oil and other hazardous materials leakages	marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase; • The contractor will be required to comply with the Civil Works Guidelines; • The contractor shall ensure that solid and hazardous waste is collected on a daily basis from the site; • Compliance in of MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14; • Ensure compliance to PCG Memorandum # 07-14; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; and	ensured, unless there will be incidents which are uncontrolled. This will also depend on DENR accredited hauler collection.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Emergency and contingency plan in case of spills (health and safety management plan must be in place).	
	Marine ecology	Increase turbidity which may interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis May also irritate and clog the gills of pelagic fish larvae and juveniles that could lead to their eventual smothering Ballast water discharges of construction/cargo/delivery vessels may introduce some phytoplankton species known to trigger harmful algal blooms or HABS/toxic red tides that can alter the structure and function of aquatic ecosystems Bilge water discharges of construction/cargo/delivery vessels may depress photosynthesis	• Use of geotextile silt curtains is recommended • Prohibit marine vessels from discharging ballast water in the sea; quarantine protocols through a Ballast Water Management Plan could be adopted • Prohibit marine vessels from discharging bilge water, or possibly by establishing treatment for bilge water; a very effective technology currently is available on the market to clean bilge water before it is discharged into the sea • Impact on shallow water/intertidal or sublittoral areas might be reduced by controlling movement of oil spill and/or dispersion at sea. Oil Spill Contingency Plans should be prepared and made readily available • Compliance to marine protocols by PPA and PCG requirements • Avoid or reduce the potential for the introduction of HABs/ toxic phytoplankton species • Avoid or reduce the potential to cause damage to phytoplankton communities • Lessen or avoid complaints received on oil spills of nearshore/coastal waters from residents, fisherfolks, and resort owners/operators	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected, Philippine Coast Guard (PCG) and other related government agencies. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		and growth of phytoplankton Pile driving will crush or destroy benthic infaunal organisms and some epibenthic macroinvertebrates in small area and cannot be mitigated; benthic re-colonization should be quite rapid and could occur a few months after construction Anchoring will crush or loose epifauna in small area Turbidity plumes (pile driving) will disturb feeding activities and respiration of benthos Accidental oil spills- significant impact (direct smothering) on benthos in shallow water or intertidal/ sublittoral areas; while in offshore areas less threatening (insignificant impact)		
	Marine ecology (Coral Reefs)	Turbidity (sediment resuspension), pile driving -resuspended fine sediments could travel to a neighboring coral reef in	• Use of geotextile silt curtains is recommended • To prevent physical damage to adjacent patch reef during construction from dropping and	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		Corregidor Island; might cause temporary impact of short duration (insignificant level) Accidental bumping of construction vessels and localized disturbance from dropping and dragging anchors and chains may destroy/break and smash live corals	dragging anchors and chains on the reef surface as well as accidental bumping by construction vessels, a marker buoy will be placed to indicate location of the adjacent reef formation. This will forewarn ship operators and aid them where they can only operate and anchor.	Use of silt curtains will be 40% efficient.
	Protected Marine Species i.e. Marine turtles	Artificial light- reproductive success of marine turtles may potentially be reduced because matured females could be deterred from nesting on sandy beaches; hatchlings may also be disoriented/ misoriented and displaced on the beach Accidental collisions/ boat strikes and propeller hits from construction vessels due to higher vessel traffic- severe injury and/or mortality from accidents is greater (marine turtles have poor hearing and vision, and often times	• Use of geotextile silt curtains is recommended • Artificial light Minimize light intensity to as low as reasonably particularly in nearshore areas. • Avoid use of white lights (e.g. mercury vapour, metal halide, halogen, and fluorescent light) in proximity to turtle beaches. Use high pressure sodium lights where possible. • Reduce lighting spill through shielding, directional alignment, window covering and other techniques. • Reduce horizon glow through the use of downward facing luminaries, attention to reflecting surfaces and minimization of external visibility of indoor lighting.	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		will not notice an approaching boat in time to move to safet Accident (oil spills) - disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality; if there is an oil spill, these impacts will be significant and not mitigatable but might be reduced. In general, impacts are considered insignificant short duration and site specific	• Lighting on moored vessels at night will be kept to a minimum for safe operations. • Periodic monitoring of the waters by trained vessel crew around construction vessels and around the construction site for the presence of hatchlings. • <u>Protected Marine Species</u> Trained personnel will be responsible for observing marine turtles during active piling at piling sites (e.g., on a jackup barge or adjacent support vessel). • Vessel crew will undergo site inductions and clear briefings covering procedures to be undertaken, to minimize disturbance to marine fauna provided by appropriately qualities personnel. • Existing acoustic control on noise-generating equipment (including vessel engines, drill and piling equipment) will be implemented to reduce notice at source. • Noise-generating equipment (including vessel engines, drill and piling equipment) will be routinely maintained and inspected to reduce unnecessary increases in noise levels from the equipment. All vessels shall operate in accordance with appropriate industry equipment noise standards.	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Where practical the practice of leaving engines, thrusters and auxiliary plant on standby or running mode will be avoided. • If marine turtles are sighted in the monitoring area, project vessels operating in the area will be notified. • Trained vessel crew will monitor and report observations of marine turtles within a designated monitoring zone (250m radius of piling barge) around the pile driving operations. Observations are to be recorded on the Observation Record Form. In the event that a marine turtle is sighted within a designated exclusion zone (500 m radius of the piling barge), piling activities will cease until the marine turtle moves outside of the exclusion zone or is not sighted for 20 minutes. Note: for reference, a 2000-m exclusion zone applies for Marine Mammals (except dolphins). • Carry out a “soft start” for piling by beginning a pile driving session with the lowest power possible and hammering at a low rate, then increasing hammer energy and rate to that desired. This should allow animals close to the source to move away and not be suddenly exposed to sound intensities sufficient to cause them serious injury. • Any injuries or mortalities will be documented and reported.	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Collisions/boat strikes/propeller hits Vessel crew will undertake site induction by appropriately trained project personnel. • Vessel speeds will be under the control of the Vessel Master who will ensure that all vessels operate in a safe manner with due respect to ongoing operations, navigational constraints and environmental considerations. • The Vessel Master will be advised of environmental matters from on-site environmental staff, including trained vessel crew, as applicable. • Trained vessel crew will monitor and report turtle sightings from project vessels during daylight hours during the construction phase. • Any incidents or injuries to turtles will be documented and reported. • Accidental oil spills Oil spill contingency plans should be prepared and made readily available.	
	Fish and Fishery resources	Disruption/ disturbance of fishing activities - temporary impact and short duration will occur but minimal or insignificant since fishing activities will still be allowed along the vicinity of the construction sites, but	• A required safety exclusion zone along construction site is recommended (i.e., 0.2 km) • Oil spill impact might be reduced by controlling movement of any spill; therefore, Oil Spill Contingency Plans should be prepared and made readily available • Geotextile silt curtains should be used to reduce turbidity	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		with a required safety exclusion zone. Moreover, existing fishing grounds around the construction sites are not the only fishing grounds in the area Accidental oil spills - generally, minimal or insignificant impacts on fish populations are expected because of probable capabilities of fishes to avoid oil spills; however, heavy loss of pelagic fish eggs and larvae can occur in shallow water area with poor water circulation	• Regular coordination with the LGU and affected fisherfolks • Regularly monitor of presence/absence of complaints from affected fishers • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	
B5. Setting up of dumping/storage areas	Terrestrial flora	Cutting down of trees within the proposed dumping/storage area	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Air quality	Dust re-suspension from earthworks and	• Water spraying of the area during dry days;	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		other construction activity	• Fencing the area to contain the dust within the project site	
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
	Solid waste	Generation / Increased in solid waste from the activity	• Implement solid waste management plan • Proper waste management and housekeeping measure • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; and • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	Waste management will be 90-100% implemented, unless there will be incidents which are uncontrolled.
B6. Setting up of haul roads	Terrestrial flora	Cutting down of trees within the proposed haul roads	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only;	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Provide noise barriers, such as site fencing, during the construction stage	
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site	
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	
B7. Development of landing site	Terrestrial flora	Removal of vegetation on the proposed landing site and along the proposed alignment leading up to the existing highway (Antero Soriano Highway for Naic and Roman Superhighway for Mariveles)	• Compensatory planting will be done as per requirements of PD 705 • Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH will ensure 80-100% efficiency on areas for land clearing; DPWH will ensure to 100% compliance with the tree permitting mandate, and tree replacement, whenever necessary.
	Noise	Increased noise level due to use of heavy equipment	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers such as site fencing, during the construction stage	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Livelihood	Removal of structures, including neighborhood sundry stores, backyard piggeries, and tricycle terminals, will lead to reduced income or income loss to affected residents/business owners	• Conduct of IEC with displaced individuals • Provide compensation options, including alternative livelihood options to project affected micro, and small entrepreneurs • Implementation of the approved Resettlement Action Plan of the Project • Provide just relocation / compensation to affected landowners, households, and owners of other establishments • Regularly monitor of presence/absence of complaints from Project-Affected-Persons • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	Provide 100% compensation based on the agreement between the proponent and the Project Affected Persons (PAPs).
	Occupational health and safety	Increased accident risks to workers due to the construction works Potential risks from natural hazards	• Provision for PPE to all workers • Training and safety drill to be given to workers • Conduct regular toolbox meeting • Record health and safety incidents on site	Impacts on health and safety will be 80-100% mitigated, considering proponent's proper sanitation practices and health and safety awareness within the construction site.
B8. Placement of precast segments	Coastal water	Siltation of coastal water may affect growth of coral reefs	• Installation of silt and sediment traps to localize the movement of silt and sediments to within the cable laying route	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Water quality	Ships/barges may discharge sewage to the sea Ships/barges may discharge its ballast water which may contain oil and contaminate marine waters	• Ships/barges will be required to have its own treatment facility • Ships/barges will not be allowed to discharge its sewage or ballast water to the sea. The ship will make use of existing facilities that accept discharge of sewage and ballast water from ships • Regular water quality monitoring • Installation of silt and sediment traps to localize the movement of silt and sediments to within the cable laying route • Regular water quality monitoring • The contractor will be required to comply with the Civil Works Guidelines; and • Compliance in of MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14.	Although use of silt curtains will be 40% efficient, impacts on water quality will be 80-100% mitigated, hence the proponent will ensure compliant with standards.
		Placement of precast segments may disturb seabed sediments which may have accumulated heavy metal content		
	Marine Ecology	Increase turbidity which may interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis; and may also irritate and clog the gills of pelagic fish larvae and juveniles that could	• Use of geotextile silt curtains is recommended • Prohibit marine vessels from discharging ballast water in the sea; quarantine protocols through a Ballast Water Management Plan could be adopted • Prohibit marine vessels from discharging bilge water, or possibly by establishing treatment for bilge water; a very effective technology currently is available on the market to clean bilge water before it is discharged into the sea	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		lead to their eventual smothering Anchoring will crush or loose infauna and epifauna in small area Accidental oil spills-significant impact (direct smothering) on benthos in shallow water or intertidal/sublittoral areas; while in offshore areas less threatening (insignificant impact)	• Impact on shallow water/intertidal or sublittoral areas might be reduced by controlling movement of oil spill and/or dispersion at sea. Oil Spill Contingency Plans should be prepared and made readily available	
	Coral Reef	Accidental bumping of construction vessels and localized disturbance from dropping and dragging anchors and chains may destroy/break and smash live corals	• Use of geotextile silt curtains is recommended • To prevent physical damage to adjacent patch reef during construction from dropping and dragging anchors and chains on the reef surface as well as accidental bumping by construction vessels, a marker buoy should be placed to indicate location of the adjacent reef formation. This will forewarn ship operators and aid them where they can only operate and anchor. If a ship ran aground on coral reef, the ship owners would be financially liable.	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Protected Marine Species i.e. marine turtles	Artificial light- reproductive success of marine turtles may potentially be reduced because matured females could be deterred from nesting on sandy beaches; hatchlings may also be disoriented/ misoriented and displaced on the beach Accidental collisions/ boat strikes and propeller hits from construction vessels due to higher vessel traffic- severe injury and/or mortality from accidents is greater (marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safety) Accident (oil spills) - disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality; if there is an oil spill, these impacts will be significant and not mitigatable but might be reduced. In	• Use of geotextile silt curtains is recommended • Artificial light Minimize light intensity to as low as reasonably particularly in nearshore areas. • Avoid use of white lights (e.g. mercury vapour, metal halide, halogen, and fluorescent light) in proximity to turtle beaches. Use high pressure sodium lights where possible. • Reduce lighting spill through shielding, directional alignment, window covering and other techniques. • Reduce horizon glow through the use of downward facing luminaries, attention to reflecting surfaces and minimization of external visibility of indoor lighting. • Lighting on moored vessels at night will be kept to a minimum for safe operations. • Periodic monitoring of the waters by trained vessel crew around construction vessels and around the construction site for the presence of hatchlings. • Protected Marine Species Trained personnel will be responsible for observing marine turtles during active piling at piling sites (e.g., on a jackup barge or adjacent support vessel).	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected. Use of silt curtains will be 40% efficient.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		general, impacts are considered insignificant short duration and site specific	• Vessel crew will undergo site inductions and clear briefings covering procedures to be undertaken, to minimize disturbance to marine fauna provided by appropriately qualities personnel. • Existing acoustic control on noise-generating equipment (including vessel engines, drill and piling equipment) will be implemented to reduce notice at source. • Noise-generating equipment (including vessel engines, drill and piling equipment) will be routinely maintained and inspected to reduce unnecessary increases in noise levels from the equipment. All vessels shall operate in accordance with appropriate industry equipment noise standards. • Where practical the practice of leaving engines, thrusters and auxiliary plant on standby or running mode will be avoided. • If marine turtles are sighted in the monitoring area, project vessels operating in the area will be notified. • Trained vessel crew will monitor and report observations of marine turtles within a designated monitoring zone (250m radius of piling barge) around the pile driving operations. Observations are to be recorded on the Observation Record Form. In the event that a marine turtle is sighted	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			within a designated exclusion zone (500 m radius of the piling barge), piling activities will cease until the marine turtle moves outside of the exclusion zone or is not sighted for 20 minutes. Note: for reference, a 2000-m exclusion zone applies for Marine Mammals (except dolphins). • Carry out a "soft start" for piling by beginning a pile driving session with the lowest power possible and hammering at a low rate, then increasing hammer energy and rate to that desired. This should allow animals close to the source to move away and not be suddenly exposed to sound intensities sufficient to cause them serious injury. • Any injuries or mortalities will be documented and reported. • Collisions/boat strikes/propeller hits Vessel crew will undertake site induction by appropriately trained project personnel. • Vessel speeds will be under the control of the Vessel Master who will ensure that all vessels operate in a safe manner with due respect to ongoing operations, navigational constraints and environmental considerations. • The Vessel Master will be advised of environmental matters from on-site environmental staff, including trained vessel crew, as applicable.	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Trained vessel crew will monitor and report turtle sightings from project vessels during daylight hours during the construction phase. • Any incidents or injuries to turtles will be documented and reported. • Accidental oil spills Oil spill contingency plans should be prepared and made readily available.	
	Fish and Fisheries resources	Disruption/ disturbance of fishing activities - temporary impact and short duration will occur but minimal or insignificant since fishing activities will still be allowed along the vicinity of the construction sites, but with a required safety exclusion zone. Moreover, existing fishing grounds around the construction sites are not the only fishing grounds in the area Accidental oil spills - generally, minimal or insignificant impacts on fish populations are expected because of probable capabilities of fishes to avoid oil spills; however, heavy	• A required safety exclusion zone along construction site is recommended (i.e., 0.2 km) • Oil spill impact might be reduced by controlling movement of any spill; therefore, Oil Spill Contingency Plans should be prepared and made readily available • Geotextile silt curtains should be used to reduce turbidity • Regular coordination with the LGU and affected fisherfolks • Regularly monitor of presence/ absence of complaints from affected fishers • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	Due to the permanent construction effect, the proponent will ensure to limit use on areas that are only necessary during construction. This will be well coordinated with LGUs/ barangays affected.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		loss of pelagic fish eggs and larvae can occur in shallow water area with poor water circulation		
	Air quality	Increased vehicular emission from use of heavy equipment	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	Impacts on increased vehicular emission will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Noise	Increased noise level due to use of heavy equipment	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers such as site fencing, during the construction stage	Impacts on noise disturbance will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.
	Employment	Temporary employment for the locals during the construction stage	• Positive impact and does not require mitigation; • Prioritize locals when hiring laborers. Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; and • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and	Providence on equal employment for qualified workers and livelihood will 80-100% be ensured by the proponent.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			women, skilled and unskilled, and PWDs. • Enforcement of RA6685	
	Economic Development	Additional income taxes for the LGU	• Positive impact and does not require mitigation • Continuous coordination with the LGUs and affected barangays	Permanent impact due to the project.
	Transportation	Traffic congestion due to trucks delivering supplies to site and movement of staff vehicles to and from the site	• Provide traffic aides to make sure smooth flow of traffic to and from project site; • Request assistance from LGUs to minimize delays in vehicular traffic; • Install signage in the entrance to the project site and around 100 meters on both sides of the road to alert motor vehicles of possible ingress and egress of site vehicles and delivery trucks • Continuous coordination with the LGUs and affected barangays • Implementation of traffic management plan	Impacts on traffic congestion will be 60-80% mitigated, but the proponent will ensure that traffic management plan will be implemented and coordination with the LGUs and affected barangays will be done
	Religious practices	Disturbance to church activities in the nearby chapel	• Proper scheduling of construction activities to minimize impact • IEC with church, community and LGU • Posting of notices on church bulletin board to inform the community	Disturbance to church activities will be 60-80% mitigated, but the proponent will ensure the construction activities will be well-coordinated with the affected parish administrator
	Occupational Health and Safety	Increased accident risks to workers due to the construction works Potential risks caused by natural hazards	• Provision of PPE to all workers • Training and safety drill to be given to workers • Conduct regular toolbox meeting • Record health and safety incidents on site	Impacts on health and safety will be 80-100% mitigated, considering proponent’s health and safety awareness practices within the construction site.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
	Community Health and Safety	Increased risks to community due to increase in vehicular movement Disturbance to nearby residents and business owners	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Continuous coordination with the LGUs and affected barangays	
	Fisheries	Docking areas within the alignment may no longer be available for boat owners. Docking and fishing areas near the alignment will be temporarily unavailable due to construction activities	• Conduct IEC and FGD with affected boat owners/fisherfolks • Provide alternative docking areas for permanently occupied docking areas • Provide temporary docking areas for temporarily unavailable docking areas • A navigable channel will be maintained, as required, to ensure safe and convenient passage of fishing boats and sea-craft in the vicinity of the project area • Continuous coordination with the LGUs and affected barangays • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	Provide 100% compensation based on the agreement between the proponent and the Project Affected Persons (PAPs).
	Livelihood	Fisherfolks from the area will temporarily be prohibited from fishing within the area of the submarine cable route	• Provide an alternative livelihood program for affected fisherfolks • Continuous coordination with the LGUs and affected barangays • Implementation of the approved RAP of the Project • Regularly monitor of presence/absence of complaints from PAPs	

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
			• Immediate action on the stakeholder complaints through the implementation of GRM	
	Maritime safety	Small fishing boats may accidentally collide with the ships/barges, especially during nighttime	• Ships/barges will be fitted with proper lighting during nighttime • Continuous coordination with the LGUs and affected barangays, PPA and other related government-offices • Assign a ship crew to assist the helmsman during nighttime steering	Risks of accidents among small fishing boats and ships/barges will be 80-100% mitigated, by ensuring that the project coordinated the construction activities to affected fishers and vessel operators.
Operation / Maintenance				
Operation of the BCIB bridge	Marine Ecology	Creation of artificial hard substrate on the seafloor – impact of operation is viewed as beneficial impact; act as artificial hard substrates or "artificial reefs"	• A positive impact; therefore, no mitigation required	Permanent impact due to the project.
Operation of the BCIB bridge	Community Health and Safety	Increased probability of road accidents due to increased traffic and higher speed limit on the bridge	• Post appropriate signage along the alignment to warn both residents and motorists; • Widely disseminate information on allowed vehicles on the bridge and speed limit • Provide a crew to monitor traffic on the bridge • Continuous coordination with the LGUs and affected barangays	The proponent will ensure 100% safe use of the bridge and efficiency of Emergency Response Team.
	Occupational Health and Safety	Accidents may befall workers as they maintain the bridge	• Regularly site safety drills • Use of prescribed PPEs	
Operation of the BCIB bridge	Local economy	Accessibility as well as traffic will be	• Positive impact.	Permanent impact due to the project.

Project Activity	Environmental Aspect	Potential Environmental Impacts	Proposed Mitigation Measures	Efficiency of Measures
		increased, increasing opportunities as well for businesses due to more people coming to and /or passing through the host LGUs.		
Decommissioning/Abandonment				
Disintegration of the demobilized structure	Water Quality/ Contamination	Impacts on existing water quality of Manila Bay	• Implementation of approved decommissioning plan by the EMB	Impacts will be 80-100% mitigated, but the proponent will ensure 100% compliant with standards.

Risks and Uncertainties relating to the findings and implications for decision making

Risks and uncertainties anticipated regarding the construction and operation of the bridge are shown in the **Table 7** below.

Table 7 Risk and uncertainties of the project

EIA Module	Risks and Uncertainties	Control Measures
Project Design	Structural failure due to possible earthquake and other unexpected calamites (i.e. volcanic eruption, typhoon)	Use of high-quality materials and scaffoldings during construction Regular maintenance and monitoring
	As the project plans and alignment may still change due to the result of detailed engineering, this may impact the timeline of the implementation and regulatory permit acquisition.	Wait for the detailed engineering survey and secure design confirmation regarding the minor adjustment to the alignment prior to the acquisition of right of way (ROW) and necessary permits
Marine	Extreme wind force and waves including swell during typhoon passage, sustained southwest monsoon winds, and storms surges	Consider forecasting of bad weather and extreme storm surges
	Strong tidal current velocities at the North Channel and South Channel of Manila Bay, as both channels are deep	To be considered in the detailed engineering design
	Threats to biodiversity: • Introduction of invasive alien species and/ or toxic dinoflagellates via ships' ballast water discharge • Possible future loss of endangered species (marine turtles) due to increased potential for accidental oil spills, and chances of collision with marine vessels during construction	By not allowing marine vessels from discharging ballast water in the area By controlling oil spills at sea; and minimizing vessel traffic/speed by incorporating routine visual reconnaissance efforts during the turtle nesting season
	None	The Marine Ecology Study and Impact Assessment covers the primary impact area (the main alignment) and the secondary impact area (adjacent areas). The possible changes for some portions of the project design during the detailed engineering

EIA Module	Risks and Uncertainties	Control Measures
		design (DED) will not affect the established Marine Ecology Sampling and Impact Assessment.
Surface Water	Degradation of water quality due to accidental contamination to nearby water body, improper effluent handling/ management/ disposal, and natural disaster (i.e heavy rains/ typhoons, earthquakes and storm surges), which may lead to deterioration, destruction and disruption of fish habitats	Application of appropriate erosion control measures such as addition of pavements, concrete sea walls, sediment traps and barriers during heavy rain periods Set up of portable sanitary facilities and collect wastewater to be disposed accordingly The contractor will be required to comply with the Civil Works Guidelines Monitoring and evaluation of benthic habitats to be conducted quarterly or bi-annually to capture changes
Ambient Air and Noise	Alteration to air quality during heavy rains, typhoons and other natural disaster.	Application of appropriate disaster risk measures and protocals Periodic monitoring to capture changes
	Excessive noise and vibration from construction equipment and vehicles may exceed national standards for noise in general areas	Periodic monitoring and evaluation of noise levels, among other parameters included in the ECC for future references Installation of noise barricade may be considered
Terrestrial Flora	None	The study area taken for the terrestrial flora study and impact assessment covers the primary impact area (the main alignment) and the secondary impact area (adjacent areas). The possible changes for some portions of the project design during the DED will not affect the established sampling points, impact management plan, and Environmental Monitoring Plan (EMoP) formulated for the proposed project. The results still cater such anticipated changes.
	Unanticipated additional cutting of trees during DED stage that may cause delays on the tree inventory and application of tree cutting permit	The project has to wait for the detailed engineering survey and secure design confirmation regarding the minor adjustment to the alignment perior to the acquisition of ROW and necessary permits
Terrestrial Fauna	None	The study area taken for the terrestrial fauna study and impact assessment covers the primary impact area (the main alignment) and the secondary impact area (adjacent areas). The possible changes for some portions of the project design during the DED will not affect the established sampling points, impact management plan, and EMoP formulated for the proposed project. The results still cater such anticipated changes.
People	As the project plans and alignment may still change due to the result of detailed engineering, this may	Wait for the detailed engineering survey and secure design confirmation regarding the minor adjustment to the alignment perior to the acquisition of ROW

EIA Module	Risks and Uncertainties	Control Measures
	impact the plans for ROW acquisition and that number of structures, PAPs may still change.	

1 Project Description

1.1 Project Location and Area

1.1.1 Description of Project Area

The project location is in Luzon, between the province of Bataan and Cavite. The alignment crosses over the Manila Bay – a natural harbour that is bounded by Cavite and Metro Manila on the east, Bulacan and Pampanga on the north and Bataan on the northwest. It has two navigation channels, the alignment will cross both the north and south channel on either side of Corregidor Island.

The Bataan-Cavite Interlink Bridge (BCIB) Project will be roughly located within the geographic coordinates of 14°27'39.273" N, 120°32'38.277" E at Bataan side (in WGS 1984 datum). On the coast of Cavite side, the bridge will be connecting around the point 14°20'7.376" N, 120°47'11.579" E as indicated in **Table 1.1** and **Annex E**.

Table 1.1 Geographic coordinates (WGS 1984)

Point	Latitude	Longitude
0	14° 27' 38.084" N	120° 32' 37.920" E
1	14° 27' 34.868" N	120° 32' 37.467" E
2	14° 27' 31.627" N	120° 32' 37.679" E
3	14° 27' 28.493" N	120° 32' 38.547" E
4	14° 27' 25.588" N	120° 32' 40.037" E
5	14° 27' 23.030" N	120° 32' 42.089" E
6	14° 27' 20.920" N	120° 32' 44.621" E
7	14° 27' 19.296" N	120° 32' 47.510" E
8	14° 27' 17.775" N	120° 32' 50.460" E
9	14° 27' 16.254" N	120° 32' 53.410" E
10	14° 27' 14.733" N	120° 32' 56.360" E
11	14° 27' 13.212" N	120° 32' 59.310" E
12	14° 27' 11.691" N	120° 33' 2.260" E
13	14° 27' 10.170" N	120° 33' 5.209" E
14	14° 27' 8.649" N	120° 33' 8.159" E
15	14° 27' 7.128" N	120° 33' 11.109" E
16	14° 27' 5.607" N	120° 33' 14.059" E
17	14° 27' 4.086" N	120° 33' 17.009" E
18	14° 27' 2.565" N	120° 33' 19.959" E
19	14° 27' 1.044" N	120° 33' 22.908" E
20	14° 26' 59.523" N	120° 33' 25.858" E
21	14° 26' 58.001" N	120° 33' 28.808" E
22	14° 26' 56.480" N	120° 33' 31.758" E
23	14° 26' 54.959" N	120° 33' 34.708" E
24	14° 26' 53.438" N	120° 33' 37.657" E
25	14° 26' 51.917" N	120° 33' 40.607" E
26	14° 26' 50.396" N	120° 33' 43.557" E
27	14° 26' 48.874" N	120° 33' 46.507" E
28	14° 26' 47.353" N	120° 33' 49.456" E
29	14° 26' 45.832" N	120° 33' 52.406" E
30	14° 26' 44.311" N	120° 33' 55.356" E
31	14° 26' 42.789" N	120° 33' 58.305" E
32	14° 26' 41.268" N	120° 34' 1.255" E

Point	Latitude	Longitude
33	14° 26' 39.747" N	120° 34' 4.205" E
34	14° 26' 38.225" N	120° 34' 7.155" E
35	14° 26' 36.704" N	120° 34' 10.104" E
36	14° 26' 35.183" N	120° 34' 13.054" E
37	14° 26' 33.661" N	120° 34' 16.003" E
38	14° 26' 32.140" N	120° 34' 18.953" E
39	14° 26' 30.619" N	120° 34' 21.903" E
40	14° 26' 29.097" N	120° 34' 24.852" E
41	14° 26' 27.576" N	120° 34' 27.802" E
42	14° 26' 26.055" N	120° 34' 30.751" E
43	14° 26' 24.533" N	120° 34' 33.701" E
44	14° 26' 23.012" N	120° 34' 36.651" E
45	14° 26' 21.490" N	120° 34' 39.600" E
46	14° 26' 19.969" N	120° 34' 42.550" E
47	14° 26' 18.447" N	120° 34' 45.499" E
48	14° 26' 16.926" N	120° 34' 48.449" E
49	14° 26' 15.404" N	120° 34' 51.398" E
50	14° 26' 13.883" N	120° 34' 54.348" E
51	14° 26' 12.350" N	120° 34' 57.291" E
52	14° 26' 10.750" N	120° 35' 0.197" E
53	14° 26' 9.082" N	120° 35' 3.061" E
54	14° 26' 7.345" N	120° 35' 5.882" E
55	14° 26' 5.541" N	120° 35' 8.659" E
56	14° 26' 3.668" N	120° 35' 11.387" E
57	14° 26' 1.729" N	120° 35' 14.066" E
58	14° 25' 59.726" N	120° 35' 16.695" E
59	14° 25' 57.660" N	120° 35' 19.272" E
60	14° 25' 55.533" N	120° 35' 21.797" E
61	14° 25' 53.342" N	120° 35' 24.263" E
62	14° 25' 51.093" N	120° 35' 26.673" E
63	14° 25' 48.787" N	120° 35' 29.026" E
64	14° 25' 46.425" N	120° 35' 31.320" E
65	14° 25' 44.006" N	120° 35' 33.551" E
66	14° 25' 41.533" N	120° 35' 35.718" E
67	14° 25' 39.009" N	120° 35' 37.823" E
68	14° 25' 36.436" N	120° 35' 39.863" E
69	14° 25' 33.814" N	120° 35' 41.837" E
70	14° 25' 31.142" N	120° 35' 43.739" E
71	14° 25' 28.425" N	120° 35' 45.574" E
72	14° 25' 25.666" N	120° 35' 47.340" E
73	14° 25' 22.865" N	120° 35' 49.035" E
74	14° 25' 20.022" N	120° 35' 50.656" E
75	14° 25' 17.140" N	120° 35' 52.203" E
76	14° 25' 14.223" N	120° 35' 53.677" E
77	14° 25' 11.279" N	120° 35' 55.096" E
78	14° 25' 8.332" N	120° 35' 56.507" E
79	14° 25' 5.385" N	120° 35' 57.919" E
80	14° 25' 2.438" N	120° 35' 59.331" E
81	14° 24' 59.491" N	120° 36' 0.742" E
82	14° 24' 56.544" N	120° 36' 2.154" E
83	14° 24' 53.597" N	120° 36' 3.566" E
84	14° 24' 50.650" N	120° 36' 4.977" E
85	14° 24' 47.703" N	120° 36' 6.389" E
86	14° 24' 44.756" N	120° 36' 7.801" E
87	14° 24' 41.809" N	120° 36' 9.212" E
88	14° 24' 38.862" N	120° 36' 10.624" E
89	14° 24' 35.915" N	120° 36' 12.035" E

Point	Latitude	Longitude
90	14° 24' 32.968" N	120° 36' 13.447" E
91	14° 24' 30.021" N	120° 36' 14.859" E
92	14° 24' 27.074" N	120° 36' 16.270" E
93	14° 24' 24.127" N	120° 36' 17.682" E
94	14° 24' 21.183" N	120° 36' 19.100" E
95	14° 24' 18.256" N	120° 36' 20.554" E
96	14° 24' 15.359" N	120° 36' 22.069" E
97	14° 24' 12.485" N	120° 36' 23.632" E
98	14° 24' 9.643" N	120° 36' 25.254" E
99	14° 24' 6.827" N	120° 36' 26.923" E
100	14° 24' 4.044" N	120° 36' 28.649" E
101	14° 24' 1.289" N	120° 36' 30.423" E
102	14° 23' 58.568" N	120° 36' 32.251" E
103	14° 23' 55.878" N	120° 36' 34.127" E
104	14° 23' 53.224" N	120° 36' 36.055" E
105	14° 23' 50.603" N	120° 36' 38.030" E
106	14° 23' 48.019" N	120° 36' 40.056" E
107	14° 23' 45.469" N	120° 36' 42.127" E
108	14° 23' 42.958" N	120° 36' 44.248" E
109	14° 23' 40.483" N	120° 36' 46.412" E
110	14° 23' 38.049" N	120° 36' 48.625" E
111	14° 23' 35.653" N	120° 36' 50.881" E
112	14° 23' 33.298" N	120° 36' 53.183" E
113	14° 23' 30.984" N	120° 36' 55.527" E
114	14° 23' 28.712" N	120° 36' 57.915" E
115	14° 23' 26.482" N	120° 37' 0.344" E
116	14° 23' 24.297" N	120° 37' 2.814" E
117	14° 23' 22.154" N	120° 37' 5.325" E
118	14° 23' 20.058" N	120° 37' 7.875" E
119	14° 23' 18.006" N	120° 37' 10.464" E
120	14° 23' 16.001" N	120° 37' 13.091" E
121	14° 23' 14.034" N	120° 37' 15.748" E
122	14° 23' 12.075" N	120° 37' 18.412" E
123	14° 23' 10.117" N	120° 37' 21.076" E
124	14° 23' 8.158" N	120° 37' 23.739" E
125	14° 23' 6.199" N	120° 37' 26.403" E
126	14° 23' 4.241" N	120° 37' 29.067" E
127	14° 23' 2.282" N	120° 37' 31.730" E
128	14° 23' 0.323" N	120° 37' 34.394" E
129	14° 22' 58.365" N	120° 37' 37.058" E
130	14° 22' 56.406" N	120° 37' 39.721" E
131	14° 22' 54.447" N	120° 37' 42.385" E
132	14° 22' 52.488" N	120° 37' 45.048" E
133	14° 22' 50.529" N	120° 37' 47.712" E
134	14° 22' 48.571" N	120° 37' 50.375" E
135	14° 22' 46.612" N	120° 37' 53.039" E
136	14° 22' 44.653" N	120° 37' 55.702" E
137	14° 22' 42.694" N	120° 37' 58.366" E
138	14° 22' 40.736" N	120° 38' 1.029" E
139	14° 22' 38.777" N	120° 38' 3.693" E
140	14° 22' 36.818" N	120° 38' 6.356" E
141	14° 22' 34.859" N	120° 38' 9.020" E
142	14° 22' 32.900" N	120° 38' 11.683" E
143	14° 22' 30.941" N	120° 38' 14.346" E
144	14° 22' 28.982" N	120° 38' 17.010" E
145	14° 22' 27.023" N	120° 38' 19.673" E
146	14° 22' 25.065" N	120° 38' 22.337" E

Point	Latitude	Longitude
147	14° 22' 23.106" N	120° 38' 25.000" E
148	14° 22' 21.147" N	120° 38' 27.663" E
149	14° 22' 19.188" N	120° 38' 30.327" E
150	14° 22' 17.229" N	120° 38' 32.990" E
151	14° 22' 15.270" N	120° 38' 35.653" E
152	14° 22' 13.311" N	120° 38' 38.317" E
153	14° 22' 11.352" N	120° 38' 40.980" E
154	14° 22' 9.393" N	120° 38' 43.643" E
155	14° 22' 7.434" N	120° 38' 46.306" E
156	14° 22' 5.475" N	120° 38' 48.970" E
157	14° 22' 3.516" N	120° 38' 51.633" E
158	14° 22' 1.557" N	120° 38' 54.296" E
159	14° 21' 59.598" N	120° 38' 56.959" E
160	14° 21' 57.639" N	120° 38' 59.623" E
161	14° 21' 55.680" N	120° 39' 2.286" E
162	14° 21' 53.721" N	120° 39' 4.949" E
163	14° 21' 51.762" N	120° 39' 7.612" E
164	14° 21' 49.803" N	120° 39' 10.275" E
165	14° 21' 47.843" N	120° 39' 12.938" E
166	14° 21' 45.884" N	120° 39' 15.601" E
167	14° 21' 43.925" N	120° 39' 18.265" E
168	14° 21' 41.966" N	120° 39' 20.928" E
169	14° 21' 40.007" N	120° 39' 23.591" E
170	14° 21' 38.048" N	120° 39' 26.254" E
171	14° 21' 36.089" N	120° 39' 28.917" E
172	14° 21' 34.130" N	120° 39' 31.580" E
173	14° 21' 32.170" N	120° 39' 34.243" E
174	14° 21' 30.211" N	120° 39' 36.906" E
175	14° 21' 28.252" N	120° 39' 39.569" E
176	14° 21' 26.293" N	120° 39' 42.232" E
177	14° 21' 24.339" N	120° 39' 44.899" E
178	14° 21' 22.422" N	120° 39' 47.594" E
179	14° 21' 20.562" N	120° 39' 50.331" E
180	14° 21' 18.752" N	120° 39' 53.103" E
181	14° 21' 16.998" N	120° 39' 55.912" E
182	14° 21' 15.299" N	120° 39' 58.757" E
183	14° 21' 13.655" N	120° 40' 1.635" E
184	14° 21' 12.069" N	120° 40' 4.548" E
185	14° 21' 10.537" N	120° 40' 7.491" E
186	14° 21' 9.067" N	120° 40' 10.467" E
187	14° 21' 7.650" N	120° 40' 13.470" E
188	14° 21' 6.298" N	120° 40' 16.504" E
189	14° 21' 5.000" N	120° 40' 19.563" E
190	14° 21' 3.766" N	120° 40' 22.649" E
191	14° 21' 2.590" N	120° 40' 25.760" E
192	14° 21' 1.475" N	120° 40' 28.894" E
193	14° 21' 0.422" N	120° 40' 32.050" E
194	14° 20' 59.429" N	120° 40' 35.227" E
195	14° 20' 58.501" N	120° 40' 38.424" E
196	14° 20' 57.631" N	120° 40' 41.639" E
197	14° 20' 56.796" N	120° 40' 44.863" E
198	14° 20' 55.961" N	120° 40' 48.087" E
199	14° 20' 55.126" N	120° 40' 51.312" E
200	14° 20' 54.291" N	120° 40' 54.536" E
201	14° 20' 53.456" N	120° 40' 57.760" E
202	14° 20' 52.621" N	120° 41' 0.985" E
203	14° 20' 51.786" N	120° 41' 4.209" E

Point	Latitude	Longitude
204	14° 20' 50.952" N	120° 41' 7.433" E
205	14° 20' 50.117" N	120° 41' 10.658" E
206	14° 20' 49.282" N	120° 41' 13.882" E
207	14° 20' 48.447" N	120° 41' 17.106" E
208	14° 20' 47.612" N	120° 41' 20.330" E
209	14° 20' 46.777" N	120° 41' 23.555" E
210	14° 20' 45.942" N	120° 41' 26.779" E
211	14° 20' 45.106" N	120° 41' 30.003" E
212	14° 20' 44.271" N	120° 41' 33.228" E
213	14° 20' 43.436" N	120° 41' 36.452" E
214	14° 20' 42.601" N	120° 41' 39.676" E
215	14° 20' 41.766" N	120° 41' 42.900" E
216	14° 20' 40.931" N	120° 41' 46.125" E
217	14° 20' 40.096" N	120° 41' 49.349" E
218	14° 20' 39.261" N	120° 41' 52.573" E
219	14° 20' 38.426" N	120° 41' 55.798" E
220	14° 20' 37.591" N	120° 41' 59.022" E
221	14° 20' 36.755" N	120° 42' 2.246" E
222	14° 20' 35.920" N	120° 42' 5.470" E
223	14° 20' 35.085" N	120° 42' 8.695" E
224	14° 20' 34.250" N	120° 42' 11.919" E
225	14° 20' 33.415" N	120° 42' 15.143" E
226	14° 20' 32.579" N	120° 42' 18.367" E
227	14° 20' 31.744" N	120° 42' 21.591" E
228	14° 20' 30.909" N	120° 42' 24.816" E
229	14° 20' 30.073" N	120° 42' 28.040" E
230	14° 20' 29.238" N	120° 42' 31.264" E
231	14° 20' 28.403" N	120° 42' 34.488" E
232	14° 20' 27.568" N	120° 42' 37.712" E
233	14° 20' 26.736" N	120° 42' 40.938" E
234	14° 20' 25.950" N	120° 42' 44.175" E
235	14° 20' 25.247" N	120° 42' 47.432" E
236	14° 20' 24.623" N	120° 42' 50.706" E
237	14° 20' 24.078" N	120° 42' 53.995" E
238	14° 20' 23.611" N	120° 42' 57.296" E
239	14° 20' 23.227" N	120° 43' 0.609" E
240	14° 20' 22.926" N	120° 43' 3.930" E
241	14° 20' 22.703" N	120° 43' 7.258" E
242	14° 20' 22.561" N	120° 43' 10.591" E
243	14° 20' 22.500" N	120° 43' 13.927" E
244	14° 20' 22.523" N	120° 43' 17.262" E
245	14° 20' 22.626" N	120° 43' 20.597" E
246	14° 20' 22.808" N	120° 43' 23.927" E
247	14° 20' 23.071" N	120° 43' 27.253" E
248	14° 20' 23.419" N	120° 43' 30.569" E
249	14° 20' 23.846" N	120° 43' 33.876" E
250	14° 20' 24.352" N	120° 43' 37.172" E
251	14° 20' 24.937" N	120° 43' 40.453" E
252	14° 20' 25.606" N	120° 43' 43.718" E
253	14° 20' 26.353" N	120° 43' 46.965" E
254	14° 20' 27.177" N	120° 43' 50.192" E
255	14° 20' 28.079" N	120° 43' 53.397" E
256	14° 20' 29.060" N	120° 43' 56.578" E
257	14° 20' 30.120" N	120° 43' 59.732" E
258	14° 20' 31.254" N	120° 44' 2.858" E
259	14° 20' 32.463" N	120° 44' 5.955" E
260	14° 20' 33.748" N	120° 44' 9.020" E

Point	Latitude	Longitude
261	14° 20' 35.110" N	120° 44' 12.050" E
262	14° 20' 36.543" N	120° 44' 15.044" E
263	14° 20' 38.048" N	120° 44' 18.002" E
264	14° 20' 39.602" N	120° 44' 20.933" E
265	14° 20' 41.098" N	120° 44' 23.895" E
266	14° 20' 42.523" N	120° 44' 26.894" E
267	14° 20' 43.876" N	120° 44' 29.927" E
268	14° 20' 45.156" N	120° 44' 32.995" E
269	14° 20' 46.358" N	120° 44' 36.094" E
270	14° 20' 47.484" N	120° 44' 39.224" E
271	14° 20' 48.534" N	120° 44' 42.382" E
272	14° 20' 49.508" N	120° 44' 45.565" E
273	14° 20' 50.406" N	120° 44' 48.771" E
274	14° 20' 51.220" N	120° 44' 52.001" E
275	14° 20' 51.957" N	120° 44' 55.250" E
276	14° 20' 52.616" N	120° 44' 58.517" E
277	14° 20' 53.196" N	120° 45' 1.800" E
278	14° 20' 53.695" N	120° 45' 5.097" E
279	14° 20' 54.112" N	120° 45' 8.406" E
280	14° 20' 54.448" N	120° 45' 11.724" E
281	14° 20' 54.706" N	120° 45' 15.049" E
282	14° 20' 54.883" N	120° 45' 18.381" E
283	14° 20' 54.975" N	120° 45' 21.716" E
284	14° 20' 54.987" N	120° 45' 25.052" E
285	14° 20' 54.918" N	120° 45' 28.387" E
286	14° 20' 54.770" N	120° 45' 31.720" E
287	14° 20' 54.540" N	120° 45' 35.048" E
288	14° 20' 54.226" N	120° 45' 38.368" E
289	14° 20' 53.833" N	120° 45' 41.680" E
290	14° 20' 53.360" N	120° 45' 44.981" E
291	14° 20' 52.808" N	120° 45' 48.269" E
292	14° 20' 52.173" N	120° 45' 51.541" E
293	14° 20' 51.459" N	120° 45' 54.795" E
294	14° 20' 50.667" N	120° 45' 58.031" E
295	14° 20' 49.797" N	120° 46' 1.246" E
296	14° 20' 48.849" N	120° 46' 4.437" E
297	14° 20' 47.821" N	120° 46' 7.602" E
298	14° 20' 46.718" N	120° 46' 10.741" E
299	14° 20' 45.539" N	120° 46' 13.850" E
300	14° 20' 44.286" N	120° 46' 16.929" E
301	14° 20' 42.956" N	120° 46' 19.973" E
302	14° 20' 41.552" N	120° 46' 22.982" E
303	14° 20' 40.076" N	120° 46' 25.955" E
304	14° 20' 38.529" N	120° 46' 28.890" E
305	14° 20' 36.911" N	120° 46' 31.784" E
306	14° 20' 35.220" N	120° 46' 34.634" E
307	14° 20' 33.462" N	120° 46' 37.441" E
308	14° 20' 31.637" N	120° 46' 40.202" E
309	14° 20' 29.746" N	120° 46' 42.916" E
310	14° 20' 27.787" N	120° 46' 45.580" E
311	14° 20' 25.764" N	120° 46' 48.192" E
312	14° 20' 23.678" N	120° 46' 50.752" E
313	14° 20' 21.547" N	120° 46' 53.273" E
314	14° 20' 19.411" N	120° 46' 55.788" E
315	14° 20' 17.274" N	120° 46' 58.304" E
316	14° 20' 15.145" N	120° 47' 0.826" E
317	14° 20' 13.080" N	120° 47' 3.404" E

Point	Latitude	Longitude
318	14° 20' 11.100" N	120° 47' 6.050" E
319	14° 20' 9.207" N	120° 47' 8.763" E
320	14° 20' 7.402" N	120° 47' 11.538" E
321	14° 27' 41.167" N	120° 32' 38.974" E
322	14° 27' 44.276" N	120° 32' 39.871" E
323	14° 27' 47.192" N	120° 32' 38.601" E
324	14° 27' 48.373" N	120° 32' 35.584" E
325	14° 27' 47.123" N	120° 32' 32.596" E
326	14° 27' 44.858" N	120° 32' 30.267" E
327	14° 27' 44.502" N	120° 32' 27.045" E
328	14° 27' 44.050" N	120° 32' 31.581" E
329	14° 27' 41.219" N	120° 32' 33.024" E
330	14° 27' 39.498" N	120° 32' 35.858" E
331	14° 27' 38.273" N	120° 32' 38.948" E
332	14° 27' 37.328" N	120° 32' 42.139" E
333	14° 27' 36.553" N	120° 32' 45.381" E
334	14° 27' 35.753" N	120° 32' 48.616" E
335	14° 27' 34.947" N	120° 32' 51.849" E
336	14° 27' 45.767" N	120° 32' 23.965" E
337	14° 27' 46.965" N	120° 32' 20.870" E
338	14° 27' 47.604" N	120° 32' 17.604" E
339	14° 27' 47.661" N	120° 32' 14.274" E
340	14° 27' 47.137" N	120° 32' 10.987" E
341	14° 27' 46.070" N	120° 32' 7.838" E
342	14° 27' 42.539" N	120° 32' 29.962" E
343	14° 27' 35.663" N	120° 32' 39.084" E
344	14° 27' 37.945" N	120° 32' 36.008" E
345	14° 20' 9.451" N	120° 47' 14.143" E
346	14° 20' 11.519" N	120° 47' 16.718" E
347	14° 20' 5.315" N	120° 47' 8.993" E
348	14° 20' 3.247" N	120° 47' 6.418" E
349	14° 20' 8.583" N	120° 47' 12.032" E
350	14° 20' 5.932" N	120° 47' 8.978" E

Figure 1.1 shows the project alignment. The directly impacted communities (DIC) along the proposed bridge are barangays Mountain View and Alas-Asin in Bataan and barangays Timalan-Balsahan and Timalan-Concepcion in Cavite as shown in Political Boundary Map (see **Figure 1.2**).

In Bataan, the alignment is situated between jurisdiction starting from the Roman Highway and then traversing the barren land area at Barangay Alas-Asin, and then skirts to the shoreline of Barangay Mountain View in Mariveles.

In Cavite side, the alignment will start from the shoreline of Barangay Timalan Concepcion in Naic, then traversing through the agricultural and residential area and terminating at Antero Soriano Highway, which is in a relatively flat terrain in Barangay Timalan Balsahan.

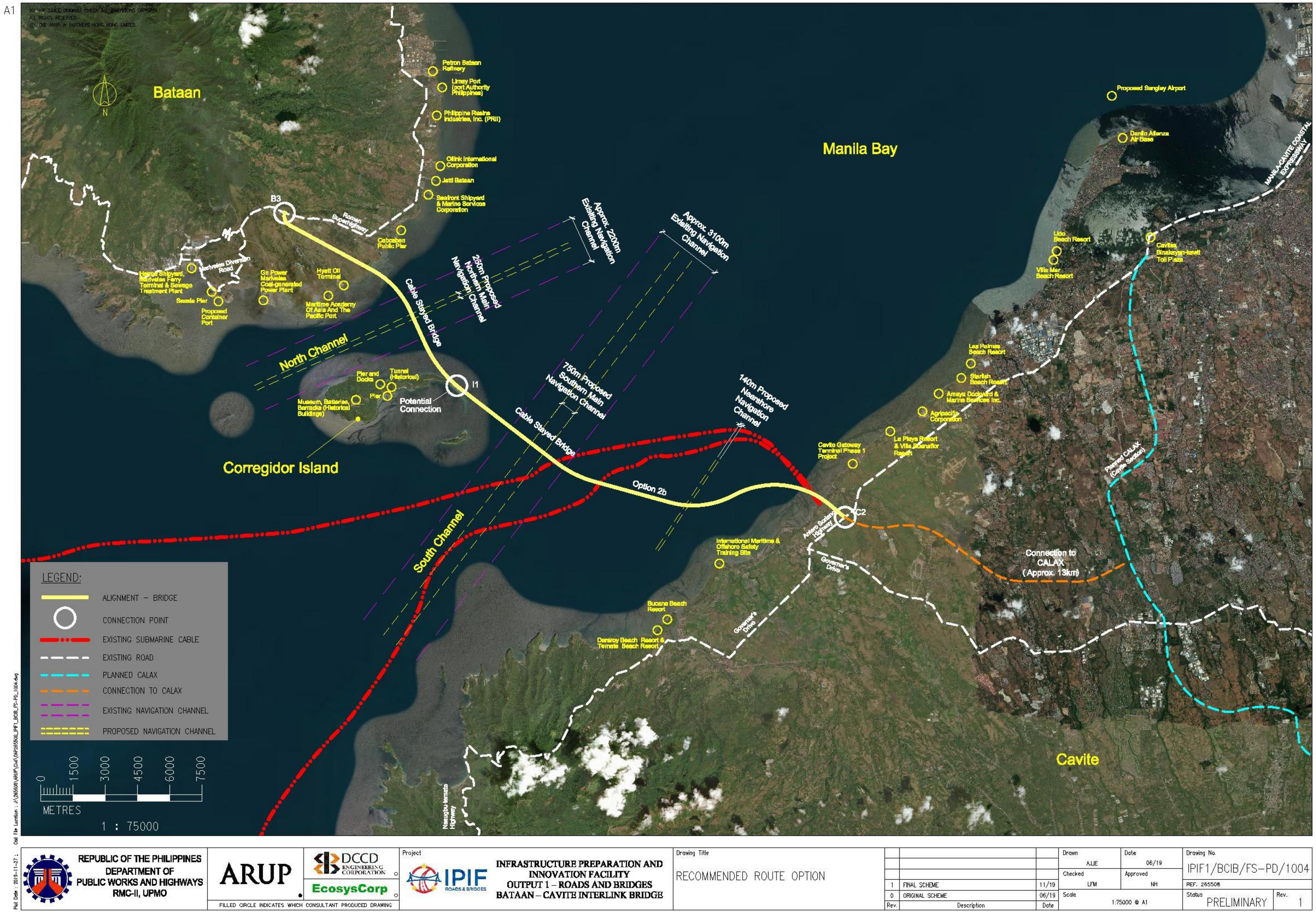

Figure 1.1 Project Alignment

Sources: PSA, PSGC, 2016

Figure 1.2 Political Boundary Map

Figure 1.3 Barangay Alas-Asin and Mountain View, Mariveles Bataan

The landing areas for Mariveles, Bataan are mostly residential, commercial, institutional and industrial areas. Agricultural lands, pasture lands and fishing boats can also be seen.

The coastal upland is composed of rocky hills, brush lands, grass lands and plantation forests. There are some residential and agricultural land at these areas. Most of the houses near the possible landing spot were made of light materials.

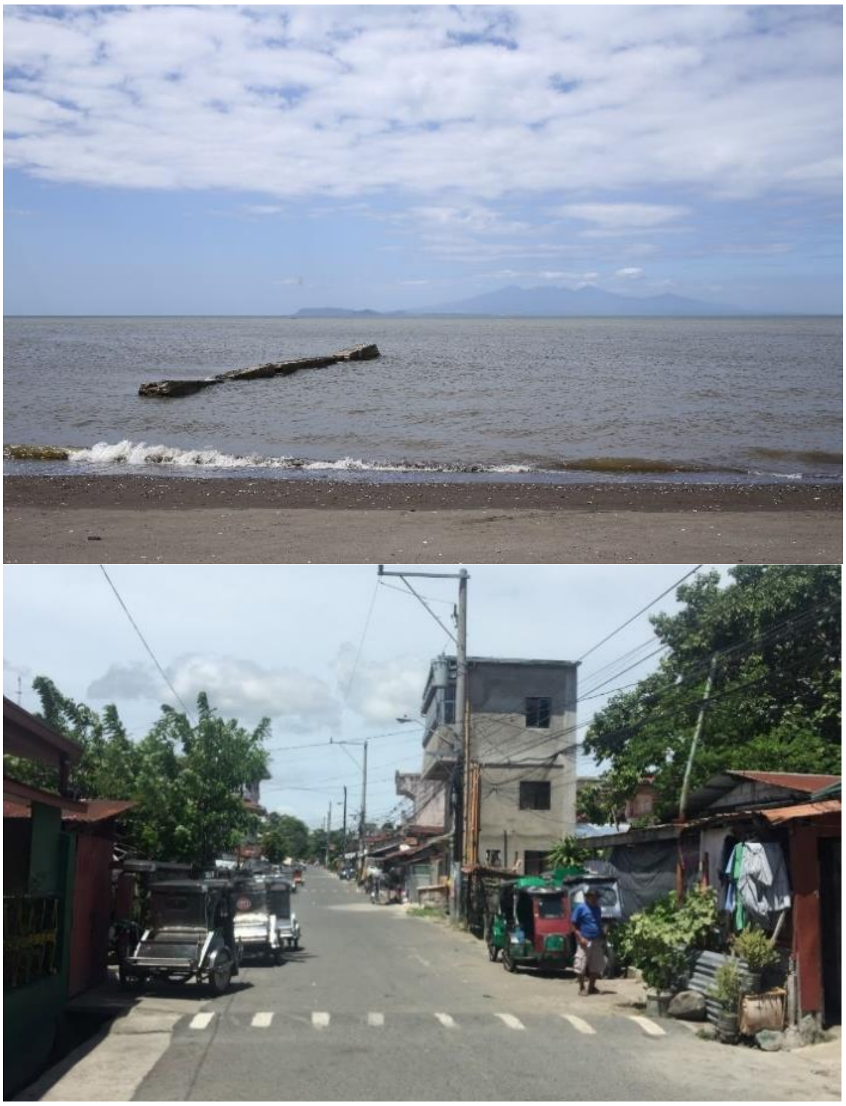

Figure 1.4 Barangay Timalan Balsahan, Naic Cavite

Majority of the lands in Cavite are designated for agricultural use, with agriculture and fishery activities as major income sources. The lowland areas, including the Municipality of Naic, are located on alluvial plains, with flat ground slope of less than 0.5% and low ground elevation. These are primarily suitable for irrigated rice cultivation and freshwater fishponds.

There are also many existing establishments along the existing roads, including commercial, institutional, and residential areas.

Public utility vehicles, tricycles, and private vehicles are the main means of transportation in the area. The fastest existing road connection between Cavite and Mariveles in Bataan is via Metro Manila, which takes approximately 4 - 5 hours on average to complete the journey. An alternative mode of transport is the passenger ferry service between the ports in Manila and Mariveles or between Mall of Asia (MOA) Jetty to Orion Port. On the Cavite side, land travel is required between Cavite and Manila Port and between Orion Port and Mariveles if the Manila Port to Orion Port ferry is taken.

1.1.2 Impact Areas

The complete list of affected areas are summarized and shown in **Table 1.2** and **Figure 1.8**.

Table 1.2 Direct and Indirect Impact Areas

Bataan		Cavite	
Direct Impact Areas	**Indirect Impact Areas**	**Direct Impact Areas**	**Indirect Impact Areas**
Brgy. Mt. View, Mariveles **Brgy. Alas-asin, Mariveles**	Adjacent areas of the alignment within Brgy. Mt. View, Mariveles Adjacent areas of the alignment within Brgy. Alas-asin, Mariveles	Brgy. Timalan Concepcion, Naic Brgy. Timalan Balsahan, Naic	Brgy. 53B, Cavite City Brgy. Sabang, Naic Corregidor Island, Cavite City

Figure 1.5 Impact Barangays

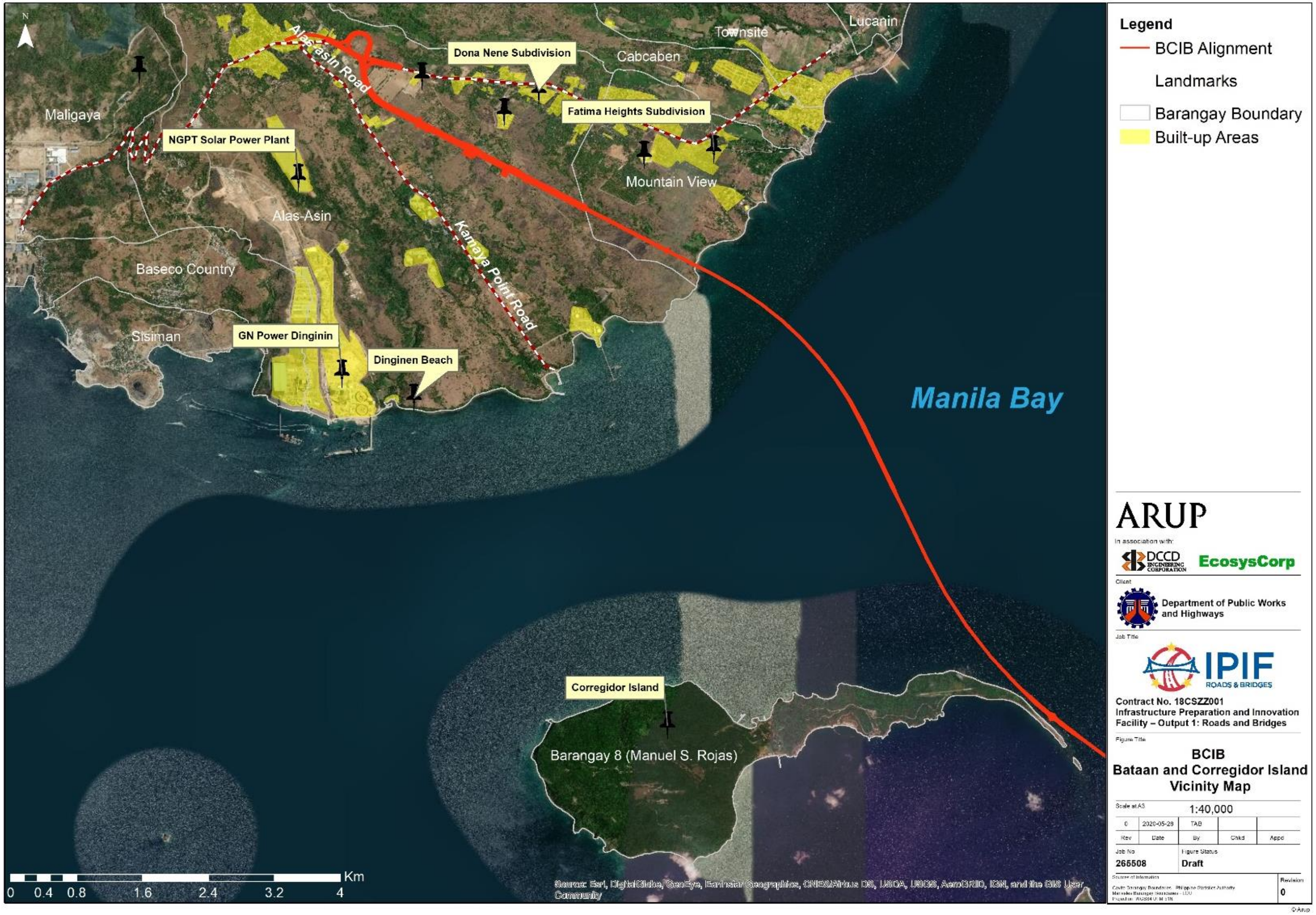

Figure 1.6 Bataan Corregidor Vicinity Map

Figure 1.7 Cavite Vicinity Map

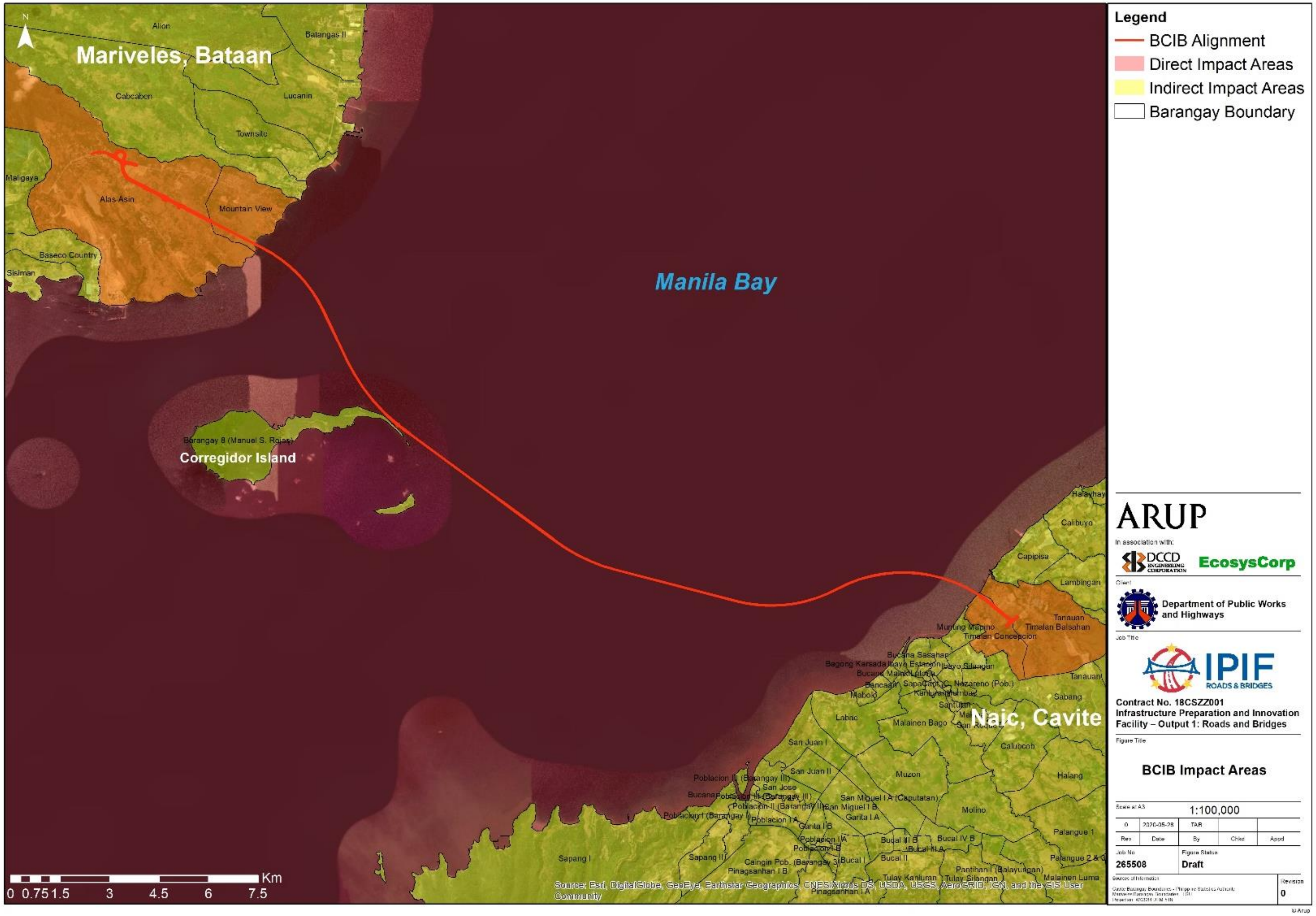

Figure 1.8 Initial direct and indirect impact areas

1.2 Project Rationale

During the World Economic Forum (WEF) on the Association of Southeast Asian Nations held in Cambodia, Philippine President Rodrigo Roa Duterte presented the administration's 0 to 10-point socio-economic agenda. The 4th agenda aims to accelerate annual infrastructure spending to account for 5% of the gross domestic product, with Public-Private-Partnership (PPP) playing the key role. In line with this, the administration intends to spend 8-9 trillion pesos from 2017-2022 solely for infrastructure. These infrastructure projects will allow the recipient communities to have an easy access going to work, businesses, markets, education and other services. According to the project administration manual of the Asian Development Bank (ADB), for the infrastructure preparation and innovation facility, the impact of underdeveloped public infrastructure in the Republic of the Philippines will impede the potential of businesses and economic opportunities in the country.

The proposed BCIB aims to provide a permanent road linkage between the provinces of Bataan and Cavite to reduce journey time and ease traffic congestion through Metro Manila as well as in the South Luzon and North Luzon gateways.

Specifically, the project aims to:

- Provide an alternative loop road to ease traffic congestion in Metro Manila and South Luzon and North Luzon gateway;
- Save time and lower vehicle operating costs;
- Provide opportunities for expansion outside Metro Manila for economic growth;
- Support development of seaports of Cavite and Bataan as premier international shipping gateway to the country;
- Support development of the famous Corregidor Island as a tourist destination;
- Improve profitability and marketability of goods; and
- Provide access to public services within the project proximity.

The project is also seen to provide economic development opportunities for:

- New and expanding businesses and seaport development due to increased accessibility to markets, suppliers and workers between the provinces of Bataan and Cavite;
- Economic integration between markets in the provinces of Bataan and Cavite;
- Leverage connectivity to promote tourism and development of Corregidor Island; and
- Employment growth in both Bataan and Cavite provinces.

The economic outcomes that this project will support/enhance are:

- Cost: Reducing the economic cost of congestion
- Productivity: Boosting economic productivity
- Tourism development: Enhanced access for visitors to the tourism destinations offered on Corregidor Island and Bataan.
- Wider economic development: Supporting integrated, equitable economic development of the Bataan and Cavite Provinces within the wider Central Luzon and Calabarzon region respectively

- Further development of Bataan and Freeport Area: Increasing the intensity of land use in Bataan and supporting the freeport expansion

The project will also impact upon social outcomes:

- Accessibility: Enhance community access to employment, education, and other public services.

1.3 Project Alternatives

1.3.1 Alternative Options

1.3.1.1 Initial Development of Options

During Stage I of the Feasibility Study, twelve initial alignment options (**Figure 1.9**) including bridges and tunnels were developed up to concept design. Subsequently, these initial alignments were further refined to nine alignment options.

Following assessment of all these options, five were shortlisted to be progressed for more detailed consideration. These options are listed in **Table 1.3** and **Figure 1.10**.

Table 1.3 Options taken forward after preliminary screening

<table>
<tr><th>Alignment Option</th><th>Landing Points</th><th>South Channel</th><th>North Channel</th><th>Corregidor</th></tr>
<tr><td>Option 2a</td><td rowspan="2">Bataan at B3
Cavite at C4
CALAX
Possible connection to Corregidor at I1</td><td>Tunnel</td><td rowspan="5">Navigation Bridge to provide 300m wide navigation channel for all options (subject to confirmation from the Philippine Coast Guard (PCG) and Philippines Port Authority (PPA))</td><td rowspan="5">Connections can be made for all options</td></tr>
<tr><td>Option 2b</td><td>Navigation Bridge</td></tr>
<tr><td>Option 4a</td><td rowspan="2">Bataan at B3
Cavite at C2
CALAX
Possible connection to Corregidor at I1</td><td>Tunnel</td></tr>
<tr><td>Option 4b</td><td>Navigation Bridge</td></tr>
<tr><td>Option 5</td><td>Bataan at B3
Cavitex
Possible connection to Corregidor at I1</td><td>Navigation Bridge</td></tr>
</table>

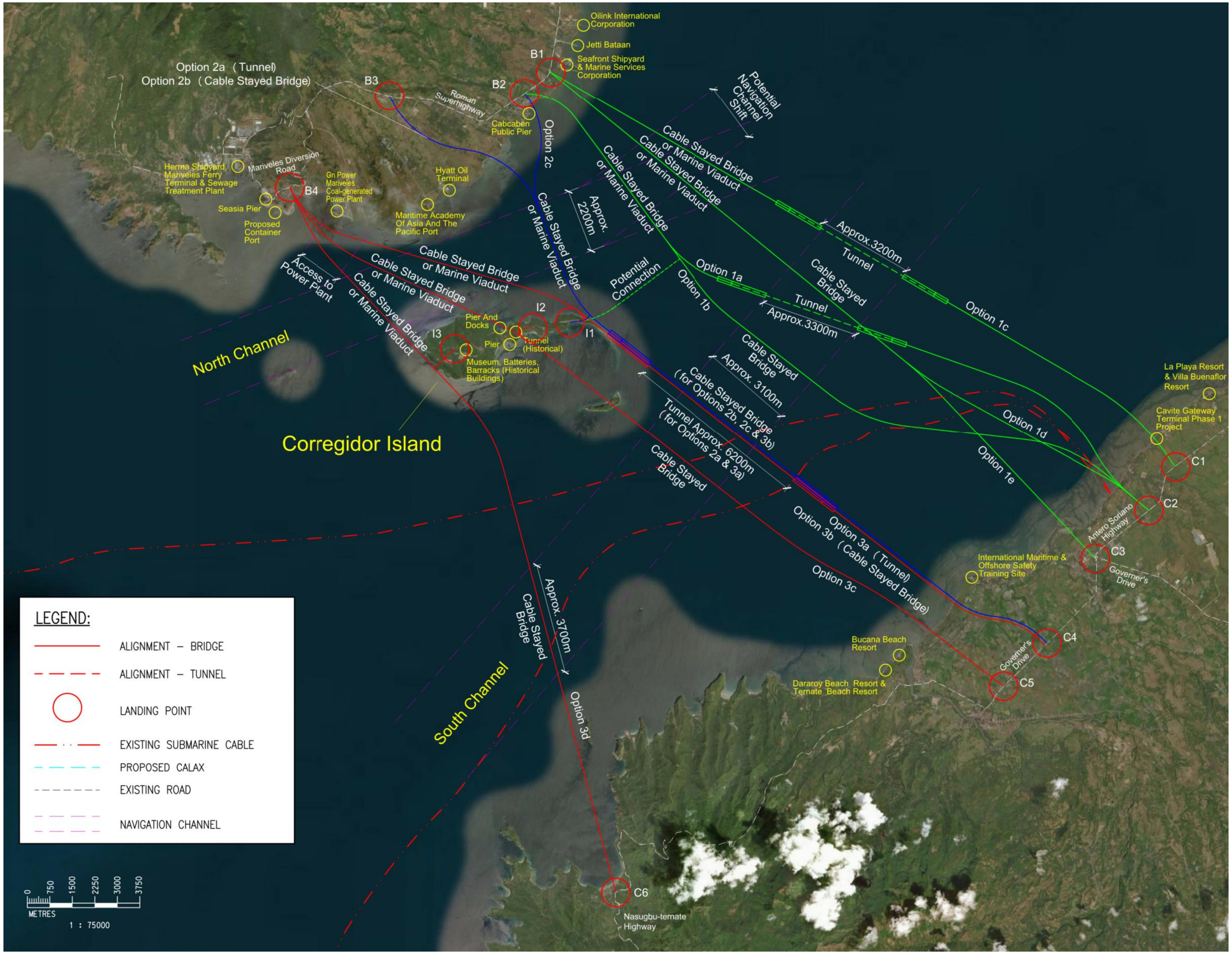

Figure 1.9 Overall plan of Stage I alignment options

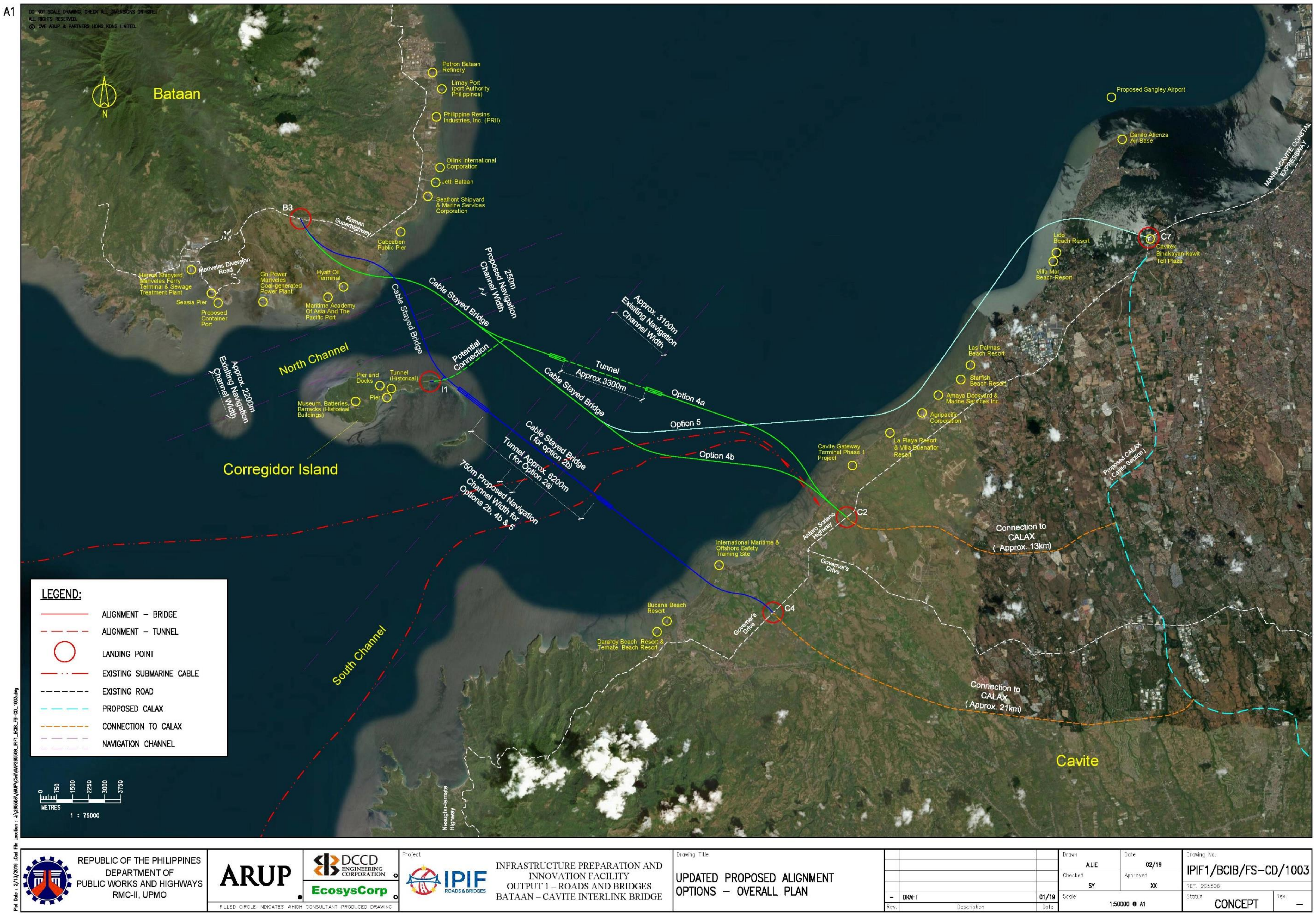

Figure 1.10 Options taken forward after preliminary screening

An option selection workshop was held on 19 February 2019 to compare the advantages and disadvantages of all options considered (**Table 1.3**), in order to select which option to take forward to Stage II of the Feasibility Study.

Through the options assessment process, each option was given a score in various criteria that had been identified as key to the success of the project in the categories: Technical, Financial, Economic, Environmental, and Social, and an overall preferred option was chosen. As a result of the options selection workshop and the findings of the Stage I Options Study, **Option 2b - Navigation Bridge scheme for the South Channel with landing point at C4** was chosen.

1.3.1.2 Further Development after the Workshop – Option 2c

After the conclusion of the Option Selection Workshop, further comparison work was carried out focusing on Option 2b and 4b with the aim to develop a new option that takes advantage of the benefits from these options based on the score in various criteria. A brief summary of explanation under each category is given in **Table 1.4**.

Table 1.4 Summary of advantages for Option 2b and 4b under each assessment criteria

<table>
<tr><th></th><th>Option</th><th>Explanation</th></tr>
<tr><td>Technical matters</td><td rowspan="2">Option 2b</td><td rowspan="2">Option 2b is slightly cheaper to implement than Option 4b due to its shorter length of structures in Manila Bay. The alignment is also closer to Corregidor Island and hence the future connection to Corregidor will also be cheaper to implement.

Option 2b scores highest technically. The Navigation Clearance Study (WP5-1) showed that tankers using the Southern Navigation Channel turn north west towards Bataan after crossing Corregidor Island. Option 4b cuts across the navigation path of these vessels and would be a major hindrance/obstacle to shipping.</td></tr>
<tr><td>Financial costs</td></tr>
<tr><td>Economics</td><td>Option 4b</td><td>There is better connectivity and hence better economics criteria scores for Option 4b which connects to C2, as opposed to Option 2b which connects to C4. The C2 connection on the Cavite side is an interchange connection with the existing Antero Soriano Highway that connects to the southern end of CAVITEX at the Binakayan-Kawit Toll Plaza. Drivers from Metro Manila wishing to use the new bridge would be able to drive from the Toll Plaza to C2 along the Antero Soriano Highway. In contrast the C4 connection would be an interchange on Governor's Drive. The distance to this interchange from the CAVITEX Binakayan-Kawit Toll Plaza is longer and there would be a major traffic bottleneck at the existing junction at Naic where the two arms of Governor's Drive and Antero Soriano Highway meet.</td></tr>
<tr><td>Environmental and Social matters</td><td>Option 4b</td><td>Connection at C2 would enable an at-grade road of approximately 13km in length to be built in the future to connect to CALAX, as opposed to approximately 21km in length if connection is at C4. Not only the shorter connection is cheaper and quicker to implement, the shorter length is likely to lead to smaller amount of land issues, environmental issues and social issues to be dealt with</td></tr>
</table>

A scoring exercise for option 2c was then carried out, based on the same scoring method in assessing Option 2b and Option 4b. The results confirmed that Option 2c scores highest amongst all the options and therefore was chosen to be taken forward to Stage II of the

Feasibility Study. This option is the most suitable with the best overall balance of positive outcomes, cost, ease of implementation, and minimum negative impact.

1.3.1.3 The Preferred Alignment Development

Option 2c was developed in Stage II of the FS. The alignment, exact location of landing points and interchange layouts to connect to the existing road networks were refined as part of the preliminary design (**Figure 1.1**).

Alignment 2c connects Bataan at Landing Point B3 along Bataan Provincial Highway (Roman Superhighway – National Road), near Godspeed Garden Memorial Park in the Barangay of Alas-asin. It then slopes down along the hilly terrain down towards the coastline and stays at a high level at the coastline to provide sufficient navigation clearance for vessels using the north channel. It then slopes down gently towards the future connection to the Corregidor Island at Landing Point I1. The alignment then stays at a low level going eastwards before climbing up to provide sufficient navigation clearance for the south channel and then slopes down at the same rate to return to a low level for the rest of the alignment in Manila Bay towards Cavite, except for crossing over a secondary navigation channel near the Cavite coast. It reaches landing point C2, southwest of Daly Village along the Antero Soriano Highway.

1.3.2 Options Selection and Scoring

An option selection workshop was held on 19 February 2019 to compare the advantages and disadvantages of the shortlisted options in order to select which option to take forward to Stage II of the Feasibility Study.

These options were assessed using the Option Selection Methodology, whereby a score is given to various criteria that had been identified as key to the success of the project in the categories, Technical, Financial, Economic, Environmental, and Social.

Each category was divided into several definable criteria, which each alignment option can be scored against. A ranking and weighting system was determined upon establishment of the criteria. The criteria for the evaluation were grouped and assigned with corresponding weights under the following criteria categories:

Table 1.5 Weighting Criteria

Criteria	Weightings
Technical	30%
Financial	25%
Economics	25%
Environmental	10%
Social	10%
Total	100%

For each of the criteria the order of preference will be identified along with a scaling of base score, which can be a maximum of 10. This is subject to agreement by relevant stakeholders.

For base score of scale of 10, the preference would be based on; score of 8 to 10 – Excellent; score 6 to 8 – Good; score 4 to 6 – Fair; score 2 to 4 – Poor and 1 to 2 – very poor. In general a score of 5 and above is considered to be relatively satisfactory and a score below 5 is less than satisfactory. A score of 1 can be considered to be highly undesirable and approaching an insurmountable problem.

When 0 is scored for a particular discipline, the entire option is insurmountable and is considered as a nonstarter. This score is required as in some cases, an option cannot be found infeasible for a particular discipline until a very late stage.

Table 1.6 Performance Scoring Criteria

Performance	Score
Excellent	9 to 10
Good	7 to 8
Acceptable	5 to 6
Poor	3 to 4
Very poor	1 to 2

In the Option Selection and Scoring Workshop, the alignment options and concept design, associated implementation duration and approximate cost estimate, were presented. The weighte scores were then calculated and the summary of results was presented. The stakeholders in the workshop were then given the opportunity to comment and discuss the scores and any other pertinent issues. The scores of all the criteria and the preferred alignment option were then agreed and concluded in the workshop.

The key challenges faced in appraising each alignment option include:

- A series of port facilities in Bataan side may see their operations affected to some degree, as large vessels would be directed to pass South Channel while smaller vessels, which are large in numbers, can navigate along both South Channel or North Channel.
- Land availability for construction at landing points, and the potential for resettlement requirements associated with acquiring the ROW.
- Integration with the existing road network
- Existing road network congestion at the landing points for some sub-options, and the impact that differing alignments may have in exacerbating these issues.

1.3.3 Assessment of Alternative Options

The project options were carefully assessed based on a set of criteria both measurable (i.e. cost) and other more subjective non-quantifiable items such as some of the potential environmental impacts. The evaluation procedure involves the comparison of each option against baseline criteria. The final alignment selected was determined through Option Selection and Scoring Workshop conducted last 19 February 2019. The findings and assessment for each criteria per alternative option are discussed in detail in **Table 1.7**.

Table 1.7 Assessment of Alternative Options for BCIB

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
Technical					
Efficiency of Road Traffic Movement	• Speed reduction - 6% upgrade at tunnel approaches • Local area improvement required at interchange with Governor's Drive"	• Local area improvement required at interchange with Governor's Drive	• Speed reduction - 6% upgrade at tunnel approaches • Local area improvement required at interchange with Antero Soriano Highway"	• Local area improvement required at interchange with Antero Soriano Highway	• Landing point closer to dense population centre but less efficient to overall transport network • Potential issue at connection to Toll Plaza of Cavitex
Impact on Marine Traffic	• South Channel Tunnel with less restriction	• South Channel Bridge with a narrower navigation channel	• South Channel Tunnel with less restriction • Adverse impact to vessels from South Channel towards Bataan	• South Channel Bridge with a narrower navigation channel • Adverse impact to vessels from South Channel towards Bataan	• South Channel Bridge with a narrower navigation channel • Some impact to vessels near Cavite shore • Adverse impact to vessels from South Channel towards Bataan
Pedestrian/Cyclist Friendliness	Not applicable for BCIB and not considered in the scoring				
Implementation Schedule	~110 months (critical path - IMT, longer than the IMT in Option 4a)	~72 months (critical path - navigation bridge)	~86 months (critical path - IMT)	~72 months (critical path - navigation bridge)	~72 months (critical path - navigation bridge)
Constraints and Risks to Implementation	• 26km road requires land resumption in Cavite	• 26km road requires land resumption in Cavite	• 14.3km road requires land resumption in Cavite	• 14.3km road requires land resumption in Cavite	• Short length of land resumption at Sangley

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
	• Tunnel and artificial island have higher construction risks • Tunnel clash with submarine telecom cables, diversion required		• Tunnel and artificial island have higher construction risks • Adverse impact to vessels from South Channel towards Bataan during construction	• Adverse impact to vessels from South Channel towards Bataan during construction	• Uncertain development plan and schedule of the proposed Sangley Airport • Adverse impact to vessels from South Channel towards Bataan during construction
Operations & Maintenance Considerations	Tunnel requires more onerous O&M arrangement and special arrangement for hazardous vehicles.	Typical O&M procedures for concrete and cable supported bridges	Tunnel requires more onerous O&M arrangement and special arrangement for hazardous vehicles.	Typical O&M procedures for concrete and cable supported bridges	Typical O&M procedures for concrete and cable supported bridges
Financial					
Construction Cost	Construction cost = PHP286 bn	Construction cost = PHP168 bn	Construction cost = PHP281 bn	Construction cost = PHP178 bn	Construction cost = PHP300 bn
Clearance, Compensation and Resettlement Cost	Land acquisition cost = PHP2.2bn	Land acquisition cost = PHP2.2bn	Land acquisition cost = PHP1.5bn	Land acquisition cost = PHP1.5bn	Land acquisition cost = PHP2.3bn
Risk and Uncertainty to Cost	• Tunnel and artificial island higher risk and uncertainty to ground condition • Some uncertainty in land resumption for connection to CALAX • Tunnel clash with	• Some uncertainty in land resumption for connection to CALAX	• Tunnel and artificial island higher risk and uncertainty to ground condition • Some uncertainty in land resumption for connection to CALAX	• Some uncertainty in land resumption for connection to CALAX • Higher marine risk during construction	• Airport development plan and require further liaison (more uncertainty) • Land resumption uncertain at this stage

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
	marine cable - diversion required				
Operations & Maintenance Cost	Maintenance cost per year = 3.8bn PHP	Maintenance cost per year = 1.7bn PHP	Maintenance cost per year = 3.6bn PHP	Maintenance cost per year = 1.8bn PHP	Maintenance cost per year = 3.0bn PHP
Economical					
Ability to Improve Existing Transport Networks	• Could add to congestion on Governors Drive and Antero Soriano Highway. • Resilience to overall road network	• Could add to congestion on Governors Drive and Antero Soriano Highway . • Resilience to overall road network	• Could add to congestion on Antero Soriano Hwy. • Resilience to overall road network	• Could add to congestion on Antero Soriano Hwy. • Resilience to overall road network	• Fast and direct route to Metro Manila • Less additional traffic on Antero Soriano Highway. • Resilience to overall road network (less than others)
Growth Opportunities of the Surrounding Area and its Supply Chains	• More dispersed development • Could support tourism development along Manila Bay	• More dispersed development • Could support tourism development along Manila Bay	• Would support more concentrated urban development • Would support industry development	• Would support more concentrated urban development • Would support industry	• Would support more concentrated urban development • Would support industry • Would support connectivity to airport and ports in Metro Manila
Accessibility Impacts on Labour Market, Employment and Productivity	• Some agglomeration benefits. • Does not connect into existing employment areas on the Cavite side	• Some agglomeration benefits. • Does not connect into existing employment areas on the Cavite side	• Some agglomeration benefits. • Connects into existing employment areas on the Cavite side	• Some agglomeration benefits. • Connects into existing employment areas on the Cavite side	• Greatest agglomeration benefits. • Better connects into Metro Manila • Reduces urban sprawl

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
Impact on Land Use Capacity and Development	• Could create more urban sprawl. • Transport infrastructure for future development of Cavite	• Could create more urban sprawl. • Transport infrastructure for future development of Cavite	• Avoids excessive urban sprawl • Transport infrastructure for future development of Cavite	• Avoids excessive urban sprawl • Transport infrastructure for future development of Cavite	• Supports connection to the proposed Sangley airport. • Fully avoids urban sprawl
Environmental					
Encroachment in Environmental Critical Areas (ECAs)	• Tunnel construction near Corregidor- more adverse impact to tourist spot	• Similar route as Option 2A but bridge construction is anticipated lesser impact	• Tunnel construction- more extensive impact to water bodies	• Similar route as Option 4A but bridge construction is anticipated lesser impact	• Similar to Option 4B but more extensive impact due to longer viaduct in water
	• No known ECAs within the alignment corridor, except that all will traverse Manila Bay				
Impacts on Cultural Heritage	• The alignment does not traverse any known areas of cultural heritage value, pending detailed investigation.				
Vegetation Removal	• Most extensive impact at Cavite due to longest length from C4 to CALAX	• Most extensive impact at Cavite due to longest length from C4 to CALAX	• Extensive impact at Cavite due to long length from C2 to CALAX	• Extensive impact at Cavite due to long length from C2 to CALAX	• Least extensive impact at Cavite- only small area affected
Loss of Habitat, Threat to Species, and Hindrance to Biological Access	• Tunnel and artificial island cause more threat • Longer connection to CALAX	• Bridge construction less significant impact • Longer connection to CALAX	• Tunnel and artificial island cause more threat	• Bridge construction less significant impact	• Bridge construction less significant impact • Alignment longer than Option 2 and 4
Impact on Marine and Freshwater	• More extensive impact from tunnel and artificial island construction	• Less impact for navigation bridge construction	• More extensive impact from tunnel and artificial island construction	• Less impact for navigation bridge construction	• Less impact for navigation bridge construction but more than Option 2B/4B due to longer alignment

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
Air Pollution and Increase in Noise Levels	Options 2A, 2B, 4A and 4B are far away from population centers compared with Option 5, which has significantly long length of viaduct along the coast and closer to the population enters causing air and increasing noise levels.				• Viaduct running in parallel with Cavite coast - closer to population centers
Existing Soil Contamination	• Tunnel construction require more soil removal	• Lesser impact compared with Option 2A	• Tunnel construction require more soil removal	• Lesser impact compared with Option 4A	• Slightly more impact on the seabed compared to Options 2B and 4B due to construction of longer of marine viaduct
Waste Generation	• Tunnel construction will have more soil removal	• Lesser waste generation compared with Option 2A	• Tunnel construction will have more soil removal	• Lesser waste generation compared with Option 4A	• Similar to Option 2B and 4B, lesser waste generation compared with Option 2A and 4A
Quality of Visual Experience	• Tunnel - less visual than navigation bridge	• Long span navigation bridge - attractive	• Tunnel - less visual than navigation bridge	• Long span navigation bridge - attractive	• Long span navigation bridge – attractive • Long stretch of viaduct parallel to Cavite Coast - adverse impact of sea view from Cavite land
Social					
Displacement of Informal Settlers	• High at Cavite alignment; • 21km road alignment connection to CALAX, higher possibilities on displacement		• High at Cavite alignment; • 13km road alignment connection to CALAX, high possibilities on displacement		• Least effect on informal settlers since the land acquisition required is minimal.
Indigenous People	• No known records of Indigenous Peoples at both sides. Hence possible migration is not discounted.				
Right of Way Conflict	• Highest on connection to CALAX		• High on connection to CALAX		• Assumed to be minimal (shortest length)
Traffic Congestion During Construction	• Impact to existing roads at Cavite - longer extent		• Impact to existing roads at Cavite • Lesser impact compared to Option 2		• Little impact to Cavite

Criteria	Option 2A	Option 2B	Option 4A	Option 4B	Option 5
Resettlement Impact	• Highest impact - 21km connection to CALAX		• High impact - 13km connection to CALAX		• Less impact due to short length on Cavite land
Economic Displacement	Some impact to existing livelihood (fisheries and agriculture)				
FINAL RANK:	**5**	**1**	**4**	**2**	**3**

Table 1.8 Summary of results of options selection workshop

Structural Form	**Option**					
	2a	**2b**	**4a**	**4b**	**5**	**2c**
	Northern Bridge + Southern Tunnel	**Northern Bridge + Southern Bridge**	**Northern Bridge + Southern Tunnel**	**Northern Bridge + Southern Bridge**	**Northern Bridge + Southern Bridge**	**Northern Bridge + Southern Bridge**
Length	29.57km	29.57km	29.79km	29.85km	47.19km	32.15km
Construction Cost	PHP268 B	PHP168 B	PHP281 B	PHP178 B	PHP300 B	PHP 176B
Implementation Schedule	~110 mos.	~72 mos.	~86 mos.	~72 mos.	~72 mos.	~81 mos.
Technical	Acceptable	Good	Acceptable	Good	Good	Best
Financial	Expensive	Cheapest	Expensive	Moderate	Most Expensive	2nd cheapest
Economics	Good	Good	Good	Good	Good	Best
Environmental and Social	Slightly Worse	Good	Slightly Worse	Good	Slightly Worse	Best

After the conclusion of the Option Selection Workshop, further comparison work was carried out focusing on Option 2b and 4b with the aim to develop a new option that takes advantage of the benefits from these options based on the score in various criteria. A brief summary of explanation under each category is given in **Table 1.9**.

Table 1.9 Summary of advantages for Option 2b and 4b under each assessment criteria

	Option	**Explanation**
Technical matters **Financial costs**	Option 2b	Option 2b is slightly cheaper to implement than Option 4b due to its shorter length of structures in Manila Bay. The alignment is also closer to Corregidor Island and hence the future connection to Corregidor will also be cheaper to implement. Option 2b scores highest technically. The Navigation Clearance Study (WP5-1) showed that tankers using the Southern Navigation Channel turn north west towards Bataan after crossing Corregidor Island. Option 4b cuts across the navigation path of these vessels and would be a major hindrance/obstacle to shipping.
Economics	Option 4b	There is better connectivity and hence better economics criteria scores for Option 4b which connects to C2, as opposed to Option 2b which connects to C4. The C2 connection on the Cavite side is an interchange connection with the existing Antero Soriano Highway that connects to the southern end of CAVITEX at the Binakayan-Kawit Toll Plaza. Drivers from Metro Manila wishing to use the new bridge would be able to drive from the Toll Plaza to C2 along the Antero Soriano Highway. In contrast the C4 connection would be an interchange on Governor's

	Option	Explanation
		Drive. The distance to this interchange from the CAVITEX Binakayan-Kawit Toll Plaza is longer and there would be a major traffic bottleneck at the existing junction at Naic where the two arms of Governor's Drive and Antero Soriano Highway meet.
Environmental and Social matters	Option 4b	Connection at C2 would enable an at-grade road of approximately 13km in length to be built in the future to connect to CALAX, as opposed to approximately 21km in length if connection is at C4. Not only the shorter connection is cheaper and quicker to implement, the shorter length is likely to lead to smaller amount of land issues, environmental issues and social issues to be dealt with.

A scoring exercise for option 2c was then carried out, based on the same scoring method in assessing Option 2b and Option 4b. The results confirmed that Option 2c scores highest amongst all the options and therefore was chosen to be taken forward to Stage II of the Feasibility Study. This option is the most suitable with the best overall balance of positive outcomes, cost, ease of implementation, and minimum negative impact.

Option 2c was further developed in Stage II of the FS. The alignment, exact location of landing points and interchange layouts to connect to the existing road networks were refined as part of the preliminary design.

Alignment 2c, in **Figure 1.1**, connects Bataan at Landing Point B3 in Barangay of Alas-asin, then slopes down gently towards the future connection to the Corregidor Island at Landing Point I1, until it reaches landing point C2 in Barangay Timalan Concepcion and Timalan Balsahan, along the Antero Soriano Highway.

The selected option takes into consideration key site constraints, including the imposed Civil Aviation Authority of the Philippines (CAAP) for the maximum permissible tower heights, as well as the vessel navigation clearance needed within the two navigational channel to ensure continued access of vessels.

1.3.4 Technology Option

No alternative technologies, operation processes and measures to minimize wastes have been identified at this stage. The process technology that will be used in preventing adverse impacts to the environment will be discussed in **Section 1.7**. The design selection for storage is not applicable for the infrastructure project.

1.3.5 Resources

Most of the materials that will be required for the construction of the project will be sourced locally to minimize the amount of imported materials and machinery required. For viaducts on land, considering that most of the bridge structures in the Philippines are concrete bridges, it is recommended that concrete bridges should be considered wherever possible. It is noted that the interchanges, due to their complex geometry, could be composite bridges (steel-concrete). As for the electricity needed for the bridge, there should be an independent back-up power supply source either from an independent power plant and network or from diesel generator sets, in case of failure of the primary supply. An uninterruptible power supply (UPS) system will cover the power demand of the vital functions during the period it takes before switch over to the back-up source.

Source of Construction Material

The construction of the long sea crossing will require a large amount of concrete for construction. The source of the raw materials (i.e. aggregates and sand) for the concrete will need to be identified. The pre-identified locations of accredited material sources by DPWH are shown in **Figure 1.11** and **Figure 1.12**.

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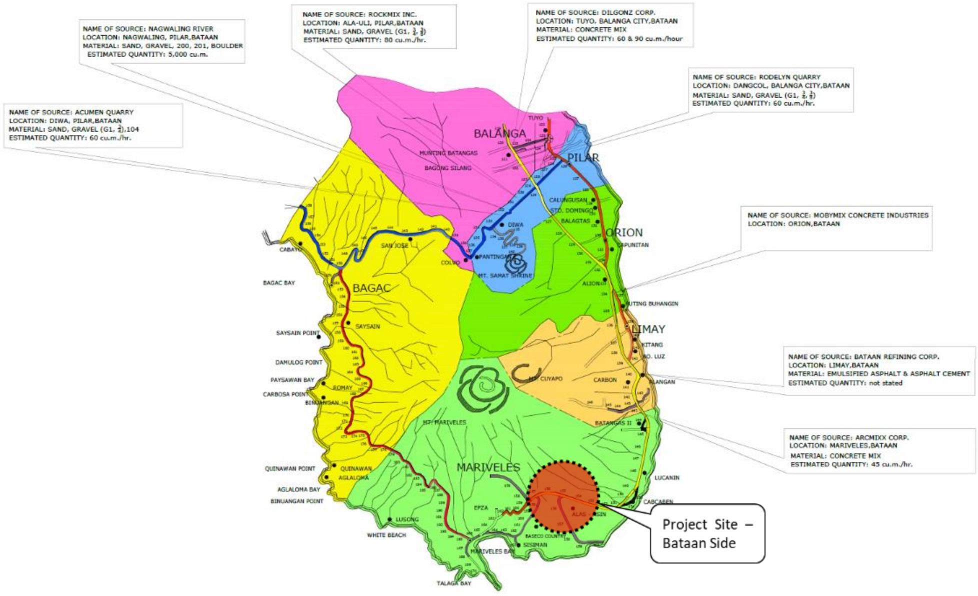


Figure 1.11 Materials Source Map (Bataan 2nd DEO, Balanga)

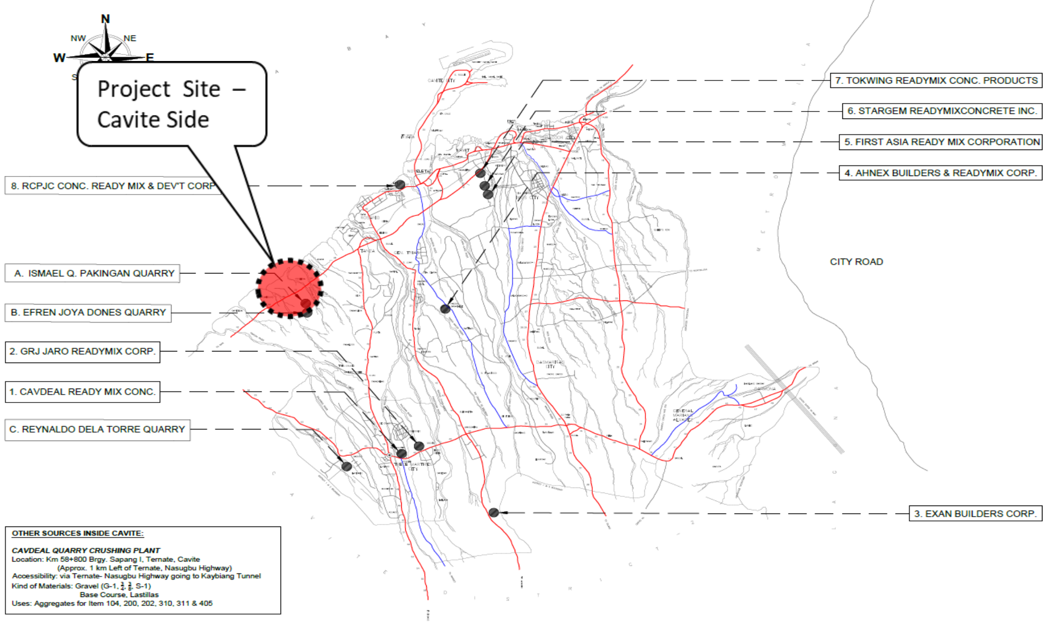


Figure 1.12 Materials Source Map (Cavite 1st DEO, Trece Martires City, Cavite)

1.3.6 Environmental Impacts of Alternatives

Five alignments were compared using defined criteria in order to define the preferred layout. The criteria identified for assessment under Environmental and Social category are described in sub-sections below. Each criteria category has been assigned a "weighting proportion" which denotes the relative percentages of the items as a fraction of the weighting value as a whole. The environmental criteria that will be used in the evaluation of the options are:

- Encroachment in Environmental Critical Areas (ECAs)
- Induced Soil Erosion
- Vegetation removal, Loss of habitat, Threat to species
- Impact on marine and freshwater
- Air pollution and increase in noise levels
- Hindrance to biological access
- Waste Generation from Construction
- Quality of Visual Experience

The social criteria that will be used in the evaluation of the options are:

- Displacement of Informal Settlers
- Indigenous People
- Right of Way Conflict
- Traffic Congestion during Construction
- Resettlement impact
- Economic Displacement

1.3.7 Summarized Comparison of Environmnetal Impacts of Each Alternatives

Listed below are the summarized environmental and social constraints for BCIB's alignment options.

Table 1.10 Summarized Environmental and Social Constraints at for BCIB.

Key Aspect	**Options**		
	2b	**4b**	**2c**
Land	This is based on the length of the alignment which requires removal of existing trees / plants / bushes. Towards Bataan and Cavite, all options require similar amount of vegetation removal. Options 2b and 2c are closer to the Corregidor Island as compared to 4b and hence it may cause more impact to the island during the bridge construction. Bridge construction relatively has less impact to the seabed as compared to the tunnels. All the options will have an impact on the existing soil / seabed. It is assumed that, Long span cable stayed bridges are more attractive as compared to Immersed tube tunnels which are less visible since tunnels will be buried under water. it is visually attractive (impactful) and could incorporate local arts and culture in the design.		

<table>
<tr><th rowspan="2">Key Aspect</th><th colspan="3">Options</th></tr>
<tr><th>2b</th><th>4b</th><th>2c</th></tr>
<tr><td>Water</td><td colspan="3">These scores directly depend on the lengths of marine portions of the alignments and the type of structures. As we have established before in the earlier criteria, the tunnel options will cause more impact to marine and freshwater due to dredging and artificial island construction, hence bridge Options 2b, 2c and 4b are better than the tunnel options</td></tr>
<tr><td>Air</td><td colspan="3">All the options are far away from population centers which may be causing air disturbances and increasing noise levels.</td></tr>
<tr><td>People</td><td colspan="3">All options have equal possibilities on the amount ofland acquisition and displacement, where there are longer impact extent to existing roads at Cavite.
Existing roads on the Cavite side are already quite congested. Construction of the bridge connections to these roads will inevitably require traffic management and likely to cause traffic congestion at times. Option 2b connect to landing point C4 which is further away from the main area of Cavite and hence a longer length of existing road will be affected. Option 4b connect to landing point C2, which is further north of C4 and hence score slightly higher.

Based on the information available, options do not encroach or are considered unlikely to impact upon areas of cultural heritage, and indigenous people are not found near the alignment options’ landing points.
Also based on the information available, overall effect on the economic displacement will be similar for all options and hence they are given similar scores.</td></tr>
<tr><td>Environmnetal Impact Rank</td><td>2</td><td>3</td><td>1</td></tr>
<tr><td>Social Impact Rank</td><td>3</td><td>2</td><td>1</td></tr>
</table>

1.3.8 No Project Option

The following are the potential effects of a no-project option:

- Costs incurred through long travel times and vehicle operating costs;
- Higher accident rates, resulting in both economic and social costs and loss of productivity;
- Reduced ability for areas within and connected to the project area to compete and develop new economic opportunities;
- Reduced accessibility to key business and tourism areas for visitors.
- Reduced accessibility to key amenities and better employment opportunities due to time and vehicle operating costs
- Greater externalities resulting from congestion, including noise, emissions and air quality impacts
- The inequitable distribution of these costs to accrue primarily to more vulnerable demographic groups such as those with low incomes.

1.4 Project Components

1.4.1 Main Components

Along the 32.15km long BCIB, the marine section's structures can be categorized into different components as shown in the sketch below. On Bataan and Cavite land area, both at grade roads and land viaducts are required.

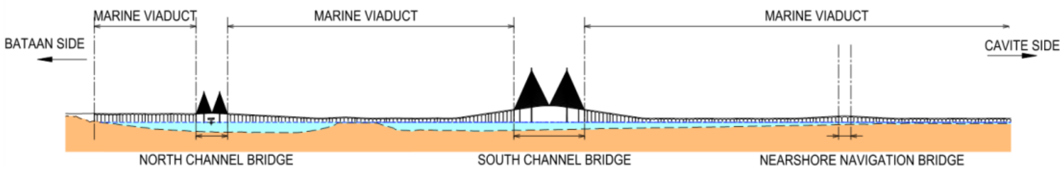


Figure 1.13 Structure Component Types along BCIB

The structures can be categorized into the following different components

Navigation bridges – The main structure that provides the necessary navigation clearance for safe operation of shipping at the project site. For BCIB, the navigation bridges are the North Channel Bridge and South Channel Bridge.

Marine viaducts – The typical viaduct structures which will be constructed above sea water with varying column heights and water depth. Constant span arrangement is adopted to have standardised construction methodologies and minimise the duration of the construction programme.

Interchanges and viaducts on land – These are the viaduct structures which will be constructed on land and provide the connection to the existing road networks.

The crossing needs to climb to height and have a sufficient main span for the navigation bridges to suit the final navigation clearance envelope and must not penetrate the airport height restrictions.

For each of the components of BCIB, an option selection exercise has been carried out to find the optimal solution for these structures.

1.4.1.1 Bridge Form

The form of the proposed bridges at the navigation spans are cable stayed bridges with two monopole towers where cables from the towers fan out to both side of the bridge deck to support the superstructure. The superstructure for the navigation span crossing the south channel consists of two orthotropic steel boxes, while for the north channel, a composite ladder deck with edge steel girders and concrete slab are adopted.

Marine approach viaducts 100m in span length with haunches at pier location are connected to the navigation span bridges at both ends. This is followed by typical marine viaduct of the same span lengths and cross sections. A special navigation span near Cavite, with a main span length of 145m also adopts a haunch at the piers to allow navigation for Coastguard vessels and other small vessels sailing near the shore.

Land viaducts would be typically conventional precast prestressed girders with insitu concrete slab suported on portal frame piers, or concrete box girders while the interchange ramp connections to the existing road network at both Bataan and Cavite landing points would be steel box tub girders with insitu concrete slab.

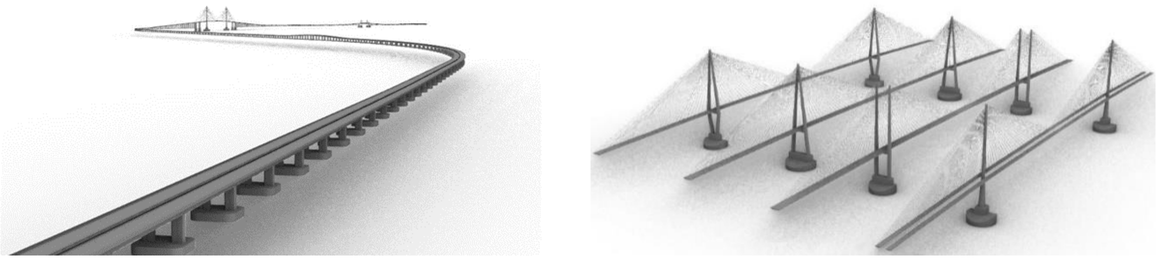


Figure 1.14 Initial Structural Concept for the Cable Stayed Bridges and marine approach viaducts

1.4.1.2 South Channel Bridges

In general, for a long span bridge with 900m span, the only practical and feasible structural forms are cable stayed bridge and suspension bridge. Considering the deep water along the alignment at Manila Bay, it is not economical, and probably infeasible, to have a suspension bridge anchor block in such deep water. Therefore, cable stayed bridge was recommended for the South Channel Bridge. Cable stayed bridge has the additional advantage that the cables can be replaced one by one if necessary and hence easier to maintain and repair compared to a suspension bridge.

Several combinations of tower shapes, deck types and stay cable arrangements were then studied and compared for the cable stayed bridge option. It is proposed that monopole towers with steel orthotropic split boxes deck is adopted.

An example of similar bridge form is Stonecutters Bridge in Hong Kong, see **Figure 1.15** below.

Figure 1.15 Stonecutters bridge, Hong Kong

Figure 1.16 below shows the general arrangement of South Channel Bridge. In order to resist the large ship impact force, the foundation of the towers and anchor piers are proposed to comprise of piles with submerged pile caps with minimal freestanding length of piles above seabed. Alternatively, caisson foundation on soil improvement by inclusion piles or other method may be considered. This will need to be studied further during detailed design stage when soil investigation data becomes available.

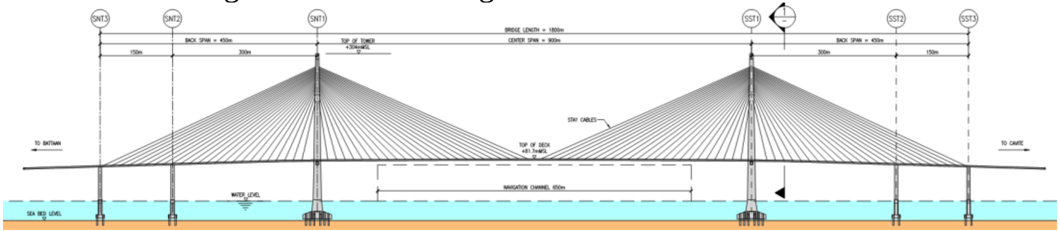


Figure 1.16 General Arrangement of South Channel Bridge

1.4.1.3 North Channel Bridges

In order to cater for a 300m navigation channel for North Channel, a long span navigation bridge is required. The bridge will have a main span of 400m. Similar to the South Channel Bridge, suspension bridge anchorage will not be possible to be built in deep water and hence is not recommended. Arch bridge is technically feasible but is difficult to build and will be more expensive than the cable stayed bridge option. Therefore, cable stayed bridge is the most appropriate and chosen structural form for this navigation bridge.

Several combinations of tower shape, deck type and stay cable arrangements have been studied and compared. It is proposed that monopole towers with steel concrete composite ladder beam deck is adopted. An example of such a bridge is the Gerald Desmond Bridge in California, see **Figure 1.17** below.

Figure 1.17 Gerald Desmond Bridge in California

Figure 1.18 below shows the general arrangement of North Channel Bridge. Similar to South Channel Bridge, foundation of piles with submerged pile cap is proposed, but the caisson alternative should also be considered during the detailed design stage.

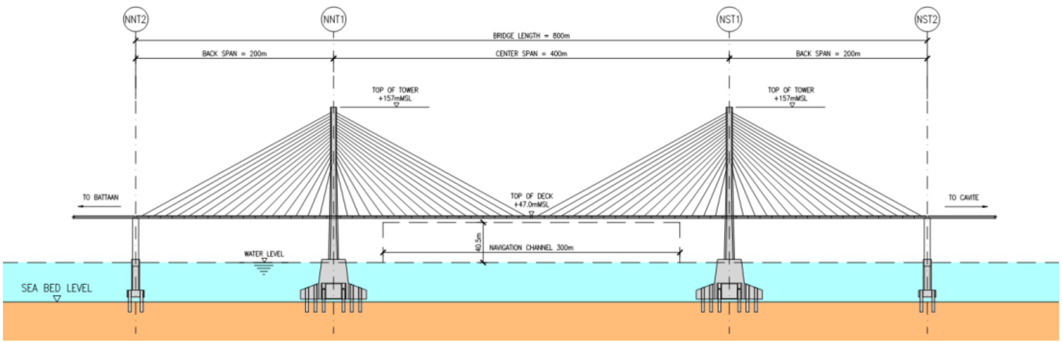


Figure 1.18 General Arrangement of North Channel Bridge

1.4.1.4 Marine Viaduct

For marine viaducts, concrete box girder and steel-concrete composite girders are the most competitive and usually most suitable for marine viaducts. Other options like beam and slab construction are not suitable for longer spans and more expensive to construct for the marine viaducts.

The marine viaduct forms a major part of the overall cost of BCIB due to its long length. Optimising the cost of viaducts could mean significant cost saving on the overall cost of the project. An optimisation study was carried out for the marine viaduct. It was found that 100m span with concrete box girder is the most optimum deck option. It was proposed that sliding pendulum bearings would be used to support the deck and provide the necessary seismic isolation to protect the foundation, which consists of driven steel tubular piles in deep water.

Figure 1.19 below shows the general arrangement of a typical 100m span marine viaduct. For speed of construction, the deck would be constructed by precast full span erection method, in which each precast element comprises a 95m long segment between the midspan of two adjacent spans. The precast elements will be erected by a lifting barge, followed by cast in-situ midspan key segment.

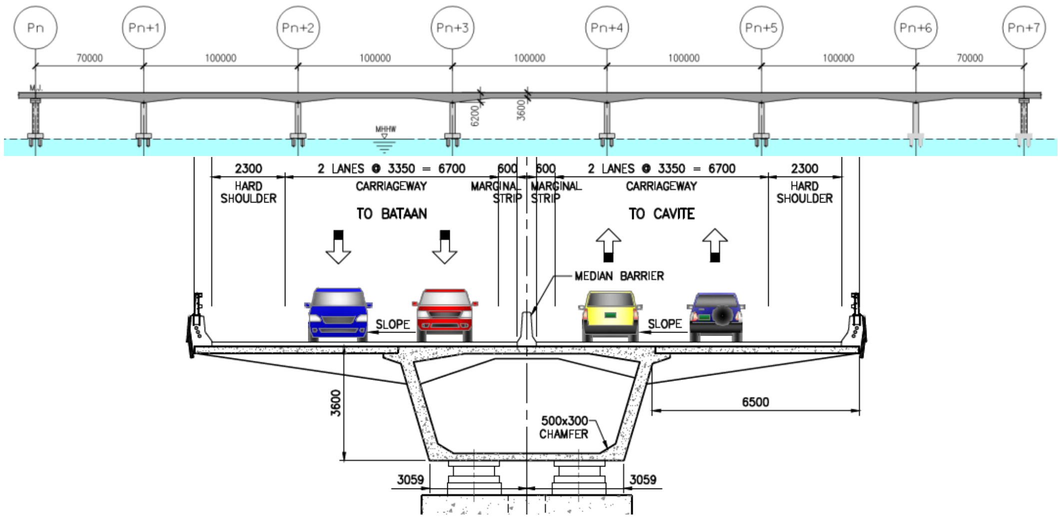


Figure 1.19 General Arrangement of Marine Viaduct

The nearshore navigation span near Cavite is proposed to have a similar structural form but with a longer span length.

Figure 1.20 below shows the general arrangement of the proposed 145m main span for the nearshore span. The deck can be constructed by cast in-situ segmental balanced cantilever construction.

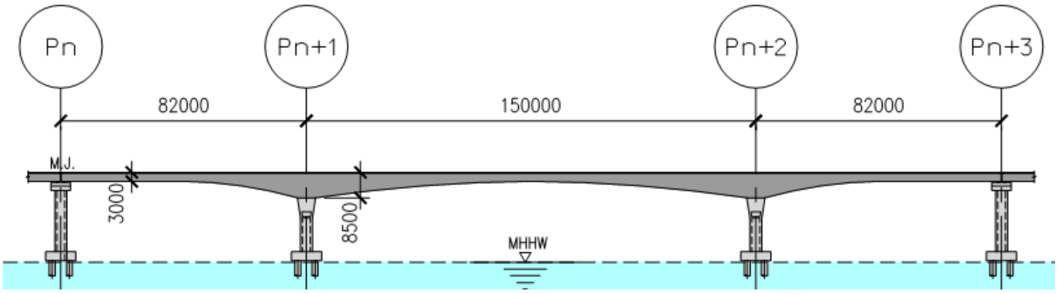


Figure 1.20 General Arrangement of nearshore navigation span near Cavite

1.4.1.5 Land Viaduct

For viaducts on land, considering that most of the bridge structures in Philippines are concrete bridges, it is recommended that concrete bridges should be considered wherever possible. The advantage is that compared to steel, concrete requires relatively less maintenance and the local construction industry is more familiar with it.

Typically, the most economical span length is likely to be relatively short. To utilize as much as possible the local construction techniques where possible, typical precast prestressed concrete beam and slab bridge structures with AASHTO Type girders are proposed. The exception is the Bataan Viaduct adjacent to Manila Bay. This section of land viaduct connects to marine viaduct and column heights vary from 7m to 36m due to the terrain and highway vertical alignment. Considering the cost of foundation and the tall columns required in this case, it is considered that concrete box girder with longer span in the range of 50-75m would be more economical.

The column type would depend on the type of deck cross section. For AASHTO girders, portal frame type pier with two columns per pier is proposed. For box girder, single column is proposed as shown in **Figure 1.21** below.

On land, concrete bored piles are proposed as they have greater advantages over driven steel piles for the ground conditions on land.

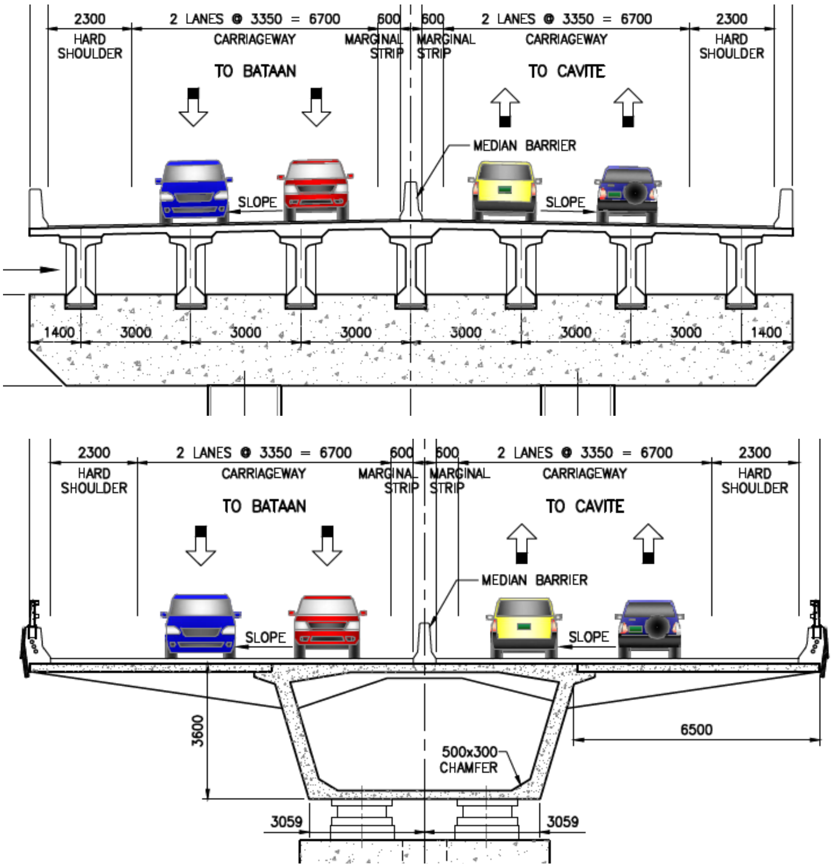


Figure 1.21 Cross Section of land viaducts (Top: Bataan Viaduct, Bottom: other locations)

1.4.1.6 Interchanges

Two types of interchange were considered in this study, namely, trumpet interchange and directional T – interchange.

For the Bataan side, a trumpet interchange provides the best overall solution (**Figure 1.22**). Though this requires more land take, it will efficiently connect the land portion of the crossing to the slower lanes of the continuous Roman Highway. This will not affect the traffic flow when entering the Roman Highway.

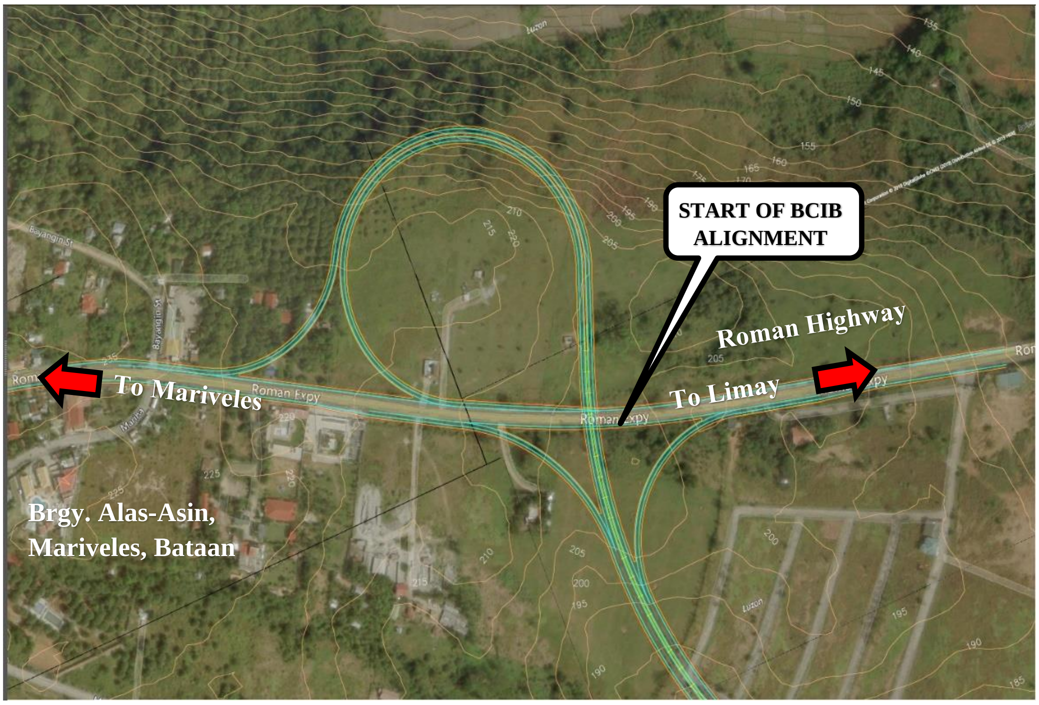


Figure 1.22 Trumpet Interchange Connection at Roman Highway

For the Cavite side, a directional T – interchange provides the best overall solution (**Figure 1.23**). A directional T – interchange is proposed in connecting to Antero Soriano Highway in the initial phase of the project. As volume of traffic entering to and from the expressway increases, it can be upgraded to a Trumpet interchange if required. A cloverleaf interchange will be required, if a future road connecting to CALAX is to be constructed to form an interchange with BCIB.

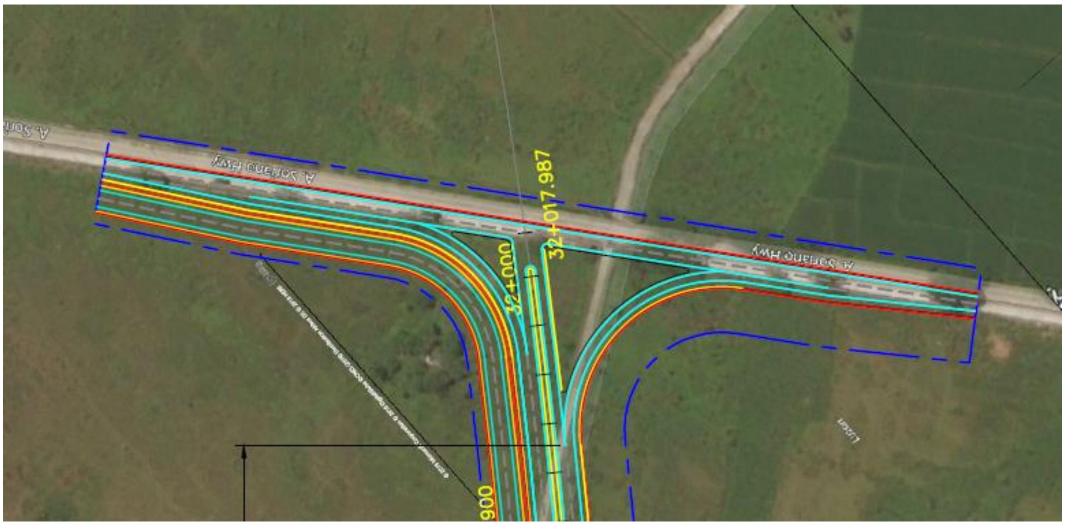


Figure 1.23 Directional T-Interchange Connection at Antero Soriano Highway

1.4.2 Support Facilities

There is a separate preliminary Basis of Design Report for the plans and designs of support facilities such as drainage design. This Basis of Design Report will be updated along with the Feasibility Study and Preliminary Design as the design and studies progress to subsequent stages.

1.4.2.1 Associated infrastructure facilities and buildings

Apart from the main bridge described above, the project will also need to include the associated infrastructure facilities/buildings for operation and maintenance purpose.

1.4.2.2 Administration building

An administration building is often required for bridge link of such scale. The building will include facilities for inspection and maintenance staff, storage of records of maintenance activities and control room for the traffic control and surveillance system (TCSS) equipment if required

1.4.2.3 Maintenance Depot

Maintenance of the bridge is important and it will be necessary to procure appropriate machines such as Under Bridge Inspection Vehicles (UBIV). This is likely to require a centralised depot where there will be parking spaces for maintenance vehicles, space for storage of spare parts, workshops as well as staff amenities and facilities.

1.4.2.4 Electricity Substation

Electricity substation may be required to provide electricity for the highway lighting and TCSS as well as other electrical facilities. The substation may require a heavy transformer and an access road will be required.

Substations along the link bridge may also be required in order to reduce the power loss of transmitting electricity for the highway lighting on the bridge.

1.4.2.5 Source of construction material

The construction of the long sea crossing will require a large amount of concrete for construction. The source of the raw materials (i.e. aggregates and sand) from identified sources in Bataan and Cavite (see **Figure 1.11** and **Figure 1.12**) for the concrete mix will need to be studied further at DED stage. If chosen to be used by the contractors, this will be moved by road transport to the casting yard and site. Roman highway will be used for Bataan, while local roads for Cavite, however exact route depends on the quarries that the contractor will plan to use. Hence expected impact to the roads to be manageable.

1.4.2.6 General works areas

It is essential that land is made available to the contractor(s) for use as a works area.

As a minimum this is required for Contractor’s offices, resident site staff offices, equipment storage yard, machine storage and repair workshop etc. The size and location of works areas must be considered carefully. It is anticipated that there will be several works areas considering the geographical extent of the project. The works areas must be as close as possible to the work fronts as possible in order to make the construction logistics feasible.

It is possible that non-critical areas of the permanent works sites can double up as works areas. For instance, the location of the administration building could be used and this could be taken into account when determining the amount of land that needs to be made available.

The locations for the proposed works area for Bataan and Cavite side are shown in **Figure 1.24** and **Figure 1.25**, respectively.

Figure 1.24 Bataan Side Works Area

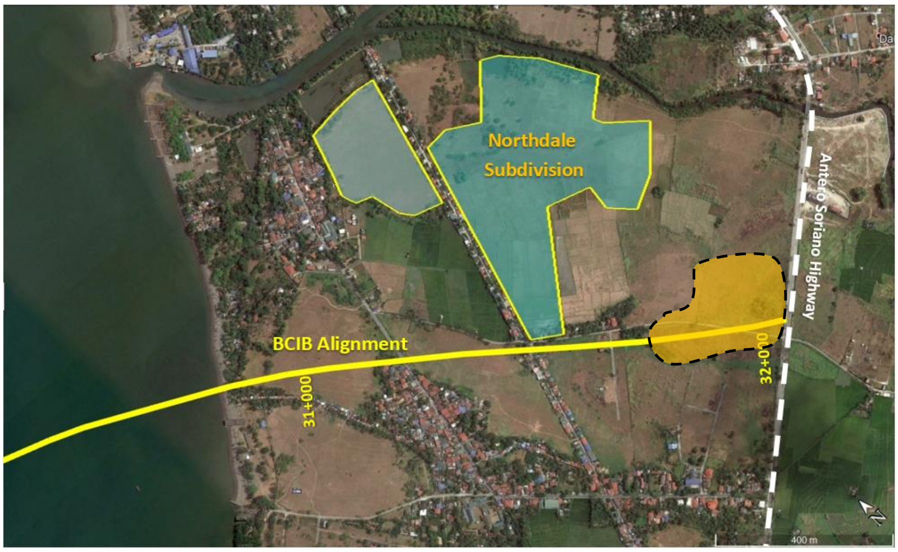


Figure 1.25 Cavite Side Works Area

1.4.2.7 Casting Yard for Marine Viaduct

In this project, it is anticipated that a large amount of precast concrete will be used as structural elements. Considering the volume of construction, if land is available it will be more economical to set up a project specific casting yard close to the site instead of importing precast elements over long distances.

The size and choice of location of casting yard are specific for each project. The relevant parameters that need to be considered include (but not limited to) the following:

- Availability of suitable land and accessibility
- Speed of construction / production rate

- Logistics of raw material and finished products
- Logistics of construction workers
- The range of activities to be carried out
- The depth of water for barges

Unlike the works areas, the casting yard does not have to be immediately adjacent to the work fronts. In general, the closer it is the better. The length of time needed to transport precast segments from the yard to the work front needs to be considered. If the barging/transportation time exceeds a work shift, then it may be beneficial to have a storage facility closer to the site (if available).

Although this would entail a penalty of double handling it means that the precast units can be reliably delivered to the working front at predictable times. Very long barging times introduce weather dependency and uncertainty. If no land is available for storage and the barging time is long, then it is possible that floating storage on barges could be adopted.

Based on the preliminary design, it is anticipated that the bridge deck of marine viaduct will be precast concrete girders that are tailor made for the project. Based on recent project experience, it is anticipated that an area of 105,000m^2 will be required on the Bataan side with access to Manila Bay, and similarly on the Cavite side, such that the two areas can be utilised for the construction of the long marine viaduct.

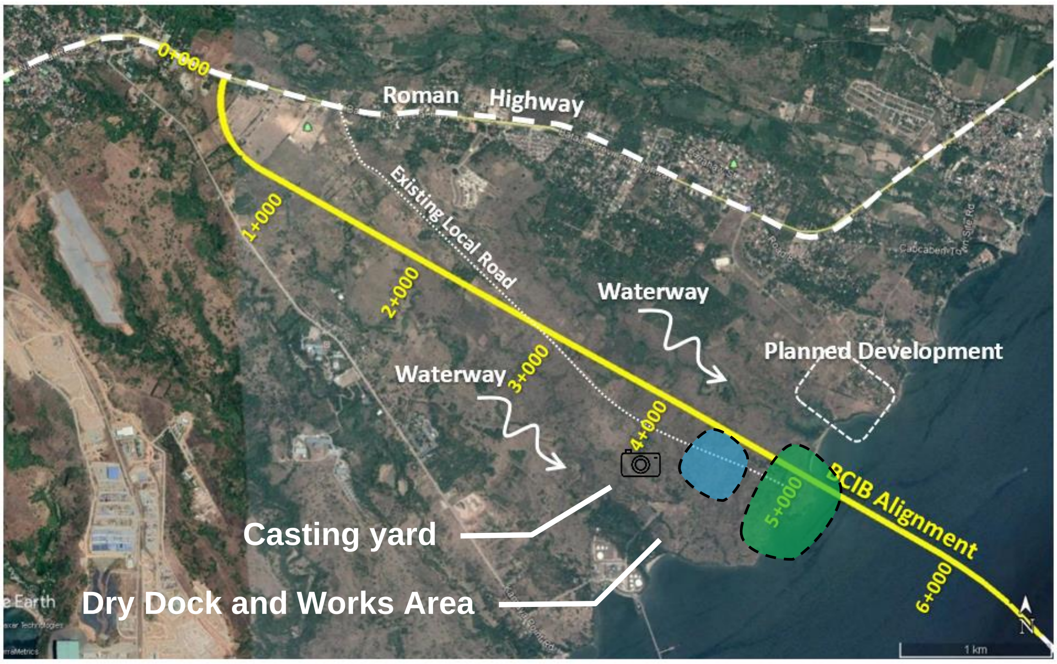


Figure 1.26 Proposed Bataan Casting Yard for Marine Viaduct (Plan)

Figure 1.27 Proposed Bataan Casting Yard for Marine Viaduct (Site Photo)

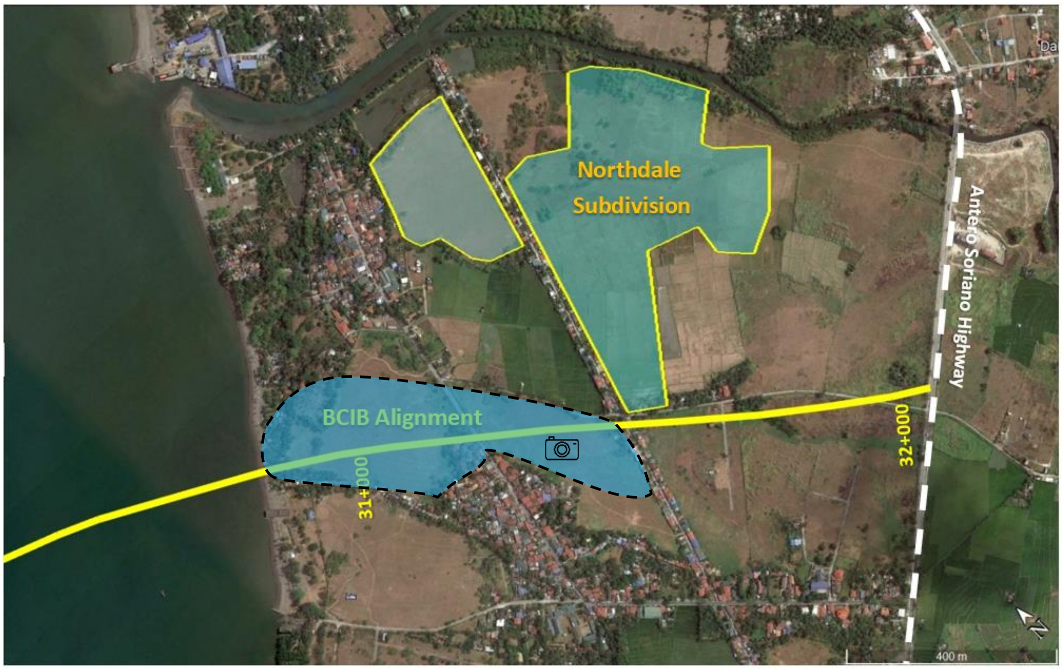


Figure 1.28 Proposed Cavite Casting Yard for Marine Viaduct (Plan)

Figure 1.29 Proposed Cavite Casting Yard for Marine Viaduct (Site Photo)

1.4.2.8 Dry Dock and Works Area for Navigation Bridge

Both the North Channel Bridge and South Channel Bridge would require works area for storage of construction material, site office etc, similar to a normal construction work site. In addition to the normal function and requirements for works area, this works area would also include land with easy access to Manila Bay. This is required for the construction of the foundation which would need to be constructed firstly in a dry dock. Once the precast construction is complete and ready to be floated out, the dry dock would need to be flooded. The prefabricated structural component would then be floated out for construction.

Based on recent project experience, it is anticipated that an area of 120,000m^2 and 240,000m^2 would be required for the North Channel Bridge and South Channel Bridge respectively.

Figure 1.30 Proposed Bataan Dry Dock and Works Area (Site Photo)

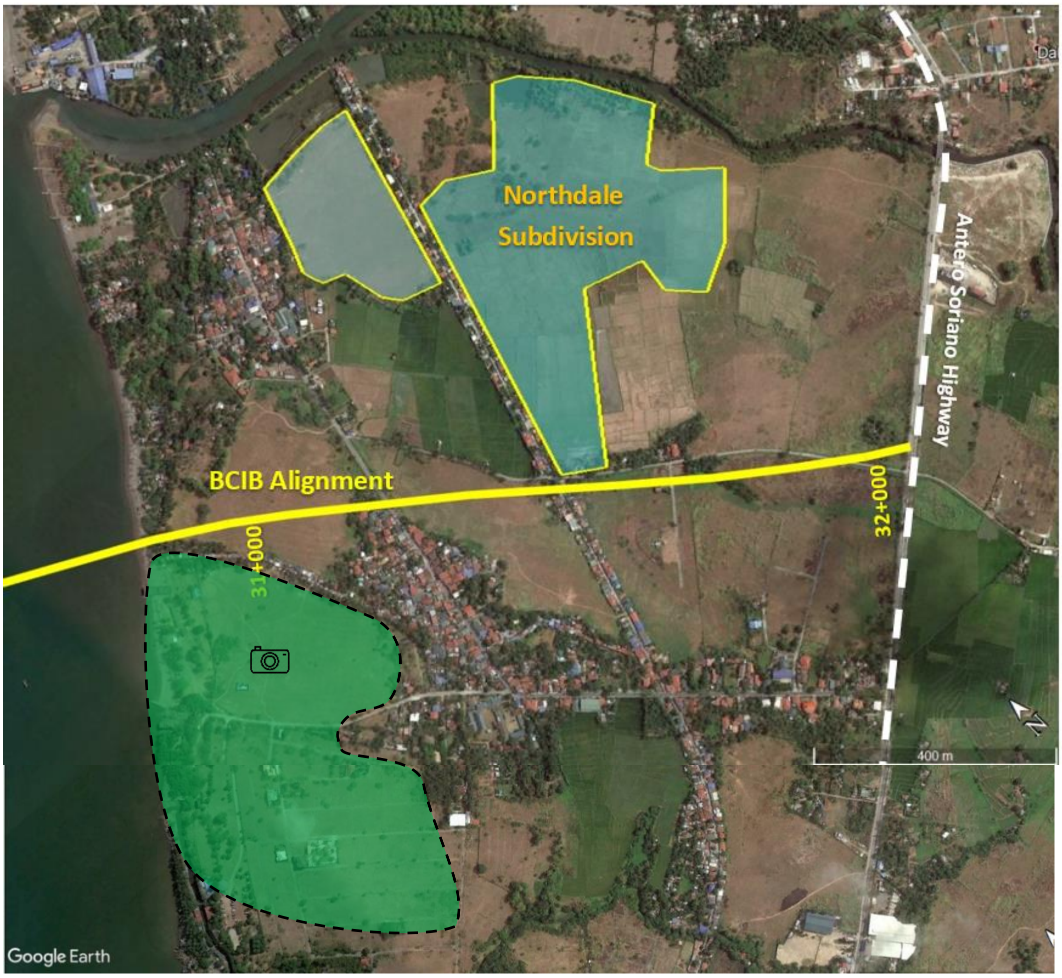


Figure 1.31 Proposed Cavite Dry Dock and Works Area (Plan)

Figure 1.32 Proposed Cavite Dry Dock and Works Area (Site Photo)

Alternatively, the foundations in available drydocks near Batangas which have been used for casting off-shore oil platforms.

1.4.2.9 Dumping area

There will be many excavation activities such as bored piling and/or pile cap construction for both land and marine viaducts. It is necessary to identify dumping/storage areas for material which is either suitable or unsuitable for re-use. If dredged from the bored piles it is likely to be unsuitable material and cannot be used for site formation works. Excavated material might need to be dumped at identified area such as landfill site. This has to be controlled in a suitable manner with minimum impact to the environment. The dumping site would ideally be as close to the project location as possible reduce the cost of transportation.

Figure 1.33 Proposed Dumping Area at Bataan Side

Figure 1.34 Proposed Dumping Area at Cavite Side

1.4.2.10 Barging points

In order to transport construction material to the site as well as to take away excavated material barging points may be required. For example, the dumping site could be offshore. The location and requirement of barging points depends on the quantities of the material that needs to be transported as well as any identified works areas.

1.4.2.11 Haul road

Haul road(s) to and from the construction sites and in particular the works area(s), barging point(s) and/or precasting yard will be required. The capacity of existing roads should be checked and upgraded if necessary, to suit the construction activities. This may need to be carried out as advanced works.

Figure 1.35 Haul Route at Bataan Side

Figure 1.36 Haul Route at Cavite Side

1.4.3 Pollution Control and Waste Management

Pollution control devices and waste management system is a significant component of the project.

1.4.3.1 Air Pollution Control

Emission of air contaminants/pollutants due to construction activities such as earthworks on site, use of heavy equipment and machineries, and other possible sources shall be minimized and if possible, avoided. The proposed use of the following air pollution correction methods to reduce emissions or limit to a manageable range include:

- Use of well-maintained equipment, machineries, and vehicles
- Use of low sulfur fuel and ensuring fuel efficiency of equipment and vehicles
- Air pollutant concentrations will be monitored via regular sampling to ensure conformity with the National Ambient Air Quality Guideline Values (NAAQGV)

1.4.3.2 Noise Pollution Control

Temporary noise barriers will be installed accompanied with monitoring of ambient noise level within the perimeter of the project and near the sensitive receptors. The management of noise pollution will be integrated with strategic scheduling of construction working hours to limit and control noise. Other proposed noise pollution control methods are:

- Use of hydraulic oscillator piling equipment to reduce noise and vibration
- Oscillator rigs will be specified to reduce vibrations
- Intallation of air bubble curtains in the sea to reduce underwater acoustic disturbance
- Use of movable noise barriers in areas where exceeding noise levels are expected to be generated by machineries/equipment

Figure 1.37 shows examples of noise barriers typically during construction.

Source: Environmental Protection Department Website, retrieved February 2020
https://www.epd.gov.hk/epd/misc/construction_noise/contents/index.php/en/home2/mitigation-measures/item/157-construction-noise-barrier.html

Figure 1.37 Movable noise barrier next to an excavator

1.4.3.3 Water Pollution and Wastewater Management

Anticipating the water pollution and wastewater that may be generated from varying project activities and in consideration with the project site's proximity to the water body and the marine area, the following water pollution and wastewater management system will include:

- Treatement and collection of wastewater from construction activities by a third-party contractor accredited by the Department of Environment and Natural Resources Environmental Management Bureau (DENR-EMB).
- Installation of a drainage system to collect rainwater
- To prevent water pollution, the drainage area will contain a filter to separate water contaminants such as oil and grease, which will be drained and collected in sump
- Installation of a well-designed silt curtain control scheme
- Separation of oil and water mixtures into separate components using oil and water separator (OWS)

1.4.3.4 Waste Management System

Waste Materials (domestic, toxic, hazardous, non-toxic and non-hazardous waste, and other types of waste) will be managed thru the development of a Solid Waste Management Plan. The plan shall follow the protocols stipulated in Republic Act No. 9003 or the Ecological Solid Waste Management Act of 2000 and in line with the local government's solid waste management plan. Waste that will be generated during the construction phase will be managed in coordination with the local government units as the LGUs may have a specific contractor/waste hauler that handles construction waste. Treatment and disposal of toxic and hazardous waste shall be done by a DENR-EMB accredited contractor.

Garbage bins shall be placed in strategic locations and regular maintenance of the area shall be done. The assigned pollution control officer (PCO) shall monitor the activities upholding the social safeguard and environmental policies concerning the project.

Prefabrication and optimized construction practices will be employed to minimize overall waste generated during construction.

CCTV cameras and monitoring on the bridge will be used with signage warnings to record and fine polluters.

Figure 1.38 Figure Preliminary Project Components Layout

1.5 Process/Technology

1.5.1 Construction Phase

Provided below are brief discussion of construction methods that the project may employ.

1.5.1.1 Navigation Span Bridges

A) Towers

Both the South and North Channel bridge adopt Monopole tower, as construction is relatively more straightforward in comparison to other tower shapes. A moving formwork traveler can be used with material delivered with help of tower crane similar to what was used in Stonecutters Bridge in Hong Kong, (see **Figure 1.15**).

Figure 1.39 Moving Formwork Construction

For SCB, the monopole tower option has split steel boxes with cross-beam in between. An example of this is the Stonecutters Bridge in Hong Kong (see **Figure 1.40).** Comparing with the more typical single steel orthotropic box of the diamond tower option, the split steel boxes is more flexible during construction.

B) SCB Deck

The deck is erected using the balanced cantilever construction involves casting or erecting prefabricated segments sequentially from the piers outwards in a balanced manner – i.e. a pair of segments, one on each side. The segments under construction / erection would be supported by lifting frames which pick up the precast segments from barges below. Temporary prestress and stay cable is then stressed to hold these segments in place so that construction can move onto the next pair.

C) NCB Deck

For the 400m span which is relatively small, ladder beam deck is feasible and would be simpler and more economical to construct than composite steel box deck.

Typically, the steel parts of the deck are pre-fabricated in segments (edge girder, floor beam, stringers) and are assembled together on site using a balanced cantilever method as shown in the figure above. Once, the steel assembly is complete the precast slabs are installed on top supported by the stringers. Finally, all the precast slabs are stitched together with cast-in-situ concrete pour in the gaps between them. This is an efficient and a common method of construction used for ladder type decks around the world.

Figure 1.40 Split steel boxes during deck erection phase of Stonecutters Bridge

The split steel box would be more complex to fabricate due to the steelwork arrangement, e.g. additional intersections due to the crossbeam/steel box intersections.

D) Precast Pile Cap Foundations

For monopole tower, the precast pile would only have one shaft going down to a base raft (see **Figure 1.41** for illustration). Similar to the tower, the monopole tower's caisson would be cheaper and quicker to construct in comparison to other possible options.

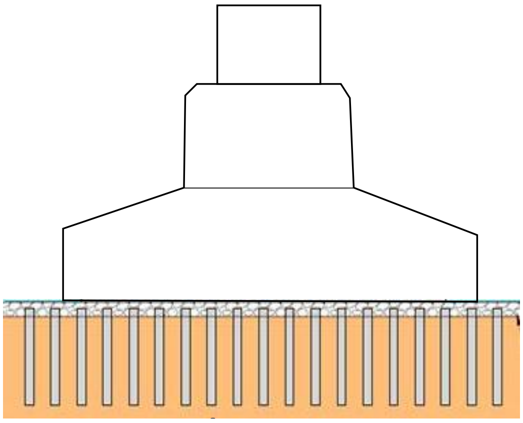


Figure 1.41 Caisson scheme for monopole tower

E) Dry dock construction

The cellular reinforced concrete pile caps (piled caissons) are envisaged to be constructed within an existing dry dock. The caissons would be formed inclusive of a stub section of tower shaft up to the 5m MS Level.

Construction of the caissons within the dry dock would employ conventional reinforced concrete methods.

Figure 1.42 Dry dock construction example - before (L) and after flooding (R) for Izmit Bay Crossing

Temporary buoyancy in the form of steel tanks will be added to the caissons to allow flotation for delivery and placement. It has been assumed that both caissons would be constructed concurrently within the dock and buoyancy fitted, then the dry dock would be flooded, and the gate opened.

F) Marine Construction

Installation of the foundations commences with the placing of a piling template which has been detailed for the central six piles and which would be placed on the seabed (-40m MSL approx.) at the tower location. The guides within this template would be adjusted and confirmed by survey to achieve the required pile placement tolerances.

Locating collars have been detailed to be clamped to the outside of the piles to provide temporary support to the bottom caisson at the correct level (3m above seabed approx.). The caisson would then be positioned above the six locating piles using slack water at high tide. The caisson would be ballasted down on to the collars using a small amount of flooding of the caisson or the temporary buoyancy tanks. The water ballast would be adjusted to ensure that there is no subsequent float-off at high tide. The temporary buoyancy tanks would be ballasted to neutral buoyancy, detached from the caisson and then towed away. The locating collars may also act as seals for the bottom of the annulus between the piles and the caisson. With these seals checked as intact, the annulus between the pile and the caisson would be grouted.

The outer piles would be installed in a similar manner to the central locating piles with the exception that the caisson itself is used as the template to guide the pile casings. After the piles have been concreted, the annulus between the pile and the caisson must be sealed at the underside of caisson level to allow it to be grout filled.

1.5.1.2 Marine Viaducts

For the typical marine viaducts, it is recommended that a full span deck is precast/prefabricated offsite, and transported and erected. Careful consideration needs to be given to the logistics as the full length of girder may not be transportable along the land-based road network in the Philippines. For BCIB Marine Viaducts, these full span decks can be transported on vessels with relatively large draft but may restrict transportation in very shallow waters. Full span girders can also be transported on the already constructed bridge deck to the construction front. Alternatively, the precast full span girders can be lifted from barges stationed below the span to be erected. The key advantages of this method are:

- This method minimizes the on-site work and is therefore quickest for erecting the spans.
- The deck casting/fabrication is done offsite at a yard, allowing better quality, safety and economy.
- Although large capacity equipment is required, initial estimates show that a single work front would be sufficient to achieve the programme, despite the long length of BCIB. This would minimise the on-site crew size and on-site works and could potentially reduce the overall construction cost
- Re-use of facility for other marine crossings of this size

A) Using Launching Gantry

This can be either done using a launching gantry, recent example would be the construction of the marine viaduct sections of Sheikh Jaber Al-ahmad Al-Sabah Causeway Project, Kuwait and the Brunei Temburong Bridge. On the former the girders were transported along the already constructed decks on a custom-built transporter and back fed into the launching gantry (see **Figure 1.43**) Considering both the erection gantry operation and the production line, a construction cycle of 2-day per box per span was achieved. A variation of this method was invented and used for the construction of the Brunei Temburong Bridge marine viaduct. In this case, the erection is carried out by a special launching gantry which can lift two precast girders simultaneously from barges (see **Figure 1.44**). However, the longest spans recently reached with these types of gantries is 65m on Sheikh Jaber Al-ahmad Al-Sabah Causeway Project, Kuwait. As the longer spans are heavy, this method could apply only on the 75m concrete span option under study.

Source: SDI

Figure 1.43 Full Span Erection of Sheikh Jaber Al-ahmad Al-Sabah Causeway Project, Kuwait

Figure 1.44 Full Span Erection of Marine Viaducts, Brunei Temburong Bridge

B) Using Floating Cranes

Another alternative could be full span erection using specially designed floating cranes. Erection of precast cantilever span, similar to Confederation Bridge could be an economical solution for this scale of construction and hence has been investigated in detail. For the longer concrete spans, if the lifting weight is constrained by available floating crane capacity, a shorter cantilever span followed by installation of drop-in segment at mid-span could be adopted.

Source: confederationbridge.com

Figure 1.45 Erection of Confederation Bridge, Canada

1.5.1.3 Land Viaducts

For typical low-level Land Viaducts, Precast beam and cast in-situ slab bridges is adopted as it is common in Philippines. There are skills already available in Philippines for this type of construction and may promote more local participation in the project if this form of construction is adopted for the structures on land. Either a portal type pier or single pier column can be used.

The precast beams may be erected by either launching gantry or directly placed by cranes. This method is economical for relatively small spans. An example of such a structural form is the 'Skyway' officially known as Metro Manila Skyway System.

Figure 1.46 below shows a portion of the elevated expressway's deck.

Figure 1.46 Metro Manila Skyway System

1.5.2 Pollution Control and Waste Management

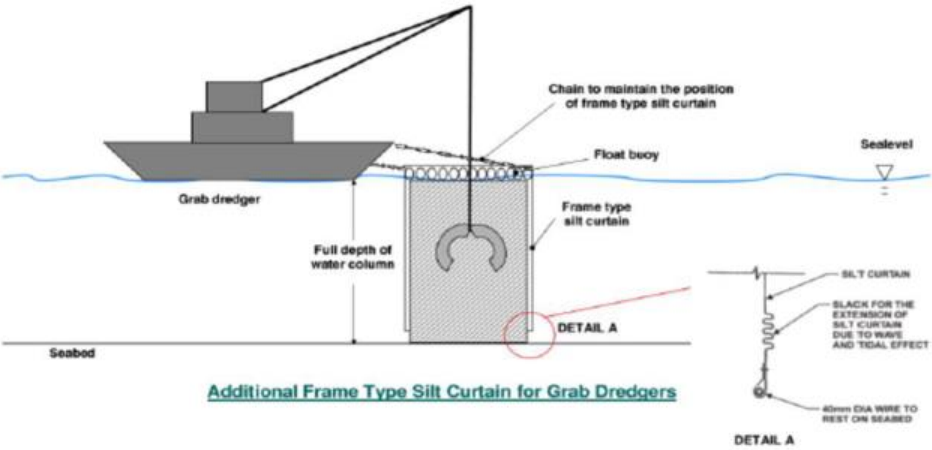
Proper solid waste management practices will be adopted to ensure pollution control especially during construction stage. Domestic wastes from construction workers will be managed through a portable toilet which will be set-up by the contractor.

Regular domestic waste disposal will be collected daily by a third-party contractor to ensure cleanliness in the workplace and avoid possible water quality impacts to drainages and waterbodies.

All construction materials and chemicals will be properly stored and managed in secured storage area with provision of secondary containment. Silt traps will be installed for all nearby water bodies. The waste soil and other debris will be properly handled and disposed on a regular basis. Trainings will be provided to site workers to improve their awareness on proper solid waste management practices.

In addition, construction vessels that will be used will have on-board noise reduction to protect construction workers from excessive noise exposure. This will be in accordance with the International Convention for the Safety of Life at Seas (SOLAS) and would limit ambient noise from on-board machineries and other noise generating equipment. Furthermore, propeller of vessels will be cleaned or polished regularly. Vessels that will be used will obseserve speed restriction and follow routing clearance to avoid sensitive marine areas.

The project will employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea. This will also be regularly checked and monitored to avoid any significant environmental incidents.



Source: MakMax Taiko Kogyo Corporation Website, retrieved February 2020, http://www.taiyokogyo.com/siltprotector/index.html (above); Tuen Mun – Chek Lap Kok Link Investigation Draft EIA Report, retrieved February 2020, https://www.epd.gov.hk/eia/register/report/eiareport/eia_1722009/pdf/Section%209%20(Water%20Quality)/Appendix%209D6.pdf (below).

Figure 1.47 Illustration of Silt Curtains

Furthermore, the proponent will ensure that the contractor will abide the Marine Pollution (MARPOL) 73/78 and Philippine Coast Guard (PCG) marine vessel operations guidelines particularly, but not limited to:

- Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL)
  - No synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ashes from plastic products which may contain toxic or heavy metal residues will be disposed into the sea.
- Regulations for the Prevention of Pollution by Sewage from Ships (MARPOL)
  - To enable pipes of reception facilities to be connected with the ship's discharge pipeline, both lines shall be fitted with a standard discharge connection in accordance to the standard dimensions of flanges for discharge connections table.
  - The vessel that shall be used during construction phase will be equipped to discharge sewerage in accordance with the requirements of regulation 11 -Annex IV of the MARPOL.
- Prevention of Pollution from Garbage (PCG Memorandum # 07-14)

  - The vessel operator will minimize the generation of garbage by limiting the taking on board ship of potential garbage
  - The vessel that will be used will have Garbage Record Book, duly registered at Marine Environmental Protection Command (MEPCOM)
- Prevention of Pollution from Sewage (PCG Memorandum # 10-14)
  - If the vessel that will be used is within the scope of the Memorandum # 10-14, the operator will be required to secure International Sewage Pollution Prevention (ISPP) Certificate on board at all times or a waiver that certifies its exceptions.
  - If the vessel that will be used is within the scope of the Memorandum # 10-14, the ship will discharge comminuted and disinfected/treated sewage at a distance of more than four (4) nautical miles from the shoreline.
- Rules on Prevention, Containment, Abatement of Oil Marine Pollution (PCG)
  - The vessel that will be used will have a minimum of three (3) kilos of rags of other sorbent materials and appropriate number of open-ended drums with cover for clean-up in cases of oil spills on decks and pump rooms.

In case of pollution incidents or spill of oil or noxious substances, the masters of vessels/persons-in-charge of vessels will immediately notify PCG. The notification will include the name of vessel, location, weather condition, type of spill and quantity or any other information necessary for immediate recovery and clean-up operations.

On the other hand, for in-land construction works, the project may use hydraulic oscillator to reduce noise and vibration. Pilling rig with acoustic mat will also be used to control noise impacts.

Source: Architectural Services Department Website, retrieved February 2020, https://www.archsd.gov.hk/archsd/html/report2011/en/supply-chain-management.html (left); Arup Project: South Island Line Independent Environmental Checker (right)

Figure 1.48 Illustration of Piling Rig and Breaker with Acoustic Mat

During operations phase, local noise barriers can be installed to reduce or deflect the noise. The design and type of noise barrier that will be installed will be carefully assessed to identify what will be suitable, if necessary. Screens can be made on the edge of the bridge to provide privacy; indeed it is likely that some noise barrier will be required and this can be designed to be dual purpose to screen any private properties from unwanted viewing and reduce noise. **Figure 1.49** below shows an example of a typical noise barrier used in Tsing Tsuen Bridge in Hong Kong.

Figure 1.49 Illustration of Noise Barrier Installed in Tsing Tsuen Bridge, Hong Kong

1.5.3 Operation and Maintenance

The design of the structures will be in accordance with the Design Standard guidelines of DPWH and other specifications of the project, where necessary. These design standards contain principles and requirements for safety, service ability and durability. It assumes that maintenance activities are performed during the working life of the bridge structures in order to enable them to fulfil the requirements for reliability.

In order to preserve the intended reliability of the structures there is an absolute requirement for ongoing inspection and maintenance. Replacement or repair of certain components shall be carried out as necessary to ensure that the reliability of the structures is not reduced during the intended service life.

1.6 Project Size

With an approximate length of 32.15km and a width of 20.92m, the proposed crossing will feature two lanes in each direction that can serve up to 4,000 vehicles per hour. The crossing includes have two navigation bridges, the North Channel Bridge and South Channel Bridge with a main span of 400m and 900m and a vertical clearance of 40.5m and 72.3m respectively. The marine viaduct is around 26km long with seabed up to 49m deep. Each navigation bridges will be supported by two pylons with a height of 157m for the North Channel Bridge and 304m for South Channel Bridge. The project will also include construction of interchanges with the existing road network, local existing junction improvements, land viaducts, turnaround facility near Corregidor Island, toll plaza, administration buildings and special span bridge near Cavite coast.

1.7 Development Plan, Description of Project Phases and Corresponding Timeframes

The project components will be implemented according to the DPWH Standard Specifications, Volume II: Highways, Bridges and Airport (the Blue Book) 2004 edition. This will be supplemented with additional project-specific specifications, where necessary.

1.7.1 Project Phases

Major activities that will be carried out in the pre-construction and operation phase are summarized in **Table 1.11**. A brief description of specific activities and the potential environmental impacts associated with the works are also in the table below.

Table 1.11 Summary of Major Project Activities

Major Activities	Description	Potential Environmental Impact
Pre-construction		
Site Preparation	This includes site preparatory activities such as land clearing and/or tree cutting activities.	Loss of vegetation, disturbance to biodiversity, may trigger soil erosion, and induce landslides
Ground Preparation and Earthworks	Activities may include excavation for foundations; cut and fill; levelling and compaction, and other engineering works	Generation of noise and air pollutants, ground shaking
Land and ROW Acquisition for Project-Affected-Persons (PAPs)	Land acquisition activities include stakeholder engagements and corresponding social activities to acquire necessary permits/ documents pertaining to land ownership.	Displacement of people and loss of livelihood
Construction		
Transport of Materials	This involves mobilization of construction vehicles (i.e. trucks and vessels) and heavy equipment for hauling and transport of materials.	Noise and air pollutant generation, traffic congestion
Construction of Temporary Facilities	These are facilities in the construction site that are built temporarily, such as housing for workers, construction offices, storage facilities, etc.	Noise and air pollutant generation, ground shaking, domestic solid wastes and wastewater accumulation, disturbance to sensitive receptors
Dredging and Excavation	Dredging and excavation involve removal of silt, sediments, and other materials. Soil will be removed to a required depth in which the foundation of the structure will be placed	Noise and air pollutant generation, change in channel beds, disturbance to marine and terrestrial habitats
Operation of Heavy Machineries	Operation of these heavy machineries are for civil works such as the construction of casting yard, foundations, bridge and interchanges, and bridge structure	Noise and air pollutant generation, ground shaking, disturbance to marine and terrestrial habitats, domestic solid wastes and wastewater

Major Activities	Description	Potential Environmental Impact
		accumulation, disturbance to sensitive receptors

1.7.1.1 Pre-construction/Pre-operational Phase

The pre-construction phase involves planning and conduct of the DED for the bridge components, obtaining ROW and necessary clearances and local permits, pre-qualification of contractors and awarding of contracts, and mobilization for construction.

During the pre-constructional phase, the contractor(s) will mobilize equipment and supplies to the project site, erect temporary facilities for workers and field office, storage sheds and workshops required for the management and supervision of the project. Construction management staff and workers, including local labor, which will include women. Casting yard and storage yard will be set up where precast concrete elements and steel segments such as girders, beams and caissons will be prefabricated and stored.

The Road ROW and compensation process will be completed before the start of construction. Affected land and property must be cleared before the start of construction, including properties that should be demolished for the construction of land viaduct, ramps and roundabout junctions. Trees and vegetation areas on the site will be removed at site clearing phase.

Detailed geotechnical and subsurface investigations will be conducted. Ground preparation and earthworks will commence at the pre-construction phase. As the layout of the structure should be already set accurately at this stage, excavation work will begin, where the soil will be removed to a required depth in which the foundation of the structure will be placed. Heavy machineries like boulders, backhoe, shovels, and scooper will be used for earthworks i.e. removing of excessive soil and other material from construction site.

A health and safety management plan will be prepared and implemented to establish protocols and procedures in addressing potential health and safety emergencies (e.g. oil spills).

Construction of temporary facilities will also be built during this stage depending on the number of workers that will be hired and the actual civil works. The acquired land will be utilized for construction of these.

There may be minimal disruption to road users in the vicinity of the project site during the construction phase. Temporary access roads may need to be opened prior to the commencement of construction-related activities. Any required road closures or detours will be clearly marked to ensure that there are no safety risks for road users, and any possible distribution will be minimized.

During bridge construction, a navigable channel will be maintained, as required, to ensure safe and convenient passage of vessels in the vicinity of the project area. The design plans will integrate required clearances for unobstructed passage of vessels under the bridges.

Following are the clearances, permits and documentations needed:

Table 1.12 Clearances, Permits, and Documentation Requirements

Permits / Clearances	**Authorities Involved**
Pre-Construction	
Authority over the land/ Waiver of Rights	Lot owner(s)
Municipal endorsement for the project/ Certificate of no objection	City/Municipal LGU
Dumping Permit	City/Municipal LGU
Building & Ancillary Permits (Mechanical, Electrical, Sanitary/Plumbing)	LGU/ City/Municipal Office of the Building Official/ Bureau of Fire Protection (BFP)/ DPWH
Fire safety evaluation clearance	BFP, City/Municipal LGU
Occupancy permit	LGU/ City/Municipal Office of the Building Official
Electrical connection agreement	City/Municipal LGU
Barangay endorsement to the project/ Certificate of no objection	All concerned barangays
Zoning/ Locational clearance (Certificate of zoning compliance)	Zoning division, City/ Municipality LGU
Proof of Ownership of Land	Registry of Deeds, or depends
Road-right-of way	DPWH/ Private lot owner
Environmental compliance certificate	EMB - DENR
Tree cutting permit	BMB - DENR
Land use conversion or Land use reclassification (as needed)	LGU/Municipal Planning/Zoning Office
Water Permit	National Water Resources Board (NWRB)
Navigational Clearance	PCG
Coastguard Clearance	PCG
Certificate of Non-Overlap	National Commission on Indigenous Peoples (NCIP)
Certificate of No Objection	LGUs/ Barangays
Construction/ Building Permit	LGUs
CAAP Clearance	Civil Aviation Authority of the Philippines
BFAR Clearance	Bureau of Fisheries and Aquatic Resources (BFAR)
Construction	
Registration of Safety Officer	Department of Labor and Employment (DOLE)
Environmental registration for managing heads	EMB
Registration for Pollution Control Officer	EMB
Hazardous waste generator ID	EMB
Permit to Transport	DENR
Wastewater discharge permit	EMB
Permit to Operate Generator Sets	EMB

1.7.1.2 Construction/ Development Phase

Bridge construction will involve the following activities:

- Casting Yard Preparation

The casting yards are where all the precast concrete and steel segments will be fabricated. The yard will have its own delivery and storage areas, concrete batching plant, and assembly area. This will need a separate ECC application, therefore, casting yard preparation is not considered as one of the project components. However, it is a significant activity in the early construction phase of the project.

  - Transport of Materials

    All materials needed for the concrete structures will be transported and stored in casting yard. Materials will be transported through freight or vessel. Specific procedure will be prepared as part of the project management and traffic management plan during DED.

After the segments are completed, it will be transported to the construction site via land and sea.

- **Foundation**

For the structures on land such as abutments, retaining walls and bridge structure, the site will be excavated for the footing and piled foundations and the completed structures will be backfilled. All excavated materials will be disposed of properly or reused for backfilling, if applicable. Work will also include the furnishing and placing of approved foundation fill material to replace unsuitable material if encountered below the foundations of structures.

For the marine viaducts, large diameter driven steel piles will be adopted. These require steel pipe segments to be first driven into the seabed. Where required, seabed material will then be excavated from within the pipe to strengthen the pipe. Steel reinforcement cages, and finally concrete will be poured into the pile cap, forming the final foundation structure.

For the navigation bridge, a number of steel piles will be installed first as explained above. The prefabricated caissons will then be immersed until they are supported by and connected structurally to the steel piles. Further steel piles will be installed and connected with the caissons.

- **Bridge Approach Construction**

The construction work will involve embankment fill and sub-grade preparation before placing the aggregate sub-base material. The sub-base materials will be spread and compacted to the required thickness. Aggregate base course material will be placed and compacted on the prepared sub-base, and a Portland Cement Concrete Pavement (PCCP), as required per the design will be constructed on the prepared base according to specifications. Road shoulders of the bridge approaches will be protected from erosion by installing grouted riprap for slope protection, as required.

- **Bridge Structures**

The construction of the land and marine viaducts and navigation bridge will involve the following activities:

  - Erection of Columns and Girders
  - Cast in place approach slab, deck slab and road curb/barriers
  - Installation of storm drain system
  - Apply bitumen wearing coarse
  - Installation of lighting/signal system
  - Marking of roads and traffic signage

1.7.1.3 Operational Phase

The bridges and roads are part of a National Highway system and will be maintained by the DPWH-Central in coordination with the DPWH Region III Bataan 2nd District Engineering Office in Bataan and with the DPWH Region IV-A Cavite 2nd District Engineering Office in Cavite. Road Traffic Management will be coordinated with the concerned local government units. Solid Waste Management will be coordinated with the concerned local government office and the DENR.

1.7.1.4 Demobilization Phase

The demobilization activities will proceed after the construction phase. This will include demobilization of temporary accommodation for works and other temporary facilities structures, and removal of all equipment. Construction areas will be cleared and cleaned of any construction waste or debris. Demobilization and restoration work will comply with the accepted procedures and standards prescribed in the approved civil works contract, per DPWH standards.

1.7.2 Project Schedule

The project schedule is shown in **Figure 1.50** below. The civil works construction will begin in 2021. The construction is expected to end by the year 2027.

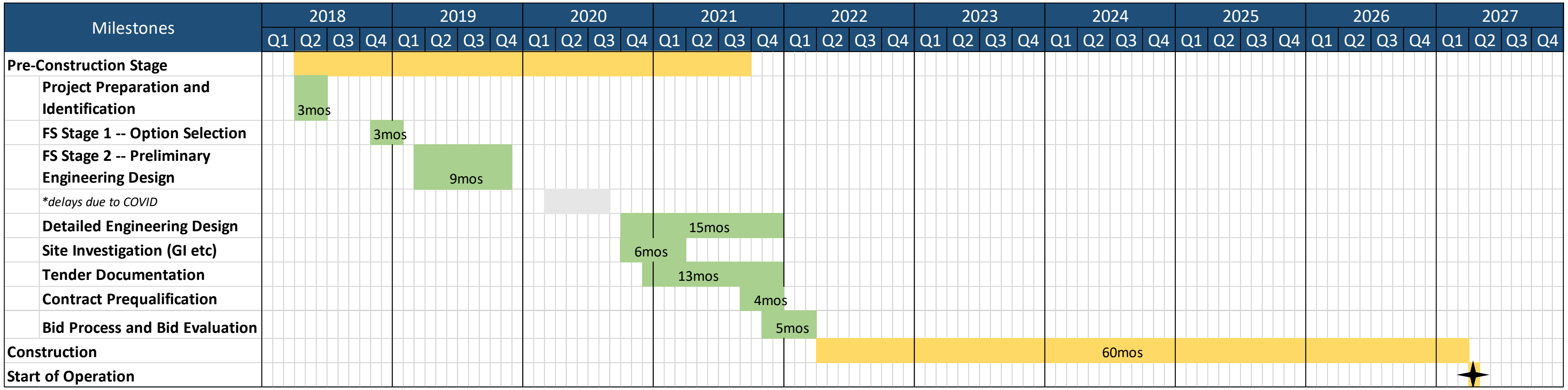


Figure 1.50 BCIB Project Schedule (as of October 2020)

1.8 Manpower

1.8.1 Preconstruction Phase

The manpower necessary during pre-construction phase are the project proponents, consultants and sub-consultants of the project. The total estimated manpower for this phase is listed in **Table 1.13**.

1.8.2 Construction Phase

During construction, the work force will consist mainly of skilled workers, which include masons. The project will need approximately 2,000 to 3,000 skilled and unskilled workers at the peak of a 5-year construction of the bridge, where hiring of qualified locals is recommended.

1.8.3 Operation Phase

For the bridge operations, there will be lesser people hired as compared to the construction phase of the project. The operation phase will need people who will handle the security and passage of vehicles, as well as the maintenance and repair work of the bridge.

Table 1.13 Summary of Manpower Requirements for the Project

Project Phase	Estimated Manpower Requirements	Tasks to Perform	Skill Requirement/s
Pre-Construction	< 5% of total workers in construction	• Pre-drilling • Surveying • Ground investigation	General site workers, surveyors, crane/heavy machinery operator etc.
Construction	Approx. 2,000 to 3,000 workers at the peak of a 5-year construction	• Site office and precast yard set up • Foundation construction – Marine • Foundation construction – Land • Viaduct construction • Cabled stayed bridge construction • At grade road construction	Concreting, formwork/falsework erection, reinforcement fixer, crane/heavy machinery operator, welders, truck/lorry drivers, general site workers, surveyors, precast factory workers etc.
Operation Phase	40-60 worker/officer	• Security • Operation • Maintenance and repair • Inspection	Inspectors, security officer, technicians for repair and maintenance,

1.9 Indicative Project Investment Cost

The civil works of the project will cost approximately PhP 120.79 Billion, while the estimated total cost of the proposed BCIB project is PhP 176.66 Billion, including taxes and contingency.

2 Assessment of Environmental Impacts

This chapter contains the assessment of environmental impacts to land, air, water, and people of the proposed Bataan-Cavite Interlink Bridge (BCIB) Project. For each subsection, methodologies on how the study was conducted will be discussed, key findings on the baseline environmental conditions will be presented, followed by the perceived significant impacts identified for each component with corresponding mitigation measures.

2.1 The Land

The proposed project will link Bataan and Cavite through a 32.15-kilometer bridge across Manila Bay. The bridge on the Bataan side will be landing on the Municipality of Mariveles, traversing the barangays of Alas-asin and Mt. View. On the Cavite side, the bridge will be landing on the Municipality of Cavite, traversing barangays Timalan Concepcion and Timalan Balsahan. The alignment will not touch Corregidor Island, which is under the jurisdiction of Cavite City, but will pass through the south west tip of the island.

2.1.1 Land Use and Classification

The lowland areas of Cavite that include portions of Naic are primarily suitable for irrigated rice/freshwater fishponds. Its central part, which include large portions of Naic, are primarily suitable for cultivated annual crops.

Primarily an agricultural area, 5,194.23 hectares (ha) of Naic is devoted to agriculture. This constitutes about 60.40 percent of the total land area of the municipality. Its vast plains are devoted to irrigated and non-irrigated rice lands. There are grassland areas where mango, coconut, and banana are predominant. Vegetable and root crop areas are likewise abundant in the area. Fishponds and swamplands can be found along the coastal barangays facing the Manila Bay.

Table 2.1 Existing General Land Uses, Municipality of Naic, 2011

Land use categories	Land area (ha)	Percent to total land area
Built-up Areas	2957.48	34.39
Agricultural Areas	5194.23	60.40
Industrial Areas	28.29	0.33
Tourism Areas	120.00	1.40
Special Use Areas	300.00	3.49
TOTAL	**8,600.00**	**100.00**

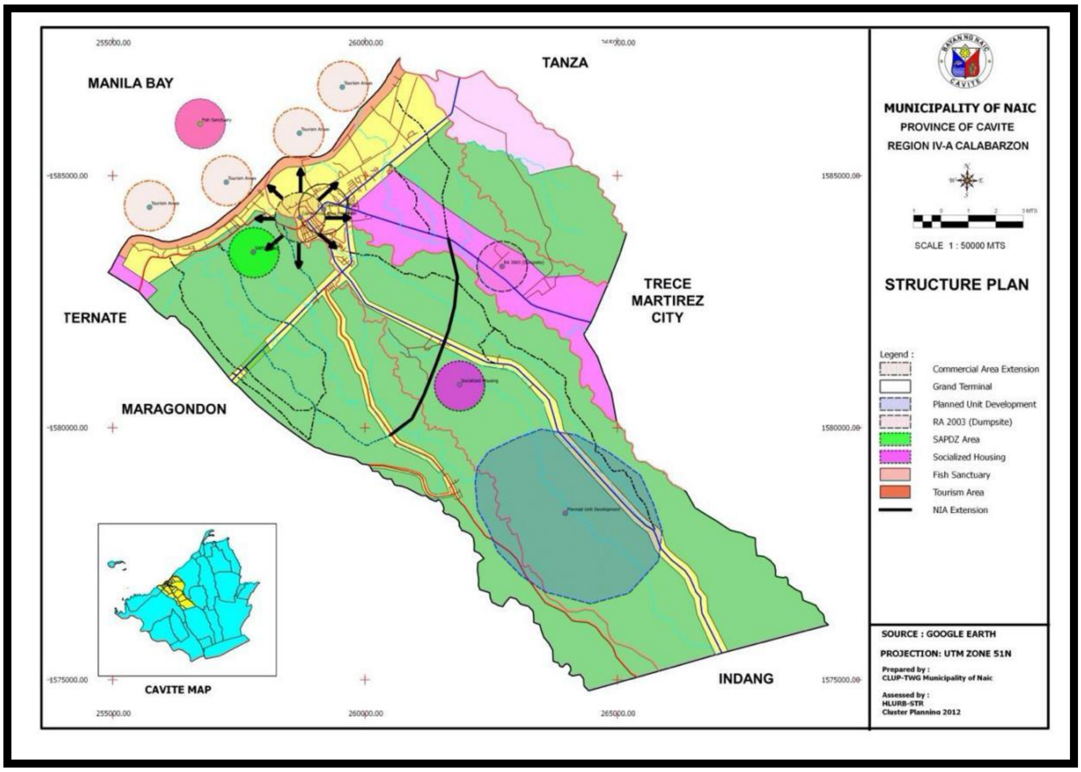
Source: Naic's CLUP 2011-2020.

With the increasing population and economic activities, however, some of these areas were transformed into built-up areas. These built-up areas consist of residential, commercial, institutional, and functional open spaces like cemeteries, parks and playgrounds, and dumpsites. These uses occupy about 2,957.48 ha, or 34.39 percent, of the total land area of Naic.

Under the present over-all framework for development of the Province of Cavite, the "Cavite Nuevo – New Cavite," the Municipality of Naic is to be considered as one of the Second

Growth Corridors of Cavite together with the municipalities of Kawit, GMA, Rosario, Gen Trias, Carmona and the Cities of Trece Martires, Imus, and Dasmariñas.

Naic is also considered part of Mega Manila. Based on its Comprehensive Land Use Plan (CLUP), it is seen to serve as a site of choice for new foreign and local investments, center for large-scale commercial activities for goods and services that will boost local economies, focal site for more residential subdivisions that will bring in competitive human resources, and become an option for road expansion and arterials roads as well as for a large number of educational institutions. Structure Plan of Naic and Land use mapverlaying project alignment are shown in **Figure 2.1** and **Figure 2.2**, respectively.



Source: Naic Comprehensive Land Use Plan, 2011-2020

Figure 2.1 Structure Plan of Naic

Of Naic’s 30 barangays, 10 are located in coastal areas. Vast areas of Naic are devoted to agriculture although there was a decrease from 6860.49 ha in 2000 to 5194.23 ha in 2011, or 24.29% of the municipality’s total agricultural area. The decrease constitutes about 19.37% of the total land area of the municipality. Its vast plains are still devoted to irrigated and non-irrigated rice farming. There are grassland areas where mango, coconut, and banana are the predominant vegetables. Root crops areas are likewise present and can be found in the barangays of Palangue 2 and 3, Palangue Central, Halang, and even in the barangay of Calubcob. **Table 2.2** shows the status of land use in Naic from 2000 to 2010

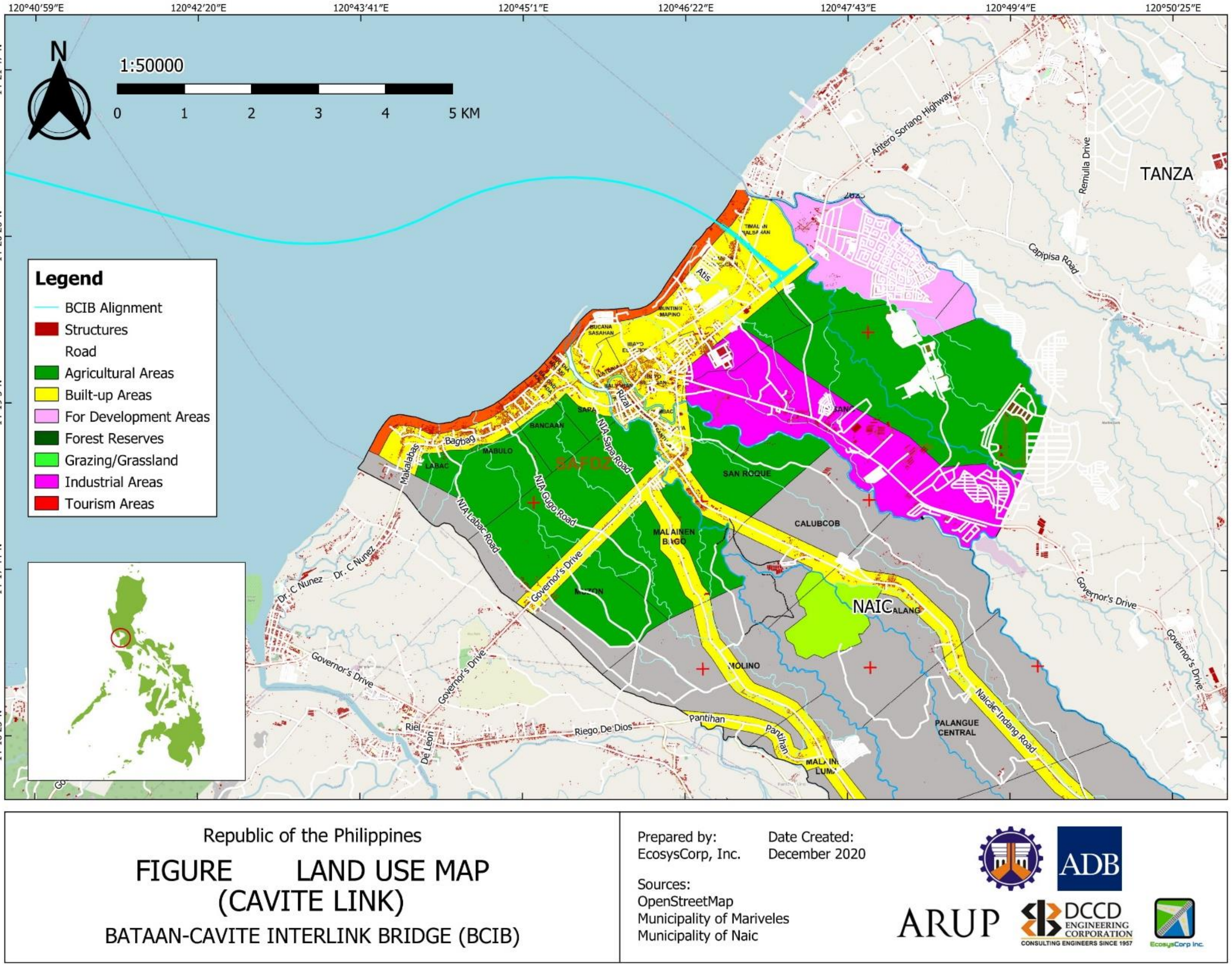


Figure 2.2 Land Use Map Overlaying BCIB Alignment in Cavite

Table 2.2 Status of Land Use (General), Municipality of Naic, 2000-2010

Land use categories	2000		2011	
	Land area (ha)	**Percent to total**	**Land area (ha)**	**Percent to total**
Built-up Areas	1,308.01	15.21	2,957.48	34.39
Agricultural Areas	6,860.49	79.77	5,194.23	60.40
Industrial Areas	11.50	0.13	28.29	0.33
Tourism Areas	120.00	1.40	120.00	1.40
Special Use	300.00	3.49	300.00	3.49
TOTAL	**8600.00**	**100.00**	**8600.00**	**100.00**

Source: Naic CLUP, 2011-2020

Naic's built-up areas increased from 1,308.01 ha in 2000 to 2,957.48 ha in 2011. The 1,656.45 ha increase accounts for a 126% increase of the built-up areas. Majority of the increase was attributed to the new residential subdivisions and increase in commercial areas. Still, residential areas utilize the biggest land area and the functional open spaces utilize the smallest area.

There was also a noticeable increase in commercial areas. The existing central business district had a concentric expansion from the poblacion. The new CBD reaches the areas in the outskirts of the poblacion up to Governors Drive extending to the highways going to nearby municipalities of Tanza and Maragondon.

The increasing population and burgeoning economic activities in the area transformed some of these areas into non-agricultural areas – built-up areas. These built-up areas consist of residential, commercial, institutional and functional open spaces like cemeteries, parks and playgrounds, dumpsites, infrastructure, utilities land uses and residential subdivisions.

One Special Use area exists at Barangay Timalan, with a total land area of approximately 300 ha. This area is well defined under Sangguniang Panlalawigan Resolutions #105 and #125 dated March 1988 and April 8, 1988 as industrial-residential-institutional mix.

Cavite City proper comprises of 338.04 ha land area as per tax declarations, and 61.27 ha of national, city, and barangay roads as certified to by the City Assessor and the City Engineer respectively. Sangley Point and Fort San Felipe comprise of 229.95 ha land area as certified by the Commander, NBC, Philippine Navy; while Corregidor Island and the adjacent islands make up a total of 609.37 ha as certified by the Administrator, National Mapping and Resource Information Authority (NAMRIA).

In May 31, 1948, by virtue of Presidential Proclamation No. 69, dated May 31, 1948, and Executive Order No. 58 S. 1954, Corregidor Island was declared a National Shrine. Thereafter, on July 1986, it was leased by the Department of National Defense (DND) to the Department of Tourism (DOT) for 50 years pursuant to Executive Order No. 123 S. 1986 and P.D. 564 for preservation and tourism development.

The island is currently managed by Corregidor Foundation, Inc. (CFI), a private non-stock and non-profit organization created by the DOT/ Philippine Tourism Authority (PTA) under PTA Board Resolution No. B-7-87 dated February 6, 1987 and registered with the Securities and Exchange Commission (SEC) in October 1987. There are no permanent residents on the island except for stay-in personnel and their families working in the various military and private facilities and amenities. In addition, the DPWH secured CFI Board Resolution in allowing the project to conduct GI and survey works within the area (**Annex M**). **Table 2.3** shows the existing general land use in Cavite City.

Table 2.3 Breakdown of Built-up Areas, Municipality of Naic

Categories	**Area**	**Built-up Area (in percent)**	**Breakdown of Total Area**		
			City Proper	**Sangley Point & Fort San Felipe**	**Corregidor & The Adjacent Islands**
				Special Institutional Zone (SIZ)	
Residential	236.09[a/]	88.38[/]	224.15[a/]	10.44[a/]	1.50[a/]
Commercial	26.60[a/]	79.40[a/]	18.20[a/]	0.50[a/]	7.90[a/]
Industrial	26.35[a/]	39.62[a/]	6.27[a/]	20.08[a/]	-
Agricultural/Fishpond	5.45[a/]	-	5.45[a/]	-	-
Institutional	101.14[a/]	83.67[a/]	24.14[a/]	71.33[a/]	5.67[a/]
Parks/Playgrounds	19.50[a/]	6.67[a/]	6.00[a/]	6.00[a/]	7.50[a/]
Infrastructure (roads, ports, piers, airstrips, water pumping stations, telegraph/power/telephone)	183.58[a/]	0.76[a/]	72.85[a/]	55.00[a/]	55.73[a/]
Other uses: Total	***639.92[a/]***	**-**	**-**	***66.60***	***531.07***
Cemetery	-	-	7.86	-	-
MRF	-	-	1.38	-	-
Reclamation	-	-	18.00	-	-
Swamp and other	-	-	15.01	-	-
Total	**1,238.63[b/]**	**26.44[a/]**	**399.31[c/]**	**229.95[a/]**	**609.37[d/]**

Source: Cavite City's Comprehensive Land and Coastal Use Plan, 2012-2022.
[a/] Quantified as per available data and/or by assumption/s certified to by authoritative sources
[b/] Aggregate of composite land areas
[c/] Certified to by the City Assessor and City Engineer
[d/] Certified to by the Administrator, National Mapping and Resource Information Authority

On the Bataan side, 91 percent of Mariveles' total land area was supposedly covered in some of form of vegetation based on 2016 data. Among the dominant land covers include agro-forestry (28%), closed forestry (22%), and coconut trees (20%). The built-up, or impervious, surface cover only less than 10 percent of the total area consisting of the Freeport Area of Bataan (FAB), existing settlement areas in both Lower and Upper Mariveles, Camaya Cove, residential areas which include informal settlements along the coastline, both sides of major or national roads, and other industrial areas spread out on the eastern portion of the municipality. **Table 2.4** shows the land cover type and area covered in Mariveles.

Table 2.4 Land cover type and area coverage in Mariveles (in hectares)

Land Cover Type	**Total Land Area**	**% to Total Land Area**
Built-up area	**1,459.81**	**9.17**
Open Spaces	**14,460.19**	**90.83**

Land Cover Type	Total Land Area	% to Total Land Area
Agro-forestry	4,507.42	28.31
Closed forest	3,464.70	21.76
Coconut	3,176.50	19.95
Fishpond	917.42	5.76
Fruit trees	511.43	3.21
Grassland	504.62	3.17
Idle land	390.60	2.45
Inland water	353.45	2.22
Mango	327.23	2.06
Open forest	108.12	0.68
Open/Barren	79.96	0.50
Paddy rice	42.97	0.27
Pastureland	37.99	0.24
Shrubs	25.91	0.16
Vegetable	6.55	0.04
Wooden grassland	5.41	0.03
TOTAL LAND AREA	**15,920.00**	**100.00**

Source: Comprehensive Land Use Plan (CLUP) and Comprehensive Development Plan (CDP) of the Municipality of Mariveles, Bataan Province, Vol. 1, 2017-2026.

In 2002, around 16.27 percent of Mariveles's total land area was built-up consisting of all settlement areas, industrial zones including FAB, and internal roads. From 2002 to 2017, the built-up area increased by a total area of 42.46 ha, from 2,589.64 ha to 2,632.10 ha. Across the 15year period, between 2002 and 2017, the municipality's built-up increased at an average rate of 2.83 ha per year.

Increase in built-up areas was entirely due to settlement expansion activities since 2002. Settlement expansion during the 15-year period occurred in many areas of Upper Mariveles. Expansion in Lower Mariveles and the coastline area extended from existing residential areas. In Lower Mariveles, expansion was facilitated through in-filling of open space in the densely packed town center.

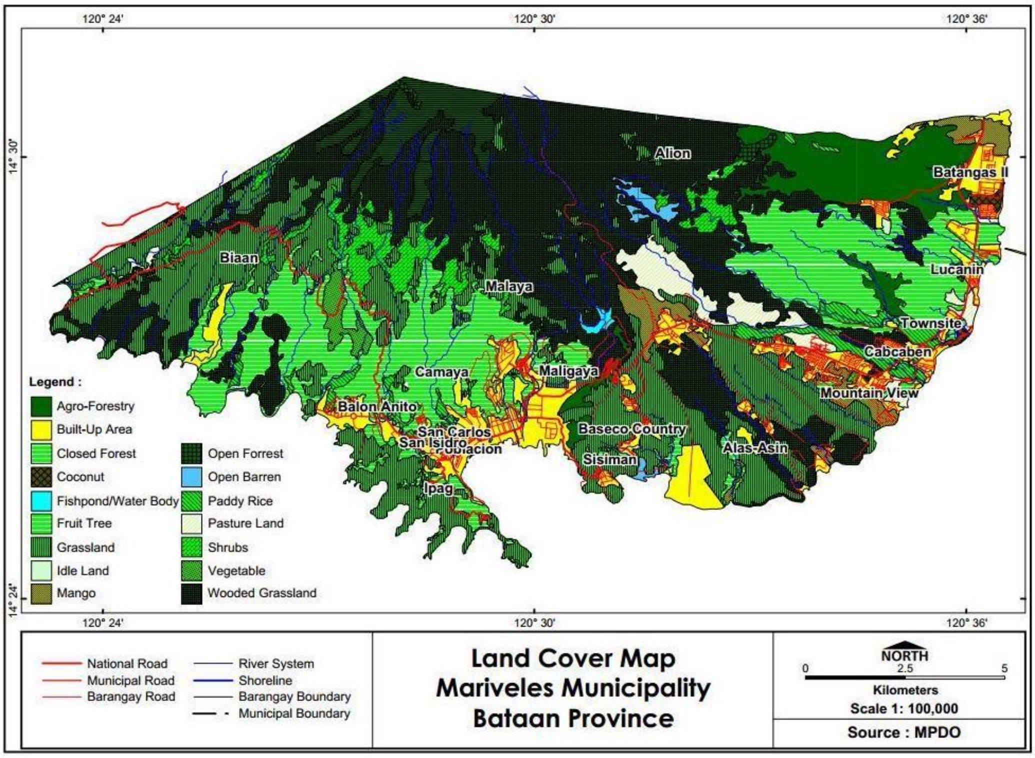
Among the municipality's open spaces, grasslands cover more than 50 percent of the total land area of Mariveles, followed by agricultural area (23%), and forests (9%). The others include surface water bodies and idle lands. The total area classified as open space in 2017 is 13,287.90 ha, which is a little more than 83 percent of the total land area of Mariveles. **Table 2.5** shows the land use in Mariveles in 2002 and in 2017.

Table 2.5 2002 Land Use vs 2017 Land Use

Land Use Category	2002		2017		Difference (in hectares)
	Total Area (in hectare)	% of Total Land Area	Total Area (in hectare)	% of Total Land Area	
BUILT-UP					
Settlements including other Industrial Areas	847.16	5.32	889.62	5.59	42.46
Freeport Area of Bataan (FAB) formerly known as Bataan Economic Zone (BEZ)	1,742.48	10.95	1,742.48	10.95	0
Sub-Total	**2,589.64**	**16.27**	**2,632.10**	**16.53**	**42.46**
OPEN SPACE					
Forest	10,101.95	63.45	1,443.09	9.06	-8,658.86
Agricultural	3,228.41	20.28	3,688.23	23.17	459.82
Grassland			8,057.78	50.61	-
Surface Water Bodies			25.91	0.16	-
Sub-Total	**13,330.36**	**83.73**	**13,287.90**	**83.47**	**-42.46**
TOTAL	**15,920.00**	**100.0**	**15,920.00**	**100.0**	

Source: CLUP and CDP of the Municipality of Mariveles, Bataan Province, Vol. 1, 2017- 2026.

The trend since 2002 established the gradual expansion of the built-up at a rate of 2.83 ha per year. One of the impacts of urban expansion is the loss of open space. Urban expansion in the municipality has been occurring within the municipality’s production forests where activities are generally unregulated. Physical developments over time are also expanding along national roads where linear or ribbon developments are unregulated, and in the town’s center where vacant, or idle, lots are experiencing in-filling. **Figure 2.3** shows the land cover of Mariveles, while **Figure 2.4** shows the Land Use Map overlaying BCIB alignment in Bataan.



Source: 2019 Socioeconomic Profile of Mariveles.

Figure 2.3 Land Cover Map of Mariveles

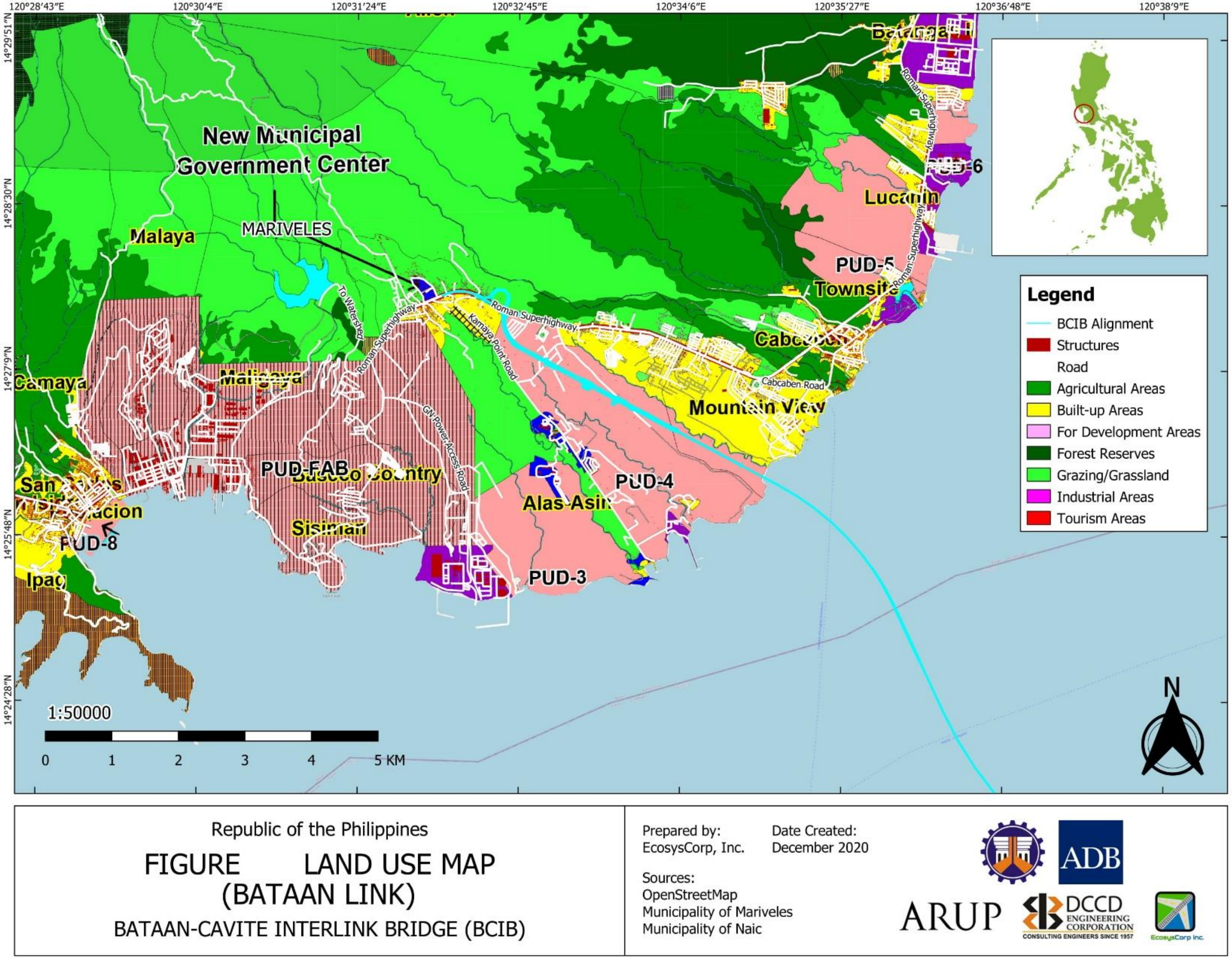


Figure 2.4 Land Use Map Overlaying BCIB Alignment in Bataan

A) Environmentally Critical Area (ECA)

Under Proclamation No. 2146, series of 1981, guided by the DAO 2003-30, there are 12 categories of Environmentally Critical Areas (ECAs). These include the following:

1. All areas declared by law as national parks, watershed reserves, wildlife preserves and sanctuaries;
2. Areas set aside as aesthetic potential tourist spots;
3. Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine Wildlife (flora and fauna);
4. Areas of unique historic, archaeological, or scientific interests;
5. Areas which are traditionally occupied by cultural communities or tribes;
6. Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.);
7. Areas with critical slopes;
8. Areas classified as prime agricultural lands;
9. Recharged areas of aquifers;
10. Water bodies characterized by one or any combination of the following conditions;
    a. tapped for domestic purposes
    b. within the controlled and/or protected areas declared by appropriate authorities
    c. which support wildlife and fishery activities
11. Mangrove areas characterized by one or any combination of the following conditions:
    a. with primary pristine and dense young growth;
    b. adjoining mouth of major river systems;
    c. near or adjacent to traditional productive fry or fishing grounds;
    d. which act as natural buffers against shore erosion, strong winds and storm floods;
    e. on which people are dependent for their livelihood.
12. Coral reefs characterized by one or any combinations of the following conditions:
    a. With 50% and above live coralline cover;
    b. Spawning and nursery grounds for fish
    c. which act as natural breakwater of coastlines.

Table 2.9 summarizes the identified ECAs and their significance, where the project is located or those that are near the project area.

Executive Order No. 20 s.1919 declares that Mariveles (Palanas) Watershed, 12 km away from the alignment, is an initial component protected area. Should these initial components be recommended to be established as protected area, National Integrated Protected Ares System (NIPAS) requires DENR to undertake the following activities (i) maps and technical descriptions (ii) conduct suitability assessment of the areas and (iii) public consultations.

Other near protected area from the alignment is Mount Mariveles, which is about 6km from the Roman Superhighway at Bataan. This has been supporting a range of endemic bird species and identified with a number of International Union for Conservation of Nature (IUCN) Red List Threatened and Near Threatened Species based on the critical habitat screening conducted by ADB in May 2020. This 3.5 km^2 protected area, though non-statutory designation produced by Birdlife International, is recognised by IUCN, World Bank, International Finance

Corporation (IFC) and ADB, and is being managed by Protected Area Management Board (PAMB).

Meanwhile, in Cavite, there are a total of 19.26 ha of coral reef areas, located in Sitio Pinagkainan and Patungan, Barangay Sta. Mercedes, Maragondon, Cavite. Sitio Pinagkaingan, located in the eastern part of Limbones Cove (~25km from the alignment) opposite Carabao Island, has a 34 percent live coral cover dominated by non-acropora corals (32.60%) and a small population of Acropora corals (1.40%). In Sitio Patungan Munti, a slightly sloping ground and good water visibility at 30 ft. depth, has about 32.76% live coral cover where the “staghorn” corals (20%) are most seen. About 40 percent of the species were members of the two biggest families, the Pomacentridae and Labridae. A school of fusiliers (*Caesio spp.*) were also observed.

In addition, there are six major river watersheds in Cavite. These are: (1) Bacoor River Watershed (2) Imus River Watershed (3) San Juan River Watershed (4) Cañas River Watershed (5) Labac River Watershed (6) Maragondon River Watershed. **Table 2.6** shows the existing mangrove and mangrove rehabilitation areas in the Province of Cavite as of May 2015.

Table 2.6 Existing mangrove and mangrove rehabilitation areas at Cavite (May 2015)

Location	Assessed Mangrove Areas (2010) (in ha)	Mangrove Rehabilitation Plantation (ha)	Existing Mangrove Areas (ha)
City of Bacoor	1.08	16.448	17.528
Kawit	29.17	33.528	54.800
Cavite City		4.200	31.620
Naic		1.000	1.000
Maragondon		1.000	1.000
Ternate		1.291	1.316
Tanza		1.000	1.000
Noveleta	27.28	42.619	83.109
Rosario	3.52	1.000	4.520
Total	**88.47**	**102.086 (Old growth is at 48.413)**	**195.893**

Source: Cavite Ecological Profile 2018.

Proclamation 1315 s. 2007 declares that the Mts. Palay-Palay Mataas-na-Gulod Protected Landscape is a protected area under R.A. No. 7586 NIPAS Act of 1992. The area however will not be affected by the implementation of the alignment as this is 10km away from the alignment in Cavite and 14km from the Antero Soriano Highway. This is also identified an Important Bird Area (IBA) with potential presence of three bird species, namely Philippine Duck (*Anas luzonica*), Philippine Eagle-owl (*Bubo philippensis*); and Ashy Thrush (*Geokichla cinerea*). Each of these is classed as IUCN Vulnerable (VU). These two protected areas that represent national reserves are found non statutory designations of IBA, hence ADB do not consider this qualification as Critical Habitat.

The Corregidor Island, although not directly affected by the alignment, is classified as a Protected Area and Natural Park under the Forest Land Classification based on the Provincial Development and Physical Framework Plan 2011-2020. Corregidor has been designated as a National Monument by the National Historic Commission (NHC) and visited by national and international tourists. In 31 May 1948, by virtue of Presidential Proclamation No. 69, and Executive Order No. 58 S. 1954, Corregidor Island was declared a National Shrine. Thereafter, on July 1986, it was leased by the Department of National Defense (DND) to the Department of Tourism (DOT) for 50 years pursuant to Executive Order No. 123 S. 1986 and P.D. 564 for preservation and tourism development.

In case there should be any impacts associated with the boundaries of the area, this will be included in the study and that the team will apply necessary clearances and permits should any of these would be needed. Also, should the alignment traverse the buffer zone, the project will make sure to account all engineering and environmental measures to eliminate the possible impacts.

Manila Bay, as part of the first area of analysis (AoA) as conducted in the critical habitat screening by ADB, has also been identified containing Internationally Important Numbers of migrant or overwintering bird species. This showed the importance of the overall bay, with midwinter numbers from 171,500 to around 208,500 water birds of 90 species occur in Manila Bay, about 75% of the species are migratory. This therefore meet the criteria for Critical Habitat under Criterion 3, Migratory and Congregatory species.

Multiple actions are currently being made to clean Manila Bay and its connected rivers and waterways in pursuant to the Clean Water Act of 2004. This activity is one of the ways EMB can monitor the progress of the efforts of the various agencies that are working for the rehabilitation of the bay. Their study showed that the shoreline along the Mall of Asia had the most distressing results. Phosphates – likely from commercial establishment and shipping vessels, nitrates – possibly from fertilizers, and fecal coliform – from human or animal wastes – were higher than the rest of the sampling stations, and that dissolved oxygen measurements were low.

Another factor that contributes to the pollution of Manila Bay is the intense aquaculture activities. These, however, are not being addressed, leading to a continuing decline in water quality. The creation and proliferation of poorly managed fishponds continues to be one of the main issues that prevent a comprehensive cleaning up of the bay, which in turn causes a decline in fish population due to increasingly poor water quality.

Local government units (LGUs), government agencies such as Metro Manila Development Authority (MMDA), DPWH, Laguna Lake Development Authority (LLDA), etc. are tasked to ensure compliance to the rules and regulations set in order to accomplish this task. Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) has also stepped in to help rehabilitate Manila Bay by spearheading a multisectoral Manila Bay Coordinating Committee. The committee would implement a plan to incorporate the Operational Plan for the Manila Bay Coastal Strategy, the Manila Bay Oil Spill Contingency Plan, the Coastal Use Zoning Plan of Bataan, and the Integrated Environmental Monitoring Program (IEMP).

There would be little to no hindrances or issues that the BCIB project would incur to the effort to clean Manila Bay because the project's own regulatory rules during construction would not allow negative impacts towards the water quality of the Bay. The project will only temporarily alter marine water bodies and sediments during the construction phase. The project will prepare mitigating measure to ensure that the construction will minimize effects on water bodies. All construction materials will be properly managed and stored in well secured area, install silt traps for all near water bodies, properly dispose all waste soil and other debris, provide solid waste management practices and awareness to workers in the site.

B) Land Tenure

There are no existing tenurial instrument along the alignment and in the proposed landing sites of BCIB Project in Naic, Cavite and Mariveles, Bataan. Along the municipality of Mariveles, the primary impact area and its adjacent sides were classified as Alienable & Disposable (A&D) and are mostly open spaces covered by grasses. Agricultural lands, pasture lands and fishing boats were also seen at the vicinity. During the finalization of the feasibility studies, Comprehensive Agrarian Reform Program (CARP) areas were redirected to minimize the effect on major agricultural sites.

On the other side of the alignment, in Naic Cavite, the alignment's primary impact and secondary impact areas were classified as Built Up and mixed – used areas. Based on the 2018 Cavite Ecological Profile, the proposed alignment on the Cavite side is within the area classified as A&D. The lowland areas of Naic, Cavite are primarily suitable for irrigated rice and freshwater fishponds. Naic and Corregidor Island are both highly restricted agricultural land covered by Network of Protected Areas of Agriculture (NPAA) according to the Land Suitability Map of the Province of Cavite.

No records or indication that these agricultural lands are classified as high yield or prime agricultural areas were found. However, potential project impacts to agricultural lands will still be assessed and considered. Surveys conducted found that informal settler families (ISFs) may be affected. Initial affected lot areas at Bataan and Cavite are summarized in **Table 2.10**.

C) Visual Aesthetics

Corregidor is a historic island and popular tourist spot located at the mouth of Manila Bay, centered approximately 5 km off the south eastern tip of Bataan, but under the jurisdiction of the City of Cavite. It has been designated as a National Monument by the NHC and visited by national and international tourists. It is covered by vegetation and natural habitat for birds and other animals. It is classified protected area and Natural Park under the Forest Land Classification (Provincial Development and Physical Framework Plan, 2011-2020). In addition, the marine environment around Corregidor is known to contain many shipwrecks (**Annex F**).

The project site will not affect any of these visually significant land and marine forms. Visual aesthetics of areas that will be traversed by the alignment (i.e. view of the beach and of the skyline) may however be affected mostly during construction phase but are temporary. The possibility of connecting the BCIB project to this island, in the future, may cause temporary physical resources impact but high advantage to tourism. However, with the careful design and choice of materials to blend with the scenery, the bridge has the potential to become an attraction for its engineering and design.

D) Solid Waste Management

Republic Act 9003 or the Ecological Solid Waste Management Act of 2000 mandates that Solid Waste Management (SWM) is the primary responsibility of city and municipal units. As such, Bataan and Cavite Province produced a Ten (10)-Year Solid Waste Management Plan that was to pave the way for a unified and streamlined SWM plan.

Part of the objective of the 10-Year SWM Plan was for each component LGU was to create its own City/ Municipal Solid Waste Management Board and Barangay Solid Waste Management Committees. For Mariveles, Bataan, the Municipal General Services Office Environmental Sanitation was given the responsibility of overseeing their jurisdiction. Another key element of their plan was to reduce wastes from the source by implementing recyclable fairs and exchanges, encouraging the use of reusable straws, utensils, paper, and plastic wastes, in line with "No Segregation, No Collection" policy of the province.

In terms of final disposal, some LGUs have their own sanitary landfills (SLFs), but Mariveles disposes of their waste at Capas, Tarlac, in a Category 4 SLF owned by Metro Clark Waste Management Corporation (MCWMC). Special household wastes, healthcare wastes, toxic and hazardous wastes are all dealt with differently. These wastes, due to their hazardous nature, are collected by specialists. As for recyclables, Mariveles has 8 junk shops, which buy them from the residents and sell to recycling businesses outside the province.

The 10-Year SWM Plan of the province organizes Information, Education, and Communication Programs to disseminate information on the plan. Signs, carefully placed signages, barangay and stakeholder meetings, lectures, and orientations have been created to further their goals relative to proper solid waste management. The projected waste generation (kg/day) for Mariveles is shown in **Table 2.7**:

Table 2.7 Projected wastes from baseline 2017 to 2026 for Mariveles, Bataan.

Year	Projected population	Projected waste generation (kg/day)
2017	142,331	28,608.53
2018	147,156	29,578.36
2019	152,145	30,581.25
2020	157,303	31,617.90
2021	162,635	32,689.64
2022	168,149	33,797.95
2023	173,849	34,943.65
2024	179,742	36,128.21
2025	185,836	37,352.89
2026	192,133	38,619.34

Source: Bataan Ten-Year Solid Waste Management Plan 2018-2027

Based on the 2016 data from the Bataan Ten-Year Solid Waste Management Plan 2018-2027, Mariveles' wastes have the following composition: 21% biodegradable, 15% recyclables, 55% residuals with potential for diversion, 5% residuals for disposal and 4% special wastes.

Table 2.8 presents the projected volume of garbage and area requirement in Naic for the period from 2010 to 2020.

Table 2.8 Projected volume of garbage and area requirement in Naic, 2010-2020

Year	Projected population	Projected volume of garbage (0.45 kgcd)	Projected area requirement Of dumpsite (1 ha/30,000 pop)
2010	88,144	39664.80	3
2011	89,860	40437.07	3
2012	91,610	41224.38	3
2013	93,393	42027.02	3
2014	95,212	42845.29	3
2015	97,066	43679.49	3
2016	98,955	44529.93	3
2017	100,882	45396.92	3
2018	102,846	46280.80	3
2019	104,849	47181.89	3
2020	106,890	48100.52	4

Source: Naic CLUP, 2011-2020

The present system of solid waste handling, storage, and disposal in Naic is typical of many growing and urbanizing municipalities in the Philippines. Household refuse, including wet and dry kitchen wastes, wrappers, discarded rags, boxes, wastepaper, leaves, and plastic bags, which constitute majority of waste collection, are generally disposed together without segregation. These are disposed in a variety of containers: cans, drums, plastic bags, carton boxes, plastic canisters, jute and straw sacks, etc. Disposal is either through municipal garbage collection trucks or by direct burning which generates air pollution and by burying.

According to the Rural Health Unit 2010 Profile, majority of the households surveyed (56.61%) used the community collection system. They rely on the garbage disposal system of the local government.

The present garbage collection and handling facilities of Naic is quite adequate but still needs serious attention. The present dumping ground is controlled landfill bought by the government but is located on an industrial area.

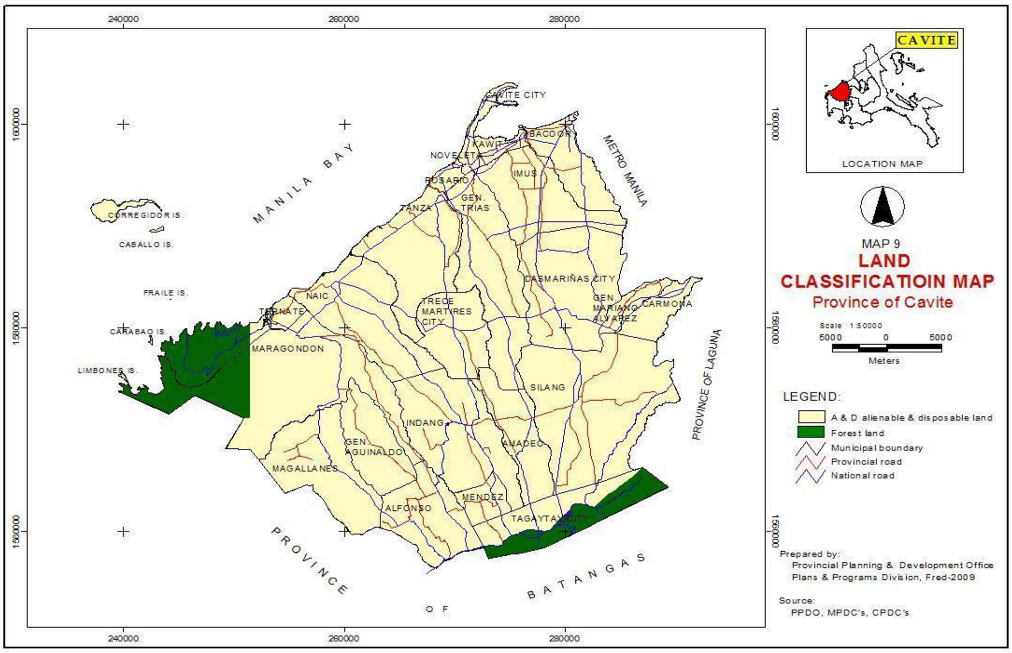
Based on the Waste Analysis and Characterization Survey (WACS) conducted by Naic's MENRO, the average waste generated in the municipality is 44.45% non-biodegradable and 55.55% biodegradable.

2.1.1.2 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Impacts on Land Use and Classification

Portions of the designated agricultural area will be located in Barangays Timalan and Sabang. A Special Use Area, classified as such by the province in 1988 under Resolutions Nos. 105 and 125, will be a special mixed-use area for residential, commercial, institutional and industrial uses. This area is located in Barangay Timalan. The designated RA 9003 Area, the controlled sanitary landfill, is located in Brgy. Sabang with an area of approximately 2.5 ha.

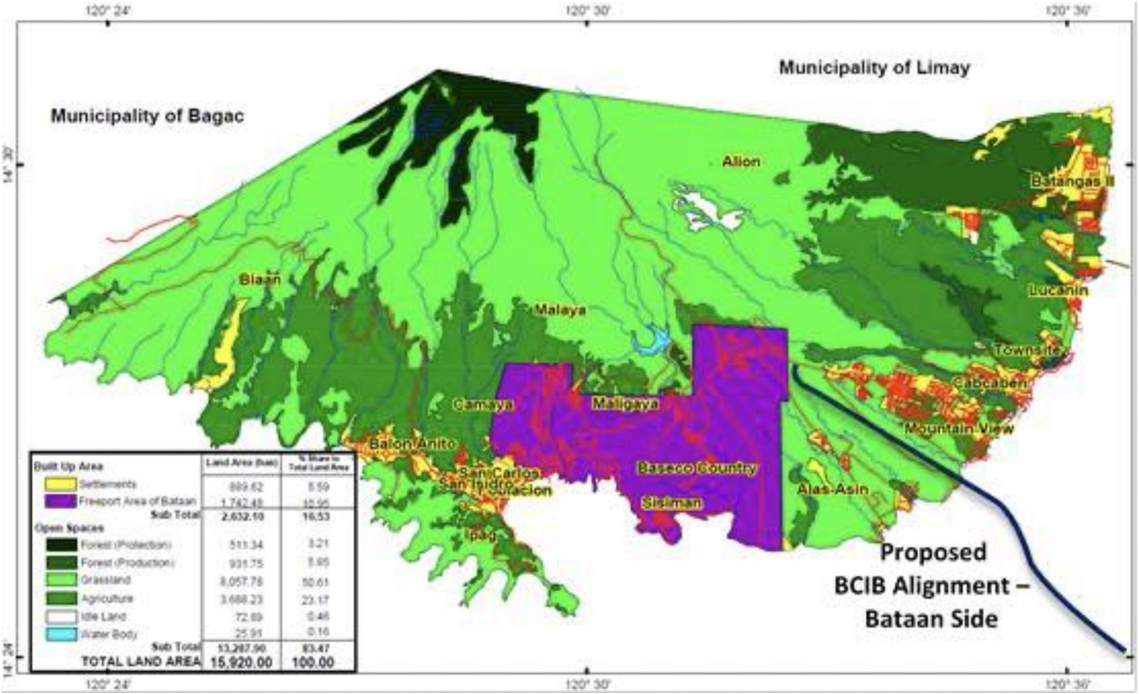
Based on the 2018 Cavite Ecological Profile, the proposed alignment on the Cavite side is within the area classified as A&D.



Source: Cavite Ecological Profile 2018.

Figure 2.5 Land Classification Map of Cavite.

Most of the affected lands on the Bataan side of the alignment are grasslands/idle lands. Data obtained from Mariveles' Municipal Planning and Development Office (MPDO) also reveal that the area in Barangays Alas-asin and Mt. View, which the proposed alignment will be traversing, have also been classified as grassland.



Source: 2019 Socioeconomic Profile of Mariveles.

Figure 2.6 Land Classification Along the Proposed Alignment in Bataan

B) Impacts on Environmentally Critical Areas (ECA)

The alignment of the proposed Bataan - Cavite Interlink Bridge Project will only traverse along Barangays of Alas-Asin and Mt. View Mariveles Bataan and Barangays Sabang, Timalan Concepcion and Timalan Balsahan of Naic. Those areas are significantly distantly away from the identified ECA and currently the proposed alignment is within the built-up areas of both Municipalities. There was also a noticeable increase in commercial areas. The existing central business district had a concentric expansion from the poblacion.

Considering the distance and the baseline information referring to the proposed project, the project has no significant impact on the identified critical areas like the coral reef situated in Sitio Pinagkainan and Patungan, Barangay Sta. Mercedes, Maragondon, Cavite. Sitio Pinagkaingan, located in the eastern part of Limbones Cove opposite Carabao Island, Sitio Patungan Munti, and the six major river watersheds in Cavite located in Bacoor River Watershed, Imus River Watershed, San Juan River Watershed, Cañas River Watershed, Labac River Watershed and Maragondon River Watershed. **Table 2.9** summarizes the identified ECAs and their significance, where the project is located or those that are near the project area.

Table 2.9 Summary of Environmentally Critical Areas (ECA) in Bataan and Cavite

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	No	There are no declared national parks, watershed reserves nor wildlife preserves and sanctuaries within and in the vicinity of the project site. The nearest areas include the 347 Mariveles (Palanas) Watershed, 12 km from the alignment, under E.O. 20 s.1919 (initial component), and the 3972.7ha-Mts. Palay-Palay Mataas-na-Gulod Protected Landscape, 10km from the alignment, under Proclamation 1315 s. 2007 and R.A. No. 7586 NIPAS Act of 1992. Although not directly affected by the alignment, the Corregidor Island is classified as a Protected Area and Natural Park under the Forest Land Classification (Provincial Development and Physical Framework Plan 2011-2020). Disturbance to wildlife, habitat loss, and hindrance to biological access may be expected but only during the construction phase but not directly in the island's protected area. It is important to note that there will be no activities anticipated in Corregidor area, but should there be any impacts associated with the boundaries of the area, this will be included in the study and that the team will apply necessary clearances and permits should any of these would be needed. Preservation of cultural heritage is also vulnerable to the development. The proposed alignment, however, is expected to further support the tourism industry.
Areas set aside as aesthetic, potential tourist spots	No	Most of the areas along the alignment are within A&D and build-up areas. As the alignment will only be in close proximity to the east part of the Corregidor, which is known tourist attraction and historical heritage, disturbance will only be expected during construction but not directly in the protected area. This island is popular former headquarters from the World War II battles and now is a protected area covered with wildlife species. In addition, the marine environment around Corregidor is known to contain many shipwrecks.
Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	Yes	Corregidor is covered with vegetation and natural habitat for birds and other animals. It is classified protected area and Natural Park under the Forest Land Classification (Provincial Development and Physical Framework Plan, 2011-2020). The preferred alignment is considered to cause loss of habitat, threat to species and hindrance to biological access considering the effect of vegetation removal and impact on marine and freshwater ecology. Along the project alignment there were observed three endangered tree species. Among these species considered threatened are namely: Narra (*Pterocarpus indicus)*, Antipolo (*Artocarpus blancoi)* and Is-is (*Ficus ulmifolia*).
Areas of unique historic, archaeological, geological, or scientific interests	No	As the alignment will not touch Corregidor, it is unlikely that there will be impacts anticipated in the south west tip of the covered area. But if this will connect to Corregidor, there may be historic markers that may be disturbed. Corregidor has been designated as a National Monument by the NHC and visited by national and international tourists. The island was also declared as National Shrine by Proclamation No. 69 s.1948, and E.O. No. 58 s. 1954 hence was leased for preservation and tourism development by the DND to the DOT for 50 years under E. O. No. 123 s. 1986 and P.D. 564.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
		A Death March marker was seen adjacent to the alignment in Bataan. This marker is considered as cultural and historical site. It is posted in every kilometer gap along the Roman Highway, which indicates the point of extent of the march, wherein thousands of soldiers died during the Japanese era. This will also be coordinated with the NHC to fully assess the area.
Areas which are traditionally occupied by cultural communities or tribe	No	The proposed project site is not within any ancestral domain inhabited by indigenous peoples or cultural communities. The nearest identified tribe is called the Aeta-Magbukon, around 5 km north of the alignment, located at Barangay Duale, Limay, Kitang 2 (port) of Barangay Maligaya (Port), all at Limay, Bataan and portion of Barangays Cabraban, Maligaya and Malaya, all at Mariveles, Bataan, under the Certificate of Ancestral Domain Title No. R03-LIM-1215-196 issued by the National Commission on Indigenous Peoples. The alignment will only be in the proximity of the east part of the Corregidor, which is a known cultural heritage site. As the alignment will not touch the area itself, it is unlikely that there will be impacts anticipated in the south west tip of the covered area.
Areas frequently visited and or hard-hit by natural calamities **Geological hazard areas** **Flood-prone areas** **Areas frequently visited or hard-hit by typhoons** **Areas prone to volcanic activities / earthquakes**	Yes	The vicinity of the project may be susceptible to various natural hazards. Also, and as with majority of the Philippines, the project is also susceptible to seismic and volcanic hazards. Also, project site is in an area affected by at least 2 to 3 typhoons annually. Their characterization and corresponding recommended mitigation measures are discussed in detail in **Section 2.1.2** of this EIS Report. Detailed, site-specific engineering mitigating measures will be identified during the DED phase of the project to address the following potential hazards: subsidence, karst subsidence, liquefaction, mass movements, flooding, erosion, ground shaking, ground rupture, ashfall, scouring and sedimentation.
Areas with critical slope	No	The topography in the project site ranges from flat to rolling.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
Areas classified as prime agricultural lands	No	Naic and Corregidor Island are both highly restricted agricultural land covered by Network of Protected Areas of Agriculture (NPAA) according to the Land Suitability Map of the Province of Cavite. While, there are agricultural lands abutting the project, these are not classified as prime agricultural lands based on Network of Protected Areas for Agricultural and Agro-industrial Development (NPAAD) of the Department of Agriculture (DA). The NPAAD covers all irrigated areas, all irrigable lands already covered by irrigation projects with firm funding commitments; all alluvial plain land highly suitable for agriculture whether irrigated or not; Agro-industrial crop lands or lands presently planted to industrial crops that support the viability of existing agricultural infrastructure and agro-based enterprises, highlands, areas located at an elevation of five hundred (500) meters or above and have the potential for growing semi temperate and high-value crops; all agricultural lands that are ecological fragile, the conversion of which will all result in serious environmental degradation.
Recharge areas of aquifer	No	The project is not within or in the vicinity of aquifer recharge areas.
Water bodies characterized by one or any combination of the following: • **tapped for domestic purposes** • **within controlled and/or protected areas declared by appropriate authorities** • **which support wildlife and fishery activities**	Yes	Manila Bay, based on ADB's Integrated Biodiversity Assessment Tool (IBAT) review was considered as a critical habitat, and has also been identified containing Internationally Important Numbers of migrant or overwintering bird species. This showed the importance of the overall bay, with midwinter numbers from 171,500 to around 208,500 water birds of 90 species occur in Manila Bay, about 75% of the species are migratory. This therefore meet the criteria for Critical Habitat under Criterion 3, Migratory and Congregatory species. The project will temporarily alter marine water bodies and sediments during the construction phase. Hence, the project will prepare mitigating measure to ensure that the construction will minimize effects on water bodies. All construction materials will be properly managed and stored in well secured area, install silt traps for all near water bodies, properly dispose all waste soil and other debris, provide solid waste management practices and awareness to workers in the site.
Mangrove areas characterised by one or any combination of the following conditions: • **With primary pristine and dense young growth**	No	No mangroves will be affected during construction of the bridge, thus further investigation is still being conducted.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
• **Adjoining mouth or major river system** • **Near or adjacent to traditional productive fry or fishing grounds** • **Which act as natural buffers against shore erosion, strong winds and storm flood** • **On which people are dependent for their livelihood, pursuant to and taking into consideration Republic Act No.7161 which prohibits the cutting of mangrove species**		
Coral Reefs: characterised by one or any combination of the following conditions: • **With 50% and above live coralline cover** • **Spawning and nursery grounds for fish**	No	Reefs were identified near the alignment, 1 fringing reef at Lucanin, Bataan, 3 at Corregidor and 2 at Cavite, particularly at Kaybangat and Paniman Point (**Figure 2.7**). In general, the coral reefs along the alignment of the project is generally degraded with only patches of remaining coral.

Technical Description of ECA Categories	Project falls within the ECA description	Relevance to the Project Site
• Which act as a natural breakwater of coastline		

Figure 2.7 Protected Area and Ancestral Domain Map

C) Impacts on Existing Land Tenure

The initial assessment of affected land acquisition requirement is shown in **Table 2.10**. BCIB project involves the construction of 32.15km bridge that will require a total land area of 492,200. Cavite needs 164,200 m^2 or 33%, while Bataan requires 328,000 or 67% of the total. The land area required for the project is subject to compensation.

Table 2.10 Total land area affected by BCIB

Project Components	**Location**		**Total Affected Land Area (m^2)**
	Bataan	**Cavite**	
Embankment and Land Viaduct + road widening	230,735	60,000	290,735
Toll Plaza	13,600	0	13,600
Administration Building	7,600	0	7,600
Electricity Substation	65	0	65
Lookout Point and Visitor Center (Optional)	5,000	0	5,000
Interchange	71,000	104,200	175,200
Total	**328,000**	**164,200**	**492,200**

There is no existing tenurial instrument in the proposed landing sites in Naic, Cavite and Mariveles, Bataan. However, issues may emanate during land acquisition phase including negotiations on compensation to landowners. Surveys conducted found that there are ISFs that may be affected.

In order to address such issues, the proponent must secure landowner acquiescence to government acquisition of the required ROW for the project, in a manner that is guided by pertinent processes and directives as issued by the Philippine government and the DPWH.

D) Impairment of Visual Aesthetics

Visual impairment of the surroundings of the project site will only occur during the construction phase of the project, due to various construction activities. Cleared areas and construction activities will visually impair the surroundings. Turbid marine water is expected to be observed due to the construction and installation of viaduct foundations. During excavation and construction of viaduct foundation at the portions of marine water, each foundation site should enclose with silt curtains to prevent silts from spreading in the bay.

The contractor should provide neat and presentable board-ups around the construction area to minimize visual impairment of the surroundings. Silt traps should be provided at the discharge points of the construction sites.

E) Devaluation of land value as a result of improper solid waste management and other related impacts

The generation of solid wastes will be negligible, if not limited to construction debris and other civil works during the construction phase, therefore, it has no impact on the devaluation of land value due to improper waste management. In fact, the project is expected to increase the value of the land in the vicinity of the project brought by better accessibility.

This concern can be addressed through an effective solid waste management plan, as part of the contractor’s commitment, which adheres to Ecological Solid Waste Management Act of 2003 (RA 9003) and local regulations. This plan may include the provision of trash bins, designation of disposal sites and regular hauling and disposal of wastes in both sides of Bataan and Cavite.

2.1.1.3 Options for Mitigation/Enhancement

Options or measures for prevention, mitigation, and enhancement for the identified impacts in land use and classification are discussed in this subsection.

A) Compatibility with the Land Use

The proposed landing site in Mariveles, Bataan is classified as A&D, while the proposed landing site in Naic Cavite is classified as mixed build up and commercial areas. These classifications are based on the information gathered from the DENR and Provincial governments of Bataan and Cavite.

Integration of the project in the future land use plans of both cities will enable each LGU to harmonize the plans intended for their development. In case of reclassification, appropriate permits and other necessary steps that entail this should be complied with to conform with the appropriate land use for the project.

B) Environmentally Critical Area (ECA)

The alignment of the proposed BCIB Project has no significant impact on the identified critical areas like the coral reef situated in Sitio Pinagkainan and Patungan, Barangay Sta. Mercedes, Maragondon, Cavite. Sitio Pinagkaingan, located in the eastern part of Limbones Cove opposite Carabao Island, Sitio Patungan Munti, and the six major river watersheds in Cavite located in Bacoor River Watershed, Imus River Watershed, San Juan River Watershed, Cañas River Watershed, Labac River Watershed and Maragondon River Watershed.

The proposed alignment will only traverse Barangays of Alas-Asin and Mt. View Mariveles Bataan and Barangays Timalan Concepcion and Timalan Balsahan of Naic. Those areas are significantly distantly away from the identified ECA and currently the proposed alignment is within the built-up areas of both Municipalities. There was also a noticeable increase in commercial areas. The existing central business district had a concentric expansion from the poblacion

C) Tenurial Instruments

There is no existing tenurial instruments in the proposed landing sites in Naic, Cavite and Mariveles, Bataan.

D) Visual Aesthetics

Depending on the future design of the bridge, and the aesthetic appeal, a bridge can blend into and contribute to the quality of the visual experience of the area. The bridge can become an iconic addition to the visual outlook of the bay. The landfall area is situated in a relatively flat and unpopulated area that would result in some visual impacts

E) Devaluation of Land Value

There is no impact on the devaluation of land and the project is expected to increase the value of the land in the vicinity of the project brought by better accessibility.

2.1.2 Geology/ Geomorphology

2.1.2.1 Methodology

Geologic assessment comprised of collation and interpretation of existing mappings, including topographic, geologic, flood maps, landslide susceptibility maps, and existing ground investigation information. Technical reports regarding the geologic conditions of the project area, other geology-related resources; and result of field inspection are also considered. Field inspection comprised of geological and geohazard mapping of the area where information such as local site geology is obtained. Mapping includes identification of rock types inherently underlying the project area and vicinity.

A) Nature/ Source of Information

The geological assessment commenced with literature research of all available geological, seismological, hydrological and hydrographical reports and maps covering the project area previously conducted at the Mines and Geo-Sciences Bureau (MGB), and the Philippine Institute of Volcanology and Seismology (PHIVOLCS). Topographic maps covering Bataan City, Corregidor Island, and Cavite City and their vicinity were acquired from the National Mapping and Resource Information Agency (NAMRIA). Climatological data was gathered from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA).

2.1.2.2 Baseline Environmental Conditions

A) Regional Geologic Setting

Tectonic Setting

The Philippine archipelago is located at the convergence between the Eurasian Plate (also referred as Sunda Plate) and the Philippine Sea Plate. The tectonics in the region is complex with 80mm – 100mm/year plate movement accommodated by the subduction zone to the east and west of the Philippine mainland. To the east, the Philippine Sea Plate is subducting westward underneath the Eurasian Plate along the East Luzon Trough and the Philippine Trench. To the west, the Eurasian Plate is subducting eastward along the Manila Trench, Negros Trench, Sulu Trench and Cotabato Trench underneath the Philippine Sea Plate (**Figure 2.8**).

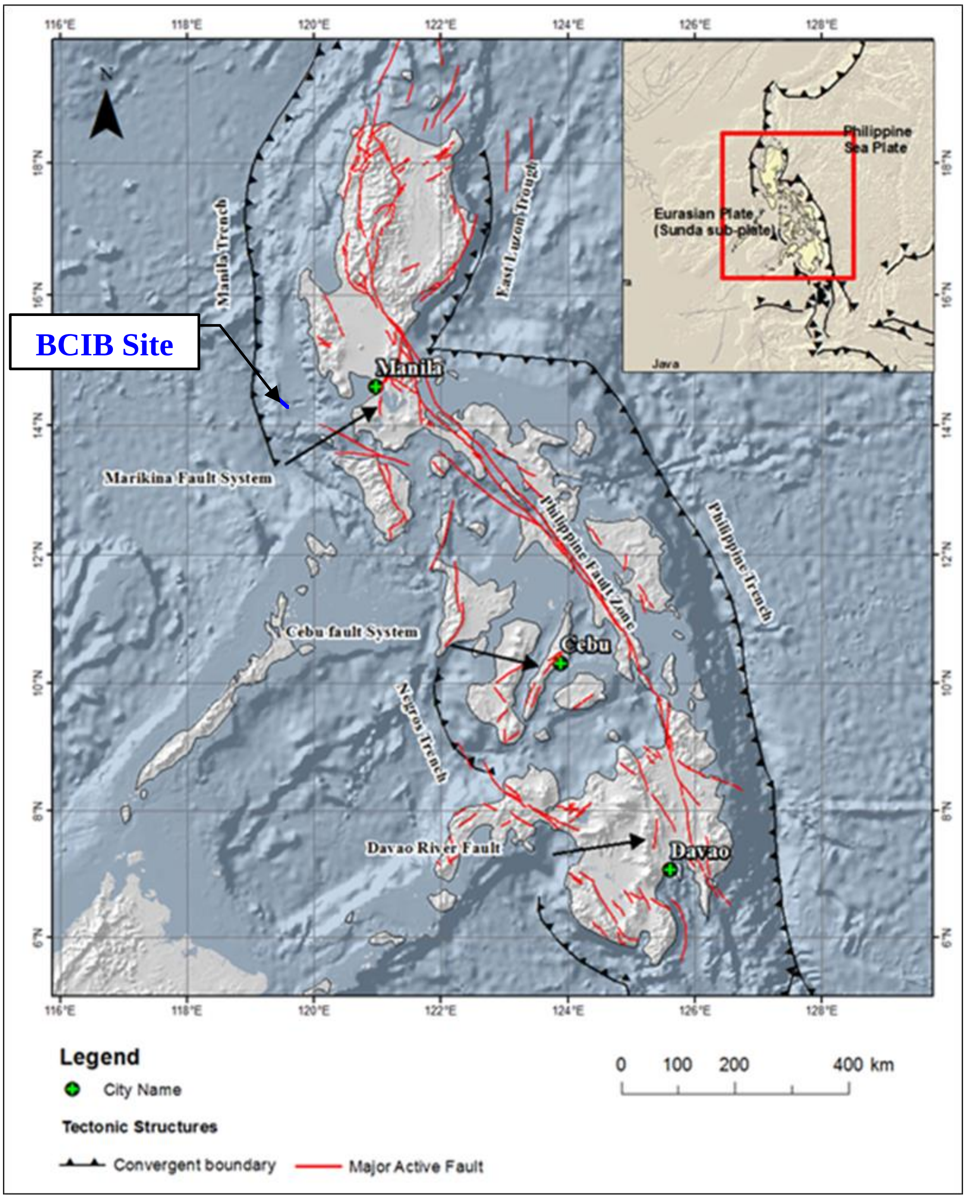


Figure 2.8 Tectonic Setting of the Philippines

As the motion of the subducting Philippine Sea Plate along the Philippines Trench is oblique, the convergence is partitioned into trench-normal and trench parallel motion. The trench-normal convergence is mainly accommodated by the subduction along Philippine trench. The trench-parallel convergence is taken up by the Philippine Fault System across the Philippine archipelago behind the Philippine Trench, and other crustal active fault across the Philippines.

The distribution of active faults and trenches near BCIB is shown in **Figure 2.9** and **Figure 2.10**. This indicates that the closest major active fault is the Marikina Fault System/ West Valley Fault System located approximately 24 kilometres to the east of the proposed alignment.

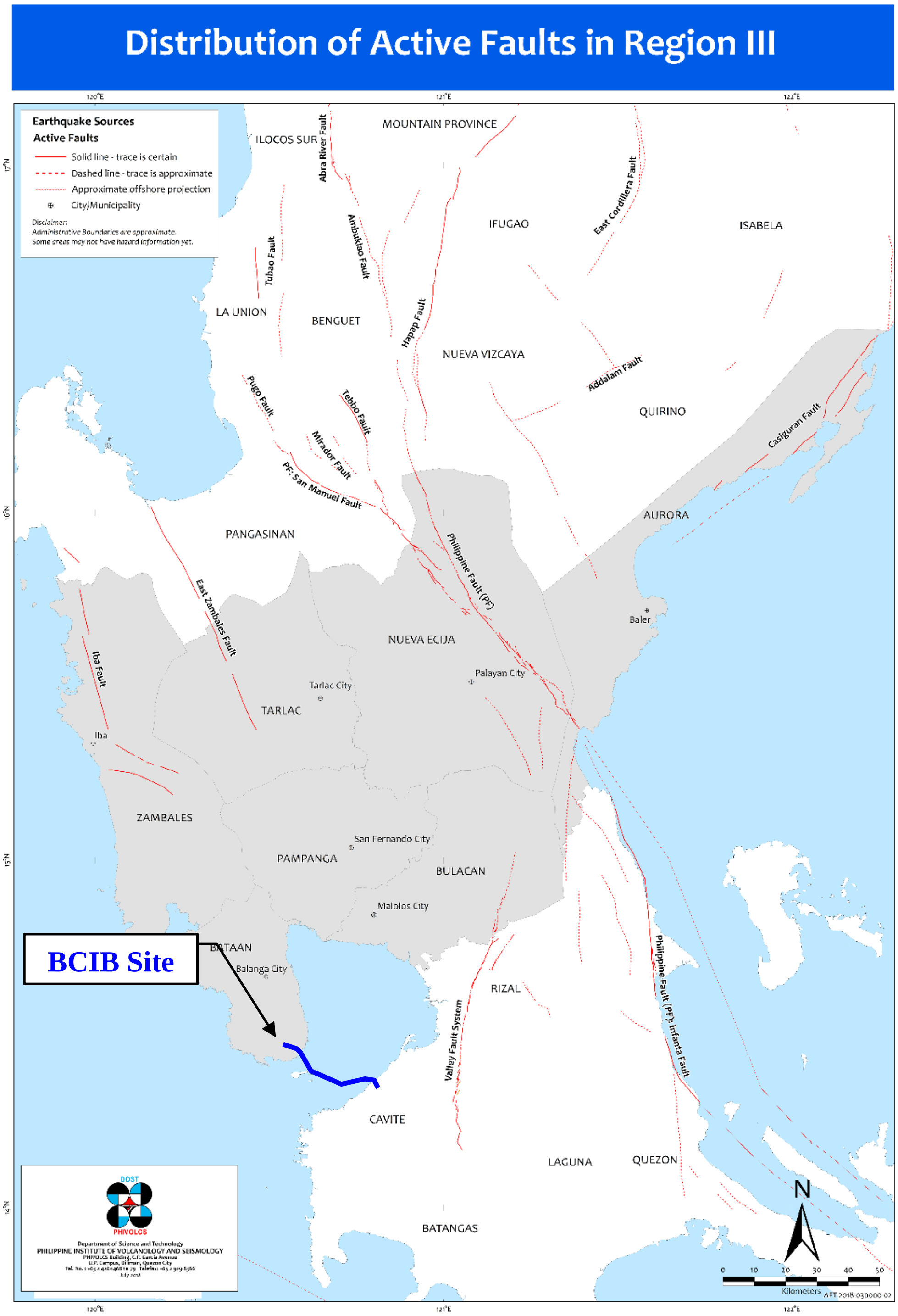


Figure 2.9 Distribution of active faults in Region III (2018)

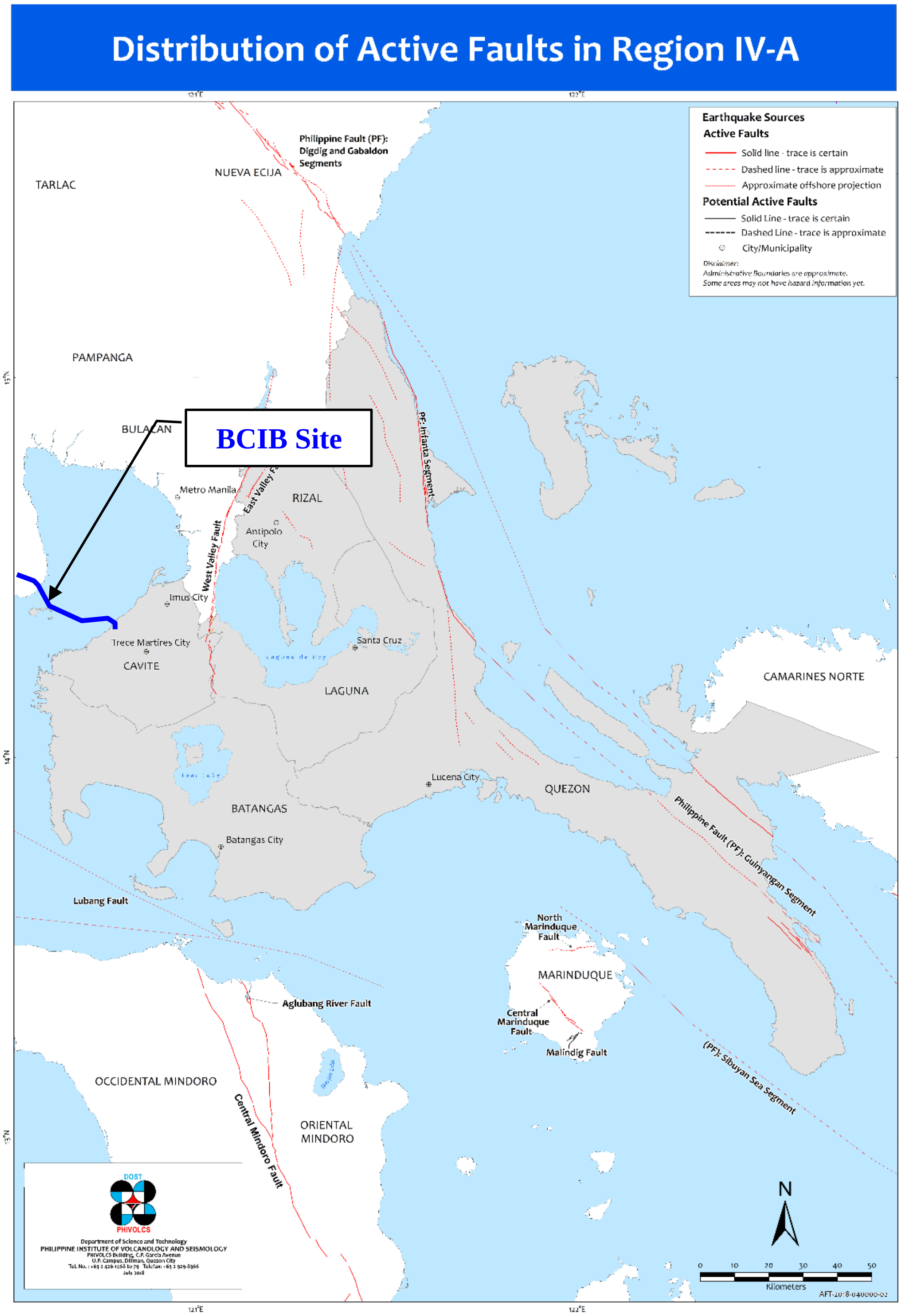


Figure 2.10 Distribution of active faults in Region IV-A (2018)

Stratigraphy and Geology

Based on the memoir 'Geology of the Philippines' published by the Mines and Geosciences Bureau (MGB) in 2010, the BCIB project lies within the Luzon Volcanic Arc associated with the Manila Trench, as shown in **Figure 2.11**. Based on the characteristics of stratigraphy and petrology, the project falls within Stratigraphic Group 7 (SG7) - Southwest Luzon Uplands. It covers the Southwestern Luzon, Marinduque Island, and Northern Mindoro, which is dominated by lithology derived from volcanic arc.

The underlying lithologies include igneous, sedimentary and metamorphic rocks. The arrangement of the lithologies is indicated in **Figure 2.12** and **Figure 2.13**, which presents sedimentary formations, volcanic activities during Middle-Miocene and since Pliocene, and a diorite intrusion during the early Miocene.

The stratigraphic column indicates that the Oligocene San Juan Formation is the eldest and thickest formation as the basement of the unit. It consists of sedimentary rock (graywacke, shale), metamorphic rock (slate, paraschist, marble, hornfels), and metavolcanic rocks (basalt, andesite). The contact metamorphism exhibited in this unit was formed by intrusion of Tolo Quartz Diorite consisting quartz diorite, quartz monzonite, diorite, and dacite during the Early Miocene. This formation is recorded approximately 8 kilometers south of the BCIB project (**Figure 2.12**).

The BCIB project is virtually entirely underlain by the Corregidor Formation recorded at the southern Bataan City, Corregidor, and Cavity City. It consists of tuffaceous conglomerate with interbeds of sandstone and shale, which grades into lapilli and ash tuffs. It was formed during the late Miocene by depositing in a littoral environment after the formation of Nasugbu Volcanic Complex and Dagatan Wacke at Nasugbu and Batangas during the Middle Miocene.

The volcanic events that form the hilly terrains near the BCIB project are the formation of the Mataas-na-Gulod Volcanic Complex during the Pliocene to Pleistocene and Macolod Volcanic Complex since the Pliocene. Mataas na Gulod caldera complex is located at the western Cavite and Batangas, which belongs to the Bataan Volcanic Arc complex and comprises of basalt, andesite, breccia, pyroclastic rocks and lahar.

The Macolod Volcanic Complex is a collection of subduction-related rocks formed by numerous Pliocene to Pleistocene volcanic centers along northeast-trending Macolod Corridor. The corridor was formed by the rifting process of an across-the-arc extension related to the sinistral movements of the Philippine Fault and the Sibuyan Sea Fault, which is associated with the subduction of the South China Sea Plate along the Manila Trench (MGB, 2010). Part of the BCIB project is underlain by Taal tuffs from the active Taal Volcano at Batangas.

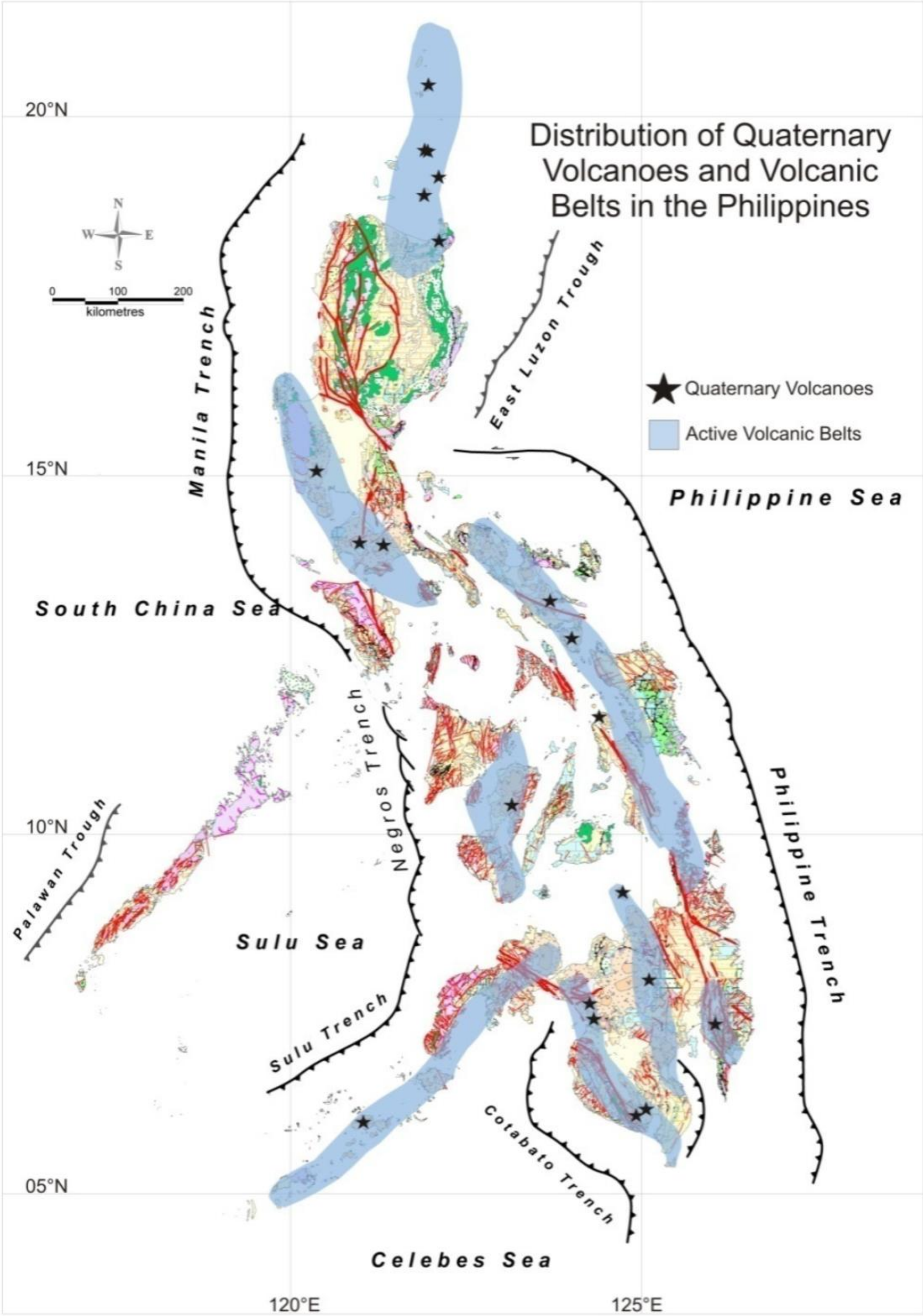


Figure 2.11 Generalized distribution map of active volcanoes and volcanic belts in the Philippines (Source: MGB)

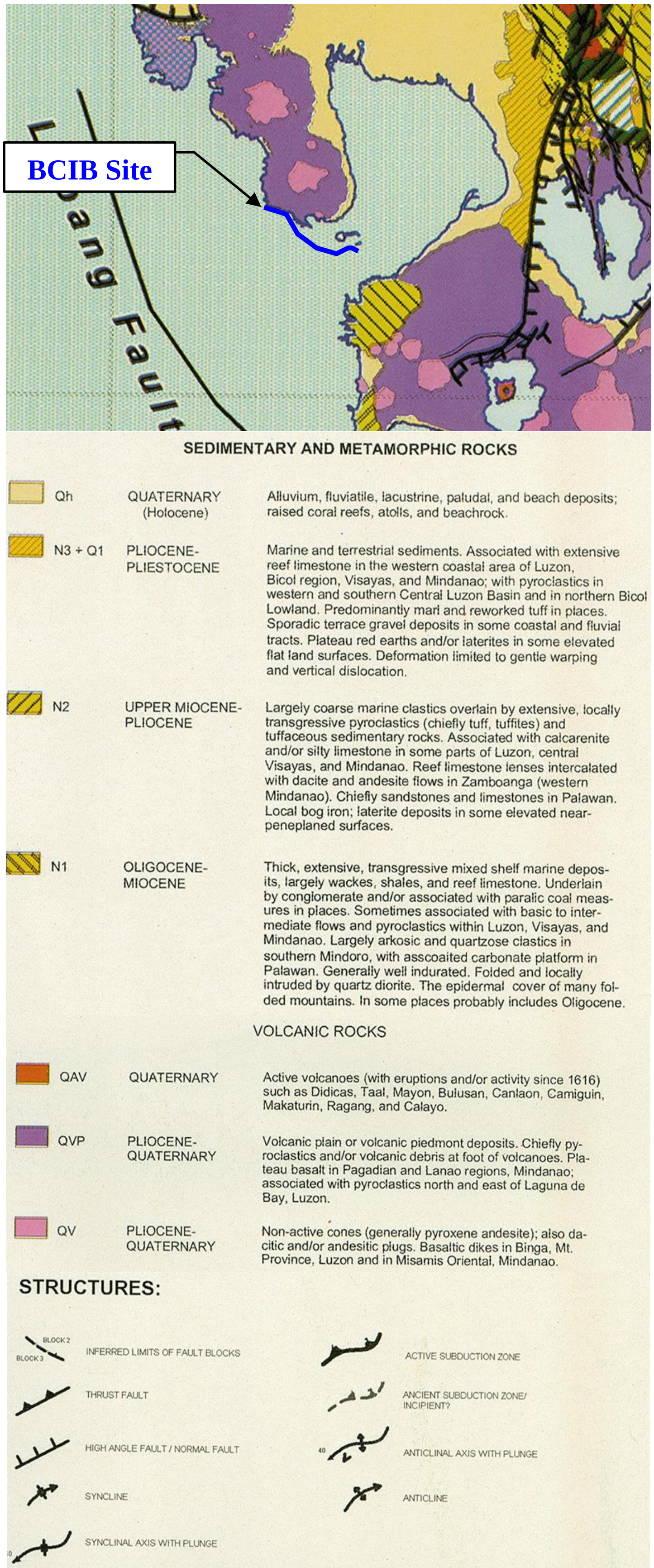
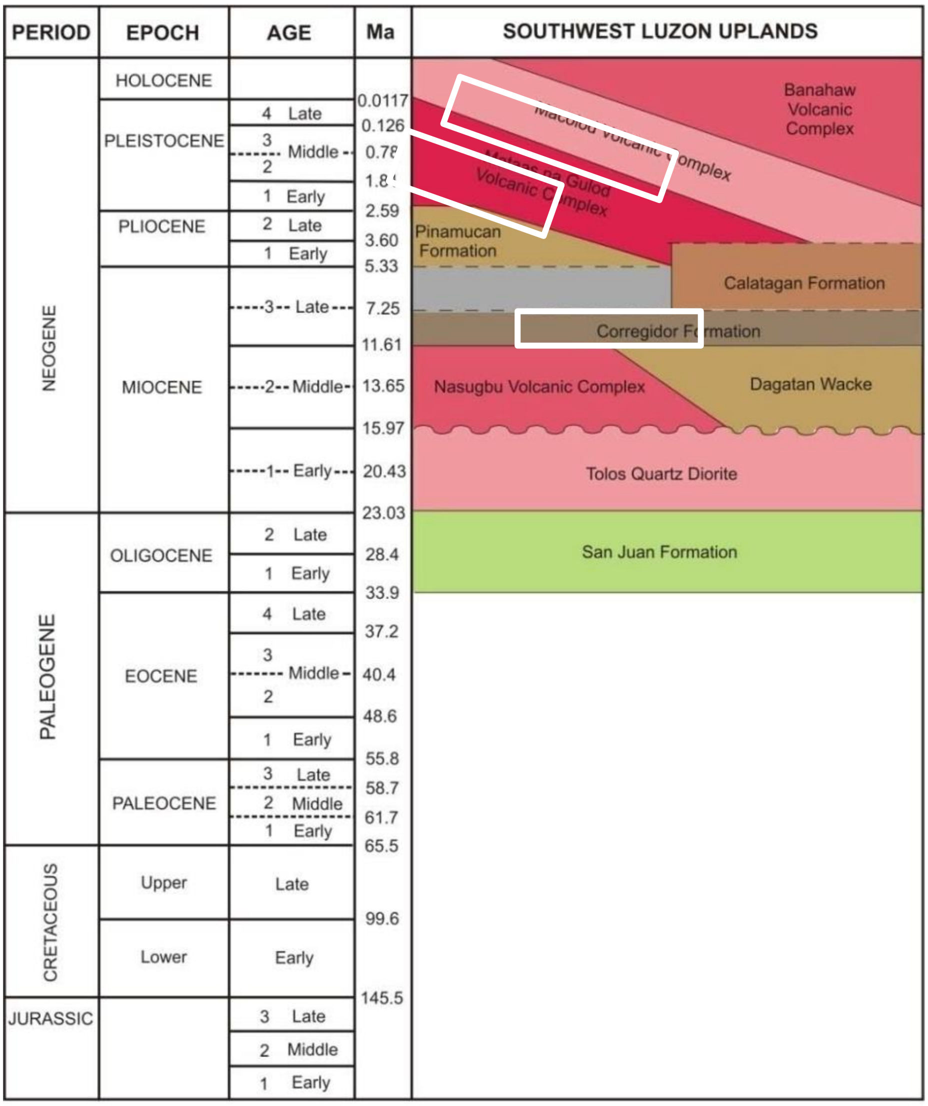


Figure 2.12 Extract of Geologic and Tectonic Map of the Philippines at BCIB project (Source: MGB)



Geologic Time Scale adopted from International Commission on Stratigraphy (2009)

Note: Relevant formations and volcanic complexes are highlighted

Figure 2.13 Stratigraphic Column for Southwest Luzon (Source: MGB)

Geological Structures

As presented in the published maps (**Figure 2.8**, **Figure 2.9**, **Figure 2.10** and **Figure 2.11**), the project region is mainly influenced by the Marikina Valley Fault System / West Valley Fault System located approximately 24 kilometers to the east, Lubang-Verde Passage Fault System (or Lubang Fault) located approximately 80 kilometers to the south, and the Philippine Fault Zone located approximately 100 kilometers to the east of the project. The active faulting of these faults is mainly driven by opposite subduction where the east-dipping subduction of China Sea Plate (the Eurasian Plate) along the Manila Trench located approximately 180 kilometers to the west and the southwest-dipping subduction of the Philippine Sea Plate along the Philippine Trench located approximately 200 kilometers to the east. The following major geological structures potentially influence the BCIB project:

- **Valley Fault system (VFS)**

It was originally named "Marikina Valley Fault System", then renamed later by PHIVOLCS as the VFS. Recent findings by the PHIVOLCS indicate that the fault is an active, right-lateral strike-slip fault. It is located 24 kilometres east of the project.

- **Lubang-Verde Passage Fault System**

It is a west-northwest-trending, left-lateral strike-slip fault located offshore between Batangas peninsula and Mindoro Island, which is situated approximately 80 kilometers to the south of the BCIB project. It transforms into a thrust/left-lateral transpressional fault and cuts the southern portion of the Manila Trench accretionary prism. The fault is considered to be an important tectonic structure which accommodates the convergence of the Philippine Sea Plate and the Eurasian Plate.

- **Philippine Fault Zone**

The Philippine Fault Zone is a major left-lateral strike-slip fault zone with a mapped length of about 1,250 kilometers from northern Luzon to southern Mindanao. a dominant tectonic feature in the Philippines. Movement on the Philippine Fault Zone accommodates part of the oblique convergence between the Philippine Sea Pate and the Eurasian Plate and hence the fault is a major earthquake source of the archipelago. Hence, the fault zone is relatively active, and has been responsible for many large earthquakes (magnitude greater than 7) in historical records, including the 1990 Luzon earthquake with magnitude of 7.7 (MGB, 2010).

The fault system is generally split into the Northern Segment (NW Luzon to Lamon Bay), Central Segment (Bondoc Peninsula to Leyte), and Southern Segment (Mindanao and the Moluccas). The project is situated approximately 100 kilometers to the west of the fault system between the Northern Segment and Central Segment near the Lamon Bay, where is a transition from north-trending branches of strike-slip faults in the Northern Segment to a relatively simple, well-defined faults in the Central Segment.

- **Manila Trench**

The Manila Trench is located west of Luzon and this is a deep ocean trough that represents the surface expression of the eastward-dipping subduction of the Eurasian Plate. The subduction has produced an accretionary prism as shown in **Figure 2.14**, which is composed of sediments and builds the landform from the northern Luzon to Lubang Island.

To the south of the Manila Trench, the plate boundary has transformed into a Collision Zone of Mindoro-Panay (MGB, 2010).

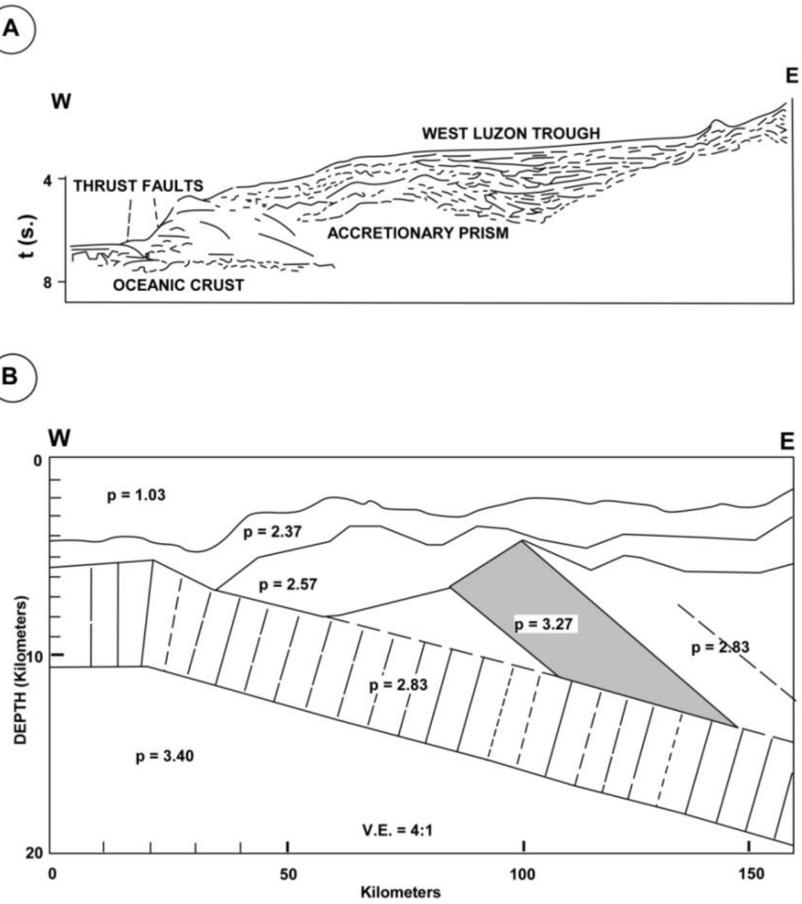


Figure 2.14 Structure of the accretionary prism of the Manila Trench from seismic profiles (A), and of the subducting slab and over-riding plate established from gravimetric data (B). (MGB, 2010)

- **Philippine Trench**

This is a major structural feature is located to the east of the Philippine archipelago that accommodates west dipping subduction of the northwest moving Philippine Sea Plate (MGB, 2010). The trench has a length of approximately 1,300 kilometers, extending from the central Luzon to the Island of Mindanao. The inferred trace of the trench is approximately located 200 kilometers to the east of the BCIB project.

B) Geomorphology

The proposed BCIB alignment links the existing road networks of Bataan and Cavite across the mouth of the Manila Bay (**Figure 2.15** and **Figure 2.16**). The alignment passes close to Corregidor Island which preserves the flexibility for future connection to the island if considered desirable.

There are two main navigation channels servicing Manila Bay, one of which is north of Corregidor Island ("Northern Main Navigation Channel") and the other is south of Corregidor Island ("Southern Main Navigation Channel"), as shown in **Figure 2.15**. They run sub-perpendicularly with the proposed alignment for BCIB.

In general, Bataan is characterized by a rocky, hilly, circular terrain of barren ground, brush lands, grass lands and plantation forests formed by the Mariveles volcano. It flattens to gently sloping terraces which are punctuated by strips of steeply sloping terrace to form series of rivers flowing towards the sea. The highest elevation is represented by the peak of Mount Mariveles at approximately 1400 meters above sea level.

The Corregidor Island is located south of the Bataan, separated by the Northern Main Navigation Channel for about 4 kilometres to 6 kilometres. The island is a relatively small, circular island with a generally flat terrain. The highest elevation is located near the centre of the island at approximately 173 meters above sea level.

Cavite is located south of the Corregidor Island, separated by the Southern Main Navigation Channel for about 13 kilometres to 16 kilometres. Cavite contains alluvial plains towards the coast with a flat ground slope of less than 0.5% and low ground elevation, which steepens towards the Mount Maculot at southeast. The Mount Maculot and the surrounded Taal Lake are formed by eruptions and flank collapses of the Taal Volcano. The highest elevation is represented by the flank of Taal Volcano at approximately 600 meters above sea level.

Figure 2.15 Extract of 1:250,000-scale Topographic Map overlaying a Digital Elevation Model (Sheet No. ND 51-5)

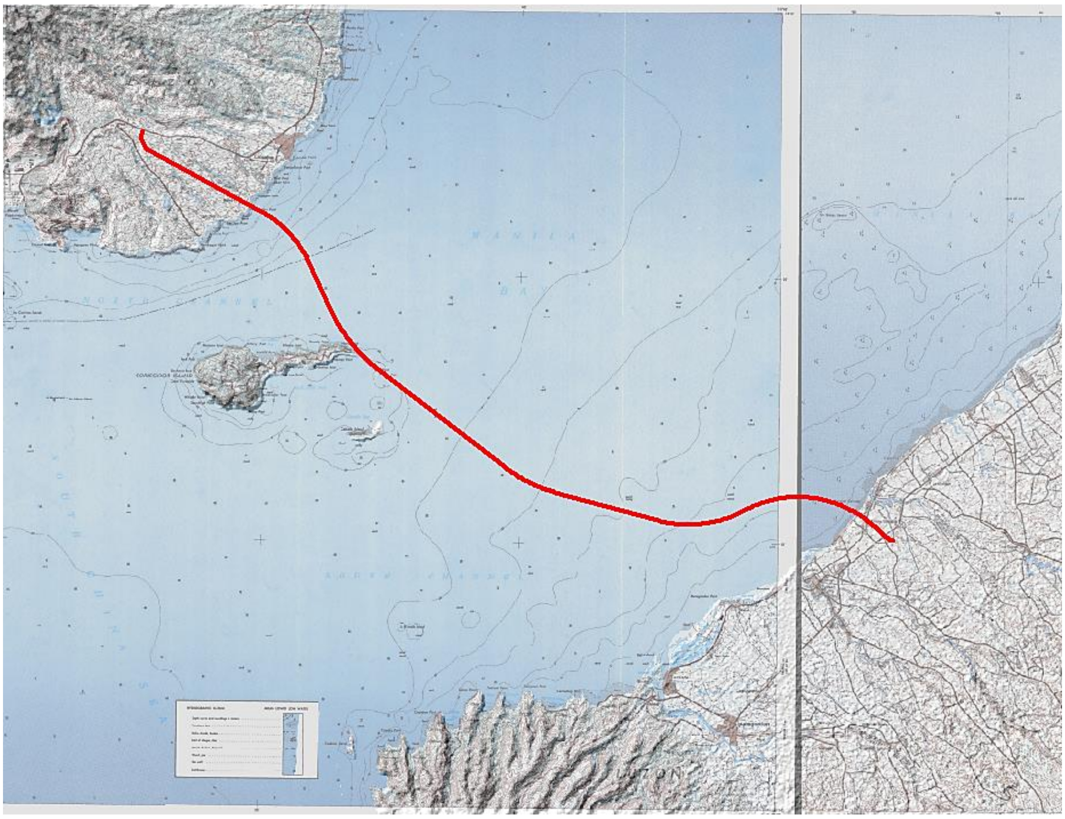


Figure 2.16 Extract of 1:50,000-scale Topographic Map overlaying a Digital Elevation Model (Sheet Nos. 7171 IV; 3129 I)

C) Topography

Along the proposed alignment of BCIB, the topography of the area is composed of hilly coasts of Bataan and Corregidor Island, alluvial plain at Cavite, flat to gently sloping bathymetry at the Southern Main Navigation Channel, and sloping bathymetry Northern Main Navigation Channel (**Figure 2.17**).

In general, three levels of marine terraces can be observed from the main navigation channels (i.e. offshore) to the inland terrace, as indicated in **Figure 2.17**. They are step-like landscape features exhibits along coastal areas and inland surface water bodies, which are formed by coastal erosions and reflects the history of sea level changes. “Level 1” is the offshore area with relatively flat and deep bathymetry where main navigation channels situate. This is terminated by a change of slope at near shores where “Level 2” reaches. “Level 3” demarcates the coastlines of Bataan, Corregidor Island, and Cavite by coastal slopes along them where slopes become steepen.

Dominated by depositional environment, the alluvial plain at Cavite exhibits a much gradual migration from “Level 3” to “Level 1” than Bataan and Corregidor Island. It forms sandy beach and low cliffs along the coast (**Figure 2.18**), and flat grassland at the landing point at Cavite (**Figure 2.19**). Most of the sandy materials along the coast have been preserved due to the construction of groynes in the area. The landform of inland area has been slightly modified by agricultural lands, small dwellings and roads.

Relatively more hilly terrains at Bataan and Corregidor Island exhibits a much sharper transition from “Level 3” to “Level 1”. It forms narrow sandy beaches, rocky shores and high coastal slopes along the coast (**Figure 2.20**), and gently sloping grassland and shrubland at landing point at Bataan (**Figure 2.21**). The landform of the upland area has been slightly modified by agricultural lands, pasture lands, small dwellings, and roads.

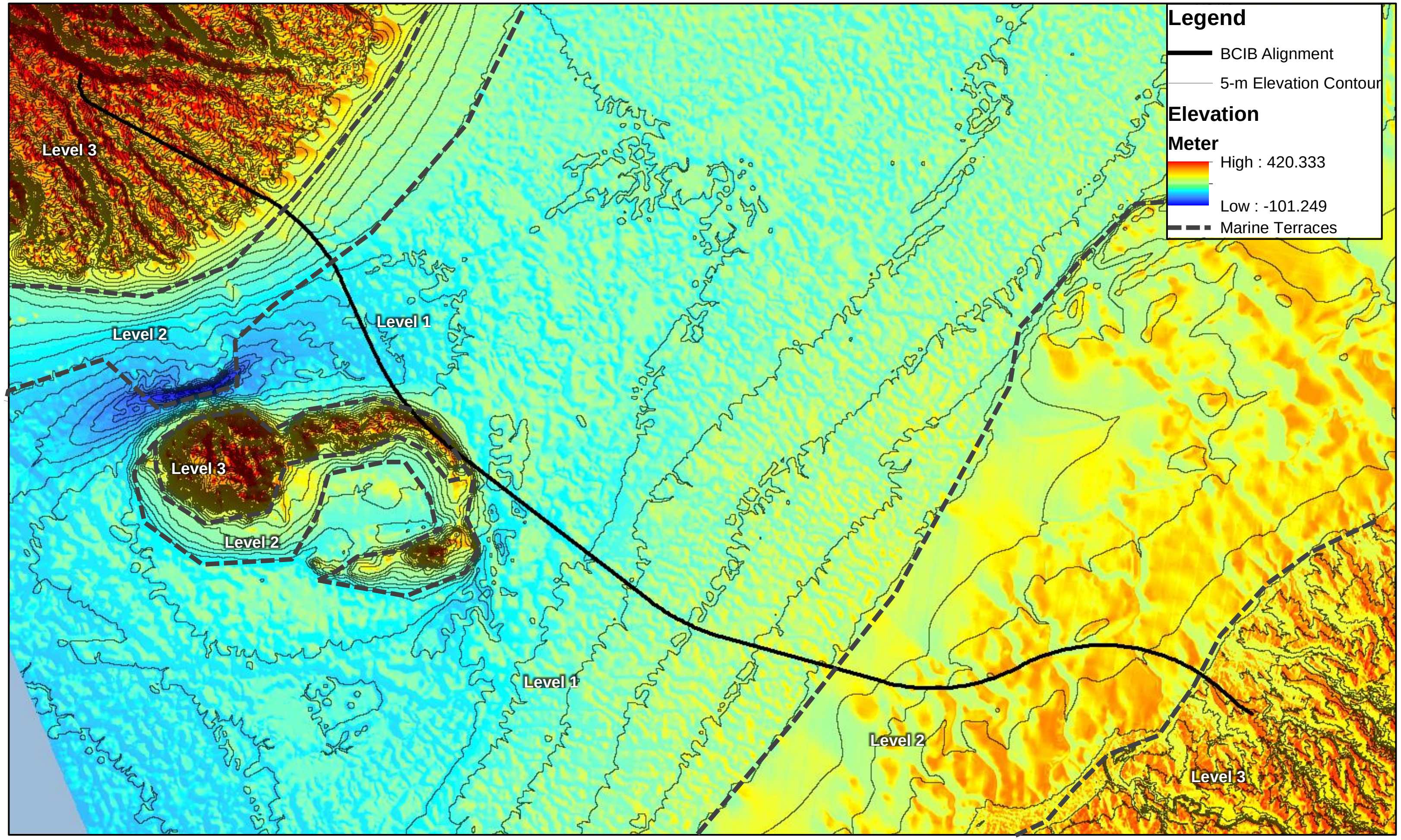


Figure 2.17 Map of topographic, bathymetric and marine terraces at the BCIB alignment

Figure 2.18 Sandy beach and coastal slopes at the coast of Cavite

Figure 2.19 Flat grassland at the landing point at Cavite

Figure 2.20 Narrow sandy beach, rocky shore, and coastal slopes at the coast of Bataan

Figure 2.21 Gently sloping grassland, shrubland, and the Roman Superhighway at the onshore portion and landing point of BCIB at Bataan

There will be no change in the surface landform, geomorphology, topography, terrain or slope associated with BCIB since the region where the alignment will be located within lands which are not significantly dissected. The proposed alignment within the extensive coastal flats of both cities and will cross shores that have relatively gentle slopes

D) Bedrock Lithology

Based on the 1:50,000-scale geological maps for Corregidor, Cavite, Limbones, and Silang published by MGB in 2000, 1984, 1987 and 1987 respectively, the proposed alignment is predominantly underlain by three major rock units. They are Guadalupe Formation (GF) at the Cavite landing point, Miocene Clastics (Nmc) within the middle part at Corregidor Island, and Bataan Pyroclastics (NQbp) at the Bataan landing point (**Figure 2.22** to **Figure 2.26**). No faults are recorded within or in the vicinity of the proposed alignment.

Currently no GI records are available along or in the near vicinity of the proposed alignment. The ground condition along the proposed alignment is primarily based on the available published geological maps. As such, the engineering properties and thickness variation of saprolite and depth of bedrock surface remain highly uncertain. These shall be further reviewed and verified by project-specific GI works when they become available as part of the upcoming DED.

North-western Portion of Proposed Alignment - Bataan

The north-western portion of the proposed alignment is located within Bataan. Bataan is a hilly area comprising a 1,388-meter-high dormant volcano named "Mount Mariveles" lying to the northwest of the proposed alignment. The Bataan Landing Point B3 is at about +200 meters above MSL, and the proposed alignment traverses several streams within Bataan before reaching the shoreline.

As revealed in the 1:50,000-scale Geological Map Sheet No. 3163 III (MGB, 2000) (**Figure 2.22** & **Figure 2.24**), the solid geology within Bataan predominantly comprises of Bataan Pyroclastics (NQbp), which is probably correspond to the Bataan Volcanic Arc Complex. It consists of chiefly pyroclastics and volcanic debris. Alluvium (Qal) of unconsolidated sand, silt and gravel deposits is evident near the shoreline of Bataan whereas a layer of marine deposits is anticipated to be present offshore at the surface of the seabed. A typical geological cross section at the area is shown in Section A1-B1 in **Figure 2.23**.

Middle Portion of Proposed Alignment - Corregidor Island

The proposed alignment runs adjacent to the north-eastern side of Corregidor Island. The island consists of a small hill with maximum height of approximately +173 meters above MSL.

Based on the 1:50,000-scale Geological Map Sheet No. 3163 III (MGB, 2000) (**Figure 2.22** & **Figure 2.25**), the geology of Corregidor Island comprises Miocene Clastics (Nmc), which belongs to the Corregidor Formation described in Section 3.1.2. It contains large marine clastics and agglomerate, dacite, tuffaceous sandstone and conglomerate with pyroclastics (MGB, 2000) which is overlain by the Alluvium. The bedrock level is anticipated to become shallower at the Corregidor Island. A typical geological cross section at the area is shown in Section A1-B1 in **Figure 2.23**.

South-eastern Portion of Proposed Alignment - Cavite

The southeastern part of the proposed alignment reaches the Cavite province and connects with the existing road networks at the Cavite Landing Point C2 at around +22 meter above MSL. The ground profile on the Cavite side is relatively flat and primarily located on the alluvial plain.

According to the 1:50,000-scale Geological Map Sheet No. 3163 II (MGB, 1984) (**Figure 2.22** & **Figure 2.26**), the Cavite Landing Point is underlain by the Diliman Tuff of Guadalupe Formation (GF). It comprises thin- to medium-bedded, fine grained vitric tuffs and welded volcanic breccias with subordinate amount of tuffaceous fine- to medium-grained sandstone. Since the alignment lies on a relatively flat alluvium plain, the saprolite is expected to be thicker than other those at the Corregidor Island and Bataan. A typical geological cross section at the area is shown in Section A2-B2 in **Figure 2.23**.

However, this is found inconsistent with the neighbouring geological maps [Sheet Nos. 3162 IV and 3162 I (MGB, 1987)] where it is recorded that the Cavite-end of the proposed alignment is underlain by Alluvium overlaying bedded basaltic tuff of the Taal Tuff (Qtt).

Manila Bay

There no available ground investigation reports at the proposed alignment across Manila Bay. It is anticipated that the bedrock in Manila Bay are primarily volcanic in nature at different ages and overlain by varying thickness of superficial deposits. Relatively older volcanic bedrock, i.e. Miocene Clastics, is expected to be present at the middle portion of the proposed alignment near Corregidor Island while younger volcanic bedrock of Pliocene and Pleistocene ages is likely to be present at the Bataan and Cavite sides of Manila Bay. The saprolite at offshore is anticipated to be thicker than those at onshore. A typical geological cross section at the area is shown in Section A1-B1 in **Figure 2.23**.

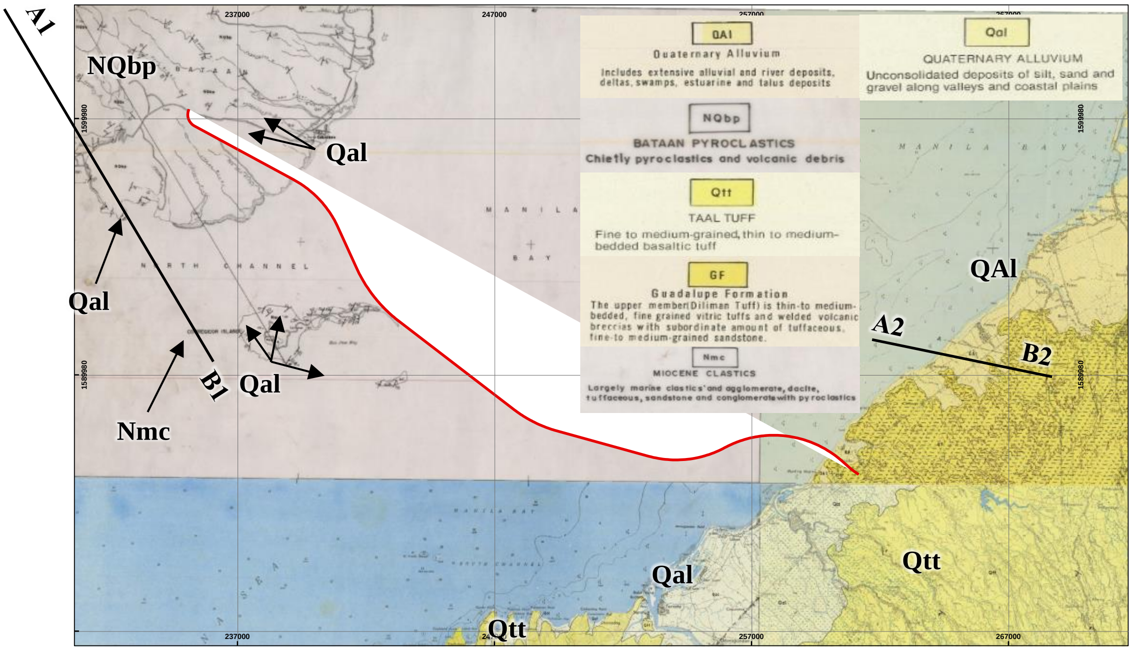


Figure 2.22 1:50,000-scale Geological map of the project area [Sheet Nos. 3163 III (top left), 3163 II (top right), 3162 IV (bottom left) & 3162 I (bottom right)] (Source: MGB)

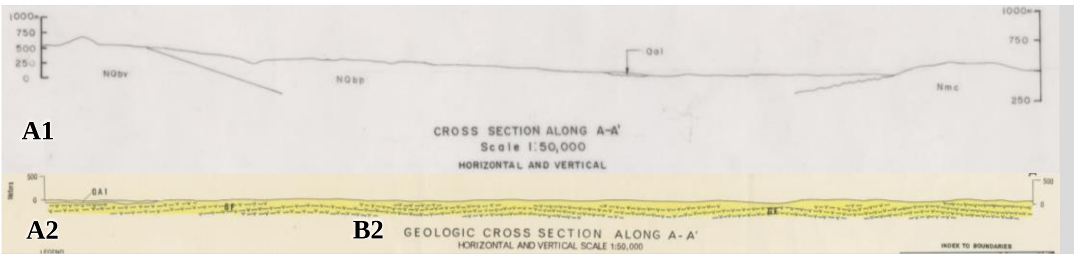


Figure 2.23 Geological Cross Sections along A1-B1 (top) and A2-B2 (bottom)

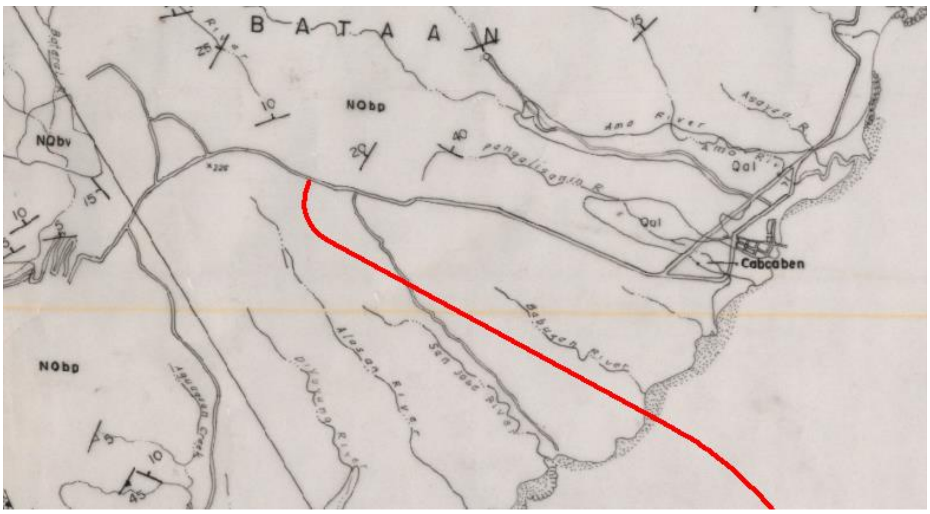


Figure 2.24 1:50,000-scale Geological map for Bataan (Sheet 3163 III) (Source: MGB)

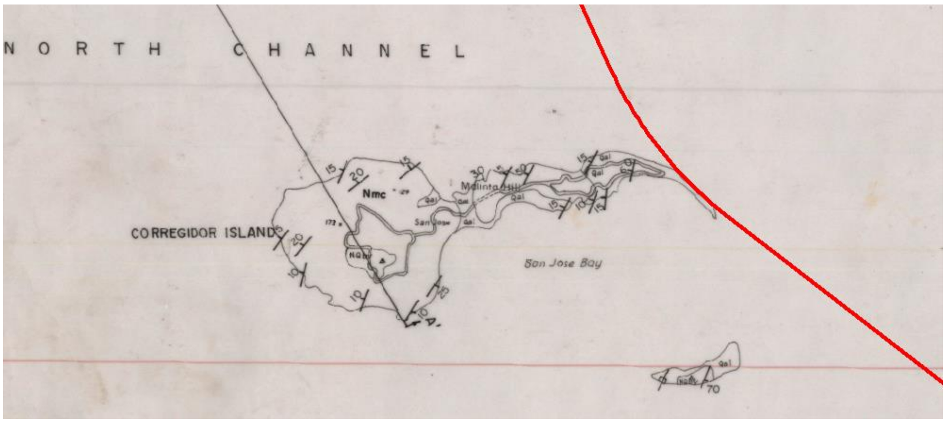


Figure 2.25 1:50,000-scale Geological map for Corregidor Island (Sheet No. 3163 III) (Source: MGB)

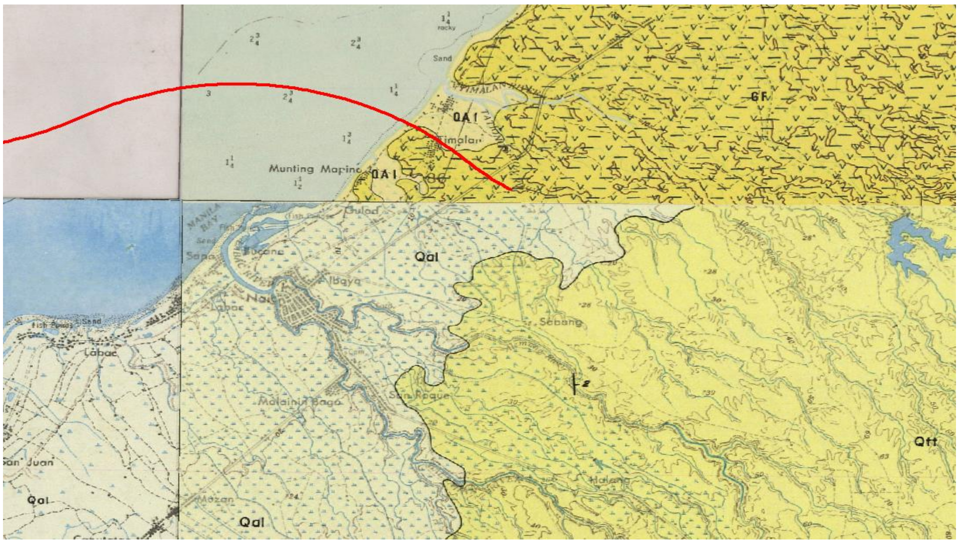


Figure 2.26 1:50,000-scale Geological map for Cavite [Sheet Nos. 3163 III (top left), 3163 II (top right), 3162 IV (bottom left) & 3162 I (bottom right)] (Source: MGB)

During the field inspection, no bedrock exposures were observed along the south-eastern portion of the proposed alignment. However, on the north-western portion, it was observed that highly decomposed pyroclastic flow spread out into a fan towards the coast. A sharp boundary between the upper ash and lower basal flow consisting coarse fragments is observed, as demarcated by a red dashed line in **Figure 2.27**. Angular to sub-rounded basalt and andesite boulders of various sizes were observed along the coast (**Figure 2.28**). This reveals that the geology of the island comprises pyroclastics with composition ranges from basalt to basaltic andesite to andesite which is consistent with the desk study finding.

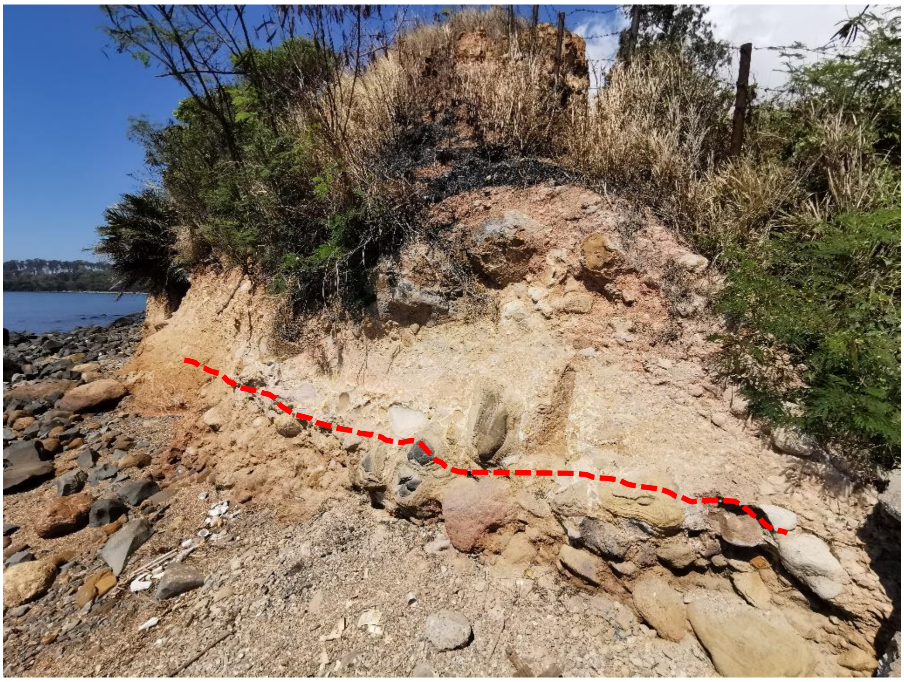


Figure 2.27 Highly-decomposed pyroclastic flow along the coast of Manila Bay in Bataan

Figure 2.28 Angular to sub-rounded basalt and andesite boulders deposited along the coast of Manila Bay in Bataan

In general, the site is underlain by tuffaceous sedimentary rocks and pyroclastic rocks. These rocks are slightly folded, contains low-dipping beddings and variable grain size. Pyroclastic rocks may contain eutaxitic textures. Adverse weak discontinuities and preferential groundwater regime may be concentrated along these structural features where rocks are weathered to clayey soils to form a variable rockhead surface. Steeply inclined rockhead poses engineering challenges for piled foundations. Site-specific ground investigation should be undertaken during the DED to obtain the thickness and geometry of deposits, rockhead profile, and the characteristics of the soils and rock. The site-specific engineering parameters would be acquired for a cost-effective engineering design of proposed structures and associated mitigating works.

E) Surficial Deposits

Based on the 1:50,000-scale geological maps for Corregidor, Cavite, Limbones, and Silang published by MGB in 2000, 1984, 1987 and 1987 respectively, Quaternary Alluvium is evident along the existing valleys on both sides of Manila Bay and near the shoreline of Corregidor Island (**Figure 2.22** to **Figure 2.26**).

Currently no GI records are available along or in the near vicinity of the proposed alignment. The ground condition along the proposed alignment is primarily based on the available published geological maps. As such, the engineering properties and thickness variation of superficial deposits remain highly uncertain. These shall be further reviewed and verified by project-specific GI works when they become available.

North-western Portion of Proposed Alignment – Bataan

Based on the 1:50,000-scale published geological map (MGB, 2000) (**Figure 2.22** & **Figure 2.24**), Alluvium of unconsolidated sand, silt and gravel deposits is evident near the shoreline of Bataan which overlays Bataan Pyroclastics (NQbp) consisting volcanic debris. As the alignment lies along a spur, the alluvium layer is anticipated to be thin or negligible. A layer of marine deposits is anticipated to be present offshore at the surface of the seabed.

Middle Portion of Proposed Alignment - Corregidor Island

Based on the 1:50,000-scale published geological map (MGB, 2000) (**Figure 2.22** & **Figure 2.25**), the Corregidor Island Quaternary Alluvium. It overlays the Miocene Clastics (Nmc) and contains unconsolidated deposits of sand, silt and gravels (MGB, 2000).

south-eastern Portion of Proposed Alignment – Cavite

According to the 1:50,000-scale published geological map (MGB, 1984 & 1987) (**Figure 2.22** to **Figure 2.26**), the geology at the Cavite Landing Point mainly consists of Quaternary Alluvium near the shoreline which overlays the Guadalupe Formation (GF) at the southern portion of the alignment. It comprises extensive alluvial and river deposits, deltas, swamps, estuarine and talus deposits (MGB, 1984). As the alignment lies on a relatively flat alluvial plain, the Alluvium is expected to be thicker than those in the other regions. A layer of marine deposits is also anticipated to be present offshore at the surface of the seabed overlaying the alluvium.

However, the boundary of the Quaternary Alluvium mapped in the geological map sheet no. 3163 II is found inconsistent with the neighbouring geological maps sheet nos. 3162 IV and 3162 I (MGB, 1987) where the alluvium is recorded further inland. Those maps reveal that the Cavite-end of the proposed alignment may be entirely underlain by Alluvium overlaying bedded basaltic tuff of the Taal Tuff (Qtt).

Manila Bay

There is no geological information available at the proposed alignment across Manila Bay. It is anticipated that the ground conditions across Manila Bay should be similar to other offshore areas in the Philippines, which comprise various thickness of marine deposits and alluvium above the bedrock.

Marine deposits typically consist of soft to very soft clay and silty sand. Based on the published geological maps, alluvium is recorded near the shoreline of Bataan, Corregidor Island and Cavite. As such, it is suggested that alluvium is also encountered beneath marine deposit within Manila Bay with reducing thickness away from the onshore areas.

Field inspection in the shores of Manila Bay in Cavite shows that it is predominantly covered by beach deposits consisting sandy materials with abundant coral and shell fragments (**Figure 2.29**). Terrain along the shore at Cavite is relatively flat and gradually rises towards a dune where the proposed alignment emerges. The shore along Manila Bay in Bataan are more ragged and composed chiefly of basalt/andesite boulders of various sizes. These deposits potentially overlay and cover the Quaternary Alluvium published in geological maps which requires verification from project-specific ground investigations which will be completed during the following DED stage.

Figure 2.29 Beach sands with abundant coral and shell fragments along Manila Bay in Cavite.

Figure 2.30 Highly- to completely-decomposed pyroclastic materials with angular to sub-rounded basalt and andesite boulders along the shore of Manila Bay in Bataan

There is uncertainty and risks on the engineering properties and thickness of these superficial deposit. The ground condition along the alignment should be further justified by the project-specific ground investigation to provide to provide site-specific geotechnical parameters and the thickness of these surficial deposits.

F) Structural Features

It is recorded in the geological maps that the bedding of the lithologies at Bataan and Corregidor Island generally dips gently towards northwest for approximately 10° to 20° and locally dips towards the east southeast indicating potential presence of NNE-SSW-trending anticline. At Cavite, open folds are noted with fold axis striking roughly north northwest as shown in the geological section A2-B2 as shown in **Figure 2.23**. It is anticipated that from geological map sheet no. 3162 I that the alignment at Cavite lies on the westerly-dipping limb of a north northwest-trending anticline. No fault is recorded within or in the vicinity of the Site.

2.1.2.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

Geotechnical Risks

There is no site-specific ground investigation along the alignment. The ground condition should be further justified by the project-specific subsurface investigations during the DED to provide to provide specific geotechnical parameters for soil and rock and geological conditions that will constrain the engineering plans.

The site is underlain by slightly folded tuffaceous sedimentary rocks and pyroclastic rocks which contains low-dipping beddings with potential eutaxitic textures. Adverse weak discontinuities and preferential groundwater regime may be concentrated along these structural features to form a variable rockhead surface. Steeply inclined rockhead raise engineering challenge to pile foundations. Site-specific ground investigation should be undertaken during the following DED stage to obtain the thickness and geometry of regolith, rockhead profile, presence of steeply inclined rockhead surface.

Detailed site-specific ground investigations will be critical in the final design of the foundations to confirm the characteristics and geometry of the materials along the proposed alignment for a cost-effective engineering design of proposed structures and associated mitigating works.

2.1.3 Geohazard Assessment

A) Seismic-Related Hazards

One of the most predominant hazards in the Philippines is earthquake-related, also known as seismic hazards. Owing to the complex tectonic setting of the country, numerous active faults and other geologic structures crisscross the archipelago. The active faults and subduction zones are usually the loci to produce ground tremors of large enough magnitude to endanger surrounding communities. The earthquake-related geohazards include ground shaking, ground rupture, liquefaction, lateral spreading, etc. This section addresses the different impacts caused by earthquake on the proposed project considering the present tectonic and geological conditions of the area.

Seismicity

The Philippines archipelago is dissected by several major faults. Review of tectonic setting and various active fault traces (provided by PHIVOLCS) suggests that the seismic hazard of proposed BCIB is mainly contributed by subduction (both inter- and intra-slab) of the Eurasian Plate along Manila Trench, active faulting along the Valley Fault System and the Philippine Fault Zone, and local active faults in forearc region and Zambales Range due to crustal deformation. There have been many large historical earthquakes (magnitude greater than 6) that have occurred near the Site.

The latest compilation of seismic events by PHIVOLCS () shows that higher seismicity occurred at shallow depth have been recorded along the Philippine Fault Zone, the Philippine Trench, forearc region offshore of Zambales and along Lubang Fault. In addition to the shallow earthquakes, some deep earthquakes, which were associated with the intraslab earthquakes of the subducting Eurasian Plate, were recorded to the south of the BCIB.

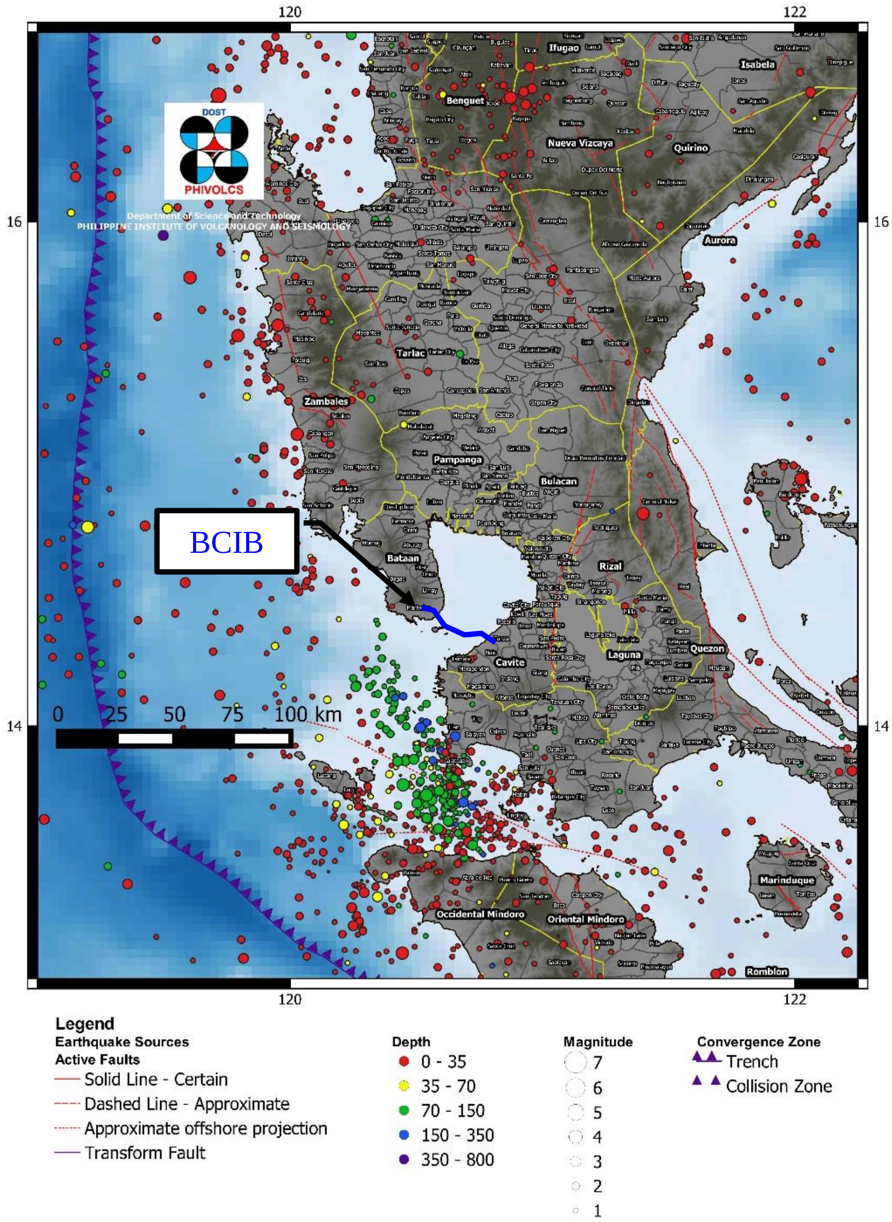


Figure 2.31 Seismicity compilation map of National Capital Region (NCR) in year 2016 (Source: PHIVOLCS)

Ground Rupture and Fault Creep

Ground rupture or fissures can be a major risk to the civil structures. This type of ground displacement usually occurs on pre-existing faults and relatively rare on entirely new fault. The ground rupture hazard is high when a civil structure or building is near a known active fault, which will affect significantly the stability of the structures or even complete failure or collapse. Fault creep is considered to be less hazardous than fault rupture, but the ground offset at very low slip rate can be still able to result in significant damage to infrastructure.

Along the proposed alignment of the BCIB, ground traces of local faults were not observed both on the Bataan and Cavite sides of the project. The active faults map of PHIVOLCS

(**Figure 2.32**) indicates that the closest identified active fault in their region is Valley Fault System, located to be about 24 kilometres to the east of the site. As such, the fault rupture or fault creep hazard is considered to be low. It is recommended to carry out geophysics test to confirm if there is any presence of active fault in later stage of design.

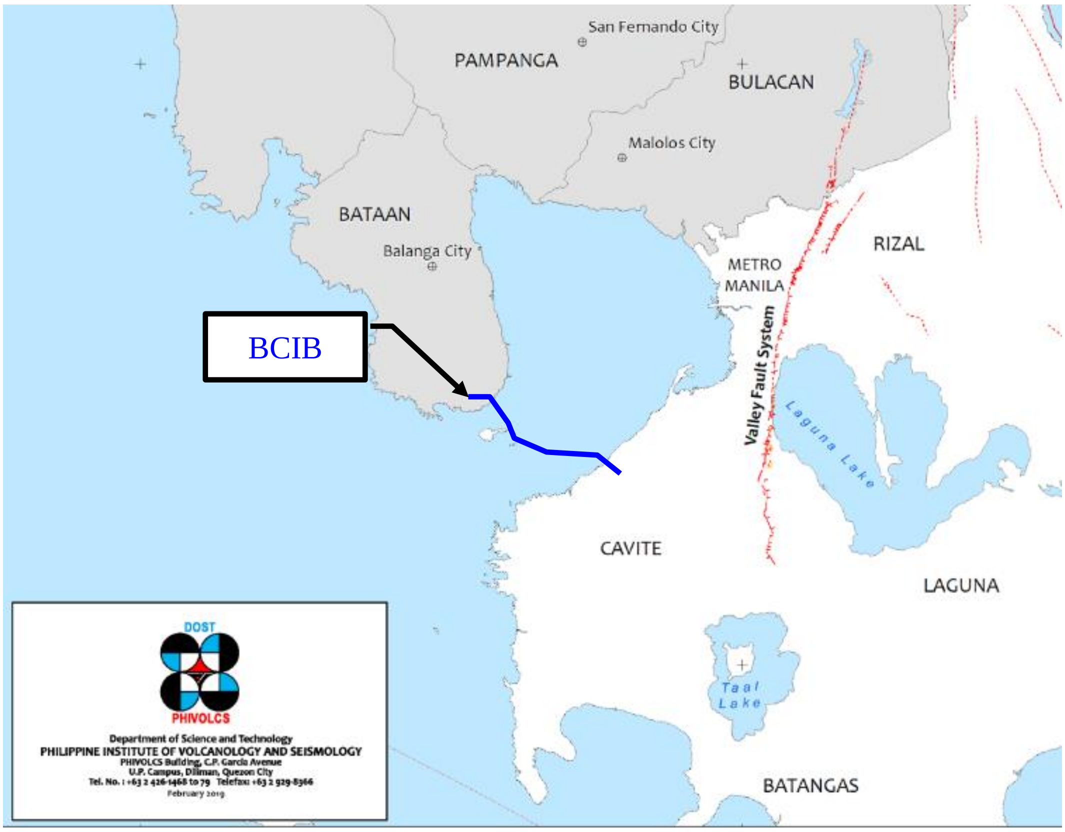


Figure 2.32 Active faults map of Region 11 from PHIVOLCS showing the location of BCIB

Ground Acceleration

Ground shaking is the most noticeable effect of earthquakes and it is also one of the most destructive to rigid civil projects. Vibrations transmitted by seismic waves in vertical and horizontal directions cause significant stresses within concrete and steel structures that are inherently stiff materials. Ground movements that exceed the allowable thresholds of dynamic movement of these structures result in instability and damage, which may ultimately lead to collapse and destruction. One of the most active earthquake generators in the country is the Philippine Fault Zone which has a history of producing large magnitude earthquakes of ≥M7.0.

Ground motion, as it relates to movement that will be affected on objects above ground, can be represented as the peak ground acceleration (PGA) which is the movement experienced on the ground, and spectral acceleration (SA) which is approximately movement experienced by a structure elevated above ground such as buildings or bridges.

The mandated agency, PHIVOLCS, has developed a Philippine Earthquake Model (PEM) which gives PGA maps by Probabilistic Seismic Hazard Analysis (PSHA) for the whole country. Based on these maps, the location of the BCIB will likely experience 0.3g, 0.3g-0.4g, and 0.4g for rock site areas at return periods of 500, 1000 and 2500 years, respectively (**Figure 2.33** to **Figure 2.36**). For areas with stiff soils, it is modelled that the BCIB location will have an expected PGA of 0.3g in 500-year return period events.

PEM also gives the SA maps of different structural periods and indicates that SA of 0.2s, 0.5s, 0.8s, 1.0s and 3.0s for BCIB are 0.9g, 0.9g, 0.6-0.7g, 0.5g-0.6g and 0.1g respectively at the stiff soil at 500-year return period (**Figure 2.37 to Figure 2.41**).

In addition to the PEM, DPWH manual on LRFD Bridge Seismic Design Specification also gives PGA and SA for 100- and 1,000-year return period.

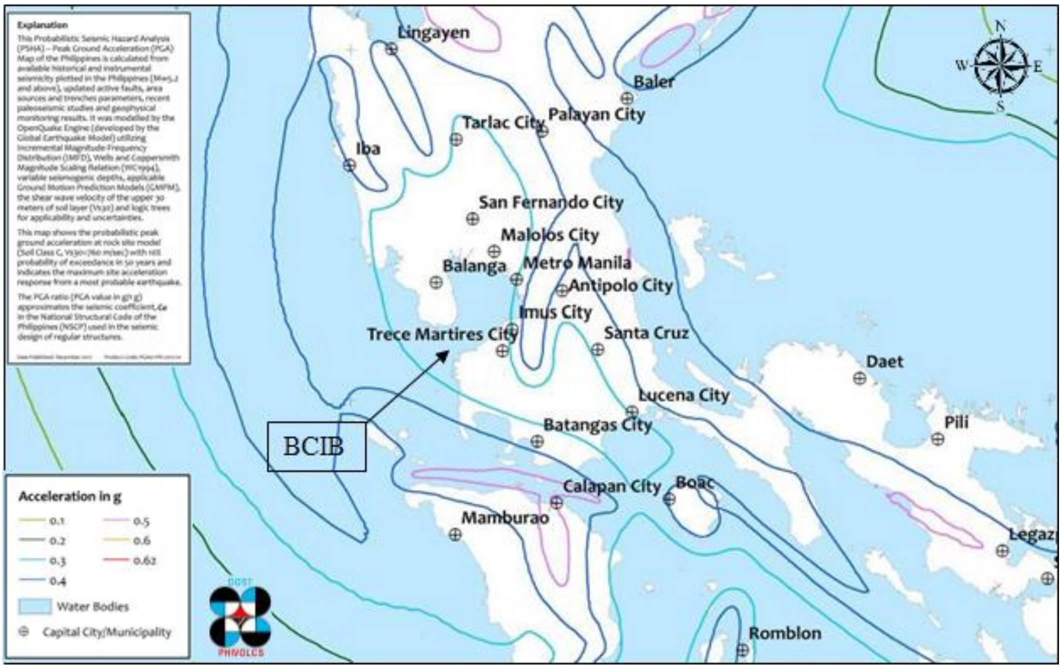


Figure 2.33 Extract of the peak ground acceleration map of the Philippines for rock sites at 500-year return period (Source: PHIVOLCS)

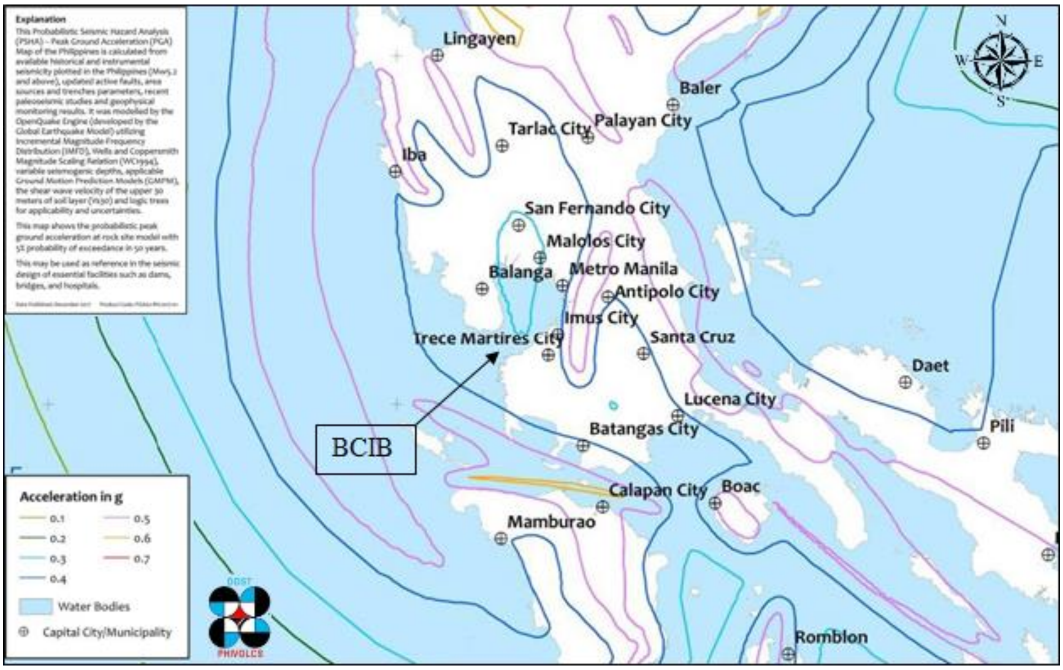


Figure 2.34 Extract of the peak ground acceleration map of the Philippines for rock sites at 1000-year return period (Source: PHIVOLCS)

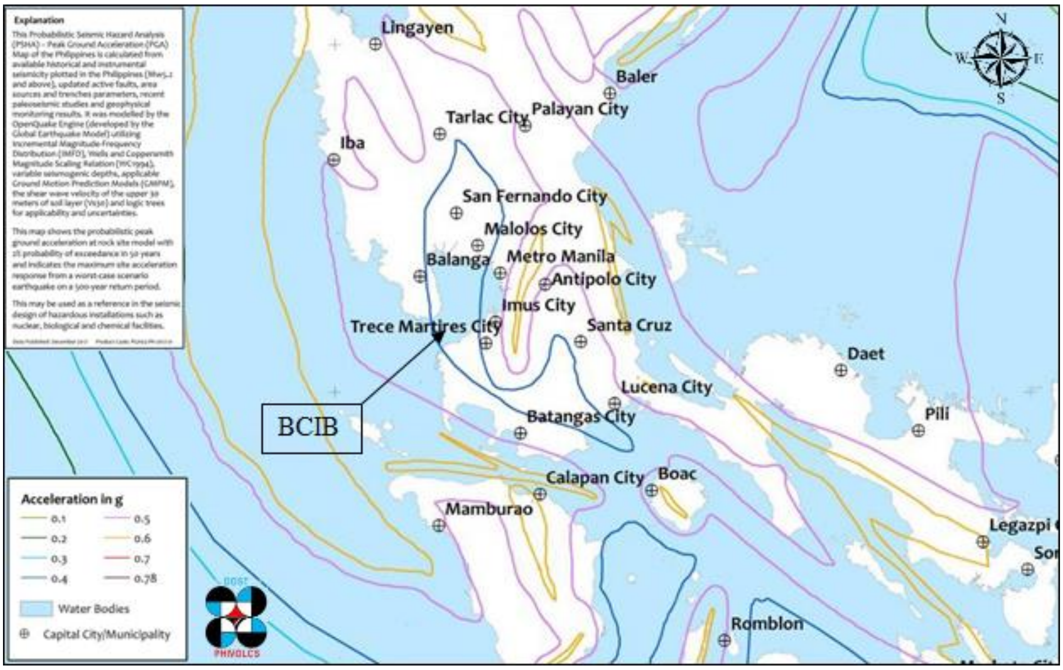


Figure 2.35 Extract of the peak ground acceleration map of the Philippines for rock sites at 2500-year return period (Source: PHIVOLCS)

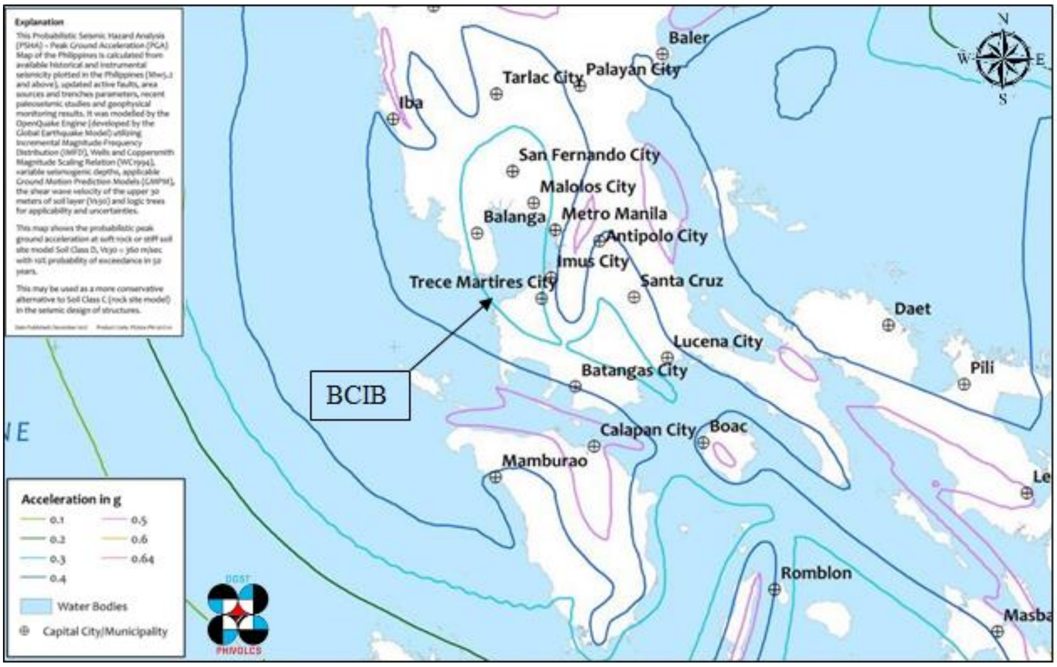


Figure 2.36 Extract of the peak ground acceleration map of the Philippines for stiff soils at 500-year return period (Source: PHIVOLCS)

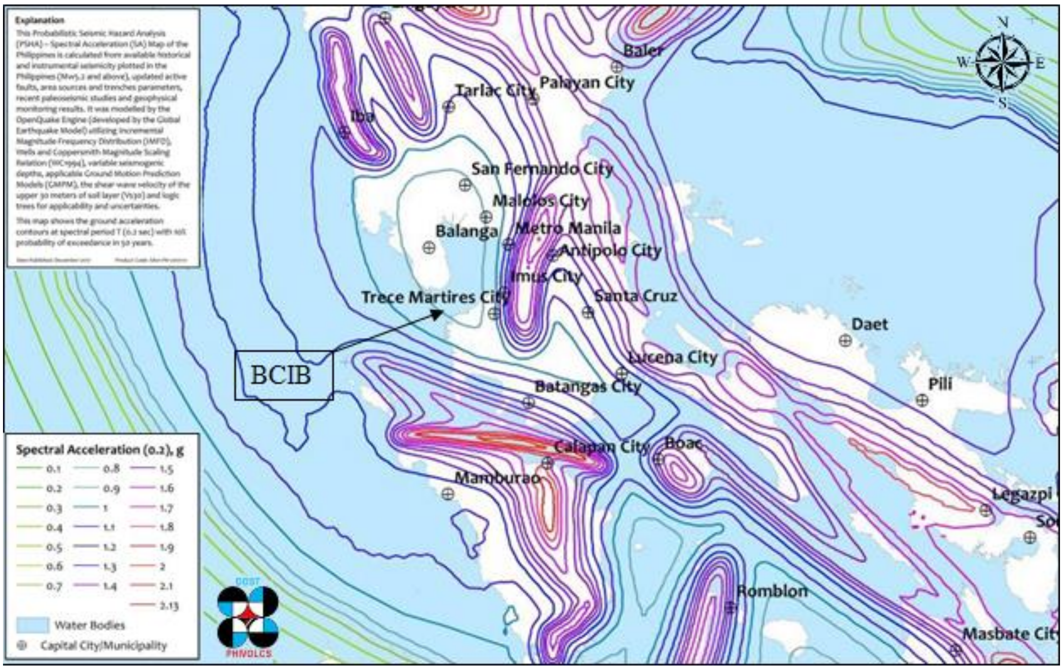


Figure 2.37 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.2 seconds) at 500-year return period on stiff soil

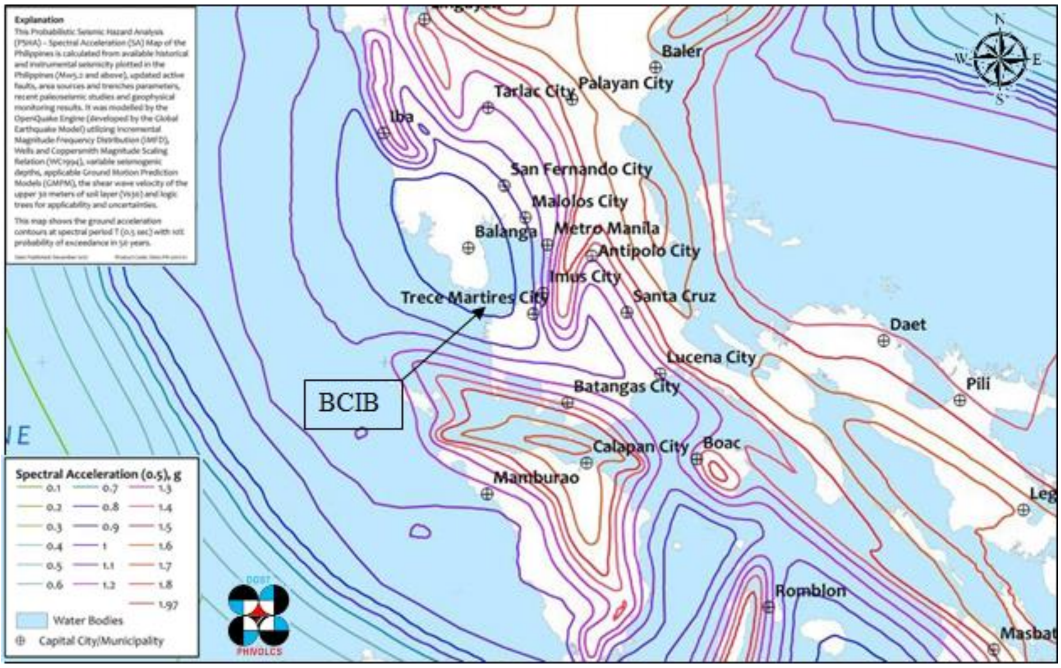


Figure 2.38 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.5 seconds) at 500-year return period on stiff soil

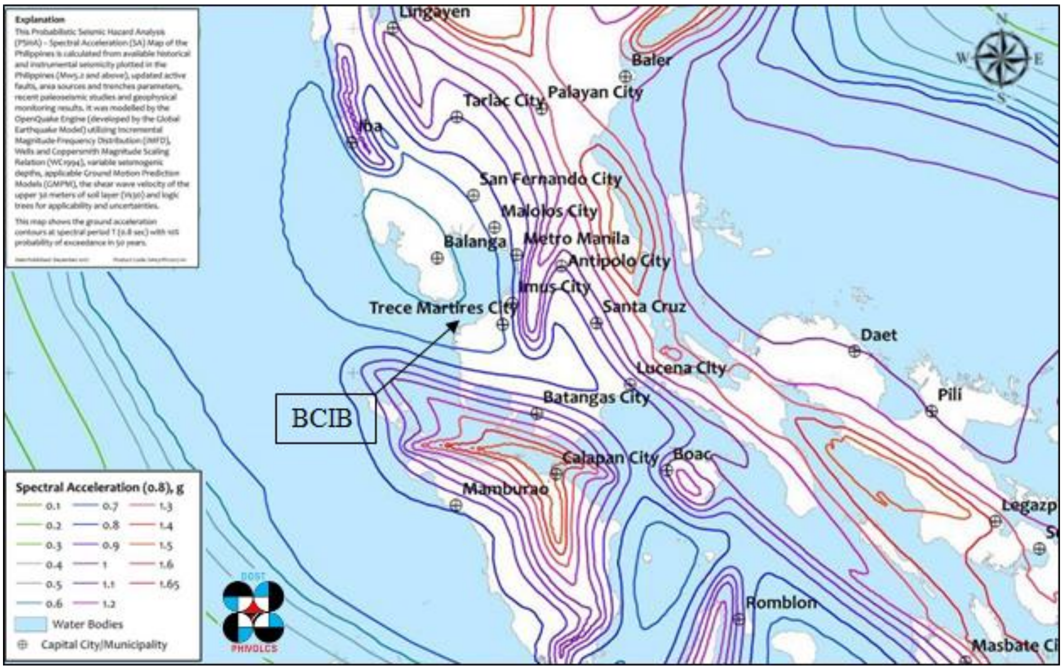


Figure 2.39 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (0.8 seconds) at 500-year return period on stiff soil

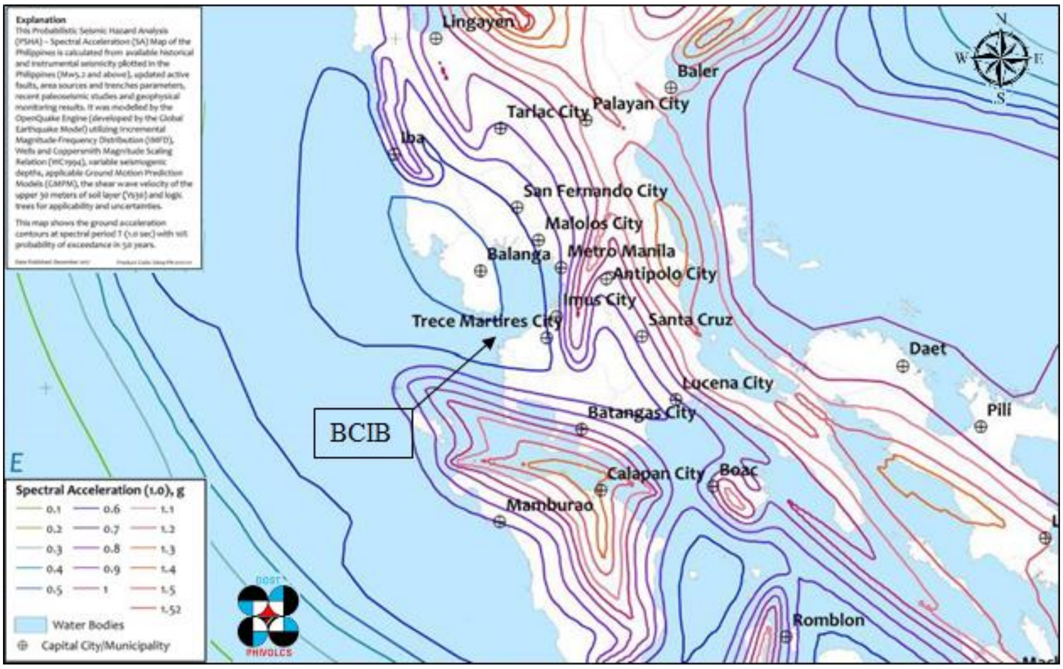


Figure 2.40 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (1.0 seconds) at 500-year return period on stiff soil

Figure 2.41 Extract of the spectral acceleration map of the Philippine by PHIVOLCS SA (3.0 seconds) at 500-year return period on stiff soil

The seismic ground motion shall be included in the design of structures. The acceleration spectra for the design can be developed by general procedure as stated in DPWH manual by using the published ground motion parameters, or the site-specific procedure where available and appropriate. When the detailed geotechnical investigation is made available in DED phase, soil amplification shall be calculated to provide site-specific response spectra for the engineering design.

B) Liquefaction

Liquefaction is conventionally defined as the substantial loss of strength of a saturated cohesionless soil, typically as a result of earthquake-induced ground shaking. Loss of soil strength causes large differential settlements and can induce large forces in the structure. Liquefaction can be a destructive hazard associated with earthquakes. Structures that are supported by ground that liquifies will be prone to damage and collapse.

The Liquefaction Potential Map of the Philippines which was published by PHIVOLCS (**Figure 2.42**) shows that the Cavite side of the BCIB is within a zone that is prone to liquefaction. In addition, the offshore region of the BCIB is considered to have a considerable thickness of superficial deposits which may comprise soft/loose material including loose sand. As such, it is anticipated that liquefiable soil is highly likely to be present. When site-specific GI is available, liquefaction potential will be further reviewed.

If liquefaction was found to be present beneath site, the liquefaction hazard effects shall be taken in the foundation design or ground improvement may be required in the liquefiable soil layers.

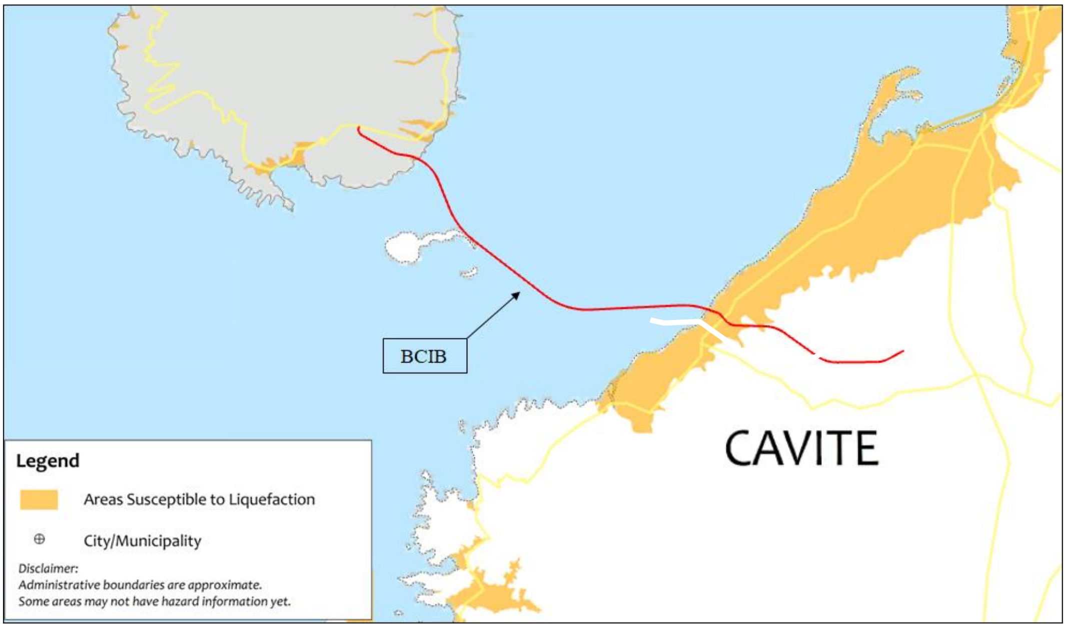


Figure 2.42 Liquefaction Susceptibility Map (Source: PHIVOLCS)

C) Lateral Spreading

Liquefaction-induced lateral spreading is defined as lateral displacement of gently sloping induced by liquefaction and this may impact the stability of the bridge. This phenomenon typically occurs on the gentle sloping ground near a waterfront which is widely underlain by considerable thickness of liquefiable soils. In the BCIB, the onshore area along the waterfront of Cavite side is located on a sloping ground and lateral spreading may potentially occur. Though there are no liquefaction susceptible soils being indicated from liquefaction susceptibility map at both onshore area of Bataan and Corregidor island, the bathometry data suggests that the nearshore area of Bataan and Corregidor island exhibit a relatively steeper slope. If liquefiable soils are present, lateral spreading may occur. When site-specific GI is available, liquefaction potential and lateral spreading shall be further reviewed.

D) Tsunami and Seiches

The Philippines is an archipelago with extensive coastlines and transacted by numerous faults and trenches. These conditions make it susceptible to tsunamis and seiches. Tsunami events are characterized by large waves generated by the displacement of large volumes of water due to submarine seismic events, volcanic eruptions or landslides. Seiches are similar events that occur in large inland bodies of water.

According the Tsunami Hazard Maps published by PHIVOLCS in 2014 (**Figure 2.43**), the coast of the Bataan City where the BCIB project transects has a thin frame of tsunami inundation of more 6 metres, potentially up to 8 metres. High tsunami inundation is noted more inland along the river situated roughly 120 metre northeast of the proposed alignment. Along the coastline of Corregidor Island, a tsunami inundation of 5 metres to 6 metres is recorded. At the Cavite side, the BCIB alignment lies on an alluvial plan with a tsunami inundation of less than 1 metre.

As the coastlines of Bataan side and Corregidor Island of the BCIB project are prone to tsunami events, mitigation measures such as breakwaters or wave dissipating blocks and coastal structures will be considered. Final designs will be based on the results of a more detailed study of the area.

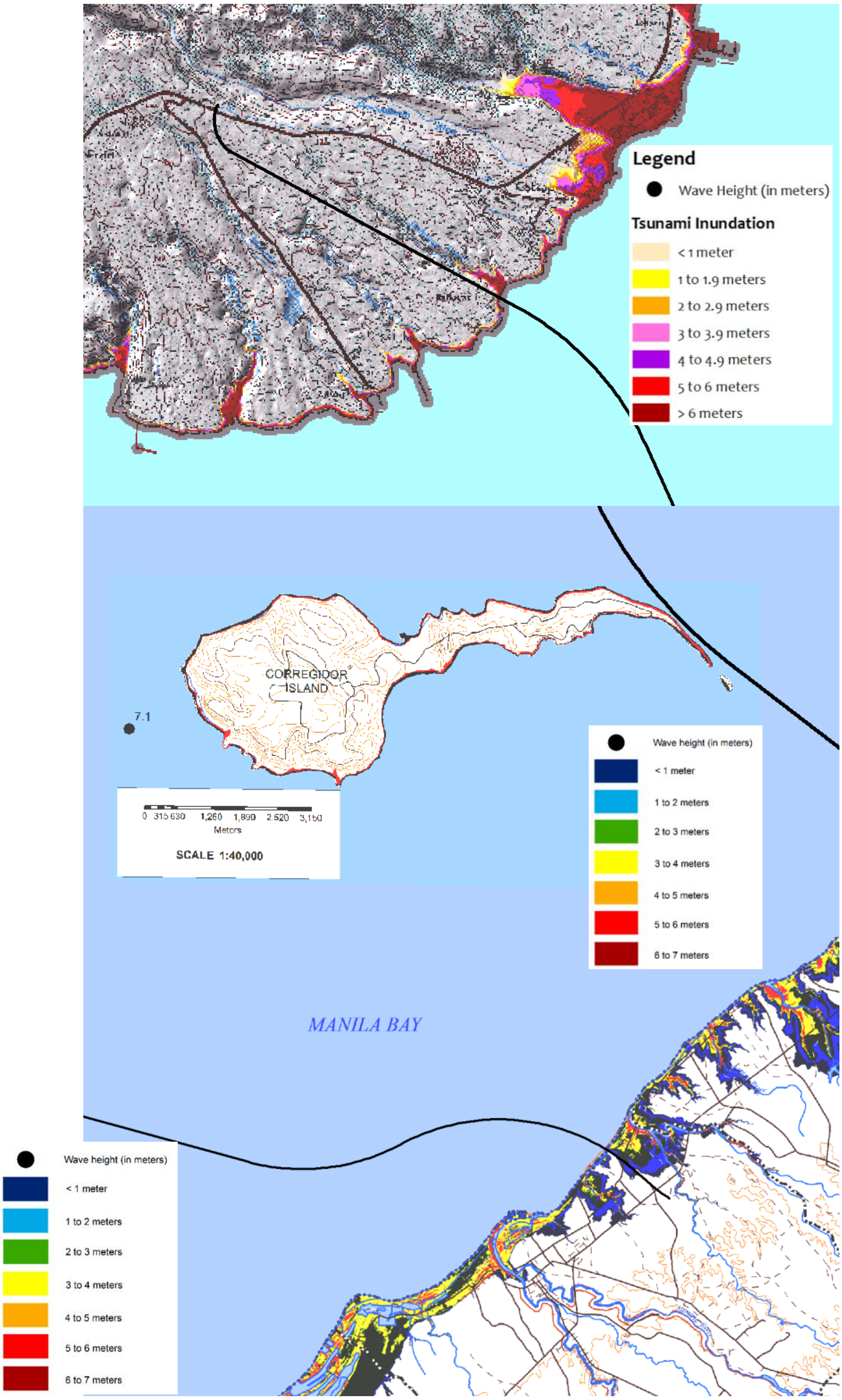


Figure 2.43 Extract of Tsunami Hazard Map along the BCIB Project at Provinces of Bataan (top) and Cavite (middle and bottom) (Source: PHIVOLCS)

E) Volcanic Hazards

General

The Philippine Mobile Belt, which comprises most of the landmass in the Philippine Archipelago, is a geological amalgamation of ancient and young volcanic island arcs brought together by the tectonic movement of adjacent crustal plates. Adding to this, the country is situated along the major plate boundary between the Philippine Sea Plate and Eurasian Plate which constitute a segment of the Pacific Ring of Fire. This geologic setting resulted to the formation of numerous volcanic centres within the country, both active and inactive. Thus, the country is also very susceptible to volcanic hazards such as lava flows, pyroclastic flows, debris flow and avalanches, lahar, ashfall, tsunami, volcanic projectiles, volcanic gases and volcanic earthquakes.

Ash Fall

The map of active volcanoes in the Philippines published by PHIVOLCS (**Figure 2.44**) shows that the nearest active volcanic centres to the BCIB project is the Taal Volcano and the Pinatubo Volcano, which is located approximately 50 kilometres to the southeast and 80 kilometres to the north northwest respectively. The potentially active volcanos are Mt. Corregidor on the Corregidor Island located about 4.4 kilometres west to the proposed alignment and Mt. Mariveles located 10.3 kilometres northwest to the proposed alignment. The closest inactive volcanic centre is Mt. Palay, which is around 16 kilometres southwest to the proposed alignment.

The dangers posed by volcanoes are associated with volcanic eruption. Hazard from volcanic eruption depends upon the magnitude of its explosion and distance to the eruption centre. Hazards associated with volcanic eruptions include pyroclastic flows and base surges, lava flows, lahars and the ash or tephra fall.

Considering the distance of the project to the active volcanoes, it is expected that the only volcanic hazard that could impact the development is ashfall. These fine materials are carried by the wind and the distances travelled by these are strongly influenced by wind and climate patterns, as well as the nature of the volcanic eruption. The far-reaching ash fall hazard may be a nuisance and reduce air quality but would not seriously affect the proposed project. Taking this into account, the final design of the BCIB project will ensure that structures will not easily accumulate the ash fall on roofs and other civil works. Taal Volcano is closely monitored, and one would likely receive a few weeks warning of a possible eruption.

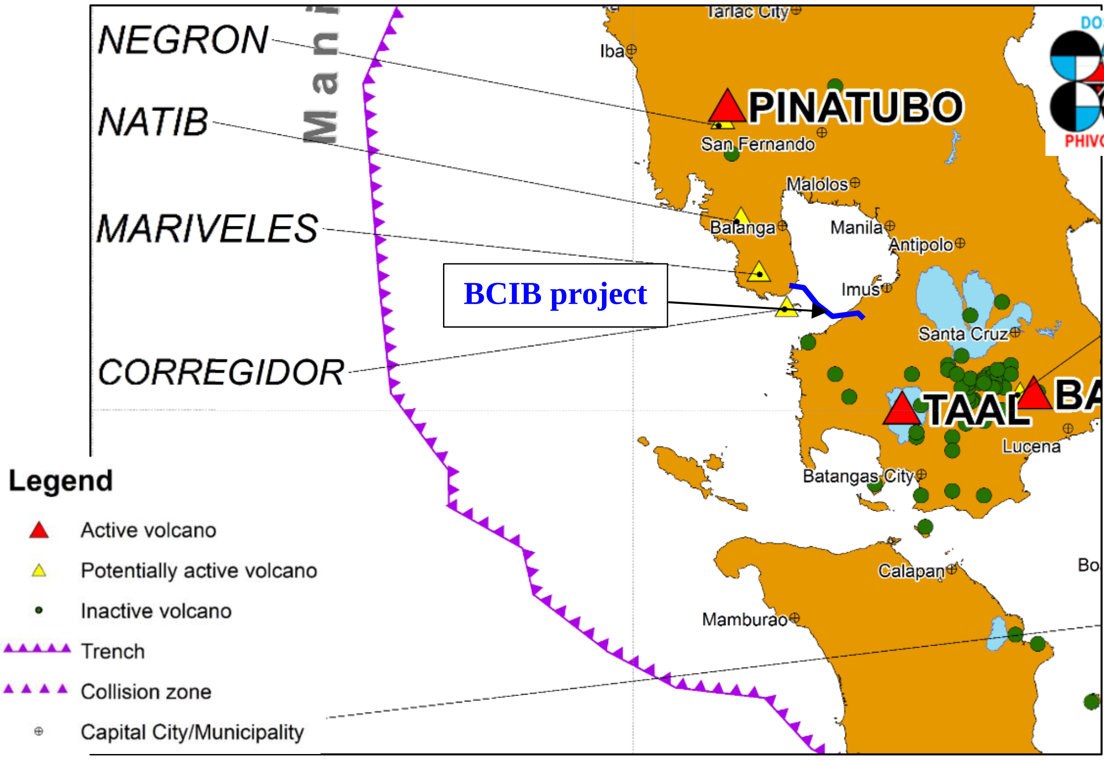


Figure 2.44 Extract from the map of active volcanoes in the Philippines published by PHOVLCS showing the location of the project

F) Mass Movement

One of the most ubiquitous geologic hazards in the Philippines are landslides or, technically, mass movements. This is mainly due to the variable topography with large areas of moderate to steep slopes, the lack of vegetative cover, thick weathering mantle and soils and the prevalence of geologic structures that contribute to the general weakness of rock and soil.

According to the 1:50,000-scale landslide and flood susceptibility maps published by MBG, the proposed BCIB will be running through a gently sloping interfluve terrain at coastal area at the Bataan end of the alignment where the susceptibility to landslide is low (**Figure 2.45**). At the Cavite end of the proposed BCIB, the alignment will be running through a gentle to flat alluvial plain at the shoreline where the susceptibility to landslide is negligible. Hence, it is expected that the hazards from mass movements would not significantly affect the proposed structures onshore. the DED will take into consideration the in-situ and site-specific geotechnical parameters that will be obtained during the detailed geotechnical investigation to ensure slope stability.

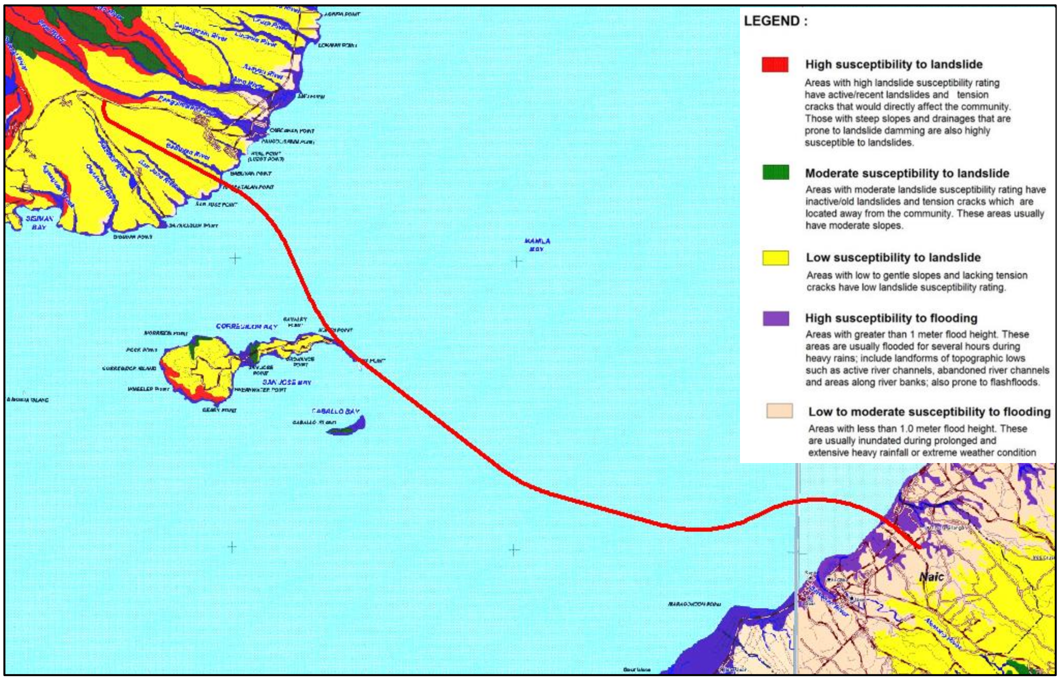


Figure 2.45 Extract of the 1:50,000-scale landslide and flood susceptibility maps [Sheet Nos. 7171 IV (left) & 3129 I (right) (Source: MGS)

G) Fluvial Hazards

Flooding is a widespread hazard that is especially frequent in highly urbanized areas. In Cavite, several low-lying regions are also susceptible to flooding, including where the proposed BCIB will be located.

Based on the combined flood and landslide susceptibility maps published by the MGB (**Figure 2.45**), the alignment will transact areas where are moderately to highly susceptible to flooding in the Cavite side. On the other hand, the Bataan side generally has a sloping ground, hence, this area is not significantly affected by flooding.

Based on the field inspection conducted on 10 March 2020 and 11 March 2020, the streams delineated in **Figure 2.21** appears to be dry. Although it was noted during an interview that a man-made structure was built to protect an existing house during elevated sea levels (**Figure 2.46**). This would suggest that the flooding in this area is mainly due to the rise of sea water rather than overflowing of water in the riverbanks on land.

Figure 2.46 Man-made structure to provide protection against sea level rise

Considering the susceptibility of the area to flooding, the final design for the approach of the BCIB project will ensure that there is efficient flow and removal of surface water by establishing appropriate drainage canals. The elevation of the area and the proximity to the sea will also be considered in design and planning.

H) Coastal Hazards

The proposed project will be located along the shores of Cavite and Bataan (**Figure 2.47**); as such, it will be susceptible to coastal hazards. Chief of these is locally generated tsunamis associated with seismic events, which were discussed in the seismic hazards section of this report. The modelled tsunami wave height and inundation were generated by the movement along Manila Trench segment between 14.0 degrees to 16.0 degrees latitude, west of Bataan and Cavite.

The other hazard that may likely affect the site and very similar to the above-mentioned phenomenon is storm surge. These are abnormally high sea waves driven by extreme weather conditions such as strong typhoons. As the site is within the coast, it may be affected by abnormal disturbances of sea level. With the current design of the BCIB, the viaduct is relatively elevated as it approaches the shoreline and may not be affected by high water levels associated with storm surges. However, these conditions will be incorporated into the design of the piers and foundations. Flooding in the Cavite coastal area is primarily due to water inundation from marine waters. On the other hand, the Bataan coastal region is located at a relatively higher elevation.

Within the submarine section of the project, increased loading due to the construction of the pylons may ensue. These conditions will be considered during construction and in the design of the final engineering plans. Moreover, detailed geotechnical characteristics of the area will be collected during the subsurface investigations in the DED phase and will be used as inputs in the design.

The Engineering Geological and Geohazard Report (EGGAR) is found in **Annex G.**

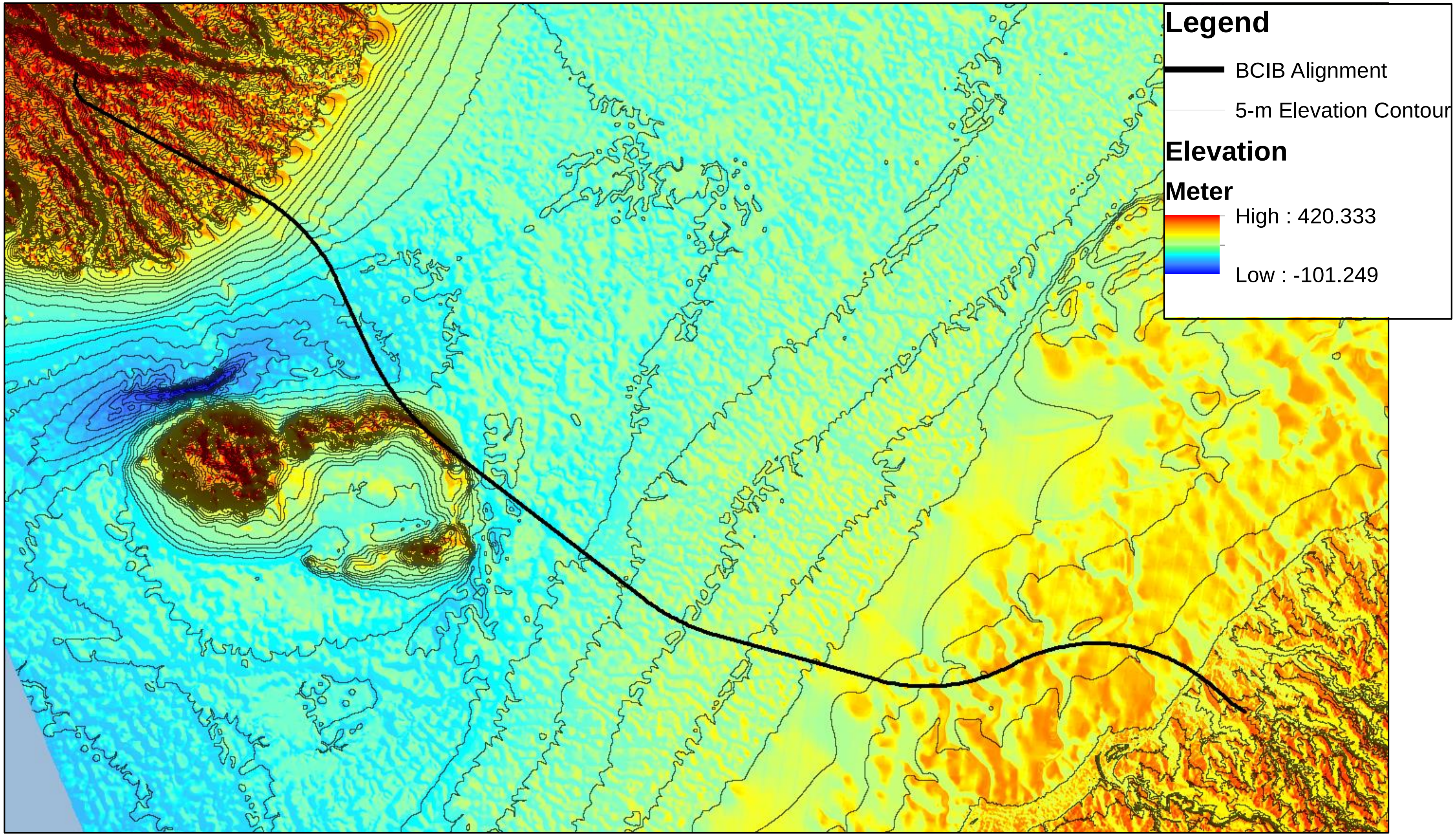


Figure 2.47 Topographic and bathymetric map of the BCIB alignment

2.1.3.2 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Earthquake / Seismic Hazards

Seismic hazards mainly include ground shaking, ground rupture, liquefaction, landslides and rock falls. The seismic hazard of Bataan-Cavite areas is mainly contributed by several seismic sources such as subduction along Manila Trench, active faulting of Valley Fault System, Philippine Fault Zone and Lubang-Verde Passage Fault System. These seismic sources have generated earthquakes with magnitude greater than 6 in the past including 1990 Luzon earthquake of magnitude 7.7 along Philippine Fault Zone. The subduction also has generated moderate size of earthquakes at deeper level underneath the site. In addition, the forearc region is under compression due to the eastward subduction of the Eurasian Plate which has induced earthquakes in the region.

As BCIB is in a seismically active region surrounded by various seismic sources, seismic hazard and associated geohazards shall be considered in the bridge design.

Ground Shaking

The most noticeable effect of seismic hazard is ground shaking or ground acceleration. Ground shaking is usually considered to be the most destructive to the civil structures or buildings as the shaking can lead to eventual collapse of the structures when the seismic load exceeds the allowable threshold. The intensity of ground shaking for engineering design can be represented by ground motion parameters including Peak Ground Acceleration (PGA) at the ground and Spectral Acceleration (SA) for structures at different structural above ground.

The Philippine Earthquake Model (PEM) by PHIVOLCS gives the PGA at rock in various return period and SA at stiff soil at 500-year return period. The acceleration spectra for the design can be developed by general procedure as stated in the code (e.g. DPWH manual on LRFD Bridge Seismic Design Specification) by using the ground motion parameters published in DPWH manual or PEM, or the site-specific seismic hazard study where available and appropriate. When the detailed geotechnical investigation is made available in DED phase, soil amplification shall be calculated to provide site-specific response spectra for the engineering design.

The seismic ground motion shall be included in the design of structures.

Liquefaction

The Cavite side of the BCIB is within a zone which is prone to liquefaction according to the liquefaction susceptibility map produced by PHIVOLCS. In addition, the offshore region of the BCIB is considered to have a considerable thickness of superficial deposits which may comprise soft/loose material including loose sand. As such, it is anticipated that liquefiable soil is highly likely to be present. Site-specific GI will be carried out during the DED, detailed liquefaction potential assessment will be carried out to confirm if there is any liquefaction potential and confirm the depth and extent of liquefiable soils, if any.

If liquefaction was found to be present beneath site, the liquefaction hazard effects shall be taken in the foundation design or ground improvement may be required in the liquefiable soil layers. Standards on bridge construction as stipulated on the DPWH manual on LRFD Bridge Seismic Design Specification shall be followed.

Lateral Spreading

The onshore area along the waterfront of Cavite side is located on a sloping ground with potential liquefiable soils underneath, the lateral spreading may potentially occur. Though there are no liquefaction susceptible soils being indicated from liquefaction susceptibility map at onshore areas of Bataan and Corregidor island, the bathometry data suggests that the nearshore area of Bataan and Corregidor island exhibit a relatively steeper slope. If liquefiable soils are present, lateral spreading may occur. When site-specific GI is available, liquefaction potential and lateral spreading shall be further reviewed.

Tsunami and Seiches

The coastlines of Bataan side and Corregidor Island of the BCIB project are prone to tsunami events. Thus, mitigation measures such as breakwaters or wave dissipating blocks and coastal structures should be considered. Final designs should be based on the results of a more detailed study of the area.

B) Volcanic Hazards

The nearest active volcanic centres to the BCIB project are the Taal Volcano and the Pinatubo Volcano, which is located approximately 50 kilometres to the southeast and 80 kilometres to the north northwest respectively. The potentially active volcanos are Mt. Corregidor on the Corregidor Island located about 4.4 kilometres west to the proposed alignment and Mt. Mariveles located 10.3 kilometres northwest to the proposed alignment. Considering the distance of the project to the active volcanoes, it is expected that the only volcanic hazard that could impact the development is ashfall. These fine materials are carried by the wind and the distances travelled by these are strongly influenced by wind and climate patterns, as well as the nature of the volcanic eruption. The far-reaching ash fall hazard may be a nuisance and reduce air quality but would not seriously affect the proposed project. Taking this into account, the final design of the BCIB project will ensure that structures will not easily accumulate the ash fall on roofs and other civil works. Taal Volcano is closely monitored, and one would likely receive a few weeks warning of a possible eruption.

C) Mass Movement

The proposed BCIB will be running through a gently sloping terrain at coastal area at the Bataan end of the alignment where the susceptibility to landslide is low. At the Cavite end of the proposed BCIB, the alignment will be running through a gentle to flat alluvial plain at the shoreline where the susceptibility to landslide is negligible. Hence, it is expected that the hazards from mass movements would not significantly affect the proposed structures onshore. Construction design will consider in-situ and site-specific geotechnical parameters that will be obtained during the detailed geotechnical investigation to ensure slope stability.

D) Flooding

Based on MGB's combined flood and landslide susceptibility map for Bataan and Cavite, the project alignment along the coast of Cavite will cross sections that are moderately and highly susceptible to flooding. Flooding in the area could be due to the lack of drainage canals to efficiently remove storm waters, elevated sea levels, its proximity to the water line, and the low elevation of the site. Thus, to minimize flooding in the project site, proper drainage canals or protection against sea level rise must be established to consider the surface water flows and existing structures in the area.

2.1.4 Pedology

2.1.4.1 Methodology

The published map of soil types by Bureau of Soils and Water Management (BSWM) indicates that Antipolo Clay and Guadalupe Clay are encountered at Bataan (north-western portion of the proposed alignment) and Cavite (north-western portion of the proposed alignment) respectively (**Figure 2.48**).

2.1.4.2 Baseline Environmental Conditions

A) North-western Portion of Proposed Alignment – Bataan

Published map of soil type by BSWM indicates the presence of Antipolo Clay (**Figure 2.49**) at Bataan. This soil belongs to Typic Dystropepts which are formed from volcanic materials. They are extensively mapped on pyroclastic and volcanic complex hills. They are brownish and reddish in colour, moderate deep to deep, well drained and clayey textured. Commonly occur on pyroclastic and volcanic hills. These soils are mainly used for grasslands and secondary frost. However, soils in areas with undulating slopes are sometimes cultivated to upland crops. Some portions are devoted to orchard mango and other tree crops.

B) South-eastern Portion of Proposed Alignment – Cavite

Published map of soil type by BSWM indicates the presence of Guadalupe Clay (**Figure 2.50**) at Cavite. It comprises dark clay with spherical tuffaceous concretions derived from Diliman Tuff (Carating et al, 2014). It is normally classified as fine, montmorillonitic, isohyperthermic Lepic Udic in lowland rice area or Lithic Trophorthents in undulating areas Typic Ustropepts, which corresponds to shallow to moderately deep poorly drained dark brown to black clay.

Based on the BSWM Soil Survey Report for Cavite province, the Guadalupe Clay in encountered in Cavite can be father subdivided into four soil taxonomies based on their distribution, namely: Aquic Ustipsamments along the coast, Typic Pellusterts on the low lying broad alluvial plan, Entic Pellusters and Lithic Tropaquepts on the volcanic plains/residual terraces. Detailed definition of the abovementioned soil taxonomies is listed below.

- Aquic Ustipsamments are shallow to moderately deep soils that occur on beach ridges and former tidal flat landscapes. These soils are relatively young with little or no diagnostic horizons that involve accumulations of clays. These soils are poorly to well drained; most dark greyish brown to very dark greyish brown. The underlying horizons have almost dark gravy, greyish brown, dark brown and brown loamy sand to sand mixed with few debris of marine shells. These soils have a very low water holding capacity. Moderate to severe flowing due to tidal movements and river overflow affects some of these soils. These soils have ustic soil moisture regime and isohyperthermic soil temperature regime. Present land use of these soils is for cultivation of coconuts, shrubs with limited patches of paddy rice. Fishponds are also observed in some areas.

- Typic Pellusterts are very fine, montmorillonitic, moderate deep to deep, poor to very poorly drained soils developed from weathering of volcanic tuff and old alluvial deposits formed on level to nearly level topographic of low lying broad alluvial plain and on nearly level to gently sloping topography of the volcanic plain/residual terrace landscape. These soils belong to ustic soil moisture regime and isohyperthermic soils temperature regime. These soils utilized to wetland irrigated or non-irrigated rice. Some areas are utilized to upland crops cultivation such as vegetable, legumes, root crops and diversified crops.

- Entic Pellusters are fine to very fine montmorillonitic, moderately deep to deep, poorly to very poorly drained soils developed from two different landscape; the water laid volcanic tuffs formed on level to nearly level broad alluvial plains, and from nearly level to gentle sloping volcanic plain/residual terraces landscape. The soils have more than 50 percent clay in its entire horizon. These soils have ustic soil moisture regime and isohypethermic soil temperature regime. These soils are utilized for irrigated and non-irrigated paddy rice. Limited patched are utilized for upland crops such as vegetable and root crops
- Lithic Tropaquepts are fine to very fine, poorly to somewhat poorly drained soils derived from volcanic tuff materials. These soils occur on level to nearly level topography of the low lying broad alluvial plain/residual terraces having a slope ranging from 0.0 to 8.0 percent. These soils have aquic soil moisture regime and isohyperthermic soil temperature regime. The soil unit is mainly sued for irrigated to non-irrigated rice paddy. Other areas are utilized for diversified crops while few areas are idle and covered with grasses for pasture. Patches of fruit trees are also present in some areas

Figure 2.48 Published Soil Type Map along the BCIB Alignment adapted from BSWM

Figure 2.49 Exposure of Antipolo Clay in Bataan

Figure 2.50 Exposure of Guadalupe Clay in Cavite

2.1.5 Terrestrial Ecology

2.1.5.1 Methodology

A) Flora Assessment

To evaluate existing vegetation within the direct and indirect impact areas of the Project, three (3) transects and two (2) transects were established in Mariveles, Bataan and Naic, Cavite, respectively. Each transect has sampling plots that were demarcated to evaluate the canopy, intermediate, and undergrowth layers. Use of quadrat sampling plot with 10m × 10m, 3m × 3m, and 1m × 1m nestled plots were done to evaluate the three different layers. All trees greater than or equal to 15 cm diameter at breast height (DBH) were measured and recorded in the 10 m × 10 m plot for canopy layer. A 3 m × 3 m plot was established randomly inside the canopy plot for the intermediate layer. For the understorey layer, a 1 m × 1 m plot was established randomly inside the intermediate plot to account for the number of species that included wildlings, herbs, vines, grasses, and shrubs. Flora species outside the established plots were also documented to characterize the immediate vegetation type. Plants outside plots, however, were not included in the computations of ecological parameters.

Tracks and coordinates of the sampling stations were recorded using a hand-held GPS. Geotagging of photos was also taken as a visual reference of the site.

Table 2.11 Flora Sampling Stations

Transect	Plot	Northing	Easting	Elevation (masl)
Mariveles, Bataan				
Transect 1	Plot 1	14°27'37.49"N	120°32'39.64"E	198
	Plot 2	14°27'4.77"N	120°33'19.30"E	126
	Plot 3	14°26'56.63"N	120°33'34.15"E	104
Transect 2	Plot 1	14°27'6.72"N	120°33'4.06"E	140
	Plot 2	14°26'45.66"N	120°33'46.62"E	89
	Plot 3	14°26'29.08"N	120°34'4.72"E	65
Transect 3	Plot 1	14°26'30.89"N	120°34'22.69"E	36
	Plot 2	14°26'19.04"N	120°34'48.07"E	5
	Plot 3	14°26'23.91"N	120°34'50.80"E	5
Naic, Cavite				
Transect 1	Plot 1	14°20'7" N	120°47'9" E	14
	Plot 2	14°20'26" N	120°46'49" E	6
	Plot 3	14°20'32" N	120°46'38" E	4
Transect 2	Plot 1	14°20'29" N	120°46'49" E	5
	Plot 2	14°20'36" N	120°46'45" E	7

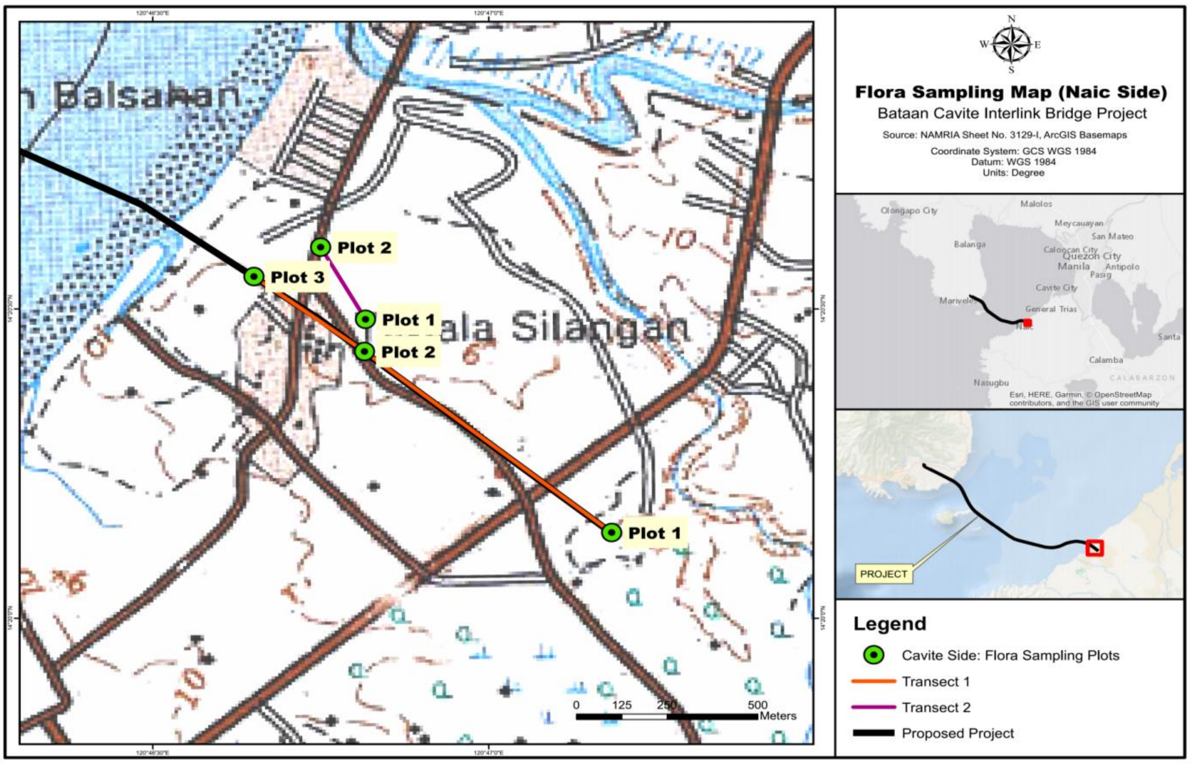


Figure 2.51 Flora Sampling Map (Naic Side)

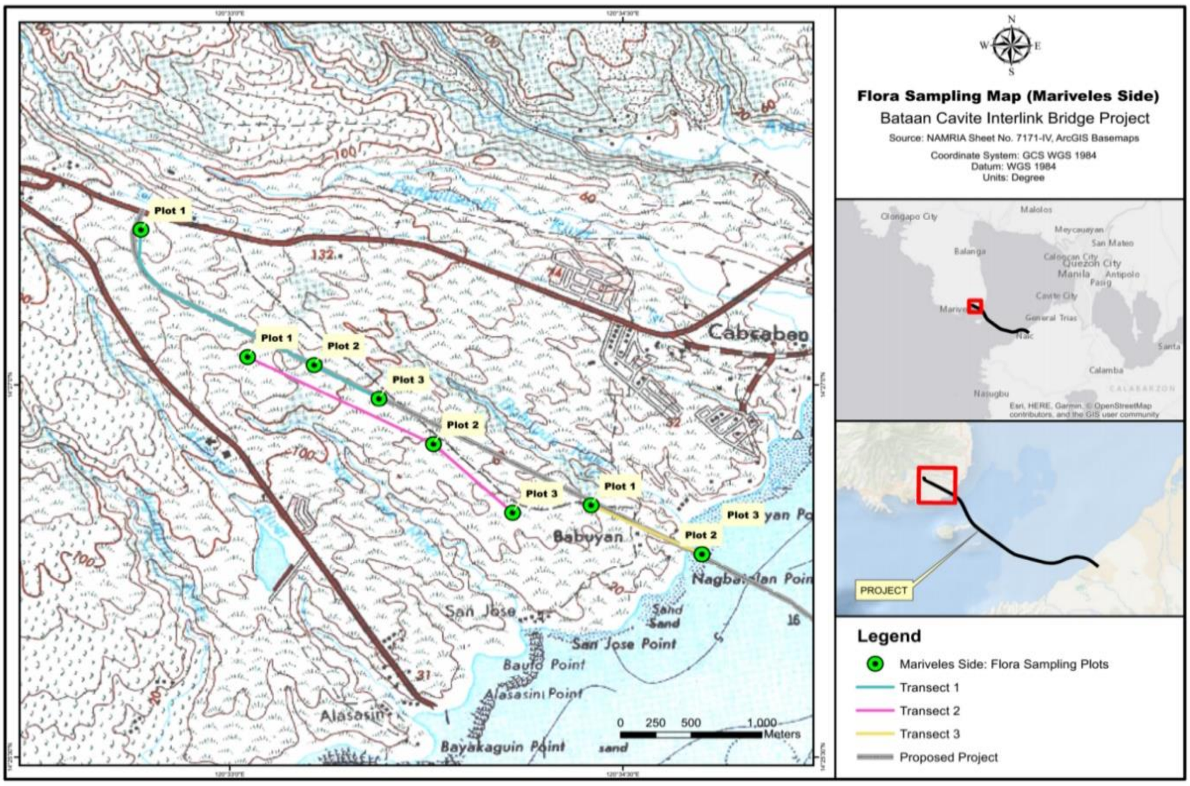


Figure 2.52 Flora Sampling Map (Mariveles Side)

(a) Vegetation Characterization

A desktop review of publicly available information was conducted to have an overview of the existing vegetation of the Project area. Reviewed data were validated during field assessment. Using results of baseline data and desktop review, vegetation cover was described, and the sites were characterized i.e. secondary forest, grassland, and agro-ecosystem type.

Plants found in each sampling plot were identified and classified either as trees or saplings. Species that could not be identified onsite was documented in detail. Photos and description of morphological features of the plant were recorded and verified using available published taxonomic literature and the National Herbarium images to identify the species. Online resources were also utilized, such as Co's Digital Flora (www.philippineplants.org) and International Plant Names Index (IPNI) [www.ipni.org].

(b) Conservation Status

After species identification, conservation status of each species was checked using the DENR Department Administrative Order (DAO) 2017-11 list and the latest International Union for Conservation of Nature (IUCN) Red List of Threatened Species (www.iucnredlist.org). Conservation status pertains to the probability of a species to survive in the present and in the future with two major categories: threatened and non-threatened. IUCN defined a threatened species as those that fall under the categories of either Vulnerable, Endangered, or Critically Endangered. Other categories used by the IUCN are Near Threatened, Least Concern, and Data Deficient.

(c) Integrated Biodiversity Assessment Tool

Based on the Integrated Biodiversity Assessment Tool (IBAT) data from the report prepared by SCE Ltd., there are two Nationally Protected Areas within the vicinity of the project area- the Mariveles Watershed Forest Reserve and Mounts Palay – Palay – Mataas na Gulod National Park. These areas are not within the project location and no flora individuals within the protected areas will be affected by the proposed project. No threatened flora species were listed in SCE Ltd. report, nevertheless, observed threatened species during field sampling are discussed in the following sections.

(d) Endemism

Endemism refers to the restriction of a taxon or species to a particular geographical area of the world. A species is classified as endemic if it is unique to a geographic location, i.e., province or country. An indigenous species, on the other hand, is also found elsewhere. Introduced species or exotic species are plants that are not native in the area but are being planted or cultivated.

The species recorded on the sampling sites were classified into Endemic (En), Indigenous (Ind) and Introduced (Int) based on the available published literature and online sources (i.e. IUCN database, 2019).

(e) Invasiveness

Invasive species are species which colonize in an area that usually outcompete the natural growing vegetation. Their presence may result in potential damage to the environment, human economy, or human health.

Using the latest Global Invasive Species Database (www.iucngisd.org), species recorded in the project site were classified as Invasive or Non-invasive.

(f) Biodiversity indices

Biodiversity indices are mathematical measure of species diversity in a community/ecosystem. It provides quantitative data of comparison between various habitats. For this project, species richness and evenness are the common concepts used.

i. **Species richness** (n) is the number of plant species in a given area

Species richness (n) = $\frac{number\ of\ species}{transect\ line}$

Shannon diversity index (H')

$$\text{Diversity Index}(H') = -\sum n_i \ln\left(\frac{n_i}{N}\right)$$

ii. **Evenness** (e') refers to how well-distributed the individuals within a community over different species.

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

Indices for plant species diversity and evenness were classified using Fernando et al, 1998. Diversity relative values categories are presented in **Table 2.12**.

Table 2.12 Relative values for plant species diversity (Fernando et. al, 1998)

Relative values	Species diversity (H')	Evenness index (e')
Very high	3.500 – 4.000	0.750 - 1.000
High	3.000 – 3.499	0.500 – 0.740
Moderate	2.500 – 2.999	0.250 – 0.490
Low	2.000 – 2.499	0.150 – 0.240
Very low	1.999 and below	0.140 and below

(g) Importance Value Index (IV)

Importance value (IV) index is used to determine the overall importance of each species in the community structure. It reflects the influence a species exerts on the ecosystem. The formulas adapted from Magurran (1988) were used to compute for the following parameters:

Population Density is the population count, density per 100 m²

Population Density (De) = $\frac{total\ number\ of\ individuals\ from\ all\ species}{100\ m^2\ or\ hectares}$

Relative Density (RDe) = $\frac{density\ of\ a\ species}{total\ density\ for\ all\ species}$

Frequency is the number of times the species encountered

Absolute Frequency (Fr) = $\left(\frac{No.of\ species\ occurence\ in\ a\ transect}{no.of\ plots\ in\ each\ transect}\right) x\ 100$

Relative Frequency (RF) = $\frac{Absolute\ frequency\ of\ a\ species}{Total\ frequency\ for\ all\ species}$

Species Dominance is the coverage/basal area of a species

Species Dominance (Do) = $0.7854\ (DBH\ in\ cm^2 or\ basal\ area)$

Relative Dominance (RDo) = $\left(\frac{dominance\ of\ a\ species}{dominance\ value\ for\ all\ species}\right) x\ 100$

(h) Importance Value

Importance Value IV = RDe + RF + RDo

B) Fauna Assessment

The fauna assessment was conducted to characterise the existing fauna assemblage along the BCIB alignment and identify potential impacts of the project on fauna and corresponding mitigation measures.

Fauna sampling was conducted in Barangay Timalan Concepcion, Naic, Cavite and in Barangay Alas-asin, Mariveles, Bataan on 8 February and 14-15 February 2020, respectively. The weather during the sampling period ranged from sunny to cloudy.

Fauna transects were established along existing roads, trails and access along the BCIP alignment that represent the direct and indirect impact areas. Each of the established transects were traversed at a pace of approximately 250m in every 15 minutes from 6am to 9am and 3pm to 5pm (**Plate 1**). All fauna species observed (seen and/or heard) along the transects were identified to the lowest possible taxa, counted and recorded.

Plate 1 Transect survey

Netting: Mist nets were installed in strategic locations particularly in select areas along the established transects (**Plate 2**). Netting was employed to survey birds and volant mammals that are cryptic, crepuscular (active during dusk and dawn), and nocturnal in nature. Nets were regularly checked and retrieved of netted individuals. Netted individuals were then identified to the lowest possible taxa, counted and recorded prior to release on site.

Plate 2 Mist netting

Trapping: Trapping was employed to survey non-volant mammals (i.e. rodents, shrews etc), see **Plate 3**. Similar with the netting, live cage traps were set in select areas along the established transects. Traps were left overnight and retrieved early the following day. Trapped individuals were identified to the lowest possible taxa, counted, and recorded prior to release on site.

Plate 3 Cage trapping

Night sampling: The cruise method was employed for the night sampling. Select areas along the transects were traversed from 6pm to 7pm to survey nocturnal fauna species particularly amphibians and reptiles. Species observed were identified to the lowest possible taxa, counted, recorded and left unharmed.

Photos were taken to document species recorded during the survey.

Integrated Biodiversity Assessment Tool: Based on the IBAT data from the report prepared by SCE Ltd., there are two Nationally Protected Areas within the vicinity of the project area- the Mariveles Watershed Forest Reserve and Mounts Palay – Palay – Mataas na Gulod National Park. These areas are not within the project location and no flora individuals within the protected areas will be affected by the proposed project. No threatened flora species were listed in SCE Ltd. report, nevertheless, observed threatened species during field sampling are discussed in the following sections.

Diversity, evenness, and dominance indices were calculated to determine the complexity of the fauna assemblage along the BCIB alignment.

Table 2.13. Fauna Transects Surveyed during the Assessment

No.	Starting point	End point	Locality	Habitat description	Photo
1	14.460414° N, 120.544344° E	14.449069° N, 120.559473° E	Barangay Alas-asin, Mariveles, Bataan	Direct impact area characterized by wooded grasslands	 

<table>
<tr><th>No.</th><th>Starting point</th><th>End point</th><th>Locality</th><th>Habitat description</th><th>Photo</th></tr>
<tr><td>2</td><td>14.451866° N, 120.551128° E</td><td>14.441410° N, 120.567978° E</td><td>Barangay Alas-asin, Mariveles, Bataan</td><td>Indirect impact area characterized by wooded grasslands</td><td>
</td></tr>
<tr><td>3</td><td>14.446389° N, 120.564853° E</td><td>14.438637° N, 120.580025° E</td><td>Barangay Alas-asin, Mariveles, Bataan</td><td>Direct impact area characterized by wooded grasslands and coastal vegetation</td><td>

</td></tr>
</table>

No.	Starting point	End point	Locality	Habitat description	Photo
4	14.335278° N, 120.785833° E	14.341945° N, 120.776667° E	Barangay Timana Concepcion, Naic, Cavite	Direct impact area characterized by wooded grassland, residential, cultivated lands (i.e. yard gardens, rice fields), and coastal vegetation.	 

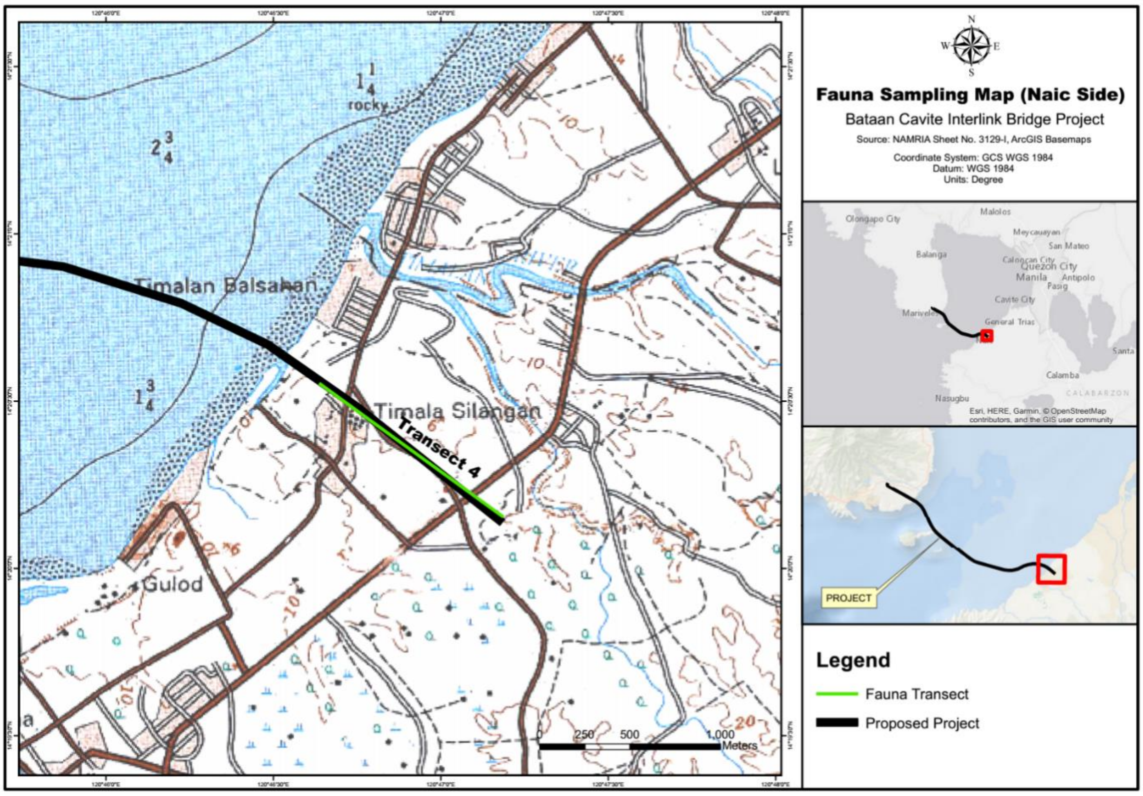


Figure 2.53 Fauna Sampling Map (Naic side)

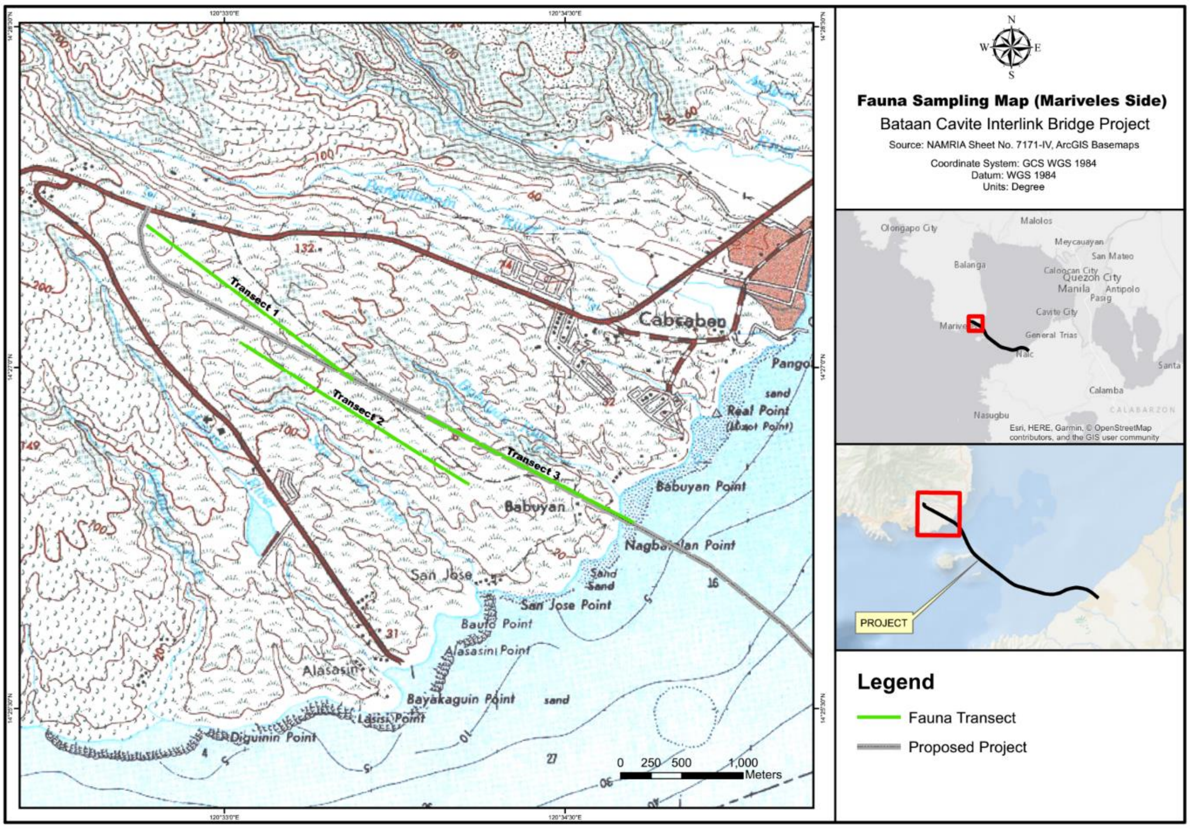


Figure 2.54 Fauna Sampling Map (Mariveles side)

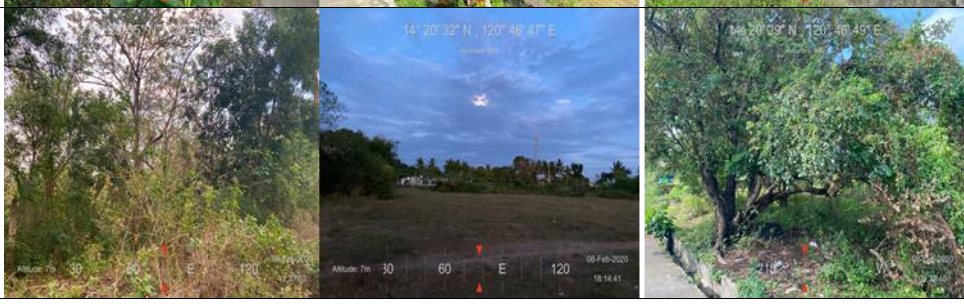
2.1.5.2 Baseline Environmental Conditions

A) Flora Assessment

General vegetation of project location in Mariveles, Bataan was grassland community with patches of trees and scattered private plantation of coconut (**Table 2.14**). Private land was fenced with Narra (*Pterocarpus indicus*), Eucalyptus (*Eucaplyptus camaldulensis*), Kakauate (*Gliricidia sepium*) and Mangium (*Acacia mangium*). Transect 1 traversed the main entrance of the proposed bridge from Roman Highway to an existing barangay road in Alas-asin. This transect was a direct impact area composed of grassland community with few patches of trees. Agroforest community composed of coconut (*Cocos nucifera*) and bananas (*Musa* sp.) was also observed along this transect. Transect 2 was an indirect impact area established parallel to the alignment of the Project. Similarly, grassland communities with patches of trees and agroforest species were noted in this transect. Grassfire was observed along this transect. It was validated in an interview with the locals that grass fire is very common in the area especially during dry season. Transect 3 was established within riparian areas and beach forest. It included fruit trees species in riparian areas such as Manga and Duhat and beach forest species such as Talisai (*Terminalia cattapa*) and Coconut.

Naic, Cavite is an urban area and an existing concrete road will serve as entrance of the bridge from this side. Most of the affected vegetation in the area were planted species mostly introduced or exotics. Transect 1 was established from the proposed entrance of the bridge to the beach area while Transect 2 was established parallel to the alignment of the Project. Both transect traversed idle grassland, built ups and residential areas hence minimal vegetation was observed in this area as compared to the Mariveles side.

Table 2.14 Photo documentation of established transects during site visits

Mariveles, Bataan	
Transect 1	
Transect 2	
Transect 3	
Naic, Cavite	
Transect 1	
Transect 2	

Plant Diversity Assessment

(a) Plant Form

Most of the flora species recorded in the direct and indirect impact area of the Project were tree species with 62% and 37% in Mariveles and Naic side, respectively. However, it should be noted that these trees were in intermediate and undergrowth layer at its juvenile (seedlings/saplings) stage. **Figure 2.55** presents plant form distribution of species recorded in the Project area.

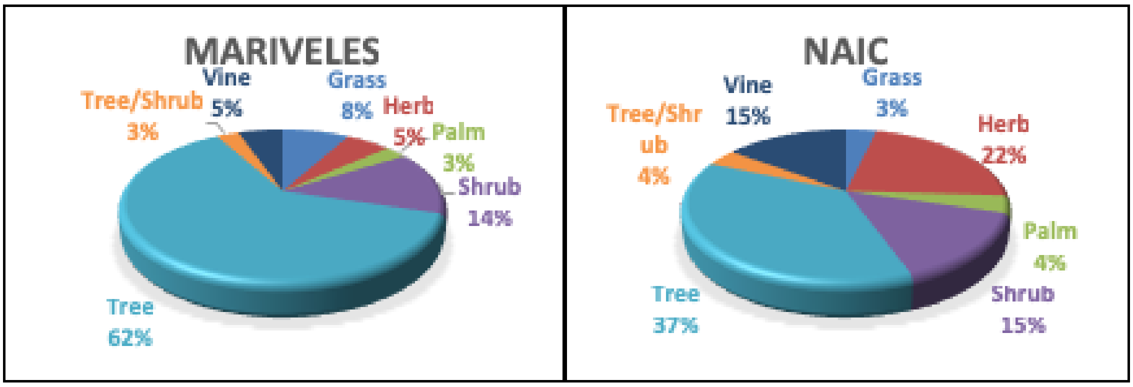


Figure 2.55 Plant form distribution of species recorded

(b) Floral taxonomy

Given the existing land use of the project area, it is expected that number of species were relatively low as compared to a natural forest (**Table 2.15**). Most of the species recorded were from FABACEAE (**Table 2.16**) family which the third largest angiosperms (flowering plants) family composing legumes and peas with vines to trees plant habit. Mariveles side has more plant taxa as compared to Naic side. This was expected as the former has longer road stretched than the latter.

Table 2.15. Taxa Richness of project area

	Mariveles	**Naic**
Species	37	27
Genus	36	26
Family	23	20

Table 2.16. Distribution of Flora family

Mariveles		**Naic**	
AMARANTHACEAE	1	AMARANTHACEAE	1
ANARCARDIACEAE	1	APOCYNACEAE	1
APOCYNACEAE	2	ARACEAE	1
ARECACEAE	1	ARECACEAE	1
ASTERACEAE	1	ASTERACEAE	2
BURSERACEAE	1	BROMELIACEAE	1
COMBRETACEAE	1	CARICACEAE	1
CONVOLVULACEAE	1	COMBRETACEAE	1
EUPHORBIACEAE	2	CONVOLVULACEAE	1
FABACEAE	6	CUCURBITACEAE	1
LAMIACEAE	3	EUPHORBIACEAE	1
LAURACEAE	1	FABACEAE	6
LYTHRACEAE	1	LAMIACEAE	1

Mariveles		Naic	
MELIACEAE	1	MELIACEAE	1
MORACEAE	4	MORACEAE	2
MORINGACEAEA	1	MORINGACEAE	1
MYRTACEAE	1	MUSACEAE	1
PHYLLANTHACEAE	1	POACEAE	1
POACEAE	3	RHAMNACEAE	1
SAPOTACEAE	1	VERBENACEAE	1
STERCULIACEAE	1		
TILIACEAE	1		
VERBENACEAE	1		

(c) Ecological Distribution

Among the plant species recorded within the established transects only 3% or only one (1) species was recorded as endemic in the country (**Figure 2.56)**. Philippine endemic species are plant species that are native and can only be found in the country. Endemic species recorded in the area was antipolo (*Artocarpus blancoi).* Indigenous plant species are those that are naturally growing in the area but are also found in other geographical location. A total of 54% and 33% in Mariveles and Naic, respectively, were recorded as indigenous species. On the other hand, there were introduced species that composed the 43% and 67% in Mariveles and Naic, respectively. Introduced species or exotic species are plants that are not native in the area but are being planted or cultivated. High percentage of exotic species in Naic side can be attributed to garden or urban landscape species that were planted in the area.

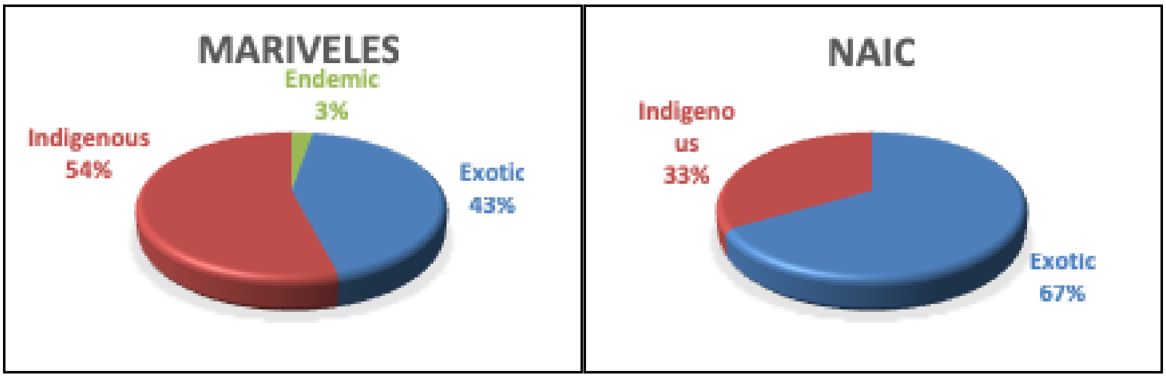


Figure 2.56 Ecological Distribution of Plant Species

(d) Diversity and Evenness

The results showed that the diversity index of established transects for both Municipalities of Mariveles and Naic are 2.19 to 2.82. Based on Fernando 1998, these values can be described as low to moderately diverse (**Figure 2.57**). Given the land use of the project area (grassland and built up) with no natural forests, these levels of diversity were expected. Evenness, on the other hand, ranged from 0.83 to 0.92 in both municipalities. Based on Fernando 1998 et al, evenness in the area both Mariveles and Naic was very high or the distribution of flora species in the area was uniform (**Figure 2.58**).

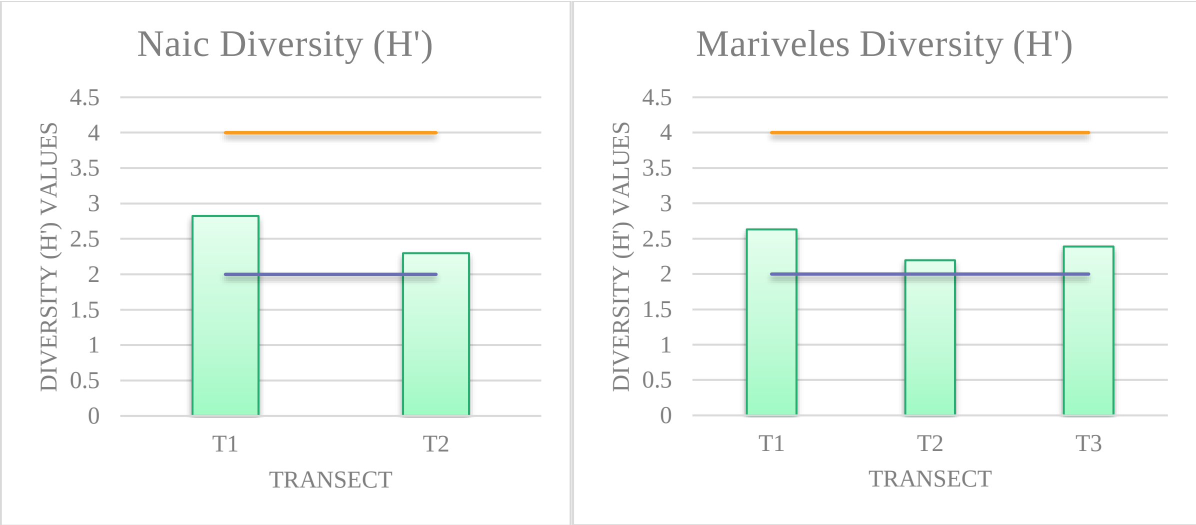


Figure 2.57 Diversity Indices

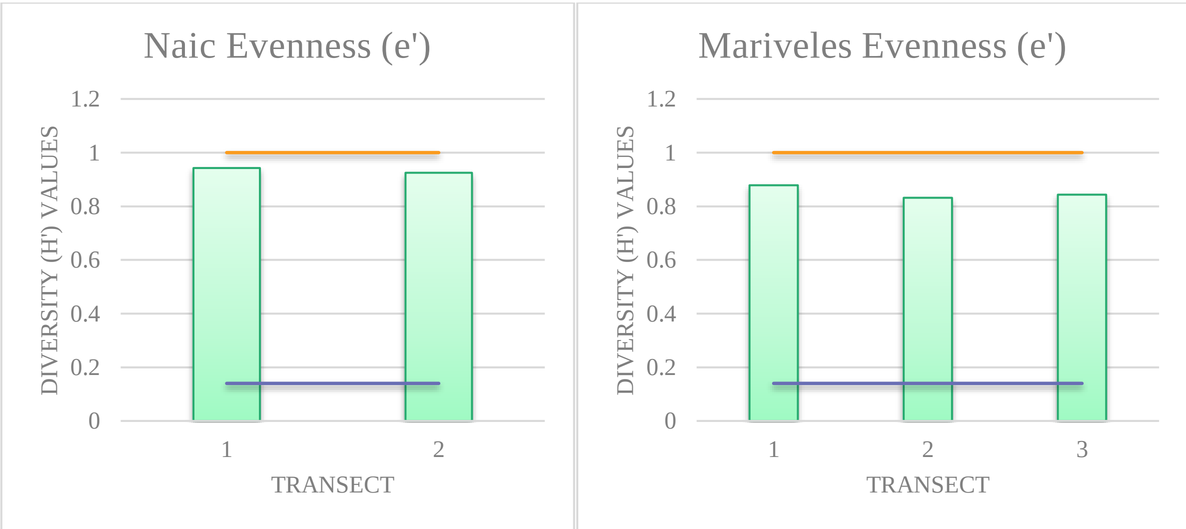


Figure 2.58 Evenness of Established Transects

(e) Density and Species Richness

Threatened Flora Species/ Floral Conservation Status

Conservation status of each species was assessed using DAO 2017-11 and the latest available IUCN Redlist. Among the species recorded in the Project area, three (3) species were considered as threatened. These three threatened species found in the Project site were categorized as Vulnerable (Vu) either by DAO 2007-01 or IUCN red list. “Vulnerable” refers to species or subspecies that is neither critically endangered nor endangered but is under threat from adverse factors throughout their range and is likely to move to the endangered category in the near future. Only Narra is considered as Endangered (En) by IUCN and Vulnerable (Vu) under DAO 2017-11. Endangered species is a species which has been categorized as very likely to become extinct in the near future.

(f) Invasive Species

A list of invasive species was generated using Global Invasive Species Database of IUCN. **Table 2.17** presents the invasive species recorded within the established transect. There were at least nine (9) species identified as invasive plant recorded during sampling. These invasive species were distributed in both municipality of the project location. While other species are considered as invasive, some of this species have economic value, especially mangium that is a good source of lumber in the country.

Table 2.17. Invasive Species Recorded within Established Transect

Common Name	Species	Family	Location	Habit
Aroma	*Acacia farnesiana*	FABACEAE	Naic	Tree
Coronitas	*Lantana camara*	LAMIACEAE	Naic & Mariveles	Shrub
Hagonoi	*Chromolaena odorata*	ASTERACEAE	Naic & Mariveles	Herb
Ipil-Ipil	*Leucaena leucocephala*	FABACEAE	Naic & Mariveles	Tree
Talisai	*Terminalia catappa*	COMBRETACEAE	Naic & Mariveles	Tree
Cogon	*Imperata cylindrica*	POACEAE	Mariveles	Grass
Duhat	*Syzygium cumini*	MYRTACEAE	Mariveles	Tree
Mangium	*Acacia mangium*	FABACEAE	Mariveles	Tree
Sablot	*Litsea glutinosa*	LAURACEAE	Mariveles	Tree

(g) Importance Value (IV)

Importance value (IV) index was used to determine overall importance of each species in the community structure. It reflects the influence a species exerts on the ecosystem. It considers the density, frequency, and basal area for the overstorey layer. The intermediate and undergrowth layers only require density and frequency. The list of dominant species recorded in three layers in six transects is shown in **Table 2.18**.

Dominant species for overstorey layer were Narra, Coconut, Antipolo and Banana. Except for antipolo, these overstorey species were all planted in the project area. The agricultural crops (Banana and Coconut) were being cultivated by the locals while Narra was planted as fencing. In the intermediate layer, dominant species were Narra, Kakauate, Ipil-ipil (*Leucaena leucocephala*), Cassava (*Manihot esculenta*), and Neem tree (*Azadirachta indica*). Except for Cassava, all these dominant species in the intermediate layer were used as yard fencing. For understorey, grass species and associated plants were observed as dominant species. Carabao grass (*Paspalum conjugatum*), Cogon (*Imperata cylindrica*), Uoko (*Mikania cordata*) and Dokot-dokot (*Achyranthes aspera*) were recorded.

Table 2.18. List of Species with Highest IV within Established Transects

Location	Overstorey	Intermediate	Understorey
Mariveles			
Transect 1	Narra (*Pterocarpus indicus*) 94.9	Narra (*Pterocarpus indicus*) 36.5	Carabao grass (*Paspalum conjugatum* (Berg.)) 60.5
Transect 2	Coconut (*Cocos nucifera*) 123.2	Kakauate (*Gliricidia sepium*) 58.3	Carabao grass (*Paspalum conjugatum* (Berg.)) 67.4
Transect 3	Antipolo (*Artocarpus blancoi*) 64.2	Ipil-ipil (*Leucaena leucocephala*) 86.7	Cogon (*Imperata cylindrica*) 60.5
Naic			
Transect 1	Banana (*Musa* sp.) 90.9	Cassava (Manihot esculenta) 71.2	Uoko (*Mikania cordata*) 29.7

Location	Overstorey	Intermediate	Understorey
Transect 2	Coconut (*Cocos nucifera*) 147.1	Neem tree (*Azadirachta indica*) 83.3	Dokot-dakot (*Achyranthes aspera*) 64.3

(h) Plant Form

Most of the flora species recorded in the direct and indirect impact area of the Project were tree species with 62% and 37% in Mariveles and Naic side, respectively. However, it should be noted that these trees were in intermediate and undergrowth layer at its juvenile (seedlings/saplings) stage. **Table 2.19** presents plant habit distribution of species recorded in the Project area.

Table 2.19. List of threatened species recorded within and adjacent to project area

Common Name	Species	Family	Transect	Plot	Layer	Plant Form/ Habit	Endemicity	IUCN	DAO 2017-11
Antipolo	*Artocarpus blancoi*	MORACEAE	3	1	Overstorey	Tree	Endemic	Vu	
Is-is	*Ficus ulmifolia*	MORACEAE	3	1	Intermediate	Shrub /small tree	Indigenous	Vu	
Narra	*Pterocarpus indicus*	FABACEAE	1	1,3	Overstorey, Intermediate	Tree	Indigenous	En	Vu

B) Fauna Assessment

(a) Diversity

Given the disturbed habitat conditions of the BCIB alignment, low diversity of mammals, amphibians, and reptiles was expected as reflected also by the low species richness recorded across these fauna groups during the survey. For the birds, overall bird diversity along the BCIB alignment is moderate with a diversity index of 2.54. Across transects, bird diversity ranged from very low (1.88) in Transect 3 to moderate (2.72) in Transect 2.

In terms of evenness, overall bird evenness was very high with an index of 0.71. Across transects, evenness ranges from high (0.54) in Transect 3 to very high (0.96) in Transect 2. Consequently, bird dominance index value was highest in Transect 3 and the least in Transect 2. Evenness and dominance values are influenced by the presence of certain species outnumbering other species recorded during the survey. Lowest evenness and highest dominance value recorded in Transect 3 reflects the high number of Eurasian tree sparrow (157 individuals) compared to the abundance of other birds recorded which only ranges from one to 12 individuals. On the other hand, highest evenness and lowest dominance index recorded in Transect 2 reflects the almost even distribution of bird abundances recorded during the survey.

(b) Conservation status

All the fauna species recorded during the survey were not listed under any threatened categories of the DAO 2019-09, IUCN Red List and CITES Appendices except for the Brahminy kite (*Haliastur indus*). Brahminy kite is listed in Appendix II of CITES. A CITES Appendix II species are not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. In addition, its inclusion as a CITES species particularly under Appendix II automatically categorizes it as an Endangered species under DAO 2019-09. **Plate 4** shows some of the fauna species recorded during the survey.

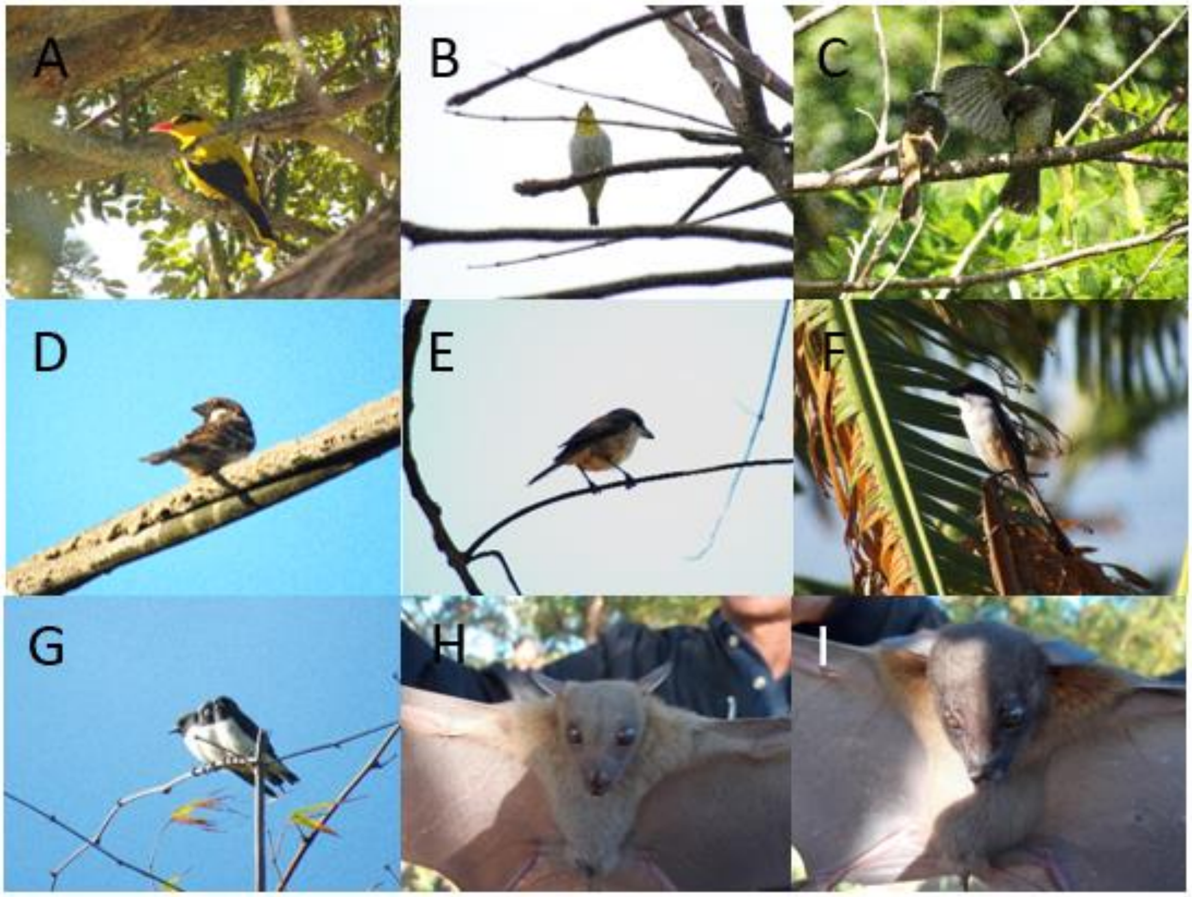


Plate 4. Fauna species recorded during the survey. A-black-naped oriole, B-lowland white-eye, C-yellow-vented bulbul, D-Eurasian tree sparrow, E-brown shrike, F-long-tailed shrike, G-white-breasted woodswallow, H-common short-nosed fruit bat, I-greater musky fruit bat.

(c) Critical Habitat Assessment

Based on the IBAT data from the critical habitat screening prepared by SCE Ltd, there are 35 threatened species listed (**Table 2.20**). An assessment on the occurrence of each species along the project alignment was conducted based on existing (1) habitat conditions along, adjacent and within the region where the project is located, (2) species habitat requirements, (3) behaviour (i.e. migratory) and (4) distribution.

Of the 35 IBAT-listed threatened species, only nine and two species were recorded to potentially and likely to occur along the project alignment. Seven of the nine potential species are migratory birds which likely passes along the project alignment during the migration months while the other two species are due to proximity of the project to protected areas: Mariveles Protected Area and Mts. Palay-Palay – Mataas na Gulod National Park. For the two species assessed as likely to occur on site are adapted to a wide range of habitats from undisturbed to disturbed at a certain degree. Although the project is foreseen to cause insignificant direct impact to these species, species should still be considered in the project implementation.

Table 2.20. List of species based on IBAT and occurrence on site

No	Scientific Name	Common Name	IUCN Status	Occurrence along the BCIB alignment
Birds				
1	*Cacatua haematuropygia*	Philippine Cockatoo	CR	Unlikely, but present in Mariveles Protected Area (MPA)
2	*Pithecophaga jefferyi*	Philippine Eagle	CR	Very unlikely, not within the species' distribution
3	*Oriolus isabellae*	Isabela Oriole	CR	Unlikely, but present in MPA
4	*Prioniturus luconensis*	Green Racquet-tail	EN	Unlikely, but present in MPA
5	*Numenius madagascariensis*	Far Eastern Curlew	EN	Potentially, but just a passer due to wintering grounds within Manila Bay
6	*Calidris tenuirostris*	Great Knot	EN	Potentially, but just a passer due to wintering grounds within Manila Bay
7	*Gorsachius goisagi*	Japanese Night-heron	EN	Potentially, but just a passer due to wintering grounds within Manila Bay
8	*Platalea minor*	Black-faced Spoonbill	EN	Potentially, but just a passer due to wintering grounds within Manila Bay
9	*Lonchura oryzivora*	Java Sparrow	EN	Likely, but an introduced species
10	*Nisaetus philippensis*	North Philippine Hawk-eagle	EN	Unlikely, but present in MPA and potentially in Mounts Palay-Palay-Mataas na Gulod National Park (MPPMGNP)
11	*Anas luzonica*	Philippine Duck	VU	Unlikely, but present in MPPMGNP and potentially in MPA
12	*Aythya ferina*	Common Pochard	VU	Potentially, but just a passer due to wintering grounds within Manila Bay
13	*Bubo philippensis*	Philippine Eagle-owl	VU	Unlikely, but potentially present in MPA and MPPMGNP
14	*Ramphiculus marchei*	Flame-breasted Fruit-dove	VU	Very unlikely, but potentially present in MPA and MPPMGNP
15	*Ducula carola*	Spotted Imperial-pigeon	VU	Very unlikely, but potentially present in MPA and MPPMGNP
16	*Egretta eulophotes*	Chinese Egret	VU	Potentially, but just a passer due to wintering grounds within Manila Bay
17	*Edolisoma mindanense*	Black-bibbed Cicadabird	VU	Very unlikely, but potentially present in MPA and MPPMGNP
18	*Hypothymis coelestis*	Celestial Monarch	VU	Very unlikely, but present in MPA nd potentially in MPPMGNP
19	*Geokichla cinerea*	Ashy Thrush	VU	Unlikely, potentially present in MPA and MPPMGNP

No	Scientific Name	Common Name	IUCN Status	Occurrence along the BCIB alignment
20	*Muscicapa randi*	Ashy-breasted Flycatcher	VU	Unlikely, potentially present in MPA and MPPMGNP
21	*Phoenicurus bicolor*	Luzon Water-redstart	VU	Unlikely, potentially present in MPA
22	*Phylloscopus ijimae*	Ijima's Leaf-warbler	VU	Unlikely, but present in MPA and potentially in MPPMGNP
23	*Erythrura viridifacies*	Green-faced Parrotfinch	VU	Potentially, due to proximity to MPA
24	*Emberiza sulphurata*	Yellow Bunting	VU	Unlikely, but potentially present in MPA and MPPMGNP
25	*Buceros hydrocorax*	Northern Rufous Hornbill	VU	Very unlikely, but potentially present in MPA and MPPMGNP in forest areas
26	*Ciconia episcopus*	Asian Woollyneck	VU	Potentially, but just a passer due to wintering grounds within Manila Bay
27	*Streptopelia dusumieri*	Philippine Collared-dove	VU	Likely, species occupies wide range of habitats
28	*Ceyx melanurus*	North Philippine Dwarf-kingfisher	VU	Unlikely, but present in MPA and potentially in MPPMGNP
Mammals				
29	*Acerodon jubatus*	Golden-capped Fruit Bat	EN	Very unlikely, but potentially present in MPA
30	*Rusa marianna*	Philippine Deer	VU	Very unlikely, but potentially present in MPA and MPPMGNP
Amphibians				
31	*Platymantis montanus*	Montane forest frog	VU	Very unlikely, but potentially present in MPA and MPPMGNP at higher elevations
Reptiles				
32	*Crocodylus mindorensis*	Philippine Crocodile	CR	Very unlikely, this is a freshwater species and has very limited distribution
33	*Dryophiops philippina*	Philippine Dryophiops	VU	Unlikely, but potentially present in MPA and MPPMGNP
34	*Hydrophis semperi*	Lake Taal Snake	VU	Very Unlikely, present only in Taal Lake
35	*Ophiophagus hannah*	King Cobra	VU	Potentially, due to proximity to MPA and open areas/grasslands.

2.1.5.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Flora

(a) Threat to Existence and/or Loss of Important Local Species

Among the species recorded within the Project area during field assessments, three (3) threatened flora species were noted based on DAO 2017-11 and latest available IUCN Red List (see **Table 2.19**). Loss of individuals of these important species will be inevitable during construction stage. However, loss of species that will result to extinction is unlikely. The three threatened species are well distributed in the country. Narra and antipolo are being used as reforestation species while Is-is is common indigenous pioneer species that is often found in open areas.

Similarly, tree cutting permit shall be secured from DENR before any cutting of trees will be implemented. All conditions of tree cutting permit following JMC 2014-01 (e.g. 1:100 replacement ratio) shall be followed. Same (threatened) species that will be removed or indigenous species that are commonly found in the area shall be used as preferred species for replacement. Replacement planting shall be planted preferably within areas with no development is deemed to be constructed. After replacement planting, regular monitoring shall be conducted to ensure growth and survival.

(b) Proliferation of invasive species

At least nine invasive plant species (**Table 2.17**) were recorded within the Project area. Possible proliferation of invasive species might occur in areas that will be cleared and opened during construction stage. To mitigate this impact, immediate revegetation with preference to indigenous plant species within the cleared and opened areas will be conducted. List of invasive species will be prepared during revegetation to avoid its re-introduction in the area. Monitoring and maintenance of revegetated areas will also be done to ensure the growth and survival of planted species.

B) Fauna

(a) Loss of habitat

Loss of habitat due to clearing along the inland sections of the BCIB alignment will be inevitable. However, this impact will be minimal and short-term given the disturbed habitat conditions along the BCIB alignment. To mitigate this impact, delineation on the ground of the areas to be cleared should be implemented to avoid and minimize unnecessary clearing. As appropriate, enhancement of nearby habitats or other areas identified by concerned LGU/government agency through tree planting as replacement of the trees that will be cut shall be implemented.

(b) Threat to the existence and/or loss of important local species

There were eight endemic and one endangered species recorded during the survey. Most of these species are birds and a bat which are highly mobile and can easily disperse to nearby suitable habitats during the development works along the BCIB alignment. Hence, there is only minimal threat to the existence of important local species recorded in the along the BCIB and it’s very likely that there will be no loss of species. Once construction is completed, important local species can recolonize their habitats near the BCIB. To protect these endemic and threatened species, a no hunting of wildlife policy will be implemented to all project personnel.

(c) Threat to abundance, frequency and distribution of fauna species

Temporary reduction in the abundance, frequency and distribution of fauna species along the BCIB and adjacent is expected due to the clearing, earthworks and other activities during the construction phase but once these activities are completed, then fauna species can recolonize nearby habitats along the BCIB alignment. To prevent further reduction of fauna species in the area, a no hunting policy shall be implemented. Delays on the implementation of the project should be avoided to lessen the time for fauna species to take refuge in other habitats and allow them to recolonize the adjacent habitats to the BCIB as soon as possible.

(d) Hindrance to Wildlife Access

The proposed project will be minimal or not cause hindrance to wildlife access. Fauna species can freely pass through the BCIB.

2.2 The Water

For this module, assessment was employed to determine baseline environmental conditions. These include:

a. Review of all available secondary information

b. Detailed field investigations

c. Water sampling

d. Marine fauna and flora inventory

The application of these methodologies is described in more detail in the subsequent sections for this module.

2.2.1 Hydrology/ Hydrogeology

This section presents the results of the studies to assess the potential water impacts from the project development. The assessments that were conducted for the project covered water resources and high-level review on the surface hydrology, as well as hydrogeology.

A) Cavite

A comprehensive study on water resources at Cavite has been undertaken in the Cavite Integrated Water Resource Management Master Plan by the Provincial Government of Cavite (Remulla, 2012). The landing point in Cavite is located inside the Labac River Basin, which has a drainage area of 94.5 km^2. This basin is considered as one of the major basins in Cavite. Based on the delineated river system of NAMRIA (**Figure 2.59**), it can be observed that the drainage pattern is radial since Cavite is located at the base of the Taal Volcano. The nearest river to the alignment is the Timalan River.

Figure 2.59 River systems in the Cavite and Bataan near BCIB landing points

A geo-resistivity survey was conducted along the coast of Cavite. Based on the results of this survey, the potential aquifer layer along the coast is located at approximately 80 to 100 meters below the mean sea level with a thickness of 100 meters. Considering the geology of the area, a potential aquifer consists of intercalated tuffs, tuffaceous sandstones, clay and silt.

B) Bataan

Like the drainage pattern in Cavite, the south-eastern portion of Bataan also exhibits radial drainage pattern, since it is located on the flanks of Mt. Mariveles. The landing point in Bataan is located inside the Pangolisanin/ Real River Basin with a drainage area of 36.3 km^2.

Based on the study of Tanuguchi in 2008, the aquifers on the south-eastern coast of Bataan consist of sand- to gravel-sized volcaniclastic sediments from the inactive volcanoes. This aquifer is confined by clay- to silt- sized ash that forms as discontinuous layers across the lower slope.

The proposed project will not likely affect the surface drainages within the Bataan and Cavite coastal areas. However, the section where the alignment will be located currently experience some flooding in Cavite side. Based on the flood susceptibility map of Cavite by the MGB (**Figure 2.45**), the alignment will transact areas which are moderately to highly susceptible to flooding. This is primarily caused by the lack of drainage canals that efficiently drain storm waters, further aggravated by the fact that the area is very close to the water line and forms a depressed low-elevation catchment the surrounding by slightly elevated highway area and residential lots. This will therefore be potentially aggravated during the construction phase. Thus, to minimize flooding in the project site, proper temporary measures must be established to consider the surface water flows and existing structures in the area.

2.2.2 Oceanography

2.2.2.1 Methodology

Hydrodynamic Modelling

In order to evaluate the hydrodynamic impact by BCIB, the Delft3D-FLOW model is adopted to predict the hydrodynamic impact due to the piers of the proposed BCIB by comparing the *without project* and *with project* cases. Hydrodynamic modelling will be used to check the possible changes in water circulation or pattern in the area. This will therefore be applicable to verify the possible changes in drainage morphology of hydrology and hydrogeology, and soil erosion.

This note presents the methodology for the relative value comparison for hydrodynamic impact assessment from the proposed BCIB under typical meteorological condition. The hydrodynamic condition during adverse weather is not considered in this technical note.

Assessment Area

The proposed BCIB connects the areas of Bataan and Cavite and will only be in the proximity to the east part of the Corregidor Island. The domain of the hydrodynamic model covers the whole Manila Bay, the BCIB, and outwards the West Philippine Sea as shown in **Figure 2.60**.

Figure 2.60. Hydrodynamic modelling assessment area

Model Grid Layout

This hydrodynamic model consists of about 7400 grids covering the area from east coastline of the Manila Bay outward the West Philippine Sea and its total distance is about 80 km. The grid size is based on the distance from the proposed BCIB. The minimum grid size of the model is about 140 m × 180 m located near the proposed BCIB, while the maximum grid of the model is about 1800 m × 2700 m and 4500 m × 800 m located near the open boundary at outer of Manila Bay and near Manila at inner of Manila Bay, respectively as shown in **Figure 2.61**. The model is divided by 10 equal thickness layers and its coordinate system is under PRS92 Zone 3.

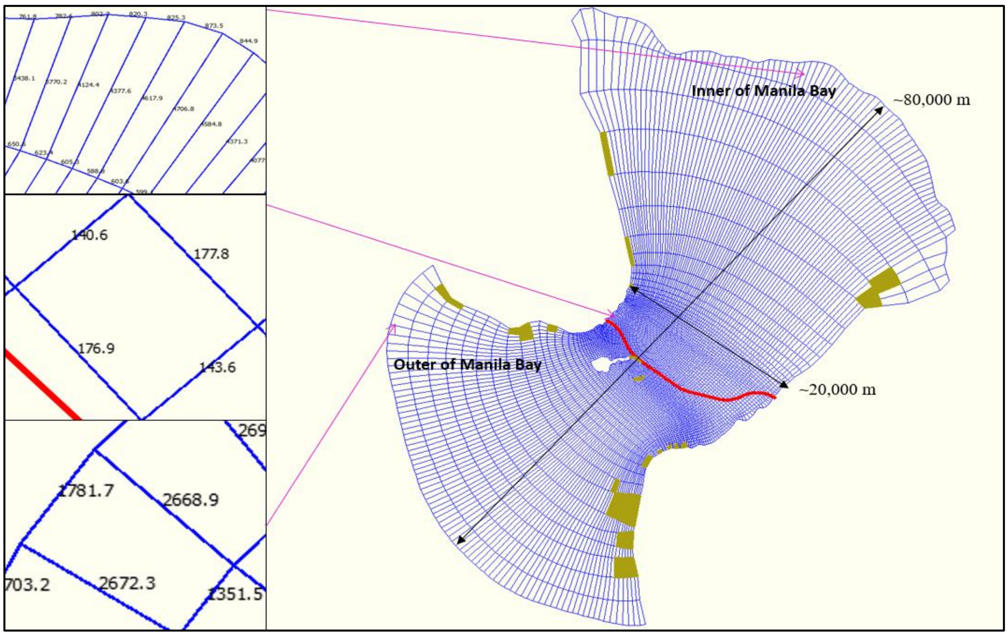


Figure 2.61. Model Grid

Model Bathymetry

The bathymetric data is based on the Nautical Charts, Manila Bay and Approaches under Philippines Islands Luzon – West Coast published by hydrographic of the Philippines. According to the overall bathymetric map, the depth of the hydrodynamic model near the western domain is about 600 m and the overall depth in the assessment area is shown in **Figure 2.62**. While a closer bathymetric map at the area along the proposed BCIB is shown in **Figure 2.63**, with surrounding depths that reaches 50 m.

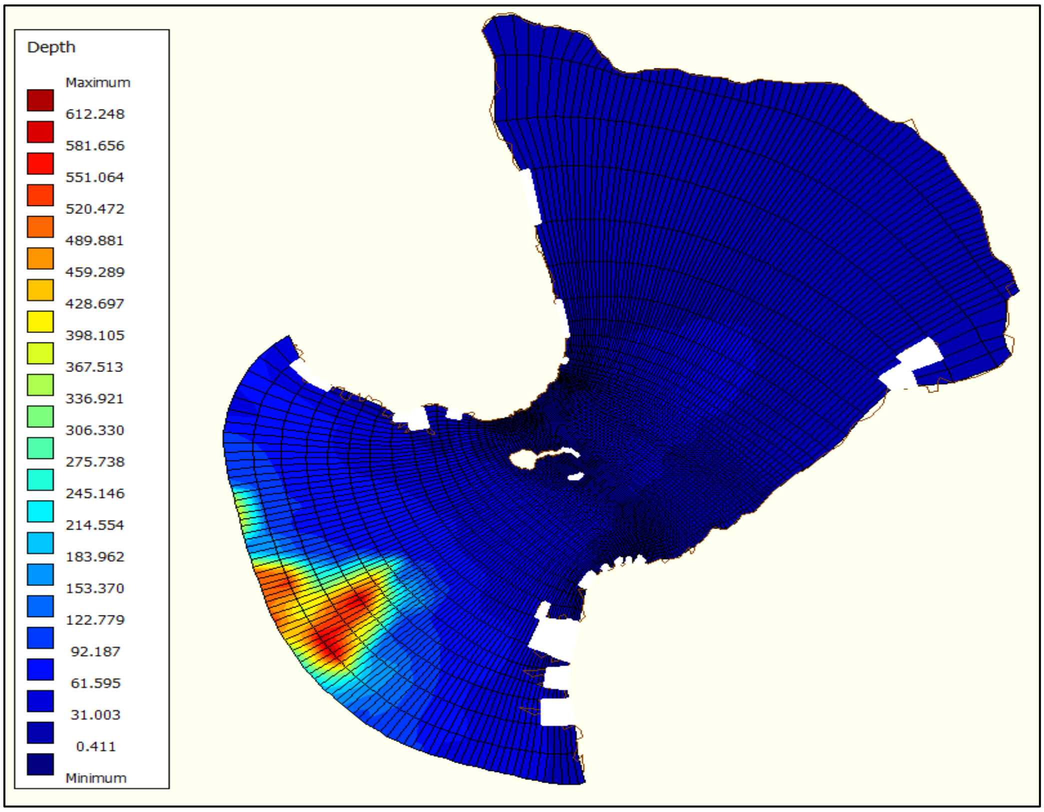


Figure 2.62. Bathymetric – Overall

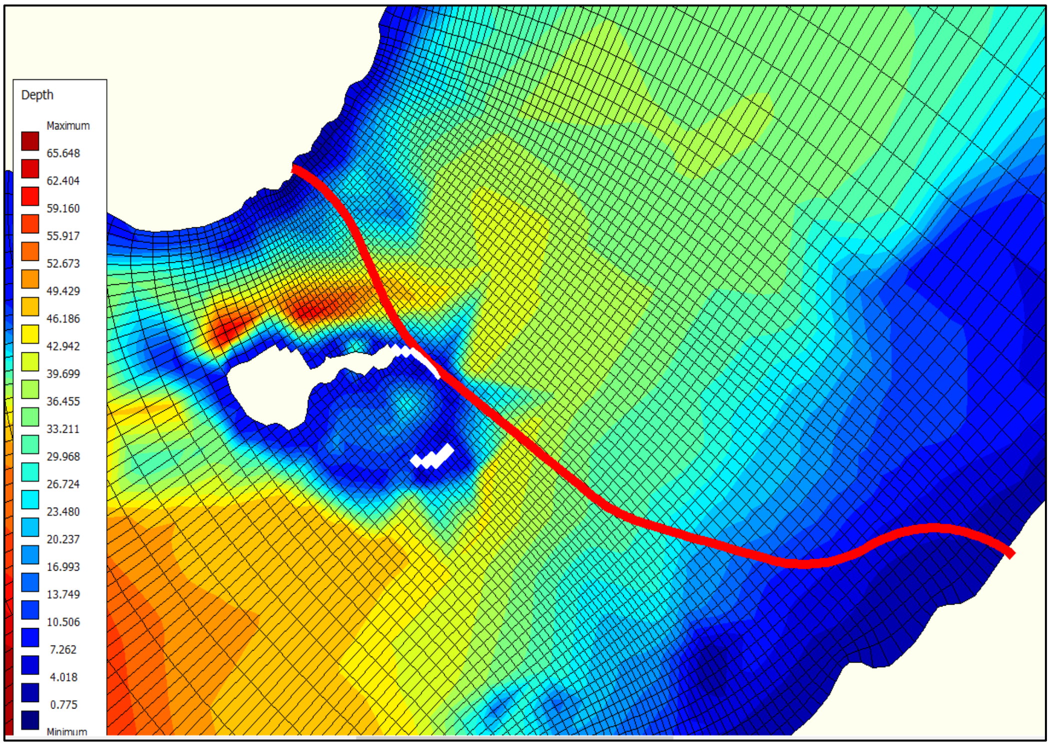


Figure 2.63. Bathymetric around BCIB

Model Scenarios

In order to compare the potential flow changes for the *with* and *without project* cases of the BCIB for both seasons, a total of four (4) scenarios are set as summarized in **Table 2.21.** Model Scenarios .

Table 2.21. Model Scenarios

Scenario	Without BCIB	With BCIB	Dry Season	Wet Season
1	√		√	
2	√			√
3		√	√	
4		√		√

Time Frame

In the hydrodynamic model, the time frame is set for a month plus 10 extra days spinning up time for the hydrodynamic simulation for both seasons. The running period for the dry season is set from 1 January 2020 to 10 February 2020, while the wet season is set from 1 July 2020 to 10 August 2020. In the running period, both seasons cover at least two spring-neap cycles. The *without project* scenario is adopted as the calibration with the online tidal data.

A time step of 6 seconds (0.1 minute) is used to achieve the Courant numbers less than 4√2, which is recommended by Section 10.4.2 in Delft3D-FLOW user manual.

The sensitivity test model with smaller time step of 0.05 minute is run as a trial to identify the difference between the time step of 0.1 and 0.05 minute. In the comparison of the result, there is insignificant difference with time steps of 0.1 minute. For achieving a more efficiency modelling, the time step of 0.1 minute is adopted for all scenarios.

According to the latest engineering design, about 260 bridge piers are required to support the proposed BCIB, which has a total length of about 20 km, crossing the Manila Bay. A summary of the number of each type of pier is given in **Table 2.22**. The locations and types of bridge piers and the layouts of the bridge piers are presented in **Annex H**. As the dimensions of each bridge pier is much smaller than the grid size, the special feature of the Delft3D-FLOW mode, namely porous plate is used for modelling the influence of the bridge piers.

Table 2.22. Summary of Pier Type

Type of Piers	Number of Piers for Each Type in BCIB	Pile Diameter (m)	No. of Piles for Each Pier
A	2	2.8	42
B	2	2.8	16
C	2	2.8	12
D	8	2.8	10
E	2	2.8	24
G	235	2.3	4
H	7	2.3	8

Physical Parameters

In accordance with the meteorological record from 1982 to 2010 of the nearest weather station at Sangley Point, Cavite (about 21 km from the BCIB), the prevailing wind directions are ESE (22.5º) and W (180º) and the average wind speed is 3 m/s for dry and wet season. Constant wind speed is used in the hydrodynamic model. Constant water temperature (World Sea Temperature, 2020) of 27ºC and 29ºC are adopted for dry and wet season, respectively. The comparison for dry and wet season in physical parameters is presented in **Table 2.23**.

Table 2.23. Comparison for Dry and Wet Season in physical parameters

Parameters	Dry Season	Wet Season
Run Time Period	1 Jan 2020 – 10 Feb 2020	1 Jul 2020 – 10 Aug 2020
Wind Data	3 m/s at 22.5°	3 m/s at 180°
Water temperature	27ºC	29ºC

The bottom roughness is in accordance with Delft Hydraulics (1998). A manning coefficient of n = 0.020 is adopted for the area with the water depth less than 5m while n = 0.026 is adopted for the area with the water depth larger than 10m. Besides, n = 0.023 is used for other water depths.

Boundary Conditions

As shown in **Figure 2.64**, the open boundary is located at the western of the model domain and is divided into four (4) boundary segments. Three boundary segments are set as “Water Level” while the remained one is set as “Current” along the open boundary. The forcing types of the model are Astronomic. The open boundaries of the model were extracted from Delft Dashboard using TPXO Global Tidal Models v7.2 (Nederhoff, 2016). A total of 13 astronomical constituents, with their respective amplitude and phase, are used for the boundary conditions. These are M2, S2, N2, K2, K1, O1, P1, Q1, MF, MM, M4, MS4, and MN4. Constant salinity is adopted in the model for all scenarios (constant transport conditions). Constant salinity (31ppt) is applied in the transport conditions for all open boundaries.

Transects and Observation Point

As shown in **Figure 2.64**, a total of three (3) transects (cross-sections) namely "Whole 1", "Whole 2", and "Whole 3" are set at outer of Manila Bay, near BCIB and inner of Manila Bay, respectively, and one (1) observation point is set at the location near Corregidor Island for the assessment in the model.

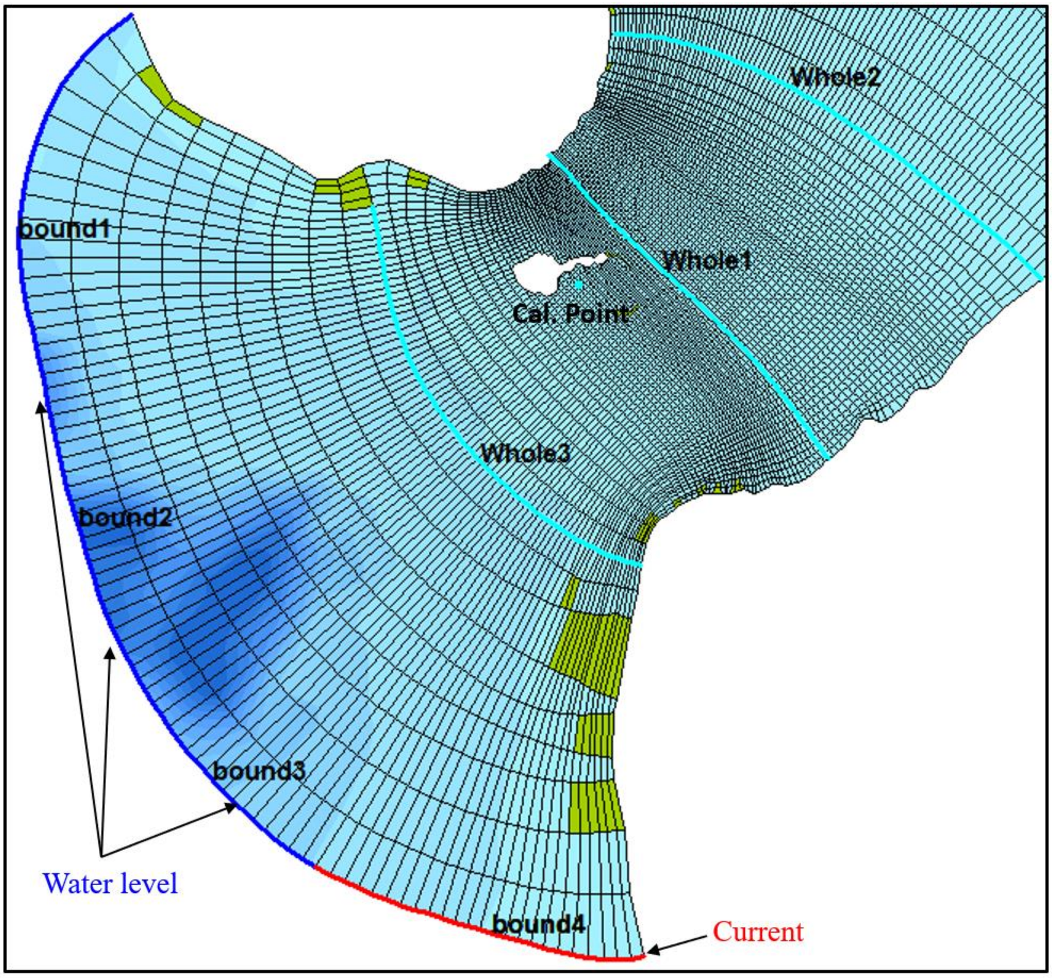


Figure 2.64. Open Boundaries, Cross-section & Calibration Point

Calibration

To validate the BCIB model, the predicted water levels at the observation point near Corregidor Island (marked in **Figure 2.64**) is adopted to compare with the data from the tidal station of Corregidor Island under International Hydrographic Organization (IHO), where data is extracted from Delft Dashboard.

Figure 2.65 shows that time series plots of water level comparing model prediction and tidal data of IHO tidal station that indicate the tidal range (the peak to peak magnitude) and the phase (timing at the tidal peak) are likely the same and has no significant difference in the hydrographic charts for both seasons. As such, the models are considered valid to assess the hydrodynamic impact.

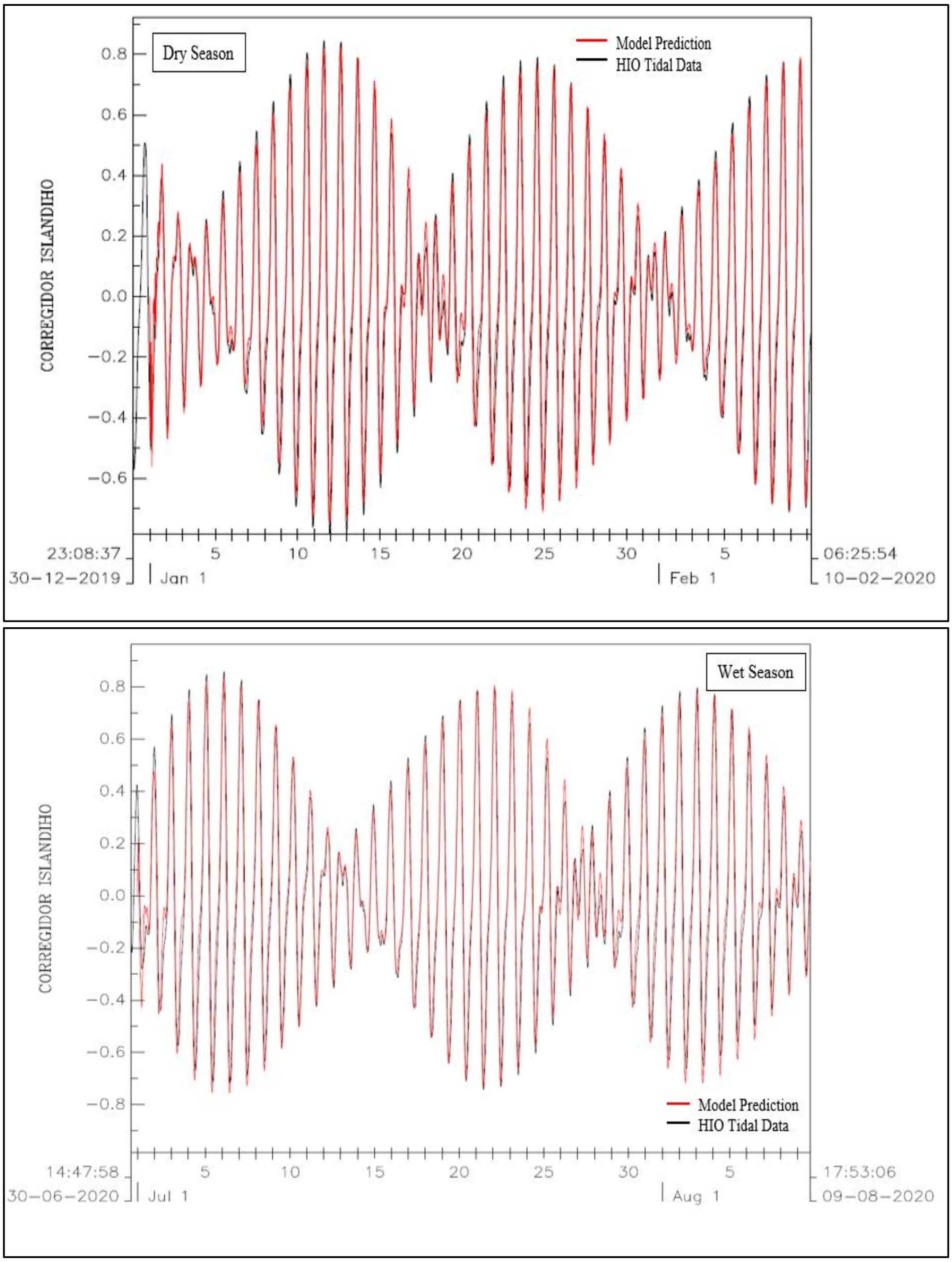


Figure 2.65. Water Level Calibration

2.2.2.2 Baseline Environmental Conditions

Hydrodynamic Modelling

Overall Momentary Flow and Accumulated Flow Across Manila Bay

The timeseries plots of momentary flow and accumulated flow are compared for the *without project* and *with project* scenarios at three (3) transects, namely Whole 1, Whole 2 and Whole 3, as indicated in **Figure 2.66.** The time series plots are presented in **Figure 2.66** and **Figure**

2.67 for dry season and **Figure 2.68Figure 2.68** and **Figure 2.69** for wet season. Their magnitude ranges are also summarised in **Table 2.24** and **Table 2.25**, respectively.

Table 2.24 Comparison Results of Momentary Flows at Representative Cross-sections

Transect	Seasons	Momentary Flow (m^3/s)			
		Without Project	With Project	Difference (m^3/s)	Difference (%)
Whole 1	Dry	-1.45E+05 / 9.48E+04	-1.44E+05 / 9.48E+04	6.72E+02 / -1.67E+01	<1%
	Wet	-1.42E+05 / 9.27E+04	-1.41E+05 / 9.27E+04	5.46E+02 / -5.96E+01	<1%
Whole 2	Dry	-1.21E+05 / 7.97E+04	-1.20E+05 / 7.97E+04	6.15E+02 / -2.66E+01	<1%
	Wet	-1.19E+05 / 7.79E+04	-1.18E+05 / 7.78E+04	5.10E+02 / -5.84E+01	<1%
Whole 3	Dry	-1.67E+05 / 1.08E+05	-1.66E+05 / 1.08E+05	7.24E+02 / -1.90E+01	<1%
	Wet	-1.63E+05 / 1.06E+05	-1.63E+05 / 1.06E+05	6.46E+02 / -6.90E+01	<1%

Table 2.25 Comparison Results of Accumulated Flows at Representative Cross-sections

Transect	Seasons	Accumulated Flow (m^3)			
		Without Project	With Project	Difference (m^3)	Difference (%)
Whole 1	Dry	-1.37E+09 / 1.49E+09	-1.37E+09 / 1.49E+09	-4.08E+06 / 1.55E+06	<1%
	Wet	-1.33E+09 / 1.46E+09	-1.34E+09 / 1.46E+09	-3.61E+06 / 1.13E+06	<1%
Whole 2	Dry	-1.11E+09 / 1.28E+09	-1.12E+09 / 1.28E+09	-3.32E+06 / 1.45E+06	<1%
	Wet	-1.15E+09 / 1.19E+09	-1.16E+09 / 1.19E+09	-3.99E+06 / 6.00E+04	<1%
Whole 3	Dry	-1.57E+09 / 1.72E+09	-1.58E+09 / 1.72E+09	-4.24E+06 / 1.61E+06	<1%
	Wet	-1.53E+09 / 1.68E+09	-1.53E+09 / 1.68E+09	-3.75E+06 / 1.17E+06	<1%

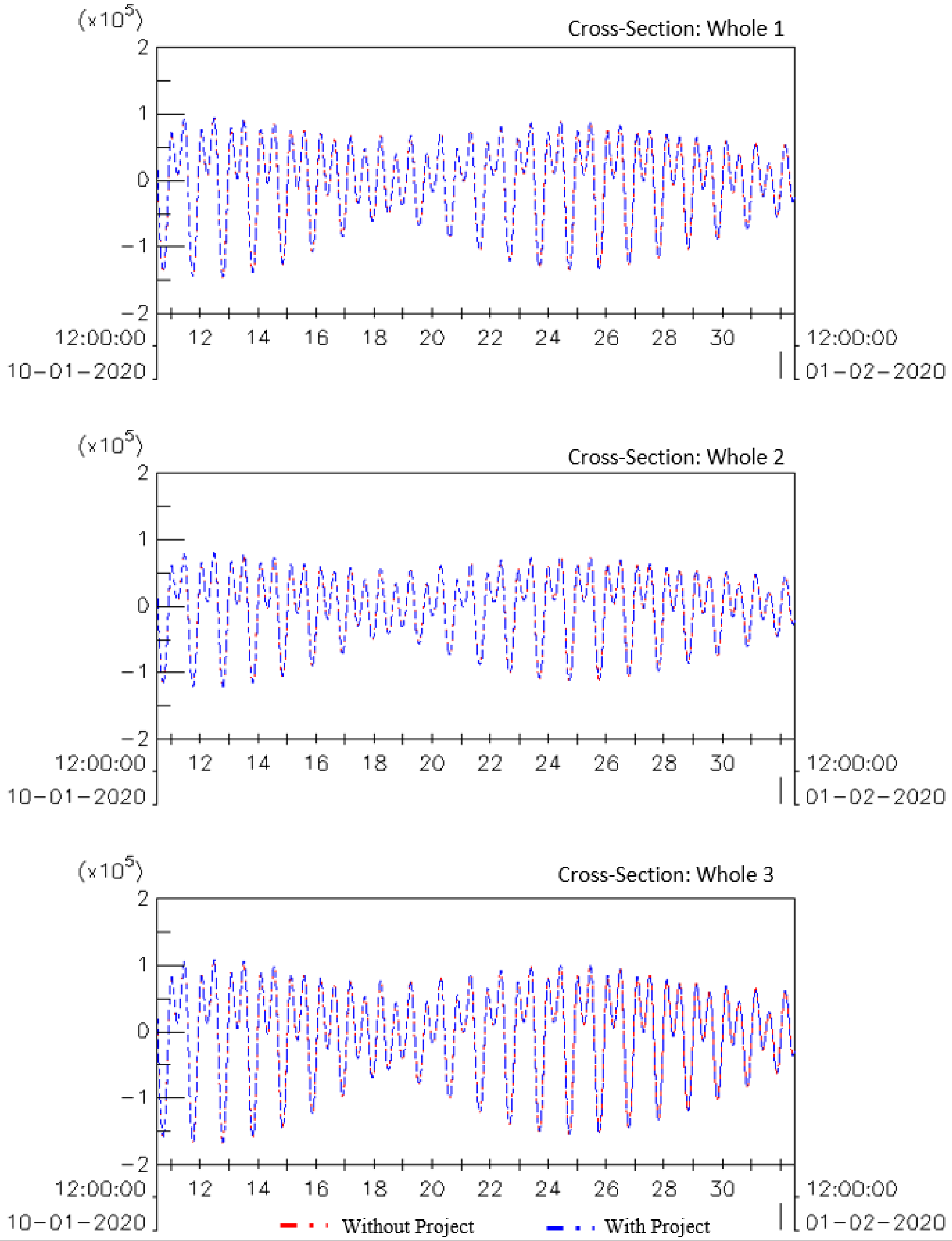


Figure 2.66. Momentary Flow Comparison – Dry Season

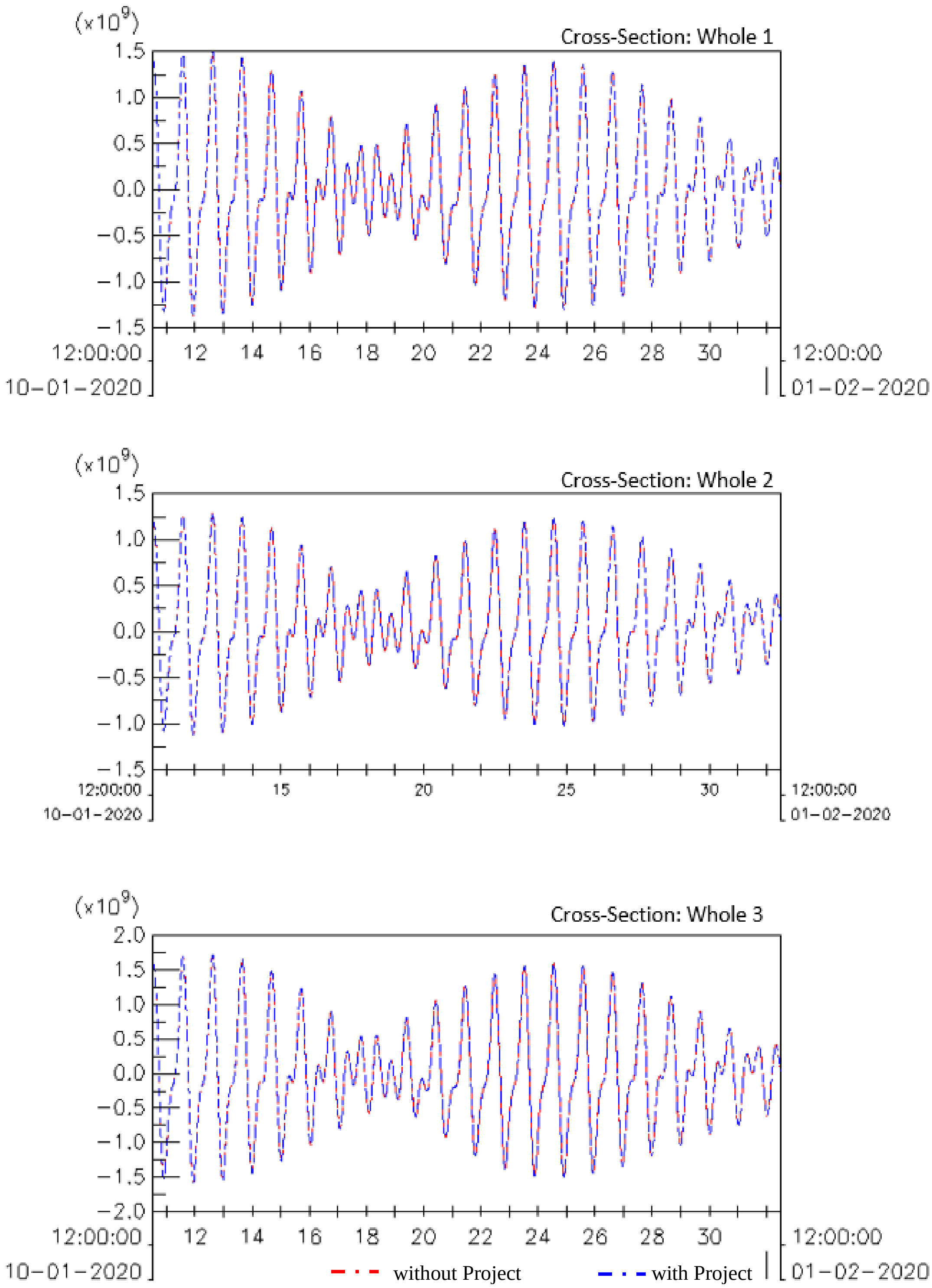


Figure 2.67. Momentary Flow Comparison – Wet Season

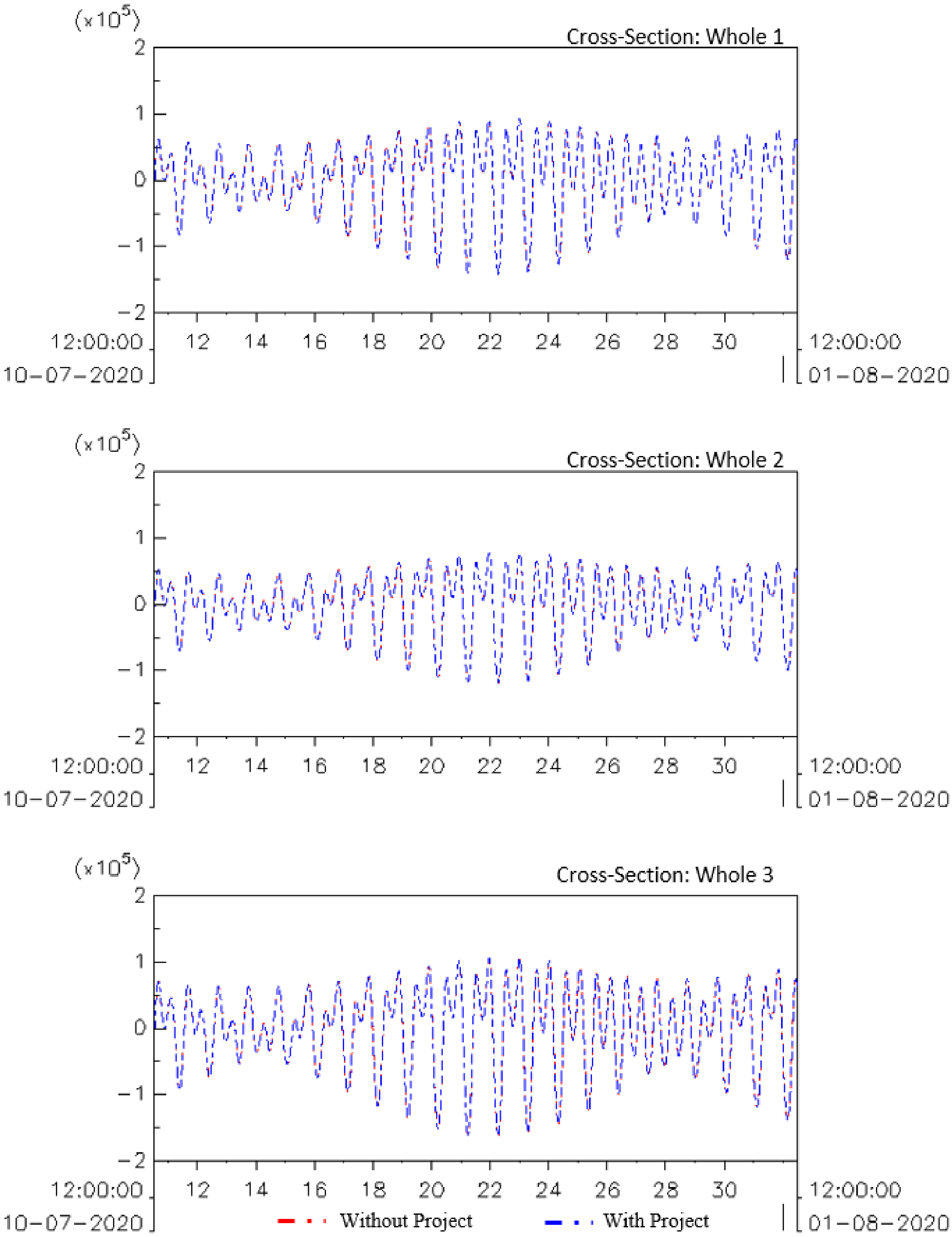


Figure 2.68. Accumulated Flow Comparison – Dry Season

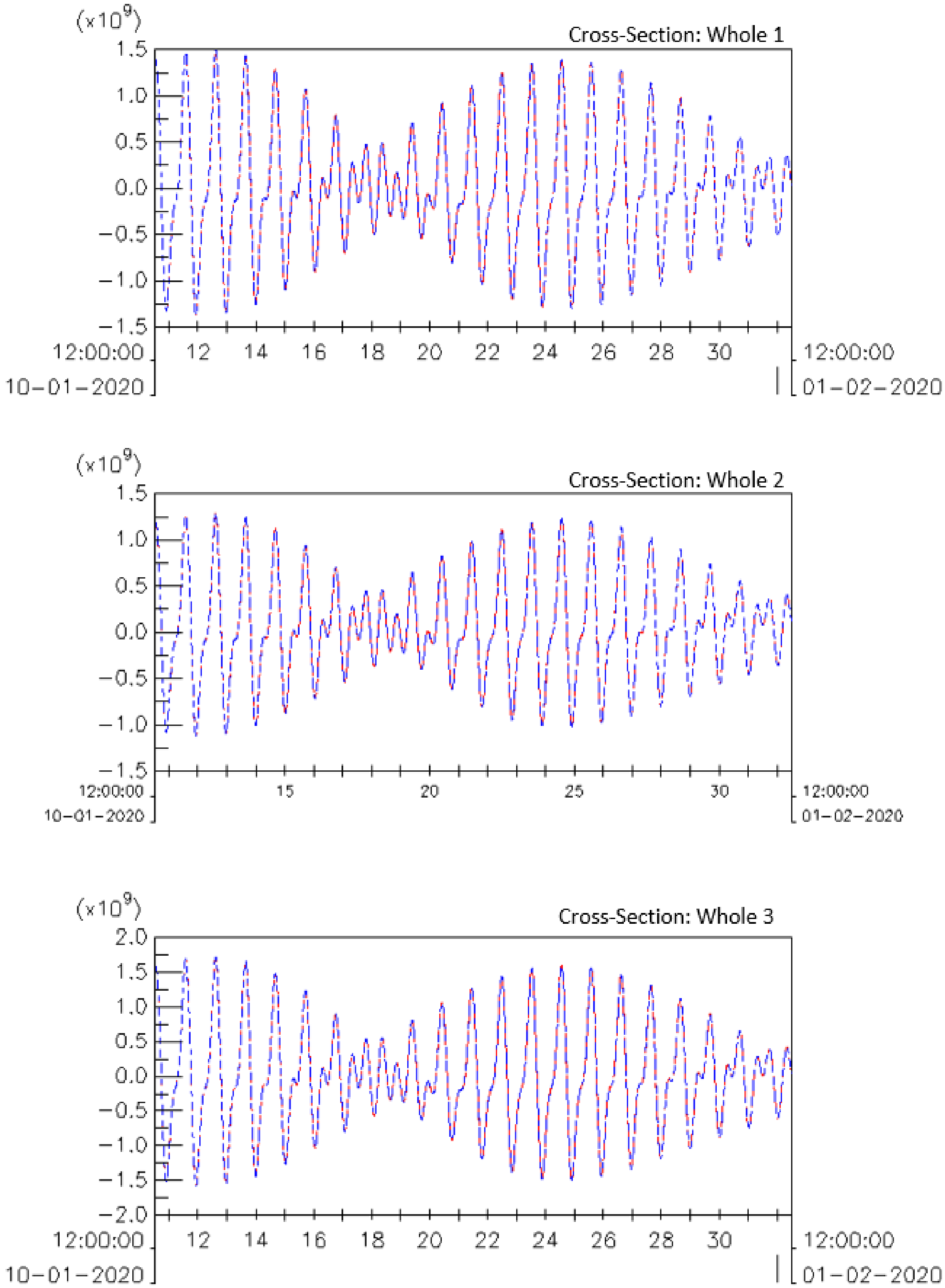


Figure 2.69. Accumulated Flow Comparison – Wet Season

The marine water exchange between the inner Manila Bay and the outer open sea is important to the water quality near the Metro Manila, as the ebbing flow would bring out the eutrophication and chemical pollution due to human activities. According to the model results, the momentary flows and the accumulated flows have no significant change between *without project* and *with project* (i.e. <1%). As such, adverse water quality impact is not anticipated due to the proposed BCIB during its operation.

Local Velocity Changes

Along the alignment of BCIB, most model grids are partially occupied by bridge piers except of several grids located at two main navigation channels. The local current speed and the current flow rate at the area (model grid) occupied by bridge pier will be decreased due to the pile frictions. However, the local current speed and the current flow rate at the area near the main navigation channels would be increased.

Except to the area near the main navigation channels, the changes in current speed caused by BCIB are less than 10% for most of the area along the BCIB alignment. However, the diameters of the pile caps are up to about 65m for the piers located at the both sides of the main navigation channels which has a span of 180 m. The tidal current blocked by the piers with large diameter would pass through the navigation channels at a higher speed. The changes in current speed along navigation channels would range from 10% to 50%. However, the highest magnitude of current change only appears for a short time (i.e. mid-flood or mid-ebb) and locally, the overall change in the current speed is still considered as minor to the ocean-going vessels.

Conclusion

Hydrodynamic models of *without project* and *with project* scenarios are conducted for both dry and wet seasons under typical meteorological conditions. Relative values for *with project* case comparing to that *without project* is used to identify any potential hydrodynamic impact due to BCIB.

Modelling results indicate that the difference in the momentary flow and accumulated flow in and out of Manila Bay for the *without project* and *with project* scenarios would be insignificant. Hence, the overall hydrodynamic water quality impacts to the entire Manila Bay caused by BCIB during the typical meteorological condition are insignificant.

However, due to the presence of the piles along the BCIB alignment, there would be some inevitable changes in the local velocity at the area around the pier piles. The subsequent DED could consider opportunities for further defining of the scheme for the piles, as necessary.

2.2.2.3 Potential Impacts and Mitigation Measures

Sediment and Siltation

Based on the physical parameters, the largest potential impact foreseen would be during construction. Sedimentation and siltation would be a crucial source of risk and impact. This would gradually trap resuspended sediments from dredging operations.

During post-construction, there could be potential impediment in water flow, with the bridge being in a narrow channel and with accumulation of sediments from construction. Each step to the completion of the bridge could leave a mark on the surrounding ecosystems.

To mitigate siltation and erosion, the following can be carried out during construction phase:

- Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods;
- Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment;
- Soil debris and other excavated materials should be hauled out from the site;

- Regular monitoring to the adjacent water bodies to ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;
- Silt traps will be installed for all nearby water bodies;
- The waste soil and other debris will be properly handled and disposed on a regular basis;
- Proper construction methodology will be strictly followed to prevent siltation from boring activities on substrate;
- A flood warning alarm system will be developed to include protocols in monitoring heavy rains and increase in water levels;
- Disclose project activities and all other needed information through proper information dissemination in the nearby communities.
- Whenever feasible, conduct immediate re-vegetation of the cleared land to prevent erosion and siltation.

2.2.3 Water Quality

A baseline water quality assessment is required to gauge the current status of the water bodies that will be traversed by the project alignment. A water quality sampling was conducted on 8-15 February 2020 to establish a baseline study, particularly for the physical and bacteriological characteristics of the upstream and downstream of water bodies affected by the project. The sampling was done during dry season with low precipitation period. This assessment aims to recommend mitigating and enhancement measures to address any identified impacts on water quality.

Water quality is defined by the Republic Act No. 9275 or the Philippine Clean Water Act of 2004 (CWA 2004), which is an act for the protection and preservation of water bodies in the country. Pursuant to Section No. 32 of this national legislation, the Department of Environment and Natural Resources (DENR) promulgated the Implementing Rules and Regulations (IRR) of the CWA 2004 under Administrative Order No. 10, series of 2005 (DAO 2005-10) to facilitate the water quality management and abatement of water pollution in the Philippines's water resources.

Compliance of the water quality results in this assessment are compared to the limitations provided under the DENR Administrative Order (DAO) DAO 2016 – 08 "Water Quality Guidelines and General Effluent Standards". Parameters that were used to compare with the standard were consist of physicochemical properties, inorganic non-metallic and bacteriological parameters, and metal. For groundwater sampling, DAO 2016 – 08 and potable water guidelines listed under DOH 2017-0010 or the Philippine National Standards for Drinking Water of 2017 were used as guidelines in comparing and analysing the baseline groundwater sampling results.

2.2.3.1 Methodology

Primary Data Source: Grab samples were obtained from 31 water sampling stations throughout the vicinity of the project area. Freshwater and groundwater sampling were performed on 8-9 February 2020 in Mariveles, Bataan and 12-13 February 2020 in Naic, Cavite. For marine water sampling, the baseline sampling was completed on 12 February 2020 in Mariveles, 13 February 2020 in Naic, and 15 February 2020 in Corregidor Island.

Groundwater Sampling. The groundwater samples were taken from water pumps in Naic and deep wells in Mariveles. The five (5) sampling sites are strategically located near the proposed alignment.

Surface Water Sampling. There are seven (7) water channels sampled for freshwater quality. Four (4) water sampling sites were done in Mariveles and three (3) were conducted in Naic.

Marine Water Sampling. There were ten (10) marine water samples conducted along the BCIB alignment and Corregidor Island. In addition, nine (9) nearshore water areas were sampled near the landing stations of the alignment in Mariveles, Bataan, Naic, Cavite and near the alignment in Corregidor Island.

In-situ measurements

Hand-held meters were used to determine the availability of dissolved oxygen in surface water, ambient temperature, conductivity, and pH of the ground, rivers and bay. The pH levels were determined using the Myron L Company pH Meter PT2, conductivity readings were obtained using the Trans Instruments Conductivity Meter HC3010, and the instrument used in analysing dissolved oxygen is the Horiba DO meter OM-71. All equipment was calibrated prior to the sampling date to ensure the validity and reliability of data. The calibration and verification certificates are attached **Annex I**.

Sampling and Handling Procedures

The sampling and handling techniques for all water bodies are based on the Water Quality Monitoring Manual for Ambient Water Quality Monitoring issued by the Environmental Management Bureau of DENR (2008).

Groundwater

Groundwater samples were obtained from the main sources of water supply. Sampling containers were directly filled with water from the hose/ faucets connected to the main source. For deep wells, grab sampling was conducted.

Freshwater

The midstream portion of the water body having the deepest water level and fastest current was chosen as the sampling point, whenever practicable. Grab samples were collected by submerging the containers, facing downward, at a depth the water level of the stream permits. After filling with water, containers were slowly lifted against the water flow. Filling and handling techniques for other parameters followed the EMB Guidelines.

Marine water

Vertical column differences in water quality of the bay occur due to stratification and influences of abiotic factors, such as temperature and sedimentation. To have representative samples, a vertical sampler was used to collect water within a column, which captures the heterogeneity of Manila Bay. 4.2-L Vandorn Depth Sampler was used from the surface, mid and bottom lowered approximately 1 m from the surface to collect composite samples.

Samples were cool stored at approximately 6°C, as necessary. Appropriate preservation reagents were added to prolong the holding time of the samples, as indicated in the US EPA 2007. Samples were transported to the partner laboratories accredited by DENR (**Annex I**)

Secondary Data Source: Collection of the most recent Manila Bay Bathing Beaches Monitoring from Department of Environment and Natural Resources – Environmental Management Bureau (DENR – EMB) was used as a secondary reference to further assess the water quality monitoring results within Manila Bay.

Furthermore, existing public provincial and national data were utilized as references for the water use of Bataan and Cavite. Manila Bay information and news are sourced from government and organizational websites such as Department of Environment and Natural Resources (DENR), National Economic and Development Authority (NEDA), Philippine News Agency (PNA), Department of Interior and Local Government (DILG), and PEMSEA.

Field Surveys and Sampling Areas

<u>Groundwater</u>

The main water supply sources of municipality of Mariveles in Bataan and Naic in Cavite are Mariveles Water District (MARIWAD) and Naic Water Supply Corporation, respectively. Based on 2017-2027 CLUP of Mariveles, the water district serves 14 out of 18 barangays. On the other hand, the 2017 Cavite Ecological Profile discussed that Naic Water Supply Corporation has a total of 8,237 customers served. However, some residences still use groundwater, which were identified sampling stations for this section. Five (5) sampling sites, from handpumps and water well, were established at the vicinity of the project alignment.

Mariveles, Bataan

Bataan has a wide and extensive groundwater system that is mostly relied on by the locality. The Mariveles Watershed is one of the biggest watersheds in the province, which replenishes the water reserves throughout the area. Rural areas have handpumps and artesian wells to collect water, while urban areas can have borewells, spring systems, communal faucets, as well as piped water supplies with private water points. There are 128 groundwater wells in the Municipality of Mariveles, Bataan (Local Water Utilities Administration, 2017). Based on 2017-2027 CLUP of Mariveles, 24 of these are operated by MARIWAD and the rest are operated by private individuals, by barangays or by different types of establishments and/or by corporations. But, according to a 2017 study by PEMSEA, the province of Bataan does not have regulatory laws yet in place to monitor or regulate groundwater extraction.

For the project, groundwater samples were collected and established within three (3) deep wells in Barangay Alas – asin and Barangay Mountain View in Mariveles, Bataan. The two (2) sampling stations in Barangay Alas – asin are approximately 100 and 50 meters from the nearest distance of the alignment, while the other station in Barangay Mountain View is around 1.8 km from the alignment.

The groundwater resource is being used by the residents for laundry and bathing purposes. **Table 2.26** provides the sampling stations and its coordinates, while **Figure 2.70** provides the ground water sampling map.

Naic, Cavite

The groundwater sources from Cavite are being used for a wide variety of activities including domestic use such as bathing and washing of clothes, industrial use, and for irrigation. This widespread usage, however, could result to widespread groundwater mining and salt-water intrusion. Excessive groundwater use is already challenging the province to secure a good supply of clean water for their future constituents (CIWRM Master Plan, 2012). As such, Senate Bills 2641 or the Water Regulatory Act of 2011 and Senate Bill 2997 or the Water Sector Reform Act (WSRA) of 2011 are being proposed to manage and hopefully replenish the aquifers to prevent further issues.

The groundwater baseline in Naic were sampled within two (2) artesian well pump, which are 452m and 475m away from the alignment. The locals use the groundwater for bathing and laundry purposes. The sampling station photos and its coordinates are shown in **Table 2.26** and **Figure 2.71** provides the sampling station map.

Table 2.26. Groundwater Sampling Stations

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Mariveles, Bataan				
GW-1		Deep well in Barangay Alas-asin, Mariveles, Bataan. Approximately 100m from the nearest point of the alignment. Water usage is for bathing and laundry purposes.	14°27’12.04” N	120°33’2.02” E
GW-2		Deep well in Barangay Alas-asin, Mariveles, Bataan. Approximately 50m from the nearest point of the alignment. Water usage is for bathing and laundry purposes.	14°26’58.38” N	120°33’34.02” E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
GW-3		Deep well in Barangay Mt. View Mariveles, Bataan. Approximately 1.8km from the nearest point of the alignment. Water usage is for bathing and laundry purposes.	14°27'5.44" N	120°35'27.33" E
Naic, Cavite				
GW-4		Artesian well in Naic, Cavite. Approximately 475m from the nearest point of the alignment. Water usage is for bathing and laundry purposes.	14°20'22.53" N	120°46'47.96" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
GW-5		Artesian well in Naic, Cavite. Approximately 452m from the nearest point of the alignment. Water usage is for bathing and laundry purposes.	14°20’29.41” N	120°46’38.83” E

Figure 2.70. Groundwater Sampling Stations in Mariveles, Bataan

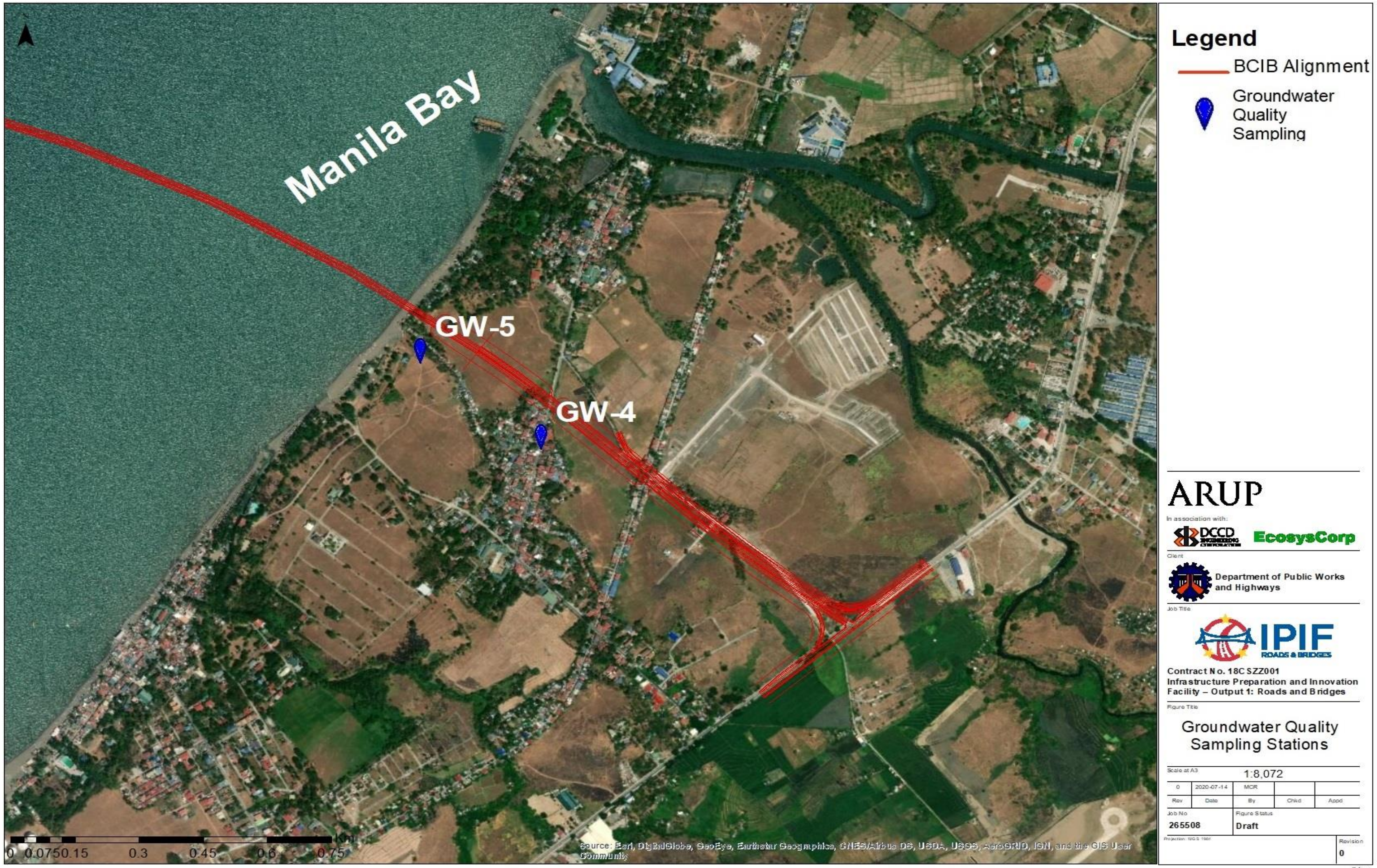


Figure 2.71. Groundwater Sampling Stations in Naic, Cavite

Surface Water

Mariveles, Bataan

Babuyan River is the only river identified within the landing point of the alignment in Mariveles, Bataan. Though located at the proximity of the alignment, only streams with wider width and with slow to medium flowing water were established as the sampling station. Other nearby rivers identified in Mariveles are Disguising River, Alas-asin River, San Jose River, Babuyan River, Pangolisanin River, Amo River, Asayan River, Cayangcam River, Lucanin River, Cruze River, Aguito River and Tobang River and its small tributaries such as Aguaguan Creek, see **Figure 2.72**.

Four (4) sampling stations were identified as surface water sampling sites to establish the baseline condition on water quality (see **Figure 2.74**). These are Diguining River (FW-1), Real River (FW-2), Pangolisanin River (FW-3 and FW-4). The rivers are still unclassified by the DENR – EMB, hence it was classified based on its beneficial usage. It is noticeable that the rivers at Mariveles, near the proposed alignment, are shallow with minimum turbulence flow (**Table 2.27**). Nonetheless, these were still sampled due to its domestic usage. Currently, these rivers were used by the residents for raising livestock, fish and other aquaculture products, recreational activities such as boating, and for agriculture purposes such as irrigation therefore Class C freshwater classification was used in the report.

The surface water sampling stations are further discussed below.

- Diguining River

The river is situated west of Barangay Alas-asin, Mariveles, Bataan, stretching approximately 3km from the inland portion of Mariveles to the shoreline of Manila Bay. Diguining river serves as a buffer between the nearest industrial area and residential communities in Brgy. Alas-asin. Industrial areas near the river are GN Power Dinginin, a coal-fired power plant scheduled for the completion of its construction by 2020 and NGPT Mariveles Solar Power Plant, which is situated upstream of the river. On the downstream of the river is where few residences and Dinginin Beach lie.

The river is approximately 1.6 km from the nearest alignment distance and is directly draining its waters to Manila Bay.

- Real River

Real River runs from Mt. Mariveles, traversing Brgy Alion, Brgy. Cabcaben and Brgy. Alas-asin. The river is tributary to Pangolisanin River, which drains its water to Manila Bay. It borders between Brgy. Cabcaben and Brgy. Alas-asin and surrounded by residential and few commercial areas in Brgy. Alas-asin. Most of the establishments near Real River are resorts and lodges. The alignment trumpet interchange is about 47 meters from Real River.

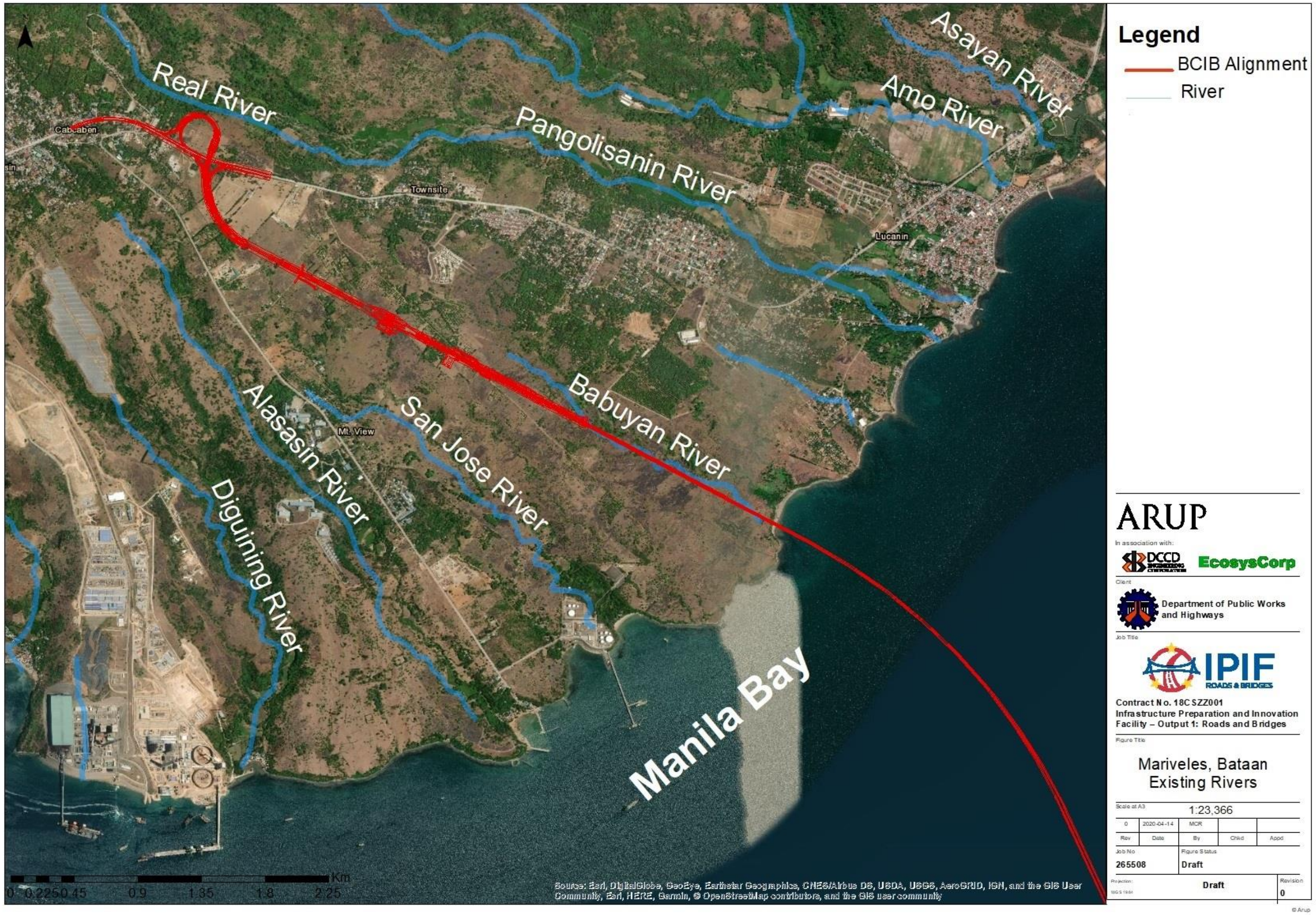


Figure 2.72. Rivers in Mariveles, Bataan

- Pangolisanin River

Pangolisanin River is a stream situated between Brgy. Cabcaben and Brgy. Alas-asin, where Real River connects. Based on the Manila Bay Coordinating Office (2020) datasets, the total length of Pangolisanin and Real River is approximately 14km. Structures draining from this river are residential areas, institutional areas and commercial areas.

Based on the CLUP of Mariveles (2017-2027), the river serves as an important water source in Mariveles. Although, water classification of the river is yet to be determined by DENR – EMB, the river has been used for domestic (e.g. laundry) purposes of the locals.

Pangolisanin River is situated approximately 780m from the nearest alignment distance in Mariveles, Bataan.

Naic, Cavite

There are two (2) secondary unnamed river close to the alignment in Naic, Cavite. Both rivers are draining its waters to Manila Bay. According to the provincial website of Cavite, major rivers in Naic are Timalan River, Alemang River and Balsahan River as shown in **Figure 2.73**.

Baseline surface sampling were conducted within three (3) sampling stations along the stretch of Timalan River (**Figure 2.75**). The surface water sampling is classified by EMB as Class C water in 2016. Based on DAO 2016-08, the beneficial uses of Class C fresh surface water are (1) fishery for the propagation and growth of fish and other aquatic resources, (2) recreational use class II, such as boating and (3) agriculture, irrigation and livestock watering purposes.

- Timalan River

Timalan River is classified by DENR – EMB as Class C freshwater. It is located southwest of Brgy. Capipisa, close to Tatlong Balon River, while its outlet that directly drain its waters to Manila Bay is within Brgy. Timalan Concepcion.

The river is surrounded by built-up areas, mostly institutional and residential areas. CTSI Capipisa Training System, PNTC Colleges and Pentagon Nautical Technological Center are some of the institutional areas near the river, while South Morning View Subdivision and Barangay Timalan Balsahan are some of the residential areas identified close to the river.

Timalan River is approximately 720m from the nearest alignment distance in Naic, Cavite.

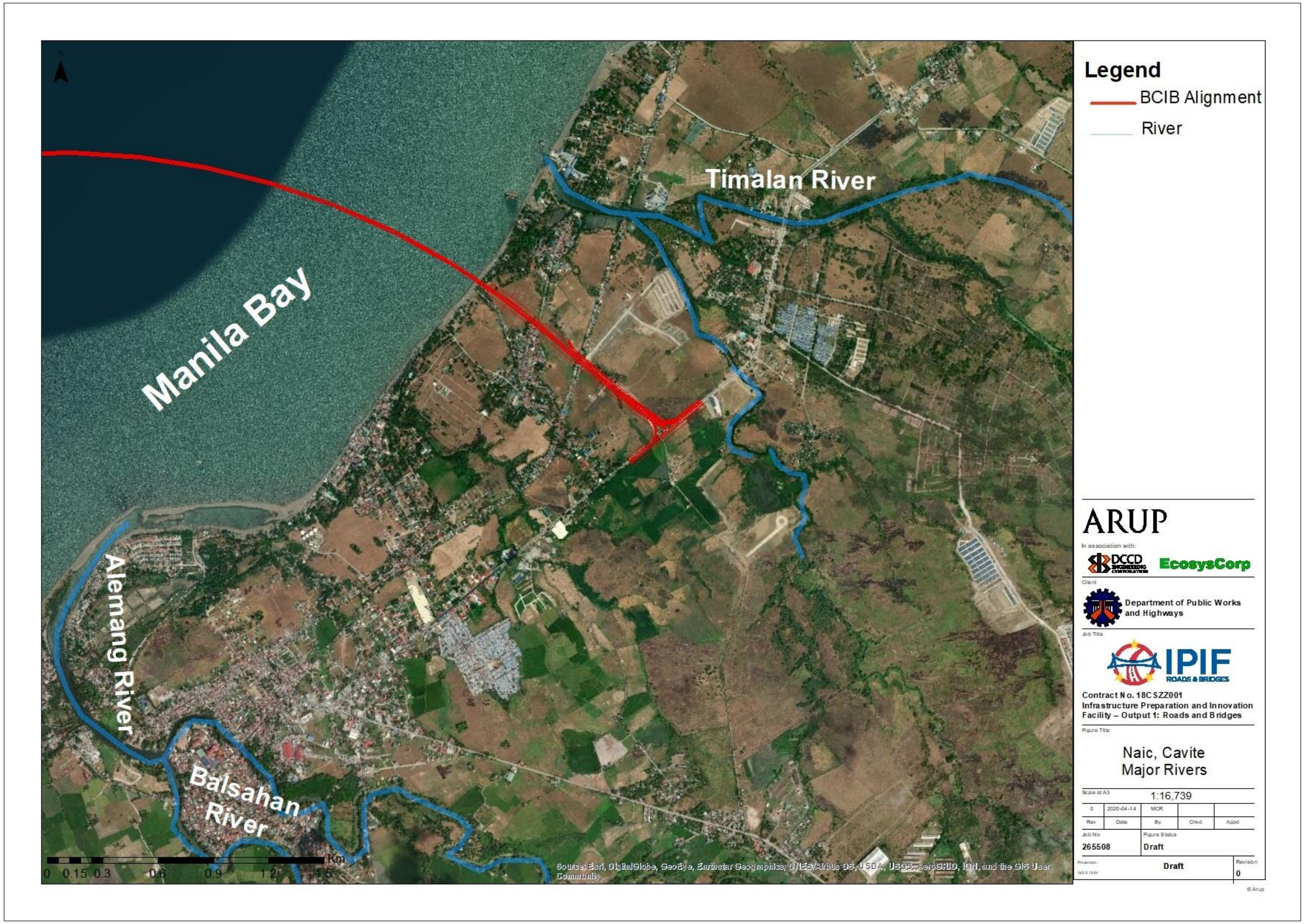


Figure 2.73. Major Rivers in Naic, Cavite

Table 2.27. Surface Water Sampling Stations

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Mariveles, Bataan				
FW-1		Water from this unclassified river located at Diguining River is used mainly for laundry by the nearby neighbouring community.	14°26’46.84” N	120°32’21.60” E
FW-2		This an unclassified river is located at Real River and situated at the end of Kamaya Point Rd. Extension	14°28’15.09” N	120°32’15.40” E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
FW-3		Waters from this unclassified river, located at Pangolisanin River, is used for laundry by the residents.	14°27’39.41” N	120°33’13.89” E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
FW-4		This sampling point is located at Pangolisanin River near the mouth of the river leading out to Manila Bay.	14°27'1.16" N	120°35'29.15" E
Naic, Cavite				
FW-5		Timalan River, classified as Class C fresh surface water, drains towards Manila Bay. Fishermen's boats can be seen docked nearby, while bigger ships can be seen further out into Manila Bay. Fish pens are also present near the sampling point. There are also visible trash floating around the area.	14°20'50.89" N	120°46'51.46" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
FW-6		An unnamed river located upstream of FW-5.	14°20’18.89” N	120°47’23.05” E
FW-7		An unnamed river located upstream of FW-6.	14°20’4.93” N	120°47’22.86” E

Figure 2.74. Surface Water Sampling Stations in Mariveles, Bataan

Figure 2.75. Surface Water Sampling Stations in Naic, Cavite

Marine Water

Manila Bay

The BCIB project will traverse Manila Bay from the side of Mariveles, Bataan and to Naic, Cavite, and will only be in the proximity of the east part of the Corregidor Island. The bay is considered as Class SB by EMB, in which DAO 2016-08 classifies as (1) waters suitable for commercial propagation of shellfish and intended spawning areas for milk fish and similar species, (2) tourist zones for ecotourism and recreational activities (primary contact e.g. bathing, swimming, skin diving etc).

Manila Bay is one of the busiest and most profitable waterways in the Philippines, accounting for more than 50% of the country's gross national products (Castillo, 2000). The bay caters to maritime activities, mainly for transport of international goods and of people that comes to and from the West Philippine Sea with harbours and terminals located at Port Area and Tondo area of Manila, facing the Manila Bay. Its marine ecosystem is also utilized for aquaculture. The creation and proliferation of poorly managed fishponds are observed within the bay. Furthermore, the shores of Corregidor Island were made available for various recreational water activities as part of its tourism trade. With several economic industries connected and dependent on the waters of Manila Bay, the continuing decline on its water quality is inevitable.

The free-flowing waters from this northeast side of Manila Bay may also be used to verify the water quality from the waters at the vicinity of the project, hence these were requested from the EMB. On 2019, DENR-EMB reported its annual findings from monthly water sampling at the Manila Bay beaches that the shoreline along Manila had the most distressing results. Phosphates – likely from commercial establishment and shipping vessels, nitrates – possibly from fertilizers, and fecal coliform – from human or animal wastes – were higher than the rest of the sampling stations, and that dissolved oxygen measurements were low.

To establish a baseline on marine water quality conditions of Manila Bay concerning the project, water sampling was conducted within ten (10) sampling stations along the BCIB alignment. Each location was sampled three times at three separate depths, one sample was taken on the surface (S), another was taken near the bottom (B), and the last was taken at the middle (M) of the surface and bottom sampling depths. Water was collected using Vandorn Depth Sampler (**Annex I**)

In addition, nine (9) nearshore water sampling areas were established near the alignment in Mariveles, Bataan, Naic, Cavite and Corregidor Island. For the nearshore areas, only surface water was collected for sampling. Overview of both set of sampling areas is showed in **Figure 2.76** and **Figure 2.77**.

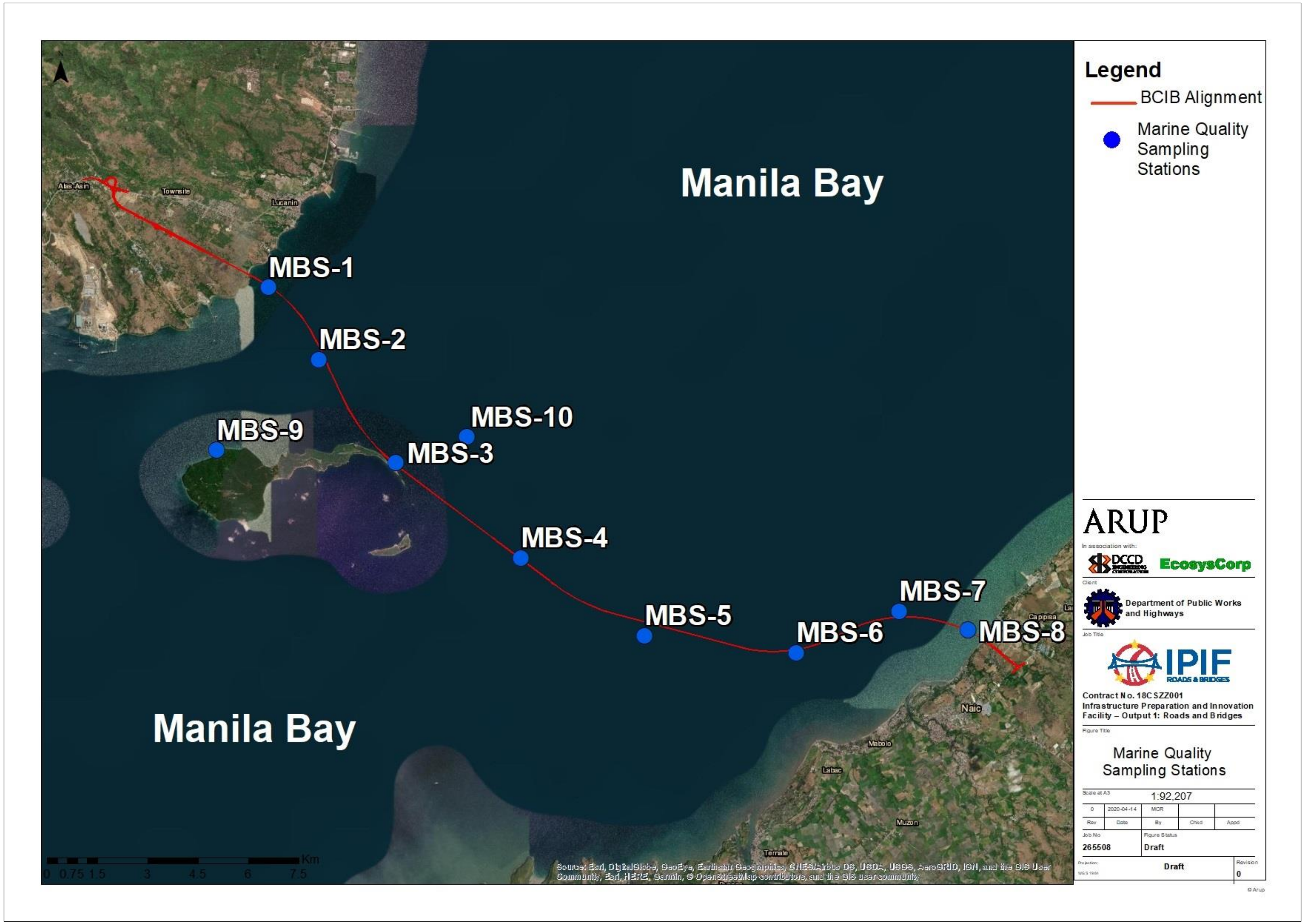


Figure 2.76. Marine Water Sampling Stations along the BCIB alignment

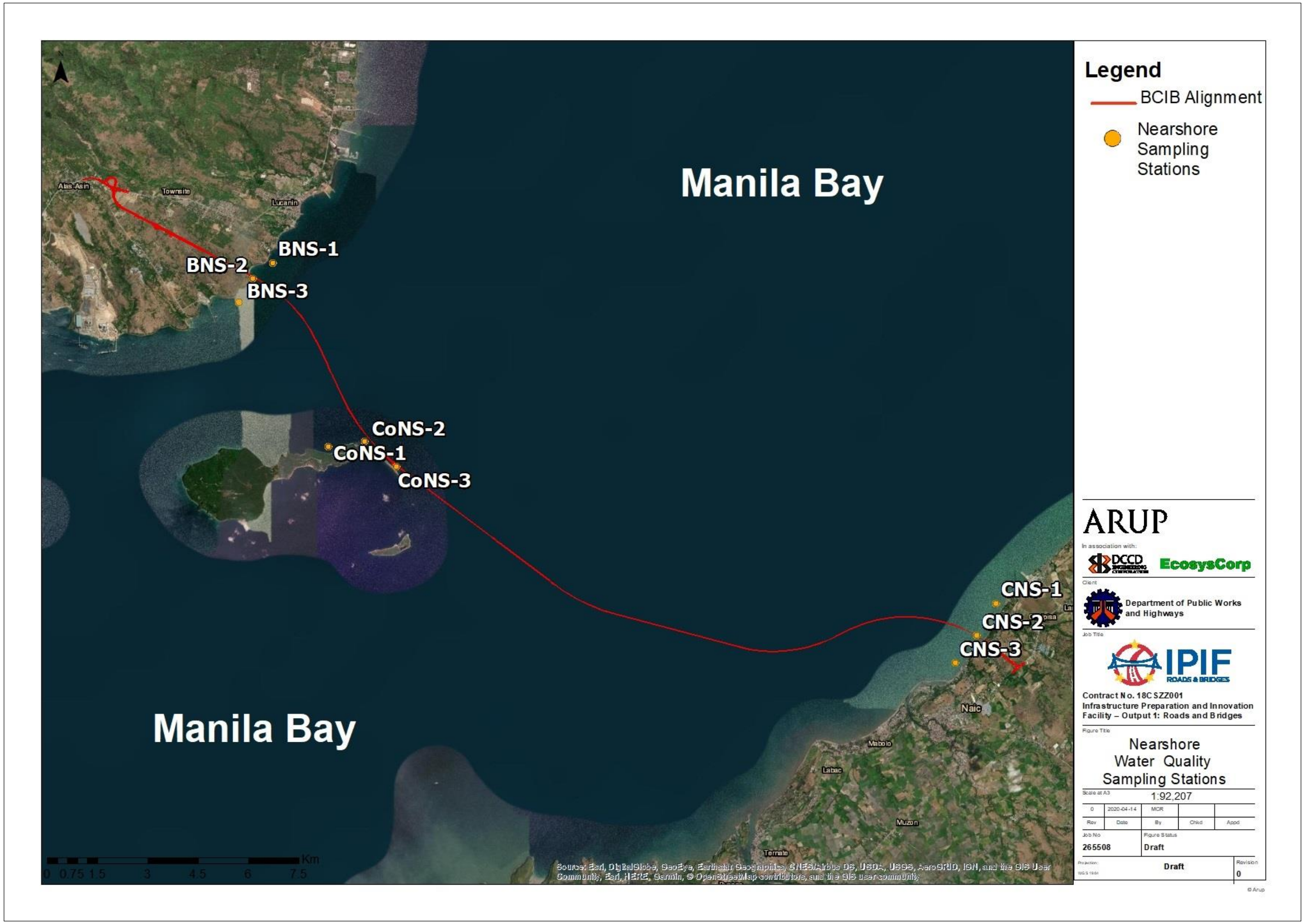


Figure 2.77. Nearshore Water Sampling Stations within the BCIB alignment and Corregidor Island

Table 2.28. Marine Water Sampling Stations

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Mariveles, Bataan side				
MBS-1		Located at around 50 m away from the proposed alignment, near Bataan side. The Bataan shore is visible. The water is blue in colour. Large barges are visible further into the bay.	14°26'04.44" N	120°35'07.32" E
MBS-2		Located at around 121 m away from the proposed alignment near Bataan side. Bataan shoreline is still visible. Water is dark blue.	14°24'56.57" N	120°35'55.80" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
MBS-3		Located at around 130 m away from the Corregidor Island Eastern shoreline, and 27 m to the East of the proposed alignment.	14°23'19.24" N	120°37'10.52" E
Corregidor Island side				
MBS-4		Located at south eastern side of the Corregidor Island. Sampling point is at the alignment. Water is deep blue.	14°21'49.57" N	120°39'11.00" E

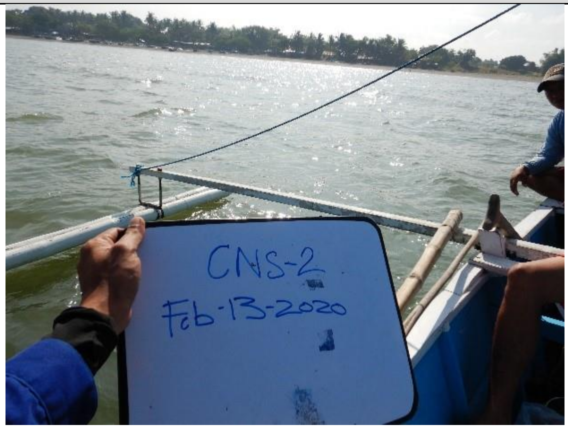
Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Naic, Cavite side				
MBS-5		Located at around 400 m from the proposed alignment in the middle of Corregidor Island and Cavite.	14°20'36.85" N	120°41'10.25" E
MBS-6	*Actual photo unavailable due to technological malfunction*	Located at around 108 m from the proposed alignment and around 2.6 km from Cavite shoreline.	14°20'20.70" N	120°43'37.20" E
MBS-7	*Actual photo unavailable due to technological malfunction*	Located at around 145 m from the proposed alignment and around 2.23 km from the Cavite Shoreline	14°20'59.52" N	120°45'16.48" E
MBS-8	*Actual photo unavailable due to technological malfunction*	Located at around 47 m from the proposed alignment and around 1.22 km away from the Cavite shoreline.	14°20'41.87" N	120°46'22.46" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
MBS-9		Located at around 60 m away from the Western shoreline of Corregidor Island facing Bataan.	14°23'31.20" N	120°34'17.36" E
MBS-10		Located at around 2.25 km from Eastern shoreline of Corregidor Island and around 1.86 km from the proposed alignment.	14°23'44.08" N	120°38'18.82" E

Table 2.29. Nearshore Water Sampling Stations

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Mariveles, Bataan side				
BNS-1		Located at around 180 m away from the shoreline of Mariveles, Bataan, where the Mountain View Resort Subdivision is located.	14°26’27.75” N	120°35’12.63” E
BNS-2		Located at around 130 m away from the shoreline of Mariveles, Bataan and around 37.5 m away from the proposed BCIB alignment.	14°26’13.10” N	120°34’53.30” E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
BNS-3		Located at around 196 m away from the shoreline.	14°25’50.88” N	120°34’39.95” E
Naic, Cavite side				
CNS-1		Located at around 200 m away from shoreline. There are barges farther off. The water looks brown and turbid.	14°21’07.32” N	120°46’50.33” E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
CNS-2		Located at around 200 m away from shoreline. There are fishermen's boats around the sampling site. The water looks brown and turbid.	14°20'36.91" N	120°46'31.84" E
CNS-3		Located at around 200 m away from shoreline, where there are houses built. There are fishermen's boats around the sampling site. The water looks greenish brown and turbid.	14°20'11.32" N	120°46'10.93" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
Corregidor Island side				
CoNS-1		Located at around 155 m away from the shore, the farthest from the alignment among Corregidor Island sampling sites. Northern area of the island. The water is dark green in color, suggesting that it has great depths, giving it a green color.	14°23'34.85" N	120°36'06.23" E
CoNS-2		Located at around 180 m away from the shore and around 130 m from the alignment. Situated at the north eastern area of the island. The water is dark blue in colour, suggesting that it has great depths.	14°23'39.69" N	120°36'41.27" E

Sampling Station ID	Sampling Areas	Description	Coordinates (WGS 1984)	
			Latitude	Longitude
CoNS-3		Located at around 86 m away from the shoreline and around 34 m away from the alignment at the eastern part of the island. The water is blue in color, suggesting that it has depth.	14°23'15.72" N	120°37'11.63" E

Figure 2.78. Nearshore Water Sampling Stations in Mariveles, Bataan

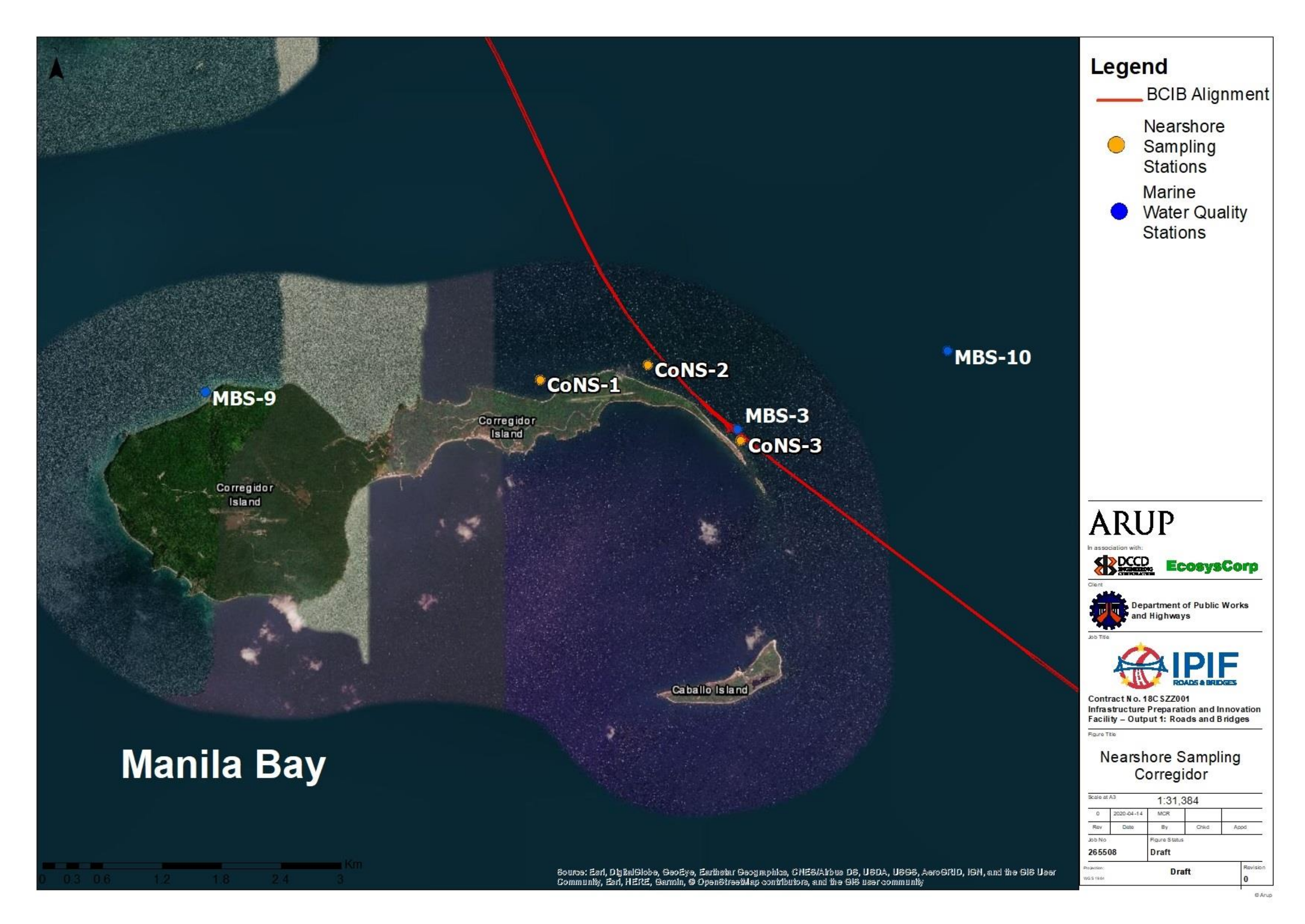


Figure 2.79. Nearshore and Marine Water Sampling Stations in Corregidor Island

Figure 2.80. Nearshore Water Sampling Stations in Naic, Cavite

Data Analysis

Parameters used for all water samples and its methodologies for sampling and analysis are summarized in **Table 2.30**. The parameters used are categorized into its physicochemical properties, inorganic non-metallic, bacteriological and metals and major cations. Results from the sampling activities are compared to DAO 2016-08 standards.

The samples were analyzed according to the following guidelines below:

- Standard Methods for the Examination of Water and Wastewater 23rd Edition, from the American Public Health Association (APHA) and the American Water Works Association (AWWA);
- Method 200.7: Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry, Revision 4.4, by Cincinnati, OH, from United States Environmental Protection Agency (USEPA) in 1994;
- Method 6010B: Inductively Coupled Plasma Atomic Emission Spectroscopy, Revision 2 from USEPA in 1996; and
- Environmental Protection Agency (EPA) 9213: Potentiometric Determination of Cyanide in Aqueous Samples and Distillates with Ion-Selective Electrode, Revision 0, in 1996.

It is important to note that turbidity, salinity, COD, TDS, and Vanadium do not have DAO 2016-08 Standards.

Table 2.30. Methodologies for Water Sampling and Analysis

Parameter	**Methods for sampling and analysis**
Physicochemical Properties	
1. pH	In situ
2. Temperature	In situ
3. True Colour	APHA 2120B
4. Oil and Grease (O&G)	APHA 5520B
5. Turbidity	APHA 2130B
6. Salinity	APHA 2520
7. Biochemical Oxygen Demand (BOD)	APHA 5210B
8. Chemical Oxygen Demand (COD)	Hach Method 8000
9. Total Dissolved Solids (TDS)	APHA 2540C
10. Total Suspended Solids (TSS)	APHA 2540D
11. Dissolved Oxygen (DO)	DO meter
Inorganic non-metallic parameters	

Parameter	Methods for sampling and analysis
12. Chloride	APHA 4500-Cl
13. Nitrate	EPA 352.1
14. Phosphate	APHA 4500-PD
15. Free Cyanide	EPA 9213
16. Ammonia	APHA 4500-NH3 F
Bacteriological Parameters	
17. Fecal Coliform	APHA 9221 E
Metals and Major Cations	
18. Arsenic (As)	APHA 3120 B
19. Cadmium (Cd)	APHA 3120 B
20. Hexavalent Chromium (Cr^{+6})	APHA 3500-Cr B
21. Lead (Pb)	APHA 3120 B
22. Mercury (Hg)	7470A Mercury (CVAA)
23. Nickel (Ni)	APHA 3120 B
24. Zinc (Zn)	APHA 3120 B
25. Vanadium (Va)	APHA 3120 B

Groundwater

The groundwater sources of the project site are classified as Class A, which are suitable for domestic use and potable water. However, further treatment of the water is required for it to be a source of drinking water.

Results from the sampling activities are compared to DAO 2016-08 standards for Groundwater Class A and Potable water guidelines listed under DOH 2017-0010 or the Philippine National Standards for Drinking Water of 2017.

Surface Water

The river samples for this project site are classified as Class C, as currently, these rivers were used by the residents for raising livestock, fish and other aquaculture products and recreational activities such as boating, and for agriculture purposes such as irrigation. Results from the sampling activities are compared to DAO 2016-08 standards for Surface Water Class A.

Marine Water

The parameters observed were the same with the parameters used in surface and groundwater sampling. The results from the sampling activities are compared against DAO 2016-08 Water Body Classification and Usage of Marine Waters Class SB.

2.2.3.2 Baseline Environmental Conditions

Groundwater

Results for the groundwater sampling are presented in **Table 2.31** and **Annex I**. The test results were checked against the DAO 2016-08 Class A Water and DOH 2017-0010 Standards.

Table 2.31. Groundwater Sampling (Class A) Results

Parameters	DAO 2016-08 Standards for Class A	DOH 2017-10 Drinking Water Standards	Mariveles, Bataan			Naic, Cavite	
			GW-1	GW-2	GW-3	GW-4	GW-5
			12-13 February 2020			8 February 2020	
Physicochemical Properties							
1. pH	6.5-8.5	6.5-8.5	9.22	6.75	7.10	7.65	7.43
2. Temperature	26-30°C	-	26.9	27.7	26.3	29.2	28.7
3. Color (TCU)	50	10	5	5	5	5	5
4. O&G	1.00	-	ND	ND	ND	ND	ND
5. Turbidity (NTU)*	-	5	6.300	6.700	6.900	0.700	4.900
6. Salinity (Units)*	-	-	0.374	ND	0.243	0.634	0.708
7. BOD (mg/L)	N/A	-	5.29	2.35	5.59	3.19	2.92
8. COD (mg/L)*	-	-	12	20	20	11	12
9. TDS (mg/L)*	-	600	66	80	388	893	1020
10. TSS (mg/L)	50.0	-	5.4	ND	6.4	ND	ND
11. DO (mg/L)	N/A	-	3.17	1.91	1.34	1.26	1.40
Inorganic Non-Metallic Parameters							
12. Cl (mg/L)	250	250	6	8	44	135	215
13. NO_3-N (mg/L)	7.000	50.00	0.778	0.841	0.040	2.420	1.930
14. Phosphate (mg/L)	0.500	-	0.043	0.033	0.295	0.174	0.128
15. Cyanide (mg/L)	0.070	0.5	0.105	ND	ND	ND	ND
16. Ammonia (mg/L as N)	0.050	-	0.162	0.425	0.140	ND	ND

Parameters	DAO 2016-08 Standards for Class A	DOH 2017-10 Drinking Water Standards	Mariveles, Bataan			Naic, Cavite	
			GW-1	GW-2	GW-3	GW-4	GW-5
			12-13 February 2020			8 February 2020	
Bacteriological Parameters							
17. Fecal Coliform (MPN/ 100mL)	<1.1	-	23	3	23	1	1
Metals and Major Cations							
18. Arsenic (mg/L)	0.010	0.01	0.007	0.007	0.007	0.007	0.007
19. Cadmium (mg/L)	0.003	0.003	0.001	0.001	0.001	0.001	0.001
20. Hexavalent chromium (mg/L)	0.010	-	ND	ND	ND	ND	ND
21. Lead (mg/L)	0.010	0.01	0.004	0.004	0.004	0.004	0.004
22. Mercury (mg/L)	0.001	0.001	ND	ND	ND	ND	ND
23. Nickel (mg/L)	0.020	0.07	0.010	0.010	0.010	0.010	0.010
24. Zinc (mg/L)	2.000	5.000	0.007	0.007	0.007	0.007	0.007
25. Vanadium*	-	-	0.140	0.140	0.140	0.140	0.140

* - No DAO 2016-08 Standard
ND – None detected
N/A – Not Applicable (According to DAO 2016-08)
Red text indicates exceedances

Based on the results, 21 out of 25 parameters in sampling station GW-1 are within the prescribed DAO standard for Class A water. The parameters with slight exceedances are pH, fecal coliform, cyanide and ammonia. Presence of ammonia with pH of 9.22 can be in a form ammonium hydroxide, which is relatively toxic. Its presence may be from the near industrial areas that may have leaked to the groundwater source. Though ammonia and fecal coliform may also be from decomposition from natural sources such as organic human and animal wastes, these may also be an indication of indirect runoff from nearby industrial effluent discharges and agricultural land at Bataan. While, presence of cyanide may also confirm an indication of industrial contamination.

For stations GW-2 and GW-3, there are 23 out of 25 parameters that conforms to DAO standard for Class A water. The parameters with above the maximum DAO limit are ammonia and fecal coliform. Same as in GW-1, these can be attributed to a nearby industrial or agricultural land at Bataan, however with lower pH, means it's not toxic.

On the other hand, parameters in sampling stations GW-4 and GW-5 are all within the set limit of DENR for Class A water. The results of fecal coliform are very low, and all metals and major cations are within their respective standards.

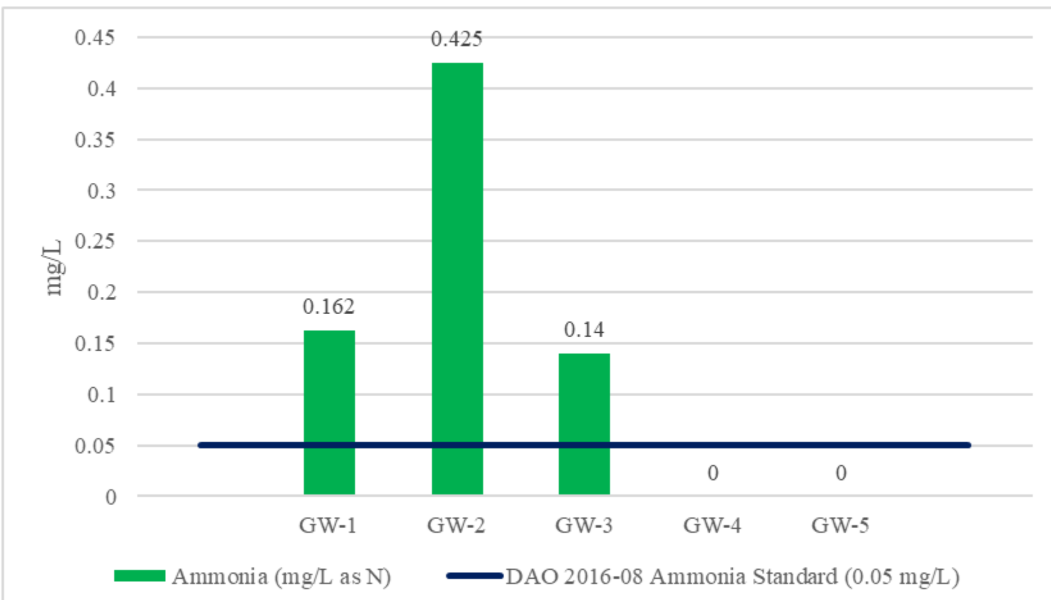


Figure 2.81. Groundwater Sampling Results for Ammonia

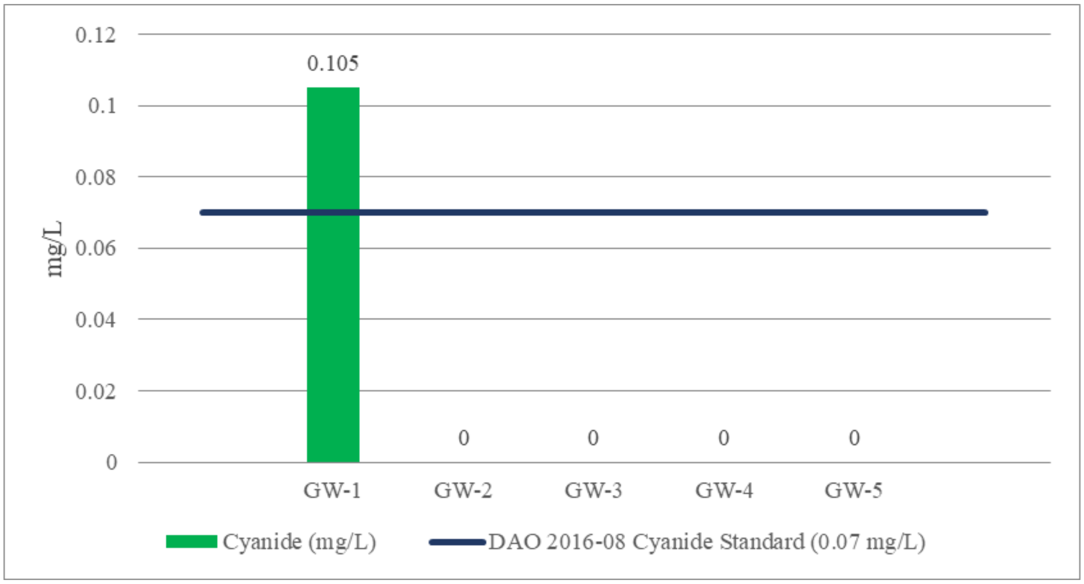


Figure 2.82. Groundwater Sampling Results for Cyanide

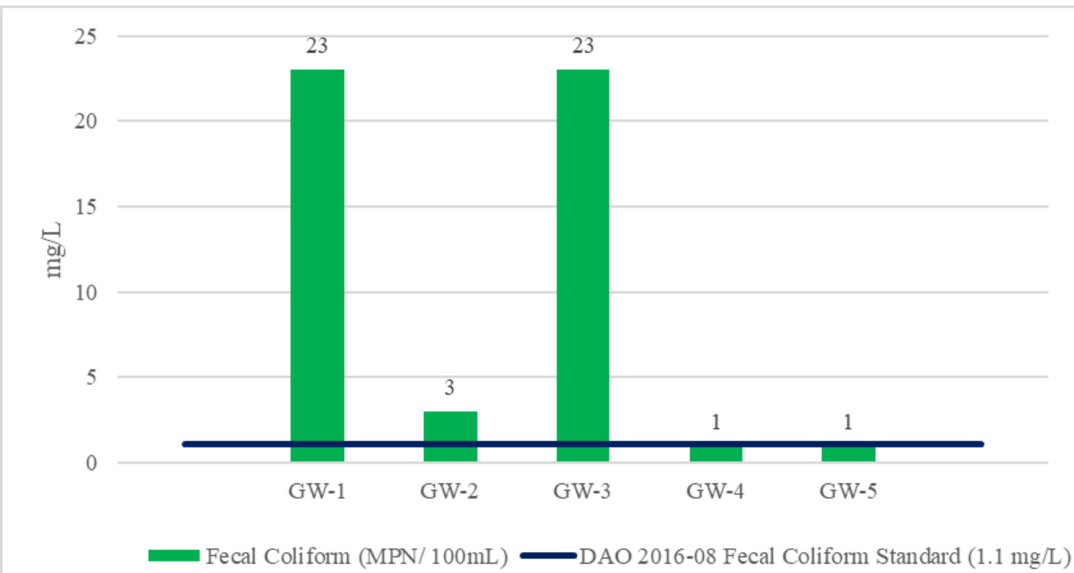


Figure 2.83. Groundwater Sampling Results for Fecal Coliform

Surface Water

Results for the freshwater sampling are presented in **Table 2.32** and **Annex I**. The test results were checked against the DAO 2016-08 Water Quality Standards for Class C.

Table 2.32. Surface Water Sampling (Class C) Results

Parameters	DAO 2016-08 Standards for Class C	Mariveles, Bataan				Naic, Cavite		
		FW-1	FW-2	FW-3	FW-4	FW-5	FW-6	FW-7
		12-13, 28-29 February 2020				8 February 2020		
Physicochemical Properties								
1. pH	6.5-9.0	6.40	7.90	7.58	7.70	7.63	7.69	7.53
2. Temp	25-31 °C	26.7	25.7	26.7	25.7	30.5	28.5	28.5
3. Color (TCU)	75	10	10	5	10	25	25	25
4. O&G mg/L	2.00	ND	ND	ND	ND	1.09	1.41	1.33
5. Turbidity (NTU)*	-	2.200	1.200	1.300	1.600	40.000	45.000	39.000
6. Salinity (Units)*	-	0.337	ND	0.369	0.687	20.900	0.703	0.355
7. BOD (mg/L)	7.00	2.25	4.36	ND	7.99	11.10	27.90	17.10
8. COD (mg/L)*	-	21	32	34	38	335	80	61
9. TDS (mg/L)*	-	55	149	50	1260	24100	922	496
10. TSS (mg/L)	80.0	ND	ND	ND	ND	80.0	51.3	54.0
11. DO (mg/L)	>5.00	3.26	1.72	3.21	4.31	4.54	1.97	1.76
Inorganic Non-Metallic Parameters								
12. Chloride (mg/L)	350	8	37	7	1210	15900	260	40
13. Nitrate (mg/L)	7.000	0.670	0.957	0.503	0.350	0.121	0.436	0.651
14. Phosphate (mg/L)	0.500	0.036	0.156	0.043	0.067	0.510	1.390	1.430
15. Cyanide (mg/L)	0.100	ND	ND	ND	ND	0.089	ND	ND
16. Ammonia (mg/L)	0.050	ND	0.585	ND	ND	2.400	7.740	8.730

Parameters	DAO 2016-08 Standards for Class C	Mariveles, Bataan				Naic, Cavite		
		FW-1	FW-2	FW-3	FW-4	FW-5	FW-6	FW-7
		12-13, 28-29 February 2020				8 February 2020		
Bacteriological Parameters								
17. Fecal Coliform (MPN/ 100mL)	200	2200	700	940	2800	3500	9200	9200
Metals and Major Cations								
18. Arsenic (mg/L)	0.020	0.004	0.004	0.004	0.004	0.004	0.004	0.004
19. Cadmium (mg/L)	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20. Hexavalent chromium (mg/L)	0.010	ND	ND	ND	ND	ND	ND	ND
21. Lead (mg/L)	0.050	0.005	0.005	0.005	0.005	0.005	0.005	0.012
22. Mercury (mg/L)	0.002	ND	ND	ND	ND	ND	ND	ND
23. Nickel (mg/L)	0.200	0.002	0.002	0.002	0.002	0.002	0.002	0.002
24. Zinc (mg/L)	2.000	0.010	0.010	0.010	0.010	0.010	0.010	0.010
25. Vanadium*	-	0.133	0.133	0.133	0.133	0.133	0.133	0.133

*-No DAO 2016-08 Standard
ND- None Detected
Red text indicates exceedances

The result of water quality testing shows that 22 out of 25 parameters for sampling stations FW-1 and FW-2 were conformant to DAO standard for Class C water. Parameters with exceedances is fecal coliform for both stations and ammonia for FW-2. On the other hand, pH and DO shows below minimum water quality standard for FW-1 and DO for FW-2.

For FW-3 and FW-4, there are 23 parameters in FW-3 and 22 parameters in FW-4 that are within the Class C guidelines. DO level in both stations are lower than 5.00mg/L, while fecal coliform is significantly higher than 200 MPN/100mL prescribed DENR standard for Class C water. In addition, TDS in FW-4 is high compared to the three sampling sites in Mariveles. The result can be attributed to agricultural and urban run-off as well as the high chloride concentration, which is at 1210 mg/L, relatively above than the minimum 350mg/L standard.

On the other hand, FW-5 sampling station in Naic has 19 out of 25 parameters within the Class C water standard while FW-6 and FW-7 in Naic, Cavite have 20 out of 25 parameters that conformant to DAO standard for Class C water. Parameters with exceedances are BOD, chloride for FW-5, phosphate, ammonia and fecal coliform. In contrast, water sampling result for these stations show that significantly low amount of DO concentration.

In terms of parameters for metals and major cations, all sampling stations are within the prescribed limit.

Parameters with exceedance in the surface water quality baseline test results are further discussed below.

- pH

pH can affect the solubility and toxicity of chemical constituents such as nutrients (phosphorus, carbon and nitrogen) and heavy metals (e.g. lead, copper, cadmium, etc.). pH also determines whether aquatic life can thrive. This can be affected by a variety of factors, both natural and man-made, relating to catchment geology, soil chemistry, vegetation, land use practices, pollution, etc. (Lek, et al., 2005). **Figure 2.84** shows that all the sampling stations are within the prescribed pH limit. However, FW-1 in Diguining River is slightly below the minimum DAO standard. This indicates that the water is acidic, which may be attributed to the effluent of the nearby industrial plant.

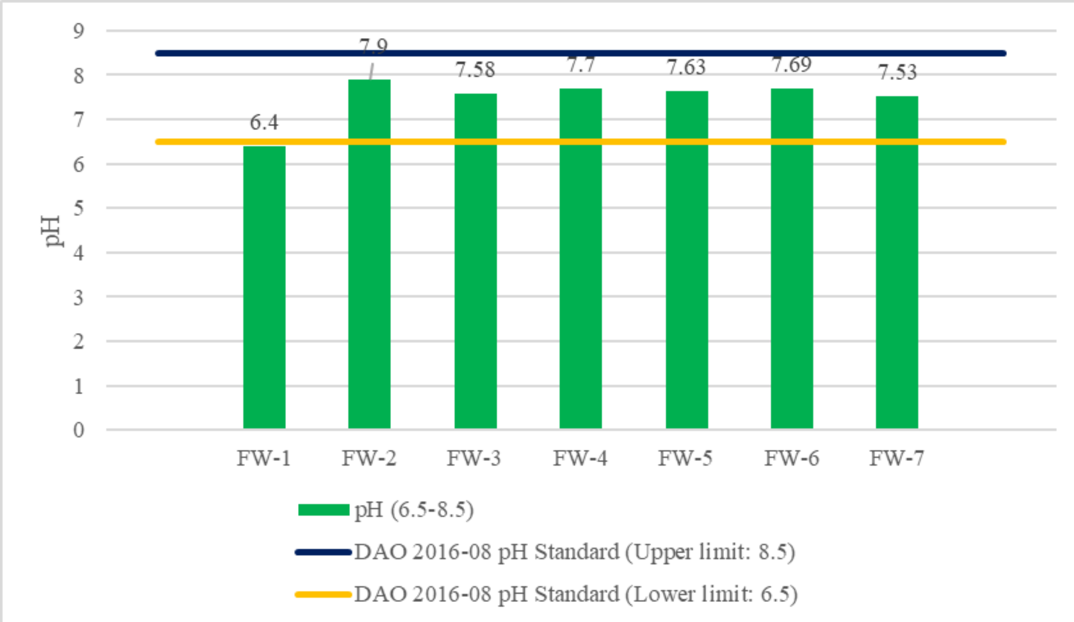


Figure 2.84. Surface water sampling results for pH Level

- Biochemical Oxygen Demand (BOD)

BOD is the amount of dissolved oxygen needed by micro-organisms to break down organic components present in water. It is an indication of pollution loads received by the lake from its tributaries. The sources of these pollution loads may come from the natural decay of vegetation, animal manure, failing septic tanks, wastewater discharges, and urban storm water runoff.

Figure 2.85 shows that the FW-4 in Bataan and sampling stations FW-5 to FW-7 in Cavite have exceeded the water quality limit for BOD. FW-4 is the downstream of Pangolisanin River. High BOD in the river may be attributed in the adjacent built-up areas, which are mostly residential, in contrast to the low BOD detected in the upstream Real River (FW-2) and Pangolisanin River (FW-3).

For Naic, Cavite sampling stations, high BOD has been noted in FW-5 to FW-7. These sampling locations are near institutional areas (FW-5) and adjacent to residential areas (FW-6 and FW-7), which may be the source of exceedances in the prescribed BOD limit.

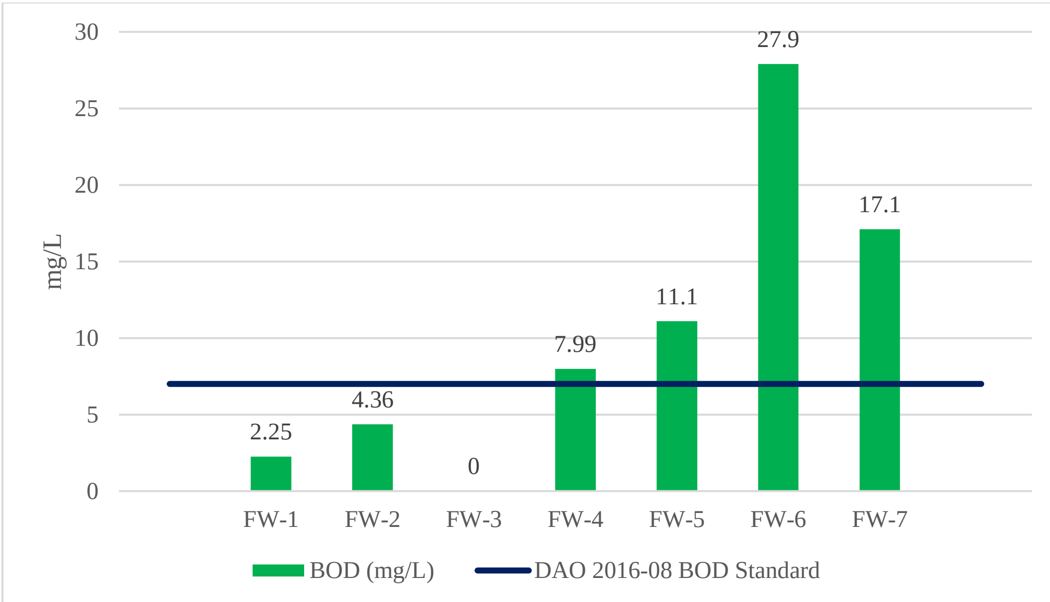


Figure 2.85. Surface Water Sampling Results for BOD

- Dissolved Oxygen (DO)

DO is the amount of oxygen needed by aquatic life to survive. DO lower than 5 mg/L can be caused by a big quantity of waste materials being degraded by bacteria into more harmful by-products such as hydrogen sulfide (Oram, n.d.), thereby negatively impacting aquatic organisms such as fish.

DO results from the water sampling activities for freshwater are presented in

From **Figure 2.86**, it is seen that all the freshwater sampling locations have low DO levels, which may mean that there are high amounts of bacterial activity that are breaking down organic and inorganic material.

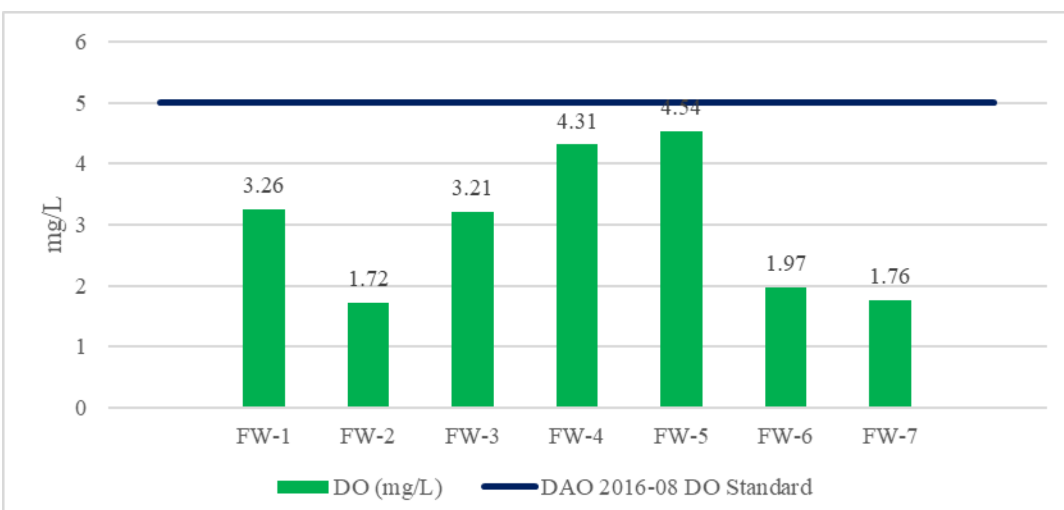


Figure 2.86. Surface Water Sampling Results for DO

Since BOD content is high, DO concentration becomes low since the demand of oxygen by the bacteria is high and that they are taking that oxygen from the oxygen dissolved in water. Since less DO is available, fish and other aquatic organisms may not survive in the area.

- Chloride

Chloride exists naturally in water. At 250 mg/L, water will begin to taste salty, and at higher levels, it may not be suitable for agricultural irrigation as it may suggest sewage contamination (Environmental Protection Agency, 2001). In general, the trend for chloride levels is lower during the wet season compared to the dry season (Edokpayi, et. Al., 2015).

Figure 2.87 shows the chloride content of the freshwater samples. FW-5 in Naic has the most chloride at 15,900mg/L, followed by FW-4 at 1,210mg/L in Mariveles. The high chloride content in this sampling stations are affected by its direct contact to water flowing from marine waters with high salinity level. The rest of the sampling sites are below standard.

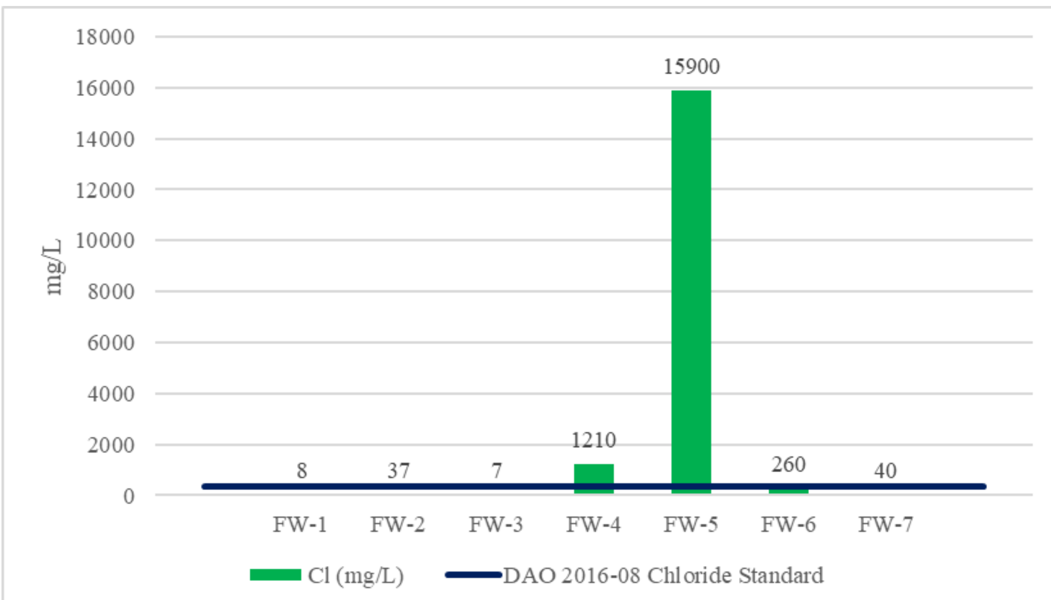


Figure 2.87. Surface Water Sampling Results for Chloride

- Phosphate

Inorganic phosphate does not pose a risk except in very high concentrations. Some of the factors that affect its concentration include wastewater and septic system effluent, detergents, fertilizers, animal waste and industrial discharge.

The DAO 2016-08 for Class C waters have set the maximum limit of phosphate to 0.5 mg/L. **Figure 2.88** shows the high phosphate content in FW-5 through to FW-7 as compared to the DAO standard of 0.5 mg/L. Agricultural land and residential areas were identified sources of high phosphate levels for all Naic, Cavite sampling stations.

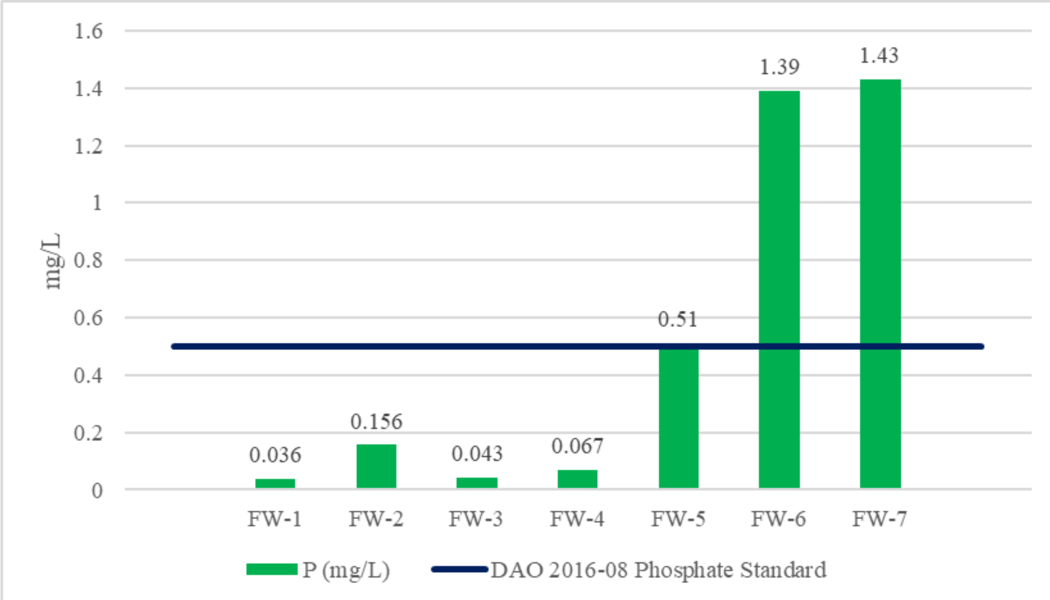


Figure 2.88. Surface Water Sampling Results for Phosphate

- Ammonia

Ammonia is naturally present in water, albeit in small amounts. A high concentration of ammonia can be attributed to sewage wastes, other unwanted waste materials, from fertilizers and effluent from industrial areas. DAO 2016-08 limit for ammonia for Class C waters is only up to 0.05 mg/L.

The results for ammonia for the freshwater samples shows that all sampling sites in Cavite have the high concentrations, while only FW-2 in Bataan shows exceedances. Stations with high ammonia concentration can be attributed to the run-off industrial effluent and agricultural discharges in Mariveles and Naic.

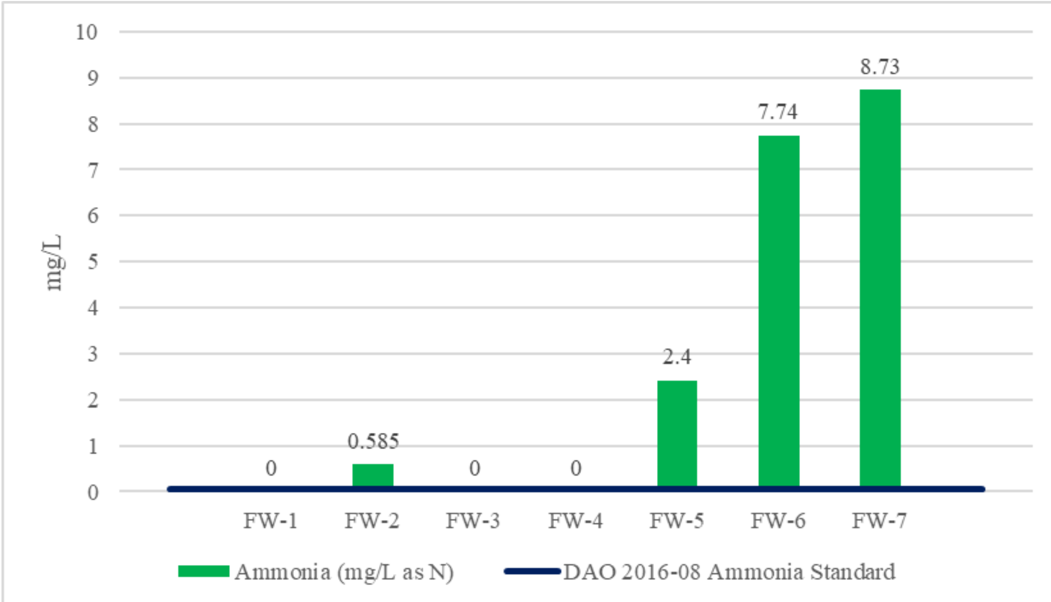


Figure 2.89. Surface Water Sampling Results for Ammonia

- Fecal Coliform

The DAO 2016-08 Class C standard for fecal coliform is at 200 MPN/mL. Fecal coliform refers to a group of total coliforms found in feces of warm-blooded mammals. This bacteriological test conveys whether the water is free from disease-causing bacteria. Such contamination may pose potential health risks.

Figure 2.90 summarizes the amount of fecal coliform per sampling site. FW-6 and FW-7 in Naic have the highest fecal coliform concentration, but all sampling sites have exceeded the allowable DAO standard. It can be noted that stations with high fecal coliform test results are adjacent to commercial and residential areas, hence results can be attributed to animal wastes and domestic water discharges from nearby communities.

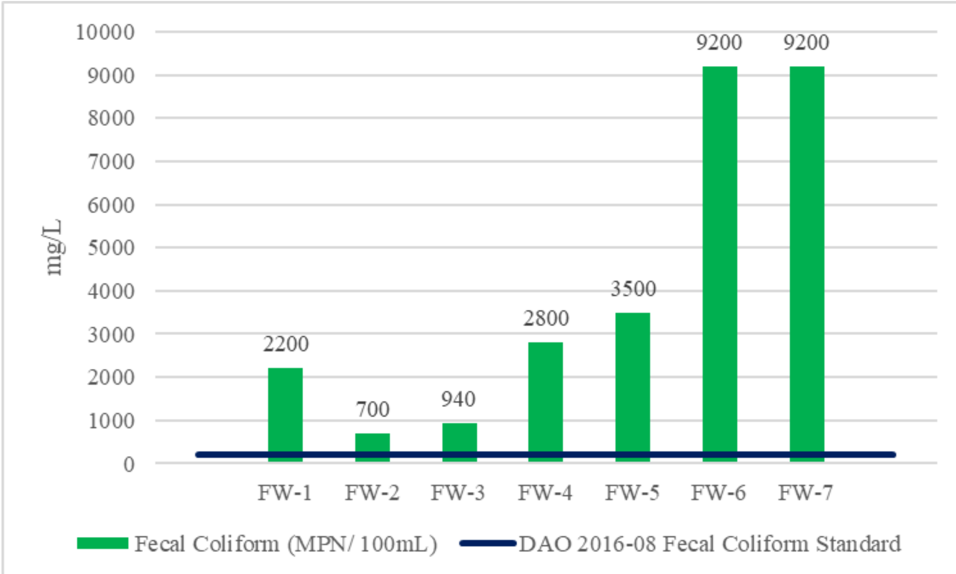


Figure 2.90. Surface Water Sampling Results for Fecal Coliform

Marine Water

Table 2.33 and **Table 2.34** show the marine sampling results taken from the sampling sites with their corresponding DAO 2016-08 **(Annex I)**. **Table 2.33** shows the results of water quality sampling collected within the proximity of the landing sites of BCIB alignment at Cavite, Bataan, and Corregidor Island. While **Table 2.34** presents the results of marine water quality along the stretch of the alignment. The values in red are those that exceed DAO 2016-08 standards.

Marine sampling (Class SB) results for physicochemical properties, inorganic non-metallic parameters, bacteriological parameters, and metals and major cations for MBS-1 to MBS-05 with their corresponding DAO 2016-08 are presented in **Table 2.34**. Samples were collected on 13-14 February 2020. Each location was sampled three times at three separate depths, one sample was taken on the surface (S), another was taken near the bottom (B), and the last was taken at the middle (M) of the surface and bottom sampling depths.

Table 2.33. Marine Water Sampling (Class SB) Results

Parameters	DAO 2016-08 Standards for Class SB	MBS-1			MBS-2			MBS-3			MBS-4			MBS-5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Physicochemical Properties																
1. pH	7.0-8.5	8.16	8.25	8.30	8.32	8.32	7.68	8.45	8.52	8.31	8.51	8.46	8.29	8.38	8.44	8.45
2. Temp	26-30 °C	28.9	28.1	27.4	29.4	29.4	28.9	32.4	25.3	29.3	28.3	26.9	27.9	26.8	29.4	27.2
3. Color (TCU)	50	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4. O&G	2.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5. Turbidity (NTU)*	-	1.400	1.100	2.100	0.800	0.900	1.400	1.700	0.800	1.000	1.100	1.300	2.000	1.300	1.300	1.000
6. Salinity (Units)*	-	29.000	29.000	29.500	29.200	29.700	30.000	28.900	29.400	29.500	31.000	30.800	31.100	30.900	31.100	31.100
7. BOD (mg/L)	N/A	7.55	6.65	2.02	ND	ND	8.16	2.12	ND	ND	8.48	6.35	7.55	ND	ND	ND
8. COD (mg/L)*	-	1730	1360	1150	1510	1410	1680	1780	1750	1300	2050	1990	1980	1890	1710	1390
9. TDS (mg/L)*	-	36100	36500	36600	36600	35200	36600	36800	37200	37600	39100	39200	40200	38700	38700	39400
10. TSS (mg/L)	50.0	ND	ND	ND	6.4	ND	ND	ND	ND	ND	9.0	ND	ND	ND	ND	ND
11. DO (mg/L)	6	3.78	4.31	4.42	4.84	4.84	3.25	7.55	6.50	9.62	7.71	3.94	3.71	7.72	7.42	7.29
Inorganic Non-Metallic Parameters																
12. Cl (mg/L)	N/A	20000	20500	20700	19900	20500	19200	20000	21200	17700	19200	22700	22200	22000	22600	23500

Parameters	DAO 2016-08 Standards for Class SB	MBS-1			MBS-2			MBS-3			MBS-4			MBS-5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
13. NO3-N (mg/L)	10.000	ND	ND	0.789	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14. P (mg/L)	0.500	0.053	0.048	0.047	0.050	0.047	0.056	0.044	0.050	0.040	0.047	0.047	0.054	0.042	0.058	0.058
15. Cyanide (mg/L)	0.02	0.129	0.129	0.219	0.138	0.124	0.126	0.139	0.149	0.145	0.139	0.131	0.134	0.119	0.137	0.108
16. Ammonia (mg/L as N)	0.050	0.693	0.121	0.118	0.110	0.133	0.962	ND	ND	0.103	0.498	0.844	0.591	0.577	0.696	0.467
Bacteriological Parameters																
17. Fecal Coliform (MPN/ 100mL)	100	110	130	140	79	140	140	9	17	46	13	79	49	23	49	70
Metals and Major Cations																
18. Arsenic	0.010	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
19. Cadmium	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20. Hexavalent chromium	0.050	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21. Lead	0.010	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
22. Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23. Nickel	0.040	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.003
24. Zinc	0.050	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Parameters	DAO 2016-08 Standards for Class SB	MBS-1			MBS-2			MBS-3			MBS-4			MBS-5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
25. Vanadium*	-	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133

* - No DAO 2016-08 Standard
S = Surface; M = Middle; B = Bottom
ND – None detected
N/A – Not Applicable (According to DAO 2016-08)

Table 2.34. Marine Water Sampling (Class SB) Results (Continuation)

Parameters	DAO 2016-08 Standards for Class SB	MBS-6			MBS-7			MBS-8			MBS-9			MBS-10		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Physicochemical Properties																
1. pH	7.0-8.5	7.50	8.26	8.47	8.35	8.31	8.31	8.44	8.47	8.48	8.32	8.26	8.14	8.17	8.43	8.39
2. Temp	26-30 ℃	26.2	26.7	26.4	25.5	28.9	26.9	25.6	25.3	25.2	29.4	28.9	28.2	26.5	27.4	28.7
3. Colour (TCU)	50	10	10	10	10	10	10	10	10	10	5	5	5	5	5	5
4. O&G	2.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5. Turbidity (NTU)*	-	2.000	2.800	3.000	6.100	4.500	5.600	3.100	7.300	5.400	0.900	0.900	0.800	1.600	0.700	1.000
6. Salinity (Units)*	-	31.000	30.900	30.800	30.900	30.800	26.600	30.500	30.800	30.700	29.200	29.000	29.300	29.900	29.700	29.300
7. BOD (mg/L)	N/A	ND	5.18	6.38	7.28	6.05	6.98	3.02	2.82	6.05	5.18	5.75	5.78	ND	ND	4.55
8. COD (mg/L)*	-	1860	2010	1690	1630	2100	1540	1290	1120	1100	2150	1810	1740	1430	2290	2030
9. TDS (mg/L)*	-	38600	38700	38400	39100	39300	39300	39000	38800	38700	36800	37000	37000	37000	37600	37600
10. TSS (mg/L)	50.0	16.8	11.0	7.5	17.5	16.8	16.8	8.8	26.7	41.6	5.7	ND	5.9	6.9	ND	ND
11. DO (mg/L)	6	8.28	8.09	8.11	5.72	6.60	6.30	7.65	8.33	8.31	4.84	7.09	7.17	8.36	4.20	5.86
Inorganic Non-Metallic Parameters																
12. Cl (mg/L)	N/A	21200	21500	22500	22100	21500	20600	20400	20600	20900	20600	20500	20600	21000	20400	21000
13. NO3-N (mg/L)	10.000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Parameters	DAO 2016-08 Standards for Class SB	MBS-6			MBS-7			MBS-8			MBS-9			MBS-10		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
14. P (mg/L)	0.500	0.056	0.063	0.063	0.075	0.086	0.068	0.099	0.055	0.064	0.047	0.043	0.051	0.045	0.047	0.052
15. Cyanide (mg/L)	0.020	0.146	0.128	0.130	0.123	0.135	0.142	0.142	0.138	0.135	0.136	0.160	0.137	0.136	0.127	0.135
16. Ammonia (mg/L as N)	0.050	0.602	0.106	1.110	0.456	0.472	0.118	0.693	0.420	0.655	0.153	0.932	0.269	-	0.189	0.956
Bacteriological Parameters																
17. Fecal Coliform (MPN/ 100mL)	100	70	79	70	170	540	220	1600	350	170	49	79	140	33	170	79
Metals and Major Cations																
18. Arsenic	0.010	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
19. Cadmium	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
20. Hexavalent chromium	0.050	ND	ND	ND	0.006	0.007	0.012	ND	ND	ND	ND	ND	ND	ND	ND	ND
21. Lead	0.010	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
22. Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0007	ND	ND
23. Nickel	0.040	0.001	0.001	0.003	0.001	0.001	0.003	0.003	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001
24. Zinc	0.050	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
25. Vanadium*	-	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133

The water quality parameters are recognized non-compliant to the DAO 2016-08 Water Quality Guideline for Class SB for both groups of marine water samples, specifically, temperature, DO, cyanide, ammonia and fecal coliform. Sampling location MBS-10 was strategically situated approximately 2 km away from the alignment, close to Corregidor Island, to serve as a control point.

The most notable water quality parameter are ammonia and cyanide, which almost all the marine water sampling results fail to comply with the standard concentrations.

Results from the rest of the considered parameters are within the standard limits and did not show imperative observations Parameters with exceedance in the surface water quality baseline test results are further discussed below.

- Temperature

The results for temperature are shown in **Figure 2.91**. DAO 2016-08 standard for temperature ranges from 26 to 30°C. Stations that exceed the range include surface of MBS-3, and those that fall short include middle of MBS-3, surface of MBS-7, and all water samples of MBS-8.

Water temperature creates a vital role in marine habitat. It is important to get the parameters at different depths of the bay as these are all influenced by temperature or thermal stratification. This is normally experienced in summer season, when warmer water is in near the surface (epilimnion) and cooler water at increasing depths (hypolimnion).

- Dissolved Oxygen (DO)

Marine water quality results for DO is shown on **Figure 2.92**. DAO 2016-08 standard for DO is 6 mg/L. The highest DO concentration of 9.62 mg/L is observed from the bottom depth of MBS-3. This location is the nearest sampling station to the Corregidor Island, which confirms high oxygen available for marine species.

Sampling locations MBS-1 and MBS-2, at the middle and bottom depths for MBS-4 and MBS-9 and MBS-10 obtained low DO results. The low DO in Mariveles side (MBS-1 and MBS-2), which ranges from 3.2-4.8 mg/L is similar to the DO result from the downstream of Pangolisanin River (FW-4). This may be attributed to the wastes caused by the nearby built-up area and residential area. These bacteria produce excessive concentration of nutrients in the water, therefore reduce solubility of oxygen. Similar to the low DO at the further east (MBS-4 and MBS-10) and pier area (MBS-9) of Corregidor Island, which may be an indication of the presence of decomposer organisms from the activities in the island and Manila Bay and that may also have been affected by temperature and salinity in the area.

- Cyanide

All water sampling results obtained cyanide values are not compliant to DAO 2016-08 standard. The cyanide concentrations were observed to be in the range between 0.10 to 0.16 mg/L with the lowest concentration at 0.108 mg/l from MBS-5 bottom sample. Elevated concentration of 0.219 mg/L was obtained from MBS-1 bottom sample, which is the only data that deviated from the rest of the results for cyanide. Cyanide contamination may be caused by diffusion of effluents from electroplating processes, gold and silver extraction and production of medicines and plastic to the marine waters. Aquatic organisms are known to have a range of sensitivities to cyanide, but fish are generally the most sensitive aquatic organisms.

- Ammonia

The results for ammonia are shown in **Figure 2.94**. Ammonia DAO 2016-08 standard for Class SB Water is 0.05 mg/L. The figure shows that all the marine water sampling locations exceed the standard except for MBS-3 surface and middle, and MBS-10 surface samples. The highest amount of ammonia analyzed at 1.110 mg/ L is at the bottom level of MBS-6.

It can be perceived that the ammonia sampling results obtained in offshore marine samples are notably higher than that of nearshore marine samples. Accumulation of decomposed organic waste matter can contribute to high ammonia levels at the bottom portion marine waters as well as offshore discharges of domestic and commercial wastes.

- Fecal Coliform

Fecal coliform amounts are shown in **Figure 2.95.** The highest exceedance of a sampling location was found on the surface of MBS-8 with 1,600 MPN/100mL. MBS-7, and MBS-8 are the sampling locations where all depths (surface, middle, and bottom) had notable exceedances from the DAO 2016-08 standard for Class SB water. These samples are taken offshore approaching the Cavite landing site of BCIB alignment. Potential source of fecal coliform within the area are sewage effluents, livestock and farming activities that might contain human and animal feces.

For other observations, MBS-1, MBS-2, MBS-9 and MBS-10 have minor exceedance to the standard limits, whilst the rest are compliant. The results hold true and consistent with the results of the surface water fecal coliform results from Cavite side, which has the highest, and Bataan and Corregidor nearshore locations.

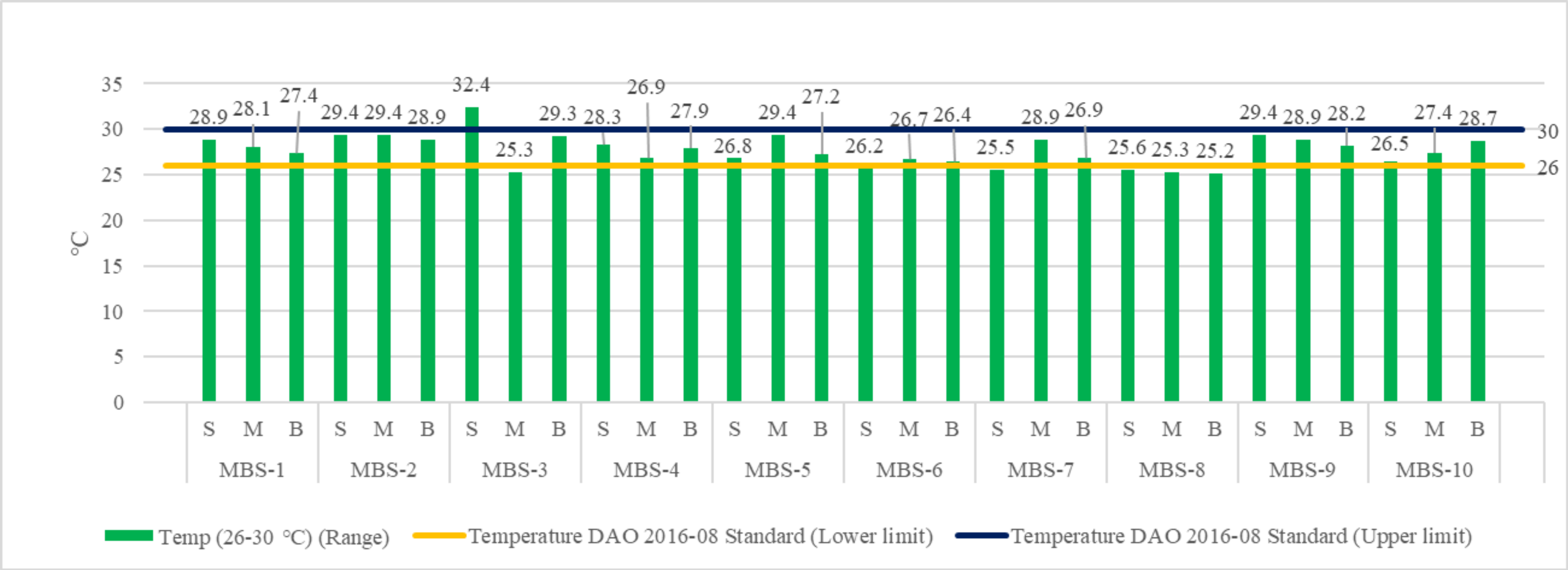


Figure 2.91. Marine Water Sampling Results for Temperature

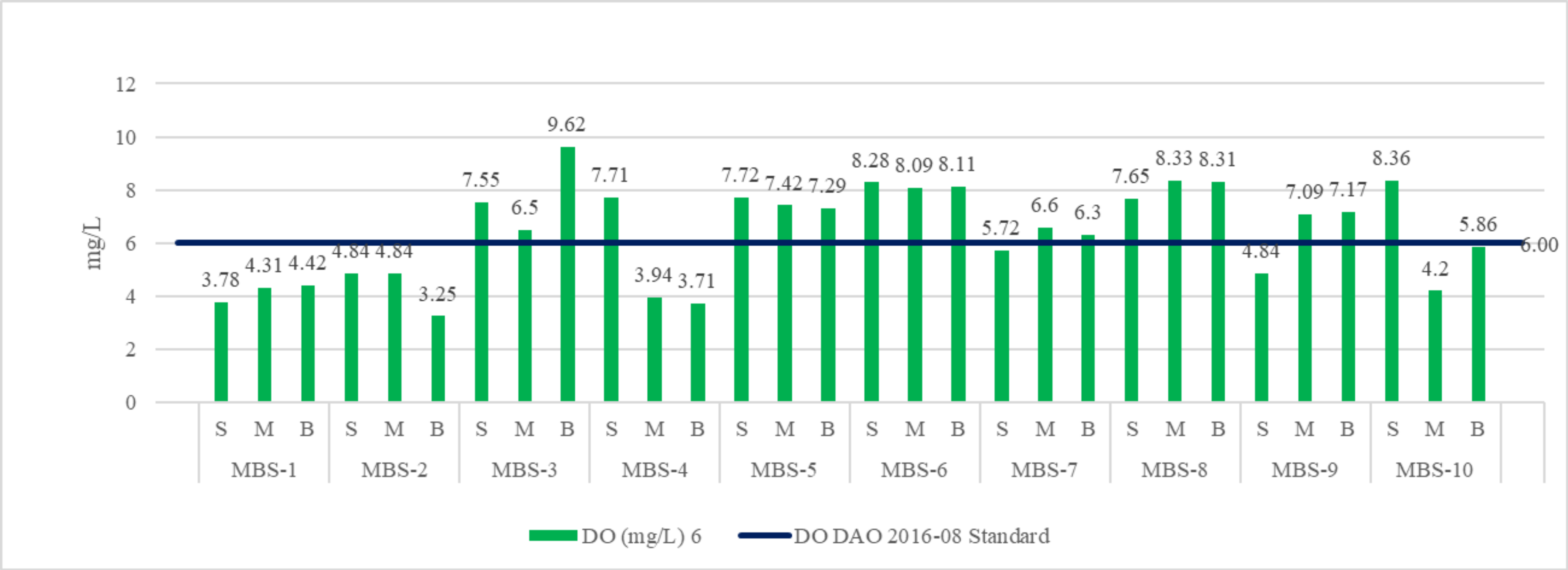


Figure 2.92. Marine Water Sampling Results for DO

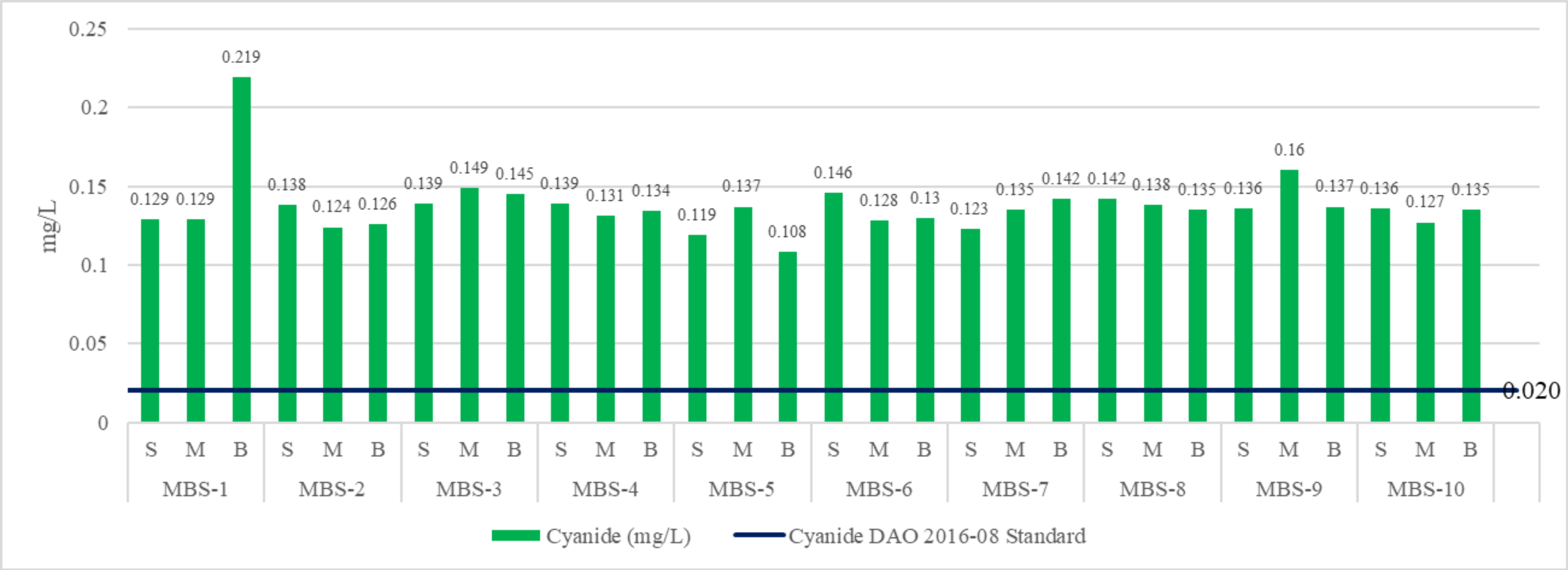


Figure 2.93. Marine Water Sampling Results for Cyanide

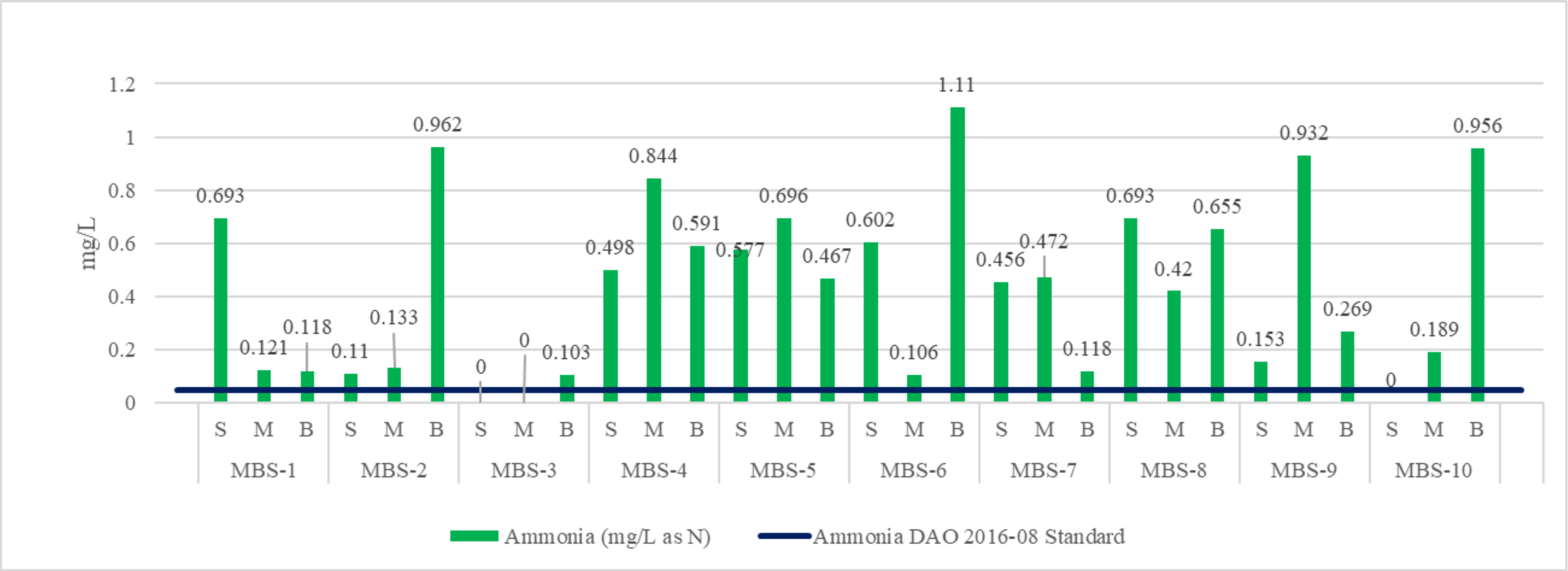


Figure 2.94. Marine Water Sampling Results for Ammonia

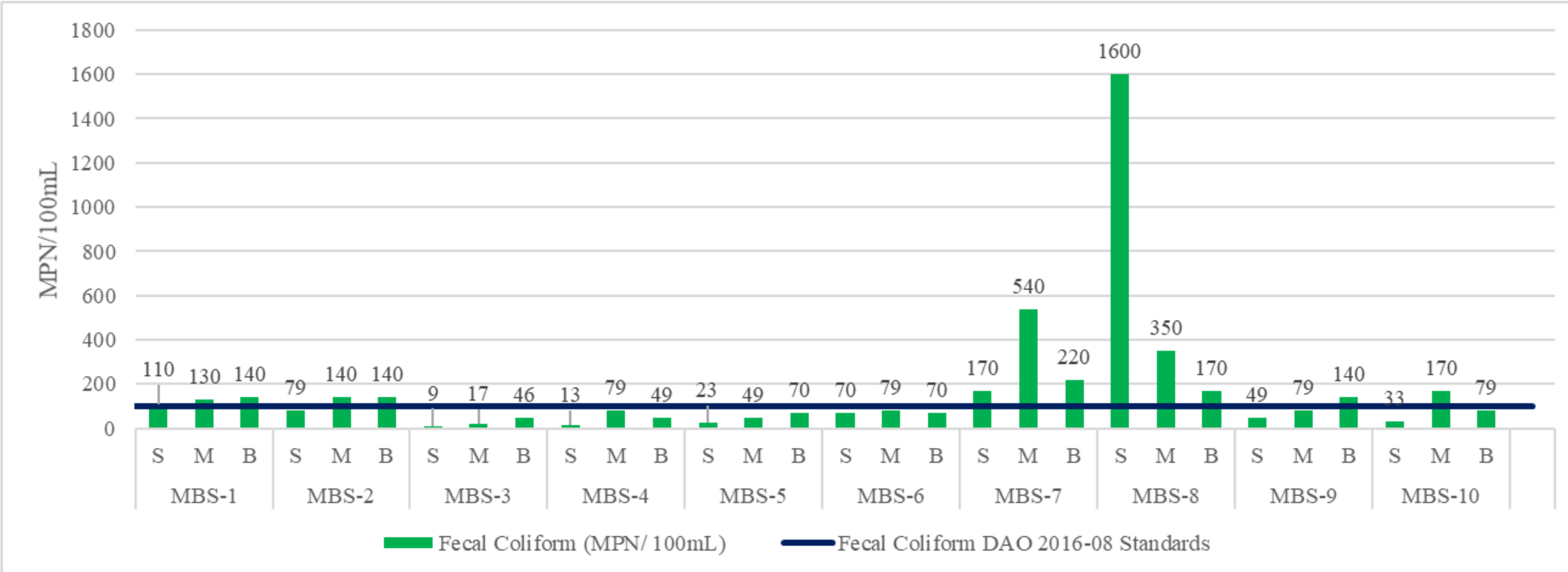


Figure 2.95. Marine Water Sampling Results for Fecal Coliform

Table 2.35. Nearshore Sampling (Class SB) Results

Parameters	DAO 2016-08 Standards for Class SB	Bataan			Cavite			Corregidor Island		
		BNS-1	BNS-2	BNS-3	CNS-1	CNS-2	CNS-3	CoNS-1	CoNS-2	CoNS-3
		12-13 February 2020			13 February 2020			15 February 2020		
Physicochemical Properties										
1. pH	7.0-8.5	7.9	8.26	8.43	7.3	7.38	8.44	8.29	8.38	8.45
2. Temp	26-30 °C	25.4	25.8	25.8	26.1	26.2	26.6	29.7	29	32.4
3. Colour (TCU)	50	5	5	5	25	10	10	5	5	5
4. O&G	2.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
5. Turbidity (NTU)*	-	0.6	1.1	0.8	4.1	5.6	3.4	0.7	0.9	1.7
6. Salinity (Units)*	-	28.8	29	29.2	30.1	30.3	30.1	29.5	29.7	29.5
7. BOD (mg/L)	N/A	8.86	7.69	6.79	54.3	4.59	7.38	4.58	5.78	ND
8. COD (mg/L)*	-	1290	1630	2020	595	1070	670	1430	1460	355
9. TDS (mg/L)*	-	34200	35300	35600	35300	34600	35500	37000	36200	36000
10. TSS (mg/L)	50.0	6.3	6.6	ND	15.1	20.9	13.8	ND	ND	ND
11. DO (mg/L)	6	4.85	4.94	4.34	4.1	4.28	4.72	5.08	5.53	7.55
Inorganic Non-Metallic Parameters										
12. Cl (mg/L)	N/A	21100	21200	21500	23100	22900	21400	22500	22400	20900
13. NO3-N (mg/L)	10.000	ND	ND	ND	ND	0.051	ND	ND	ND	ND
14. P (mg/L)	0.500	0.0472	0.054	0.044	0.068	0.069	0.068	0.0461	0.045	0.0439
15. Cyanide (mg/L)	0.020	0.151	0.22	0.157	0.129	0.123	0.115	0.131	0.142	0.125
16. Ammonia (mg/L as N)	0.050	0.154	0.158	ND	1.17	0.189	0.202	0.438	0.502	0.426

Parameters	DAO 2016-08 Standards for Class SB	Bataan			Cavite			Corregidor Island		
		BNS-1	BNS-2	BNS-3	CNS-1	CNS-2	CNS-3	CoNS-1	CoNS-2	CoNS-3
		12-13 February 2020			13 February 2020			15 February 2020		
17. Bacteriological Parameters										
18. Faecal Coliform (MPN/ 100mL)	100	940	94	17	130	79	110	49	110	79
Metals and Major Cations										
19. Arsenic	0.010	0.004	0.004	0.004	0.004	0.004	0.004	0.00416	0.00416	0.00416
20. Cadmium	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.000727	0.000727	0.000727
21. Hexavalent chromium	0.050	ND	ND	ND	ND	ND	ND	ND	ND	ND
22. Lead	0.010	0.005	0.005	0.005	0.005	0.005	0.005	0.00517	0.00517	0.00517
23. Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
24. Nickel	0.040	0.001	0.001	0.001	0.001	0.001	0.001	0.00128	0.00128	0.00128
25. Zinc	0.050	0.01	0.01	0.01	0.01	0.01	0.01	0.0102	0.0102	0.0102
26. Vanadium*	-	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.133

* - No DAO 2016-08 Standard.

ND – None detected

N/A – Not Applicable (According to DAO 2016-08)

Similar observations can be derived between Nearshore and Offshore marine water quality sampling results. The nearshore sampling location which have the most non-conformances to the water classification standard is BNS-1. The same water sampling data result exceedance are found in temperature, DO, cyanide, ammonia, and fecal coliform parameters.

Based from the results, the inherent marine water quality issues amongst the sampling areas near the shorelines of Cavite, Bataan and Corregidor Island are primarily the relatively elevated water temperatures, depleted DO, presence of significant concentrations of cyanide and ammonia, as well as high levels of fecal coliform.

Results from the rest of the considered parameters are within the standard limits and did not show imperative observations. Parameters with exceedance in the surface water quality baseline test results are further discussed below.

- Temperature

DAO standard range for temperature is from 26°C to 30°C. The temperature readings measured in-situ near the shores of Corregidor Island are observed to be on the higher tier with one reading at CoNS-3 exceeded the standard at 32.4°C.

Nearshore water within Cavite and Bataan area exhibits lower water temperature readings. All the temperature readings measured near Bataan shores obtained consistent results of 25.4 to 25.8°C, which are slightly beyond the standard lower limit for temperature. These observations are shown in **Figure 2.96**.

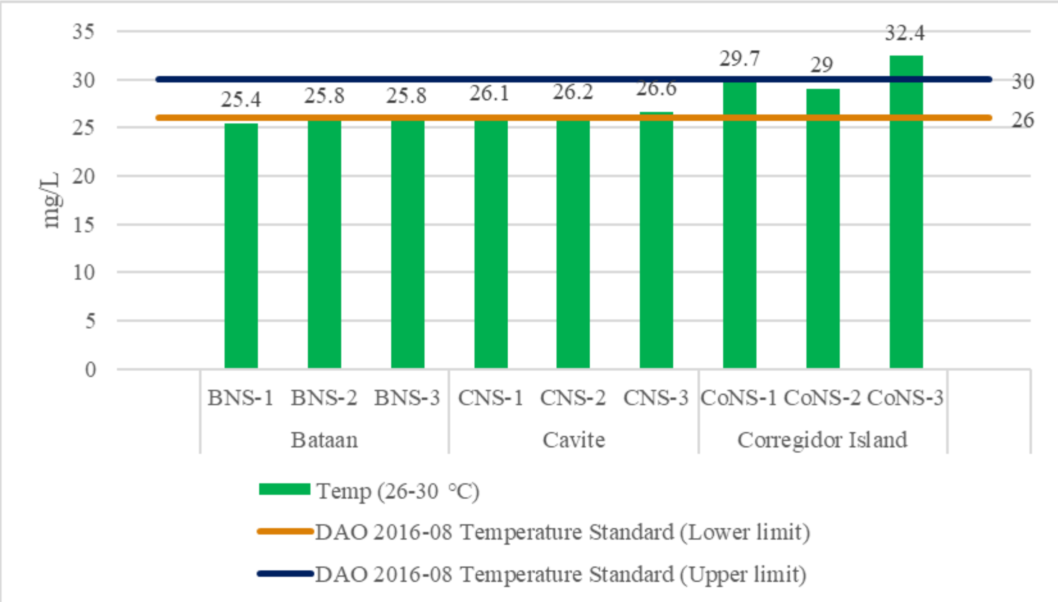


Figure 2.96. Nearshore Water Sampling Results for Temperature

- Dissolved Oxygen (DO)

DO concentrations fall below the standard limit of 6 mg/L for Class SB Marine Waters. The results illustrate that DO levels across all the nearshore sampling locations are relatively depleted, which means that there are potential presences of biodegradable wastes which are partially responsible for heightened oxygen uptake of bacteria and other aquatic life in marine waters. Insufficient DO concentrations would be detrimental to aquatic organisms that live in these waters.

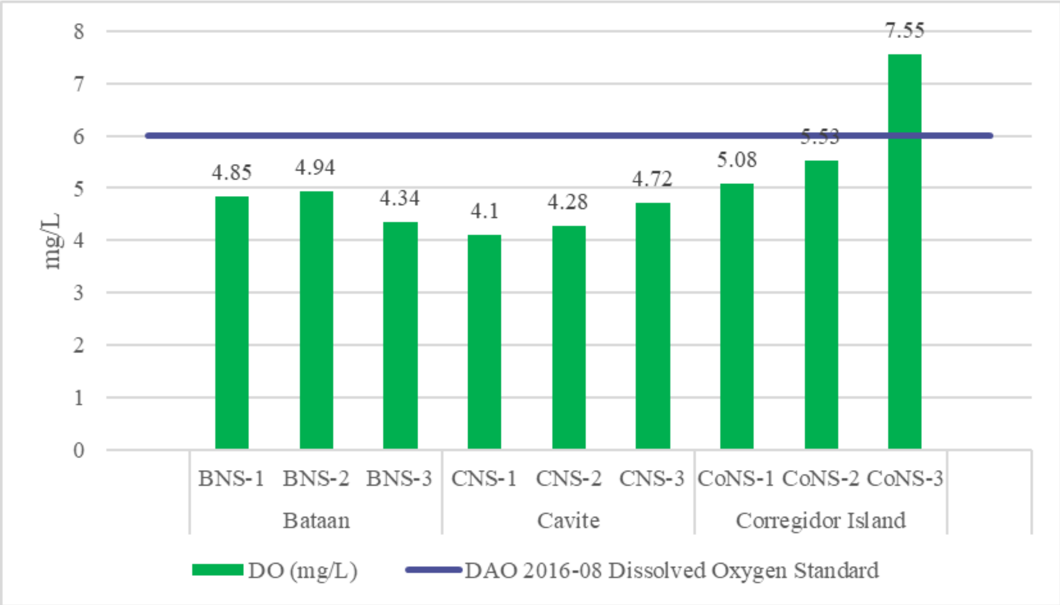


Figure 2.97. Nearshore Water Sampling Results for DO.

- Cyanide

DAO Class SB standard limit for cyanide is 0.02 mg/L. **Figure 2.98** shows the cyanide results for the nearshore water samples in comparison to its corresponding DAO 2016-08 standard values.

The cyanide concentrations in nearshore water samples collected in all three areas are coherently above the standard limit. The highest cyanide concentrations observed are from water samples collected near Bataan shore, with the BNS-2 sample analyzed at 0.22 mg/L. Presence of industries dealing with metals and other chemical industries involving plastics could be a factor in cyanide levels in nearshore waters.

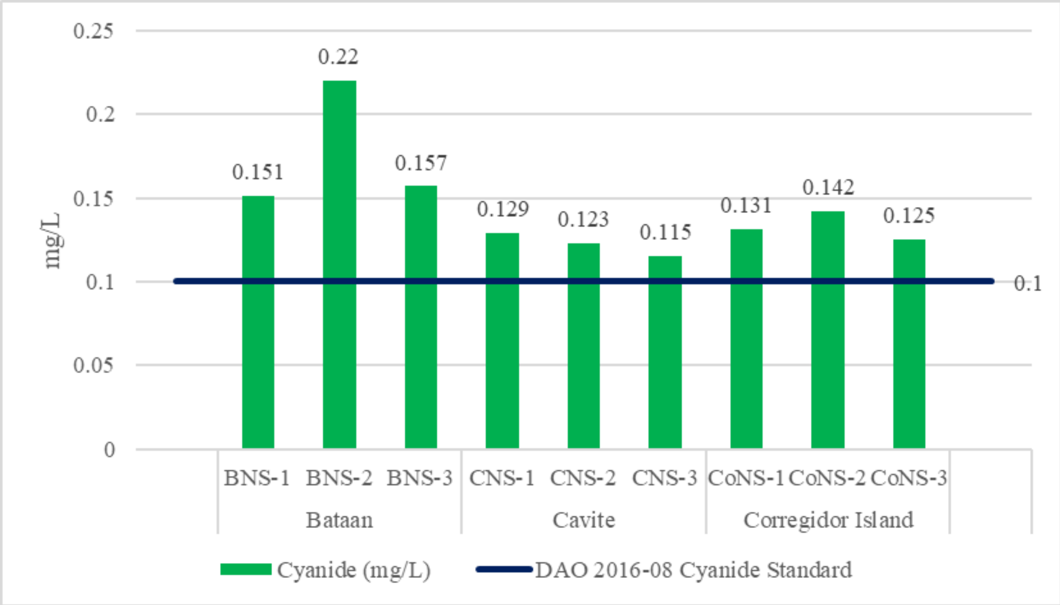


Figure 2.98. Nearshore Water Sampling Results for Cyanide.

- Ammonia

DAO Class SB standard limit for ammonia is 0.05 mg/L. **Figure 2.99** shows ammonia results for the nearshore water samples in comparison to its corresponding DAO 2016-08 standard values.

Based on the sampling data results, almost all nearshore samples also do not comply with standard value for ammonia. The group of samples with coherent elevated ammonia concentration levels are those taken from near Corregidor Island shore, followed by nearshore samples from Cavite then Bataan. However, CNS-1 obtained a prominent ammonia concentration of 1.17 mg/L, which is unusually high for marine water. Fertilizer run-off, wastewater discharge and commercial waste can contribute to high ammonia concentration especially in marine waters near the shore.

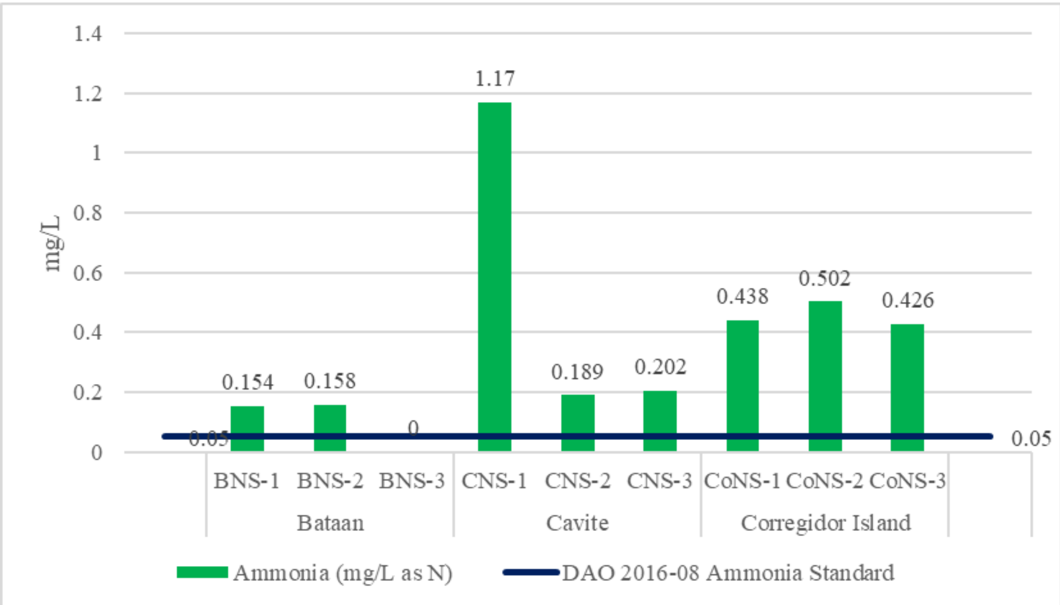


Figure 2.99. Nearshore Water Sampling Results for Ammonia.

- Fecal Coliform

A nearshore sample in BNS-1 shows an exceptionally high concentration of fecal coliform of 940 MPN/100mL in contrast to the Class SB Standard of 100 MPN/mL. Fecal coliform is an indication of contamination due to fecal material of man or other animals.

Other fecal coliform non-conformances among the sampling results are observed in samples CNS-1 at 130 MPN/100mL and CNS-3 and CoNS-2 at 110 MPN/100mL.

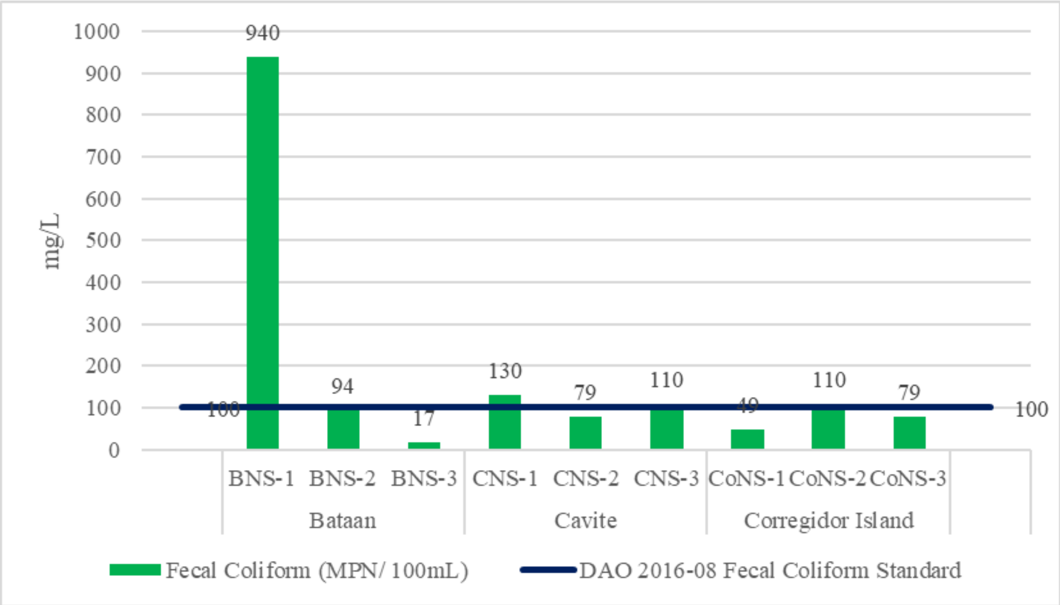


Figure 2.100. Nearshore Water Sampling Results for Fecal Coliform.

Sources of threats at current condition/without the project

With the observations at the current conditions of the water bodies potentially affected by the project, it can be inferred that there are inherent and prevailing threats in these water bodies at the present.

In Mariveles, Bataan area, the groundwater is contaminated with ammonia and cyanide. Pollutant may reach ground water from activities on the land surface such as high concentration of fertilizers and spills from stored industrial wastes that seep through the soil in contact with the groundwater or from upstream intrusion on the ground water source before flowing into the groundwater sites where the samples were collected. In this case, the potential source of high concentrations of ammonia and cyanide in Bataan groundwater sampling sites can be accounted to underground septic systems. Currently, there is no sewerage system in the province of Bataan and household sewerage is stored in septic tanks (PEMSEA, 2017). According to the latest Mariveles, Bataan Comprehensive Land Use Plan (CLUP, 2017-2026), there were no surveys conducted to check the magnitude of the household and commercial septic tanks within the province that comply with the provision in the National Building Code of the Philippines (NBCP, 2004) for construction of proper septic tanks. Septic systems that are improperly sited, designed, constructed or maintained can continually contaminate ground water with bacteria, viruses, nitrates, detergents, oils and chemicals through leaching to the ground. Although each individual system releases a relatively small amount of waste into the ground, the large number and widespread use of these systems makes them a serious contamination source.

In Naic, Cavite side, the groundwater poses no serious problems in terms of water quality however, the surface waters sampling sites have significant concentrations of BOD, phosphate, ammonia, fecal coliform and depleted DO. These parameters are commonly associated with domestic sewage. As per Cavite Integrated Water Resource Management (CIWRM) Master Plan 2012, there are no public sewerage systems in Cavite and most households in urban centres dispose of their wastewater through septic tanks which pass effluents directly into street canals or adjacent watercourses. The growth in population and economic activities in the Province of Cavite has become a pronounce problem on its sewerage and septage management. With inadequate or absence of a robust wastewater, collection system, sewerage wastes are often unaccounted and unmonitored, hence the contamination in the concerned watercourses will potentially be sustained if no immediate intervention and long-term plans is implemented to address the lack of appropriate sewerage and septage systems. Since the waterways are directly connected to Manila Bay, the extension of the contamination is present in the marine and seashore waters. Chloride intrusion in surface waters on the other hand are usually observed due to natural changing of tides, where saltwater infiltrates the river systems.

Majority of marine pollution originates on land, in different forms of pollutant, mostly as a result of various human activities. Manila Bay, aside from being the discharge point of waterways from both Bataan and Cavite, it has also been extensively used for various trades, primarily shipping, aquaculture and tourism. Its waters currently suffer from contamination of cyanide, ammonia, and fecal coliform, which can be inferred as run-off from upstream surface and ground waters. The pollution can also be accounted to several large-scale commercial establishments that discharges its effluent within Manila Bay. Various vessels that use Manila Bay for transport also potentially discharges solids and liquid wastes in form of ballast water, grey water, food wastes, dunnage and other pollutants to the seawater and produces negative impacts on the marine water quality. As a result, the physical properties of the marine water are affected in terms of the pH, temperature and depletion of dissolved oxygen.

2.2.3.3 Potential Impacts and Options for Prevention, Mitigation and/or Enhancement from the Proposed Project

A) Potential Impacts

Degradation of water quality

The impact of the construction works and operation of the project to the water quality of receiving streams and marine waters are foreseen to be the increase in suspended solids, dissolved solids, color and turbidity. This is primarily due to the expected soil excavation activities and disturbances in waterbed silt.

Presence of heavy metal as well as excessive oil and grease and other particulate materials in the water may also be possible if construction work area run-off and spillages onsite is left unaccounted and finds its way in water streams, eventually contaminating the marine waters.

Increase in organic contaminants such as BOD, ammonia, phosphorus will be observed if domestic wastes from construction site is not properly managed.

Physical properties of the water, such as pH, temperature and DO will be affected if significant contamination is present in the waters.

Siltation and erosion

The project involves works such as soil stripping, land clearing, excavation on rivers, coastal shores and marine waters including the construction of temporary facilities and bridge piers. These activities could result in disturbance and resuspension of bottom sediments in the waterbodies and/ or encourage siltation and erosion in the water. Particles displaced from land may also lead towards sources of water via surface runoff and/ or excavation dewatering.

Siltation, erosion and resuspension of particles in the water resulting from the construction works would negatively affect the water quality particularly in terms of increase in turbidity and suspended solids. In cases where contaminated particles or sediments are introduced to the affected water systems, pollutants from soil will potentially be dissolved in the water when turbulence in the water occurs.

Stream contamination

Runoff from the surface construction works areas may contain increased loads of sediments, other suspended solids (SS) and contaminants, if uncontrolled, may carry pollutants (adsorbed onto the particle surfaces) into any nearby stormwater drains and eventually to water streams. On-site construction activities may result in water pollution from the uncontrolled discharge of debris and rubbish such as packaging, construction materials, the spillages of liquids stored on-site, such as oil, diesel and solvents, and the release of concrete washings and dust suppression waste waters.

Construction of the bridge on land may also result to soil compaction, increasing the risk of surface runoff followed by the risk of flooding. It may also alter the water flow of nearby streams, affecting the water quality leading to larger bodies of water.

Surface runoff would pick up particulate matter on the bridge itself and/or on land and will eventually join existing streams. Depending on the contaminant carried over from the particulate matters, it would negatively affect the water quality of the receiving water stream and its destination.

Sewage effluent from construction workforce and solid wastes

Domestic sewage would be generated from the workforce during the construction phase, as well as solid and chemical wastes.

Poor waste management would allow biodegradable and non-biodegradable wastes to accumulate on the bridge or in its canals which may be carried into the nearest body of water via surface runoff, affecting the water quality of the receiving stream or the destination. Domestic sewage may cause eutrophication in the waters due to excessive nutrient content.

Change in quality of groundwater sources

Digging activities may accidentally tap groundwater sources which contaminates the water table. A change in water quality would then be observed, depending on which contaminants enter the water table.

Waste materials (domestic or otherwise) from contractors' activities may be left untreated and penetrate through soil striations.

Areas on land where water percolates and not lead off into streams may seep through soil and penetrate groundwater reserves. If untreated, it may contaminate the water table with fecal coliform or other contaminants that it is privy to on the surface which wasn't filtered through the soil nor used as uptake by the flora.

Effect to marine wildlife and resources

The long-term impacts on the marine and freshwater is considered minimal. Most threats will be present during construction and other elements of control of surface runoff from the bridge will be designed to minimize the impacts and manage and mitigate the construction and operational aspects of the bridge.

Piers may act as footholds for a variety of marine organisms, particularly barnacles and other anchoring organisms. This may provide a new place for different kinds of ecosystems which may benefit fish and other aquatic plants or animals. According to studies by Wellman, et. al (2000) and Pluym, et. al. (2006) bridges do not affect fish communities.

B) Proposed Mitigation Plans

Degradation of water quality

To ensure that the adjacent water bodies are not contaminated during the construction and operation phase, proper management of stockpiles and the drainage system should be undertaken. Stockpiles should be distant from the waterways and covered in order to avoid contamination caused by rain washing the solids into the water body and increasing sedimentation. Sediment traps should be installed.

The bridge design will be equipped with frequent drains with an appropriate catchment system to prevent the runoff of waste materials into Manila Bay. Strict implementation of the waste management rules and regulations will be strongly advised.

To mitigate water pollution due general construction activities (i.e. dredging and excavation on water; operation of vessels; installation of columns/ foundations and construction of bridge structure), the following are proposed to be carried out:

- Apply appropriate siltation control measures such as well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea;
- Soil debris and other excavated materials should be hauled out from the site;
- Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;
- The contractor will be required to comply with the Civil Works Guidelines;
- Compliance to MARPOL 73/78 -Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14;
- Disclose project activities and all other needed information through proper information dissemination in the nearby communities.
- The management will establish strategies to ensure the integrity of water and soil.
- The BCIB will be designed to meet internationally accepted standards to ensure safe operation.
- Emergency response procedures will be in place to manage any possible failures.

Degradation of water quality due to oil, fuel or other lubricant agents leaks

To mitigate water pollution due to hazardous wastes, the following are proposed to be carried out during construction phase:

- Project shall be equipped with oil-water separator to remove oil from effluents prior to discharge to the water bodies;
- Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment;
- Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil;
- Waste oils, oily water and other hazardous wastes will be
- collected and disposed offsite by an accredited third-party
- waste hauler and treater;
- Emergency and contingency plan in case of spills (health and safety management plan must be in place);
- Maintenance and proper use of construction materials and heavy vehicles;
- Ensure compliance to PCG Memorandum # 07-14.

Siltation and erosion

To mitigate siltation and erosion, the following are proposed to be carried out during construction phase:

- Secure appropriate erosion control measures such as additional pavements, concrete sea walls, sediment traps and barriers during heavy rain periods;
- Stockpiles will be placed away from the water courses and protected against natural elements to prevent the transport of soil and sediment;
- The seawater trapped inside marine piles/ casing / cofferdam will be pumped out to sedimentation tank or settling devices before discharge to reduce the water quality impacts to the sea;
- Soil debris and other excavated materials should be hauled out from the site;
- Regular monitoring to the adjacent water bodies to ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;
- Silt traps will be installed for all nearby water bodies;
- The waste soil and other debris will be properly handled and disposed on a regular basis;
- Proper construction methodology will be strictly followed to prevent siltation from boring activities on substrate.
- Whenever feasible, conduct immediate re-vegetation of the cleared land to prevent erosion and siltation.

Stream contamination

To mitigate stream contamination, the following are proposed to be carried out during construction phase:

- Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment;
- Implement a proper waste management (handling, storage and disposal) and housekeeping measures to prevent possible contamination in soil;
- Waste oils, oily water and other hazardous wastes will be collected and disposed offsite by an accredited third-party waste hauler and treater;
- Emergency and contingency plan in case of spills (health and safety management plan must be in place).

Sewage effluent from construction workforce and solid wastes

To mitigate wastewater from construction and solid waste accumulation, the following are proposed to be carried out:

- Locate motor-pool area at least 500 meters away from any body of water;
- The contractor will be required to comply with the Civil Works Guidelines;
- Conduct training and seminars to disclose the plans for the project;

- Stockpiles should be distant from the waterways and covered in order to avoid contamination caused by rain washing the solids into the water body and increasing sedimentation;
- Drainage system should be maintained to prevent oil/ lubricant and/or chemical run-off contaminating water bodies (i.e. rivers, lake);
- Sewage and other domestic discharges will be directed to a local septic tank;
- Temporary sanitary facilities, such as portable chemical toilets, should be employed on-site where necessary to handle sewage from the workforce. A licensed contractor would be responsible for appropriate disposal of waste matter and maintenance of these facilities.
- Proper storage of chemicals should be implemented to prevent spillage and possible contamination of soil and water.

Change in quality of groundwater sources

To mitigate groundwater contamination, the following are proposed to be carried out during construction phase:

- Proper planning to avoid accidentally tapping or contaminating groundwater sources should be implemented.
- Excessive percolation can be avoided by re-vegetation practices and by proper planning of slopes, drainage pipes and canals and the application of silt and waste barriers.
- Proper waste management and strict adherence to rules and regulations would help in mitigating any effluent entering groundwater sources.
- Drainage and slopes should not allow excessive surface runoff. Percolation should still happen to recharge groundwater sources (Transportation Research Board, 2005).

Effect to marine wildlife and resources

Potential impacts can be more reasonably mitigated as the extent of construction works within the marine environment are restricted to the foundation areas, and thus mitigating measures such as silt curtains can be utilized. Other mitigation measures to be undertaken are:

- Employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea;
- Dredging must be confined at the immediate area so that only a small part of the meadow will be affected;
- Engineering modifications will be applied to provide greater surface complexity and encourage marine growth;
- Engineering design does not hinder longshore currents and ensures free circulation of water;
- Proper disposal of debris;

- Any debris or concrete waste must be removed as quickly as possible;
- Monitoring and evaluation of benthic habitats to be conducted quarterly or bi-annually to capture changes;
- Strict observance and implementation of Site Protection and Rehabilitation Program and materials handling which provide for soil erosion control measures;
- Observe best practices in proper construction procedures that promote care and minimal disturbance to the existing environment.

2.2.4 Freshwater Ecology

The project implementation will have no impact on freshwater ecology.

2.2.5 Marine Ecology

2.2.5.1 Purpose and Station Locations

This baseline study was designed to collect primary and secondary data on the marine environments and biological characteristics along the proposed bridge project and neighbouring coastal/marine and river estuarine ecosystems, and to provide an analysis of the potential environmental impacts of this project on the local coastal and marine environments and biological resources in the Mariveles, Corregidor and Naic nearshore areas and Manila Bay open water area. The study area is consists of sampling stations (a) along the nearshore/beach areas specifically in the river estuaries, open coastal beaches, and intertidal and subtidal shallows in Mariveles, Corregidor and Naic; and (b) open water area along the main bridge route near the mouth of Manila Bay (from Mariveles-Corregidor-Naic). A total of three (3) river stations for plankton, primary productivity and soft bottom benthos investigations; nine (9) intertidal stations for soft bottom benthos only; nine (9) subtidal stations for soft bottom benthos, plankton and primary productivity; and eight (8) open water stations along the main bridge alignment also for soft bottom benthos, plankton and primary productivity were sampled in this study. The locations of these sampling stations are indicated in **Figure 2.101**, **Figure 2.102**, and **Figure 2.103**. The data on coordinates, dates and time of sampling, sea conditions, water depths, color of the sea, and type of sediments collected at each sampling station are shown in **Table 2.20**. The coordinates and water depths of each sampling station were taken with a GPS 7 Garmin *Etrex 30x* instrument and a hand-held portable echo-sounder, respectively.

In addition, ichthyoplankton (fish eggs and larvae), mangrove and coastal vegetation, coral reef and associated fish assemblages, macroinvertebrates, macrophytes (seagrass and macrobenthic algae), red tides or harmful algal blooms (HABs), fish sanctuaries, artificial hard structures (artificial reefs/shipwrecks), protected marine species (threatened or endangered species), and fisheries resources of nearshore and open water areas were also included in this baseline study.

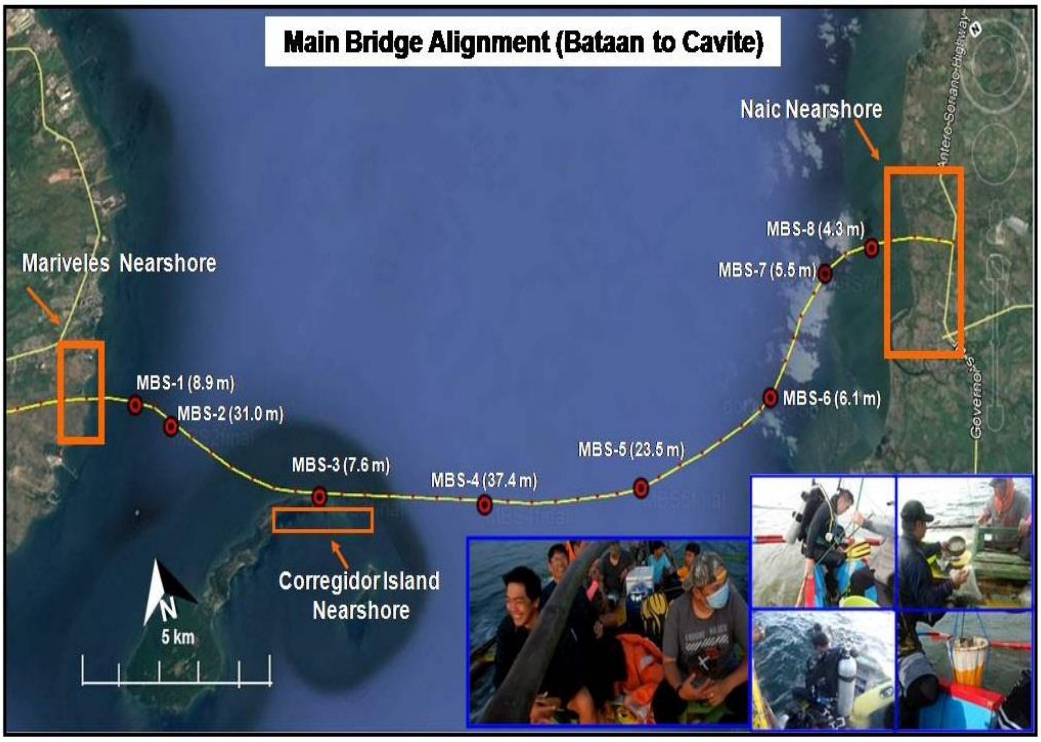


Figure 2.101. Sampling Station Locations for offshore/open water plankton, soft bottom infaunal benthos (subtidal), and primary productivity surveys along the proposed main bridge alignment from Mariveles (Bataan) to Naic (Cavite)

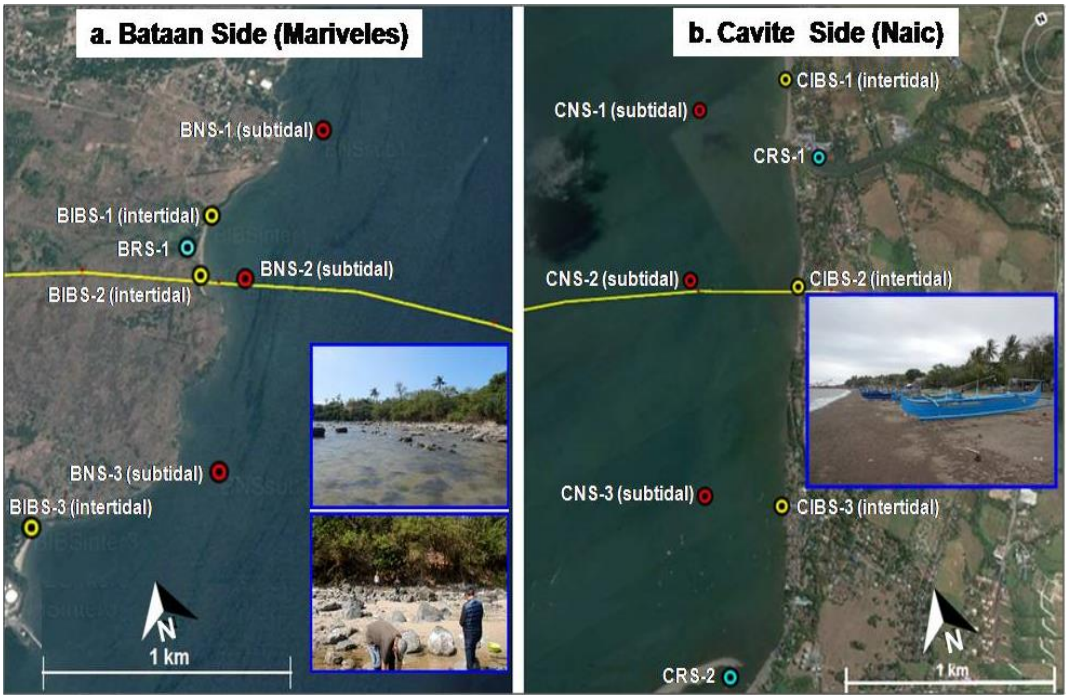


Figure 2.102. Sampling station locations for nearshore plankton, soft bottom infaunal benthos (intertidal and subtidal), and primary productivity surveys along Barangays Alas-asin and Mt. View (Mariveles, Bataan) and Barangays Timalan Balsahan and Timalan Concepcion (Naic, Cavite)

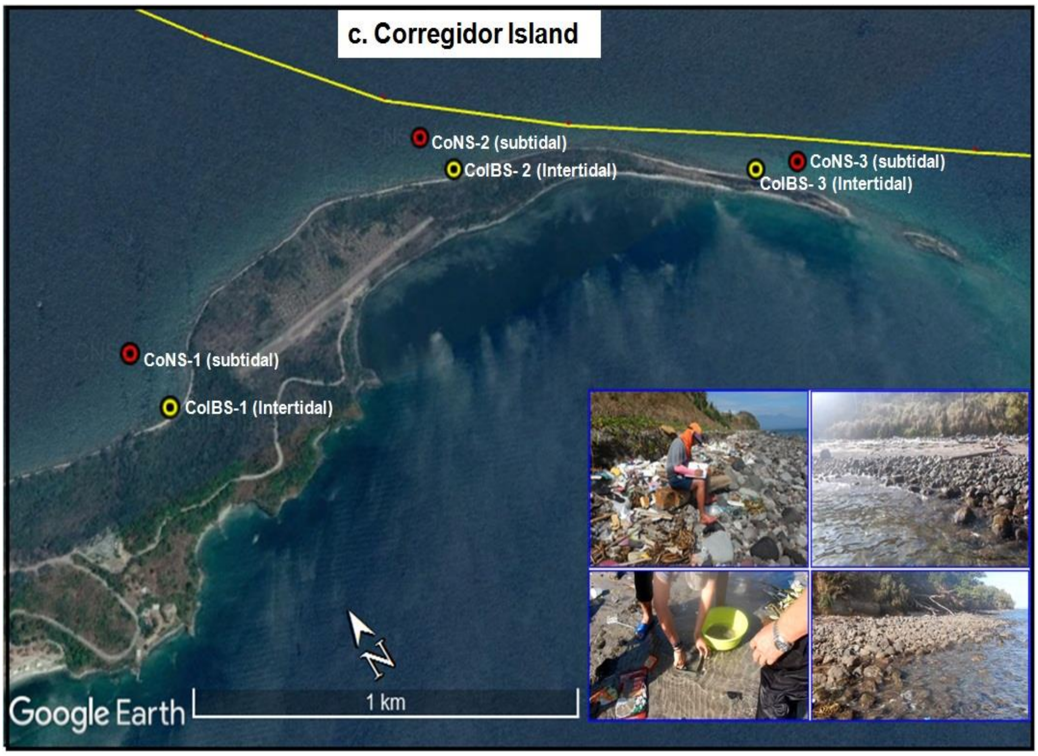


Figure 2.103. Sampling station locations for nearshore plankton, soft bottom infaunal benthos (intertidal and subtidal), and primary productivity surveys along Corregidor Island (Cavite City)

Table 2.36. Marine sampling data and conditions

Study Site	Habitat Type	Station	Coordinates		Sonic Depth (m)	River/Sea Condition	Prevailing Wind	Substrate Type	Color of Water	Date/Time of Sampling (2020)
			Latitude North	Longitude East						
Bataan - Mariveles (Nearshore/Beach Area)	River Estuary	BRS-1	14°26'21.40"	120°34'47.40"	0.3	Calm	NE	Sandy-muddy with shell fragments	Greenish	12 Feb/11:30 a.m.
	Intertidal	BIBS-1	14°26'24.00"	120°34'52.40"	Bare at low tide	Calm	NE	Fine sand with pebbles & shell fragments	-	12 Feb/10:25 a.m.
		BIBS-2	14°26'16.71"	120°34'47.64"	Bare at low tide	Calm	NE	Sand-muddy with shell fragments	-	12 Feb/11:00 a.m.
		BIBS-3	14°25'56.88"	120°34'14.54"	Bare at low tide	Calm	NE	Sandy	-	12 Feb/08:45 a.m.
	Subtidal	BNS-1	14°26'27.75"	120°35'12.63"	2.3	Choppy	NE	Muddy with shell fragments	Green	12 Feb/10:00 a.m.
		BNS-2	14°26'13.10"	120°34'53.30"	2.7	Choppy	NE	Sandy-muddy with shell fragments	Green	12 Feb/09:30 a.m.
		BNS-3	14°25'50.88"	120°34'39.95"	3.5	Choppy	NE	Sandy-muddy with shell fragments	Green	12 Feb/08:45 a.m.
Corregidor Island (Nearshore/Beach Area)	Intertidal	CoIBS-1	14°23'28.40"	120°36'07.38"	0.1	Choppy	NE	Fine sand with pebbles	-	13 Feb/08:45 a.m.
		CoIBS-2	14°23'33.13"	120°36'41.42"	0.1	Choppy	NE	Sand with pebbles	-	13 Feb/09:30 a.m.
		CoIBS-3	14°23'16.29"	120°37'07.28"	0.1	Choppy	NE	Coarse sand with pebbles	-	13 Feb/10:20 a.m.
	Subtidal	CoNS-1	14°23'34.85"	120°36'06.23"	8.2	Choppy	NE	Coarse sandy-muddy	Greenish grey	13 Feb/09:00 a.m.
		CoNS-2	14°23'39.69"	120°36'41.27"	9.9	Choppy	NE	Coarse sand	Green	13 Feb/10:00 a.m.
		CoNS-3	14°23'15.72"	120°37'11.63"	4.2	Choppy	NE	Coarse sand	Green	13 Feb/10:45 a.m.
Cavite - Naic		CRS-1	14°20'49.30"	120°46'53.40"	0.5	Calm	NE	Sandy-muddy with shell fragments, black	Brown	08Feb/10:00 a.m.

Study Site	Habitat Type	Station	Coordinates		Sonic Depth (m)	River/Sea Condition	Prevailing Wind	Substrate Type	Color of Water	Date/Time of Sampling (2020)
			Latitude North	Longitude East						
(Nearshore/Beach Area)	River Estuary	CRS-2	14°19'52.60"	120°45'56.60"	0.5	Choppy	NE	Muddy, black	Brown	08Feb/11:20 a.m.
	Intertidal	CIBS-1	14°21'03.69"	120°46'56.09"	Bare at low tide	Choppy	NE	Sandy, blackish	-	08Feb/07:40 a.m.
		CIBS-2	14°20'33.31"	120°46'37.69"	Bare at low tide	Choppy	NE	Sandy, blackish	-	08Feb/07:30 a.m.
		CIBS-3	14°20'07.58"	120°46'16.50"	Bare at low tide	Choppy	NE	Sandy, blackish	-	08Feb/07:20 a.m.
	Subtidal	CNS-1	14°21'06.60"	120°46'39.10"	2.1	Choppy	NE	Muddy, greyish black	Brown	08Feb/09:30 a.m.
		CNS-2	14°20'43.10"	120°46'21.90"	3.1	Choppy	NE	Muddy, greyish black	Brown grey	08Feb/08:45 a.m.
		CNS-3	14°20'14.70"	120°46'06.40"	2.7	Choppy	NE	Fine sandy-muddy, grey	Brown grey	08Feb/10:55 a.m.
Main Bridge Alignment – Near	Open Water	MBS-1	14°26'04.44"	120°35'07.32"	8.9	Choppy	NE	Sand-muddy	Greenish grey	12 Feb/01:50 p.m.
		MBS-2	14°25'42.07"	120°35'29.91"	31.0	Choppy	NE	Muddy, grey	Greenish grey; zero underwater horizontal visibility at the bottom (totally black)	13 Feb/05:10 p.m.
		MBS-3	14°23'19.24"	120°37'10.52"	7.6	Choppy	NE	Coarse sand with shell fragments	Greenish grey	13 Feb/04:15 p.m.

Study Site	Habitat Type	Station	Coordinates		Sonic Depth (m)	River/Sea Condition	Prevailing Wind	Substrate Type	Color of Water	Date/Time of Sampling (2020)
			Latitude North	Longitude East						
Mouth of Manila Bay (Offshore Area)		MBS-4	14°21'49.57"	120°39'11.00"	37.4	Choppy	NE	Muddy grey with shell fragments	Brown; zero underwater horizontal visibility at the bottom (totally black)	13 Feb/03:20 p.m.
		MBS-5	14°20'36.85"	120°41'10.25"	23.8	Choppy	NE	Muddy, blackish	Greyish brown	13 Feb/02:30 p.m.
		MBS-6	14°20'20.70"	120°43'37.20"	6.1	Choppy	NE	Coarse sand with silt	Greenish grey	13 Feb/01:55 p.m.
		MBS-7	14°20'59.52"	120°45'16.48"	5.5	Choppy	NE	Coarse sand with silt	Greenish grey	13 Feb/01:25 p.m.
		MBS-8	14°20'51.39"	120°46'01.37"	4.3	Choppy	NE	Muddy, greyish	Greenish grey	13 Feb/12:45 p.m.

2.2.5.2 Methodology

A) Intertidal, Exposed Coastal Beach and River Estuary

Collection of primary data for this project component includes on site observation, interview and coastal characterization. Physical, topographic and ecological characteristics features of the intertidal, coastal beaches and river estuaries in Alas-asin (Mariveles), Corregidor Island (Cavite City) and Timalan Balsahan/Concepcion (Naic) such as the type of sediment (sand, rocks, mixed sand-rocks, coral rubble, and broken shell fragments) and occurrence of coastal vegetation (such as trees, palms, shrubs and grasses) or mangrove, garbage or solid waste, marine turtle nesting site, marine plants and animals attached to intertidal/subtidal rocks, seagrass/seaweed debris, fishing boats/paraphernalia, and economic activities (oyster farming or “talabahan”, fish landing/fish port, beach resort, dry docking and ship repair, and pier/oil terminal and refinery) were also recorded.

B) Collection and Analysis of Phytoplankton and Zooplankton

Conventional plankton net was used with stainless circular frame and detachable cod end (specs. 30 cm mouth diameter, 20 µm mesh size and 1-meter length) for marine phytoplankton and zooplankton analysis (**Plate 5**). Duplicate plankton samples were collected by vertical hauling of the net from approximately near the bottom to the surface of each station to minimize the effect of variations brought about by diurnal migration of plankton (Jillett, 1971; Estudillo, 1979). In this manner, all levels of the water column were sampled. A calibrated flowmeter was attached to the center of the mouth of the plankton net to obtain an estimate of the volume of water filtered by the net during each haul. The sample was transferred and stored in 250 ml polyethylene bottle and preserved in 10% buffered seawater formalin. Samples were brought to laboratory for sorting, identification, counting and recording of the phytoplankton and zooplankton.

In the laboratory, the biomass of plankton was determined for each sample using the “wet” displacement volume method (using a graduated cylinder) (Ahlstrom, 1976). The numerical density of phytoplankton and zooplankton organisms was determined using a 1 ml aliquot. The sample in the aliquot was, at first, examined microscopically using compound light and epifluorescence microscopes (Olympus CX41 and Nikon E600) with camera attachment (Infinity 1-Lumenera and Nikon FOX-35) to determine the identity of the components represented and was, later, counted for organisms using a Sedgewick-Rafter counting chamber. Individual phytoplankton and zooplankton were identified up to the lowest possible taxa. The density of phytoplankton and zooplankton organisms was estimated, and then transformed to number of cells and organisms per cubic meter of seawater (cells/m^3 and organisms/m^3, respectively).

For river estuary, a duplicate 1-liter water samples were also collected at each station for phytoplankton and zooplankton analysis and were then preserved in 10% formalin while at the site. In the laboratory, the samples were made to stand undisturbed for one (1) week to allow organisms to settle at the bottom of the container. The supernatant liquid was siphoned off and an aliquot was taken as sub-sample of the plankton catches for analysis. The samples in aliquot were then examined and counted using a Sedgwick - Rafter cell, and the total number of organisms was determined. The counts of individuals in each phytoplankton and zooplankton groups were converted to number of individual cells or organisms per liter (cells or organisms/L) of water sampled

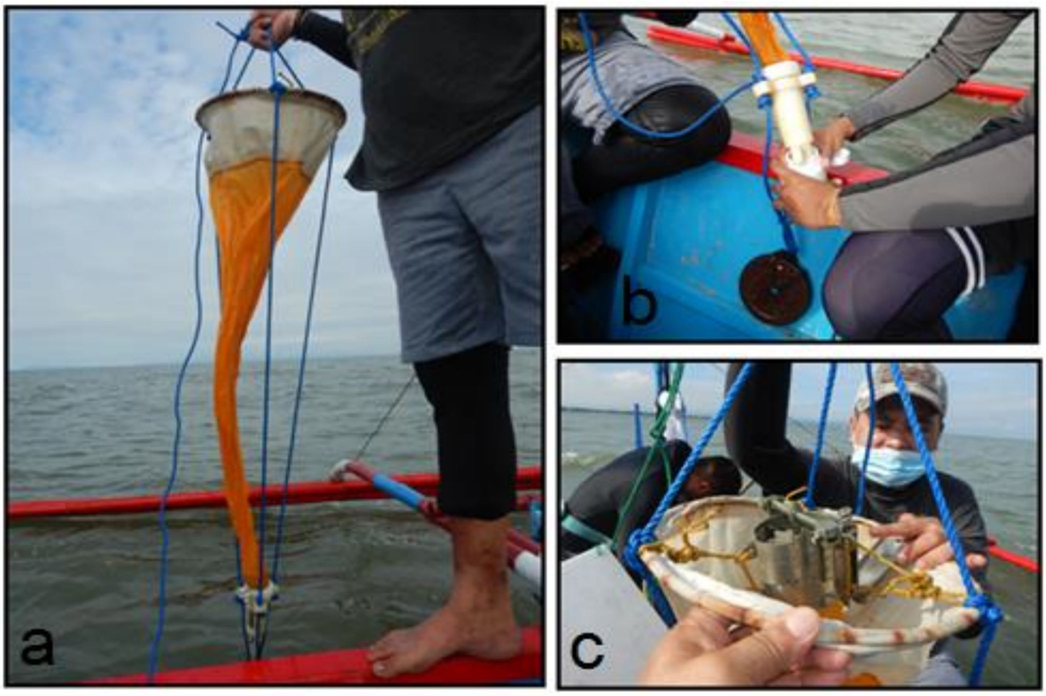


Plate 5. The plankton net used during the entire marine plankton survey (a), transferring the sample from the cod end to the 250 ml polyethylene bottle (b), and calibrated flowmeter attached at the center of the mouth of the net (c)

C) Ichthyoplankton (Fish Eggs and Fish Larvae)

The data describing baseline information in the Manila Bay solely derived from a published report for fish eggs and fish larvae studies done in the bay by Tobias et al. (2017), wherein surface horizontal tow for the collection of fish eggs and fish larvae using a Bongo net (50-cm mouth diameter, 2.5 m length and 364 µm mesh size) was carried out every other month on monsoonal basis, which started in January 2012-2015, during trade winds/southwest monsoon in May, and northeast monsoon in November, January, and March. Eight (8) sampling stations were established in the entire bay, with Stations 1 and 2 sampled near the mouth of Manila Bay.

D) Primary Productivity (Chlorophyll-a Concentration)

One-liter of surface water samples for chlorophyll-a determination were collected at each pre-determined sampling station (see **Figure 2.101**, **Figure 2.102**, and **Figure 2.103**). While in the field, samples were preserved in a cooler with ice. In the laboratory, the seawater samples were filtered through a membrane filter (0.45 µm Whattman) using Eyela A-3S vacuum filter. The filters were drained thoroughly before removing it from the filtration equipment. After filtration, the filters were sealed in aluminium foil and placed in a dark plastic bag and stored and frozen until analysis. The filters were extracted at the laboratory using the methods of Parsons et al. (1984). The chlorophyll-a extracts were measured using a Merck Spectroquant Pharo 300 UV-VIZ spectrophotometer.

E) Harmful Algal Blooms

Secondary information was gathered from published papers and articles on HAB events by several researchers. However, the data describing baseline conditions for red tides or harmful algal blooms in Manila Bay mostly gathered from a published paper "Occurrence of harmful algal blooms (HABs) caused by various phytoplankton species in the last three (3) decades in

Manila Bay, Philippines by Borja et al. (2019). A major part of this paper is based on the review of previous works related to the HAB episodes in Manila Bay from 1998 to 2011 and the results of the 2012-2015 research project "Investigation on hydrobiology and water quality of Manila Bay", a study component of the National Fisheries Research Development Institute-Bureau of Fisheries and Aquatic Resources (NFRDI-BFAR). This paper is supplemented with the results of their recent research in Manila Bay from year 2017-2018.

F) Soft Bottom Infaunal Benthos

The river estuary and intertidal sediment samples for infaunal benthos analysis were collected using a metal frame covering an area of 0.0225 m^2 (**Plate 6**). The metal frame was pushed into the substrate and all sediments found within the frame were then slowly-hand shovelled into the plastic container. Sediment sampling for subtidal infaunal benthos was done with the used of Ekman bottom grab sampler, also with an area of 0.0225 m^2 (**Plate 7**). In offshore/open water area (along the main bridge alignment), SCUBA diving with the used of the metal frame was also used to collect benthos samples. All sediment samples in this study were collected at each station in duplicate and were sieved into a 0.5 mm mesh right after each sampling (**Plate 8**). Prior to description and analysis, the sediments were washed with distilled water to remove salts and oven dried. The dried sediments were weighed on a top loading balance. Dry sieve analysis of the sediments was done following a method of ASTM D4464: 15 Standard Test Method for Particle Size Distribution of Catalytic Materials. Retained sediments in the sieve were placed in a plastic container, stained with Rose Bengal and fixed in 10% formalin.

Plate 6 Intertidal benthos sampling at the bridge shore approach in Timalan Concepcion, Naic (a), and a metal frame covering an area of 0.0225 m^2 used to collect intertidal infaunal benthos samples (b)

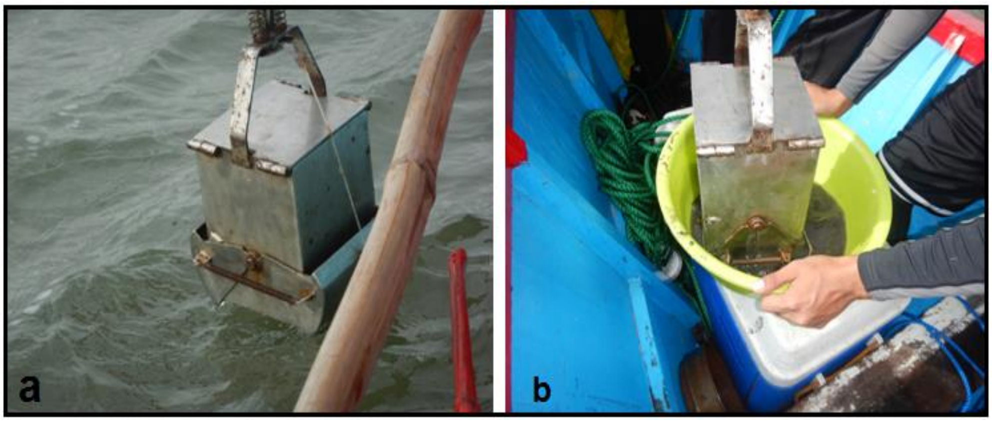


Plate 7 Ekman bottom grab sampler (also covering an area of 0.0225 m^2) used to collect subtidal infaunal benthos samples along nearshore waters (a), and collected sediment sample for sieving (b)

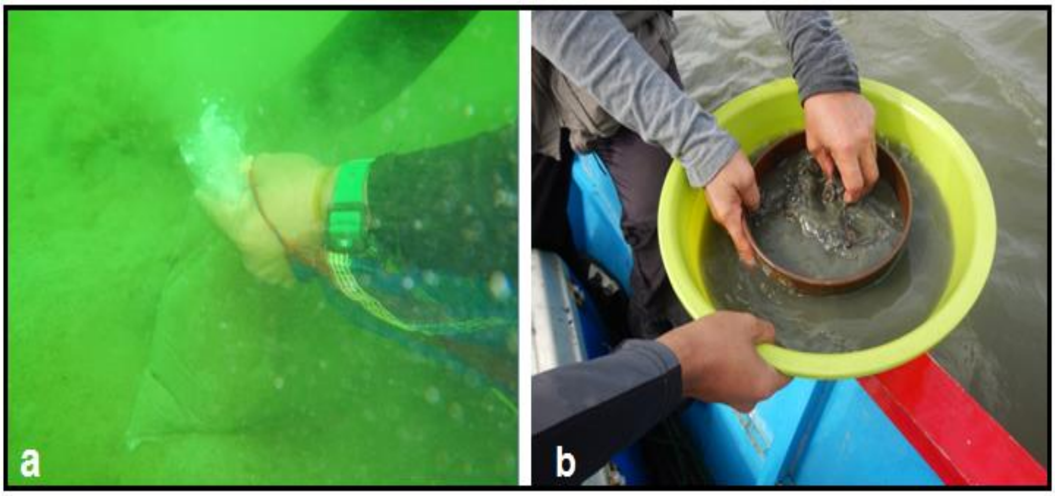


Plate 8 Sediment sampling in offshore/deeper area with the used of SCUBA (a), and sieving of sediment sample into a 0.5 mm mesh (b)

The sediment samples collected were processed in the laboratory where they were washed with tap water to get rid of excess formalin. Sorting of organisms was done by the aid of a stereo zoom microscope. Identified organisms were placed in vials containing 70% alcohol and classified to family and species level if possible. Specimens sorted from the sediment samples were counted to analyze their density. Density was expressed in terms of individuals per square meter (indv/m^2). An index of diversity of benthic organisms (within major taxonomic group) using Shannon-Weaver Index was computed for the communities found in different stations. Biomass of the benthic infauna for each benthos sample was also measured and expressed in terms of wet weight in grams per square meter (wwt g/m^2).

G) Corals and Associated Fish Assemblages

In this present baseline study, a rapid reef survey was conducted wherein a snorkeler was towed by a motorized outrigger boat to determine the presence of coral communities along the main bridge alignment (shore approach) in Alas-asin, Mariveles (**Plate 9**). During the survey, a patch reef was located adjacent to the bridge alignment (0.11 km away from the alignment**, Figure 2.104**) and immediately a GPS position was determined (Lat. 11^{o}26'7.80"N/ Long.120^{o}34'54.50"E). The reef was relocated for SCUBA dive inspection (**Plate 10**). Since the patch reef is relatively small, charaterized mainly by rock boulders, usually arising in rather shallow water, only two (2) 10 m long transect lines were set on the bottom of the reef. The transects were separated from each other by about 5 meters. The coral cover photo quadrat survey was conducted along the established transect lines (Done, 1996; English et al., 1997; WCPI, 1997a, 1997b, 1998). In this coral photo quadrat survey technique, small sections of the reef were photographed. A Sony cyber-shot digital camera (8.1 megapixels) super steady shot inside a Sony MPK Marine Pack 40m/132 ft underwater casing attached to a nylon rope (0.5 m long) was used to photograph sections along the transect. The percentage distribution of the major parameters or attributes of the bottom cover from the photographs on each of the transect line was estimated.

Plate 9 Modified manta tow survey technique wherein a snorkeler is being towed by a motorized outrigger boat along the proposed bridge alignment in Barangay Alas-asin (Mariveles)

Figure 2.104 Location of patch reef in Barangay Alas-asin

Plate 10. Dive inspection on the patch reef along the shore of Barangay Alas-asin (Mariveles)

Data for information on coral reefs of Manila Bay region particularly for Bataan (Mariveles), Corregidor and Caballo Islands, and Cavite were mainly taken from a final technical report “Manila Bay vulnerability assessment: application of GIS and remote sensing technologies, and information convergence” by DENR-ERDB (2019).

For the reef associated fish communities on the patch reef (Station RRSS), a fish survey was also conducted using the daytime underwater fish visual census technique (English et al., 1997). All fishes observed within 10 meters across a 25-meter long transect line were identified to species level whenever possible. Fish abundances were determined by actual counts, while fish sizes (total length) were estimated to the nearest centimeter. Fishes were categorized as “target”, “indicator” and “major” species or families. Fish were identified to the lowest possible taxon based on photographic references such as Allen et al., 2003, Lieske and Myers 2002, Randall et al., 1997, fishbase.org and others. The total lengths of fish were estimated to the nearest centimeter, and their abundance determined by actual counts. The fish biomass was estimated using the formula $W=aL^b$, where W is the weight in grams, *a* being the multiplicative factor, L, the total length of the fish (cm), and *b* the exponent. The *a* and *b* values compiled in Kulbicki et al. (1993), Letourner et al. (1998) and Froese and Pauly (2001) and www.fishbase.org were used in the calculation.

H) Macroinvertebrates

A visual observation while on SCUBA diving along the two (2) 10 m long transects attached to the patch reef of Alas-asin (Mariveles) and on the sandy bottom at 7.6 m-depth of Station MBS-3 (Corregidor Island) was also conducted. Animals not readily identifiable in the field were photographed for later identification.

I) Macrophytes (Seagrasses and Macrobenthic Algae)

The major resources describing baseline conditions of these marine resources mainly retrieved from the final technical report “Manila Bay vulnerability assessment: application of GIS and remote sensing technologies, and information convergence” by DENR-ERDB (2019).

Interviews with local fisherfolks and visual inspections were also made during the present baseline survey along the exposed coastal beaches and intertidal and subtidal shallows of Alas-asin (Mariveles), Corregidor Island, and Timalan Concepcion (Naic) on the presence of seagrasses and macrobenthic algae (seaweeds).

J) Mangrove and Other Coastal Vegetation

Flora assessment was done using point sampling method. A total of eight (8) stations were established at Mariveles (Bataan), three (3) stations at Corregidor Island, and 15 stations at Naic (Cavite). All sampling plots were demarcated, and coordinates were recorded (**Table 2.38**). Likewise, approximate distance of mangrove areas to the centreline of the proposed road and bridge project were also documented (**Table 2.39**).

Sample plots with a 20 m x 20 m (upper canopy) were established in each location. In each sample plot, heights of all species with 15 cm in trunk diameter and above were identified, counted and measured. A 5 m x 5 m subplot (middle canopy) located at one corner of upper canopy was also established. In this smaller plot, all trees/saplings 15 centimeter in diameter and below were identified, counted and recorded. Furthermore, a 1 m x 1 m plot (lower canopy) located within the 5 m x 5 m plot was also established. All wildlings and other smaller plants (1 cm and below) within the plot were also identified, recorded and counted. Photos and GPS coordinates of each sampling station have been recorded.

Ecological parameters, which are indicative of ecosystem stability and productivity, were measured. Shannon biodiversity index is a mathematical measure of species diversity in community. These indices provide important information about rarity and commonness of species in community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present) and they also take the relative abundances of different species into account. The formulas adapted from Magurran (1988) were used to compute for the following parameters:

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Area of the plot}}$$

$$\text{Dominance} = \frac{\text{Basal area of a species}}{\text{Area of the plot}}$$

$$\text{Frequency} = \frac{\text{Number of quadrats where a species occurs}}{\text{Total number of quadrats}}$$

$$\text{Relative Density (RDe)} = \frac{\text{Density of a species}}{\text{Total Density of all species}} \times 100$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Dominance of a species}}{\text{Total Dominance of all species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total Frequency of all species}} \times 100$$

$$\text{Importance Value (IV)} = \text{RDE} + \text{RDo} + \text{RF}$$

$$\text{Shannon's Diversity Index} = \sum pi \ln pi;$$

where: pi = proportion of individuals in total sample belonging to the nth species

Indices for plant species diversity and evenness were classified into relative categories as shown in **Table 2.37**.

Table 2.37. Biodiversity scale as used by Fernando (1998)

Relative Values	Shannon-Weiner Index (H’)	Evenness Index (e’)
Very High	3.5 - 4.00	0.750 – 1.000
High	3.0 - 3.49	0.500 – 0.740
Moderate	2.5 - 2.99	0.250 – 0.490
Low	2.0 - 2.49	0.150 – 0.240
Very Low	1.0 - 1.99	0.140 and below

Coordinates of all sample plots were taken and demarcated as shown in **Table 2.38** while **Table 2.39** shows the approximate distance of mangroves to the centreline of the proposed bridge project.

Table 2.38. Coordinates of All Sampling Stations

Station No.	Mariveles, Bataan	Corregidor Island	Naic, Cavite
1	N14°26'08.8	N14°23'28.3	N14°20.709
	E120°34'48.4	E120°36'05.7	E120°47.550
2	N14°26'21.0	N14°23'33.0	N14°20.686
	E120°34'49.4	E120°36'41.1	E120°47.296
3	N14°26'21.5	N14°23'15.5	N14°20.798
	E120°34'47.5	E120°37'08.0	E120°46.914
4	N14°26'21.4	-	N14°20.664
	E120°34'47.4	-	E120°46.731
5	N14°26'22.9	-	N14°20.596
	E120°34'45.8	-	E120°46.677
6	N14°26'24.0	-	N14°20.556
	E120°34'42.4	-	E120°46.631
7	N14°26'23.3	-	N14°20.421
	E120°34'50.6	-	E120°46.559
8	N14°26'27.2	-	N14°20.357
	E120°34'59.2	-	E120°46.481
9	-	-	N14°19.2
	-	-	E120°46.263
10	-	-	N14°20.163
	-	-	E120°46.325
11	-	-	N14°19.872
	-	-	E120°46.082

Station No.	Mariveles, Bataan	Corregidor Island	Naic, Cavite
12	-	-	N14°19.462
	-	-	E120°45.426
13	-	-	N14°19.248
	-	-	E120°45.523
14	-	-	N14°19'06.6
	-	-	E120°45'44.9
15	-	-	N14°18.977
	-	-	E120°44.681

Table 2.39. Approximate distance of mangrove areas from the centreline of the proposed bridge alignment

Station/Name of Mangrove Area	Approximate Distance from the Centreline of the Proposed Bridge Alignment (km)
1. Station 1, Alas-asin, Mariveles, Bataan	0.26
2. Babuyan River, Alas-asin, Mariveles, Bataan	0.14
3. Timalan River mouth, Timalan Balsahan, Naic, Cavite	0.7
4. Station 9 Aroma Beach, Timalan Concepcion, Naic, Cavite	0.6
5. Station 12 Bukanang Maliit, Naic, Cavite	2.9
6. Station 15 Barangay Mabolo, Naic, Cavite	4.5

K) Fish Sanctuary and Artificial Hard Structures (Artificial Reef and Shipwreck)

Information for nearby fish sanctuary and artificial hard structure (artificial reef and shipwreck) in Manila Bay, particularly the Mariveles, Corregidor Island and Naic areas, were obtained from the results of the interviews carried out in the Municipal Agricultural Office (MAO), Fisheries and Aquatic Resources Management Council (FARMC), Corregidor Foundation Incorporated (CFI), and community-based Bantay Dagat (Sea Patrol). A site visit to these local marine resources was made and GPS coordinates were taken for future reference. In addition, the presence of shipwrecks around Corregidor Island was based upon the map provided by CFI.

L) Protected Marine Species (Threatened or Endangered Species)

Data and information on the presence of marine turtle nesting beaches were collected through interviews with the staff from the MAO, FARMC, PENRO and Bantay Dagat at the project sites in Mariveles and Naic. Actual site visits and direct observations assisted by Bantay Dagat members were also conducted at the nesting beaches. Personal communications were also done with Manolo Ibias, Chairman of Bantay Pawikan, Inc. in Morong, Bataan for the information on the distribution and biology of the marine turtles in Manila Bay and neighbouring areas. Interviews with the local fisherfolks and Bantay Dagat regarding possible occurrence of other protected marine species in the area such as dolphins, whales, whale sharks, and dugongs were also conducted during the survey. Furthermore, much of the data and secondary information for these marine species were culled from the works of Alava and Cantos (2004), Aragones et al. (2010), Marine Wildlife Watch of the Philippines (2014) and a number of published reports, as well as from media coverage/news reports on marine mammal strandings in Manila Bay.

M) Fisheries Resources

The data and information collected were done through site inspections, actual observations and interviews with fisherfolks, boat operators and Bantay Dagat personnel at the project sites in Barangay Alas-asin (Mariveles, Bataan), Barangays Timalan Balsahan and Timalan Concepcion (Naic, Cavite) and along Corregidor Island. Interviews were also conducted from the staff of the Naic Municipal Agriculture Office (MAO) as well as from the Bureau of Fisheries and Aquatic Resources-Provincial Fisheries Office (BFAR-PFO) in Naic. In addition, at 2:00 a.m. on 8 February 2020, a visit was made to a designated fish port or landing site at nearby Barangay Munting Mapino to document the landing of fish catch and practice of selling catch as well as the types of fish and invertebrates being landed in the area. A visit was also made to the brackish water aquaculture oyster farming ("talabahan") along Timalan River of Barangay Timalan Balsahan. Other sources of information were also gathered from published reports and technical publications of the National Fisheries Research and Development Institute (NFRDI) and PEMSEA.

2.2.5.3 Baseline Environmental Conditions

2.2.5.3.1 Intertidal Habitats and Exposed Coastal Beaches

(a) Alas-asin and Mt. View (Mariveles, Bataan)

Viewed at the closer range, the intertidal and exposed coastal beaches at the bridge shore approach along Bataan Side in Alas-asin (Lat. 14°26'16.71"N and Long. 120°34'47.64"E) are characterized by flat topography (gentle slope) of mixed sand-boulder type rock bottom (**Plate 11**); however, a 250 meter length open sandy coastal beach occur in the northern part of the project site (**Plate 12**). Generally, these beaches tend to be composed of finer-grained sediments with pebbles, coral rubbles and broken shell fragments. But one thing in common, these beaches particularly along the project site is peppered with mostly plastic trash (**Plate 13**) and drift material such as dried macroalgae (mainly seaweed *Sargassum*). The uppermost portion of the beach region is densely or sparsely overgrown with coastal vegetation such as trees, shrubs and grasses.

Plate 11 Intertidal and exposed coastal beach at the bridge shore approach along Alas-asin with flat topography of mixed sand-boulder type rock bottom

Plate 12 Open sandy coastal beach (gentle slope) along the northern part of the project site

Plate 13 Upper portion of the beach at the project site is heavily covered with garbage mostly plastic trash

Marine intertidal communities in Alas-asin and Mt. View occupy both hard and sandy coastal substrates. These habitats are typically regarded as open ecosystems in which energy and materials are regularly imported and exported. Changes in the daily tidal cycle in conjunction with numerous other environmental factors (e.g., wave action, insolation, desiccations, etc.) broadly define the distribution and abundance of intertidal species. An intertidal benthos study was conducted in this present baseline survey, and the intertidal benthic infaunal organisms found in the area are presented in **Section 2.2.5.3.7** of this EIS component.

Onshore along the exposed coastal sandy beach, a river estuary (sandy-muddy bottom with shell fragments; and at certain point near the mouth of the river - Lat. 14°26'21.40" N and Long. 120°34'47.40" E, a 0.3 m depth was measured) occurs about 125 m north from the bridge shore approach (**Plate 14**). An estuary is an area where a freshwater river or stream meets the ocean. In this area, the salty ocean mixes with a freshwater river, resulting in brackish water. Along this area, trees, shrubs and “nipa” vegetation cover both sides of the river estuary. Furthermore, several oil terminals/refineries, jetty/ports, a power plant, beach resorts, fish ports/fish landing centers, and marine turtle nesting sites are also located in adjacent coastal beaches.

Plate 14 Babuyan River estuary occurs around 125 m north from the proposed bridge shore approach along Alas-asin, Mariveles

(b) Corregidor Island

The intertidal zone of the Corregidor Island facing the main bridge alignment is generally rocky (**Plate 15**). The rocky intertidal is a highly productive biotope in many parts of the world. The rocks provide a firm attachment for the holdfasts of many species of large algae or seaweed which are the key to the productivity of rocky beaches, since they provide both shelter and food supply for large animal populations. Productive rocky shores of this type are common in the temperate regions of both northern and southern hemispheres. Well-studied examples occur on the coasts of England, Japan and the United States, to name only a few places.

Rocky beaches along Corregidor, in contrast, cannot be highly productive. The main reason is that at low tide, especially in summer the rock surface is subjected to intense heating and desiccation by the sun, which effectively prevents the establishment of a vigorous growth of large algae. Due to the absence of algal shelter in this harsh environment, the fauna of Corregidor rocky beaches is limited to animals which inhabit crevices, holes and the underside of boulders, or else are mobile forms capable of retreating to shelter when the tide is out. At the time of the survey, the only macrobenthic or seaweeds seen attached to some exposed rocks are some species of brown algae (*Sargassum* and *Turbinaria*) and green algae (*Caulerpa*). An intertidal benthos study was conducted in this present baseline survey, and the intertidal benthic infaunal organisms found in the study area are presented in **Section 2.2.5.3.7** of this EIS component.

Above the rocky intertidal zone is the short relatively somewhat steep slope of the exposed beach proper which consists of fine-coarse sand with pebbles and shell fragments (**Plate 16**). Like Alas-asin in Mariveles, these exposed coastal beaches in Corregidor Island are also heavily peppered with solid waste or plastic trash.

Plate 15 Rocky intertidal zone of the Corregidor Island

Plate 16 Somewhat steep slope of the exposed beach proper of Corregidor Island which is heavily peppered with solid waste or plastic trash

(c) Timalan Concepcion and Timalan Balsahan (Naic, Cavite)

The outstanding feature of the coastline in the proposed bridge shore approach in Timalan Concepcion (Lat. 14°20'33.31"N and Long. 120°46'37.69"E) is its extremely low relief (relatively flat coastal topography) (**Plate 17**). Since the same gentle slope continues below low tide mark, the coastal beaches are generally fronted by a wide belt of subtidal shallows which become sites of mud deposition. The intertidal flats therefore tend to consist of somewhat finer-grained sand (blackish in color) while the subtidal shallows consist of fine sand-muddy substrate (greyish black in color). The intertidal flats are subject to alternate wetting and drying with the rise and fall of the tide, and consequently to fluctuating conditions which amount to considerable environmental stress for organisms living there. An intertidal benthos study was conducted in this present baseline survey, and the intertidal benthic infaunal organisms found are presented in **Section 2.2.5.3.7** of this EIS component.

Plate 17 The proposed bridge shore approach in Timalan Concepcion (Naic) characterized by its extremely low relief (relatively flat coastal topography)

Above the intertidal flats occurs a coastal strip of exposed coastal beaches of varying width and relatively flat topography which also tend to consist of sandy substrate. The main features of this zone include the occurrence of fishing boats and fishing paraphernalia, while at the back of the beach is more or less overgrown with some trees with a number of houses (**Plate 18**). In addition, several beach resorts can also be seen south from the proposed site for the bridge shore approach. Moreover, a dry docking and repair industry, fish ports, fish sanctuary, artificial reef, and a marine turtle nesting site are also located in adjoining beach areas.

Plate 18 Presence of fishing boats and fishing paraphernalia, some trees and a few houses at the proposed bridge shore approach in Timalan Concepcion (Naic)

River estuaries are the most important type of intertidal environment in terms of ecological and economic importance, along the Naic coast. Because of the extremely abundant supply of nutrients and the high oxygen levels (among other factors), the estuarine habitat is more productive than any other ecosystem known except the coral reef (Owen, 1975). Many marine species use the estuary as a "nursery" in which they spend the larval period immediately after hatching from egg. The estuary is extremely rich in nutrients because the tides tend to concentrate those nutrients carried "down" to the estuary by stream flow and carried "up" from the ocean by the incoming high tide. Another aspect of high productivity of estuaries is the accumulation of excess organic matter trapped in the sediment. This undergoes degradation by bacteria and provides an energy source for burrowing animals, and particularly for meiofauna. Much more important, the inert organic material (decayed bodies of marsh grasses, crustaceans, worms, fishes, bacteria, algae, and so on), known as detritus, may be consumed directly by detritus feeders, such as clams, oysters, lobsters, and crabs. There are two major river estuaries in Naic, and these are called Timalan River located in Brgy. Timalan Balsahan (about 0.75 km north from the proposed site for the bridge shore approach) and Bucana River located in Barangays Bucana Sasahan and Bucana Malaki (about 1.75 km south from the proposed bridge shore approach). Both river estuaries are navigable by local fishing boats. Moreover, Timalan River is well known for its oyster farming or "talabahan" while Bukana River is well known for its hook and line, and gill net fishing.

2.2.5.3.2 Phytoplankton (Photosynthetic Microalgae)

Plankton is a term used to describe collectively small, mostly microscopic organisms, which drift about passively in the water. Plant and animal members of the plankton are considered separately under the terms “phytoplankton” and “zooplankton”, respectively. Phytoplankton (or photosynthetic microalgae) are made up of representatives of at least five very diverse taxonomic groups within the plant kingdom and represent the primary producers or “grass of the sea,” forming the base of the food web upon which almost all-marine animal life depends. In contrast, zooplankton (or animal plankton) are consumer organisms and depend upon the phytoplankton, and to some extent on dead organic matter, for their source of food and energy (Basson et al., 1977).

Phytoplankton can be found both in freshwater and saltwater. Most freshwater phytoplankton are made up of green algae and cyanobacteria (also known as blue-green algae). Marine phytoplankton is mainly comprised of microalgae known as diatoms (class Bacillariophyceae) and dinoflagellates (class Dinophyceae) though other algae and cyanobacteria can be present. Diatoms make up the largest single contribution to global oceanic net primary production (Geider et al., 2014).

(A) Nearshore Phytoplankton

(a) Alas-asin and Mt. View (Mariveles, Bataan)

Phytoplankton population was composed of three (3) major groups, namely: diatoms, blue-green algae, and dinoflagellates. Diatoms (average 97.85%) dominated the phytoplankton community followed by the dinoflagellates (average 1.90%), and the least were the blue-green algae (average 0.25%) (**Figure 2.105**). A total of 17 taxa/genera were recorded: 12 diatoms, one (1) blue-green alga, and four (4) dinoflagellates (**Table 2.40**). Skeletonema, Chaetoceros, Thalassionema, Rhizosolenia, and Pseudo-nitzschia, were the most dominant among the diatoms while Protoperidinium, Noctiluca scintillans, and Ceratium furca dominated the dinoflagellates population. The blue-green algae represented solely by Trichodesmium erythraeum also occurred but in relatively low densities. Relative abundance of all phytoplankton species sampled in the area is also shown in **Table 2.40**. Photomicrographs of the most dominant phytoplankton species are presented in **Plate 19**.

The recent results of the phytoplankton studies conducted by Gatdula et al. (2017) for the entire Manila Bay from 2012 to 2015 also shows that phytoplankton community was composed of diatoms, blue-green algae, and dinoflagallates. Skeletonema and Chaetoceros were also the most dominant among the diatoms while Ceratium, Protoperidinium and Noctiluca scintillans were also the dominant among the dinoflagellates. In marine waters the phytoplankton community is often dominated by diatoms-microscopic representatives of the plant phylum Chrysophyta which possesses characteristic silica impregnated cell walls; and may be extremely abundant in nearshore or bay ecosystems (Basson et al., 1977).

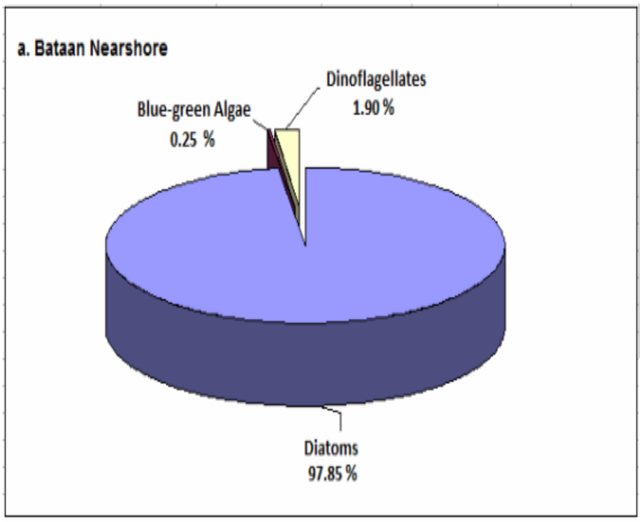
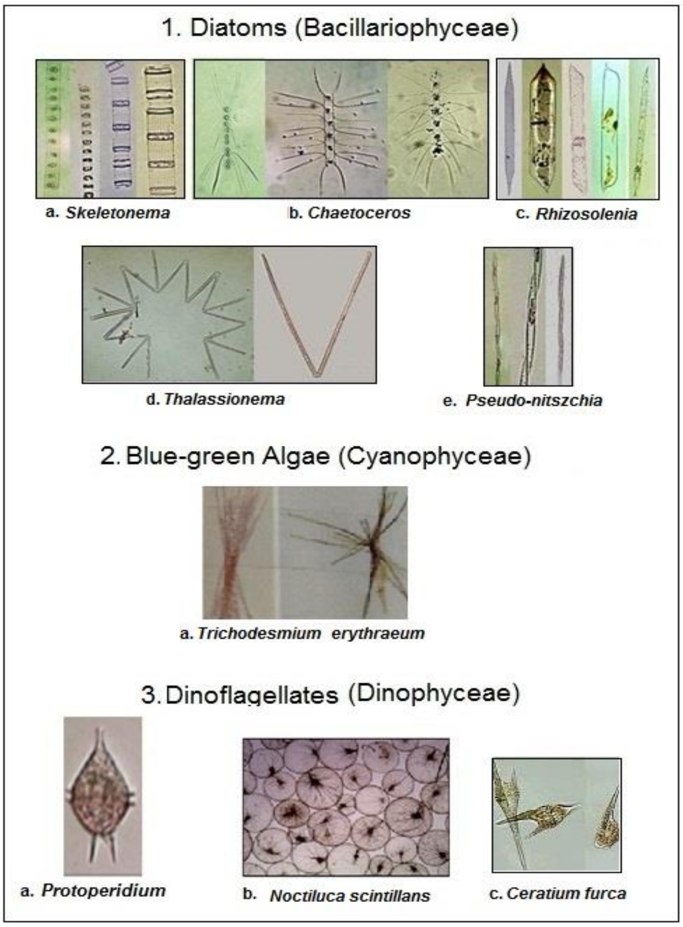


Figure 2.105 Mean relative abundance of major phytoplankton groups in the nearshore waters along Alas-asin, Mariveles

Table 2.40. Phytoplankton composition, density, relative abundance and plankton biomass at three stations sampled in nearshore waters along Alas-asin, Mariveles

Phytoplankton Taxa	**Station**			**Mean Total Density (No./m^3)**	**Mean Relative Abundance (%)**	
	BNS-1	**BNS-2**	**BNS-3**		**Species**	**Group**
Bacillariophyceae (Diatoms)						97.85
Asteromphalus	23,148		20,161	14,436	0.11	
Chaetoceros	1,355,820	2,592,166	2,620,968	2,189,651	17.27	
Coscinodiscus	82,672	70,084	100,806	84,521	0.67	
Dictyocha	23,148	20,161	14,436		0.15	
Navicula	23,148	29,762	40,323	31,078	0.25	
Odontella		159,370	80,645	80,005	0.63	
Pleurosigma	76,058	79,685	60,484	72,076	0.57	
Pseudo-nitzschia	251,323	209,293	221,774	227,463	1.79	
Rhizosolenia	357,143	659,562	483,871	500,192	3.95	
Skeletonema	4,695,767	10,579,877	10,080,645	8,452,096	66.66	
Thalassionema	922,619	429,147	262,097	537,954	4.24	
Thalassiosira		249,616	342,742	197,453	1.55	
Sub-total	7,810,846	15,078,723	14,328,952	12,406,173	97.85	
Cyanophyceae (Blue-green Algae)						0.25
Trichodesmium erythraeum	52,910		40,323	31,078	0.25	
Sub-total	52,910		40,323	31,078	0.25	
Dinophyceae (Dinoflagellates)						1.90
Ceratium furca		29,762	100,806	43,523	0.34	
Dinophysis caudata		70,084		23,361	0.18	
Noctiluca scintillans	29,762	70,084	100,806	66,884	0.53	
Protoperidinium	82,672	79,685	161,290	107,882	0.85	
Sub-total	112,434	249,615	362,902	241,650	1.90	
TOTAL PHYTOPLANKTON	**7,976,190**	**15,328,338**	**14,732,177**	**12,678,901**	**100.00**	**100.00**

Total No. of Taxa	**13**	**15**	**16**		
Plankton Biomass/ Wet Displacement Volume (mL/m3)	**11.51**	**15.17**	**15.32**	**Mean: 14.00**	



Note: - Photomicrography by Val Borja

Plate 19 Photos of the most dominant phytoplankton species recorded for the nearshore waters of Alas-asin, Mariveles

The total number of phytoplankton organisms in Bataan nearshore ranged from 7,976,190 to 15,328,338 cells/m3 with an average of 12,678,901 cell/m3 (**Figure 2.106**), while the displacement volume or biomass of the plankton samples collected ranged from 11.51 to 15.32 mL/m3 with an average of 14.00 mL/m3 (**Figure 2.107**). Variations in the plankton biomass (see **Figure 2.107**) by sampling station showed a similar general trend to that of the total number of phytoplankton (see **Figure 2.106**). This indicates that the variates increase and decrease together, i.e., with high phytoplankton more plankton biomass may be expected and with low phytoplankton, less biomass. This relationship may be explained based on the major role of the phytoplankton groups. The diatoms in particular may be considered as biomass contributors in view of their abundance/dominance.

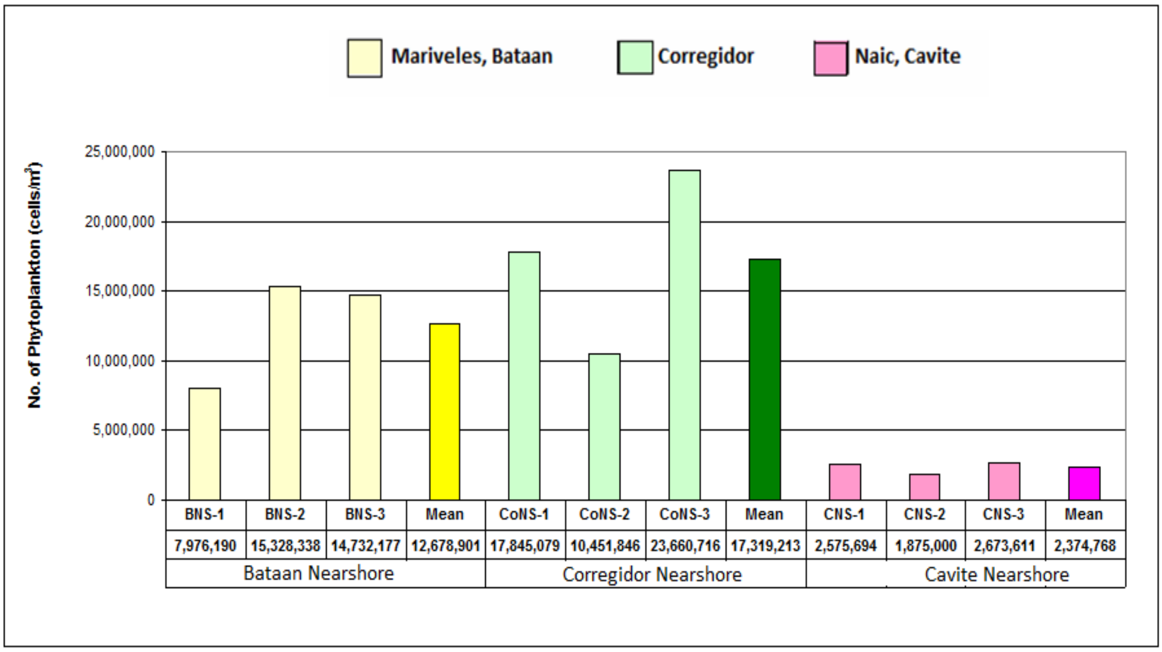


Figure 2.106 Total numbers of phytoplankton at each station sampled in nearshore waters of Alas-asin (Mariveles), Corregidor Island and Naic (Cavite)

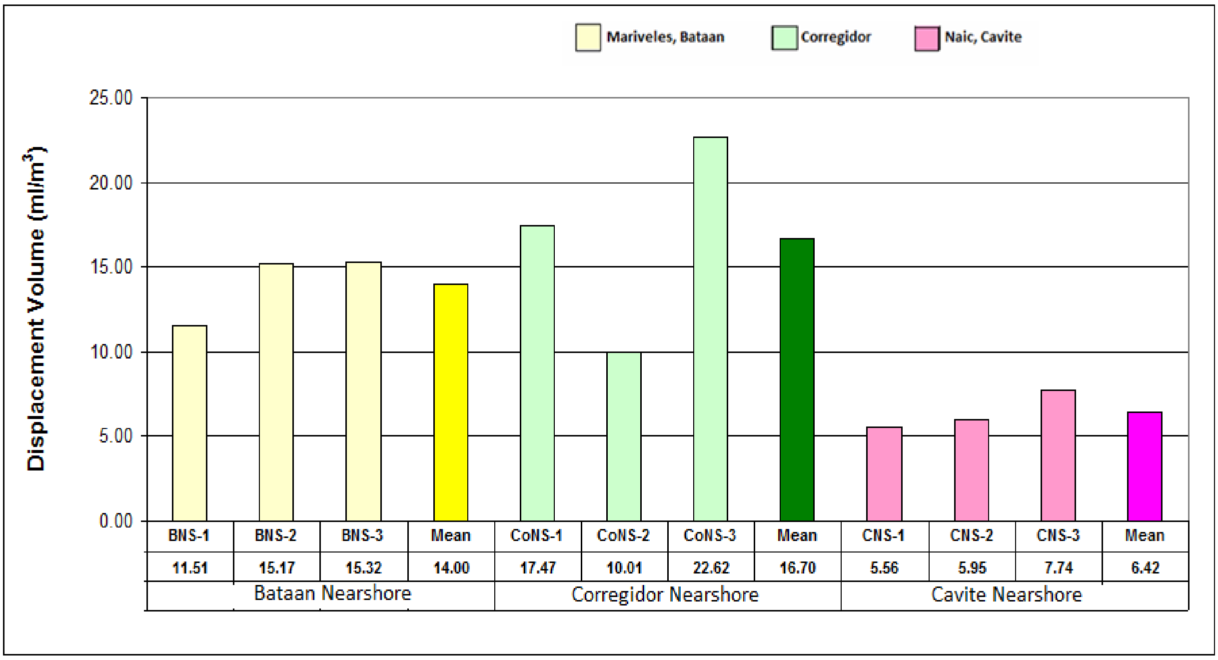


Figure 2.107 Plankton biomass at each station sampled in nearshore waters of Alas-asin (Mariveles), Corregidor Island, and Naic (Cavite)

(b) Corregidor Island

Phytoplankton population in Corregidor nearshore was composed of only two (2) major groups, also dominated by the diatoms (average 97.88%) and the least were dinoflagellates (2.12%) (**Figure 2.108**). A total of 14 taxa/genera were recorded: nine (9) diatoms and five (5) dinoflagellates (**Table 2.41**). Skeletonema, Chaetoceros Thalassionema, Rhizosolenia, and Pseudo-nitzschia, were also the most dominant among the diatoms while Noctiluca scintillans, Ceratium fusus, and Protoperidinium, dominated the dinoflagellates. Relative abundance of all phytoplankton species sampled in the area is also shown in **Table 2.41** Photomicrographs of the most dominant phytoplankton species collected are presented in **Plate 20**.

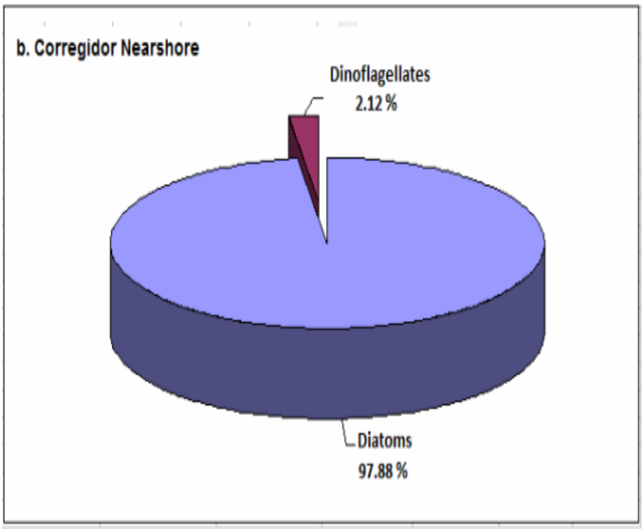
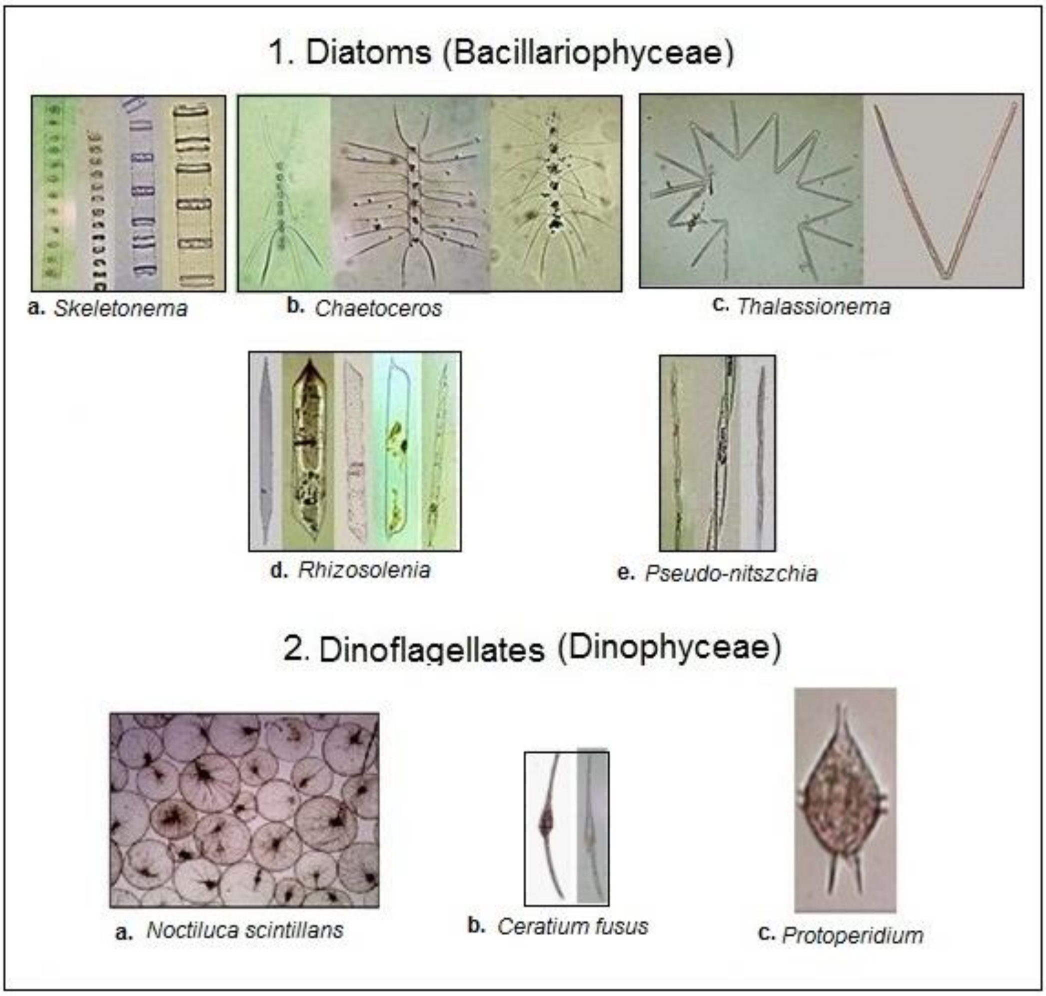


Figure 2.108 Mean relative abundance of major phytoplankton groups in the nearshore waters along Corregidor Island

Table 2.41. Phytoplankton composition, density, relative abundance and plankton biomass at three stations sampled in nearshore waters along Corregidor Island

Phytoplankton Taxa	**Station**			**Mean Total Density (No./m3)**	**Mean Relative Abundance (%)**	
	CoNS-1	**CoNS-2**	**CoNS-3**		**Species**	**Group**
Bacillariophyceae (Diatoms)						97.88
Asteromphalus		16,026		5,342	0.03	
Chaetoceros	2,501,609	1,715,916	5,357,143	3,191,556	18.43	
Coscinodiscus	76,416	78,565	59,524	71,501	0.41	
Odontella	139,961			46,654	0.27	
Pleurosigma	29,762	30,488	59,524	39,925	0.23	
Pseudo-nitzschia	296,815	285,335	327,381	303,177	1.75	
Rhizosolenia	666,023	451,454	565,476	560,984	3.24	
Skeletonema	13,400,901	6,863,665	16,071,429	12,111,998	69.93	
Thalassionema	283,945	806,754	773,810	621,503	3.59	
Sub-total	**17,395,432**	**10,248,203**	**23,214,287**	**16,952,640**	**97.88**	
Dinophyceae (Dinoflagellates)						2.12
Ceratium fusus	63,546		89,286	50,944	0.29	
Dinophysis caudata			59,524	19,841	0.11	
Noctiluca scintillans	322,555	188,399	267,857	259,604	1.50	
Protoperidinium	46,654	15,244	29,762	30.553	0.18	
Phyrophacus	16,892			5,631	0.30	
Sub-total	**449,647**	**203,643**	**446,429**	**366,573**	**2.12**	
TOTAL PHYTOPLANKTON	**17,845,079**	**10,451,846**	**23,660,716**	**17,319,213**	**100.00**	**100.00**

Phytoplankton Taxa	**Station**			**Mean Total Density (No./m3)**	**Mean Relative Abundance (%)**	
	CoNS-1	**CoNS-2**	**CoNS-3**		**Species**	**Group**
Total No. of Taxa	**12**	**10**	**11**			
Plankton Biomass/ Wet Displacement Volume (mL/m3)	**17.47**	**10.01**	**22.62**	**Mean: 16.70**		



Note: - Photomicrography by Val Borja

Plate 20 Photos of the most dominant phytoplankton species recorded for the nearshore waters of Corregidor Island

Total number of phytoplankton in Corregidor nearshore ranged from 10,451,846 to 23,660,716 cells/m3 with an average of 17,319,213 cell/m3 (see **Figure 2.108**), while the displacement volume or biomass of the plankton samples ranged from 10.01 to 22.62 mL/m3 with an average of 16.70 mL/m3 (see **Figure 2.109**). Both the total phytoplankton number and plankton biomass were higher compared to those observed in Bataan nearshore. Variations in the plankton biomass (see **Figure 2.109**) by sampling station showed a similar general trend to that of the total number of phytoplankton (see **Figure 2.108**).

(c) Timalan Concepcion and Timalan Balsahan (Naic, Cavite)

Like Corregidor, phytoplankton in Cavite nearshore was also composed of only two (2) major groups, also dominated by the diatoms (average 93.64%) and the least were dinoflagellates (6.36%) (**Figure 2.109**). A total of only 11 taxa/genera were recorded: eight (8) diatoms and three (3) dinoflagellates (**Table 2.42**). In this area, Rhizosolenia, Skeletonema, Odontella, Coscinodiscus, and Pseudo-nitzschia, were the most dominant among the diatoms while Protoperidinium, Ceratium furca, and Prorocentrum micans, dominated the dinoflagellates population. Relative abundance of all phytoplankton species sampled in the area is also shown in **Table 2.42**. Photomicrographs of the most dominant phytoplankton species are presented in **Plate 21**.

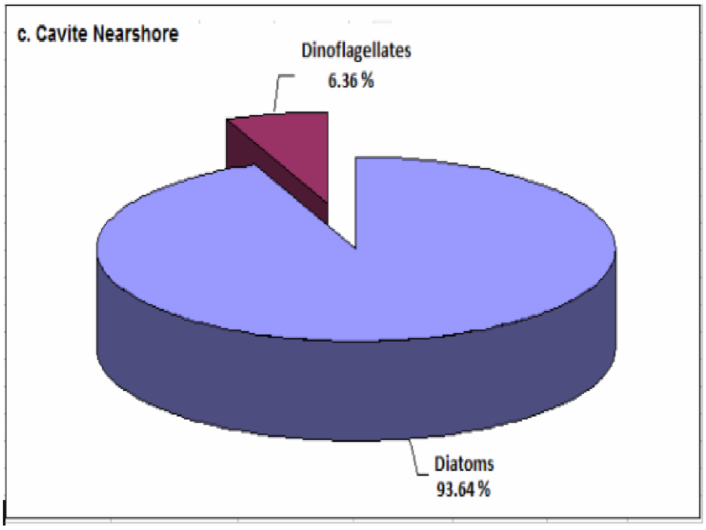
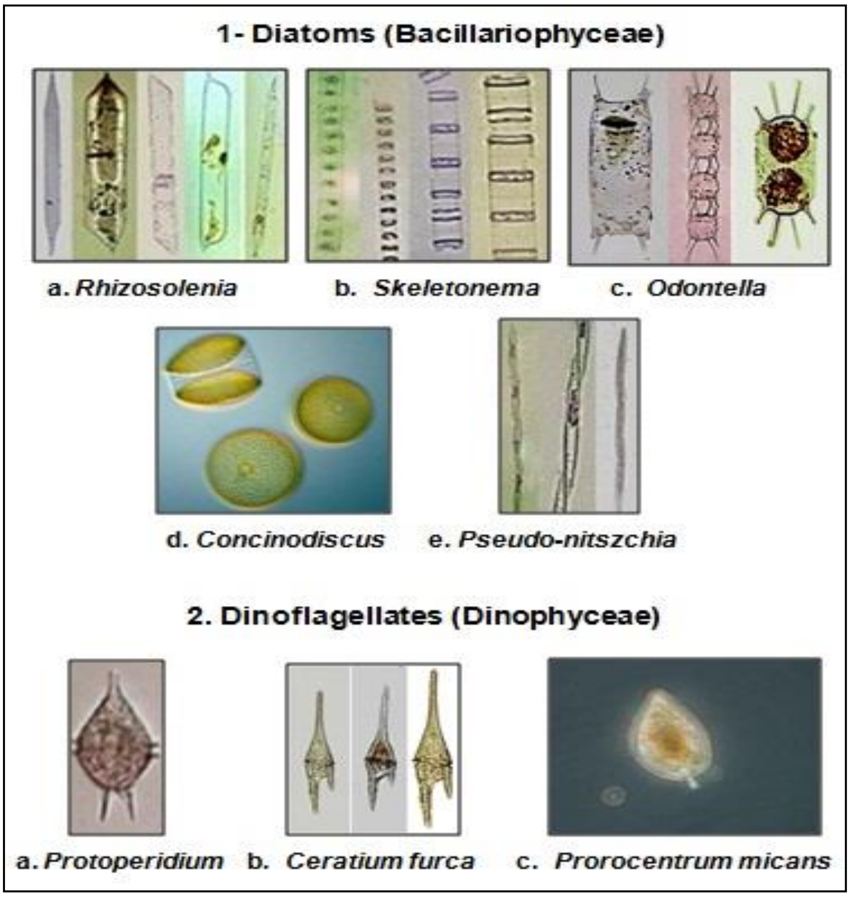


Figure 2.109 Mean relative abundance of major phytoplankton groups in the nearshore waters along Naic, Cavite

Table 2.42. Phytoplankton composition, density, relative abundance and plankton biomass at three stations sampled in nearshore waters along Naic, Cavite

Phytoplankton Taxa	Station			Mean Total Density (No./m^3)	Mean Relative Abundance (%)	
	CNS-1	CNS-2	CNS-3		Species	Group
Bacillariophyceae (Diatoms)						93.64
Chaetoceros	208,333	148,810	228,175	195,106	8.21	
Coscinodiscus	173,611	178,571	317,460	223,214	9.40	
Odontella	277,778		491,071	256,283	10.79	
Pleurosigma	34,722		94,246	42,989	1.81	
Pseudo-nitzschia	243,056	178,571	228,175	216,601	9.12	
Rhizosolenia	1,284,722	1,071,429	540,675	965,608	40.66	
Skeletonema	104,167	148,810	545,635	266,204	11.21	
Thalassionema	173,611			57,870	2.44	
Sub-total	**2,500,000**	**1,726,191**	**2,445,437**	**2,223,875**	**93.64**	
Dinophyceae (Dinoflagellates)						6.36
Ceratium furca		59,524	99,206	52,910	2.23	

Phytoplankton Taxa	Station			Mean Total Density (No./m^3)	Mean Relative Abundance (%)	
	CNS-1	CNS-2	CNS-3		Species	Group
Prorocentrum micans	34,722		29,762	21,495	0.91	
Protoperidinium	40,972	89,286	99,206	76,488	3.22	
Sub-total	**75,694**	**148,810**	**228,174**	**150,893**	**6.36**	
TOTAL PHYTOPLANKTON	**2,575,694**	**1,875,000**	**2,673,611**	**2,374,768**	**100.00**	**100.00**
Total No. of Taxa	**10**	**7**	**10**			
Plankton Biomass/ Wet Displacement Volume (mL/m3)	**5.56**	**5.95**	**7.74**	**Mean: 6.42**		



Note: - Photomicrography by Val Borja

Plate 21 Photos of the most dominant phytoplankton species recorded for the nearshore waters of Naic, Cavite

Total number of phytoplankton in Cavite nearshore ranged from 1,875,000 to 2,673,611 cells/m3 with an average of 2,374,768 cell/m3 (see **Figure 2.106**), while the displacement volume or biomass of the plankton samples ranged from 5.56 to 7.74 mL/m3 with an average of 6.42 mL/m3 (see **Figure 2.107**). Both the total phytoplankton number and plankton biomass in this area were much lower than in Corregidor and Bataan nearshore. Variations in the plankton biomass (see **Figure 2.106** by sampling station also showed more or less a similar general trend to that of the total number of phytoplankton (see **Figure 2.107**).

(B) Offshore/Open Water Phytoplankton

(a) Near Mouth of Manila Bay from Mariveles (Bataan) to Naic (Cavite)

The phytoplankton collected from eight (8) stations along this offshore/open water area (near the mouth of the bay from Bataan to Cavite) was typically composed of three (3) major groups, namely: diatoms, blue-green algae, and dinoflagellates. The phytoplankton population was dominated by the diatoms (96.74%) followed by the dinoflagellates (3.22%), while the least were the blue-green algae (0.04%) (**Figure 2.110**). A total of 26 taxa/genera were recorded: 15 diatoms, one (1) blue-green algae, and 10 dinoflagellates (**Table 2.43**). Skeletonema, Chaetoceros, Thalassiosira, Rhizosolenia, and Thalassionema, were the most dominant among the diatoms while Ceratium furca, Protoperidinium, Ceratium fusus, and Dinophysis caudata, dominated the dinoflagellates. The blue-green alga, Trichodesmium erythraeum, also occurred but at only one station along Bataan (Station MBS-1). Relative abundance of all phytoplankton species is also shown in **Table 2.43**. Photomicrographs of the most dominant phytoplankton species are presented in **Plate 22**.

The recent results of the phytoplankton studies conducted by Gatdula et al. (2017) for the entire Manila Bay from 2012 to 2015 also shows that phytoplankton community was composed of diatoms, blue-green algae, and dinoflagallates. Skeletonema and Chaetoceros were also the most dominant among the diatoms while Ceratium, Protoperidinium and Noctiluca scintillans were also the dominant among the dinoflagellates. In marine waters the phytoplankton community is often dominated by diatoms-microscopic representatives of the plant phylum Chrysophyta which possesses characteristic silica impregnated cell walls; and may be extremely abundant in nearshore or bay ecosystems (Basson et al., 1977).

Borja et al. (2019) also reported that diatoms are the most dominant micro-sized taxa responsible for nearly all the phytoplankton bloom events in Manila Bay. Amongst these diatoms, Chaetoceros spp., Skeletonema costatum, and Thalasiossira spp. appeared to be the most dominant species.

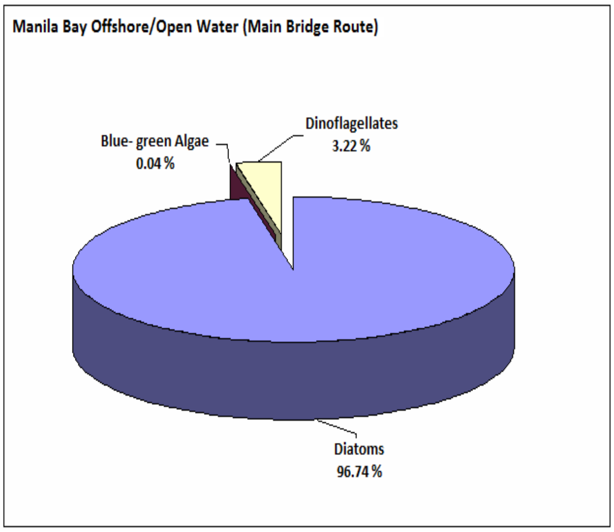


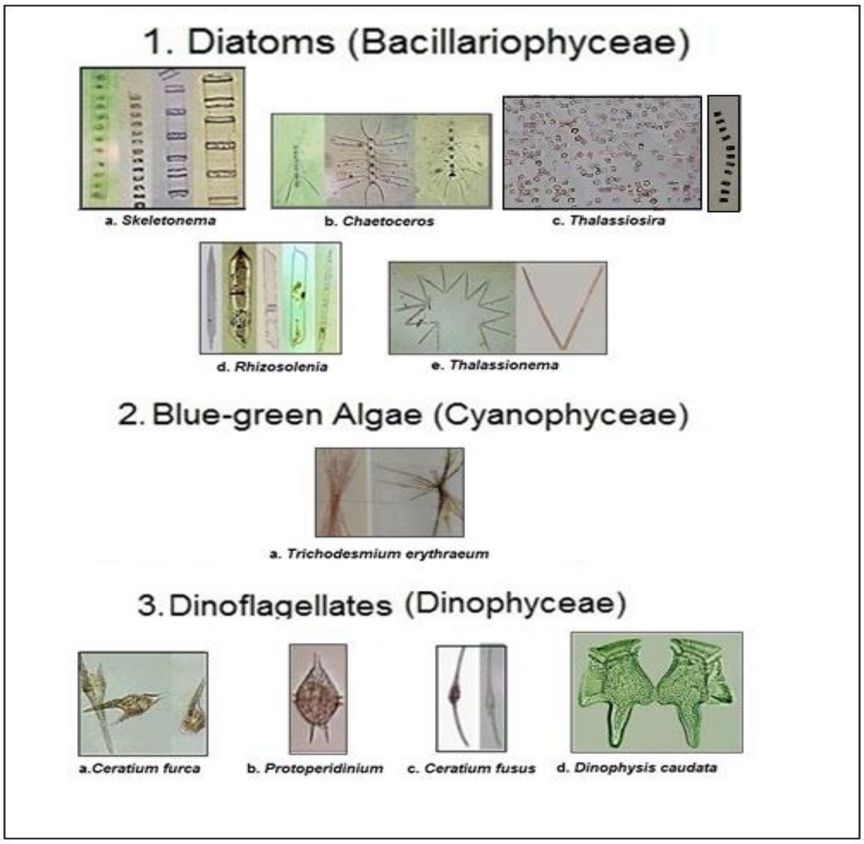
Figure 2.110 Mean relative abundance of major phytoplankton groups in the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Table 2.43. Phytoplankton composition, density, relative abundance and plankton biomass at eight stations sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Phytoplankton Taxa	Station								Mean Total Density (No./m3)	Mean Relative Abundance (%)	
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MBS-8		Species	Group
Bacillariophyceae (Diatoms)											96.74
Asteromphalus	47,939				23,585	29,762			12,661	0.11	
Asterionella		170,486							21,311	0.19	
Bacteriastrum					24,057	29,762			6,727	0.06	
Chaetoceros	1,639,785	1,599,154	3,190,476	2,227,577	2,332,285	3,398,618	7,375,776	1,436,335	2,900,001	25.32	
Coscinodiscus	88,262	42,621	54,762	212,677	102,725	79,685	84,110	56,936	90,222	0.79	
Guinardia		13,298			79,140		56,936		18,672	0.16	
Lauderia	363,351		169,048	55,812	79,140				83,419	0.73	
Leptocylindrus		170,486	169,048						42,442	0.37	
Odontella	117,384	26,596	54,762	45,486			27,174	27,174	37,322	0.33	
Pleurosigma	61,828	55,919	109,524	55,812	13,889		197,981	143,634	79,823	0.69	
Pseudo-nitzschia	252,240	197,422	713,095	476,613	284,591	369,624	366,201	311,853	371,455	3.24	
Rhizosolenia	2,815,412	522,709	791,667	926,810			764,752	282,091	762,930	6.66	
Skeletonema	5,851,254	12,244,272	9,261,905	860,543			1,979,814	5,098,344	4,412,016	38.53	

Phytoplankton Taxa	Station								Mean Total Density (No./m3)	Mean Relative Abundance (%)	
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MBS-8		Species	Group
Thalassionema	509,409	858,565	663,095	805,714	417,191	621,160	693,582	515,010	635,466	5.55	
Thalassiosira	300,179	546,577	797,619	364,624	1,818,658	4,185,868	3,959,627	866,977	1,605,016	14.01	
Sub Total	12,047,043	16,448,104	15,975,000	6,031,668	5,175,262	8,714,478	15,505,952	8,738,354	11,079,483	96.74	
Cyanophyceae (Blue-green Algae)											0.04
Trichodesmium erythraeum	34,050								4,256	0.04	
Sub-total	34,050								4,256	0.04	
Dinophyceae (Dinoflagellates)											3.22
Amphisolenia					13,889				1,736	0.02	
Ceratium furca	54,211	42,621	104,762		74,948	49,923	143,634	143,634	76,717	0.67	
Ceratium fusus	94,534	101,268	109,524	40,568	25,681		27,174	84,110	60,357	0.53	
Dinophysis caudata	34,050		109,524	96,258	41,111	29,762	86,698	86,698	60,513	0.53	
Dictyocha			59,524			49,923			13,681	0.12	
Gonyaulax	13,889	6,250					29,762	29,762	9,958	0.09	
Noctiluca scintillans	238,351	29,324	104,762	91,218					57,957	0.51	
Prorocentrum micans					25,681	49,923	27,174		12,847	0.11	

Phytoplankton Taxa	Station								Mean Total Density (No./m3)	Mean Relative Abundance (%)	
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MBS-8		Species	Group
Protoperidinium	54,211	101,268	104,762	40,568	25,681	79,685	59,524	84,110	68,726	0.60	
Phyrophacus	13,889	47394.98091							5,924	0.05	
Sub-total	503,136	328,127	592,857	268,612	206,992	259,217	373,965	428,313	368,416	3.22	
TOTAL PHYTOPLANKTON	**12,584,229**	**16,776,231**	**16,567,857**	**6,300,280**	**5,382,254**	**8,973,694**	**15,879,917**	**9,166,667**	**11,452,155**	**100.00**	**100.00**
Total No. of Taxa	19	18	17	14	16	12	16	14			
Plankton Biomass/ Wet Displacement Volume (mL/m^3)	13.06	11.51	18.52	7.49	6.16	8.79	14.75	10.30	Mean: 11.32		



Note: - Photomicrography by Val Borja

Plate 22 Photos of the most dominant phytoplankton species recorded for the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

For the offshore/open water area, total number of phytoplankton ranged widely from 5,382,254 to 16,776,231 cells/m3 with an average of 11,452,155 cell/m3 (**Figure 2.111**), while the estimated displacement volume or biomass of the plankton samples collected also ranged widely from 6.16 to 18.52 mL/m3 with an average of 11.32 mL/m3 (**Figure 2.112**). Higher total phytoplankton number and plankton biomass were recorded on the western part of the bay between Bataan and Corregidor, particularly at Stations MBS-1, MBS-2, and MBS-3, while the lower total phytoplankton number and plankton biomass were recorded on the eastern part between Corregidor and Cavite, except at one particular station (MBS-7) wherein a high total phytoplankton and plankton biomass were recorded (see **Figure 2.111** and **Figure 2.112**, respectively). Variations in the plankton biomass (**Figure 2.112**) by sampling station also showed a similar general trend to that of the total number of phytoplankton (**Figure 2.111**). As mentioned earlier, the variates increase and decrease together, i.e., with high phytoplankton more plankton biomass may be expected and with low phytoplankton, less biomass may otherwise be expected. In this case, the diatoms may be considered as the biomass contributors in view of their abundance

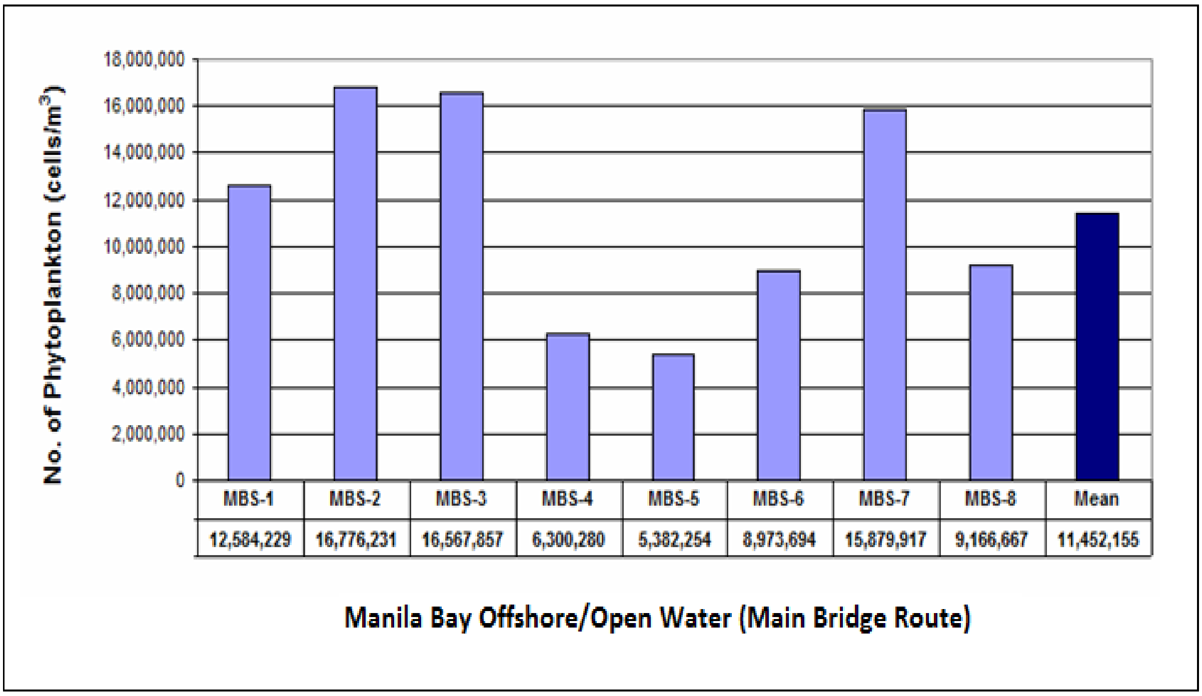


Figure 2.111 Total numbers of phytoplankton at each station sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

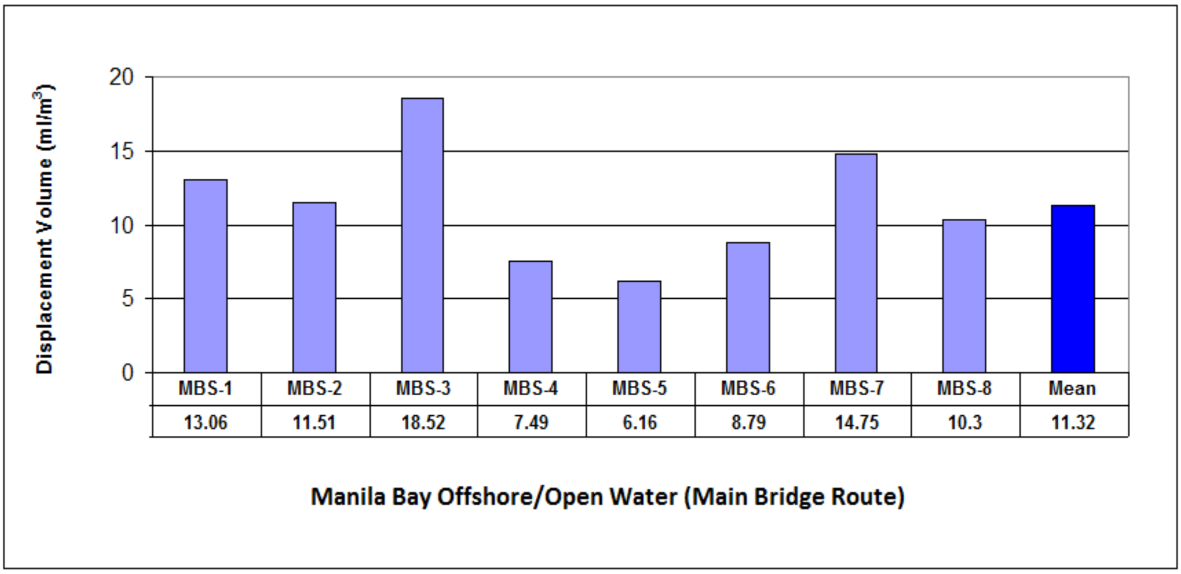


Figure 2.112 Plankton biomass at each station sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

In a study of Manila Bay plankton, particularly on four (4) sites namely Ternate, Maragondon, Corregidor Island (including adjacent Caballo Island) all in Cavite and Mariveles, Bataan (DENR-ERDB, 2019), it was concluded that the assemblage of the diatoms shows a consistent low diversity among the sites assessed with the highest diversity recorded at the surface of Corregidor Island (H'=1.87). Only the surface-level of the Ternate had a moderate diversity (0.46). The rest of the stations have a low to very low diversity. Aside from diatoms, some species of dinoflagellates like the species Ceratium furca and Prorocentrum micans were also observed. It was also reported that copepod nauplius larvae are the most common zooplankton organisms observed on the area. The blue-green alga Trichodesmium sp. was also found in several stations of Corregidor and Mariveles and is found in all the sampling stations assessed. Moreover, Mariveles has the highest density of plankton collected. Both the surface and bottom samples registered an over 100 million cells/m^3.

(C) River Estuary Phytoplankton

(a) Station BRS-1 (Babuyan River, Alas-asin, Mariveles)

The phytoplankton represented in the samples, its density, and their relative abundance is shown in **Table 2.44**. The phytoplankton population in Station BRS-1 consists of three (3) major groups: diatoms, green algae, and blue-green algae. Blue-green algae represented by three (3) taxa/genera appeared to be the most dominant group comprising 99.80% (801,200 cells/L) of the total phytoplankton population (**Figure 2.113**). Diatoms were the next most abundant which comprised 0.15% (1,200 cells/L) consisting of two (2) taxa/genera. The least were the green algae solely represented by only one (1) species/taxon, comprising 0.05% (400 cells/L). Overall, the most abundant phytoplankton organisms were the blue-green alga Microcystis (800,000 cells/L, or 99.65%). This was followed by the diatom Navicula (800 cells/L, or 0.10%), blue-green alga Trichodesmium (800 cells/L, or 0.10%), diatom Coscinodiscus (400 cells/L, or 0.05%), blue-green alga Nostoc. (400 cells/L, or 0.05 %), and green alga Closterium (400 cells/L, or 0.05%) (**Plate 23**). At this river station, a total of 802,800 phytoplankton cells/L was recorded (**Figure 2.114**).

Table 2.44. Phytoplankton composition, density and relative abundance at three river stations sampled in Mariveles and Naic

Phytoplankton Taxa	Stations					
	BRS-1 (Babuyan River)		CRS-1 (Timalan River)		CRS-2 (Bucana River)	
	No./L	Relative Abundance (%)	No./L	Relative Abundance (%)	No./L	Relative Abundance (%)
Bacillariophyceae (Diatoms)						
Chaetoceros			400	0.02	400	0.01
Coscinodiscus	400	0.05	400	0.02		
Gyrosigma			400	0.02	2,000	0.05
Navicula	800	0.10	1,200	0.07	1,600	0.04
Skeletonema			400	0.02		
Thalassiosira			1,600	0.10	2,000	0.05
Sub-total	**1,200**	**0.15**	**4,400**	**0.27**	**6,000**	**0.14**
Chlorophyceae (Green Algae)						
Closterium	400	0.05	800	0.05	400	0.01
Sub-total	**400**	**0.05**	**800**	**0.05**	**400**	**0.01**
Cyanophyceae (Blue-green Algae)						
Microcystis	800,000	99.65	1,600,000	99.58	4,200,000	99.82
Oscillatoria			400	0.02	400	0.01
Nostoc	400	0.05	800	0.05	400	0.01
Trichodesmium	800	0.10	400	0.02	400	0.01
Sub-total	**801,200**	**99.80**	**1,601,600**	**99.68**	**4,201,200**	**99.85**
TOTAL PHYTOPLANKTON	**802,800**	**100.00**	**1,606,800**	**100.00**	**4,207,600**	**100.00**
Total No. of Taxa	**6**		**11**		**9**	

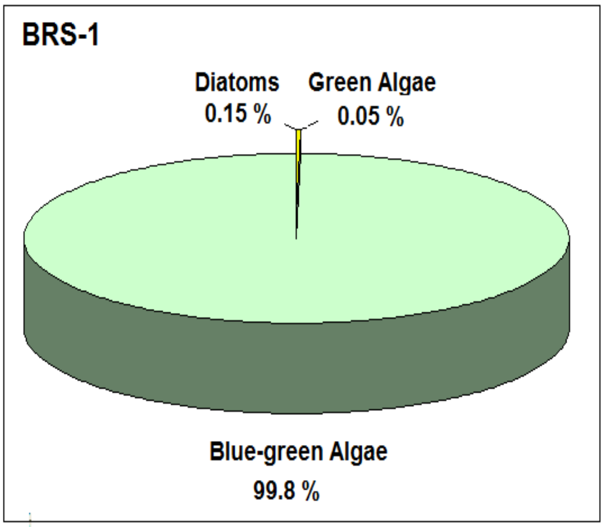
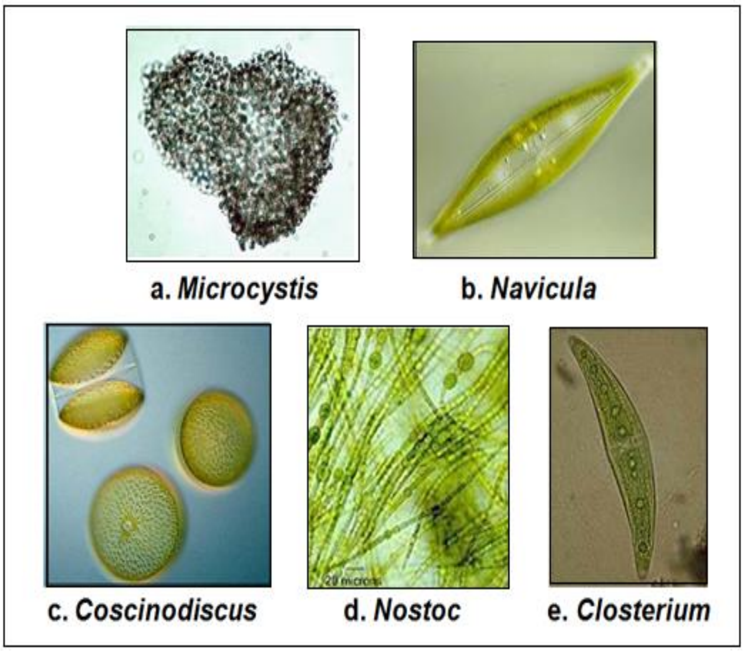


Figure 2.113 Relative abundance of the major phytoplankton groups for Babuyan River, Alas-asin (Station BRS-1)



Note: - Photomicrography by Val Borja

Plate 23 Photos of the most dominant phytoplankton species recorded for Babuyan River, Alas-asin (Station BRS-1)

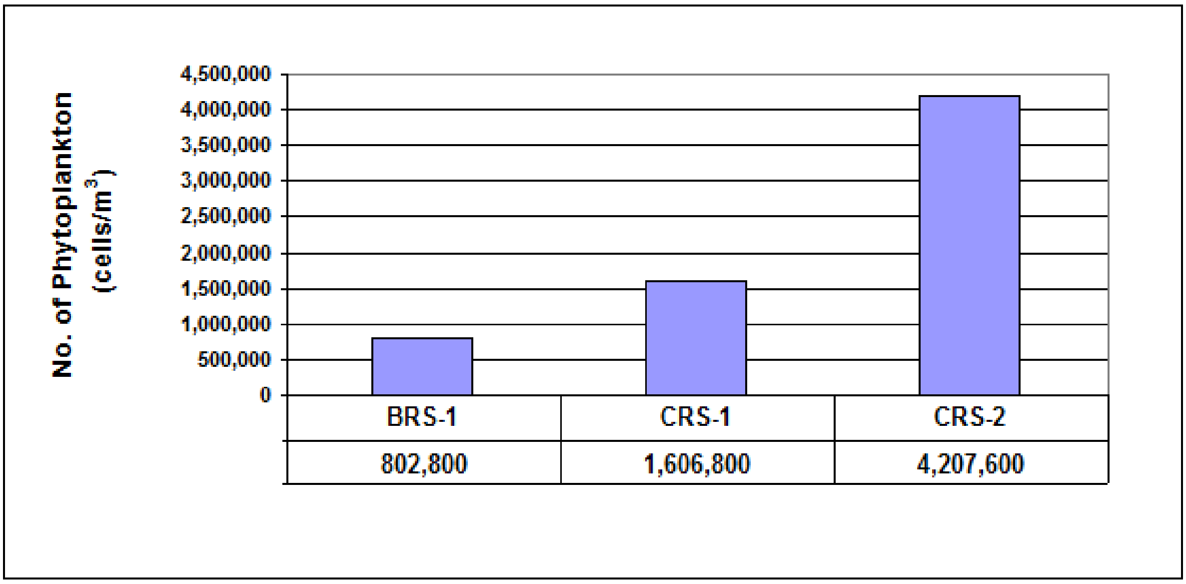


Figure 2.114 Total numbers of phytoplankton at each river station sampled in Mariveles and Naic

(b) Station CRS-1 (Timalan River, Brgy. Timalan Balsahan, Naic, Cavite

The phytoplankton population in Station CRS-1 (Timalan River) also consists of three (3) major groups: diatoms, green algae, and blue-green algae (see **Table 2.44**). Blue-green algae represented by six (6) taxa/genera also appeared to be the most dominant/abundant group comprising 99.68% (1,601,600 cells/L) of the total phytoplankton population (**Figure 2.115**). Diatoms were the next most abundant which comprised 0.27% (4,400 cells/L) consisting of six (6) taxa/genera. The least were the green algae solely represented by only one (1) species/taxon, comprising 0.05% (800 cells/L). The most abundant phytoplankton organisms were the blue-green alga Microcystis (1,600,000 cells/L, or 99.58%) followed by the diatoms Thalassiosira (1,600 cells/L, or 0.10%) and Navicula (1,200 cells/L, or 0.07%) (**Plate 24**). All the other remaining phytoplankton taxa/genera were poorly represented which comprised only 0.02 – 0.05% of the total phytoplankton population. A total of 1,606,800 phytoplankton cells/L were recorded in the river estuary which was higher compared to that estuary sampled in Babuyan River (see **Figure 2.114**).

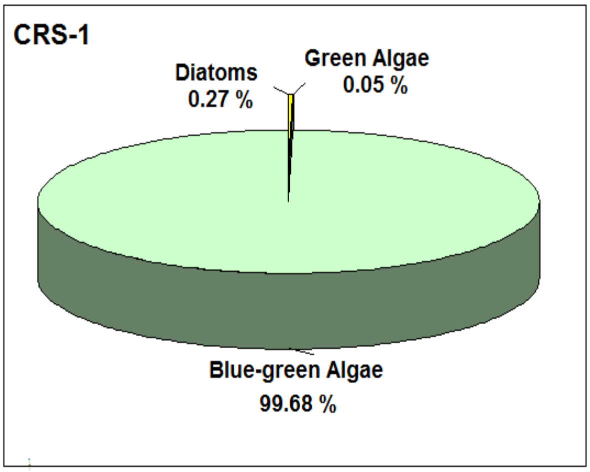
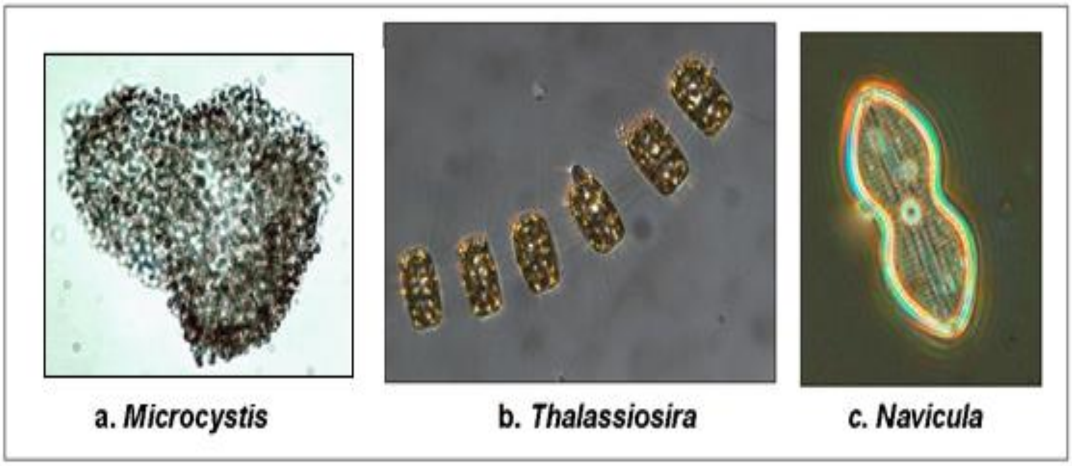


Figure 2.115 Relative abundance of the major phytoplankton groups for Timalan River, Naic (Station CRS-1)



Note: - Photomicrography by Val Borja

Plate 24 Photos of the most dominant phytoplankton species recorded for Timalan River, Naic (Station CRS-1)

(b) Station CRS-2 (Bucana River, Brgy. Bucana, Naic, Cavite)

Station CRS-2 (Bucana River) also consists of three (3) major phytoplankton groups: diatoms, green algae, and blue-green algae (see **Table 2.44**). Blue-green algae represented by four (4) taxa/genera also appeared to be the most dominant/abundant group comprising 99.85% (4,201,200 cells/L) followed by diatoms which comprised 0.14% (6,000 cells/L) consisting of four (4) taxa/genera (**Figure 2.116**). The least were the green algae solely represented by only one (1) species/taxon, comprising 0.01% (400 cells/L). The most abundant phytoplankton were the blue-green alga Microcystis (4,000,000 cells/L, or 99.82%) followed by the diatoms Thalassiosira and Gyrosigma (2,000 cells/L, or 0.05% each), and Navicula (1,600 cells/L, or 0.04%) (**Plate 25**). All the other remaining phytoplankton taxa/genera were poorly represented in the plankton samples comprising only 0.01% of the total phytoplankton count. This river station had the highest density of phytoplankton among the three (3) river estuaries sampled which comprised a total of 4,207,600 phytoplankton cells/L (see **Figure 2.115**).

The above observations on the phytoplankton of the river estuaries in Naic may indicate that the plankton condition of the water bodies surveyed is the so-called eutrophic ("nutrient rich") plankton type because of the great abundance of the blue-green alga Microcystis. This is probably caused by excessive nutrient loading.

When algal blooms (in large quantities) form and decay or degrade, cyanobacteria (also referred to as blue-green algae) may release algal toxins that can be harmful to animal and human life. The toxins can cause gastroenteritis, neurological disorders and possibly cancer. Numerous cases of livestock, pet, and wildlife poisonings have been reported, and evidence has been mounting that humans are also affected (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/blue-green-algae). The most common toxic cyanobacteria in freshwater are Microcystis. (https://www.who.int/water_sanitation_health/bathing/ srwe1-chap8.pdf/).

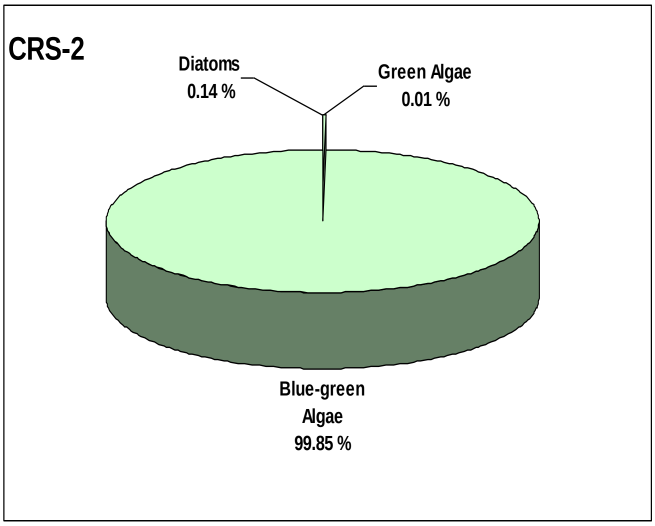
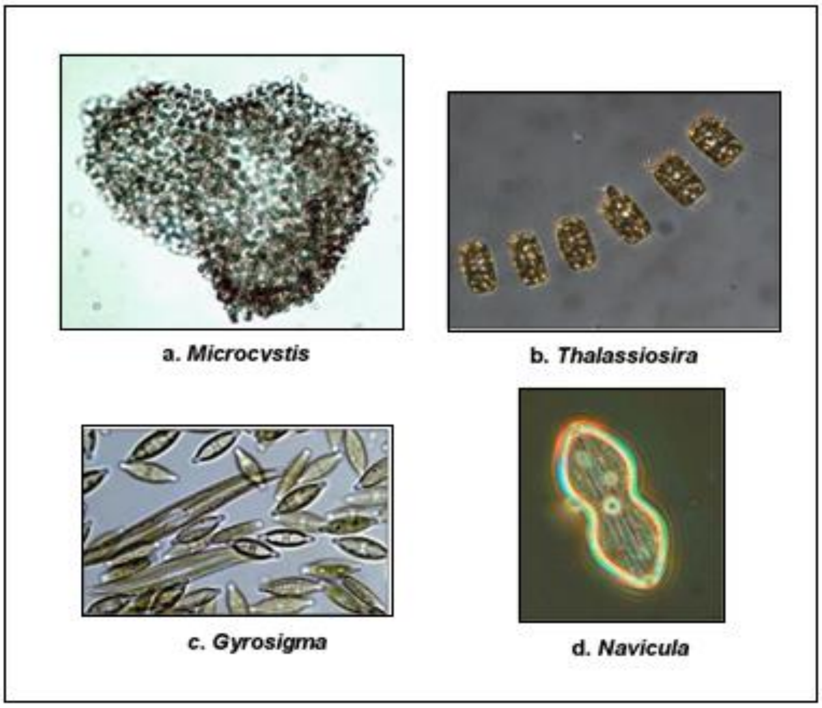


Figure 2.116 Relative abundance of the major phytoplankton groups for Bucana River, Naic (Station CRS-2)



Note: - Photomicrography by Val Borja

Plate 25 Photos of the most dominant phytoplankton species recorded for Bucana River, Naic (Station CRS-2)

2.2.5.3.3 Zooplankton (Animal Plankton)

(A) Nearshore Zooplankton

(a) Alas-asin and Mt. View (Mariveles, Bataan)

Results from the analysis of the plankton showed that the zooplankton composition in the nearshore area of Bataan includes three (3) taxa belonging to only one (1) major group, the copepods (**Figure 2.117**). Copepod nauplius larvae (74.67%) dominated the zooplankton community followed by the adult calanoid copepods (13.24%), while the least were the adult cyclopoid copepods (12.09%) (**Table 2.45**, see **Figure 2.117**, and **Plate 26**). Total numbers of zooplankton ranged from 199,693 to 362,903 ind/m3 with an average of 277,920 ind/m3 (**Figure 2.118**).

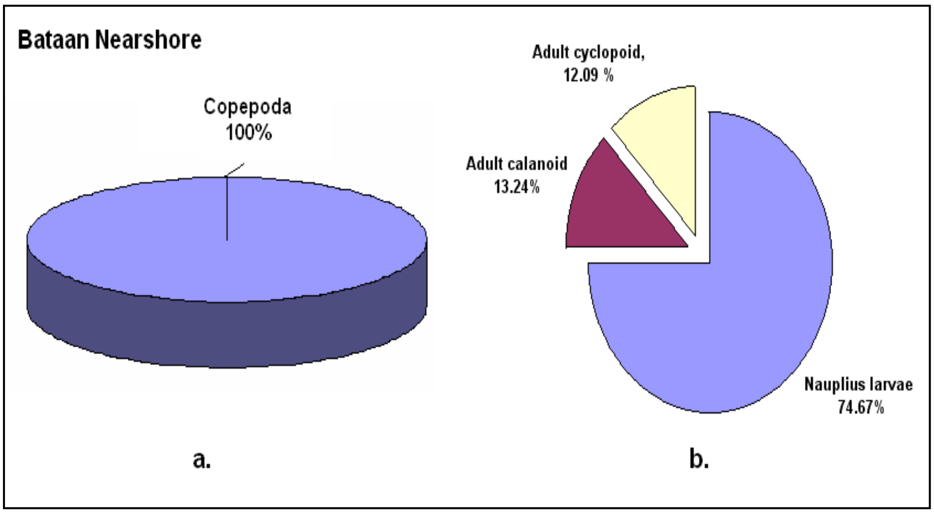
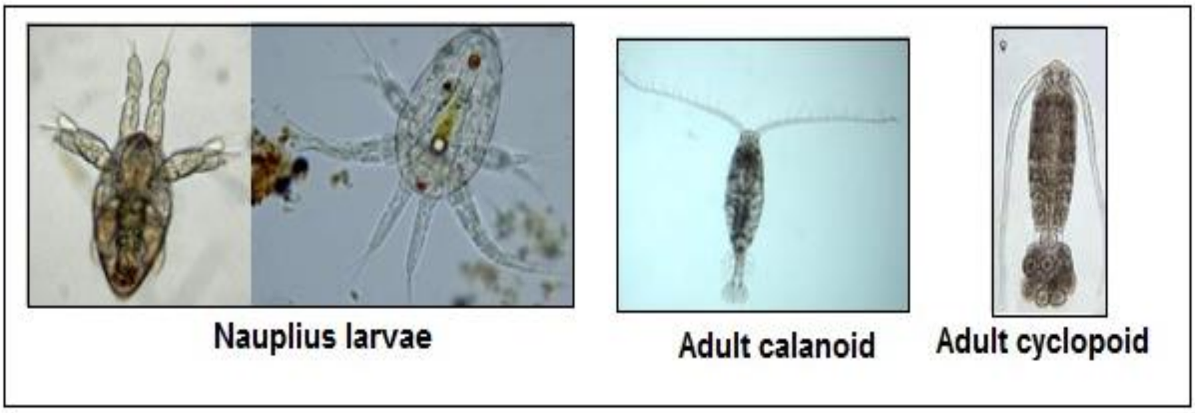


Figure 2.117 Mean relative abundance of major zooplankton groups in the nearshore waters along Alas-asin, Mariveles

Table 2.45. Zooplankton composition, density and relative abundance at three stations sampled in nearshore waters along Alas-asin, Mariveles

Zooplankton Taxa	Station			Mean Total Density (no./m^3)	Mean Relative Abundance (%)	
	BNS-1	BNS-2	BNS-3		Species	Group
Copepoda						100.00
Nauplius larvae	271,164	169,931	181,452	207,516	74.67	
Adult calanoid		29,762	80,645	36,802	13.24	
Adult cyclopoid			100,806	33,602	12.09	
TOTAL ZOOPLANKTON	**271,164**	**199,693**	**362,903**	**277,920**	**100.00**	**100.00**



Note: - Photomicrography by Val Borja

Plate 26 Photos of the most dominant zooplankton organisms recorded for nearshore waters along Alas-asin, Mariveles

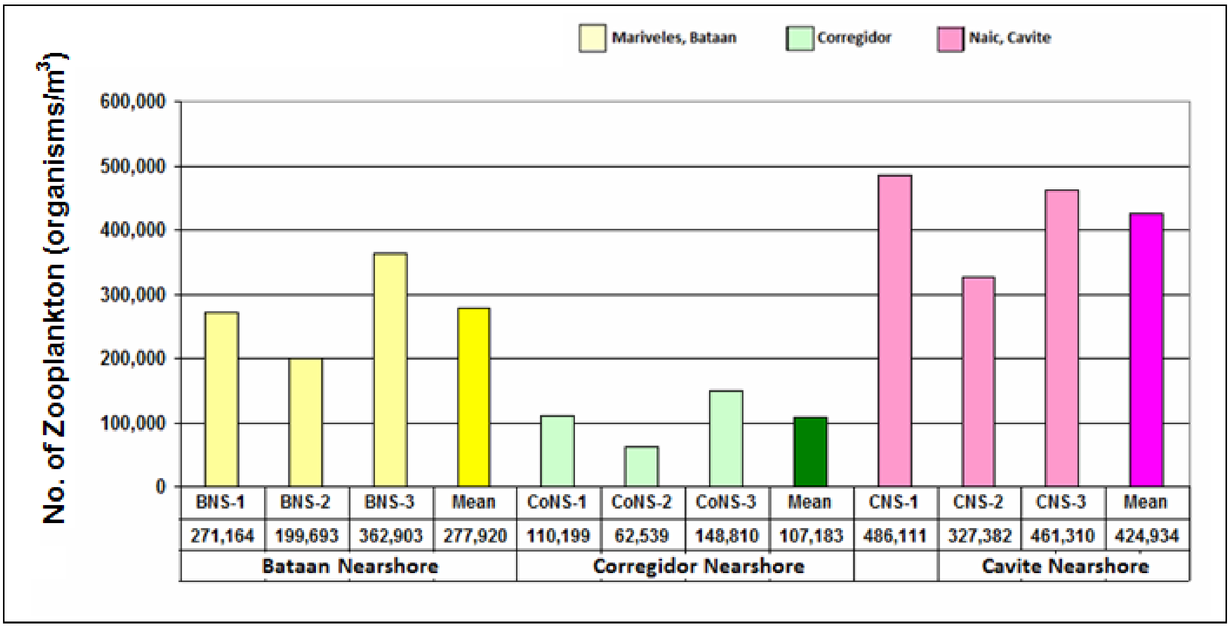


Figure 2.118 Total numbers of zooplankton at each station sampled in nearshore waters of Alas-asin (Mariveles), Corregidor Island, and Naic (Cavite)

(b) Corregidor Island

A total of only 2 taxa were recorded belonging to 2 major groups, the ciliates and copepods (**Figure 2.119**). Copepod nauplius larvae (95.02%) were the most dominant and the least were the ciliate tintinnids (4.98%) (**Table 2.46**, see **Figure 2.119**, and **Plate 27**). Total numbers of zooplankton ranged from 62,539 to 148,810 ind/m3 with an average of 107,183 ind/m3, which was relatively lower compared to Bataan nearshore (average 277,920 ind/m3) (see **Figure 2.118**).

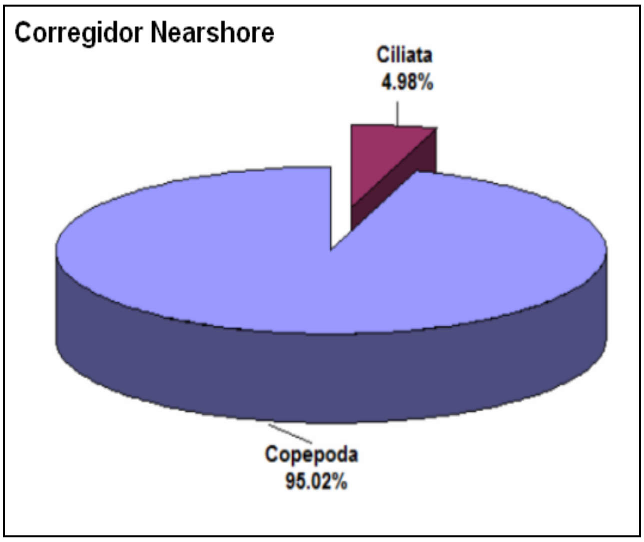
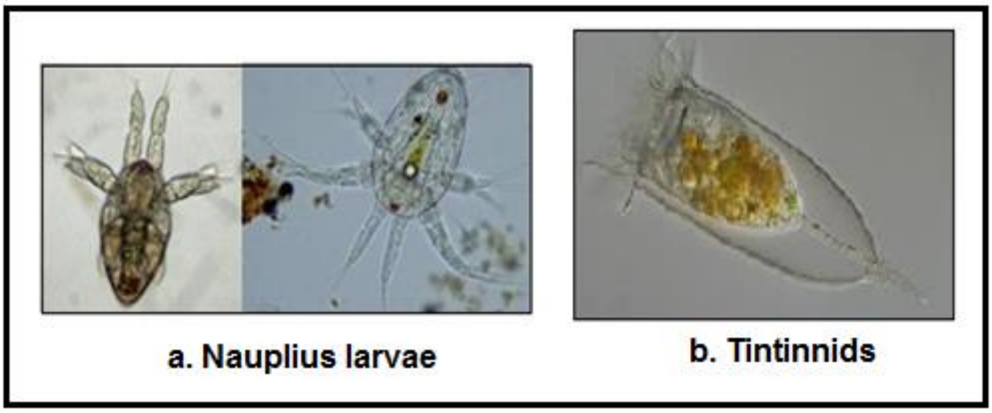


Figure 2.119 Mean relative abundance of major zooplankton groups in the nearshore waters along Corregidor Island

Table 2.46. Composition, density and relative abundance of zooplankton at the three stations sampled in nearshore waters of Corregidor Island

Zooplankton Taxa	Station			Mean Total Density (No./m^3)	Mean Relative Abundance (%)	
	CoNS-1	CoNS-2	CoNS-3		Species	Group
Ciliata						4.98
Tintinnids		16,026		5,342	4.98	
Sub-total		16,026		5,342	4.98	
Copepoda						95.02
Nauplius larvae	110,199	46,513	148,810	101,841	95.02	
Sub-total	**110,199**	**46,513**	**148,810**	**101,841**	**95.02**	
TOTAL ZOOPLANKTON	**110,199**	**62,539**	**148,810**	**107,183**	**100.00**	**100.00**



Note: - Photomicrography by Val Borja

Plate 27 Photos of the most dominant zooplankton organisms recorded for nearshore waters of Corregidor Island

(c) Timalan Concepcion and Timalan Balsahan (Naic, Cavite)

A total of five (5) taxa were recorded belonging to only two (2) major groups, the copepods (average 59.14%) and ciliates (average 40.86%) (**Figure 2.120**). As always, the copepod nauplius larvae (average 43.19%) were the most dominant followed by the ciliates Codonellopsis (28.41%) and tintinnids (12.45%), adult calanoid copepod (10.89%), and adult cyclopoid copepod (5.06%) (**Table 2.47** and **Plate 28**). Total numbers of zooplankton ranged from 327,382 to 486,111 indv/m3 with an average of 424,934 indv/m3, which was relatively higher compared to Bataan and Corregidor nearshore areas (average 277,920 and 107,183 indv/m3, respectively) (see **Figure 2.118**).

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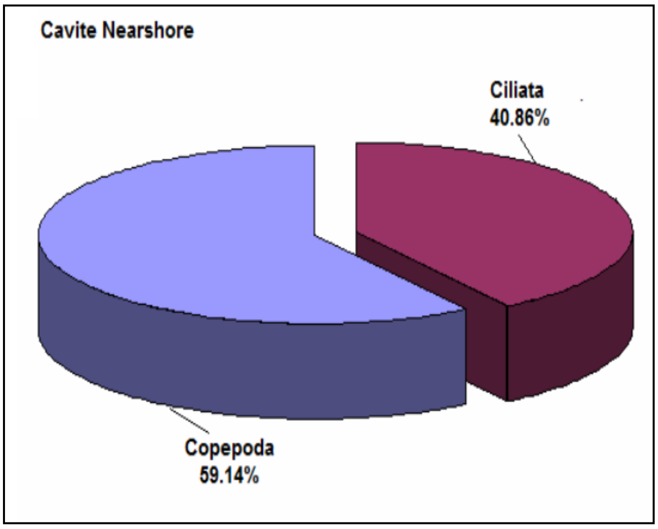
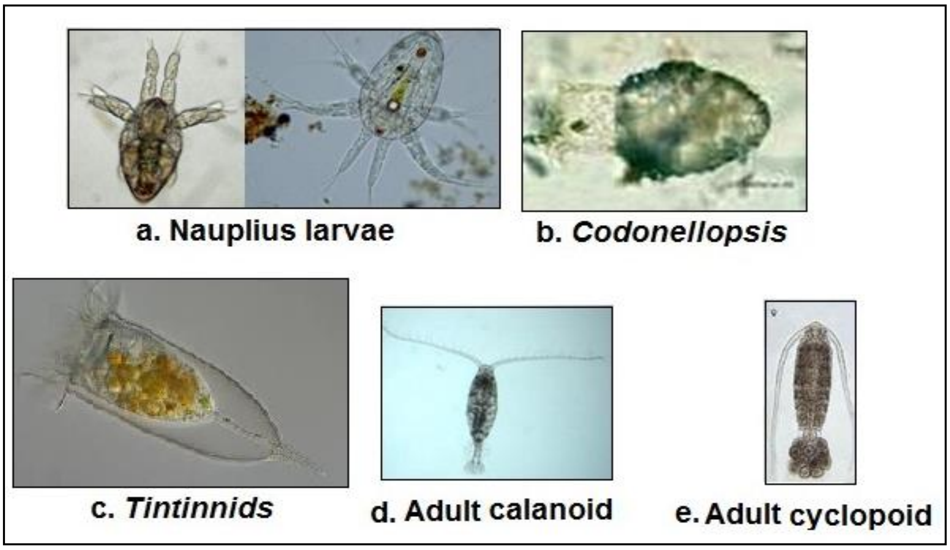


Figure 2.120 Mean relative abundance of major zooplankton groups in the nearshore waters along Naic, Cavite

Table 2.47. Composition, density and relative abundance of zooplankton at the three stations sampled in nearshore waters of Naic, Cavite

Zooplankton Taxa	Station			Mean Total Density (No./m^3)	Mean Relative Abundance (%)	
	CNS-1	CNS-2	CNS-3		Species	Group
Ciliata						40.86
Tintinnids	69,444	89,286		52,910	12.45	
Codonellopsis	173,611	89,286	99,206	120,701	28.41	
Sub-total	243,055	178,572	99,206	173,611	40.86	
Copepoda						59.14
Nauplius larvae	138,889	148,810	262,897	183,532	43.19	
Adult calanoid	104,167		34,722	46,296	10.89	
Adult cyclopoid			64,484	21,495	5.06	
Sub-total	243,056	148,810	362,103	251,323	59.14	
TOTAL ZOOPLANKTON	**486,111**	**327,382**	**461,310**	**424,934**	**100.00**	**100.00**



Note: - Photomicrography by Val Borja

Plate 28 Photos of the most dominant zooplankton organisms recorded for nearshore waters of Naic, Cavite

(B) Offshore/Open Water Zooplankton

(a) Near Mouth of Manila Bay from Mariveles (Bataan) to Naic (Cavite)

The zooplankton population was composed of four (4) major groups, namely: ciliates, copepods, molluscs, and appendicularians. Copepods (average70.75%) represents the bulk of the zooplankton population near the mouth of Manila Bay. This was followed by the ciliates (average 16.94%), appendicularians (average 8.39%) and the least were the molluscs (average 3.92%) (**Figure 2.121**). A total of eight (8) taxa/genera were recorded: four (4) copepods, two (2) ciliates, one (1) mollusc, and one (1) appendicularian (**Table 2.48**). Copepod nauplius larvae (average 50.23%) comprised the bulk of zooplankton followed by the adult calanoid copepod (15.69%), ciliates tintinnids and Codonellopsis (average 8.72 and 8.22%, respectively), appendicularian Oikopleura (average 8.39%), adult cyclopoid copepod (4.05%), molluscan bivalve larvae (average 3.92%), and adult harpacticoid copepod (0.78%) (**Plate 29**). The total numbers of zooplankton near the mouth of Manila Bay from Bataan to Cavite ranged from 123,656 to 239,331 indv/m3 with an average of 162,521 indv/m3 (**Figure 2.122**). This figure indicates that zooplankton population was found to be greater on the eastern side of the project site (Cavite side).

A zooplankton study at Manila Bay conducted in 2013 by Jose et al. (2017) reported that, zooplankton was most abundant near the mouth of the bay, particularly at Station 2 (along Cavite side) which has the highest density while Station 12 (near Manila) has the lowest density. The zooplankton population of these stations was found to be dominated by adults and nauplius larvae of copepods followed by appendicularian Oikopleura and chaetognath Sagitta. The zooplankton community was the most diverse in the month of September in general while the lowest diversity was recorded in the month of January.

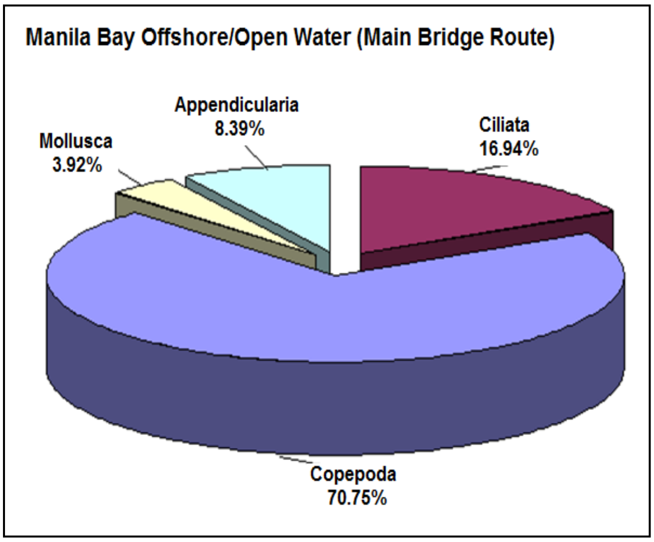
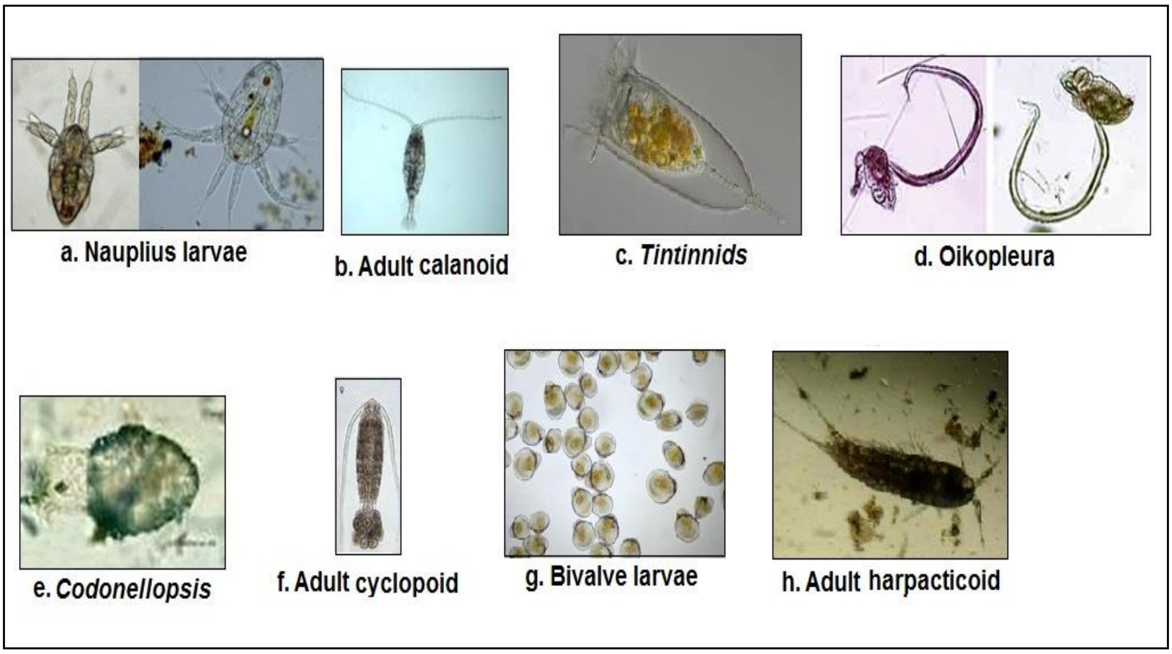


Figure 2.121 Mean relative abundance of major zooplankton groups for the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Table 2.48. Zooplankton composition, density and relative abundance at eight stations sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Zooplankton Taxa	Station								Mean Total Density (No./m3)	Mean Relative Abundance (%)	
	BMS-1	BMS-2	BMS-3	BMS-4	BMS-5	BMS-6	BMS-7	BMS-8		Species	Group
Ciliata											16.94
Tintinnids		29,324					27,174	56,936	14,179	8.72	
Codonellopsis						49,923	56,936		13,357	8.22	
Sub-total		29,324				49,923	84,113	56,936	27536	16.94	
Copepoda											70.75
Nauplius larvae	47,939	45,349	134,524	65,893	79,140	49,923	86,698	143,634	81,637	50.23	
Adult calanoid	47,939	29,324		25,325	51,363	49,923			25,484	15.69	
Adult cyclopoid		42,621		10,081					6,588	4.05	
Adult harpacticoid				10,081					1,260	0.78	
Sub-total		**117,294**	**134,524**	**111,380**	**130,503**	**99,846**		**143,634**			

Zooplankton Taxa	**Station**								**Mean Total Density (No./m3)**	**Mean Relative Abundance (%)**	
	BMS-1	**BMS-2**	**BMS-3**	**BMS-4**	**BMS-5**	**BMS-6**	**BMS-7**	**BMS-8**		**Species**	**Group**
	95,878						**86,698**		**114,969**	**70.75**	
Mollusca											3.92
Bivalve larvae	13,889			25,325	11,792				6,376	3.92	
Sub-total	13,889			25,325	11,792				6,376	3.92	
Appendicularia											8.39
Oikopleura	13,889	13,298	25,000				27,174	29,762	13,640	8.39	
Sub-total	**13,889**	**13,298**	**25,000**				**27,174**	**29,762**	**13,640**	**8.39**	
TOTAL ZOOPLANKTON	**123,656**	**159,915**	**159,524**	**136,703**	**142,296**	**149,770**	**197,981**	**230,331**	**162,521**	**100.00**	**100.00**



Note: - Photomicrography by Val Borja

Plate 29 Photos of the most dominant zooplankton organisms recorded for the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

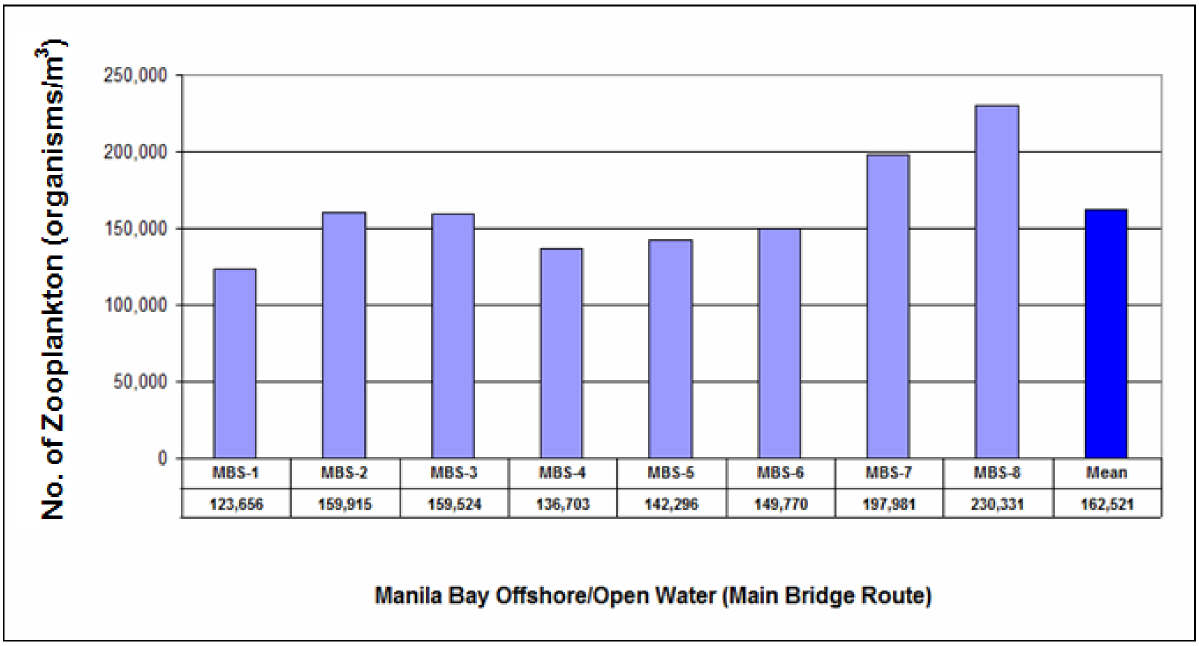
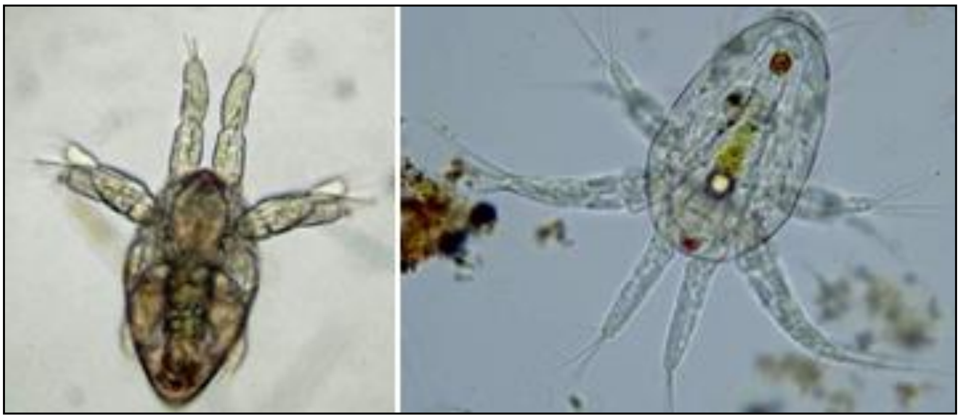


Figure 2.122 Total numbers of zooplankton at each station sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

(C) River Estuary Zooplankton

(a) Stations BRS-1 (Babuyan River, Alas-asin, Mariveles), CRS-1 (Timalan River, Naic), and CRS-2 (Bucana River, Naic)

The zooplankton collected in all these river stations comprised a total of only one (1) zooplankton taxon (the nauplius larvae) belonging to Copepoda (**Plate 30**). **Figure 2.123** shows that the total zooplankton in all stations ranged from 400 to 800 ind/L. The highest zooplankton densities were observed in Stations BRS-1 (Alas-asin) and CRS-2 (Bucana River), while the least was observed in Station CRS-1 (Timalan River).



Note: - Photomicrography by Val Borja

Plate 30 Photos of copepod nauplius larvae

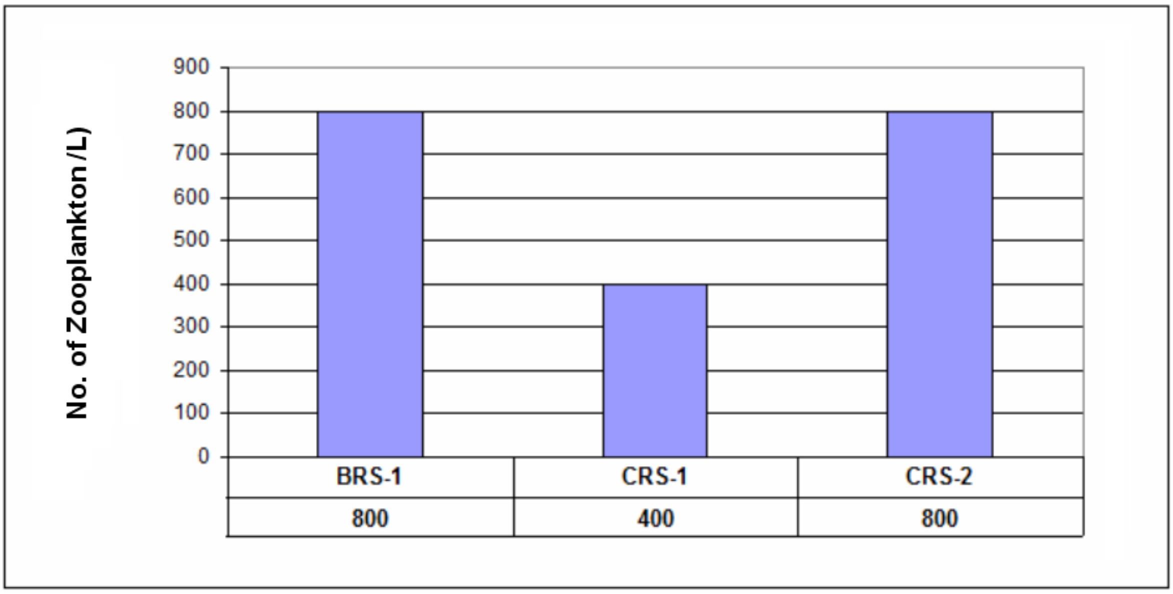


Figure 2.123 Total numbers of zooplankton at each river station sampled in Mariveles and Naic

2.2.5.3.4 Ichthyoplankton (Fish Eggs and Fish Larvae)

Ichthyoplankton studies are important for fish stock assessment purposes. Fish eggs and larvae occurrence and abundance facilitate the location of probable spawning and nursery grounds of fishes. As mentioned earlier in the methodology, a survey of fish eggs and larvae was conducted by Tobias et al. (2017) in Manila Bay waters to determine the distribution, abundance, and composition of fish eggs and larvae in the bay. They state that despite the current status and worsening condition of water quality of the bay, high abundances of fish eggs and larvae were consistently observed during the NE monsoon surveys (March) from 2012 to 2015.

Tobias et al. (2017) further reported that a total of 3,008 individuals were identified belonging to 34 fish families. The highest fish egg density was observed during March 2013 with 1,550 indv/100m3, followed by March 2012 and 2015 with 1,484 indv/m3 and 1,182 indv/100m3, respectively (**Figure 2.124**). Abundance of fish larvae were observed during March 2015 with 414 indv/100m3, followed by March 2012 and March 2014 (329 indv/100m3 and 311 indv/100m3, respectively) (**Figure 2.125**). The lowest density observed was in September 2012 with a density of 132 indv/100m3 fish eggs and 46 indv/100m3 fish larvae. Furthermore, the results were consistent that most fish eggs aggregates in the middle part of the bay. For fish larvae, they were usually found in the stations near the shore especially in Metro Manila, Cavite and Bataan areas where high concentrations of phytoplankton, zooplankton and nutrients were observed. High abundance of fish eggs and larvae was observed during northeast monsoon than southwest monsoon.

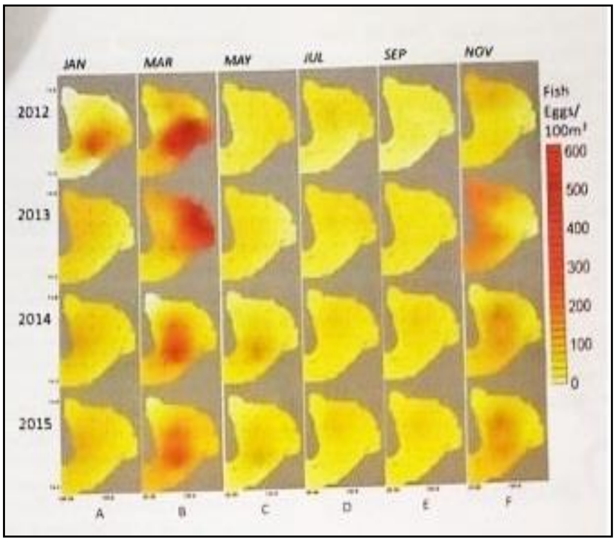


Figure 2.124 Spatial distribution and abundance of fish eggs in Manila Bay, 2012-2015 (Source; Tobias et al., 2017)

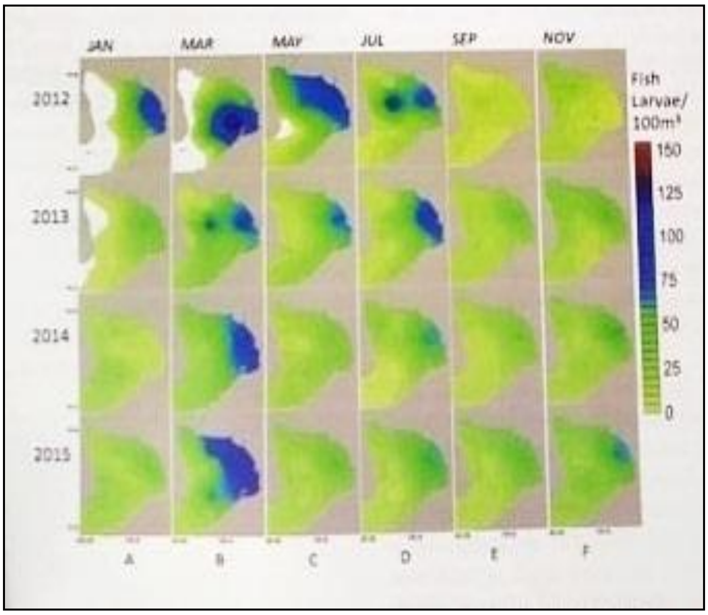


Figure 2.125 Spatial distribution and abundance of fish larvae in Manila Bay, 2012-2015 (Source: Tobias et al., 2017)

The results of the survey also indicated that fish larvae family was dominated by small pelagic fish, such as sardines, slipmouths, and mullets. The most dominant fish families found were Clupeidae, followed by Leiognathidae and Mugilidae (**Figure 2.126**). Other groups that include in the top five abundant families that occur every sampling period were Nemipteridae Sillaginidae.

Ichthyoplanakton study in Manila Bay in relation to oceanographic conditions is a continuing research activity of the National Fisheries Research and Development Institute (NFRDI), which re-started the sampling activities (every other month) last July 2017 up to July 2020. Results of this two (2) year sampling period will be released by the end of 2020 (Val Borja, Senior Scientist of NFRDI, pers. comm., 20 August 2020).

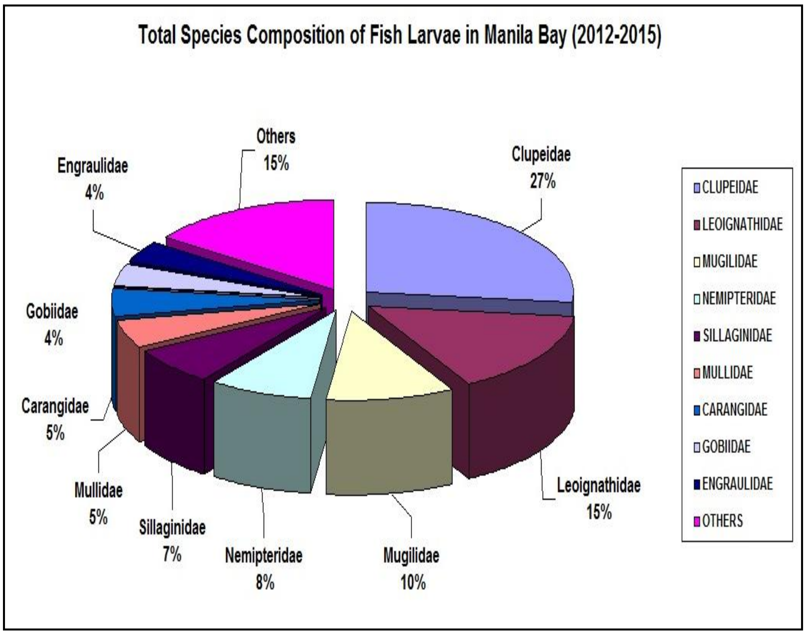


Figure 2.126 Total species composition of fish larvae in Manila Bay, 2012-2015 (Source: Tobias et al., 2017)

2.2.5.3.5 Primary Productivity (Chlorophyll-a Concentration)

A common feature to all phytoplankton is that they contain chlorophyll-a; but there are other necessary pigments such as chlorophyll-b and chlorophyll-c, as well as photosynthetic carotenoids (Kirk, 1994 and Barlow et al., 2008 as cited by Kyewalyanga, 2012). Chlorophyll is photosynthetic pigments that are often used as an indicator of phytoplankton biomass (https://en.wikipedia.org/ wiki/Phytoplankton). Chlorophyll-a is a chemical required for oxygenic photosynthesis (the same process used by plants and algae). This process uses carbon dioxide, water and sunlight to produce oxygen and glucose (sugar) for energy. Moreover, chlorophyll-a is used to capture the energy from sunlight to help this process (https://www.fondriest.com/ environmental- measurements/ parameters/ water-quality/algae-phytoplankton-chlorophyll/#algae1).

One of the most adequate quantitative indicators of marine phytoplankton development is primary productivity (Sorokin, 1990). Primary production is illustrated by phytoplankton biomass, which is often expressed in chlorophyll-a estimation (Delesalle et al., 1993; McGlone et al., 1995). Thus, chlorophyll-a concentration was employed in characterizing the phytoplankton biomass in this baseline survey.

(A) Nearshore Chlorophyll-a

(a) Alas-asin/Mt. View (Mariveles), Corregidor Island, and Timalan Balsahan/Concepcion (Naic)

Chlorophyll-a concentration in the nearshore area of Mariveles did not vary much in all sampling stations that ranged from 0.363 to 0.569 mg/m3 with an average of 0.478 mg/m3. The highest concentration in this area was observed at Station BNS-3 while the lowest was observed at Station BNS-1.

Along Corregidor Island, chlorophyll-a concentration also did not vary much in all stations which ranged from 0.501 to 0.531 mg/m3 with an average of 0.515 mg/m3, slightly higher compared to Mariveles (average 0.478 mg/m3).

For the nearshore waters of Naic, chlorophyll-a concentration ranged widely from 0.582 up to 2.566 mg/m3 with an average of 1.426 mg/m3, which was much higher compared to Corregidor Island and Mariveles (average 0.515 and 0.478 mg/m3, respectively). This indicates that the largest concentration of chlorophyll-a was found along Cavite.

It can be seen in **Figure 2.127** that, chlorophyll-a concentrations in all stations sampled at Mariveles, Corregidor and Naic showed a more or less similar general trend to that of the total numbers of phytoplankton (see **Figure 2.106**). This indicates that there is a good correspondence between chlorophyll-a pigment content and total phytoplankton numbers.

It has been traditionally assumed that chlorophyll-a associated with high standing crop of phytoplankton is an index of primary production and is supporting the reproduction and growth of pelagic zooplankton, which in turn, provide an energy supply for higher tropic level (i.e., fish larvae) in the water.

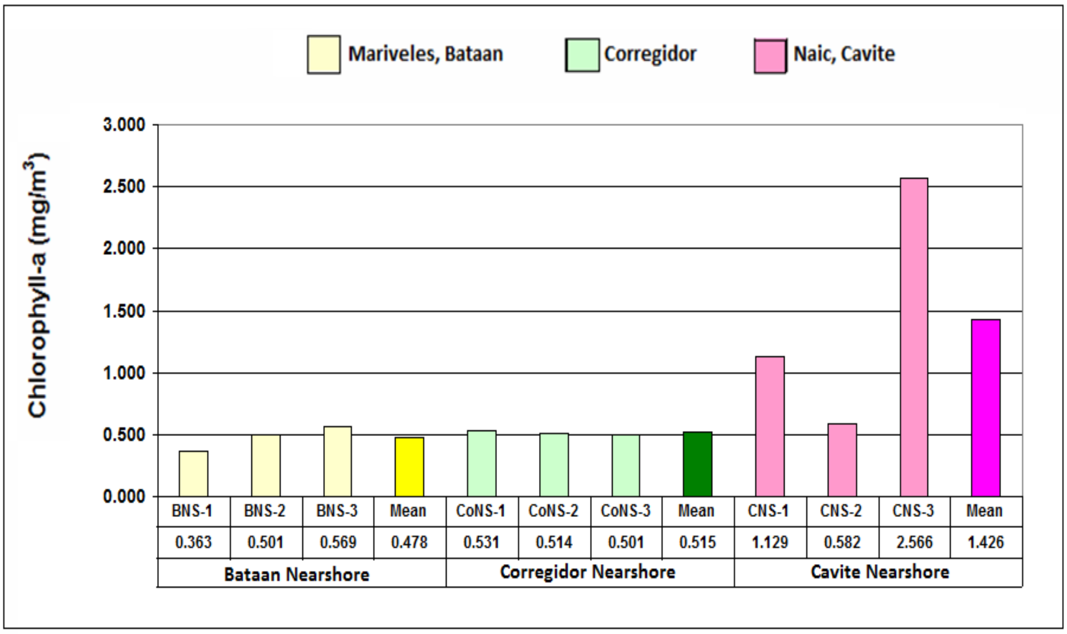


Figure 2.127 Chlorophyll-a concentration at each station sampled in nearshore waters of Alas-asin (Mariveles), Corregidor Island, and Naic (Cavite)

(B) Offshore/Open Water Chlorophyll-a

(a) Near Mouth of Manila Bay (from Mariveles, Bataan to Naic, Cavite)

Chlorophyll-a concentration vary in all sampling stations that ranged widely from 0.366 to 1.551 mg/m3 with an average of 0.934 mg/m3 (**Figure 2.128**). Relatively lower chlorophyll-a concentrations were observed on the western side at Stations MBS-1, MBS-2, and MBS-3 (between Bataan and Corregidor) while relatively higher chlorophyll-a concentrations were observed on the eastern side at Stations MBS-4, MBS-5, MBS-6, MBS-7, and MBS-8 (between Corregidor and Cavite). This coincided with the results of the remote sensing-derived chlorophyll-a concentration analysis in Manila Bay, wherein chlorophyll-a concentration was generally concentrated on the eastern side of the bay (near Manila and Cavite) all throughout 2014 and the first half of 2015 (Poniente and Santos, 2017).

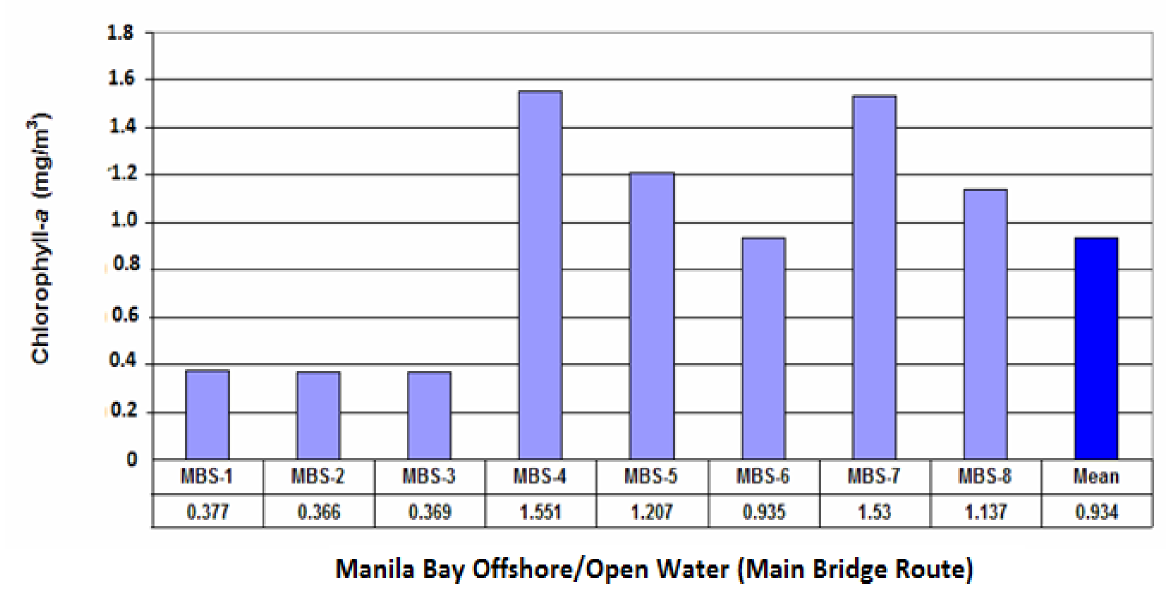


Figure 2.128 Chlorophyll-a concentrations at each station sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Comparison of chlorophyll-a values at the proposed project site with those obtained in other areas is difficult because of a number of factors such as light, temperature, nutrient and grazing among others. Nevertheless, the range of chlorophyll-a values from other sites both in the Philippines and other countries were compared with the values obtained in this present baseline study (**Table 2.45**). Chlorophyll-a concentrations obtained in the present study appeared more or less of similar magnitude to that of Pantukan, Compostela Valley, Mindanao (Davao Gulf); SWP 50 km NW of Palawan (South China Sea); Off Pinamalayan, Oriental Mindoro, Tablas Strait; off Marinduque Island, Tablas Strait; Puerto Galera Bay, Oriental Mindoro; Tayabas Bay, Quezon/Batangas; Subic Bay; and Balayan Bay (Batangas); but higher than those obtained elsewhere.

Table 2.49. Comparison of chlorophyll-a content in different locations

Place	Chlorophyll-a (mg/m3)	References
Mariveles, Corregidor, Naic, and Manila Bay (Bataan to Cavite)	0.36 - 2.57	This present study (February 2020)
Offshore Near Mouth of Manila Bay (Between Bataan and Cavite)	0.22 – 0.65	Data provided by Mr. Val Borja of NFRDI (National Fisheries Research Development Institute - January 2020)
Dahican Bay and Adlay (Carrascal Bay), Surigao del Sur	0.02 - 0.17	Monitoring Study (MEAESCF, 2020) (August & December 2019)
Nagbayukan, Naglatore, Sueste, and Parola; Redondo Peninsula, Subic Bay	0.09 - 0.19	Monitoring Study (MEAESCF, 2017) (August 2017)
Brgys. Caticlan, Union and Rizal (Sulu Sea/Sibuyan Sea)	0.07 - 0.12	Baseline Study (LCI, 2014)
Pantukan, Compostela Valley, Mindanao (Philippines)	0.13 - 1.87	EIA Study (ECI, 2011)
SWP, 50 km NW of Palawan (South China Sea)	2.14 - 2.61	Baseline Study (MEAESCF, 2003)

Place	**Chlorophyll-a (mg/m3)**	**References**
Stations 22, 23 and 24; 50 km NW of Palawan (South China Sea)	2.44 - 2.62	Baseline Study MEAESCF (2003)
Off Pinamalayan, Oriental Mindoro, Tablas Strait (Philippines)	0.49 - 0.93	Baseline Study (WCPI, 2000)
Off Marinduque Island, Tablas Strait (Philippines)	0.09 - 1.23	Baseline Study (WCPI, 1999)
Puerto Galera Bay, Oriental Mindoro (Philippines)	0.80 - 1.20	McGlone et al. (1997)
Tayabas Bay, Quezon/Batangas (Philippines)	0.04 - 1.95	FSP-REA Tayabas Bay (1996)
Subic Bay (Philippines)	0.07 - 6.34	WCPI (2001)
Balayan Bay, Batangas (Philippines)	0.26 - 0.80	FSP-REA Balayan Bay (1996)
Northwest Mediterranean Sea	0.10 - 0.70	Agawin and Agusti (1997)
Moorea Island, French Polynesia	0.12 - 0.21	Delesalle et al. (1993)
Bikini Atoll (Marshall Island)	0.16 - 0.60	Marshall (1965)
D'Ambaro Bay, Nosy Be (Madagascar)	0.16 - 1.20	Angot (1968)
Oceanic Waters off Nosy Be (Madagascar)	0.05 - 0.35	Angot (1968)

(C) River Estuary Chlorophyll-a

Figure 28 showed that the highest chlorophyll-a concentration (2.902 mg/m3) was observed at Station CRS-2 (Bucana River, Naic). This is also the river estuary where highest concentration of phytoplankton (particularly the blue-green alga Microcystis) was observed (see **Figure 2.129**). The other station in Naic, Station CRS-1 (Timalan River), however had chlorophyll-a concentration slightly lower (0.279 mg/m3) compared to that of Station BRS-1 (Alas-asin, Mariveles) (0.295 mg/m3).

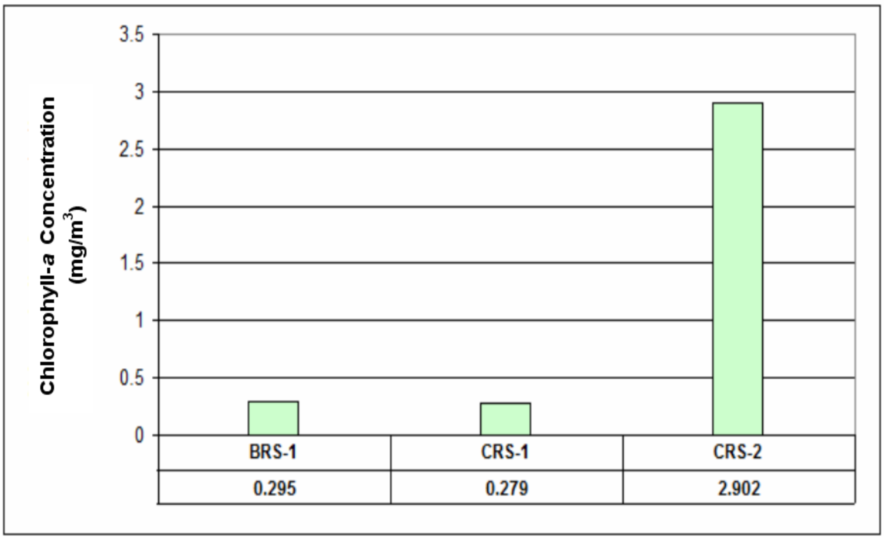


Figure 2.129 Chlorophyll-a concentration at each river station sampled in Mariveles and Naic

2.2.5.3.6 Harmful Algal Blooms or Red Tides

Harmful algal blooms (HABs) are caused by algae, many of which are microscopic diatoms, dinoflagellates, and cyanobacteria that produce toxins or grow excessively, harming humans, other animals, including the environment (Anderson et al., 2008). In the ocean, these species commonly make their presence known through massive "blooms" of cells that discolor the water (hence the common use of the term "red tide"); through illness and death of humans who have consumed contaminated shellfish or fish; or through mass mortalities of fish, seabirds, and marine mammals along coastal shores (Hallegraeff, 1993). The spatial and temporal expansion and increased intensity of HABs is a globally recognized phenomenon (Hallegraeff, 1993; Anderson et al., 2008) and this expansion has already been observed in Manila Bay where HABs have become a human health, economic and environmental threat.

Manila Bay has seen an increased incidence of HABs over the past three (3) decades (Borja et al., 2019). The bay experiences at least two (2) distinctive types and detrimental impacts of HABs annually since 1988, which are: (i) toxins-producing algae causing a variety of illnesses in humans due to consumption of contaminated shellfish and/or fish, and (ii) mono-species blooms or "fish killer" red tide directly causing fishery economic losses due to massive fish kills of shellfish and fish from both aquaculture farms and natural environment.

Borja et al. (2019) discussed the HABs affecting the Manila Bay including their historical occurrence, causative phytoplankton species, and impacts and are summarized below.

(A) Occurrence of Shellfish Poisoning Causative Species

The western side of Manila Bay (off Orion and Limay, Bataan) had its first experience of the blooms of toxic dinoflagellate, Pyrodinium bahamense var. compressum (**Plate 31**) in August 1988 which lasted until December of the same year. Consequently, there were 121 cases of paralytic shellfish poisoning (PSP) with four (4) deaths, of which, only 65 cases were validated, due to ingestion of contaminated shellfish on the said period alone. Pyrodinium bloom was observed annually since then until 1998, recording a total of 1,108 PSP cases with 44 deaths.

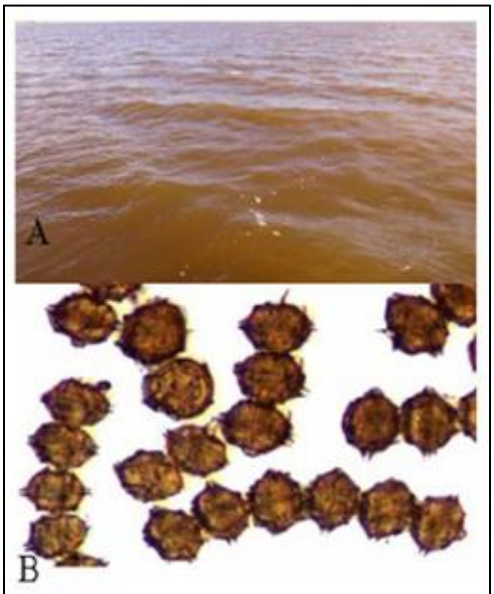


Plate 31 Red tide/phytoplankton bloom of toxic dinoflagellate Pyrodinium bahamense var. compressum in Manila Bay during 1997-1998 (Photo taken from Borja et al., 2019)

The presence of two (2) species of Alexandrium were confirmed in the bay namely, A. tamiyavanichii and A. minutum (**Plate 32**). Both are HAB-causative species producing PSPs. Although no incidence of PSP cases was ever reported with the occurrence of A. tamiyavanichii in the bay, on 12 January 2018 the western side of Manila Bay is positive for PSP toxin that is beyond regulatory limit. The responsible organism was A. minutum, the same species that was first detected in the coastal waters of Bolinao, Pangasinan on 22 April 2003 wherein two (2) children died out of six (6) PSP cases shortly after ingesting mussels.

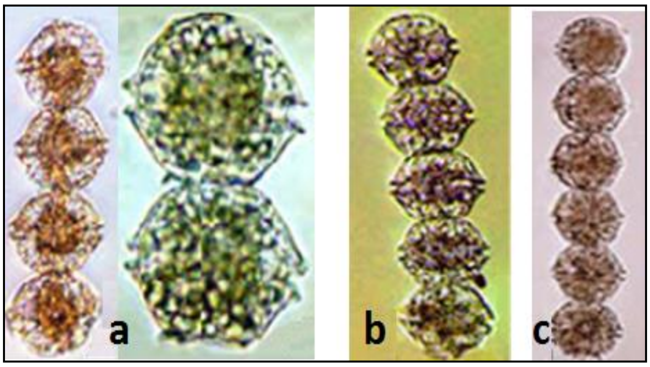


Plate 32 Three species of chain-forming dinoflagellate Alexandrium found in Manila Bay. a) Alexandium tamiyavanichii, b) Alexandrium sp. 1, and Alexandrium sp. 2 (Photos taken from Borja et al., 2019)

Gymnodinium catenatum (**Plate 33**) is an athecate, unarmored dinoflagellate that produces PSP toxin that was first detected in the Manila Bay in August 1990. Since then, G. catenatum were mostly detected in the western side of the bay albeit in low density but was undetected from 2012 to 2015. No PSP cases related to G. catenatum was reported in the surrounding areas of the bay.

Plate 33 Chain-forming cells of dinoflagellate Gymnodinium catenatum found in Manila Bay (Photo taken from Borja et al., 2019)

From 1999 until 2013, green Noctiluca scintillans (**Plate 34**) formed blooms and became more recurrent, prevalent and eventually succeeded Pyrodinium. Red N. scintillans bloom took place for the first time in the bay between the last week of January and the first week of February 2014. Although Red N. scintillans were present during the months of January to February from 2015 to 2018, density ranges of 21-35 cells/L did not produce water discoloration.

Plate 34 Green and red discoloration caused by dinoflagellate Noctiluca scintillans in Manila Bay in July 2012 and January 2014, respectively (Photos taken from Borja et al., 2019)

In 1941, three (3) species of Dinophysis were identified by Roxas (1941) as Dinophysis miles f. indica, D. caudata and D. hastata. The first two (2) species were said to be the most common in Manila Bay while the latter was sometimes seen in Mindoro waters. Since BFAR had started HAB monitoring in 1998, the same species were also seen with an addition of Dinophysis mitra (**Plate 35**). Nevertheless, no diarrhetic shellfish poisoning (DSP) cases were reported in the surrounding areas of the bay and there was no record of blooming of this species.

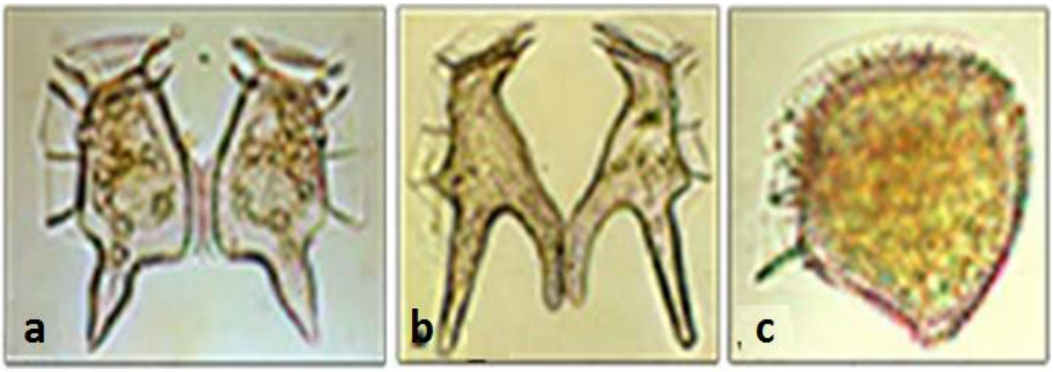


Plate 35 Three dinoflagellate Dinophysis species found in Manila Bay: a) Dinophysis caudata, b) Dinophysis miles, and c) Dinophysis mitra (Photos taken from Borja et al, 2019)

(B) Occurrence of Fish Killer Species

In 1908, Peridinium sp. bloomed in the western side of Manila Bay where it had depleted the water of dissolved oxygen that led to the fish kill in the area (Gonzales, 1989). Thereafter, the bloom of this non-toxic species was observed annually in the south-eastern area (Gonzales, 1989). Eleven species commonly found in Manila Bay were identified by Roxas (1941) as Peridinium conicoides, P. latissimum, P. leonis, P. subinerme, P. depressum, P. divergens, P. obtusum, P. venustum, P. africanoides, P. curtipes, and P. pellucidum. Gran had separated the genus Peridinium into Protoperidinium in 1902 to distinguish the freshwater photosynthetic Peridinium species from the marine non-photosynthetic Protoperidinium species (Ake-Castillo et al., 2011). Gatdula et al. (2017) had enumerated the Protoperidinium species seen in Manila Bay from 2012 to 2015 as Protoperidinium claudicans, P. compressum, P. crassipes, P. denticulatum, P. depressum, P. divergens, P. mite, P. oceanicum, P. pallidum, P. pentagonum, P. pyriforme, P. steinii, Protoperidinium sp., and Peridinium quinquecome.

The unarmored dinoflagellate Cochlodinium polykrikoides (**Plate 36**) was first seen in Manila Bay in October 2004. Few species can occasionally be detected in the waters since then, but these are in very low densities and do not cause any fisheries concern. However, in other coastal waters in the Philippines, blooms of C. polykrikoides formed a rusty brown discoloration and massive fish kills particularly in the western coast of Palawan.

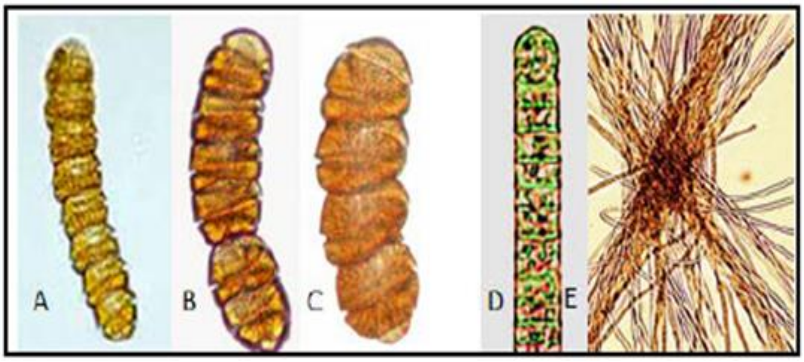


Plate 36 Harmful red tide forming phytoplankton found in Manila Bay: a-c) chain-formed unarmored dinoflagellate Cochiodinium polykrikoides, and d-e) filamentous cyanobacterium or blue-green alga Trichodesmium erythraeum (Photos taken from Borja et al., 2019)

Roxas (1941) reported 11 species of Ceratium in Manila Bay and Puerto Galera Bay (Mindoro). Ceratium furca (**Plate 37**) was reported to be one of the most common species, which caused fish kill in Puerto Galera Bay (Mindoro) and Balayan Bay (Batangas) in the past years. Visible reddish discoloration blooms of C. furca was documented in September 2012 and September 2017 on the eastern side of Manila Bay with maximum cell densities of 6,578 cells/L and 5,658 cells/L, respectively. However, no damaging effects to biotic communities were reported.

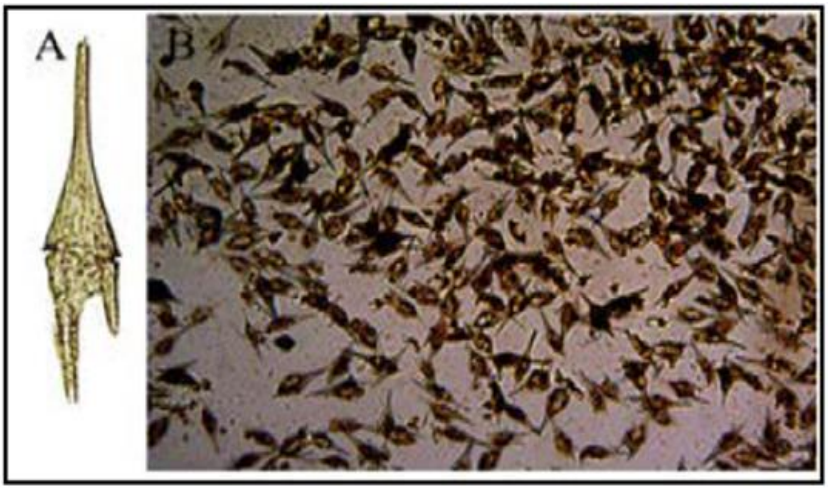


Plate 37 Bloom forming armored dinoflagallate Ceratium furca in Manila Bay: a) single cell of C. furca, and b) phytoplankton bloom dominated by C. furca (Photos taken from Borja et al., 2019)

A filamentous cyanobacterium/blue-green alga Trichodesmium erythraeum (see **Plate 36**), is found in tropical and sub-tropical body of waters noted for fish killing potential. So far, this species had never caused any fisheries resources trouble in Manila Bay, no information on it has been recorded.

There are two (2) diatom species causing amnesic shellfish poisoning (ASP) that has been identified in Manila Bay, namely Pseudo-nitzschia pungens and Nitzschia navis-varingica. Bajarias et al. (2006) collected samples every month from January 2005 until June of the same year. In-vitro culture revealed that P. pungens was negative for domoic acid (DA) toxin.

However, N. navis-varingica isolated in south-eastern side showed toxins of DA and isodomoic acid B, while N. navis-varingica from the northern part revealed toxins of isodomoic acid A and B.

To date based on this review of previous works; no occurrence of red tides or harmful algal blooms (HABs) and PSP-DSP-ASP cases have been reported along the proposed bridge project site located near the mouth of Manila Bay including the coastal/nearshore marine waters of Mariveles (Bataan), Corregidor Island, and Naic (Cavite). It may be hypothesized that the strongest tidal current velocities at the mouth of the bay prevent algal blooms.

Currently, no occurrence of red tides or HABS and PSP-DSP-ASP cases were reported in in Manila Bay. The last reported case of red tide/PSP toxin was in January 2018 along the west side of Manila Bay. The responsible dinoflagellate organism was Alexandrium minutum.

2.2.5.3.7 Soft Bottom Infaunal Benthos

Benthic or bottom dwelling animals are classified according to their habits. Those animals that burrow into soft sediments are called infauna and those that are attached to hard substrates or live in or on the bottom substrate form the epifauna.

The present soft bottom infaunal benthos study is divided into two sectors: intertidal and subtidal. These two sectors were described by Basson et al. (1977) as follows:

At the edge of the sea lies the intertidal zone, a narrow ribbon of land which is alternately exposed to air and sunlight, and covered by sea water, as a result of the rhythmic changes of sea level called tides. The dominant factor controlling the occurrence of plants and animals in the intertidal zone is the alternate exposure and submergence of the habitat, which subjects organisms living there to drastic and sudden changes in temperature, salinity and the availability of oxygen and nutrients. At low tide surface living organisms undergo intense heating and drying by the sun and are sometimes exposed to catastrophic salinity reduction during periods of rainfall. These fluctuations play a major part in establishing the distinctive character of the intertidal communities.

Subtidal benthic biotopes include all assemblages of organisms found below the low tide level and occurring on, in, or associated with the bottom. Obviously, this category includes a great variety of habitats and many different community types. The most important factor determining which organisms occur in these habitats is undoubtedly the physical nature of the seabed, which may consist either of rocks or rock-like materials such as coral (hard bottoms), or unconsolidated sediments of various kinds (soft bottoms).

For the present purposes, therefore, it is convenient to consider soft bottom infaunal benthos under the two main headings of intertidal benthos and subtidal benthos.

The soft bottom communities are one of the least studied biological components. These faunas, which are associated with soft bottom substrate, constitute as one of the most abundant major components of the food habits of many benthic or demersal (bottom dwelling) fishes and edible invertebrates on the sea. The soft bottom benthic communities are diverse and play an important role as support systems for the aquatic environment.

(A) Sediment sampling and grain size results

Table 2.50. Sediment sampling results

Sediment Sampling	Bataan			Cavite			Corregidor Island			Manila Bay							
	BNS-1	**BNS-2**	**BNS-3**	**CNS-1**	**CNS-2**	**CNS-3**	**CoNS-1**	**CoNS-2**	**CoNS-3**	**MBS-1**	**MBS-2**	**MBS-3**	**MBS-4**	**MBS-5**	**MBS-6**	**MBS-7**	**MBS-8**
Physicochemical Properties																	
Moisture content (%)	17.3	26.1	16.8	25.1	19.9	23	56.2	32	32.8	26.1	63.9	26.4	29	24.9	25.3	32.5	37.7
Oil and Grease (mg/Kg dry)	122	99.5	72.9	156	146	134	60.9	54.1	75.2	86.3	223	168	215	93.5	98.1	104	177
Metals and Major Cations																	
Arsenic (mg/Kg dry)	19	10.6	19.2	15.8	15.4	11.6	13.8	10.5	12.6	17.4	15.6	13.9	38.7	108	54.7	15.7	39.9
Nickel (mg/Kg dry)	0.852	2.7	3.72	2.26	0.84	1.76	5.18	3.52	3.5	3.72	12.1	1.63	10.3	10.2	4.75	4.39	8.02
Cadmium (mg/Kg dry)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium (mg/Kg dry)	2.23	7.09	2.81	9.68	3.85	6.82	5.51	3.64	3.66	8.21	19.6	5.73	12.1	20.9	8.65	6.77	8.32
Lead (mg/Kg dry)	ND	4.76	ND	1.15	0.926	2.2	14.2	8.71	8.11	3.91	9.85	1.84	7.81	ND	1.25	5.21	4.98
Vanadium (mg/Kg dry)	7.36	47.6	8.31	51.7	19.7	57.9	50.9	45.2	47.9	32.1	74.7	41.6	36.7	65.8	44.9	98.1	64.2
Zinc (mg/Kg dry)	18.6	35.6	10.3	12.6	8.21	17.5	74.2	65.1	50.4	34.7	92.8	14	35.6	27.5	22.6	60.9	50.6

Sediment Sampling	**Bataan**			**Cavite**			**Corregidor Island**			**Manila Bay**							
	BNS-1	**BNS-2**	**BNS-3**	**CNS-1**	**CNS-2**	**CNS-3**	**CoNS-1**	**CoNS-2**	**CoNS-3**	**MBS-1**	**MBS-2**	**MBS-3**	**MBS-4**	**MBS-5**	**MBS-6**	**MBS-7**	**MBS-8**
Mercury (mg/Kg dry)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inorganic Non-Metallic Parameters																	
Ammonia (mg/Kg dry)	42	6.06	12.8	34.4	34.2	48	224	18.5	20.8	6.06	12.4	41.8	3.15	2.24	2.25	4.15	7.2
Total Cyanide (mg/Kg dry)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrates (mg/Kg dry)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Orthophosphates (mg/Kg dry)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Grain size																	
Clay - less than 0.00391 mm (%)	NT	0.8	NT	0.21	0.05	ND	16.3	3.61	1.51	4.35	10.74	0.04	0.33	0.11	ND	3.95	9.09
Coarse Sand - 0.5 to 1 mm (%)	1	3.12	14.6	26.5	16.96	20.98	ND	ND	3.76	1.93	ND	25.42	22.55	55.71	27.82	ND	ND
Fine Sand - 0.125 to 0.25 mm (%)	2	52.2	0.6	15.2	7.49	18.62	12.33	19.9	29.21	38.84	16.99	15.44	9.61	1.31	12.17	19.21	18.02
Gravel - < 2 mm (%)	91.4	ND	39	11.07	12.15	ND	ND	ND	ND	ND	ND	ND	22.03	ND	ND	ND	ND
Medium Sand – 0.25 to 0.5 mm (%)	0.7	12.6	4.8	25.74	20.03	50.06	ND	ND	6.5	14.22	0.24	35.82	17.38	30.35	52.29	4.14	2.62

Sediment Sampling	Bataan			Cavite			Corregidor Island			Manila Bay							
	BNS-1	BNS-2	BNS-3	CNS-1	CNS-2	CNS-3	CoNS-1	CoNS-2	CoNS-3	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MBS-8
Silt – 0.00391 to 0.625 mm (%)	NT	4.54	NT	0.69	0.62	ND	51.01	23.13	11.93	16.75	59.33	0.74	1.53	0.35	ND	22.59	51.6
Total Silt and Clay – 0 to 0.0625 mm (%)	0.5	5.34	0.3	0.9	0.67	ND	67.31	26.73	13.44	21.1	70.7	0.78	1.86	0.45	ND	26.54	60.69
Very Coarse Sand – 1 to 2 mm (%)	3.6	0.48	40.4	18.56	41.98	10.12	ND	ND	0.09	1.93	ND	20.92	24.4	12.07	7.44	ND	ND
Very Fine Sand – 0.0625 to 0.125 mm (%)	0.7	26.26	0.2	2.02	0.72	0.22	20.36	53.36	47.01	23.91	12.7	1.62	2.18	0.11	0.27	50.11	18.67

ND – None Detected

NT – Not Tested

(B) Intertidal Benthos and Nearshore Subtidal Benthos

(a) Alas-asin and Mt. View (Mariveles, Bataan)

Intertidal Benthos

A total of 81 intertidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 22. These animals were represented by 20 taxa belonging to six (6) major groups, namely: Foraminifera, Sipunculida, Nematoda, Polychaeta, Mollusca and Crustacea. The polychaetes were the most abundant organisms collected comprising 39% of the total collection followed by molluscans (23%), foraminiferans (18%), nematodes (9%), crustaceans (8%) and the least were the sipunculids with only 1% (**Table 2.51** and **Figure 2.130**). Photos of some of the intertidal benthic organisms are shown in **Plate 38**.

Table 2.51. Composition, density, relative abundance and biomass of intertidal benthic infauna at three stations sampled along the shore of Alas-asin, Mariveles

Taxa	Station			Mean Total Density (no./m2)	Mean Relative Abundance (%)
	BIBS-1	BIBS-2	BIBS-3		
Phylum Foraminifera					
Family Peneroplidae	111	44	44	67	11
Family Miliolidae	44	67		37	6
Family Amphisteginidae	22			7	1
Phylum Sipunculida		22		7	1
Phylum Nematoda	44		111	52	9
Phylum Annelida					
Class Polychaeta					
Family Orbiniidae	22			7	1
Family Spionidae	244	289	89	207	35
Family Capitellidae	22			7	1
Family Amphinomidae	22			7	1
Family Nephtyidae		22		7	1
Phylum Mollusca					
Class Gastropoda					
Family Turridae	44	67	44	52	9
Family Cerithiidae			44	15	2
Family Conidae					
Conus sp.	22	22		15	2
Family Trochidae		22		7	1
Family Naticidae	22	67		30	5
Family Nassariidae		22	22	15	2
Family Fasciolariidae		22		7	1
Family Cypraeidae			22	7	1
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Isopoda			67	22	4
Order Amphipoda					
Family Gammaridea		44	22	22	4

Taxa	**Station**			**Mean Total Density (no./m2)**	**Mean Relative Abundance (%)**
	BIBS-1	**BIBS-2**	**BIBS-3**		
TOTAL	**622**	**711**	**467**	**600**	**100**
No. of Taxa	11	12	9		
Species Diversity (H')	1.95	2.03	2.04		
Biomass (wet weight in g/m2)	26.00	117.00	47.00		
Type of Substrate	Fine sand w/	Sandy-	Sandy		
	pebbles & shell fragments	muddy w/ shell fragments			
Depth (meter)		Bare at low tide			

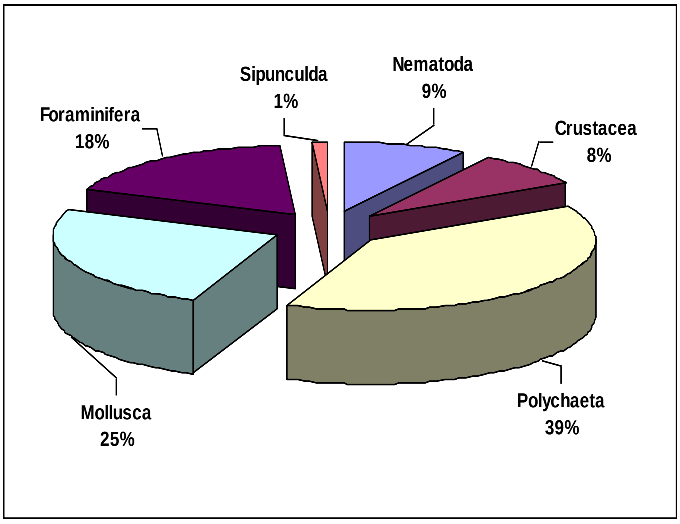


Figure 2.130 Mean relative abundance of major groups of intertidal infaunal benthos collected along the shore of Alas-asin, Mariveles

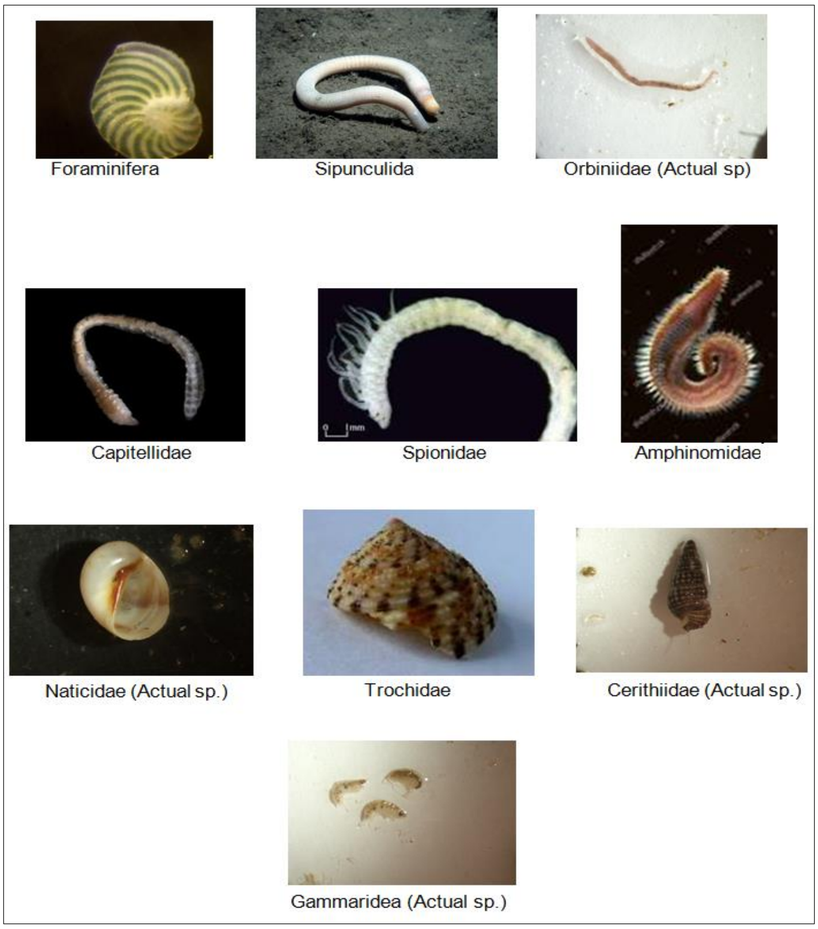


Plate 38 Photos of some benthic intertidal organisms collected along the shore of Alas-asin, Mariveles (Source: Internet and actual specimen)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 467 to 711 indv/m2 (**Figure 2.131**). The mean density recorded was 600 indv/m2. The highest density of benthic organisms (711 indv/m2) was sampled at Station BIBS-2 with sandy-muddy substratum with shell fragments due to the abundance of polychaetes particularly the spionids. Ranked second in density (622 indv/m2) was recorded at Station BIBS-1 with fine sand bottom associated with pebbles and shell fragments. The polychaetes particularly the spionids and the foraminiferans predominated by the peneroplids were the most abundant organisms found. The least density was recorded at BIBS-3 (467 indv/m2) with the nematodes and spionids as the commonly found organisms.

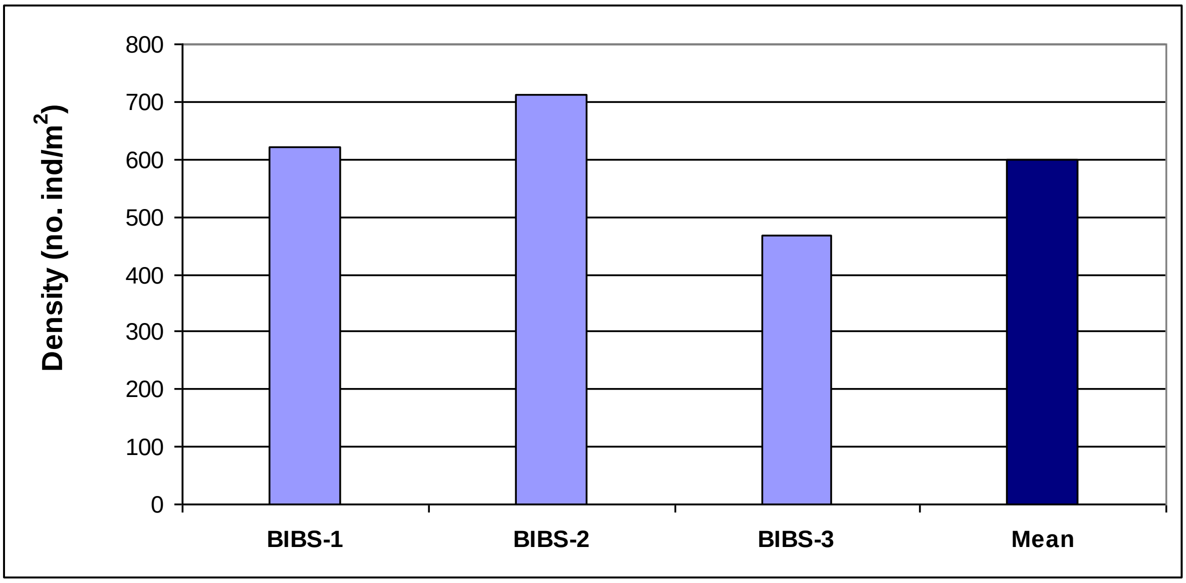


Figure 2.131 Density of intertidal infaunal benthos at three stations sampled along the shore of Alas-asin, Mariveles

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station BIBS-2 occurred with the highest obtaining 12 out of the 20 taxa found, followed by Station BIBS-1 and BIBS-3, with 11 and 9, respectively. The index both measures the variety and number of individuals per taxa. The mean species diversity (H') was 2.01. Highest diversity was found at BIBS-3 (H'=2.04) followed closely by BIBS-2 (2.03) and BIBS-1 (1.95) (**Figure 2.132**).

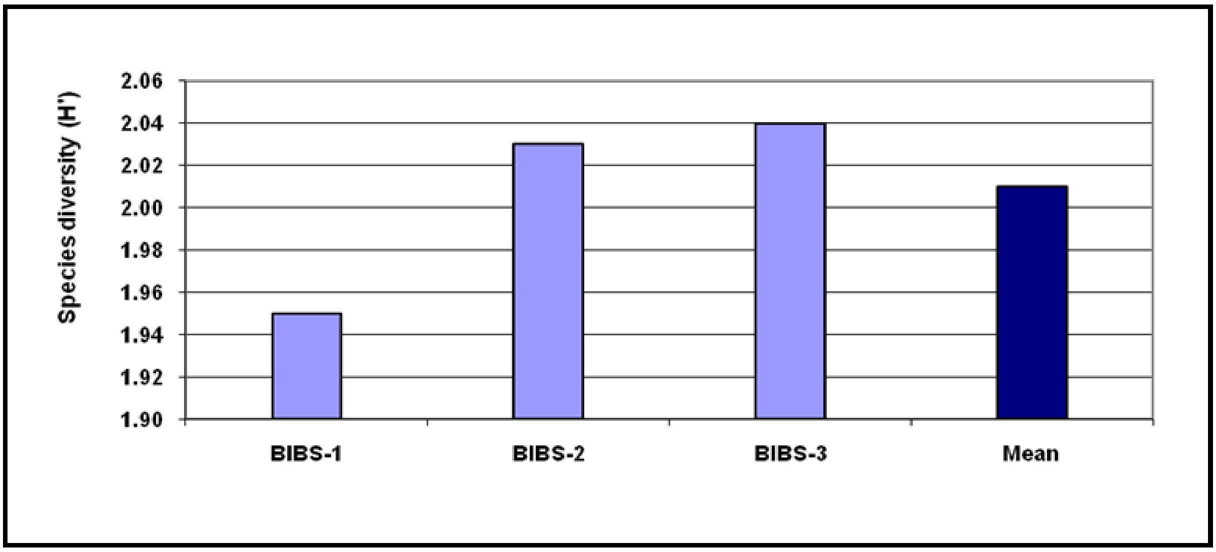


Figure 2.132 Species diversity of intertidal infaunal benthos at three stations sampled along the shore of Alas-asin, Mariveles

The biomass ranged from 26 to 117 wwt g/m2. Inter-station comparison showed Station BIBS-2 with the highest biomass attributable to the presence of gastropods. Stations BIBS-3 and BIBS-1 have lower biomass values with below 50 wwt g/m2. The mean biomass recorded was 63 wwt g/m2 (**Figure 2.133**).

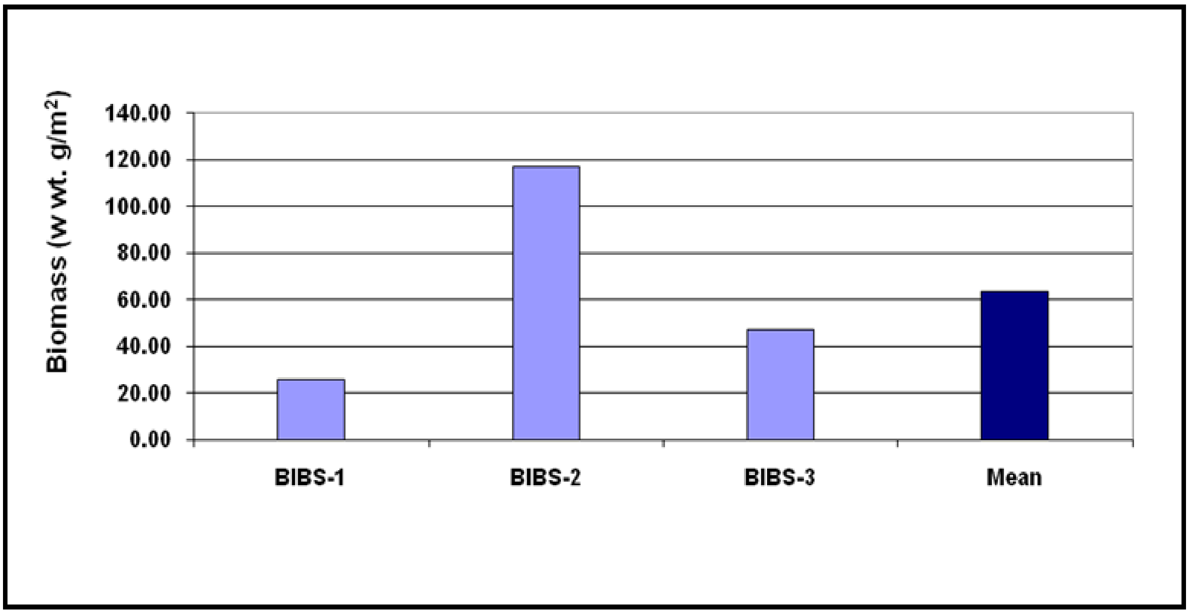


Figure 2.133 Biomass of intertidal infaunal benthos at three stations sampled along the shore of Alas-asin, Mariveles

Nearshore Subtidal Benthos

A total of 483 subtidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 161. These animals were represented by 37 taxa belonging to eight (8) major groups, namely: Foraminifera, Sipunculida, Rhynchocoela, Nematoda, Polychaeta, Mollusca, Crustacea and Echinodermata. The crustaceans were the most abundant organisms collected comprising 49% of the total collection followed by the polychaetes (42%) and nematodes (5%). The percentage composition of the remaining groups was an aggregate of 4% (**Table 2.52** and **Figure 2.134**). Photos of some nearshore subtidal benthic organisms collected from Alas-asin are shown in **Plate 39**.

Table 2.52. Composition, density, relative abundance and biomass of subtidal benthic infauna at three stations sampled along the nearshore waters of Alas-asin, Mariveles

Taxa	**Station**			**Mean Total Density (no./m2)**	**Mean Relative Abundance (%)**
	BNS -1	BNS-2	BNS-3		
Phylum Foraminifera					
Family Miliolidae		67		22	0.62
Phylum Sipunculida		44		15	0.41
Phylum Nematoda			489	163	4.55
Phylum Nemertea					
Class Rhynchocoela	44	67	22	44	1.24
Phylum Annelida					
Class Polychaeta					
Family Orbiniidae	22	1356	22	467	13.04
Famly Spionidae	89	400	67	185	5.18
Family Capitellidae	467	22	378	289	8.07
Family Cirratulidae	22	67		30	0.83
Family Magelonidae			22	7	0.21
Family Poecilochaetidae		44		15	0.41

Taxa	**Station**			**Mean Total Density (no./m2)**	**Mean Relative Abundance (%)**
	BNS -1	BNS-2	BNS-3		
Family Pisionidae		22		7	0.21
Family Phyllodocidae	22			7	0.21
Family Amphinomidae	44	111	67	74	2.07
Family Opheliidae	444	22	133	200	5.59
Family Nephtyidae	22			7	0.21
Family Syllidae	111		44	52	1.45
Family Sigalionidae		22		7	0.21
Family Onuphidae	22			7	0.21
Family Hesionidae	22			7	0.21
Family Eunicidae	22		22	15	0.41
Family Glyceridae			44	15	0.41
Family Sabellidae	44	244		96	2.69
Family Ampharetidae			22	7	0.21
Phylum Mollusca					
Class Gastropoda					
Family Naticidae	44			15	0.41
Family Cerithiidae	44		22	22	0.62
Family Turritellidae			22	7	0.21
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Isopoda	733		89	274	7.66
Order Cumacea		22		7	0.21
Order Tanaidacea	67	22	311	133	3.73
Order Amphipoda					
Family Gammaridea	3422	67	333	1274	35.61
Family Caprellidae			22	7	0.21
Order Decapoda					
Family Portunidae					
Thalamita sp.	22			7	0.21
Family Xanthidae	89			30	0.83
Family Penaeidae	22			7	0.21
Class Ostracoda					
Subclass Myodocopa					
Order Myodocopida	22			7	0.21
Subclass Podocopa					
Order Podocopida		44		15	0.41
Phylum Echinodermata				0	
Class Ophiuroidea	89			30	0.83
TOTAL	**5956**	**2644**	**2133**	**3578**	**100.00**
No. of Taxa	24	17	18		
Species Diversity (H')	1.67	1.80	2.28		
Biomass (wet weight in g/m2)					
	48	10	20		

Taxa	Station			Mean Total Density (no./m2)	Mean Relative Abundance (%)
	BNS -1	BNS-2	BNS-3		
Type of Substrate	Muddy w/ shell fragments	Sandy-muddy w/ shell fragments	Sandy-muddy w/ shell fragments		
Depth (meter)	2.3	2.7	3.5		

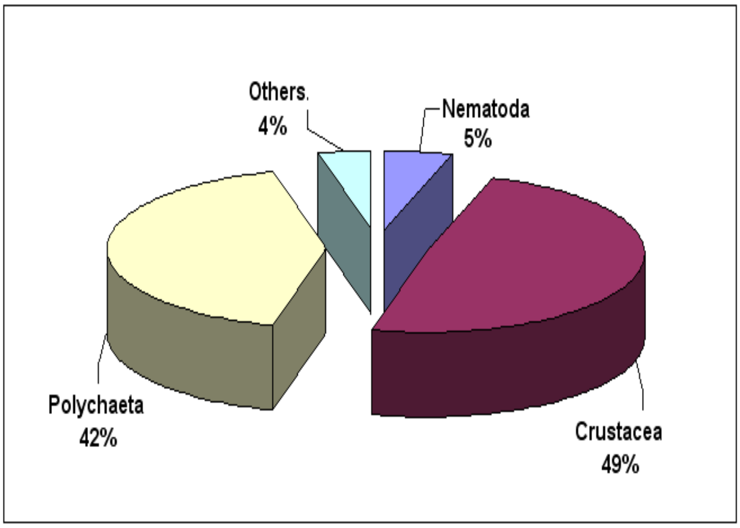


Figure 2.134 Mean relative abundance of major groups of subtidal infaunal benthos sampled along the nearshore waters of Alas-asin, Mariveles

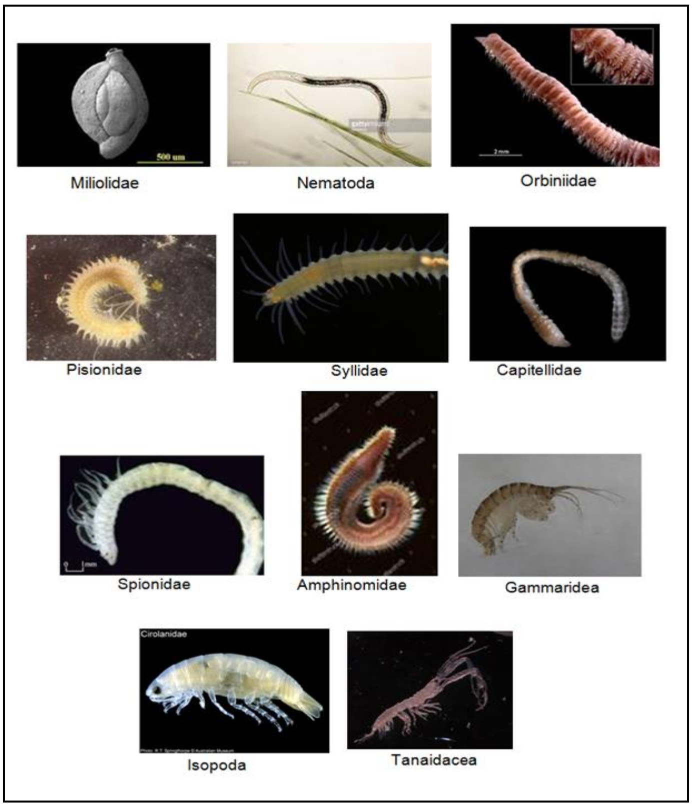


Plate 39 Photos of some benthic subtidal organisms collected from the nearshore waters of Alas-asin, Mariveles (Source: Internet)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 2,133 to 5,956 indv/m2 (**Figure 2.135**). The mean density recorded was 3,578 indv/m2. The highest density of benthic organisms (5,956 indv/m2) was sampled at the muddy bottom with shell fragments at 2.3 meter-depth of Station BNS-1 owing to the numerous collections of crustaceans, particularly, the gammarids and isopods, followed by the polychaetes dominated by the capitellids and opheliids. Ranked second to the highest density (2,644 indv/m2) was recorded at Station BNS-2 with sandy-muddy substrate with shell fragments at 2.7 meter-depth due to the large collection of polychaetes, especially the orbiniids. The least density was found at Station BNS-3 with sandy-muddy habitat with shell fragments at depth of 3.5 meters. The common organisms collected were the nematodes, crustaceans and polychaetes, particularly the capitellids.

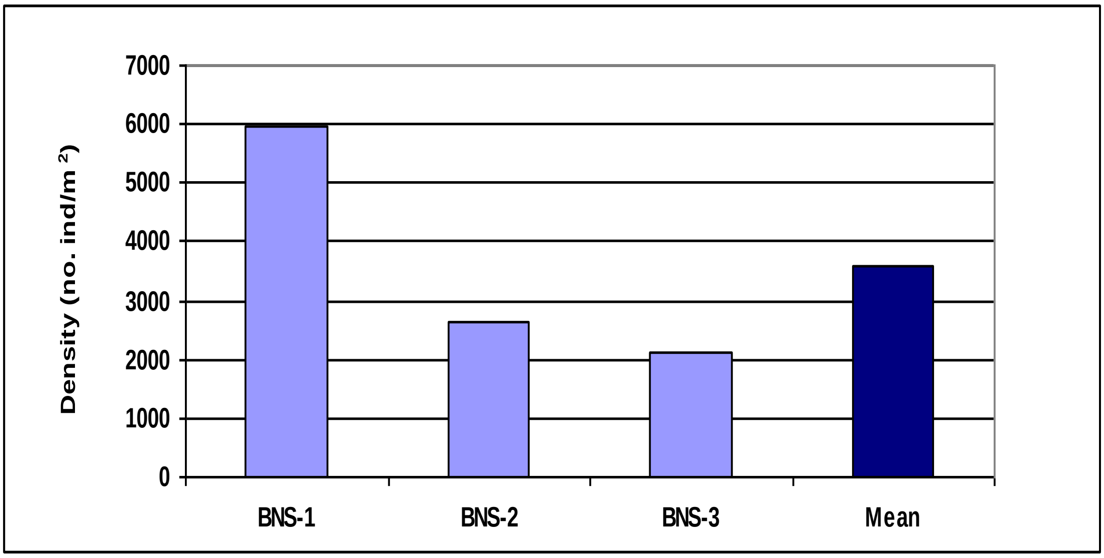


Figure 2.135 Density of subtidal infaunal benthos at three stations sampled from the nearshore waters of Alas-asin, Mariveles

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station BNS-1 with highest, 24 out of the 37 identified taxa. Stations BNS-3 and BNS-2 have 18 and 17 taxa, respectively. The mean species diversity was 1.92. Highest diversity was found at Station BNS-3 (H'=2.28) followed by Station BNS-2 (H'= 1.80) and least at Station BNS-1 (H'=1.67) (**Figure 2.136**).

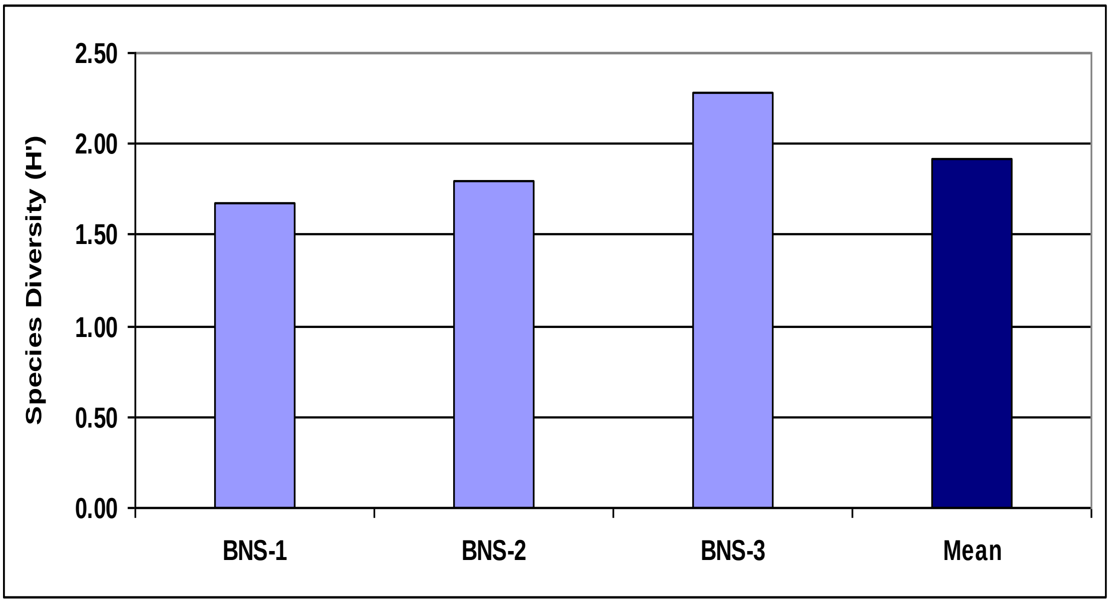


Figure 2.136 Species diversity of subtidal infaunal benthos at three stations sampled from the nearshore waters of Alas-asin, Mariveles

The biomass ranged from 10 to 48 wwt g/m2. Inter-station comparison showed Station BNS-1 with the highest biomass due to the collection of gastropods and polychaetes. The other two stations, BNS-3 and BNS-2 have biomass values of 20 and 10 wwt g/m2, respectively. The mean biomass recorded was 26 wwt g/m2 (**Figure 2.137**).

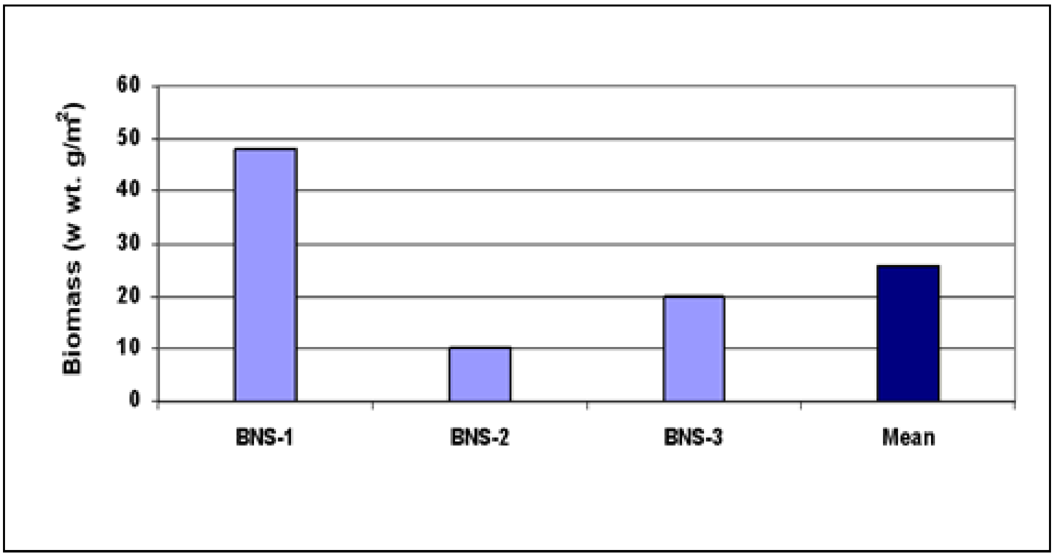


Figure 2.137 Biomass of subtidal infaunal benthos at three stations sampled from the nearshore waters of Alas-asin, Mariveles

(b) Corregidor Island

Intertidal Benthos

A total of 230 intertidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 77. These animals were represented by 29 taxa belonging to seven (7) major groups, namely: Foraminifera, Nematoda, Rhynchocoela, Polychaeta, Mollusca, Crustacea and Echinodermata. The polychaetes were the most abundant organisms collected comprising 45% of the total collection followed by crustaceans (34%), and the other groups ranged only from 1 to 7% (**Table 2.53** and **Figure 2.138**). Photos of some intertidal benthic organisms collected from Corregidor Island are shown in **Plate 40**.

Table 2.53. Composition, density, relative abundance and biomass of intertidal benthic infauna at three stations sampled along Corregidor Island

Taxa	Station			Mean Total Density (no./m2)	Mean Relative Abundance (%)
	CoIBS-1	CoIBS-2	CoIBS-3		
Phylum Foraminifera					
Family Peneroplidae			111	37	2
Phylum Nematoda		22	311	111	7
Phylum Nemertea					
Class Rhynchocoela		67		22	1
Phylum Annelida					
Class Polychaeta					
Famly Spionidae	1378		22	467	27
Family Capitellidae	22	22		15	1
Family Cirratulidae		22		7	0
Family Amphinomidae		44		15	1
Family Opheliidae		22		7	0
Family Syllidae	44	533		193	11
Family Nereididae	44	22	22	30	2
Family Hesionidae	22			7	0
Family Glyceridae			133	44	3
Phylum Mollusca					
Class Bivalvia					
Family Veneridae		22		7	0
Class Gastropoda					
Family Neritidae					
Neritina sp.		156		52	3
Family Turridae		44		15	1
Family Trochidae		22		7	0
Family Cerithiidae		22		7	0
Family Rissoidea		22		7	0
Family Buccinidae			44	15	1
Class Polyplacophora					
Order Chitonida					
Family Chitonidae		22		7	0
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Isopoda	22	200	22	81	5
Order Cumacea		22		7	0

Taxa	Station			Mean Total Density (no./m2)	Mean Relative Abundance (%)
	CoIBS-1	CoIBS-2	CoIBS-3		
Order Tanaidacea		67	244	104	6
Order Amphipoda					
Family Gammaridea	67	956	111	378	22
Order Decapoda					
Family Portunidae					
Thalamita sp.		22		7	0
Family Pandalidae		22		7	0
Class Ostracoda					
Subclass Myodocopa					
Order Myodocopida	44			15	1
Phylum Echinodermata					
Class Ophiuroidea	22			7	0
Class Holothuroidea					
Family Holothuriidae		67		22	1
TOTAL	1,667	2,422	1,022	1,704	100
No. of Taxa	9	22	9		
Species Diversity (H')	0.81	2.09	1.84		
Biomass (wet weight in g/m2)	16.00	727.00	15.00		
Type of Substrate	Fine sand w/ pebbles	Sand w/ pebbles	Coarse sand w/ pebbles		
Depth (meter)	0.1	0.1	0.1		

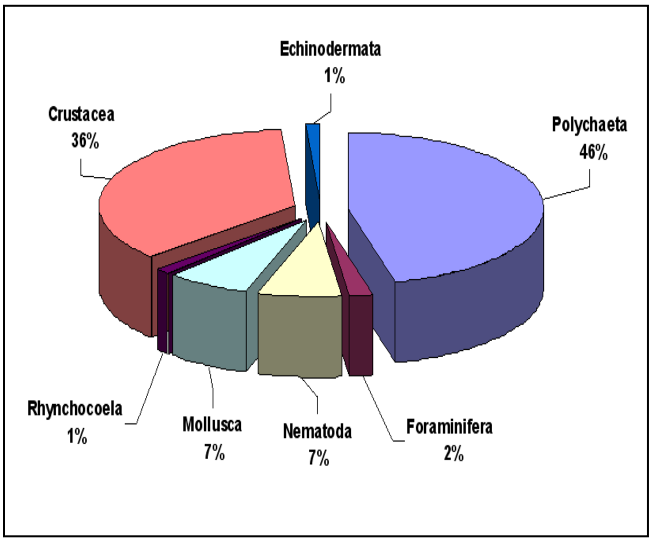


Figure 2.138 Mean relative abundance of major groups of intertidal infaunal benthos collected along Corregidor Island

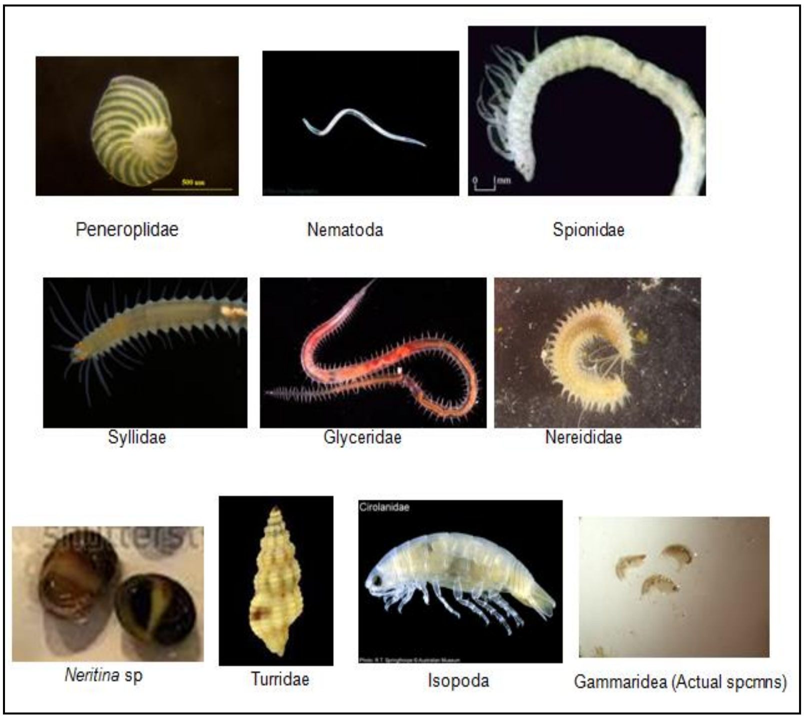


Plate 40 Photos of some benthic intertidal organisms collected from Corregidor Island (Source: Internet and actual specimen)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 1,022 to 2,422 indv/m2 (**Figure 2.139**). The mean density recorded was 1,704 indv/m2. The highest density of benthic organisms (2,422 indv/m2) was sampled at Station CoIBS-2 with sandy substratum with pebbles owing to the abundance of gammarids, syllid worms and Neretina sp., a gastropod. Ranked second was recorded at Station CoIBS-1 (1,667 indv/m2) having a fine sand with pebbles habitat. The polychaetes, particularly the spionids were the most abundant organisms found. The least density was recorded at the coarse sand with pebbles substrate at Station CoIBS-3 (1,022 indv/m2) with the nematodes and tanaidacids as the predominating animals found.

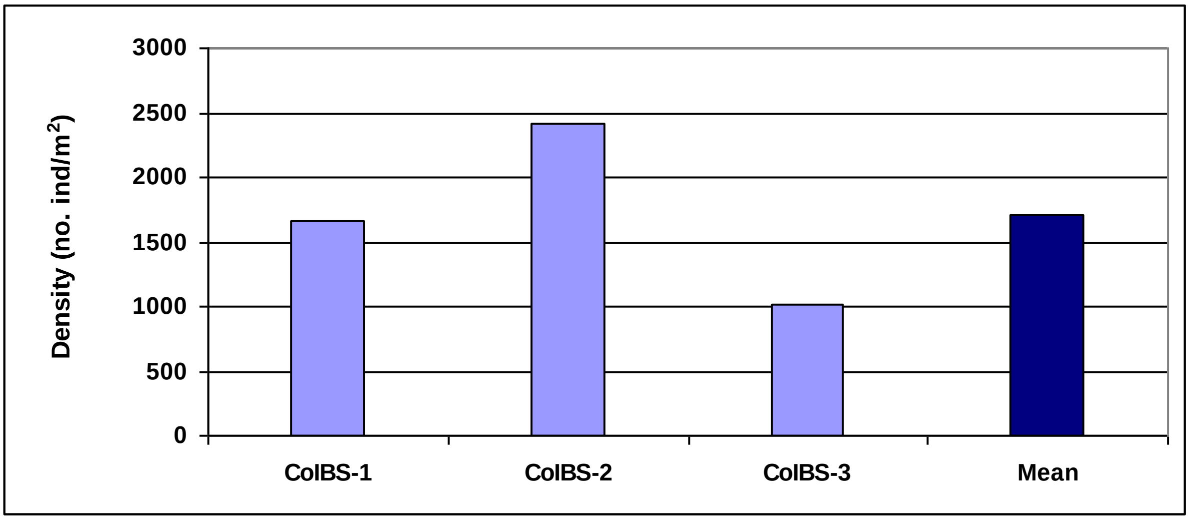


Figure 2.139 Density of intertidal infaunal benthos at three stations sampled along Corregidor Island

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station CoIBS-2 occurs with the highest obtaining 22 out of the 29 taxa found. The Stations CoIBS-1 and CoIBS-2 have nine (9) taxa each. An index of diversity of benthic organisms using Shannon-Weaver Index was computed for the communities found in different stations in the study area. The index both measures the variety and number of individuals per taxa. The mean species diversity (H') was 1.58. Highest diversity was found at Station CoIBS-2 (H'=2.09) followed by Station CoIBS-3 (1.84) and least at Station CoIBS-1 (0.81) (**Figure 2.140**).

The biomass ranged from 15 to 727 wwt g/m2. Inter-station comparison showed Station CoIBS-2 with the highest biomass attributable to the abundance of gastropods and polychaetes. Stations CoIBS-1 and CoIBS-3 have the low biomass values below 20 wwt g/m2. The mean biomass recorded was 253 wwt g/m2 (**Figure 2.141**).

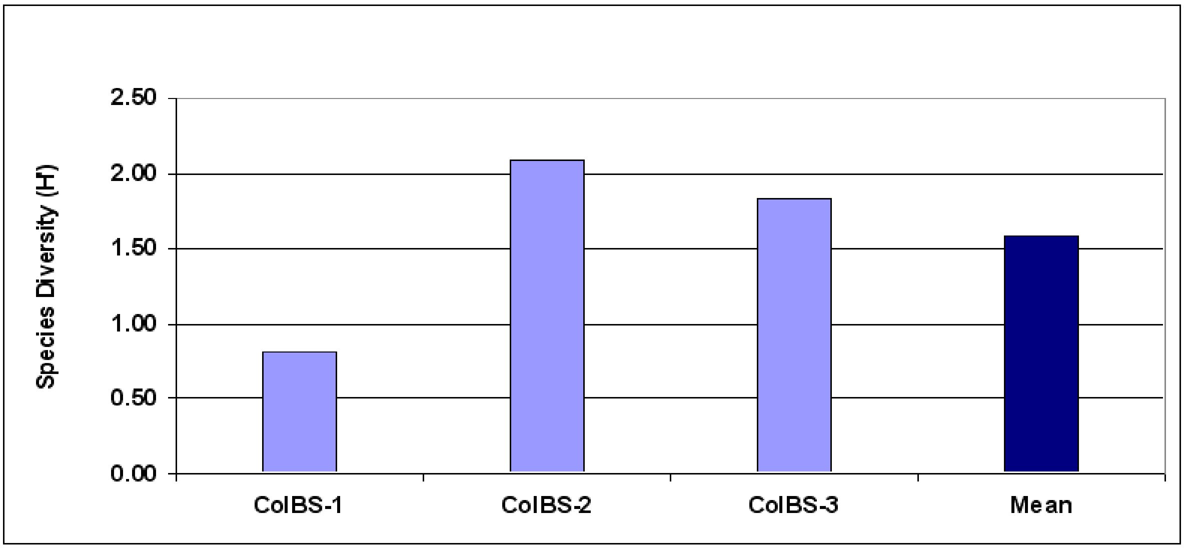


Figure 2.140 Species diversity of intertidal infaunal benthos at three stations sampled along Corregidor Island

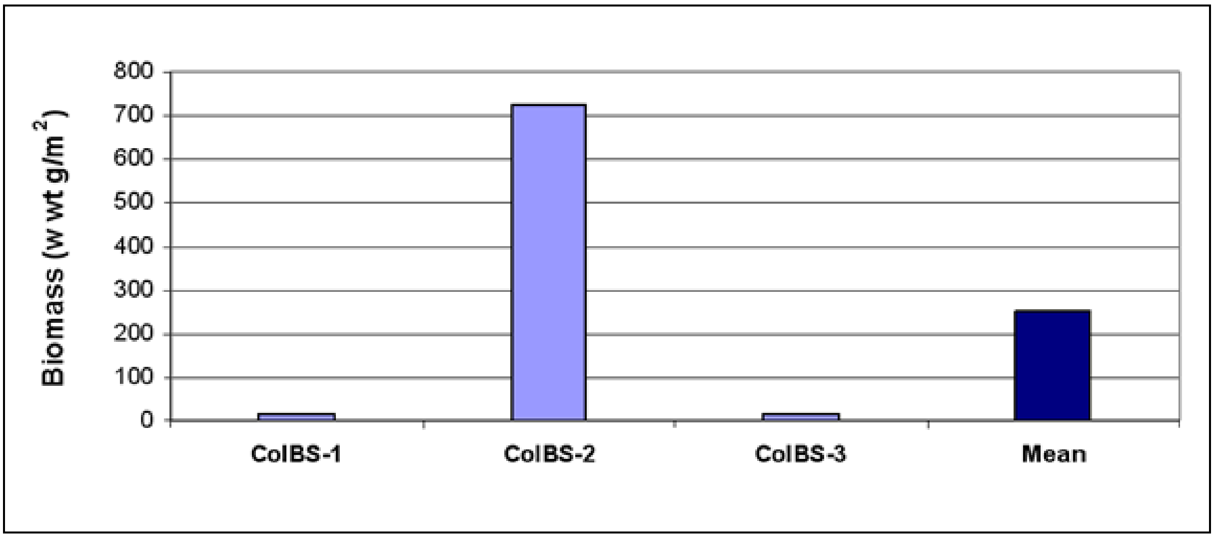


Figure 2.141 Benthos biomass of intertidal infaunal benthos at three stations sampled along Corregidor Island

Nearshore Sub-tidal Benthos

A total of 1,693 subtidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 564. These animals were represented by 26 taxa belonging to (6) major groups, namely: Rhynchocoela, Nematoda, Polychaeta, Mollusca, Crustacea and Chordata. The main bulk of the collection belongs to crustaceans constituting 95% of the total collection dominated mostly by the gammarids and tanaidacids. Only 3% was represented by the polychaetes and 1% by the mollusks (**Table 2.54** and **Figure 2.142**). The percentage composition of the remaining groups was an aggregate of only 1%. Photos of some subtidal benthic organisms collected from Corregidor Island are shown in **Plate 41**.

Table 2.54. Composition, density, relative abundance and biomass of subtidal benthic infauna at three stations sampled along the nearshore waters of Corregidor Island

Taxa	Station			Mean Total Density (no/m2)	Mean Relative Abundance (%)
	CoNS-1	CoNS-2	CoNS-3		
Phylum Nematoda		111		37	0.30
Phylum Nemertea					
Class Rhynchocoela	22	22		15	0.12
Phylum Annelida					
Class Polychaeta					
Family Orbiniidae	22			7	0.06
Famly Spionidae		67		22	0.18
Family Capitellidae		22		7	0.06
Family Cirratulidae		22	44	22	0.18
Family Amphinomidae		200	22	74	0.59
Family Opheliidae		44		15	0.12
Family Chaetopteridae	22		22	15	0.12
Family Syllidae		111		37	0.30
Family Onuphidae		22		7	0.06
Family Eunicidae	22	578	22	207	1.65
Family Lumbrineridae	22			7	0.06
Phylum Mollusca					
Class Bivalvia					
Family Veneridae	22	67	22	37	0.30
Class Gastropoda					
Family Cerithiidae			111	37	0.30
Family Conidae					
Conus sp.	22	22		15	0.12
Family Trochidae			22	7	0.06

Taxa	Station			Mean Total Density (no/m2)	Mean Relative Abundance (%)
	CoNS-1	CoNS-2	CoNS-3		
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Isopoda	44			15	0.12
Order Cumacea	22			7	0.06
Order Tanaidacea	2467	4867	2111	3148	25.10
Order Mysida	22			7	0.06
Order Amphipoda					
Family Gammaridea	5400	4133	16556	8696	69.34
Order Decapoda					
Family Portunidae	44	89	44	59	0.47
Thalamita sp.	22	22		15	0.12
Megalopa (Larva)		22		7	0.06
Phylum Chordata					
Class Leptocardii					
Order Amphioxiformes					
Family Branchiostomidae					
Branchiostoma			44	15	0.12
TOTAL	**8,178**	**10,422**	**19,022**	**12,541**	**100.00**
No. of Taxa	14	17	11		
Species Diversity (H')	0.85	1.28	0.48		
Biomass (wet weight in g/m2)	310	373	78		
Type of substrate	Coarse sandy-muddy	Coarse sand	Coarse sand		
Depth (meter)	8.2	9.9	4.2		

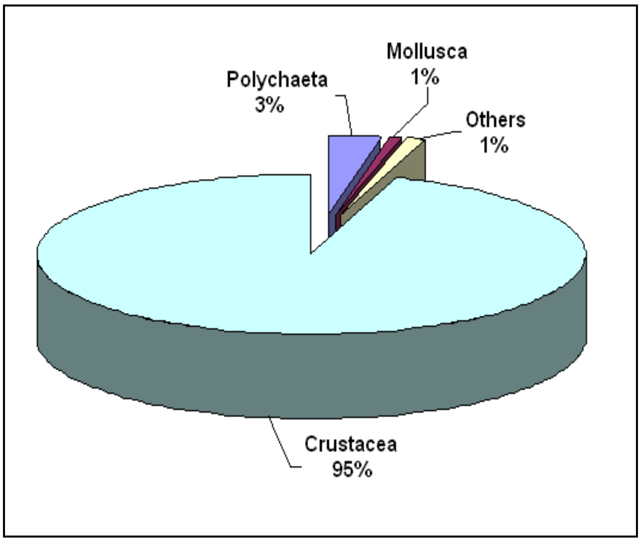


Figure 2.142 Mean relative abundance of major groups of subtidal infaunal benthos sampled along the nearshore waters of Corregidor Island

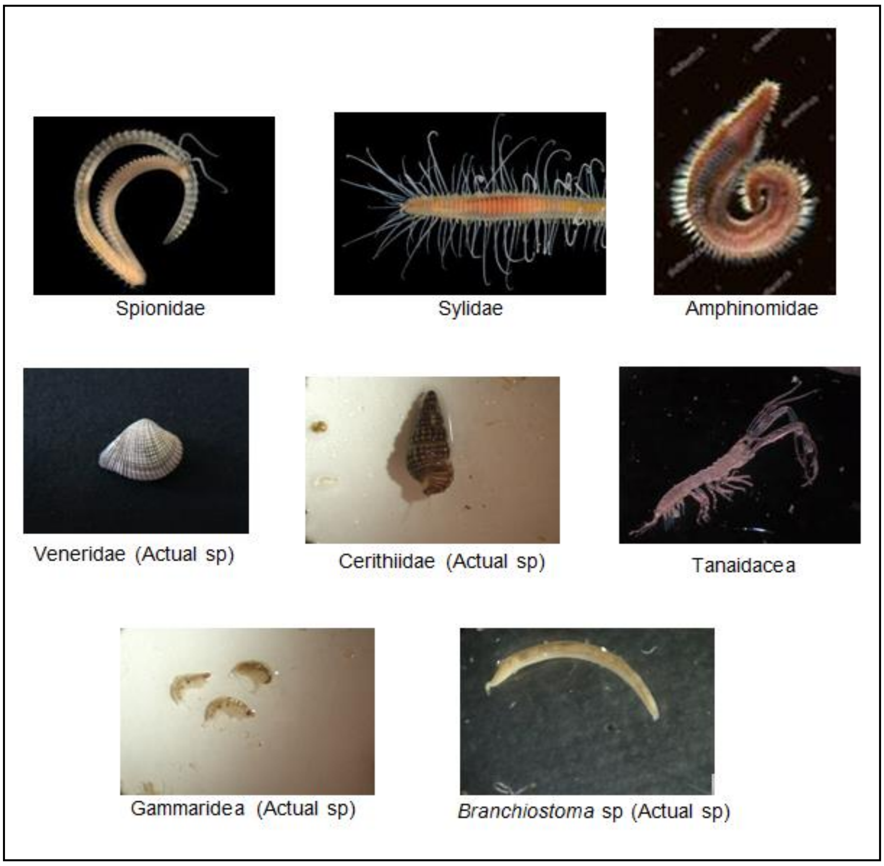


Plate 41 Photos of some benthic subtidal organisms collected from the nearshore waters of Corregidor Island (Source: Internet and actual specimen)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 8,178 to 19,022 indv/m2 (**Figure 2.143**). The mean density recorded was 12,541 indv/m2. The highest density of benthic organisms (19,022 indv/m2) was sampled at the coarse sandy bottom at 4.2 meter-depth of Station CoNS-3 owing to the numerous collections of gammarids and tanaidacids. Ranked second in density (10,422 indv/m2) due to the predominance of crustaceans under tanaidacids and gammarids was found at Station CoNS-2 characterized by a coarse sandy substrate at 9.9 m-depth. The euniciids and amphinomids known as fireworms were the common polychaetes found in this station. The least density of organisms with below 10,000 indv/m2 was recorded at Station CoNS-1 with coarse sandy-muddy bottom at a depth of 8.2 m. The common organisms collected were also the gammarids and tanaidacids.

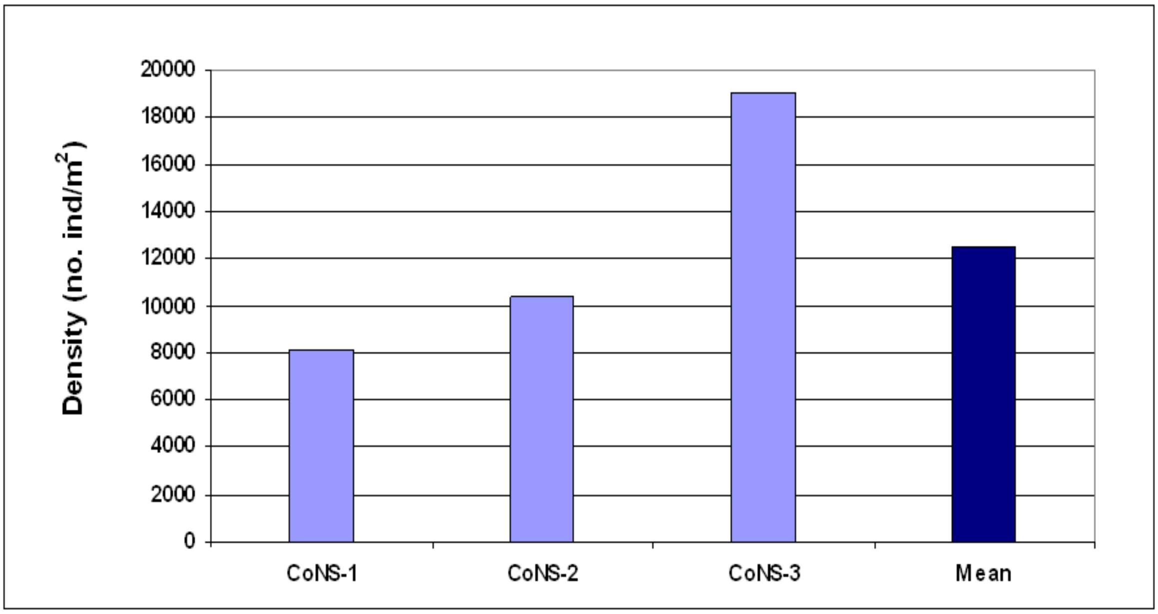


Figure 2.143 Density of subtidal infaunal benthos at three stations sampled along the nearshore waters of Corregidor Island

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station CoNS-2 having the highest taxa with 17, followed by Station CoNS-1 with 14 and the least was Station CoNS-3 with 11. An index of diversity of benthic organisms using Shannon-Weaver Index was computed for the communities found in different stations in the study area. The index both measures the variety and number of individuals per taxa. The mean species diversity was 0.87 (**Figure 2.144**). Highest diversity was found at Station CoNS-2 (H'=1.28). Low species diversity values were found at Stations CoNS-1 and CoNS-3 with below 1.

The biomass ranged from 78 to 373 wwt g/m2. Inter-station comparison showed Station CoNS-2 with the highest biomass due to the collection of mollusks and occurrence of several polychaetes followed by Station CoNS-1 (310 wwt g/m2) due to the presence of Conus sp. and a bivalve. Though Station CoNS-3 had the highest density of organisms, its biomass value was the least. The biomass of the benthic organisms is therefore not correlated with the population density since the biomass depends on the type and size of organisms which predominate in the area. The mean biomass recorded was 254 wwt g/m2 (**Figure 2.145**).

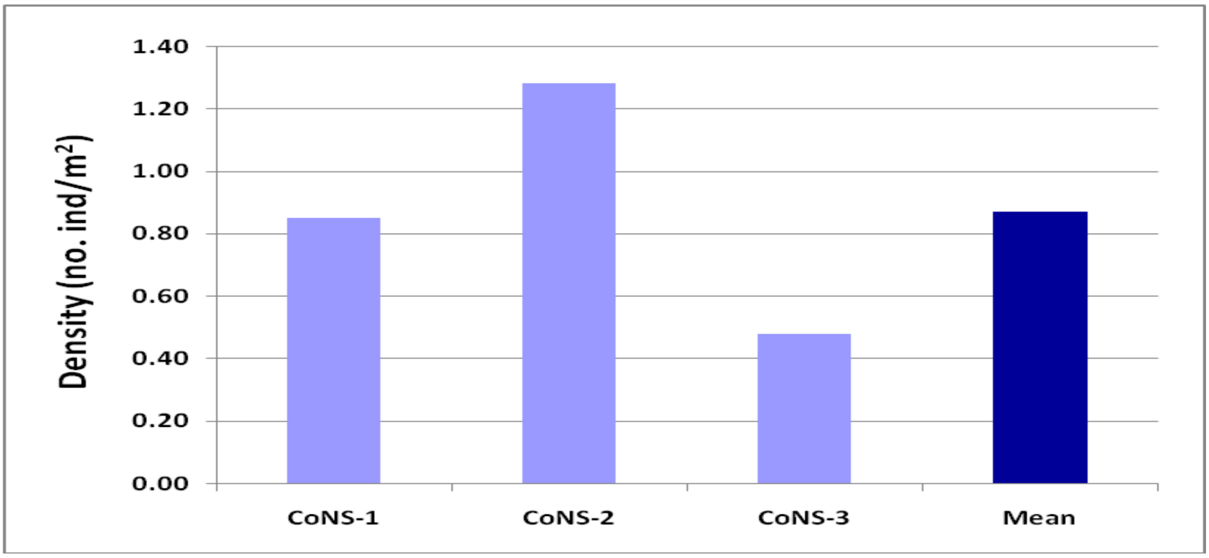


Figure 2.144 Species diversity of subtidal infaunal benthos at three stations sampled along the nearshore waters of Corregidor Island

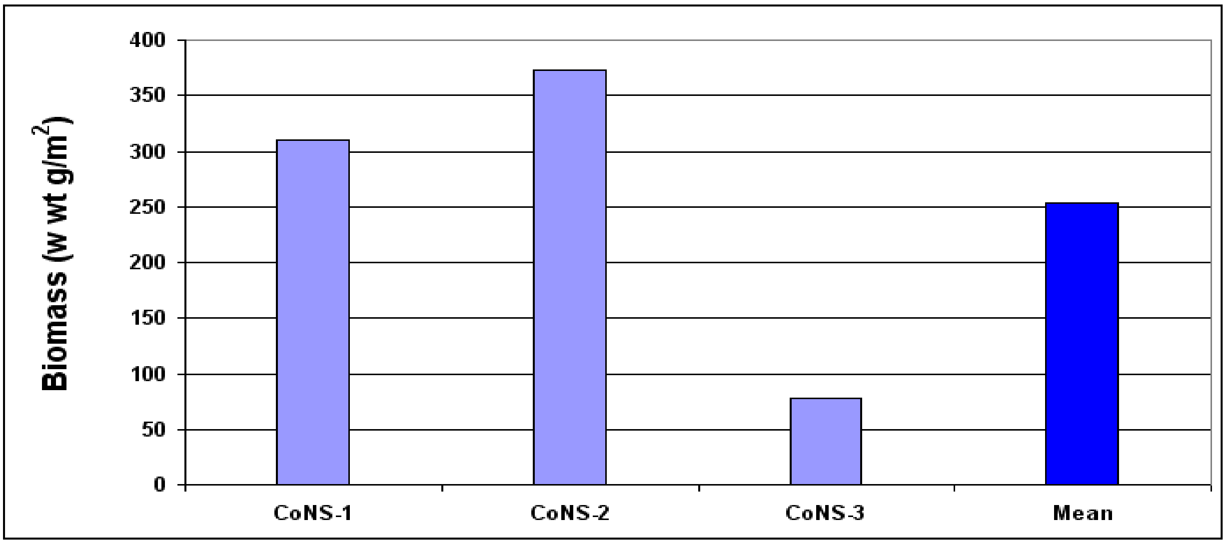


Figure 2.145 Benthos biomass of subtidal infaunal benthos at three stations sampled along the nearshore waters of Corregidor Island

(c) Timalan Balsahan/Timalan Concepcion (Naic, Cavite)

Intertidal Benthos

A total of 68 intertidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 23. These animals were represented by 13 taxa belonging to five (5) major groups, namely: Foraminifera, Nematoda, Polychaeta, Mollusca and Crustacea (**Table 2.55**). The foraminiferans were the most abundant organisms collected comprising 51% of the total collection followed by crustaceans (17%), polychaetes (13%), mollusks (12%) and the least were the nematodes with 7% (**Figure 2.146**). Photos of some intertidal benthic organisms collected from Naic are shown in **Plate 42**.

Table 2.55. Composition, density, relative abundance and biomass of intertidal benthic infauna at three stations sampled along Naic, Cavite

Taxa	**Station**			**Mean Total Density ($no.m^2$)**	**Mean Relative Abundance (%)**
	CIBS-1	**CIBS-2**	**CIBS-3**		
Phylum Foraminifera					
Family Peneroplidae		178	267	148	29
Family Miliolidae	22	67	156	82	16
Family Amphisteginidae		67		22	6
Phylum Nematoda			111	37	7
Phylum Annelida					
Class Polychaeta					
Famly Spionidae	111	22		44	9
Family Glyceridae	67			22	4
Phylum Mollusca					
Class Gastropoda					
Family Trochidae	22	22	22	22	4
Family Turbinidae		22	22	15	3
Family Turridae		22		7	1
Family Nassariidae			44	15	3
Class Scaphopoda					
Family Dentaliidae		22		7	1
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Tanaidacea		22		7	2
Order Amphipoda					
Family Gammaridea	156	67		74	15
TOTAL	**378**	**511**	**622**	**502**	**100**
No. of Taxa	5	10	6		
Species Diversity (H')	1.36	1.98	1.44		
Biomass (wet weight in g/m2) in g/m2)	61.00	134.00	128.00		
Type of Substrate	Sandy, blackish	Sandy, blackish	Sandy, blackish		
Depth (meter)		Bare at low tide			

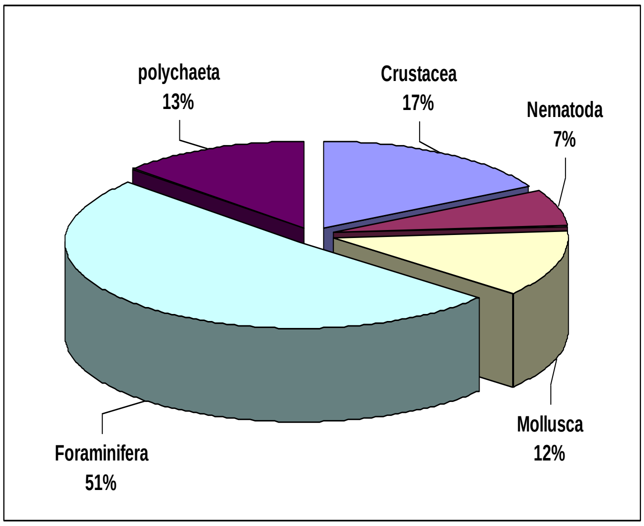


Figure 2.146 Mean relative abundance of major groups of intertidal infaunal benthos sampled along Naic, Cavite

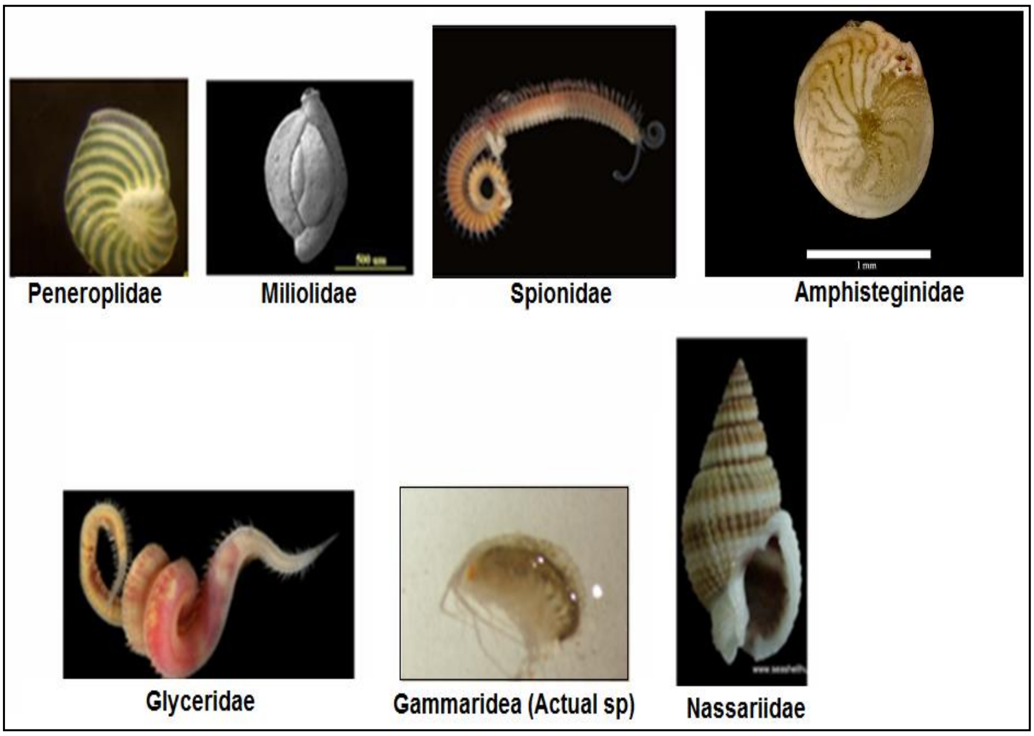


Plate 42 Photos of some benthic infaunal organisms collected from the intertidal waters of Naic, Cavite (Source: Internet and actual specimens)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 378 to 622 indv/m2. The mean density recorded was 504 indv/m2 (**Figure 2.147**). The highest density of benthic organisms (622 indv/m2) was sampled at Station CIBS-3 with sandy substratum owing to the abundance of foraminiferans represented by the peneroplids amphisteginids, and miliolids. The second highest density (511 indv/m2) was recorded at Station CIBS-2 sandy bottom. The foraminiferans, particularly the peneroplids were the most abundant organisms found. The least density was recorded at Station CIBS-1 (378 indv/m2) with the gammarids as the predominating animals found followed by the spionid worms.

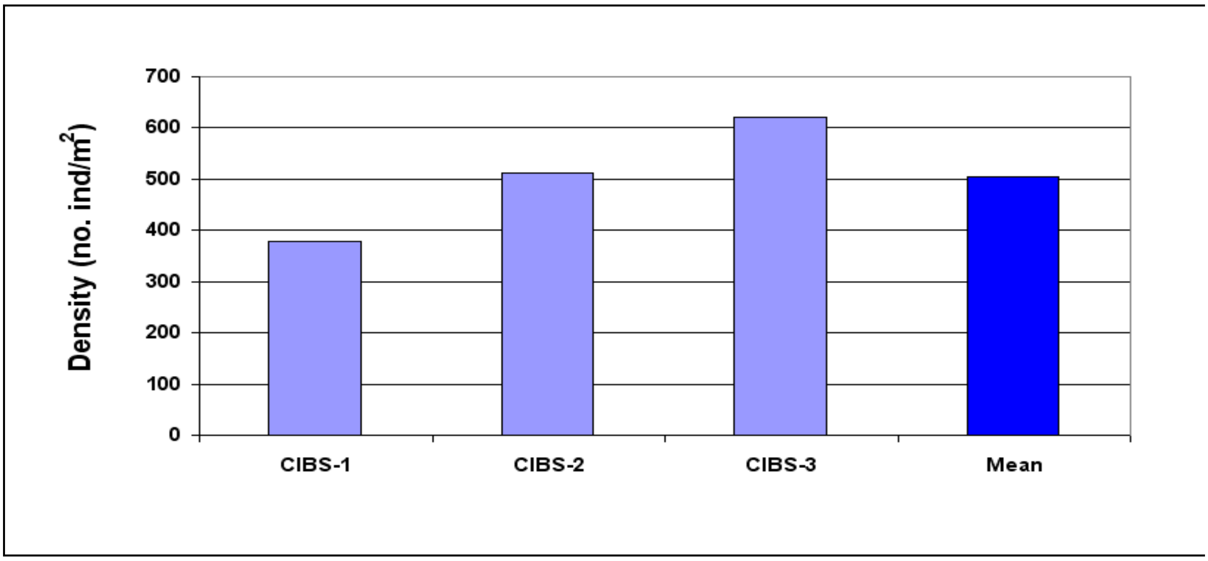


Figure 2.147 Density of intertidal infaunal benthos at three stations sampled from Naic, Cavite

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station CIBS-2 occurred the highest obtaining 10 out of the 13 taxa found, followed in decreasing order by Stations CIBS-2 and CIBS-1, with 6 and 5, respectively. The mean species diversity (H') was 1.50. Highest diversity was found at CIBS-2 (H'=1.98) followed by CIBS-3 (1.44) and CIBS-1 (1.36) (**Figure 2.149**).

The biomass ranged from 61 to 134 wwt g/m2. Inter-station comparison showed Station CIBS-2 with the highest biomass attributable to the presence of gastropods. Station CIBS-3 ranked second in biomass due to the presence also of gastropods. Station CIBS-1 had the least biomass value. The mean biomass recorded was 108 wwt g/m2 (**Figure 2.149**).

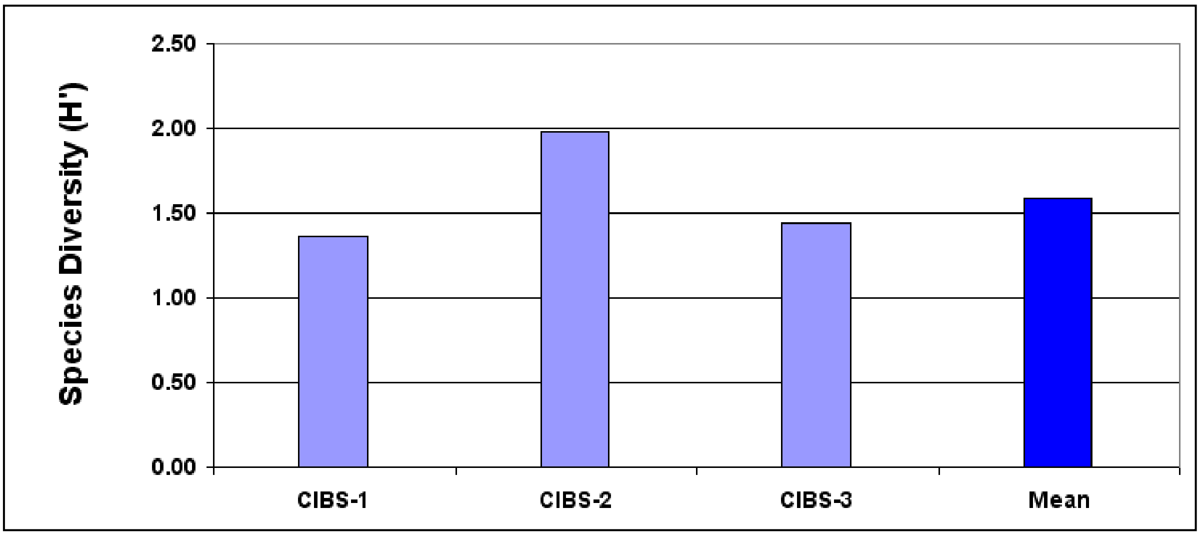


Figure 2.148 Species diversity of intertidal infaunal benthos at three stations sampled from Naic, Cavite

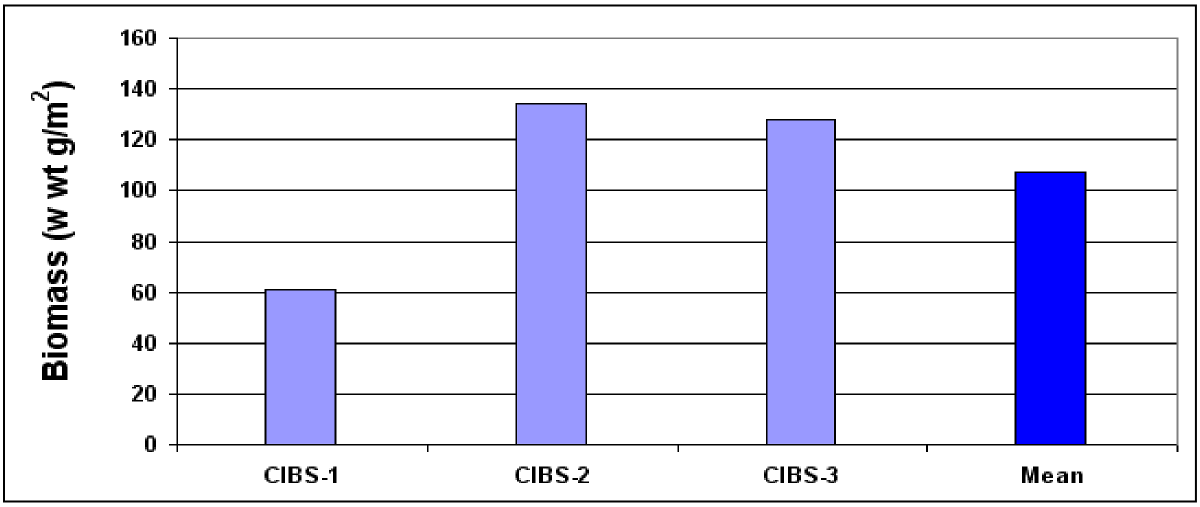


Figure 2.149 Benthos biomass of intertidal infaunal benthos at three stations sampled from Naic, Cavite

Nearshore Subtidal Benthos

A total of 244 subtidal benthic animal organisms were recorded in the samples taken from the three (3) stations. The mean number of individuals per station was 81 (**Table 2.56**). These animals were represented by 22 taxa belonging to seven (7) major groups, namely: Foraminifera, Rhynchocoela, Nematoda, Polychaeta, Mollusca, Crustacea and Echinodermata. The crustaceans were the most abundant organisms collected comprising 66% of the total collection followed by the polychaetes (24%) and mollusks (8%). The percentage composition of the remaining groups was an aggregate of 2% (**Figure 2.150**). Photos of some subtidal benthic organisms collected from Naic are shown in **Plate 43**.

Table 2.56. Composition, density, relative abundance and biomass of subtidal benthic infauna at three stations sampled from the nearshore waters of Naic, Cavite

Taxa	**Station**			**Mean Total Density (no./m2)**	**Mean Relative Abundance (%)**
	CNS-1	**CNS-2**	**CNS-3**		
Phylum Foraminifera					
Family Peneroplidae			44	15	0.82
Phylum Nematoda	22			7	0.41
Phylum Nemertea					
Class Rhynchocoela	22			7	0.41
Phylum Annelida					
Class Polychaeta					
Family Orbiniidae		22		7	0.41
Famly Spionidae		267	244	170	9.43
Family Capitellidae	22	400	111	178	9.84
Family Magelonidae		22		7	0.41
Family Poecilochaetidae					
Family Pilargidae		67		22	1.23

Taxa	**Station**			**Mean Total Density (no./m2)**	**Mean Relative Abundance (%)**
	CNS-1	**CNS-2**	**CNS-3**		
Family Maldanidae					
Family Amphinomidae		67		22	1.23
Family Opheliidae					
Family Nephtyidae	22			7	0.41
Family Onuphidae	22			7	0.41
Family Nereididae					
Family Eunicidae	22			7	0.41
Family Glyceridae		22		7	0.41
Phylum Mollusca					
Class Bivalvia					
Family Tellinidae			22	7	0.41
Family Mytilidae	400			133	7.38
Phylum Arthropoda					
Subclass Crustacea					
Class Malacostraca					
Order Cumacea			22	7	0.41
Order Tanaidacea	22		22	15	0.82
Order Amphipoda					
Family Gammaridea	956	89	89	378	20.91
Order Decapoda					
Family Pinnotheridae		1,778	556	778	43.04
Family Portunidae					
Thalamita sp.	22			7	0.41
Portunus sp.	22			7	0.41
Phylum Echinodermata					
Class Ophiuroidea		22		7	0.41
TOTAL	**1,556**	**2,756**	**1,111**	**1,807**	**100**
No. of Taxa	11	10	8		
Species Diversity (H')	1.19	1.24	1.48		
Biomass (wet weight in g/m2)	23.45	3.47	1.89		
Type of Substrate	Muddy, grey	Muddy, grey	Fine Sandy-muddy, grey		
Depth (meter)	2.1	3.1	2.7		

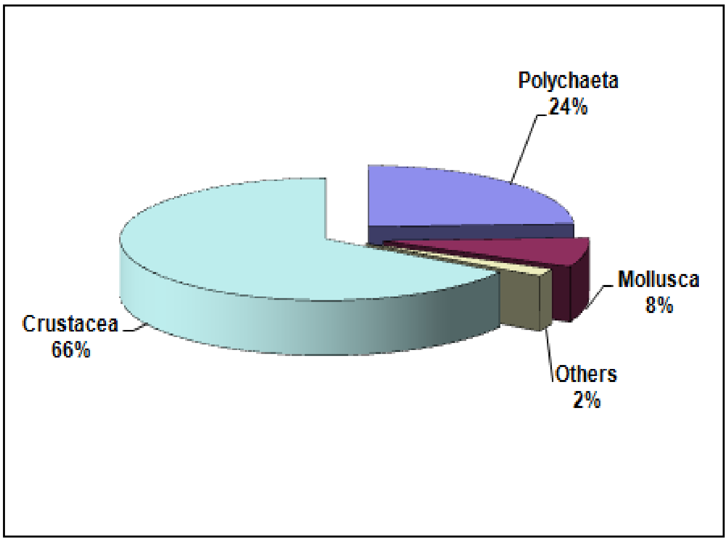


Figure 2.150. Mean relative abundance of major groups of subtidal infaunal benthos sampled from the nearshore waters of Naic, Cavite

Plate 43 Photos of some benthic subtidal infaunal organisms collected from the nearshore waters of Naic, Cavite (Source: Internet and actual specimens)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 1,111 to 2,756 indv/m2. The mean density recorded was 1,807 indv/m2 (**Figure 2.151**). The highest density of benthic organisms (2,756 indv/m2) was sampled at the grey muddy bottom at 3.1 meter-depth of Station CNS-2 owing to the numerous collections of young crabs belonging to family pinnotheridae, followed by the polychaetes, particularly capitellids. The second highest density (1,556 indv/m2) due to the predominance of gammarids followed by the mytilids was found at Station CNS-1 characterized by a gray muddy substrate at 2.1 m-depth. The least density was recorded at Station CNS-3 with fine sandy-muddy bottom, grey in color at a depth of 2.7 m. The common organisms collected were the pinnotherids (crustaceans) and polychaetes, particularly spionids and capitellids. The Pinnotheridae, known as pea crab are a family of tiny soft-bodied crabs that live commensally in the mantles of certain bivalve mollusks and they are edible. Gammarids are carnivorous, feeding on small invertebrates and because of their widespread in distribution they are significant in the food web, and sensitive to a wide range of pollutants. They are important as bioindicators for water quality assessment.

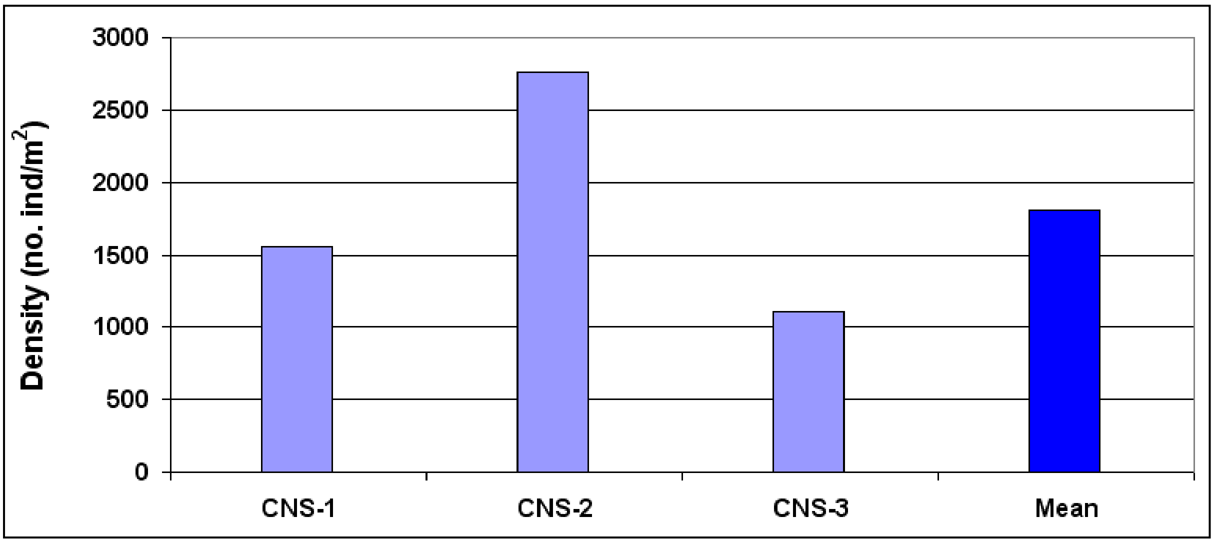


Figure 2.151. Density of subtidal infaunal benthos at three stations sampled from the nearshore waters of Naic, Cavite

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Stations CNS-1 with 11, CNS-2 with 10 and the least was CNS-3 with 8. The mean species diversity was 1.30. Highest diversity was found at Station CNS-3 (H'=1.48) followed by Station CNS-2 (H'= 1.24) and least at Station CNS-3 (H'=1.19) (**Figure 2.152**).

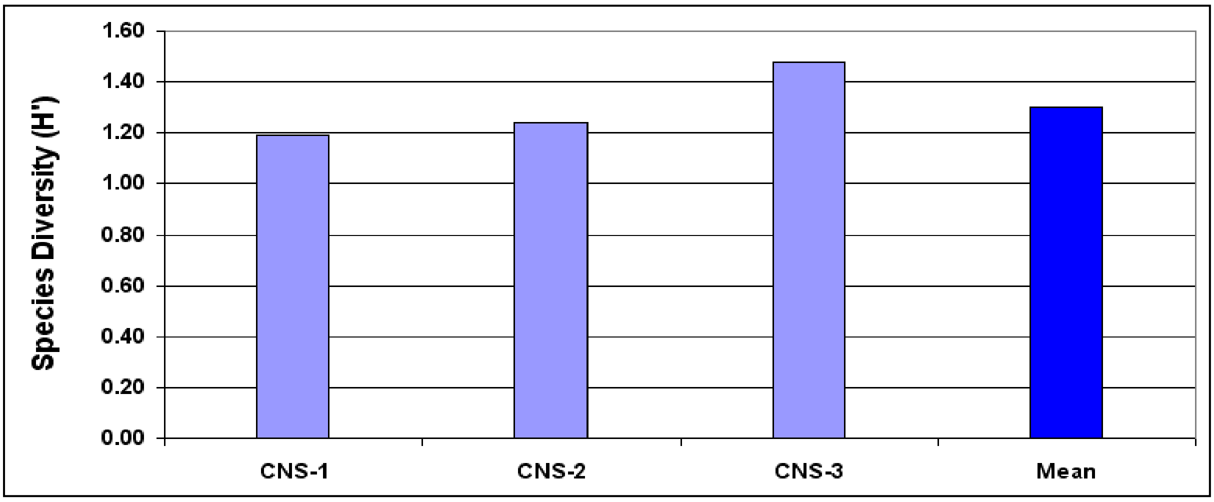


Figure 2.152. Species diversity of subtidal infaunal benthos at three stations sampled from the nearshore waters of Naic, Cavite

The biomass ranged from 1.89 to 23.45 wwt g/m2. Inter-station comparison showed Station CNS-1 with the highest biomass due to the collection of bivalves. Though Station CNS-2 had the highest density of organisms its biomass value was low. The biomass of the benthic organisms is therefore not correlated with the population density since the biomass depends on the type and size of organisms which predominate in the area. The mean biomass recorded was 9.60 wwt g/m2 (**Figure 2.153**).

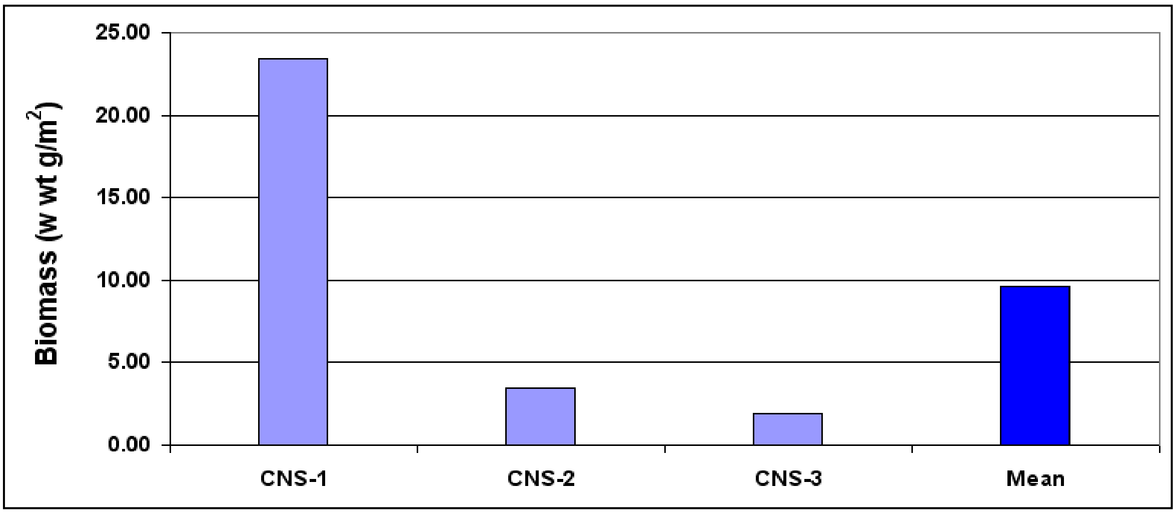


Figure 2.153. Biomass of subtidal infaunal benthos at three stations sampled from the nearshore waters of Naic, Cavite

(C) Offshore/Open Water Subtidal Benthos

(a) Near Mouth of Manila Bay (from Mariveles, Bataan to Naic, Cavite)

A total of 970 offshore benthic organisms were recorded in the samples taken from the eight (8) stations. The mean number of individuals per station was 122. These animals were represented by 54 taxa belonging to nine (9) major groups, namely: Foraminifera, Sipunculida, Nematoda, Rhynchocoela, Polychaeta, Mollusca, Crustacea Echinodermata, and Chordata. **Table 2.57** presents the composition, density and relative abundance of the major taxonomic groups sampled during the survey. The crustaceans were the most abundant organism collected comprising 54% of the total collection followed by polychaetes (22%) and foraminiferans (14%). The other remaining groups ranged only from 1 to 3% (**Figure 2.154**). Photos of some subtidal benthic organisms collected offshore/open area along the proposed bridge alignment from Mariveles to Naic are shown in **Plate 44**.

Table 2.57. Composition, density, relative abundance and biomass of infaunal benthos at eight stations sampled in offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

TAXA	Station								Mean Total Density (no.m^2)	Mean Relative Abundance (%)
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MB-8		
Phylum Foraminifera										
Family Peneroplidae		267			89	89	67	67	72	2.68
Family Miliolidae		289		578	844	178	400	200	311	11.55
Family Amphisteginidae	44								6	0.21

TAXA	Station								Mean Total Density (no.m^2)	Mean Relative Abundance (%)
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MB-8		
Phylum Sipunculida	44	22		222	133			89	64	2.37
Phylum Nematoda				67			244		39	1.44
Phylum Nemertea										
Class Rhynchocoela			111		44			44	25	0.93
Phylum Annelida										
Class Polychaeta										
Family Orbiniidae	22				22			22	8	0.31
Famly Spionidae	1222	178	44	44	111	22	89	511	278	10.31
Family Capitellidae	133	67	22	67	44			67	50	1.86
Family Magelonidae							44	22	8	0.31
Family Amphinomidae	111		44	44	22			67	36	1.34
Family Maldanidae		44				22		44	14	0.52
Family Poecilochaetidae	111								14	0.52
Family Sigalionidae	67		44	22	22				19	0.72
Family Opheliidae			22			22			6	0.21
Family Chaetopteridae	22		67				22		14	0.52
Family Pilargidae	44	22			22				11	0.41
Family Nephtyidae	111						44		19	0.72
Family Syllidae			44						6	0.21
Family Hesionidae			44						6	0.21
Family Onuphidae			22				22		6	0.21
Family Nereididae		22	22		44				11	0.41
Family Glyceridae				22				22	6	0.21
Family Eunicidae			89	22	22	22	22		22	0.82

TAXA	Station								Mean Total Density (no.m^{2})	Mean Relative Abundance (%)
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MB-8		
Family Lumbrineridae					67	22			11	0.41
Family Sabellidae	267	22	22		22				42	1.55
Family Ampharetidae			22						3	0.10
Family Terebellidae					44				6	0.21
Phylum Mollusca										
Class Bivalvia										
Family Tellinidae	22	67			22	22			17	0.62
Family Veneridae		22	22			44	44		17	0.62
Family Solenidae							22		3	0.10
Class Gastropoda										
Family Cerithiidae			44				22		8	0.31
Family Conidae										
Conus sp.					22				3	0.10
Family Turridae		44		44					11	0.41
Family Nassariidae		89				22			14	0.52
Family Turritellidae		22			22				6	0.21
Family Trochidae			22			22	22		8	0.31
Family Rissoidea							22		3	0.10
Family Oliviidae							22		3	0.10
Class Scaphopoda										
Family Dentaliidae		22			44	22		22	14	0.52
Phylum Arthropoda										
Subclass Crustacea										
Class Malacostraca										
Order Isopoda	22			22			44		11	0.41
Order Cumacea			44				67	178	36	1.34

TAXA	Station								Mean Total Density (no.m^{2})	Mean Relative Abundance (%)
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MB-8		
Order Tanaidacea	289	44	1200				22		194	7.22
Order Mysida			44		22	89			19	0.72
Order Amphipoda										
Family Gammaridea	489	200	7889	22	89	44	178	289	1150	42.69
Family Caprellidae	22					22			6	0.21
Order Decapoda										
Family Portunidae			22						3	0.10
Family Pinnotheridae	22					22	22	22	11	0.41
Family Sesarmidae			44						6	0.21
Order Stomatopoda	44			22	22				11	0.41
Class Ostracoda										
Subclass Myodocopa										
Order Myodocopida				22		22	44		11	0.41
Subclass Podocopa										
Order Podocopida						44	22		8	0.31
Phylum Echinodermata										
Class Ophiuroidea		67							8	0.31
Phylum Chordata										
Class Leptocardii										
Order Amphioxiformes										
Family Branchiostomidae										
Branchiostoma	22								3	0.10
TOTAL	**3,133**	**1,511**	**9,956**	**1,222**	**1,800**	**756**	**1,511**	**1,667**	**2,694**	**100.00**
No. of Taxa	20	18	23	14	22	18	22	15		

TAXA	Station								Mean Total Density (no.m^{-2})	Mean Relative Abundance (%)
	MBS-1	MBS-2	MBS-3	MBS-4	MBS-5	MBS-6	MBS-7	MB-8		
Species Diversity (H')	2.15	2.41	0.91	1.85	2.19	2.59	2.54	2.30		
Biomass (wet weight in g/m2)	39.77	35.33	99.55	44.44	144.00	45.55	12.66	9.11		
Type of substrate	Sandy-muddy	Muddy, gray	Coarse sand wt shell fragments	Muddy, gray, with shells fragments	Muddy, blackish	Coarse sand w/ silt	Coarse sand wt silt	Muddy, greyish		
Depth (meter)	8.9	31.0	7.6	37.4	23.8	6.1	5.5	4.3		

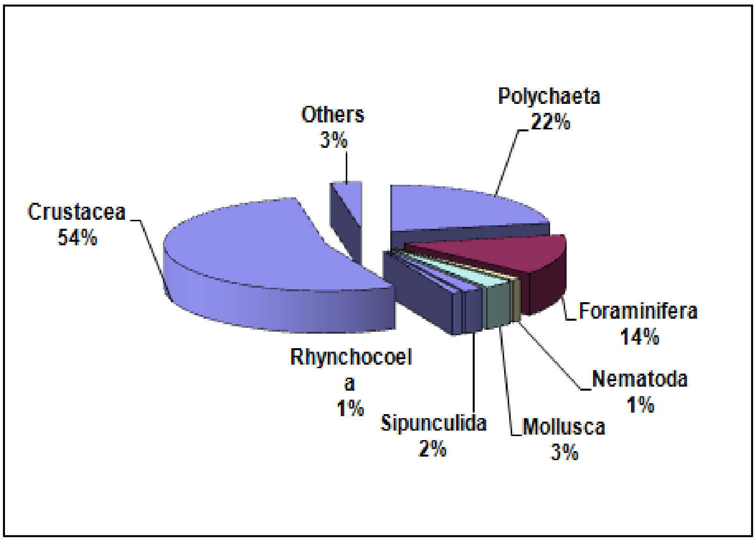


Figure 2.154. Mean relative abundance of major groups of infaunal benthos sampled from the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

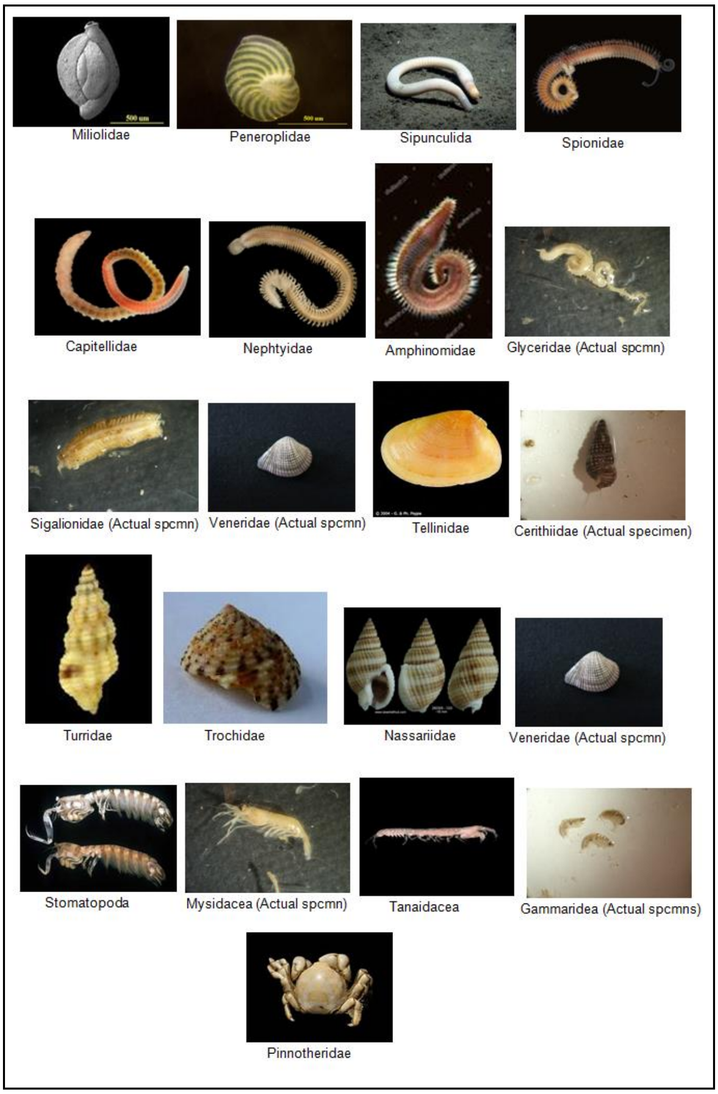


Plate 44 Photos of some infaunal benthic organisms collected from the offshore/open waters near the mouth of Manila Bay, Bataan to Cavite (Source: Internet and actual specimens)

The abundance of benthic organisms was found to be variable among the sampling stations and ranged from 756 to 9,956 indv/m2. The mean density recorded was 2,694 indv/m2 (**Figure 2.155**). The highest density of benthic organisms (9,956 indv/m2) was sampled at Station MBS-3 with coarse sandy substratum at 7.6 m owing to the numerous occurrences of crustaceans, particularly gammarids and tanaidacids. Ranked second in density (3,133 indv/m2) was recorded at the sandy muddy bottom at 8.9 meter-depth of Station MBS-1. The polychaetes, particularly the spionids were the most abundant organisms found, followed by the gammarids. The density values of the other stations in decreasing order were: Stations MBS-5 (1,800 indv/m2), MBS-8 (1,667 indv/m2), MBS-2 and MBS-7, both with 1,511 indv/m2 each and MBS-4 (1,222 indv/m2). The least density was recorded at the coarse sand bottom with silt at 6.1 meter-depth of Station MBS-6 (756 indv/m2) and having the foraminiferans as the most dominant animals found.

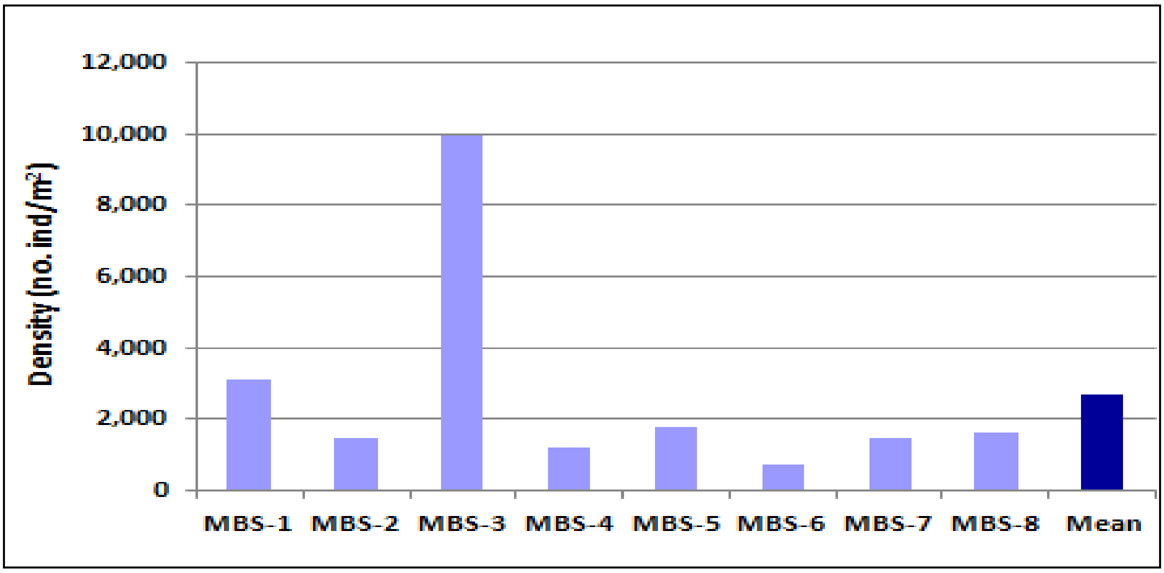


Figure 2.155. Density of infaunal benthos at eight stations sampled from offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Based on the number of identified taxa along the sampling sites, the results of the present survey showed Station MBS-3 occurred with the highest obtaining 23 out of the 54 taxa found, followed by Stations MBS-5 and MBS-7, both with 22 taxa, and MBS-1 with 20 taxa. Other stations with below 20 taxa were, Stations MBS-2 and MBS-6 with 18 taxa each, MBS-8 with 15 taxa and least at MBS-4 with 14 taxa. An index of diversity of benthic organisms using Shannon-Weaver Index was computed for the communities found in different stations in the study area. The index both measures the variety and number of individuals per taxa. The mean species diversity (H') was 2.12. Highest diversity was found at Station MBS-6 (H'=2.59) followed by Stations MBS-7 (2.54), MBS-2 (2.41), MBS-8 (2. 30), MBS-5 (2.19), MBS-1 (2.15) and MBS-4 (1.85). The least species diversity was found at MBS 3 (0.91) (**Figure 2.156**).

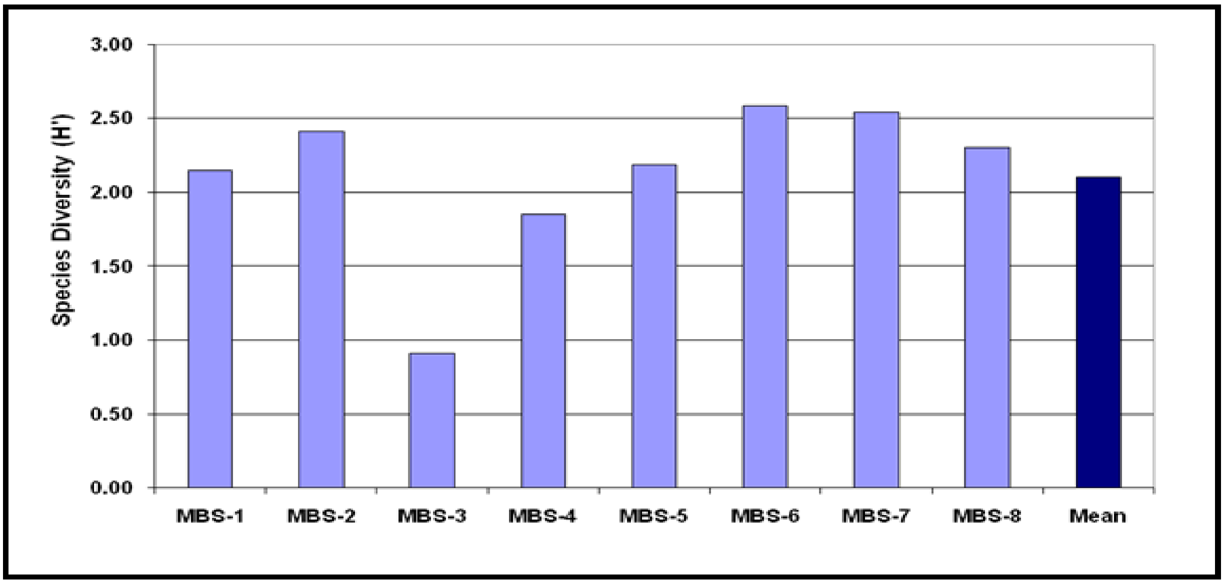


Figure 2.156. Species diversity of infaunal benthos at eight stations sampled from the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

Biomass of the benthic organisms in all sampling stations is also shown in Table 20 and graphically presented in **Figure 2.157**. The biomass ranged from 9.11 to 144 wwt g/m2. Inter-station comparison showed Station MBS-5 with the highest biomass attributable to the presence of gastropods and scaphopod followed by Station MBS-3 due to the abundance of polychaetes, crustaceans and the occurrence of gastropods. The remaining stations have biomass values below 50 wwt g/m2 with Station MBS-8 having the least biomass (9.11 wwt g/m2). The mean biomass recorded was 53.8 wwt g/m2.

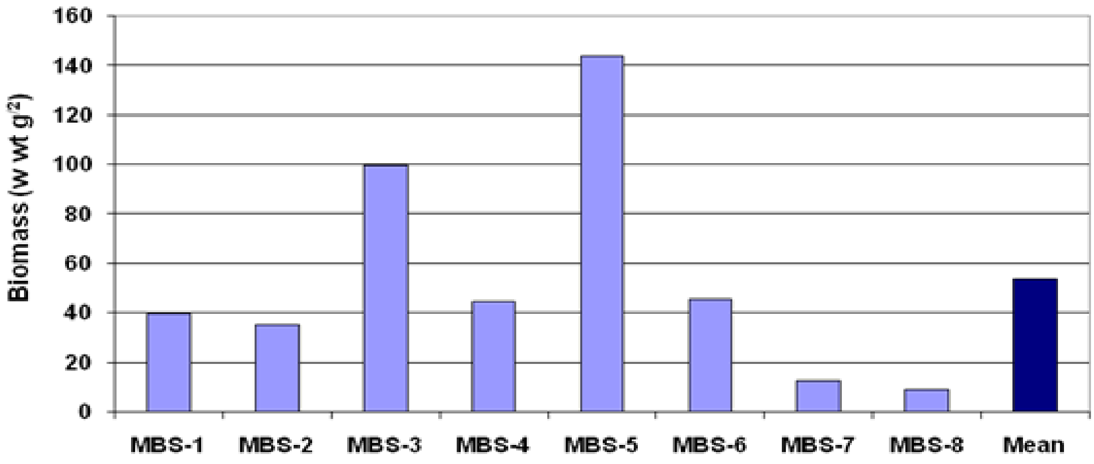


Figure 2.157. Benthos biomass of infaunal benthos at eight stations sampled from the offshore/open waters near the mouth of Manila Bay from Mariveles to Naic

(D) River Estuary Infaunal Benthos

(a) Stations BRS-1 (Babuyan River, Alas-asin, Mariveles)

A total number of 63 benthic organisms were obtained from two (2) replicate samples. These organisms were represented by seven (7) taxa belonging to four (4) major groups, namely: Polychaeta, Nematoda, Crustacea and Insecta. **Table 2.58** presents the composition, density and relative abundance of the major taxonomic groups sampled during the survey. The most important groups of soft bottom fauna belong to Crustacea constituting 47% followed by Insecta with 30% and by Polychaeta with 19%. Nematoda had a composition of 5% only (**Figure 2.158**).

There were two (2) taxa found among the polychaete groups dominated by the spionids. The crustaceans were represented by three (3) taxa predominated by the gammarids. The insects were represented only by Chironomous sp. (**Plate 45**).

Table 2.58. Composition, density, relative abundance and biomass of infaunal benthos sampled at the Babuyan River (BRS-1) in Alas-asin, Mariveles

Taxa	Station BRS-1 (no./m2)	Relative Abundance (%)
Phylum Nematoda	67	5
Phylum Annelida		
Class Polychaeta		
Famly Spionidae	244	17

Taxa	Station BRS-1 (no./m2)	Relative Abundance (%)
Family Nereididae	22	2
Phylum Arthropoda		
Subclass Crustacea		
Class Malacostraca		
Order Tanaidacea	22	2
Order Amphipoda		
Family Gammaridea	600	43
Order Decapoda		
Family Paguridae	22	2
Class Insecta		
Order Diptera		
Family Chironomidae		
Chironomous	422	30
TOTAL	1,400	100
No. of Taxa	7	
Species Diversity (H')	1.37	
Biomass (wet weight in g/m2)	14.44	
Type of Substrate	Sandy-muddy	
	w/shell fragments	
Depth (meter)	0.3	

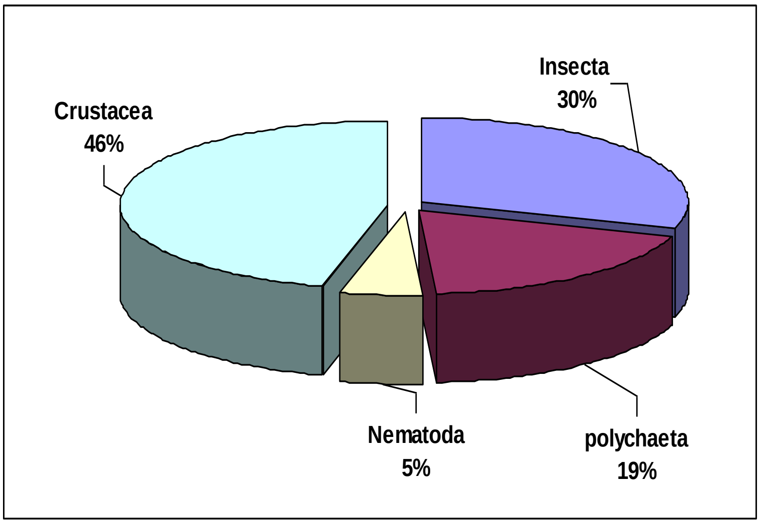


Figure 2.158. Mean relative abundance of major groups of infaunal soft bottom benthos sampled from Babuyan River (BRS-1), Alas-asin, Mariveles

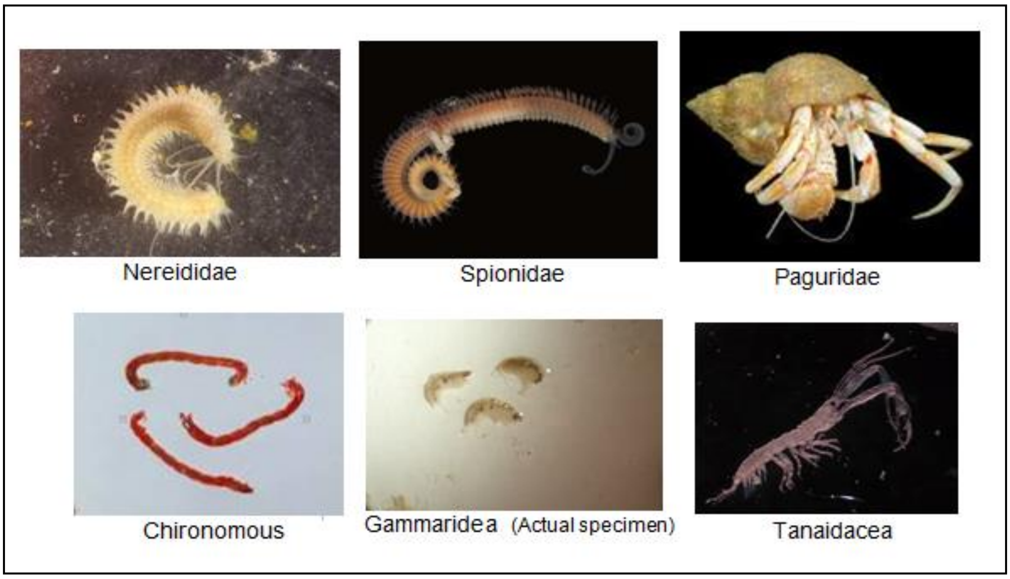


Plate 45 Photos of some infaunal benthic organisms collected from Babuyan River (BRS-1), Alas-asin, Mariveles (Source: Internet and actual specimen)

The density of organisms at the sandy-muddy bottom with shell fragments of Station BRS-1 was 1,400 indv/m2 owing to the numerous collections of gammarids and chironomids (see **Table 2.58**). The presence of polychaetes was due to its proximity to the Nipa swamp that contributes nutrients for the growth and multiplication of detritus feeders in the community.

An index of diversity of benthic organisms using Shannon-Weaver Index was computed for the communities found in the sampling station. Species diversity is a function of not only of species composition but also of the proportional distribution of individuals to each species. The species diversity (H') was 1.37.

Macroinvertebrate biomass (weight of organisms per unit area) is a useful quantitative estimation of standing crop. Biomass value of the benthic organisms found at the river estuary was 14.44 wwt g/m2.

(b) Stations CRS-1 (Timalan River, Naic) and CRS-2 (Bucana River, Naic)

A total number of 85 benthic organisms were obtained from four (4) replicate samples taken at two (2) sampling stations (CRS-1 and CRS-2). The mean number of individuals per station was 43. These organisms were represented by seven (7) taxa belonging to three (3) major groups, namely: Polychaeta, Mollusca, and Crustacea. **Table 2.59** presents the composition, density and relative abundance of the major taxonomic groups sampled during the survey. The most important groups of soft bottom fauna belong to Crustacea constituting 55% and by Polychaeta with 40%. Mollusca had a composition of 2% only (**Figure 2.159**). There were four (4) taxa found among the polychaete groups dominated by the nereids and spionids. The crustaceans were represented by two (2) taxa, 53% of which belong to gammarids and the tanaidacids comprising 2% of the crustacean collections. The mollusks were represented only by Anomalocardia sp., under Bivalvia (**Plate 46**).

Table 2.59. Composition, density, relative abundance and biomass of infaunal benthos sampled at Timalan River (CRS-1) and Bucana River (CRS-2) in Naic, Cavite

Taxa	Station		Mean Total Density (no./m^2)	Mean relative Abundance (%)
	CRS-1	CRS-2		
Phylum Annelida				
Class Polychaeta				
Family Orbiniidae	44		22	2
Famly Spionidae	111	44	78	8
Family Capitellidae	67		33	4
Family Nereididae	511	22	267	28
Phylum Mollusca				
Class Bivalvia				
Family Cardiidae				
Anomalocardia sp.	44		22	2
Phylum Arthropoda				
Subclass Crustacea				
Class Malacostraca				
Order Tanaidacea	44		22	2
Order Amphipoda				
Family Gammaridea	578	422	500	53
TOTAL	**1400**	**489**	**944**	**100**
No. of Taxa	7	3		
Species Diversity (H')	1.41	0.49		
Biomass (wet weight in g/m2)	299.00	12.00		
Type of substrate	Sandy-muddy w/ shell fragments	Muddy, black w/ shell fragments		
Depth (meter)	0.5	0.5		

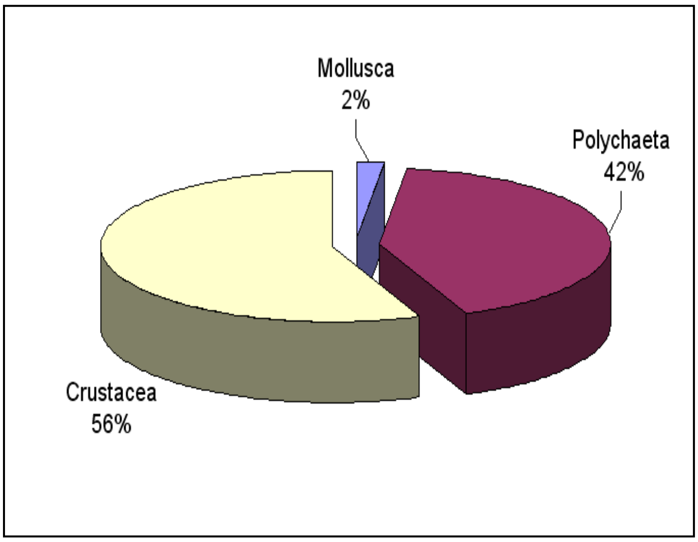


Figure 2.159. Mean relative abundance of major groups of infaunal soft bottom benthos in all stations sampled from Naic, Cavite

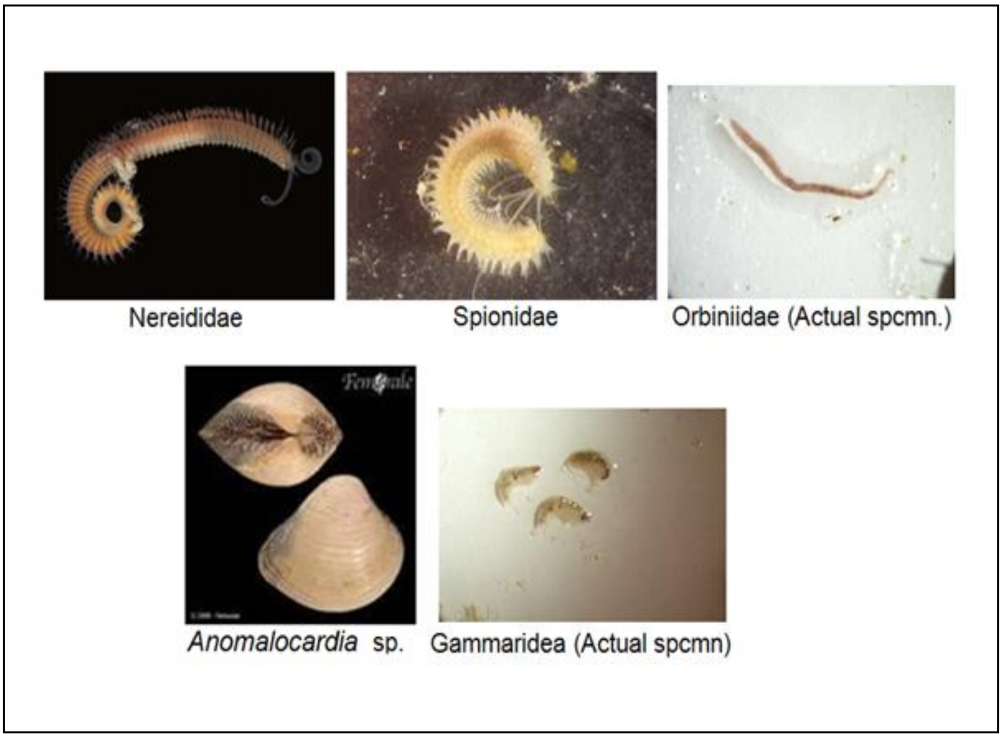


Plate 46 Photos of some infaunal benthic organisms collected from Timalan River (CRS-1) and Bucana River (CRS-2) in Naic, Cavite (Source: Internet and actual specimen)

The abundance of benthic organisms in this survey ranged from 489 to 1,400 indv/m2 with mean density of 944 indv/m2 (**Figure 2.160**). The density of organisms at the sandy-muddy bottom with shell fragments at Station CRS-1 was higher than at Station CRS-2 with 1,400 indv/m2 owing to the numerous collections of polychaetes and gammarids. The presence of polychaetes was due to its proximity to the swamp that contributes nutrients for the growth and multiplication of detritus feeders in the community.

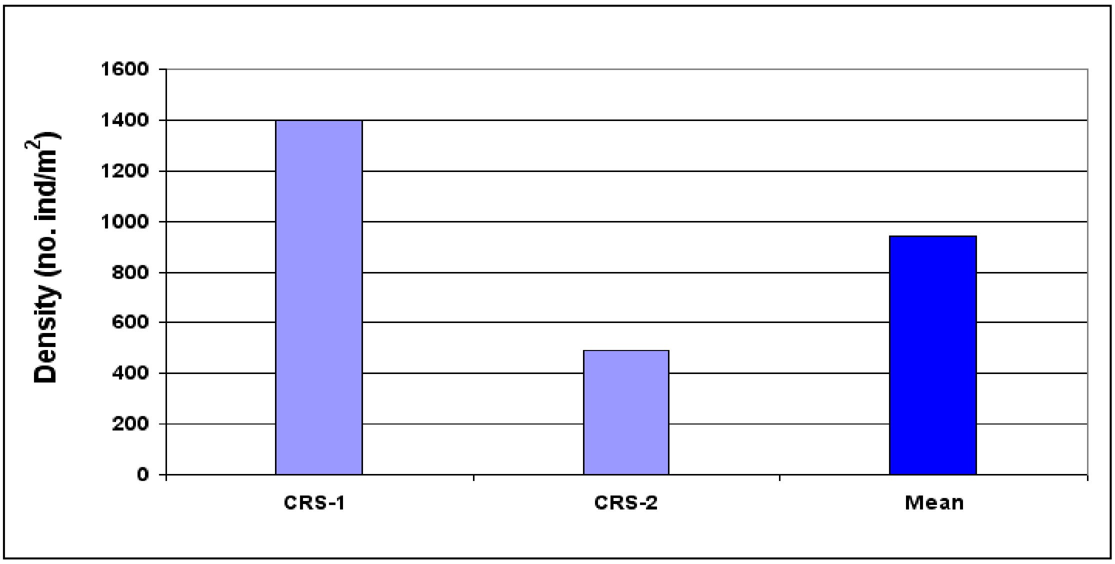


Figure 2.160. Density of soft bottom infaunal benthos at two sampling stations CRS-1 (Timalan River) and CRS-2 (Bucana River), Naic, Cavite

An index of diversity of benthic organisms using Shannon-Weaver Index was computed for the communities found in the two (2) stations. Species diversity is a function of not only of species composition but also of the proportional distribution of individuals to each species. The mean species diversity (H') was low (0.95), Higher diversity was found at Station CRS-1 (1.41) than at Station CRS-2 (0.49) (**Figure 2.161**). Less stressful environment promotes high diversity. As stresses in the particular area increased, benthic infauna communities may be dominated only by few kinds.

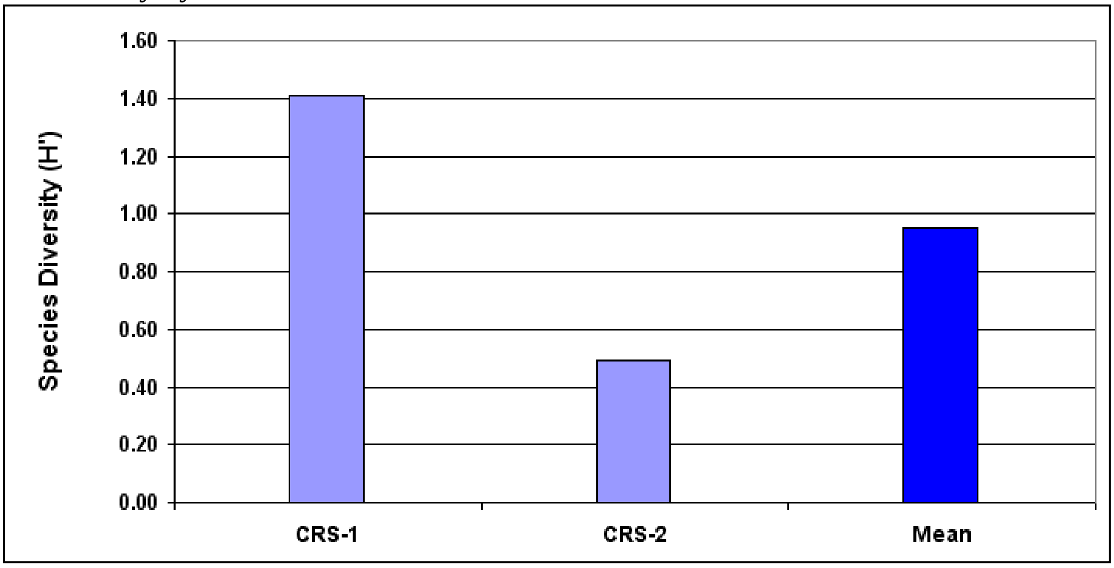


Figure 2.161. Species diversity of soft bottom infaunal benthos at two sampling stations CRS-1 (Timalan River) and CRS-2 (Bucana River), Naic, Cavite

The benthos biomass ranged from 12 to 299 wwt g/m2. Inter-station comparison showed Station CRS-1 with the higher biomass compared to CRS-2 owing to its higher collections of infaunal benthic organisms. The mean biomass recorded was 156 wwt g/m2 (**Figure 2.162**).

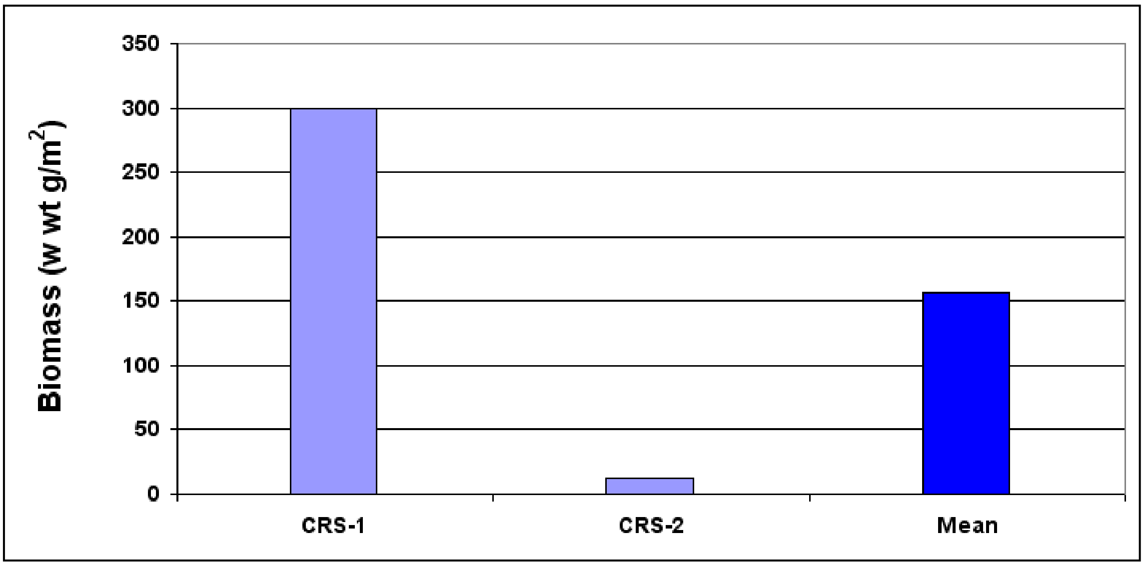


Figure 2.162. Benthos biomass of soft bottom benthic infauna at two sampling stations CRS-1 (Timalan River) and CRS-2 (Bucana River), Naic, Cavite

2.2.5.3.8 Corals and Associated Fish Assemblages

(A) Coral Communities

The report of DENR-ERDB (2019) presented the most recent information on the coral communities in the Manila Bay Region. According to the report, around 72 % of the total reef area (294 hectares) is located in the Province of Cavite and most of the reefs present in the area are fringing types. Meanwhile, the Corregidor and Caballo Islands, including that in Mariveles (Bataan) have reefs characterized by rock boulders, which corals and other marine organisms used as the substrate for settlement, growth, and development.

The EIA marine ecology team of the proposed bridge project had observed similar reef formations during the rapid reef survey in Alas-asin, Mariveles. Results of the manta tow survey and SCUBA dive inspection adjacent to the bridge alignment (Station RRSS - Lat.14o26’07.8”N and Long. 120o34’54.5”E, **Figure 2.163**) showed that the reef structure is of the so called patch reef, as its name suggest, relatively small, flat-topped reef structure, usually arising in rather shallow water. This reef is nearly 0.11 km south of the proposed bridge alignment which was characterized by rock boulders where marine biofouling organisms are attached resulting in a higher cover of invertebrates (33.33%) and algae (46.67%). The invertebrate fauna sighted were mostly barnacles, black sea urchins, zoanthids, and sponges. Meanwhile, abiotics were relatively common at the reef, registering a cover of 19.17% which were composed of rocks and sand. The patch reef has a live coral cover (LCC) of only 0.83%, classified as poor coral condition (**Plate 47**).

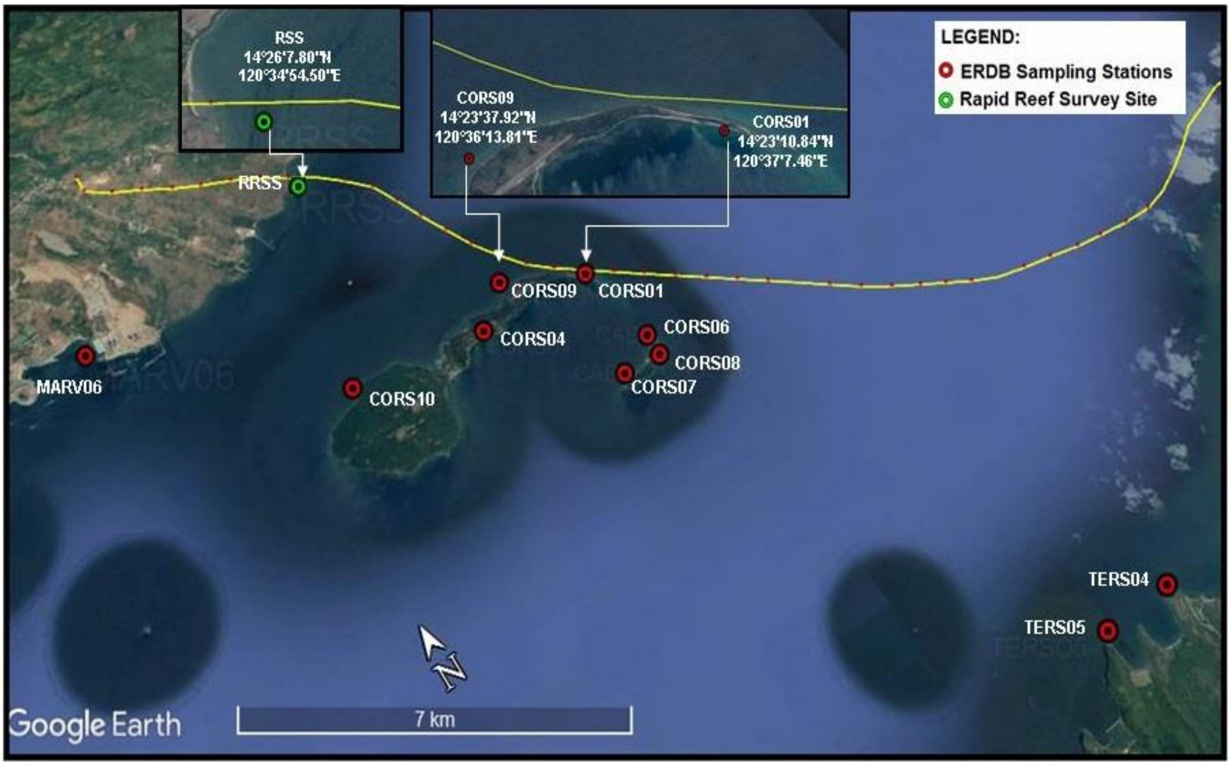


Figure 2.163. Location of the sampling stations of the rapid reef survey site of this report and DENR-ERDB. This map only presents the sampling stations that are relatively close to the proposed bridge project. The sampling stations in Maragondon, Cavite are not shown in the map

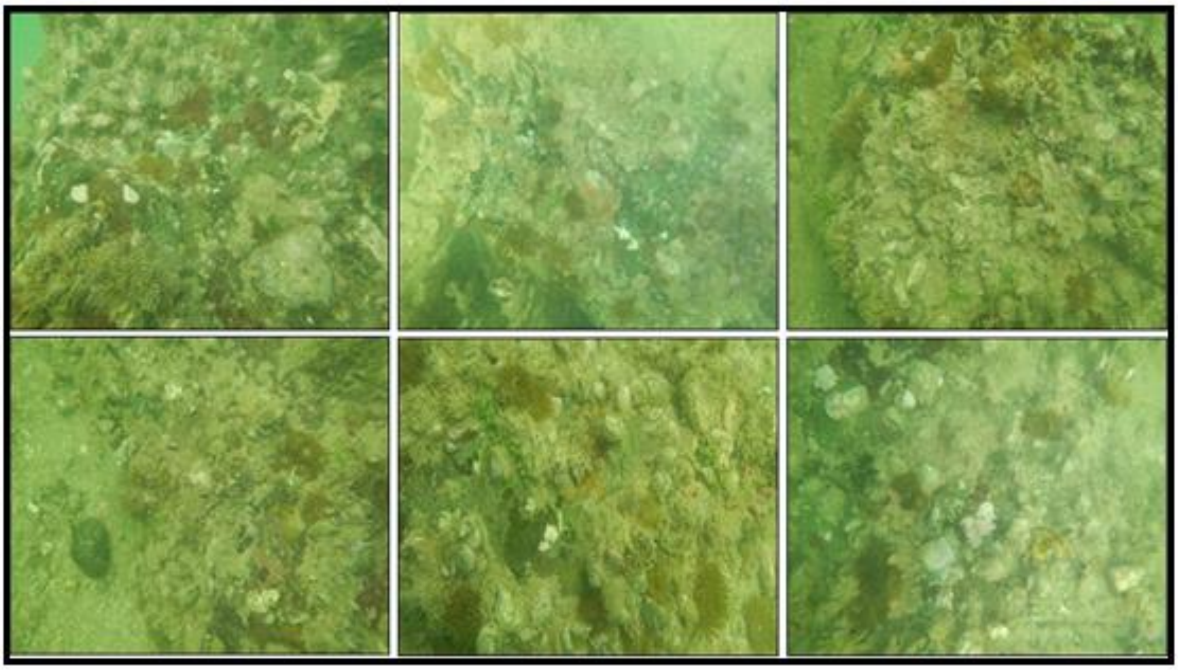
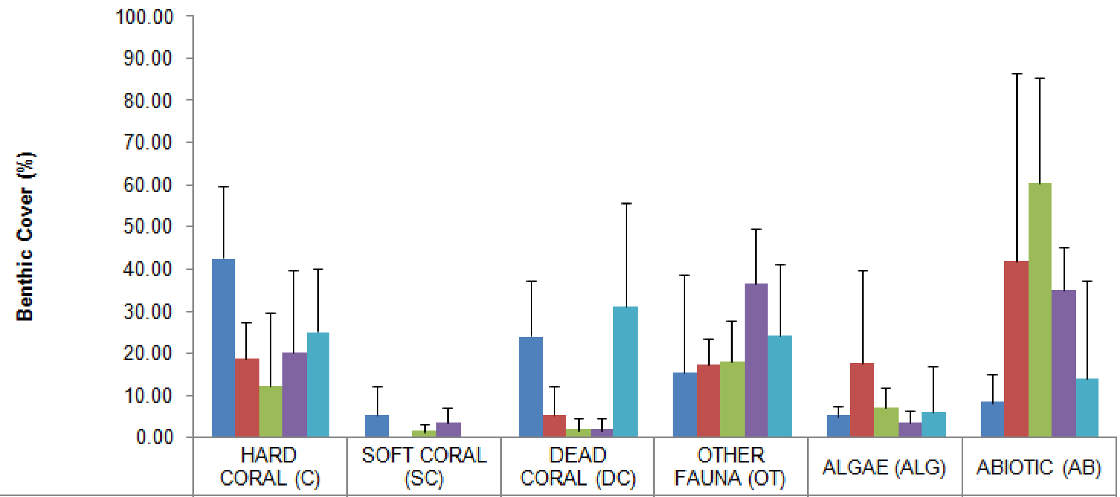


Plate 47 Condition of the patch reef found south of the proposed bridge alignment near the shore of Alas-asin (Mariveles)

The previously mentioned DENR-ERDB (2019) report covered 14 sampling stations and most of these stations are also presented in Figure 62. The mean cover of benthic features per sampling site was computed to summarize the findings of DENR-ERDB (2019) and the output is exhibited in Figure 63. The highest mean hard coral cover (HCC) was derived from Maragondon site with 42.51%, followed by Mariveles (25%), Caballo (20.08%), Ternate (18.62%), and Corregidor (11.91%). Soft corals were recorded only in Maragondon, Corregidor Island, and Caballo Island with cover ranging from 1.29 to 5.13%. The cover of dead corals was relatively higher in areas with higher hard coral cover such as in Maragondon (23.85%) and Mariveles (31.0%). Dead coral cover in Mariveles exceeded the cover of hard corals. The cover of other fauna ranged from 15.31 to 36.55%, while the algal cover was relatively low in most of the stations, except in Ternate with 17.41% cover. Approximately, 35 to 60% of the total benthic cover in Ternate, Corregidor, and Caballo was contributed by abiotics, mostly rocks, rubbles, and sand (see **Figure 2.164**).

The reefs in Maragondon and Mariveles have fair coral cover based on the live coral cover (LCC) scale of Gomez et al. (1981) (**Table 2.60**). Live coral cover is aggregate cover values of hard and soft corals. The rest of the stations had poor coral cover. However, the proposed HCC scale of Licuanan et al. (2017) suggested good coral condition in Maragondon, while Mariveles and Caballo had fair coral condition. The reefs in Ternate and Corregidor were consistently in poor condition. Using the indices of Manthachitra (1994), the condition of reef assemblages in most of the sampling sites was in the poor category, except in Maragondon with a fair category (Table 24). The development of reef assemblages, on the contrary, was in fair to a very good level, except in Corregidor with poor status. The succession of algae on dead corals and other fauna was very poor to fair in most of the sites. The succession of other fauna on dead corals appeared to be poor in reef sites with very good reef development. In the 1990s, the coral reef status in Manila Bay was in fair condition with a mean coral cover of 40% (PEMSEA and MBEMP TWG-RRA, 2004). Based on the latest data, the mean coral cover can be estimated at 25.60%, which suggests that the coral cover in the bay had declined over the years. Moreover, the remaining reefs with live corals seem to thrive in areas close to the mouth of the bay.



	HARD CORAL (C)	SOFT CORAL (SC)	DEAD CORAL (DC)	OTHER FAUNA (OT)	ALGAE (ALG)	ABIOTIC (AB)
Maragondon, Cavite	42.51	5.13	23.85	15.31	4.97	8.23
Ternate, Cavite	18.62	0.00	5.00	17.04	17.41	41.93
Corregidor Island, Cavite	11.91	1.29	1.67	17.72	6.93	60.49
Caballo Island, Cavite	20.08	3.44	1.67	36.55	3.21	35.05
Mariveles, Bataan	25.00	0.00	31.00	24.00	6.00	14.00

The locations were represented by 14 sampling stations (Data Source: DENR-ERDB, 2019)

Figure 2.164. Summary of the cover of benthic features in the selected sampling locations within the Manila Bay Region.

Table 2.60. Relative condition of the reefs in the sampling locations based on Live Coral Cover (LCC) and Hard Coral Cover (HCC) Scales (Data Source: DENR-ERDB, 2019). LCC is the sum of live hard coral and soft coral cover

Sampling Site	Live Coral Cover (LCC)	LCC Scale*	Hard Coral Cover (HCC)	HCC Scale**
Maragondon, Cavite	47.64	Fair	42.51	Good
Ternate, Cavite	18.62	Poor	18.62	Poor
Corregidor Island, Cavite	13.19	Poor	11.91	Poor
Caballo Island, Cavite	23.53	Poor	20.08	Fair
Mariveles, Bataan	25.00	Fair	25.00	Fair

*Gomez et al. (1981)
**Licuanan et al. (2017)

Table 2.61. Status of the reef in the sampling locations based on the condition, development, and succession indices described by Manthachitra (1994)

Indices	**Maragondon, Cavite**	**Ternate, Cavite**	**Corregidor Island, Cavite**	**Caballo Island, Cavite**	**Mariveles, Bataan**
Condition Index (CI)	Fair	Poor	Poor	Poor	Poor
Development Index (DI)	Very Good	Fair	Poor	Good	Very Good
Succession Index (SI)					
a. SI algae	Very Poor	Fair	Poor	Very Poor	Very Poor
b. SI other fauna	Poor	Fair	Good	Very Good	Poor

As regards to coral lifeforms, massive corals were more common in the sampling locations, followed by encrusting and foliose corals (**Figure 2.165** and **Plate 48**). Among the 16 coral genera found within the sampling frames, the genus Porites were dominant (**Figure 2.166**). The preponderance of the aforementioned dominant lifeforms and stress-tolerant taxa might be a response to varying levels of perturbation on those reefs. Massive and submassive growth forms are more tolerant to sedimentation, low light intensity, pollution, and wave stress (Edinger and Risk (2000); Junjie et al. 2004; Guest et al. 2016). In like manner, the genus Porites including Turbinaria can adapt to stressful environmental conditions because of their capacity to offset reduced photosynthetic processes, undergo fast tissue regeneration, shed sediments from their colonies, and capture of light through morphological adaptations (Dikou and van Woesik 2006; Guest et al. 2016). Nonetheless, the aforementioned reef sites are considerably distant from the alignment points of the proposed bridge project. For instance, the reef sites in Mariveles are about 6.34 km away from the nearest alignment point. In the case of Corregidor and Caballo, the reef sites are approximately 0.7 to 4.22 km from the alignment. Meanwhile, the reefs in Ternate are relatively the farthest (12.37 km) from the bridge alignment in Naic, Cavite.

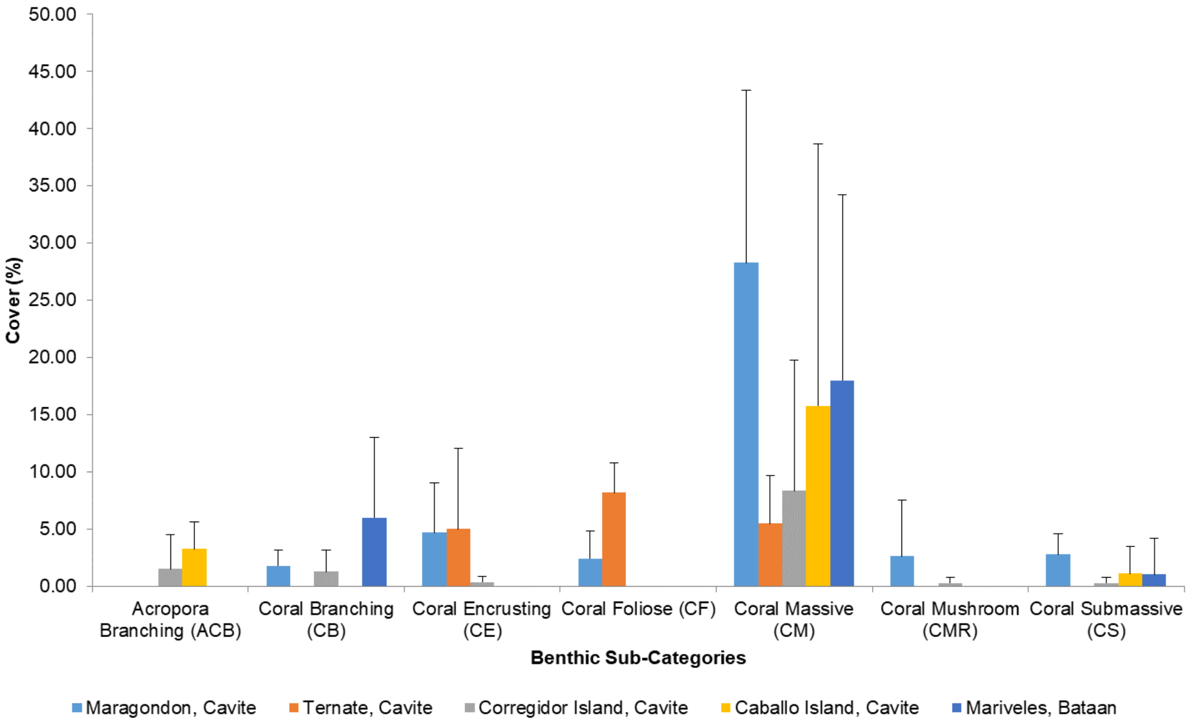


Figure 2.165. Mean cover of coral lifeforms in the sampling locations within the Manila Bay Region

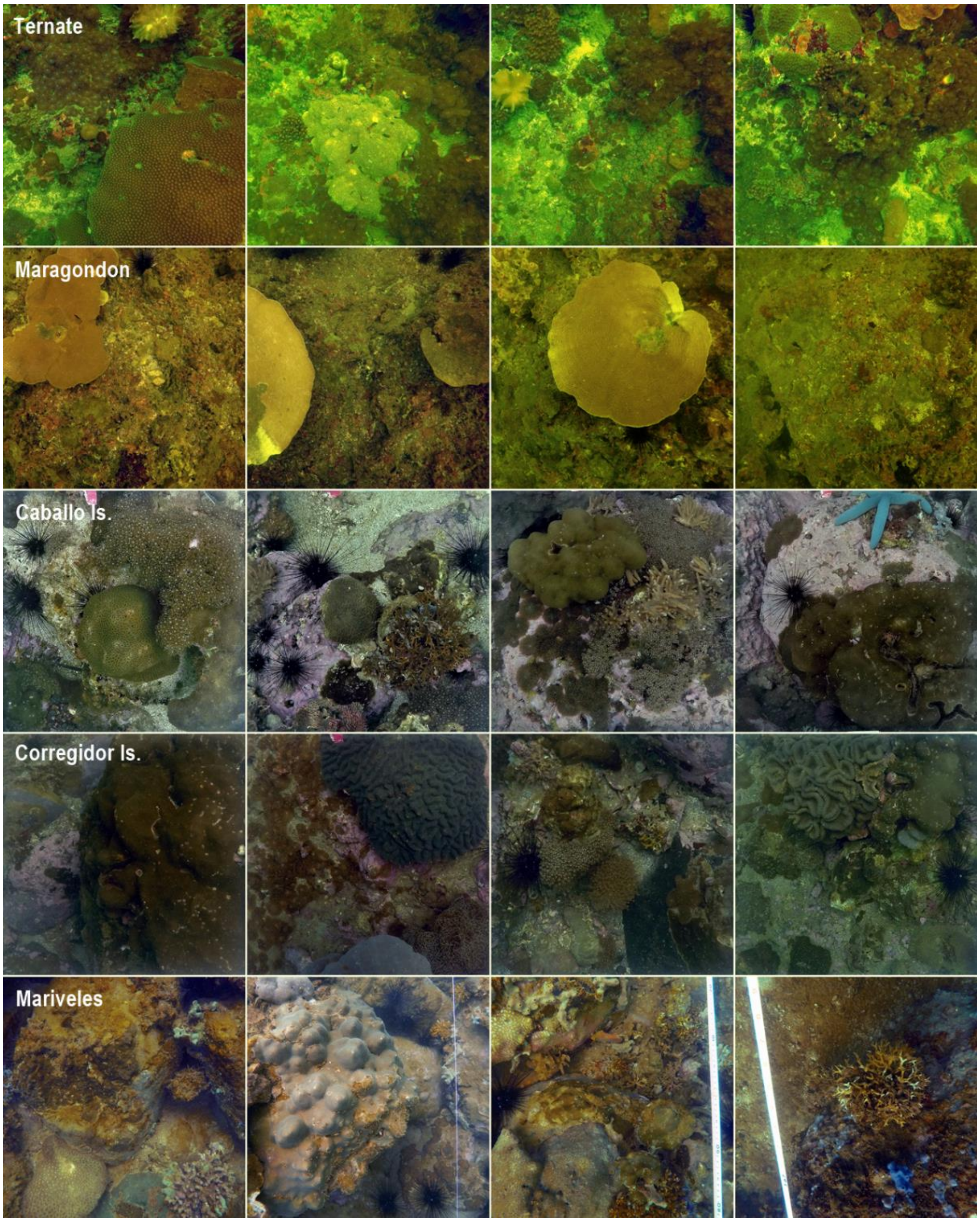


Plate 48 Samples images of the benthic features found in the sampling locations in Cavite (i.e. Ternate, Maragondon, Corregidor Island, and Caballo Island. Occurrence of massive, encrusting, and plate to foliose coral lifeforms in the images is more frequent. (Image Source: DENR-ERDB, 2019

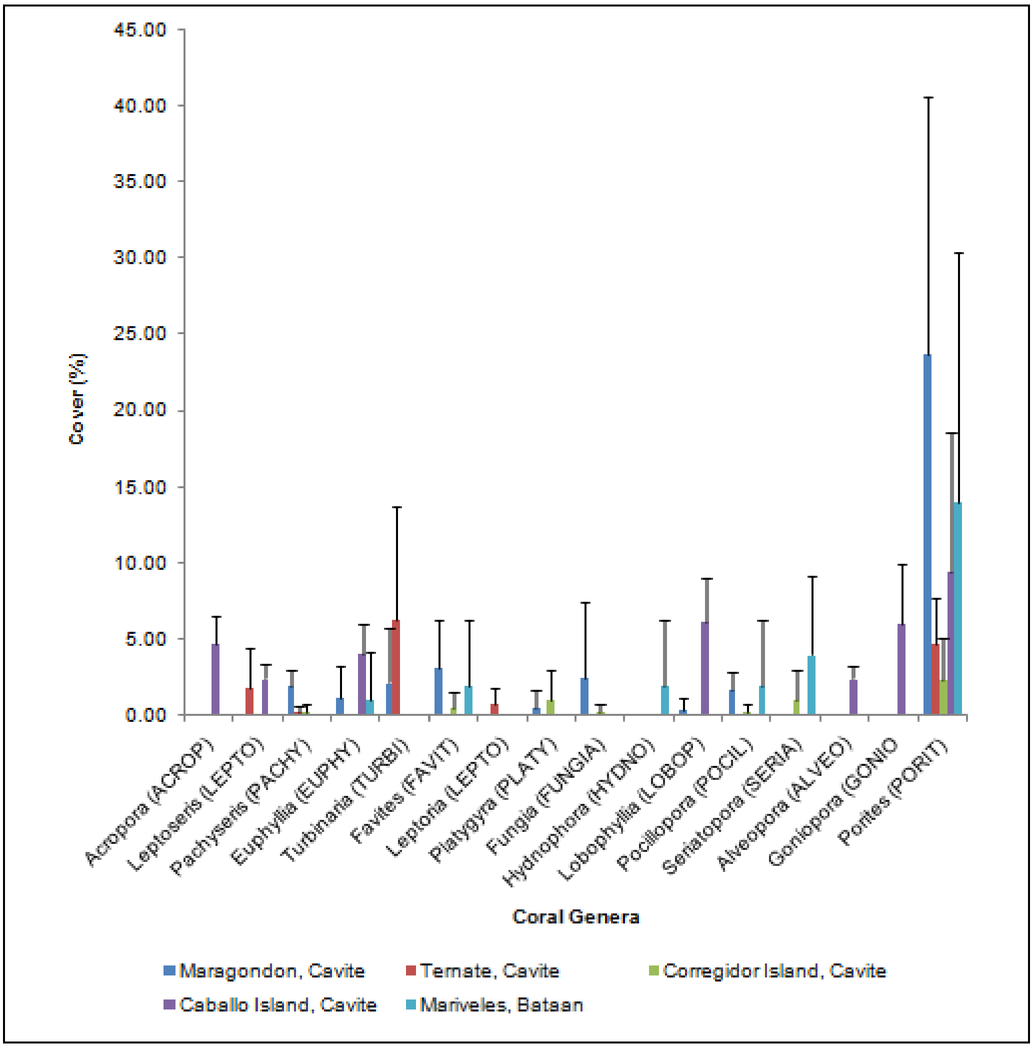


Figure 2.166. Mean cover of coral genera in the sampling locations within the Manila Bay Region

(B) Associated Fish Assemblages

The patch reef in Alas-asin (Station RRSS) recorded two (2) families with nine (9) species. Absence of indicator and target species has been observed in the area. Hence, species composition was dominated by major species group dominated by pomacentrids followed by wrasses. The nine (9) reef fishes recorded on the patch reef were Abudefduf sexfasciatus, Amphiprion clarkia, Amphiprion ocellaris, Dascylus reticulatus, Dascylus trimaculatus, Plectroglyphidodon lacrymatus, Pomacentrus sp., Stegastes sp, and Thalassoma lunare.

In terms of fish density, the patch reef had only 17 individuals/250 m2. The standardized values of fish density showed poor fish populations at the sampling station based on the categories of Hilomen et al. (2000). This is expected since the reef had poor coral cover. Coral cover and reef heterogeneity are among the core factors that influence the structure of the associated fish community (Bell et al., 1984; Komyakova et al., 2013).

In terms of biomass, the total fish biomass was only 0.44 kg/250 m2. The extrapolated values revealed very low fish biomass, which can be attributed to habitat conditions. As regards to species diversity, the patch reef had moderate fish diversity (H’=1.88).

2.2.5.3.9 Macroinvertebrates

The most widely distributed species in aquatic environment are the invertebrates, animals lacking a vertical column or without backbones. Over 95% of all animal species are invertebrates (Basson et al., 1977). Macroinvertebrates are organisms which can be readily observed with the naked eye. Macroinvertebrates not only form an integral part of the aquatic ecosystem but also serve as important link in the aquatic food chain. They serve as food items on a worldwide scale; for example, shrimp, lobsters, crabs, clams, mussels, oysters and scallops. These aquatic invertebrates live in the bottom (epibenthic) parts of a body of water.

Epibenthic fauna (macroinvertebrates) serve a number of ecosystem roles at various levels of the food chain. Macroinvertebrates are good integrators of environmental conditions over time and can be used as indicators of water quality and the general "health" of the aquatic environment (Rosenberg and Resh, 1993).

More typical macrobenthic invertebrates, are the long-spined black sea urchins Diadema setosum recorded on the Alas-asin Reef (reef boulders) (**Plate 49**). The species can be found throughout Indo-Pacific region, from Australia and Africa to Japan and the Red Sea. Other macroinvertebrate fauna sighted are mostly attached to rock boulders, such as the barnacles, zoanthids, and sponges. Likewise, the long-spined sea urchins Diadema setosum were observed on the coarse sandy flat bottom (7.6 m in depth) of Station MBS-3 located offshore along the main bridge alignment fronting Corregidor Island (**Plate 50**). Together with D. setosum are the pennatulacean octocorals Virgularia sp. (sea pen), which were commonly seen in the area (**Plate 51**). Virgulariid sea pens are known to range from intertidal habitats to approximately 1,200 m in depth (William, 2011).

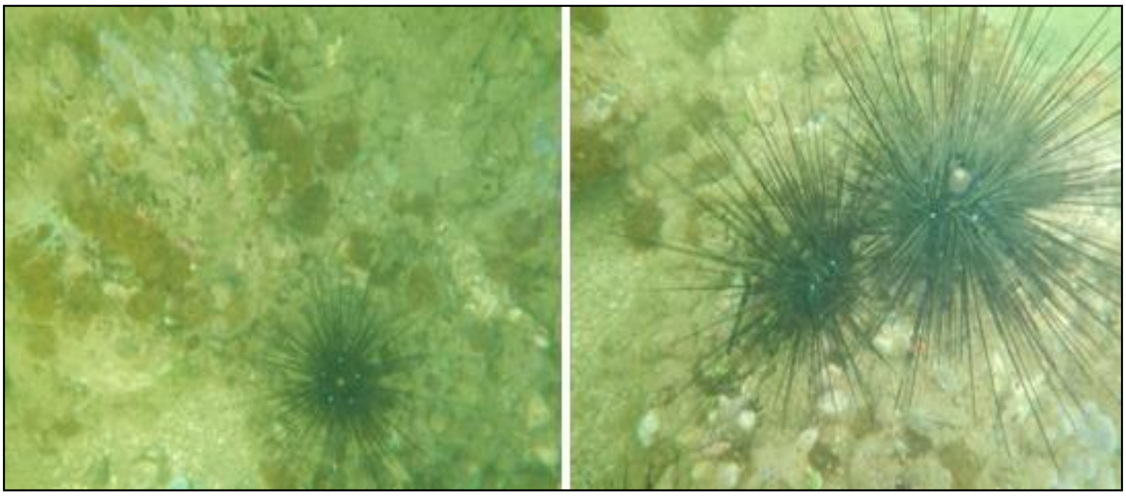


Plate 49 The long-spined black sea urchin Diadema setosum, Alas-asin patch reef (Station RRSS)

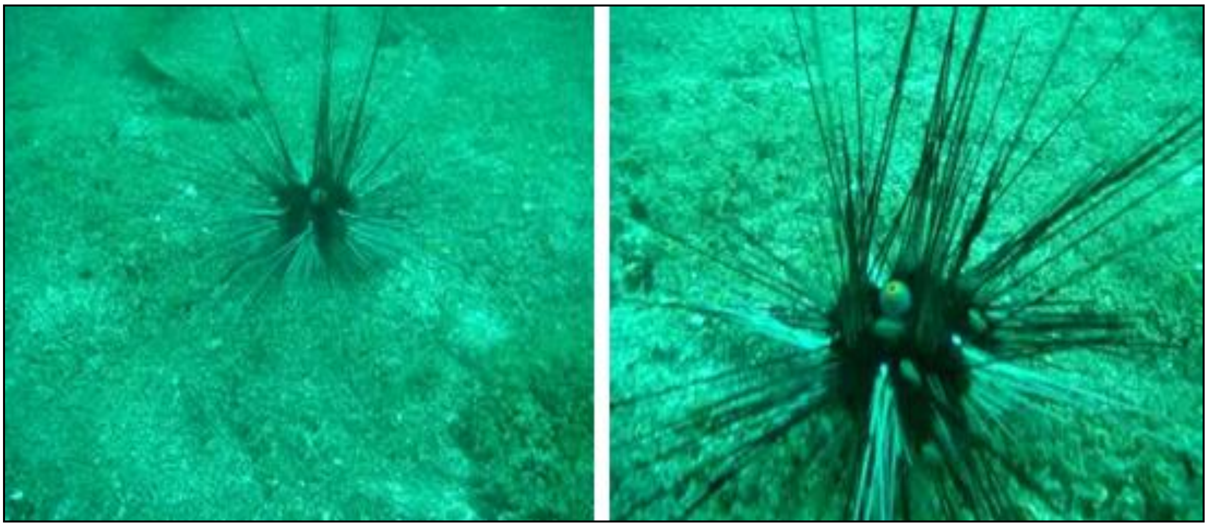


Plate 50 Long-spined black sea urchin Diadema setosum at Station MBS-3 off Corregidor Island

Plate 51 The pennatulacean octocorals Virgularia sp. (sea pen), Station MBS-3 off Corregidor Island

2.2.5.3.10 Artificial Hard Structures (Shipwrecks/Artificial Reefs) and Fish Sanctuaries

(a) Alas-asin and Barangay II (Mariveles, Bataan)

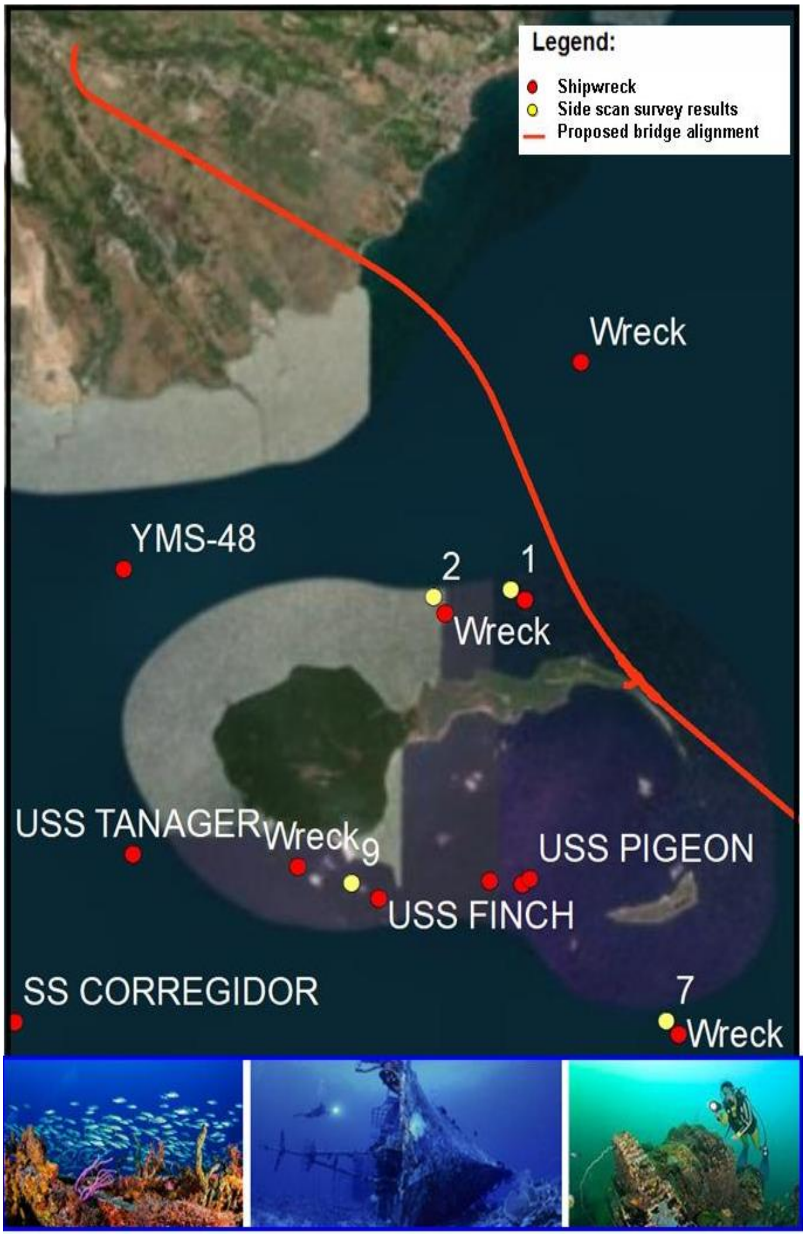
Almost any man-made object made of hard materials such as steel, concrete or sometimes wood placed in the sea is soon colonized by marine organisms. Artificial structures deployed in the marine environments may function as recruitment or aggregation sites for both benthic and reef fish communities (Munro and Balgos, 1995). Artificial structures are numerous and ecologically important along Mariveles and neighbouring areas such as, for example, the pile structures and the breakwaters/revetments/armour rocks on the seabed of the nearby jetties, piers of power plants, oil or bulk terminals, depots, and refineries in the area. Such artificial hard structures assume the status of "artificial reef" (AR). However, there are no available information describing the benthic fouling community and fish assemblages that reside or frequent these underwater artificial hard structures. So far, no study has been conducted on these artificial hard structures since the start of their operations.

About seven (7) km north from the project site, a part of the Mariveles area at Barangay II has been designated as fish sanctuary (**Figure 2.167**). The PNOC Petrochemical Development Corporation fishery reserve area was established through Municipal Ordinance No. 14 in October 2001 and covers an area of 49.925 hectares (PEMSEA and the Provincial Government of Bataan, 2007). Fish sanctuary is a designated area where fishing or other forms of activities that may damage the ecosystem of the area are prohibited and human access is restricted.

Figure 2.167. Location of the fish sanctuary in Barangay II, Mariveles, Bataan (Map modified from PEMSEA and the Provincial Government of Bataan, 2007)

(b) Corregidor Island

To date, there have been no marine protected area or fish sanctuary as well as assemblage of artificial reefs (ARs) established around Corregidor Island. However, the entrance or mouth of Manila Bay is home for shipwrecks (or sunken ships). Just around or near Corregidor Island and Caballo Island, there are about 12 shipwrecks (Figure 67). These shipwrecks also assume the status of “artificial reef”. These hard structures provide habitat for an abundant and diverse fish fauna and diverse community of marine biofouling and/or attached organisms (hard and soft corals, sponges, barnacles, starfishes, crinoids, and mollusks), and potentially enhance the complexity of biological diversity and productivity. Among these shipwrecks, the nearest to the proposed bridge alignment is shipwreck No. 1 with an approximate distance of about 0.7 km from the alignment (see **Figure 2.168**).

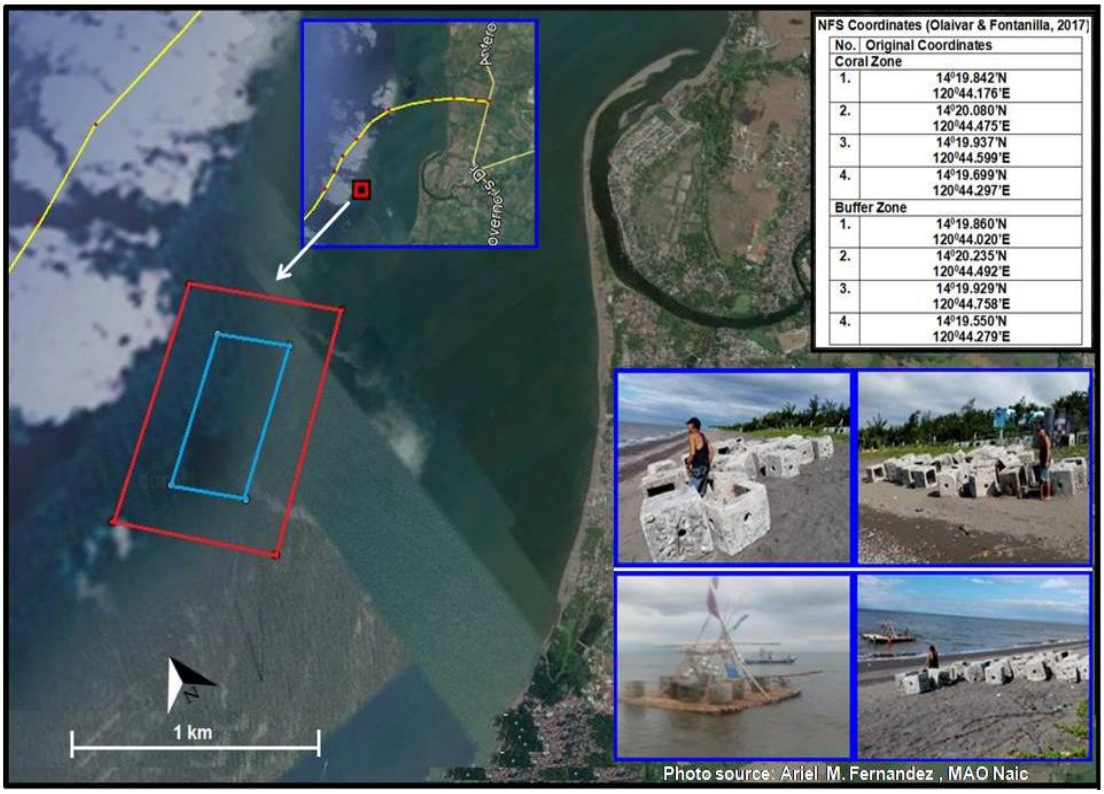


Map source: Shipwreck near BCIB Alignment by ARUP-DCCD-EcosysCorp-DPWH-IPI (Photo source: www.google.com)

Figure 2.168. Shipwrecks location around Corregidor and Caballo Islands which also assume the status of "artificial reef"

(c) Bagong Kalsada (Naic, Cavite)

Results of the field investigation conducted during this baseline study showed the presence of a fish sanctuary at Barangay Bagong Kalsada in Naic (Municipal Ordinance/Resolution No. 03 Series of 2003 - declaring a portion of the municipal waters of Brgy. Bagong Kalsada as fish sanctuary), which is located at a distance of about 3.70 km away from the proposed bridge shore approach in Timalan Concepcion and about 0.78 km away from the main bridge alignment (**Figure 2.167**). The sanctuary or the so called Naic Fish Sanctuary (NFS) is a community-based coastal resource management project co-established by the Philippine Rural Reconstruction Movement and Samahang El Gancho, and had a total area of 59.33 ha in 2003 but was apparently reduced to 20.0 ha in 2009 (Cullado and Fajardo, 2019). The location of the NFS in the area is defined by four (4) water markers or buoys with flags at the time of the baseline study. Moreover, the foodfishes caught by fishing fleet in the area are “lapu-lapu” (grouper), “banak” (mullet), “pargo” (snapper), “bagaong” (crescent grunter), “samaral” (rabbit fish), “kanduli” (sea catfish), “alamang” (small shrimp/krill) and “lato” (seaweed/sea grapes) (Cullado and Fajardo, 2019).



Note: - Figure modified from Cullado and Fajardo (2019)

Figure 2.169. Location of the Naic Fish Sanctuary (NFS), a community-based coastal resource management project, Brgy. Bagong Kalsada. Insets are photos of recruitment blocks or artificial reefs (RBs/ARs) ready for deployment within the fish sanctuary

It was also reported that a total of 40 recruitment blocks or artificial reefs (RBs/ARs) were deployed within the sanctuary only last December 2019 (see Figure 68), which accordingly said AR deployment was a joint project of BFAR and DA (Romeo Miranda, 75 years old, Bantay Dagat Adviser, pers. comm., 07 February 2020). This assemblage of ARs for coral reef enhancement will result in the beneficial development of a substantial marine biofouling community (attached forms) and an associated reef fisheries community. The addition of substantial hard substrate should be expected to alter, and potentially enhance the complexity of biological diversity and productivity. However, presumably, little or no available information for biotic communities associated with the existing fish sanctuary and ARs was observed in the area. No dive survey of the ARs was done during the present field study due to rough sea condition and very poor water visibility.

2.2.5.3.11 Marine Macrophytes (Seagrasses and Macrobenthic Algae)

Seagrass communities play two (2) primary roles in coastal ecosystems. They provided a tropic role through their direct contribution to ecosystem primary production (Zieman, 1982; Thayer et al., 1984; Murray and Wetzel, 1987) and are among the most important primary producers in shallow water habitats (Zieman and Wetzel, 1980). Seagrass also provides structure (Kenworthy et al., 1988) because seagrass stands provide surfaces for epiphytic growth and shelter to animal communities (Heck and Orth, 1980; Kenworthy et al., 1988) including commercially important fish and shrimp during at least a portion of their life cycle (Zieman, 1982). On a worldwide scale seagrass influence the global budget of carbon. Smith (1981) estimated that marine macrophytes (algae and seagrasses) impact the global C budget by sequestering as much as 10^9 tons of carbon per year.

The following information on seagrasses and macrobenthic algae (seaweeds) along the study area was taken from DENR-ERDB (2019):

> The marine macrophytes (seagrasses and macrobenthic algae) within Manila Bay Region (MBR) cover an estimated area of 130.97 ha (NAMRIA Coastal Resource Map 2015). Available information, however, is inadequate to identify the specific locations of seagrass or macroalgae within the MBR. The most recent inventory confirmed the absence of seagrass in all the identified sites. Patches of brown macroalgae *Sargassum* spp. were sighted on the rocky boulders along the coastal area of Mariveles, Bataan (**Plate 52**). None of these macroalgae was observed in Ternate and Maragondon sampling points, but green filamentous algae were conspicuous on the boulders along the coast during low tide. Anecdotal evidence revealed that cover of brown macroalgae is denser during the summer period. Surveys done in 1995 and 1996 recorded six seagrass species in Bataan (Orion-Mariveles-Corregidor-Limbones) and Cavite (Maragondon) (PEMSEA and MBEMP TWG-RRA 2004). Among the species, *Halophila ovalis*, *Halodule pinifolia*, and *Cymodocea rotundata* were numerically dominant. For the time being, the rate of seagrass decline in the MBR is difficult to infer due to insufficient baseline information.

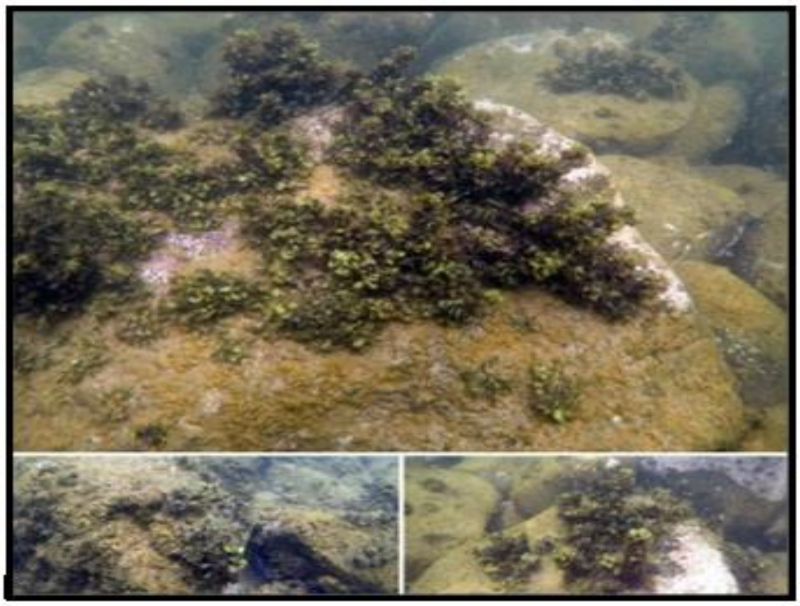


Plate 52 Clumps of brown algae *Sargassum* spp. on the reef boulders along the coast of Mariveles, Bataan (Source: DENR-ERDB, 2019)

In the present baseline survey, remains of sturdy thallus of brown algae *Sargassum*, usually the basal and rhizoid portions were found to cover some of the rock boulders along the shallow subtidal area of Alas-asin (Mariveles). Moreover, along the mixed rock-sandy beach of this area, drift material of dried *Sargassum* was also observed (**Plate 53**), but no physical evidence of dried material of seagrasses on the beach was noticed.

Some of the rocky boulders in the intertidal zone along Corregidor Island were observed to be covered by growth of macroalgae, conspicuously the brown algae *Sargassum* spp. and *Turbinaria* sp., and the green algae *Caulerpa* spp.(**Plate 54**).

Based on interview with fisherfolks of Mariveles and Cavite, the only seaweed species that they usually see is the edible "lato" (green alga *Caulerpa lentillifera*) typically found in rocky shores. Other species of seaweeds and seagrasses in the area have reportedly been depleted due to excessive sedimentation, water borne pollution, human encroachment, and destruction of submerged and fringing vegetation (Canopy International, DENR-ERDB, Vol. 26 No. 5, p.2, Sept-Oct. 2000 as cited by FDC, 2019).

Plate 53 Drift material of dried brown seaweed *Sargassum* on the beach near the proposed bridge shore approach, Alas-asin (Mariveles)

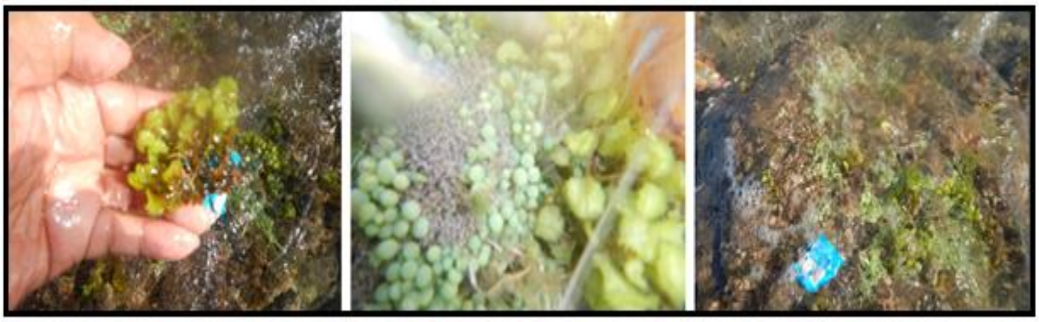


Plate 54 Growth of seaweeds *Sargassum* spp., *Turbinaria* sp., and *Caulerpa* spp. attached to rock boulders in the intertidal zone, Corregidor Island

2.2.5.3.12 Mangrove and Other Coastal Vegetation

(A) Alas-asin (Mariveles, Bataan)

A total of eight (8) sampling stations were established along the area wherein two (2) are mangrove areas (**Figure 2.170**).

Figure 2.170 Location map of the eight sampling stations at Alas-asin, Mariveles

Station 1 is a mangrove area approximately 100 m^2 extending to the beach and located almost 260 meters away from the center line of the proposed roads and bridges project. Young regenerations of bungalon (*Avicennia marina*) and pagatpat (*Sonneratia alba*) with an average diameter of 3.55 cm were recorded thriving on the rocky part of the beach (**Plate 55**). These species are also called front liners because of their ability to live and survive on high salinity and withstand on strong waves. These species are frequently seen on the mouth of a river.

Plate 55 Stands of pagatpat and bungalon thriving on rocky shore at Station 1

Station 2 is approximately 160 meters away from the center line of the proposed road and bridge project. A limited number of beach species was observed due to steepness of the land next to beach (**Plate 56**). Two (2) pieces of bungalon (*A. marina*) species with 2.5 cm diameter were recorded on the rocky part of the station. Several pieces of garbage were seen accumulating near the rocky part of the shore (**Plate 57**).

Plate 56 Arenga sp. growing on the slope at Station 2

Plate 57 Assorted garbage accumulates along the beach between Stations 2 and 3

Station 3 is center line of the proposed road and bridge project. Various species of plants were seen and recorded in this station (**Plate 58**). Large diameter species of scaevola and taluto (Pterocymbium tinctorium) can also be seen in this station. No mangrove species was observed in the area.

Plate 58 Centerline at Station 3 of the proposed road and bridge project

Station 4 is located at the mouth of Babuyan River mangrove area. This station is located 140 meters away from the center line. Pagatpat (S. alba), nipa (Nypa fruticans) and tui (*Dolichandron espathacea*) are the mangrove species thriving in the area (**Plate 59**). Putat (*Barringtonia racemosa*) is the most common associate species thriving in this area.

Plate 59 Mouth of Babuyan River at Station 4 showing nipa stand

Station 5 is located at the middle part of the Babuyan mangrove. Nipa (*N. fruticans*) and tui (*D. spathacea*) are the mangrove species found in the area (**Plate 60**). Mature stands of putat (*B. racemosa*) are thriving while ipil-ipil (*Leucaena leucocephala*) and duhat (*Syzygium cumini*) trees are also growing on the slope near the mangrove. Traps for monitor lizard were seen along the side of the mangrove.

Plate 60 Fruits of putat (left) and stand of nipa (right) at Station 5

Station 6 is located at the uppermost part of Babuyan mangrove (**Plate 61**). Nipa *(N. fruticans*) and tui (*D. spathacea*) are still the most common mangrove species recorded. Traps for monitor lizard were noticed in the mangrove area (**Plate 62**).

Plate 61 Uppermost part of Babuyan river (Station 6)

Plate 62 Trap for monitor lizard near Station 6

Station 7 is approximately 180 meters way from the centerline. The area is dominated by aroma with some coconut and large diameter kalumpang tress (Sterculia foetida) (**Plate 63**).

Plate 63 Stand of aroma on its fruiting stage thriving along the beach at Station 7

Station 8 is the farthest station which is approximately 350 meters away from the centerline. Pandan dagat (*Pandanus tectorius*) and ipil-ipil (*L. leucocephala*) are the most common tree species in the area (**Plate 64**).

Plate 64 Pandan dagat growing along the beach at Station 8

Mariveles is a coastal community of Bataan where it is usual to see people dependent on coast and marine ecosystem for livelihood. But with the rapid development of its industry, just very few people are living near the coastline. Most of the coastline are privatized and turned into resorts. Two (2) mangrove areas, however, were seen during the assessment. Nipa (N. fruticans) is the most dominant species in the upper canopy with 135.99 IV followed by talisay (Terminalia catappa) and kalumpang (Sterculia foetida) with 24.73 IV and 21.95 IV, respectively (**Table 2.62**). Nipa has the most number of individuals (105) and highest Relative dominance (64.81). Talisay is the most distributed plant in the area with 16.67 Relative frequency.

For the middle canopy, Arenga sp. is the most dominant species with 26.70 IV followed by pandan dagat (*P. tectorius*) and ipil-ipil (*L. leucocephala*) with 25.87 IV and 20.00 IV, respectively (**Table 2.63**). For the lower canopy, ipil-ipil (*L. leucocephala*) is the most dominant species with 65.54IV followed by putat (Barringtonia racemosa) and pagatpat (S. alba) with 41.22 IV and 34.12IV, respectively (**Table 2.64**). Ipil-ipil has the most number of individuals with 40.54 Relative dominance. Putat and ipil-ipil are widely distributed in the area with 25.0 Relative frequency.

A total of 28 species, 25 genera and 19 families were recorded during the inspection at Mariveles, Bataan. Three (3) exotic or introduced species were also recorded in the area (**Table 2.65**).Computation of Biodiversity indices of all sample plots showed “moderate” status while species distribution or evenness is also “moderate” which means sample plots at Mariveles, Bataan is moderately diverse and equally distributed species in all sample plots.

Table 2.62 Importance value of all species in upper canopy (20m x 20m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Nipa	Nypa fruticans	Arecaceae	3	105	58.67627811	64.81481481	12.5	135.9910929
Talisay	Terminalia catappa	Combretaceae	4	7	3.741409962	4.320987654	16.66666667	24.72906428
Kalumpang	Sterculia foetida	Malvaceae	2	3	11.76395598	1.851851852	8.333333333	21.94914116
Coconut	Cocos nucifera	Arecaceae	2	8	5.181211025	4.938271605	8.333333333	18.45281596
Tui	Dolichandrone spathacea	Bignoniaceae	2	7	2.29841997	4.320987654	8.333333333	14.95274096
Duhat	Syzygium cumini	Myrtaceae	2	3	2.838943293	1.851851852	8.333333333	13.02412848
Scaevola	Scaevola sp.	Goodeniaceae	1	8	3.156241645	4.938271605	4.166666667	12.26117992
Taluto	Pterocymbium tinctorium	Malvaceae	1	1	6.457579521	0.617283951	4.166666667	11.24153014
putat	Barringtonia racemosa	Lecythidaceae	1	7	2.238627567	4.320987654	4.166666667	10.72628189
Alagaw dagat	Premna serratifolia	Lamiaeae	1	6	1.913356895	3.703703704	4.166666667	9.783727265
Ipil-ipil	Leucaena leucocephala	Fabaceae	1	3	0.538131627	1.851851852	4.166666667	6.556650145
Binunga	Macaranga tanarius	Euphorbiaceae	1	1	0.498270025	0.617283951	4.166666667	5.282220642
Auri	*Acacia auriculiformis	Fabaceae	1	1	0.287800766	0.617283951	4.166666667	5.071751384
Balinghasai	Buchanania arborescens	Anacardiaceae	1	1	0.230400059	0.617283951	4.166666667	5.014350677
Artocarpus	Artocarpus sp.	Moraceae	1	1	0.179377209	0.617283951	4.166666667	4.963327826
				162				

(*) = Exotic species

Table 2.63 Importance value of all species in middle canopy (5m x 5m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Arenga sp.	Arenga sp.	Arecaceae	2	35	20.31488065	1.255380201	5.128205128	26.69846598
Pandandagat	Pandanus tectorius	Pandanaceae	2	41	19.27591961	1.470588235	5.128205128	25.87471297
Ipil-ipil	Leucaena leucocephala	Fabaceae	3	44	10.73206123	1.578192253	7.692307692	20.00256118
Tui	Dolichandron espathacea	Bignoniaceae	3	13	9.112675034	0.466284075	7.692307692	17.2712668
Aroma	*Acacia farnesiana	Fabaceae	2	41	10.16904883	1.470588235	5.128205128	16.76784219
Talisay	Terminalia catappa	Combretaceae	5	6	1.839947762	0.215208034	12.82051282	14.87566862
Putat	Barringtonia racemosa	Lecythidaceae	3	12	4.991656388	0.430416069	7.692307692	13.11438015
Scaevola	Scaevola sp.	Goodeniaceae	1	30	8.532249873	1.076040172	2.564102564	12.17239261
Binunga	Macaranga tanarius	Euphorbiaceae	2	11	6.634259595	0.394548063	5.128205128	12.15701279
Pagatpat	Sonneratia alba	Lythraceae	2	17	2.642385547	0.609756098	5.128205128	8.380346773
Padakaki	Tabernaemontana pandacaqui	Apocynaceae	2	7	1.143437568	0.25107604	5.128205128	6.522718736
Duhat	Syzygium cumini	Myrtaceae	2	2	1.126024813	0.071736011	5.128205128	6.325965953
Bangkoro	Morinda citrifolia	Rubiaceae	2	2	0.354059348	0.071736011	5.128205128	5.554000488
Bungalon	Avicennia marina	Acanthaceae	2	4	0.130595661	0.143472023	5.128205128	5.402272812
Botong	Barringtonia asiatica	Lecythidaceae	1	1	0.980918523	0.035868006	2.564102564	3.580889093
Dapdap	Erythrina variegata	Fabaceae	1	1	0.702314445	0.035868006	2.564102564	3.302285015
Bani	Pongamia pinnata	Fabaceae	1	4	0.371472103	0.143472023	2.564102564	3.07904669
bayok	Pterospermum diversifolium	Malvaceae	1	4	0.371472103	0.143472023	2.564102564	3.07904669
Tiesa	*Pouteria rivicoa	Sapotaceae	1	2	0.429514619	0.071736011	2.564102564	3.065353195
Balete	Ficus sp.	Moraceae	1	1	0.14510629	0.035868006	2.564102564	2.74507686
				278				

(*) = Exotic species

Table 2.64 Importance value of all species in lower canopy (1m x 1m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Dominance	Relative Frequency	Importance Value
Ipil-ipil	Leucaena leucocephala	Fabaceae	2	15	40.54054054	25	65.54054054
Putat	Barringtonia racemosa	Lecythidaceae	2	6	16.21621622	25	41.21621622
Pagatpat	Sonneratia alba	Lythraceae	1	8	21.62162162	12.5	34.12162162
Aroma	*Acacia farnesiana	Fabaceae	1	4	10.81081081	12.5	23.31081081
Nipa	Nypa fruticans	Arecaceae	1	3	8.108108108	12.5	20.60810811
binunga	Macaranga tanarius	Euphorbiaceae	1	1	2.702702703	12.5	15.2027027
				37			

(*) = Exotic species

Table 2.65 List of exotic species recorded in Mariveles (Bataan) Naic (Cavite)

Local Name	Scientific Name	Family Name
Mariveles, Bataan		
Auri	Acacia auriculiformis	Fabaceae
Aroma	Acacia farnesiana	Fabaceae
Tiesa	Pouteria rivicoa	Sapotaceae
Naic, Cavite		
Mangga	Mangifera indica	Anacardiaceae
Atis	Annona squamosa	Annonaceae
Achuete	Bixa orellana	Bixaceae
Papaya	Carica papaya	Caricaceae
Aroma	Acacia farnesiana	Fabaceae
Rain Tree	Albizia saman	Fabaceae
Fringon	Bauhinia monandra	Fabaceae
Golden Shower	Cassia fistula	Fabaceae
Kakawate	Gliricidia sepium	Fabaceae
Kamachile	Pithecellobium dulce	Fabaceae
Sampalok	Tamarindus indica	Fabaceae
Avocado	Persea gratissima	Lauraceae
Malunggay	Moringa oleifera	Moringacaea
Bayabas	Psidium guajava	Myrtaceae
Calachuchi	Plumeria sp.	Apocynaceae

(B) Corregidor Island

Three (3) sampling stations were established along the beach of Corregidor Island (**Figure 2.171**).

Figure 2.171 Location map of the 3 sampling stations

Station 1 is located almost 1 km southeast of the Corregidor Foundation Inc. (CFI) office. Large diameter species of bitaog (Calophyllum inophyllum), kalumpang (Sterculia foetida) and ipil (Instiabijuga) were recorded in the area (**Plate 65**). This station has the most number of species among the three (3) sampling stations of Corregidor. Assorted garbage were noticed along the beach near Station 1 (**Plate 66**). Station 2, on the other hand, is dominated of grasses. Pandan dagat (Pandanus tectorius) and talisay (Terminalia catappa) are the most common species in this area. Unfortunately, garbage can be seen accumulating around this station (**Plate 67**). Lastly, Station 3 is situated almost at the tip of the island and is also dominated by grass (**Plate 68**). Several coconut trees were also planted in this area.

Plate 65 Large diameter species of bitaog at Station 1

Plate 66 Pile of garbage near Station 1

Plate 67 Garbage below the grassy slope in Station 2

Plate 68 Grassland area at Station 3

Coconut (*Cocos nucifera*) is the most dominant species in the upper canopy with 106.44 IV. It is followed by bitaog (*Calophyllum inophyllum*), kalumpang (*Sterculia foetida*) and ipil (*Instia bijuga*) with 63.42 IV, 41.83 IV and 36.65 IV, respectively (**Table 2.66**). Ipil was used as rail road ties because of its hardness. It is listed as vulnerable under IUCN Red List of Threatened Species. For the middle canopy, pandan dagat (*P. tectorius*) is the most dominant with 161.53 IV followed by Arenga sp. and bangkoro with 39.98 IV and 26.94 IV, respectively (**Table 2.67**). Pandan dagat and bangkoro (*Morinda citrifolia*) are the most disperse species in the beach area with 23.08 Relative frequency.

Botong (*Barringtonia asiatica*) and talisay (*T.catappa*) were the only beach species recorded in the lower canopy with 110 IV and 90 IV, respectively (**Table 2.68**). The small number of beach species growing in the area may be due to limited space available and the site is frequently hit by strong waves during habagat or amihan.

A total of 11 species, 11 genera and 11 families were recorded during the assessment at Corregidor Island. No exotic species was recorded in the area. Likewise, there is no mangrove area near the proposed site. Computation of Biodiversity indices of the three (3) sample plots showed "low" status while species distribution or evenness is "moderate" meaning there are few species thriving but species are equally distributed in all sample plots.

Piles of garbage are seen from Stations 1 to 3. This may be coming from neighboring towns brought in by tides or currents.

Table 2.66 Importance value of all species in lower canopy (20m x 20m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Coconut	Cocos nucifera	Arecaceae	1	6	26.43797131	60	19.999996	106.4379673
Bitaog	Calophyllum inophyllum	Clusiaceae	1	1	53.41564394	10	0	63.41564394
Kalumpang	Sterculia foetida	Malvaceae	1	1	11.82906994	10	19.999996	41.82906594
Ipil	Instia bijuga	Fabaceae	1	1	6.653851841	10	19.999996	36.65384784
Botong	Barringtonia asiatica	Lecythidaceae	1	1	1.66346296	10	19.999996	31.66345896
			3	10				

Table 2.67 Importance value of all species in lower canopy (5m x 5m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Pandan dagat	Pandanus tectorius	Pandanaceae	3	80	68.88809694	69.56521739	23.07694083	161.5302552
Arenga	Arenga sp.	Arecaceae	1	15	19.24447612	13.04347826	7.692313609	39.98026799
Bangkoro	Morinda citrifolia	Rubiaceae	3	4	0.383107627	3.47826087	23.07694083	26.93830932
Coconut	Cocos nucifera	Arecaceae	1	5	8.731290093	4.347826087	7.692313609	20.77142979
Talisay	Terminalia catappa	Combretaceae	2	4	0.882038489	3.47826087	15.38462722	19.74492658
Bitaog	Calophyllum inophyllum	Clusiaceae	1	5	0.57911618	4.347826087	7.692313609	12.61925588
Binunga	Macaranga tanarius	Euphorbiaceae	1	1	1.282965075	0.869565217	7.692313609	9.844843902
Alagaw dagat	Premna serratifolia	Lamiaeae	1	1	0.00890948	0.869565217	7.692313609	8.570788307
			3	114				

Table 2.68 Importance value of all species in lower canopy (1m x 1m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Dominance	Relative Frequency	Importance Value
Botong	Barringtonia asiatica	Lecythidaceae	2	3	60	50	110
Talisay	Terminalia catappa	Combretaceae	2	2	40	50	90
				5			

(C) Naic, Cavite

A total of 15 sampling stations were established along the beach wherein four (4) of the sample plots are mangrove areas (**Figure 2.172**).

Figure 2.172 Location map of the 15 sampling stations at Naic, Cavite

Stations 1-3 are mangrove areas located at Barangay Timalan Balsahan. Station 1 is located near Timalan Bridge (**Plate 69**). Nipa (*Nypa fruticans*), avicennia, pagatpat (*Sonneratia alba*), tabigi (*Xylocarpus granatum*) and bakauan babae (Rhizophora mucronata) are the common mangrove species thriving in the area (**Plate 70** and **Plate 71**). The mouth of Timalan Balsahan River is approximately 0.7 km from the centerline of the proposed road project (see **Figure 2.172**). These areas are full of oyster farms and communities which can be found in the vicinity. Mangroves present in this area are visibly small but thriving.

Plate 69 Location of Station 1 near Timalan Bridge

Plate 70 Bakauan babae planted along Timalan River at Station 2

Plate 71 Wildlings and pneumatophore roots of Avicennia species seen along the river inside Station 3 at Barangay Timalan Balsahan

Stations 4 and 5 are located along the beach of Barangay Timalan (**Plate 72** and **Plate 73**). Large diameter species of talisay (*Terminalia catappa*), kamachile (*Pithecellobium dulce*), coconut and aroma are the common species found in these two (2) stations.

Plate 72 Big talisay trees, bani and kamachile inside Station 4 at Barangay Timalan Balsahan

Plate 73 Large diameter species of aroma at Station 5

Station 6 is near the centerline of the proposed road and bridge project (**Plate 74**). This station has several houses around which are surrounded by large diameter species of kamachile (P. *dulce*) and malunggay (*Moringa oleifera*) as well as fruit trees like guava (*Psidium guajava*), santol (*Sandoricum koetjape*), mango (*Mangifera indica*) and atis (**Annona squamosal*). These trees are planted and cared by the community. Clumps of kawayan tinik (*Bambusa blumeana*) were also seen growing sparsely outside the plot.

Plate 74 Location of the centerline at Station 6 with coconut and talisay trees growing around several houses

Station 7 is located inside Maria Estela private resort. Big trees species of mango (*M. indica*), sampaloc (*Tamarindus indica*) and kamachile (*P. dulce*) with a diameter as large as 110 cm were recorded in this area (**Plate 75**). No regeneration was seen nor recorded here because of regular land clearing or grass cutting as maintenance activity of the resort. Station 8 is located at Villa Criselda Resort (**Plate 76**). Coconut (*Cocos nucifera*), talisay (*T. catappa*) and bani (*Pongamia pinnata*) are the common species grown and maintained in the area.

Plate 75 Large diameter species of mango with 110 cm at Maria Estela Resort (Station 7)

Plate 76 Station 8 at Villa Criselda with house surrounded of trees (bani, talisay and rain tree)

Station 9 is a small mangrove area located at the mouth or outfall of the creek at the back of Aroma beach (**Plate 77**). Mangrove species such as bungalon (*Avicennia marina*), buta-buta (*Excoecaria agallocha*) and pototan lalaki (*Bruguiera sexangula*) are thriving in the area. These trees are growing along the river banks.

Plate 77 Strip of mangrove species at Station 9 growing along the waterway at the back of Aroma Beach

Station 10 is located at Barangay Munting Mapino. Coconut (*C. nucifera*), mango (*M. indica*), duhat (*Syzygium cumini*) and nangka (*Artocarpus heterophyllus*) are the common fruit trees in the area. Botong (*Barringtonia asiatica*) was observed to be in its flowering stage (

Plate 78). Station 11 is located at Naic Healing Beach Resort (**Plate 79**). Coconut (*C. nucifera*) and talisay (*T. catappa*) with an average diameter of 35 cm are the common species in the area.

Plate 78 Big balete tree at Station 9 (left) and botong tree on its flowering stage

Plate 79 Large diameter species of talisay at Naic Healing Beach Resort (Station 11)

Station 12 is located at Bukanang Maliit mangrove area. Bakauan babae (*Rhizophora mucronata*), buta-buta (*E. agallocha*) and nipa (*N. fruticans*) are the common mangrove species while talisay (*T. catappa*) and alagaw dagat (*Premna serratifolia*) are the beach species growing in the vicinity. Bakauan babae (R. mucronata) was seen in its flowering stage (**Plate 80**). The mangrove area is located approximately 2.9 km from the centerline of the proposed road and bridge project.

Plate 80 Station 12 at Bukanang Maliit with bakauan babae on fruiting stage (right)

Stations 13 and 14 are situated at Barangay Sapa. Strips of bakauan babae (*R. mucronata*), planted in 2007 are on its fruiting stage (**Plate 81**). The planting of mangrove propagules was initiated by Cavite College of Fisheries. Nipa (*N. fruticans*) is also a common mangrove species in the area and known to be a source of local wine lambanog (**Plate 82**). According to the guide, locals used to harvest nipa for wine production ("lambanog"). However, there were no signs of harvesting of nipa leaves. Thus, this indicates that locals have already stopped their practice of wine making.

Plate 81 Stand of bakauan babae at Station 13 planted in 2007 initiated by Cavite College of Fisheries

Plate 82 Stand of nipa with fruits at Station 14 at Barangay Sapa

Station 15 is the farthest among the four (4) mangrove areas. It is located approximately 4.5 km from the centerline of the proposed road and bridge project. It is located at Barangay Mabolo with an area of approximately 1,000 sqm. The area is planted with bakauan babae (*R. mucronata*) (**Plate 83**). The planting activity was initiated by BFAR CALABARZON last September 2019. Approximately 3,000 propagules were planted in the area. Nipa (N. fruticans), bakauan babae (*R. mucronata*), Sonneratia sp., buta-buta (*E. agallocha*) and pototan lalaki (*B.*

sexangula) are the common species thriving in the area. Aroma (*A. farnesiana*), coconut (*C. nucifera*), and ipil-ipil (*Leucaena leucocephala*) were also recorded in this region.

Plate 83 Propagules of bakauan babae planted at Station 15 at Barangay Mabolo

Naic is a coastline community in Cavite wherein people are dependent on coastal and marine ecosystems for livelihood. Aside from fishing, oyster farming is flourishing in the area. Four (4) mangrove areas were seen during the assessment. Nipa (*N. fruticans*) is the most dominant species in the upper canopy with 86.56 IV followed by coconut (C. nucifera) with 56.04 IV and talisay (T. catappa) with 24.36 IV (**Table 2.69**). Relative dominance showed nipa and coconut have the most number of individuals with 39.32 and 22.75, respectively. Coconut and talisay, on the other hand, are the most distributed or widely spread and commonly planted species in the area with 14.71 and 10.29 Relative frequency. The average diameter of trees in the upper canopy is 31.91cm. Large diameter species of mango (M. indica), sampaloc (*Tamarindus indica*) and coconut are just among the common plants being grown in the area. Twenty-six species were recorded in the upper canopy of which six (6) are true mangrove species, eight (8) are beach or associate species and 12 are non-mangrove or mixed species that usually grow in the upland.

For the middle canopy, bakauan babae (*R. mucronata*) is the most dominant species with 41.87 IV followed by aroma and ipil-ipil (L. leucocephala) with 28.30 IV and 26.97 IV, respectively (**Table 2.70**). Bakauan babae has the highest number of individuals recorded with Relative dominance value of 26.4 followed by aroma (11.2).

For the lower canopy, bungalon (*Avicennia marina*) is the most dominant species with 46.69 IV followed by bani (*Millettia pinnata*) (38.52 IV) and bakauan babae (28.58 IV) (**Table 2.71**).

A total of 41 species, 27 genera and 21 families were recorded during the inspection at Naic, Cavite. Fifteen exotic or introduced species were also recorded in the area (see **Table 2.71**). Some of these species were planted long ago by the communities for subsistence like fruit trees and for other individual uses. Computation of Biodiversity indices of all sample plots showed "moderate" status while species distribution or evenness is also "moderate" meaning sampling plots at Naic is moderately diverse and equally distributed species in all sample plots.

Table 2.69. Importance value of all species in upper canopy (20m x 20m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Nipa	Nypa fruticans	Arecaceae	6	140	38.41924036	39.3258427	8.8235359	86.56861895
Coconut	Cocos nucifera	Arecaceae	10	81	18.57786379	22.75280899	14.70589317	56.03656595
Talisay	Terminalia catappa	Combretaceae	7	26	6.766828828	7.303370787	10.29412522	24.36432483
Mangga	Mangifera indica	Anacardiaceae	5	11	12.0331462	3.08988764	7.352946583	22.47598042
Kamachile	*Pithecellobium dulce	Fabaceae	4	7	8.122067531	1.966292135	5.882357266	15.97071693
Bani	Pongamia pinnata	Fabaceae	4	13	3.728347156	3.651685393	5.882357266	13.26238982
Bungalon	Avicennia marina	Acanthaceae	3	11	1.763203012	3.08988764	4.41176795	9.264858602
Buta-buta	Excoecaria agallocha	Euphorbiaceae	2	14	1.934408752	3.93258427	2.941178633	8.808171655
Malungai	*Moringa oleifera	Moringacaea	3	11	0.918940205	3.08988764	4.41176795	8.420595796
Sampaloc	*Tamarindus indica	Fabaceae	3	3	2.671337806	0.842696629	4.41176795	7.925802385
Aroma	*Acacia farnesiana	Fabaceae	2	13	0.926143813	3.651685393	2.941178633	7.519007839
Piapi	Avicennia marina var. rumphiana	Acanthaceae	2	4	0.334487511	1.123595506	2.941178633	4.39926165
Duhat	Syzygium cumini	Myrtaceae	2	2	0.555638264	0.561797753	2.941178633	4.05861465
Kakawate	*Gliricidia sepium	Fabaceae	2	3	0.251646024	0.842696629	2.941178633	4.035521287
Ipi-ipil	Leucaena leucocephala	Fabaceae	2	3	0.176968626	0.842696629	2.941178633	3.960843888
Balete	Ficus sp.	Moraceae	1	1	1.536769614	0.280898876	1.470589317	3.288257807
Sonneratia	Sonneratia sp.	Lythraceae	1	4	0.278299372	1.123595506	1.470589317	2.872484195
Malibago	Talipariti tiliaceum	Malvaceae	1	1	0.150075158	0.280898876	1.470589317	1.901563351
Rain tree	*Albizia saman	Fabaceae	1	1	0.150075158	0.280898876	1.470589317	1.901563351
Santol	Sandoricum koetjape	Meliaceae	1	1	0.150075158	0.280898876	1.470589317	1.901563351
Botong	Barringtonia asiatica	Lecythidaceae	1	1	0.116218202	0.280898876	1.470589317	1.867706395
Alagaw dagat	Premna serratifolia	Lamiaceae	1	1	0.096048101	0.280898876	1.470589317	1.847536294

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Bayok	Pterospermum diversifolium	Malvaceae	1	1	0.096048101	0.280898876	1.470589317	1.847536294
Golden shower	*Cassia fistula	Fabaceae	1	1	0.096048101	0.280898876	1.470589317	1.847536294
Nangka	Artocarpus heterophyllus	Moraceae	1	1	0.096048101	0.280898876	1.470589317	1.847536294
Bakauanbabae	Rhizophora mucronata	Rhizophoraceae	1	1	0.054027057	0.280898876	1.470589317	1.80551525
				356				

(*) = Exotic species

Table 2.70. Importance value of all species in middle canopy (5m x 5m). Legend: * Exotic species

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Bakauan babae	Rhizophora mucronata	Rhizophoraceae	6	33	0.086918731	26.4	15.38461538	41.87153412
Aroma	*Acacia farnesiana	Fabaceae	3	14	9.408952629	11.2	7.692307692	28.30126032
Ipil-ipil	Leucaena leucocephala	Fabaceae	2	8	15.44980443	6.4	5.128205128	26.97800956
Buta-buta	Excoecaria agallocha	Euphorbiaceae	1	10	15.88439809	8	2.564102564	26.44850065
Malungai	*Moringa oleifera	Moringacaea	2	4	7.062146893	3.2	5.128205128	15.39035202
Bungalon	Avicennia marina	Acanthaceae	1	6	6.692742286	4.8	2.564102564	14.05684485
Banana	Musa sp.	Musaceae	1	2	7.344632768	1.6	2.564102564	11.50873533
Mangga	Mangifera indica	Anacardiaceae	2	2	4.389395915	1.6	5.128205128	11.11760104
Kalachuchi	*Plumeria sp.	Apocynaceae	1	7	2.433724468	5.6	2.564102564	10.59782703
Atis	*Annona squamosa	Annonaceae	1	1	6.562364189	0.8	2.564102564	9.926466754
Talisay	Terminalia catappa	Combretaceae	1	5	2.716210343	4	2.564102564	9.280312907
Calamansi	xCitrofortunella microcarpa	Rutaceae	1	7	0.782268579	5.6	2.564102564	8.946371143
Dalanghita	Citrus reticulata	Rutaceae	1	7	0.347674924	5.6	2.564102564	8.511777488
Pagatpat	Sonneratia alba	Lythraceae	2	2	0.499782703	1.6	5.128205128	7.227987831
Bani	Pongamia pinnata	Fabaceae	1	1	3.672316384	0.8	2.564102564	7.036418948
Bayok	Pterospermum diversifolium	Malvaceae	1	1	3.672316384	0.8	2.564102564	7.036418948

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Density	Relative Dominance	Relative Frequency	Importance Value
Kakawate	*Gliricidia sepium	Fabaceae	1	1	3.672316384	0.8	2.564102564	7.036418948
Tabigi	Xylocarpus granatum	Meliaceae	1	2	2.129508909	1.6	2.564102564	6.293611473
Piapi	Avicennia marina var. rumphiana	Acanthaceae	1	2	2.129508909	1.6	2.564102564	6.293611473
Pototan	Bruguiera sexangula	Rhizophoraceae	1	1	1.825293351	0.8	2.564102564	5.189395915
Hauili	Ficus septica	Moraceae	1	1	1.760104302	0.8	2.564102564	5.124206867
Fringon	*Bauhinia monandra	Fabaceae	1	2	0.217296827	1.6	2.564102564	4.381399392
Alagaw dagat	Premna serratifolia	Lamiaceae	1	1	0.347674924	0.8	2.564102564	3.711777488
Podocarpus	Podocarpus sp.	Podocarpaceae	1	1	0.347674924	0.8	2.564102564	3.711777488
Pandakaki	Tabernaemontana pandacaqui	Apocynaceae	1	1	0.195567145	0.8	2.564102564	3.559669709
santol	Sandoricum koetjape	Meliaceae	1	1	0.195567145	0.8	2.564102564	3.559669709
Avocado	*Persea gratissima	Lauraceae	1	1	0.086918731	0.8	2.564102564	3.451021295
Guava	*Psidium guajava	Myrtaceae	1	1	0.086918731	0.8	2.564102564	3.451021295

Table 2.71. Importance value of all species in lower canopy (1m x 1m)

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Dominance	Relative Frequency	Importance Value
Bungalon	Avicennia marina	Acanthaceae	3	39	33.05084746	13.63636361	46.68721106
Bani	Pongamia pinnata	Fabaceae	4	24	20.33898305	18.18181814	38.52080119
Bakauan babae	Rhizophora mucronata	Rhizophoraceae	2	23	19.49152542	9.09090907	28.58243449
Nipa	Nypa fruticans	Arecaceae	2	6	5.084745763	9.09090907	14.17565483
Buta-buta	Excoecaria agallocha	Euphorbiaceae	1	10	8.474576271	4.545454535	13.02003081
Mangga	Mangifera indica	Anacardiaceae	2	2	1.694915254	9.09090907	10.78582432
Aroma	*Acacia farnesiana	Fabaceae	1	4	3.389830508	4.545454535	7.935285044
Talisay	Terminalia catappa	Combretaceae	1	3	2.542372881	4.545454535	7.087827416
Papaya	*Carica papaya	Caricaceae	1	2	1.694915254	4.545454535	6.240369789
Achuete	*Bixaorellana	Bixaceae	1	1	0.847457627	4.545454535	5.392912162

Common Name	Scientific Name	Family Name	Number of Plots	Number of Individuals	Relative Dominance	Relative Frequency	Importance Value
Atis	*Annona squamosa	Annonaceae	1	1	0.847457627	4.545454535	5.392912162
Dalanghita	Citrus reticulata	Rutaceae	1	1	0.847457627	4.545454535	5.392912162
Guava	*Psidium guajava	Myrtaceae	1	1	0.847457627	4.545454535	5.392912162
Piapi	Avicennia marina var. rumphiana	Acanthaceae	1	1	0.847457627	4.545454535	5.392912162
				118			

The highlights of the assessment for mangrove and other coastal vegetation include the following:

- The Shannon biodiversity index showed “very low” for Corregidor Island area and “moderate” for Mariveles, Bataan and Naic, Cavite areas. In terms of evenness index, all areas are considered “moderate”;
- A total of 28 species, 25 genera and 19 species were recorded at Marivelez, Bataan;
- A total of 11 species, 11 genera and 11 species were recorded at Corregidor Island;
- A total of 41 species, 27 genera and 21 families were recorded at Naic, Cavite;
- Naic Cavite area has the most number of species recorded followed by Mariveles, Bataan area while Corregidor Island area has the least number of species;
- A total of 15 exotic or introduced species was recorded in Naic, Cavite, 3 at Mariveles, Bataan and none at Corregidor Island;
- Ipil, listed as vulnerable under IUCN Red List of Threatened Species, was seen at Corregidor; and
- Piles of garbage can be seen at Stations 2 and 3 of Mariveles and at all sample plots of Corregidor and its shoreline at the time of assessment.

2.2.5.3.13 Protected Marine Species (Threatened or Endangered Species)

The Philippine Environmental Impact System (EIS) addresses species accorded with protected status under Republic Act No. 9147 (the Wildlife Resources Conservation and Protection Act of 2001). In the same vein, Republic Act No. 8550 (the Fisheries Code of 1998), authorizes Department of Agriculture (DA) to protect all species listed under the Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna Appendices I and II (**Table 2.72**). Harming these protected species is a criminal act that can be penalized by Philippine courts with imprisonment up to 12 years, fines up to P1 million or both.

Ascertaining the presence of protected marine species in any project impact area is one way of ensuring compliance with environmental protection laws.

Table 2.72. List of Marine Protected Vertebrate Species in the Philippines with Protection and Conservation Status based on CITES Appendix listing and IUCN Red List criteria and categories (Legend: CR = critically endangered; DD = data deficient; EN = endangered; LR/cd = lower risk, conservation dependent; V = vulnerable).

Taxa	Common Name	CITES	Red List 2000
CLASS ELASMOBRANCHII			
Order ORECTOLOBIFORMES			
Family Rhincodontidae			
1. *Rhincodon typus* Smith, 1828	Whale shark	Appendix II	VU A1bd+2d
Order RAJIFORMES			
Family Mobulidae			
Manta virostris (Walbaum, 1792)	Manta ray		DD
CLASS REPTILIA			
Order TESTUDINATA			
Family Cheloniidae			

Taxa	Common Name	CITES	Red List 2000
1. *Chelonia mydas* (Linnaeus, 1758)	Green turtle	Appendix I	EN A1bd
2. Eretmochelys imbricata (Linnaeus, 1766)	Hawksbill turtle	Appendix I	CR A1bd
3. Lepidochelys olivacea (Eschscholtz, 1829)	Olive ridley turtle	Appendix I	EN A1bd
4. Caretta caretta (Linnaeus, 1758)	Loggerhead turtle	Appendix I	EN A1abd
Family Dermochelyidae			
1. *Dermochelys coriacea* (Vandelli, 1761)	Leatherback turtle	Appendix I	CR A1abd
CLASS MAMMALIA			
Order CETACEA			
Family Balaenopteridae			
1. *Balaenoptera physalus* (Linnaeus, 1758)	Fin whale	Appendix I	EN - AIabd
2. Balaenoptera edeni Anderson, 1878	Bryde’s whale	Appendix I	DD
3. Megaptera novaeangliae (Borowski, 1781)	Humpback whale	Appendix I	VU A1ad
Suborder MYSTICETI			
Family Delphinidae			
1 *Feresa attenuata* Gray, 1875	Pymy killer whale	Appendix II	DD
2. *Globicaphala macrorohynchus* Gray, 1846	Short-finned pilot whale	Appendix II	LR/cd
3. *Grampus griseus* (G. Cuvier, 1812)	Risso’s dolphin	Appendix II	DD
4. *Lagenodelphis hosei* Frazer, 1956	Fraser’s dophin	Appendix II	DD
5. *Orcaella brevirostris* (Gray, 1866)	Irrawaddy dolphin	Appendix II	DD
6. *Orcinus orca* (Linnaeus, 1758)	Killer whale	Appendix II	LR/cd
7. *Sousa chinensis* (Osbeck, 1765)	Indo-pacific humpback dolphin	Appendix I	DD
8. *Peponocephala electra* (Gray, 1846)	Melon-headed whale	Appendix II	LR/lc
9. *Pseudorca crassidens* (Owen, 1846)	False killer whale	Appendix II	LR/lc
10. *Stenella attenuata* (Gray, 1846)	Pantropical spotted dolphin	Appendix II	LR/cd
11. *Stenella longirostris* (Gra,1828)	Spinner dolphin	Appendix II	LR/cd
12. *Steno bredanensis* (Lesson, 1828)	Roughed toothed dolphin	Appendix II	DD
13. *Stenella coeruleoalba* (Meyen, 1833)	Striped dolphin	Appendix II	LR/cd

Taxa	Common Name	CITES	Red List 2000
14. *Tursiops truncatus* (Montagu, 1821)	Bottlenose dolphin	Appendix II	DD
Family Kogiidae			
1. *Kogia sima* Owen, 1866	Dwarf sperm whale	Appendix II	LR/lc
Family Physeteridae			
1. *Physeter catodon* Linnaeus, 1766	Sperm whale	Appendix I	VU A1bd
Family Ziphiidae			
1. *Mesoplodon densirostris* (de Blainville, 1817)	Blainville's beaked whale	Appendix II	DD
2. *Ziphius cavirostris* G. Cuvier, 1823	Cuvier's beaked whale	Appendix II	DD
Order SIRENIA			
Family Dugongiidae (sea cow)			
1. *Dugong dugon* (Müller, 1776)	Dugong	Appendix I (except Australian population)	VU A1cd (IUCN 2002)
CLASS ACTINOPTERYGII			
Order SYNGNATHIFORMES			
Family Syngnathidae			
1. *Hippocampus barbouri* Jordan and Richardson, 1908	Barbour's seahorse	Appendix II for all *Hippocampus* spp. (Enters into effect on 15 May 2004)	VU A4cd
2. *Hippocampus bargibanti* Whitley, 1970	Pygmy seahorse		DD
3. *Hippocampus comes* Cantor, 1850	Tiger tail seahorse		VU A2cd
4. *Hippocampus kelloggi* Jordan and Snyder, 1902	Great seahorse		DD
5. *Hippocampus kuda Bleeker*, 1852	Common seahorse		VU A2cd
6. *Hippocampus spinosissimus* Weber, 1913	Hedgehog seahorse		VU A2cd
7. *Hippocampus trimaculatus* Leach, 1814	Flat-faced seahorse		VU A1cd+2cd
(Legend: CR = critically endangered; DD = data deficient; EN = endangered; LR/cd = lower risk, conservation dependent; V = vulnerable)			

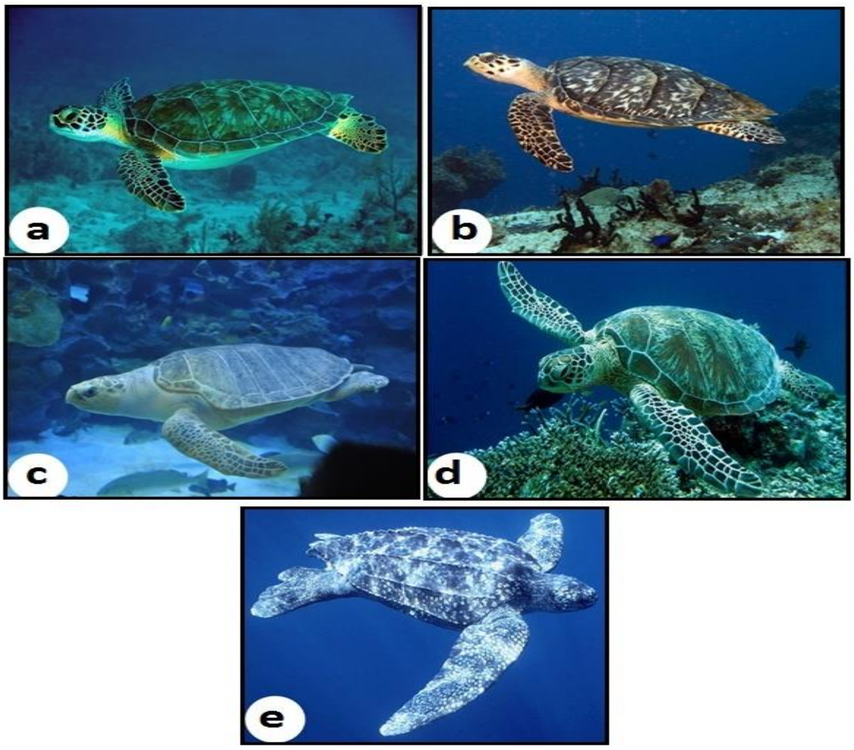
Source: Taken from Alava and Cantos (2004)

i. Marine Turtles

Out of the seven (7) species of marine turtles worldwide, five (5) species are found in almost all the seas in the Philippines, namely: (1) the green turtle (*Chelonia mydas*), (2) the hawksbill (*Eretmochelys imbricata*), (3) the olive ridley (*Lepidochelys olivacea*), (4) the loggerhead

(*Caretta caretta*), and (5) the leatherback (*Dermochelys coriacea)* (**Plate 84**). However, the green turtle, hawksbill, and olive ridley have been found to occur nationwide with nesting recorded in the western coast of Luzon, particularly in Batangas, Cavite, Bataan, and Zambales. All three (3) species are listed in CITES Appendix I. Moreover, the International Union on the Conservation of Nature and Natural Resources (IUCN) categorizes the olive ridley turtle and green turtle as "endangered" while the hawksbill turtle is "critically endangered" (Alava and Cantos, 2004). Additionally, DAO 2004-15 also classifies hawksbill turtles as "critically endangered" (DENR, 2004).

Critically Endangered Species refers to a species or subspecies facing extremely high risk of extinction in the wild in the immediate future. *Endangered Species* refers to a species or subspecies that is not critically endangered but whose survival in the wild is unlikely if the causal factors continue operating. This shall include varieties, formae or other intraspecific categories (DAO 2007-01).



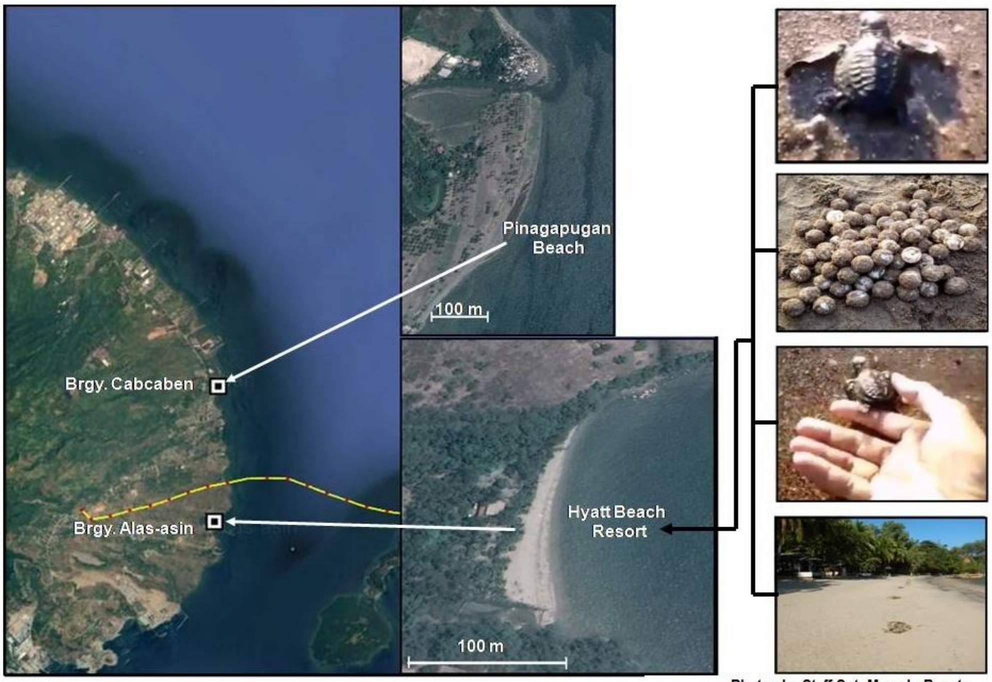
Photos Source: Google

Plate 84 The five marine turtle species known to be present in the Philippines: (a) the green turtle (*Chelonia mydas*), (b) the hawksbill (*Eretmochelys imbricata*), (c) the olive ridley (*Lepidochelys olivacea*), (d) the loggerhead (*Caretta caretta*), and (e) the leatherback (*Dermochelys coriacea)*

Based on the data/records of the PENRO, MAO, FARMC and Bantay Dagat, and from the results of the site inspection of the turtle nesting beaches in the area during the baseline survey, the olive ridley (**Plate 85**) is the most frequently observed and reported among the marine turtle species present in Manila Bay. This species was confirmed in this present baseline survey to nest in two (2) beaches of Mariveles in Bataan, namely: Hyatt Beach Resort in Brgy. Alas-asin and Pinagapugan Beachfront in Brgy. Cabcaben (Lat. 14°25'55.20"N and Long. 120°34'12.20"E and Lat. 14°27'33.13"N and Long. 120°35'56.42"E, respectively, **Figure 2.173**). The former is located south of the bridge shore approach (about 1.28 km away) while the latter is located north of the bridge shore approach (about 3.10 km away) (see **Figure 2.173**). For the Cavite side in Naic, the olive ridley had also records of nesting at Labac Beachfront (Lat. 14°19'23.90"N and Long. 120°45'10.80"E) which is located south of the proposed shore approach (about 3.45 km away and about 2.81 km away from the main bridge alignment) (**Figure 2.174**).

Photo source: Internet

Plate 85 Olive Ridley on the Beach



Photos by Staff Sgt. Marcelo Ronato
(Retired Marines, Security Guard of the Hyatt Beach Resort)

Figure 2.173. Pinagapugan "pawikan" nesting beach (Brgy. Cabcaben) and Hyatt Beach Resort "pawikan" nesting beach (Brgy. Alas-asin), Mariveles, Bataan

Figure 2.174. Labac "Pawikan" Nesting Beach (Brgy. Labac), Naic, Cavite

The town of Naic, where 10 of its barangays are located, annually celebrates the "Pawikan Festival" to drumbeat PENRO's information campaign to save the sea turtles which are now in its vulnerable stage to be endangered due to irresponsible killing for meat and illegal trade of its shells and other body parts. PENRO Information Officer and Focal Person of Manila Bay Coordinating Office Judaline Fabro said, that in terms of egg emergence and percentage of returning sea turtles to Naic's coastlines, from 300-700 since they started the campaign seven (7) years ago, "it (the number) increased to thousands; the highest so far is 1,900" (https://www.pna.gov.ph/articles/1026405).

The nesting season for olive ridley is August to February, particularly in Bataan and Zambales provinces (ADB, 2014). An apparent peak season occurs from November to February (Manolo Ibias, Chairman Bantay Pawikan, Inc., Morong, Bataan, pers. comm., 28 February 2020). The olive ridley nesting season near the proposed project site seemed to coincide well with the season reported for the same species in Morong and Subic Bay (**Figure 2.175**).

Exploitation of turtle populations in various parts of the world has usually centered on the nesting beaches. Whether or not the present level of such interference is adversely affecting the turtle population, it is clear that any large increase of human activity on the nesting beaches would result in the rapid disappearance of sea turtles from Manila Bay and neighboring areas. Turtle eggs, baby turtles and even the adult females on the beach have no real protection against many kinds of predators (humans, dogs, rats, or other animals) common on beaches. Both the size of the nesting population and the volume of eggs produced are indicators of the status and degree of abundance of marine turtles.

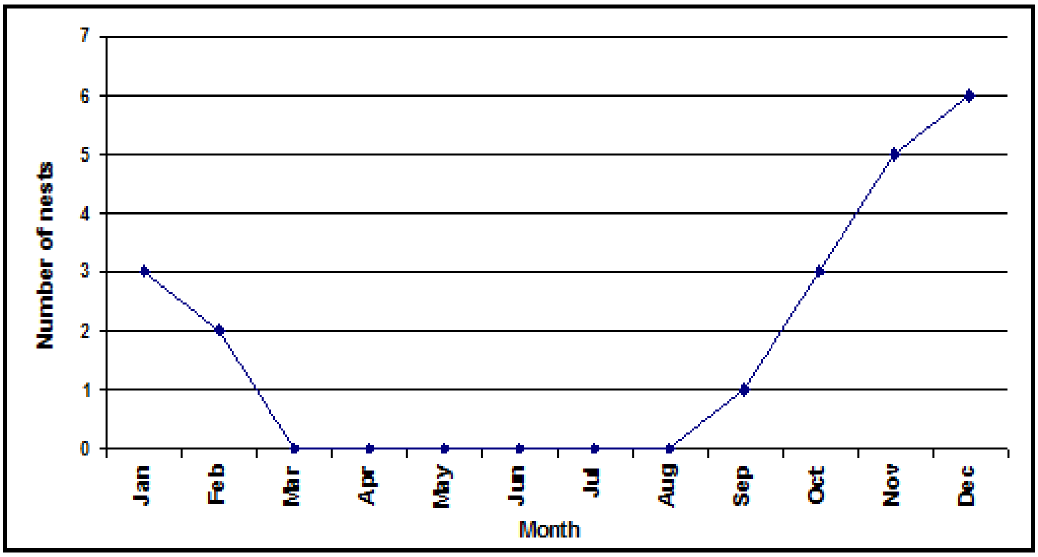


Figure 2.175. Graph of Marine Turtle Nestings including False Crawls (Data Source: SBMA Ecology Center and Internet Sources)

ii. Dolphins and Whales

Cetaceans (dolphins and whales) are protected by virtue of their listing in the CITES Appendices I and II. Strandings of dolphins and whales have been observed in Manila Bay and adjacent areas of Bataan and Zambales. According to Marine Wildlife Watch of the Philippines or MWWP (2014), a stranding is the occurrence of a marine mammal on the beach, in shallow water, or accidentally trapped or entangled outside of its normal habitat and is unable to return to their natural habitat without assistance. The animal could be dead or alive. It is also called beaching.

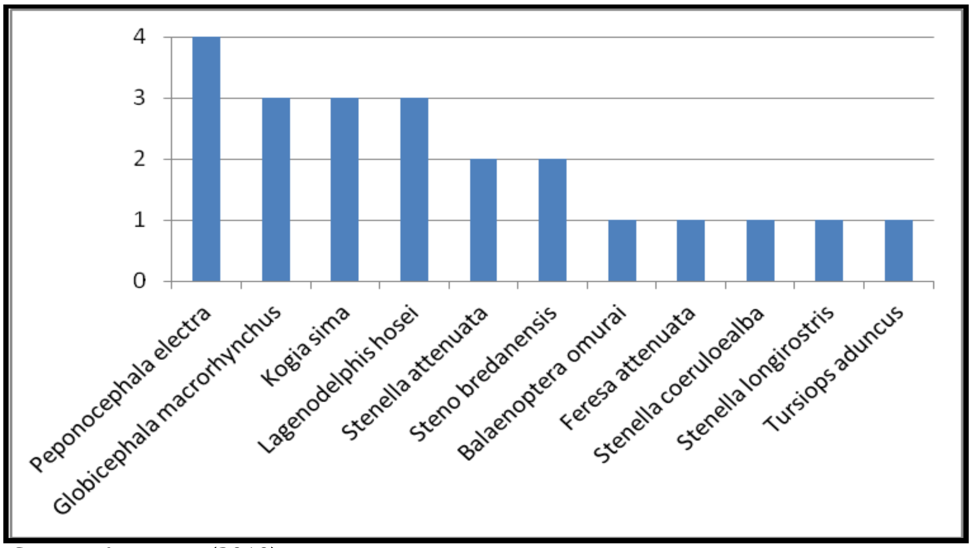
Aragones (2010) identified 22 individuals belonging to 11 species of cetaceans which have stranded in Zambales, Bataan and Manila Bay within a 100-kilometer radius of the neighboring Subic Bay area between 2003 and 2009 (**Table 36**). This constitutes a high proportion (12%) of stranded cetaceans reported by Aragones (2010) for the entire Philippines for the said period. The species reported include: (1) pygmy killer whale, (2) pantropical spotted dolphin, (3) melon-headed whales, (4) dwarf sperm whale, (5) Fraser’s dolphin, and (6) spinner dolphin.

Table 2.73. List of stranded cetaceans in Zambales, Bataan and Manila Bay within 100- kilometer radius of the neighboring Subic Bay

Date	Province	Common English Name	Scientific Name
1997	Zambales	Short-finned pilot whale	*Globicephala macrorhynchus*
2003	Bataan	Indo-pacific bottlenose dolphin	*Tursiops aduncus*
2003	Zambales	Dwarf sperm whale	*Kogia sima*
2003	Zambales	Pygmy killer whale	*Feresa attenuata*
2003	Zambales	Melon-headed whale	*Peponocephala electra*
2004	Zambales	Rough-toothed dolphin	*Steno bredanensis*
2004	Zambales	Fraser's dolphin	*Lagenodelphis hosei*
2004	Zambales	Dwarf sperm whale	*Kogia sima*
2004	Bataan	Striped dolphin	*Stenella coeruloealba*
2004	Bataan	Pantropical spotted dolphin	*Stenella attenuata*
2005	Subic Bay	Spinner dolphin	*Stenella longirostris*
2005	Zambales	Fraser's dolphin	*Lagenodelphis hosei*
2005	Bataan	Melon-headed whale	*Peponocephala electra*
2006	Zambales	Short-finned pilot whale	*Globicephala macrorhynchus*
2006	Bataan	Rough-toothed dolphin	*Steno bredanensis*
2006	Zambales	Pantropical spotted dolphin	*Stenella attenuata*
2006	ManilaBay	Dwarf sperm whale	*Kogia sima*
2006	Zambales	Short-finned pilot whale	*Globicephala macrorhynchus*
2008	Bataan	Short-finned pilot whale	*Globicephala macrorhynchus*
2008	Bataan	Melon-headed whale	*Peponocephala electra*
2008	Manila Bay	Omura's whale	*Balaenoptera omurai*
2009	Manila Bay (Bataan)	Melon-headed whale	*Peponocephala electra*
2009	Zambales	Fraser's dolphin	*Lagenodelphis hosei*

Source: Aragones (2012) and Network News (1998)

The peak season for marine mammal strandings is April to June. **Figure 2.176** shows the relative frequencies of stranded cetaceans. The melon-headed whales (*Peponocephala electra*) have the highest stranding frequency which is four (4); the months and years of occurrence are June 2003, November 2005, September 2008, and February 2009.



Source: Aragones (2010)

Figure 2.176. Frequencies of stranded cetaceans along the Zambales, Bataan and Manila Bay area within a 100-kilometer radius of Subic Bay

Aragones et al. (2010) in their Philippine marine mammal strandings (1998-2009) reported that 28 species of marine mammals (i.e., 27 cetaceans and one sirenian/the dugong) were recorded in the Philippines, and several accounts indicate that they strand in various parts of the country. However, they mentioned that most reporting of marine mammal strandings in the Philippines have been sporadic and opportunistic. They also added that some locations might be considered hotspots by virtue of being a site of unusual stranding events. For instance, based on the same study, the shoreline of Bulacan (Region III) in Manila Bay is a hot spot because this was where the first recorded specimen of pygmy sperm whale in the Philippines stranded. Similarly, Batangas is a hot spot because it had the highest number (n=4) of stranding of baleen whales (Bryde's).

In Manila Bay, an unusual near mass stranding event (300-350 individuals) of melon headed dolphins was observed in Bataan on 10 February 2009 (Aragones et al., 2010). Media coverage of this stranding event in 2009 reported more than 200 melon-headed dolphins, known as *Peponocephala Electra*, were rescued from shallow waters of Manila Bay by hundreds of volunteers and fishermen (**Plate 86**) (https://www.theguardian.com/environment/gallery/2009/feb/10/wildlife-conservation). It is possible that that some illegal fishing practice(s) such as dynamite fishing (causing acoustic trauma) or environmental changes contributed to such an unusually high incidence of strandings (Aragones et al., 2010).

Photo source: www.youtube.com

Plate 86 More than 200 melon-headed dolphins (*Peponocephala electra*) were rescued from shallow waters of Bataan in Manila Bay, 10 February 2009

Another stranding event was observed on the morning of 28 February 2018, a school of about 12 melon-headed dolphins were rescued after they were seen swimming close to the coast of Manila Bay, in the area near the breakwater of Solaire Hotel (**Plate 87**). A combined team from BFAR and the police maritime group was organized to lead "the dolphins away from the breakwater into the deeper waters of the bay." According to the rescue team, the dolphins looked active and healthy and showed no signs of sickness or wounds. The dolphins were probably attracted to the schools of fish present in the area, which is near the spawning ground of herring. Another possible reason is that the dolphins got lost because of the noises coming from the ships near the area (https://www.bworldonline.com/dolphins-swimming-near-manila-bay-coast-guided-sea).

Photo source: www.youtube.com

Plate 87 A school of about 12 melon-headed dolphins seen swimming close to the coast of Manila Bay, near the breakwater of Solaire Hotel, were rescued on 28 February 2018

For stranded whales, on 17 May 2006, a small injured whale stranded in the shallow waters of Manila Bay died hours after being rescued in Brgy. Tambo, Parañaque City (philstar.com > headlines > whale-found-manila-bay). In August 2007, a carcass of a baleen whale was reported floating at the mouth of Manila Bay, bloated and badly decomposed. The cause of death of the animal was not determined due to the decomposing condition of the animal's body. In January 2009, another body of a baleen whale was found floating beside a passenger ship along Manila Bay's Pier 13 (gmanetwork.com/news/news/nation/142303/whale-s-death-in-manila-bay-indicates-grim-problem-story).

iii. Whalesharks and Dugong

Only very limited information is available on whale sharks (*Rhincodon typus*) and dugongs (*Dugong dugon*) in Manila Bay. Information on the occurrence (sighting) of whale sharks in the bay also comes mainly from media coverage/news reports and is presented below

(a) On 13 April 2012, a whale shark (commonly called "butanding") nearly 5 meters long was spotted swimming near the seawall across the Rajah Sulaiman Park in Manila. The whale shark appeared to have a broken dorsal fin. To prevent it from hitting the rocks along the seawall, Coast Guard teams made the effort of keeping the whale shark at a distance of 10 meters (https://www.philstar.com/headlines/2012/04/13/796112/whale-shark-spotted-manila-bay). It may be assumed that the cause of the broken dorsal fin of the stranded whale shark could be due to boat strikes or propeller hits. This is very evident in areas like the Manila Bay, with busy shipping channels for inter-island and large ocean-going vessels overlapping with the migratory route, coastal habitats or even feeding areas of marine mammals (MWWP, 2014).

(b) On 5 September 2013, a 5 meter (17 feet) and about 300 kilogram dead whale shark has washed ashore in Tanza, Cavite, a fishing district near the mouth of Manila Bay

(**Plate 88**) (rappler.com/nation/38205-dead-whale-shark-in-cavite, africa.chinadaily.com.cn/world/2013-09/05/content_16946872.htm,and phys.org/news/2013-09-rare-whale-shark-ashore-philippines.html).

Plate 88 A dead whale shark floating at the water of Tanza, Cavite, 5 September 2013

(c) On 9 September 2017, a dead whale shark was found in the vicinity of Tanza Bay in Cavite (**Plate 85**). Fishermen noticed the whale shark floating lifelessly. It was approximately 17 feet in length and 8 feet in diameter. They decided to bring it to the Pandawan Fish Port in Rosario, Cavite to turn it over to the Coast Guard Station (https://www.rappler.com/nation/181660-dead-whale-shark-tanza-cavite).

Plate 89 A dead whale shark found dead in Tanza Bay, Cavite, 9 September 2017

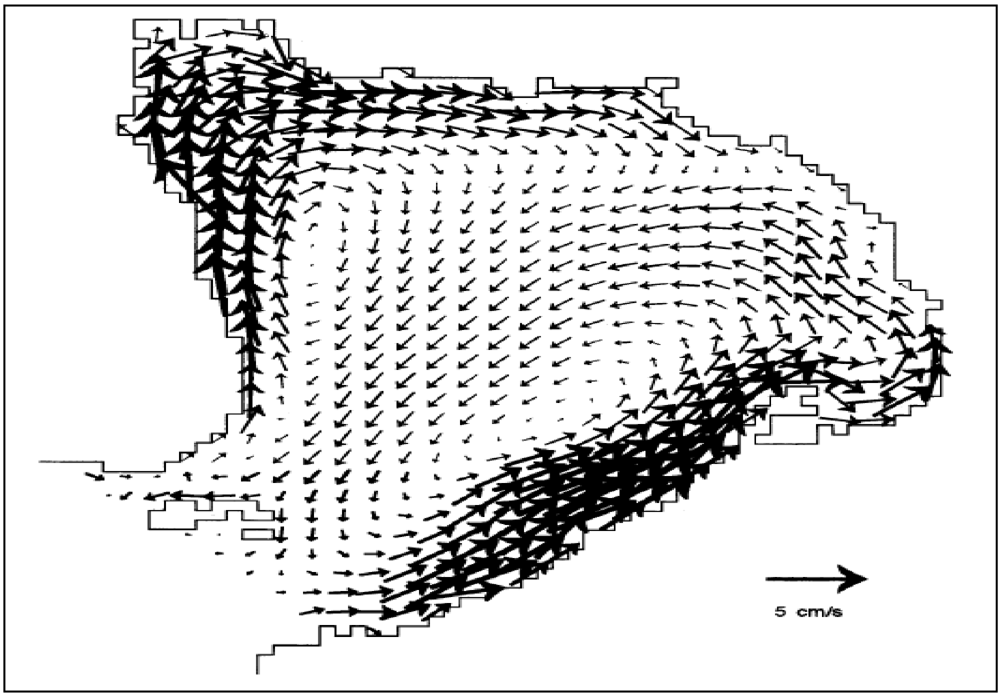
On 17 August 2018, a dead whale shark was seen at the Navotas Fish Port in Manila **(Plate 90)**. The whale shark, which measured about 5 meters long and weighed 800 kilograms, was found floating at the bay. (https://www.philstar.com/headlines/2018/08/18/1843736/photos-dead-butanding-seen-navotas

Plate 90 Residents look at a dead whale shark at the Navotas Fishery Port in Manila, 17 August 2018. (Noel Celis/AFP)

It was unusual to see whale sharks inside Manila Bay. Their migration patterns or habitats (usually pelagic, living in open waters) might be far from here. It may be hypothesized that these documented dead whale sharks that occurred in the bay during the months of August-September came from the approach or entrance/mouth of the bay, and they were possibly washed ashore by ocean currents towards Cavite and Manila which coincided with the prevailing habagat winds (southwesterly winds). This hypothesis is supported by the current circulation modeling study of Villanoy and Martin (1997) using southwesterly winds, wherein the model results show that adjacent to the coast, the transport of water is along the direction of the winds (**Figure 2.177**). Hence, it may then be possible that the stranded whale sharks were already dead or may be dying (or too weak to swim) when they got inside Manila Bay. However, up to now, the cause of their deaths was still unclear. One probable cause of their deaths was due to accidental ingestion of marine debris such as plastic trash while these animals were pursuing their prey. A 2019 study of dolphins, whales and seals in waters of UK found that 100% of dead animals on their coast ingested plastic (theaseanpost.com/article/death-plastic-waste). On 11 February 2019, a juvenile whale shark has been found washed ashore in Sabah with the cause of the death discovered to be from the whale ingesting a plastic bag (seavoicenews.com/2019/02/11/another-whale-shark-dies-

due-to-plastic- bag). On 9 August 2018, TV News posted that a necropsy revealed that ingestion of pieces of plastic caused the death of the whale shark that has been found washed ashore in Tagum City, Davao Del Norte (news.abs-cbn.com/focus/09/09/18/plastic-food-wrappers-found-inside-dead-whale-shark-in-davao). A whale shark was also found dead in waters off Tanjung Aru Beach in Kota Kinabalu on 9 January 2019, with a big plastic bag stuck in its stomach (thestar.com.my/news/nation/2019/02/09/whale-shark-killed-by-plastc-off-tanjung-aru-w).
Postmortem results showed that whale shark died due to intestinal obstruction leading to indigestion, starvation and finally, death. Plastics are often mistaken for jellyfish or squids and other food sources by marine mammals and have found to be the sources of death in many of them. These strandings caused by marine debris ingestion have been reported in the Philippines (MWWP, 2014).

Whale sharks are found in tropical and warm seas of the world, they are currently vulnerable to extinction. According to IUCN, the Indo-Pacific population of whale sharks is thought to have reduced 63% over the past 75 years (sharksteamone.org/whale-shark-ecology.html). This species has been on the IUCN Red List of endangered species since 2000 due to several factors working against them. From habitat destruction caused by pollution, climate change, oil and gas developments and spills, the oceans they inhabit are no longer the same as they once were. CITES lists the whale sharks as Appendix II and the species is thus fully protected under RA 8550 (Alava and Cantos, 2004)



Source: Villanoy and Martin, 1997

Figure 2.177. Simulated Wind-Driven Current Velocities for Southwesterly Winds

Presently, there have been no reported dugongs in Manila Bay. However, according to IUCN, all the islands of the Philippines were believed to have once provided habitats for dugongs, which even Manila Bay was supposed to harbor some dugongs in the early 70's. Manila Bay was previously fringed with mangrove trees and probably rich in seagrass. Nishikawa et al. (1979), in fact reported that dugongs were present in Manila Bay. Dugongs were also reportedly present in 1975 (about 45 years ago) in Morong, Bataan, an area that is relatively close to the bay. According to PCP-PAWB-DENR-Toba Aquarium (1995), the decreasing number of dugongs is caused by various threats. Direct threats include hunting and incidental catches which are prevalent throughout their range. Long term threats include pollution, destruction of seagrass beds, and encroachment in coastal areas by the increasing human population and development. The name dugong was derived from the Tagalog word of northern Philippines, which means "lady of the sea." The dugong is classified by the IUCN-World Conservation Union as vulnerable to extinction since 1982. In 2003, 20 scientists considered the dugongs in the Philippines as *Critically Endangered* (https://maritimereview.ph/2016/11/01/the-disappearing-dugong/). CITES also lists the dugongs in Appendix I (except the Australian population which is listed in Appendix II) and likewise, the species is thus fully protected under RA 8550. As such, the killing or taking of such species for whatever purpose, except for scientific research and the destruction or disturbance of its habitat is prohibited.

In the neighboring marine waters of Manila Bay, particularly along the west coast of Luzon such as in Subic Bay, dugongs, have been reported as extinct in Zambales (Marsh et al, 2002). However, in 2011, Yaptinchay and Viloria (2011) included the entire coast of Zambales province including Subic Bay as part of the existing dugong range in the Philippines. Understanding how such distribution is related to changes in seagrass abundance and quality has been the focus of recent researches (Lawler et al., 2002).

The status of protected marine species (megafauna) in the Manila Bay region and neighboring areas remains unknown due to insufficient information. Only further study can clarify the status of their population in the area.

2.2.5.3.14 Fisheries Resources

Manila Bay is one of the major fishing grounds of the Philippines. It is a multi-gear and multispecies fisheries with moderately flat bottom contour particularly suited for trawl and other similar fishing operations involving dragging or pushing nets. The bottom substrate of the entire bay is classified as sandy muddy with a few patches of corals in Cavite and Bataan. Fisheries and aquaculture are major sources of livelihood in areas surrounding the bay (PEMSEA, MBEMP-MBIN, 2007). Recent studies already show that the Bay's resources are experiencing overfishing as proven by the declining fish catch and in the change of the quality of fish caught to lesser valued species (Dicdiquin et al., 2017). In addition, the Bay is also suffering from habitat degradation and its water quality is deteriorating due to pollution (PEMSEA and MBE TWG-RRA, 2004; Su et al., 2009; Chang et al., 2009).

The Bureau of Fisheries and Aquatic Resources (BFAR) classified the fishing sector into municipal fishing and commercial fishing sectors. The Philippine Fisheries Code or RA 8550 as amended by RA 10654 defines Municipal Fishing as fishing within municipal water using fishing vessels of three (3) gross tons or less, or fishing not requiring the use of fishing vessels. Commercial fishing is define as the taking of fishery species by passive or active gear for trade, business and profit beyond subsistence or sports fishing, to be further classified as: (1) Small scale commercial fishing-fishing with passive or active gear utilizing fishing vessels of 3.1 gross tons (GT) up to 20 GT; (i2) Medium scale commercial fishing-fishing utilizing active gears and vessels of 20.1 GT up to 150 GT; and 3) Large commercial fishing - fishing utilizing active gears and vessels of more 150 GT.

iv. Alas-asin and Mt. View (Mariveles, Bataan)

One of the 11 coastal Municipalities of Bataan is Mariveles which has 18 Barangays. The population of Mariveles in 2015 was 127,536. The population of Alas-asin in the same year was 15,047, the highest among the 18 Barangays of Mariveles. This is around 11.8% of the total population of Mariveles. However, the population of Alas-asin is concentrated in the barangay proper not in the coastal areas of Alas-asin. The adjacent barangays of Alas-asin are: Baseco Country (Nassco), Sisiman, Mt. View, Cabcaben, and Lucanin.

The shorelines of Barangays Sisiman, Baseco, Alas asin, Mt. View, Cabcaben, Lucanin, and Batangas II are classified as the Bataan ecozones (industrial zone). The coastal waters of Mariveles are considered as shipping and navigational zone based on the Philippine Ports Authority (PPA) and Coast Guard standard (**Figure 2.178a**). The municipal fishing zone inside Manila Bay which is located up to about 17 km seaward from the shoreline of Bataan is shown in **Figure 2.178b**, while the traditional fishing zone is shown in **Figure 2.178c**. Municipal fishing zone refers to fishing activities within municipal waters using small-sized and medium-sized fishing vessels of three (3) gross tons or less. Trawling ("galadgad") and modified Danish seine ("hulbot-hulbot" or "buli-buli") and other destructive forms of fishing are strictly prohibited. On the other hand, traditional fishing zone covers areas where the traditional form of fishing is practiced with the used of gears, such as hook and line ("kawil"), spear gun ('pamana"), scoop net ("panalok"), snares ("panukot"), and cover pot ("pangilaw") for subsistence.

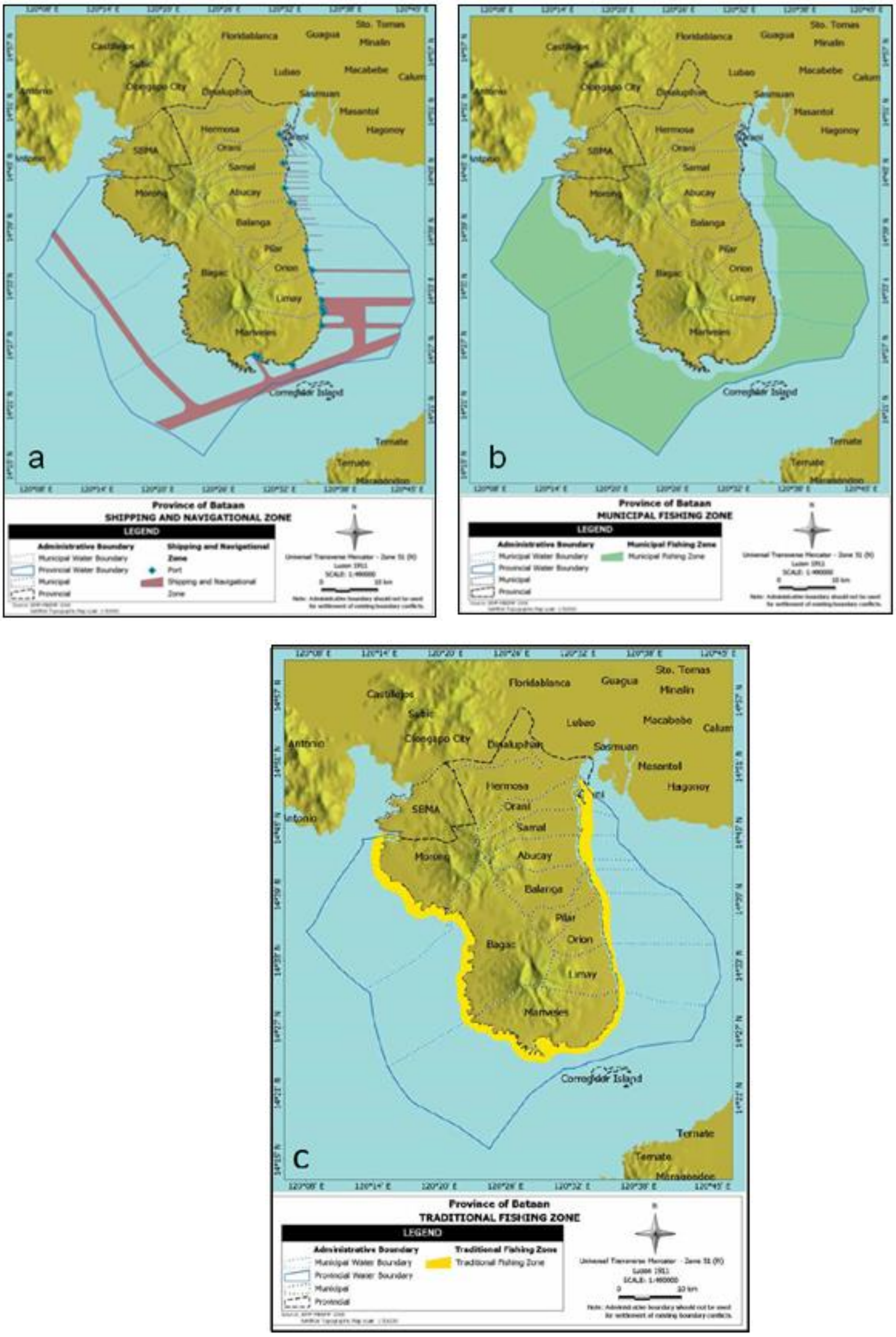


Figure 2.178. Shipping and navigational zone (a), municipal fishing zone (b) and traditional fishing zone (c) of the Province of Bataan (Source: PEMSEA and the Provincial Government of Bataan, 2007)

There are three (3) major fish landing sites in Mariveles located in Barangays San Carlos, Townsite and Batangas II (**Figure 2.179**). The largest fish landing site is in Barangay San Carlos located at the Mariveles town proper (Lat. 14°26’13.60” N and Long. 120°29’16.31"

E), and also the nearest fish landing site from Barangay Alas-asin to the west. All the boats that land are municipal boats and they commonly arrive at about 6:00 am to 12:00 nn. The catches are placed in “banyera” or pail and go directly to the respective consignaciones, where there are five (5), for bidding. Most of the bidders are vendors of the town market, where they sell the fish at a higher price (Anit et al., 2017).

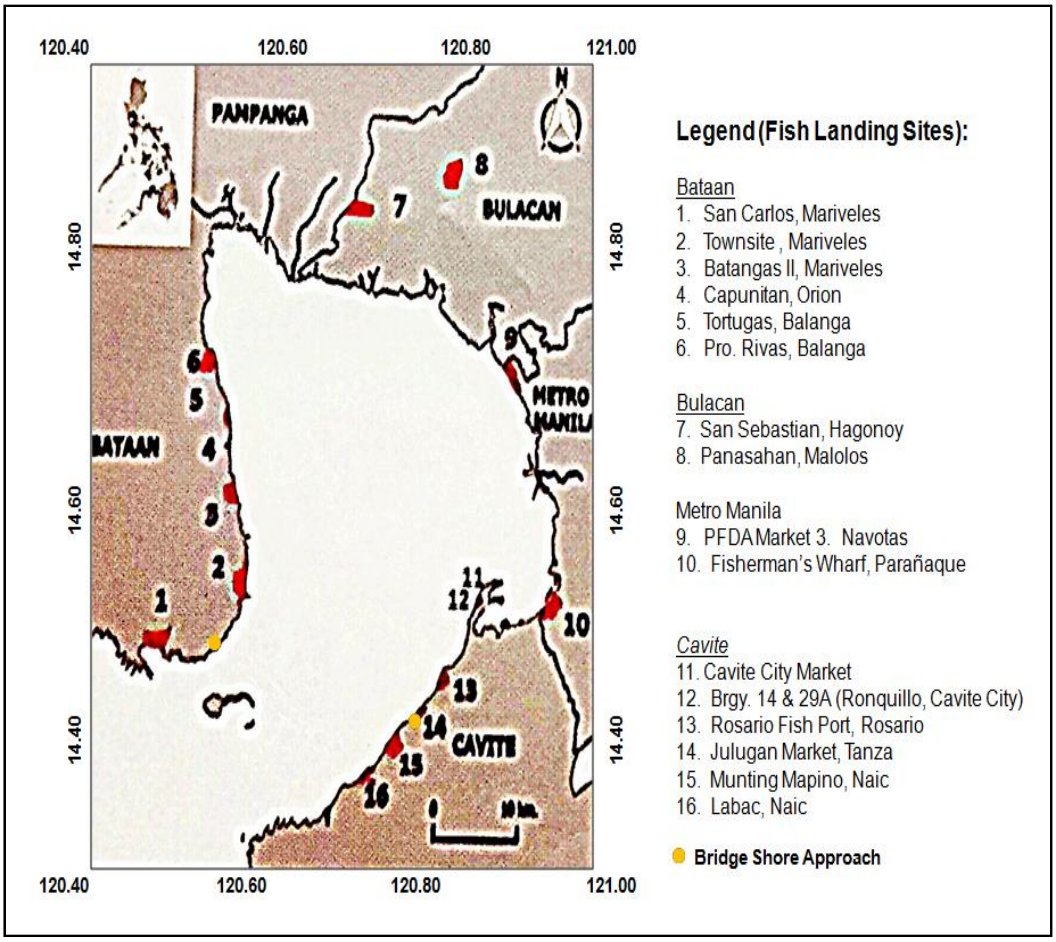


Figure 2.179 Manila Bay showing the fish landing sites (Source: Anit et al., 2017)

The number of registered municipal and commercial fisher folks in Mariveles based on Municipal FishR (Fisherfolk Registration) data as of February 2016 was 14,002. In the same year, based on Municipal BoatR (Fishing Vessels and Gears Registration) the number of municipal fishing boats were 1,814 and the commercial fishing boats were 54.

The fishing season in Mariveles is all year round with peak season during rainy months June to August and also during summer months March to May. The fishing activities are mostly done in Manila Bay while some of the commercial fishing boats are fishing in the West Philippine Sea. The major gears being used in Mariveles are bottom gillnet (“panting lubog”), bottom set longline (“kitang”), drift gill net (“panting paanod”), trawl (Norway), crab gill net (“panti pang alimasag”), motorized push net (“pang alamang”), crab pot (“bubo pang alimasag”), squid trap (“bubo pang pusit”) (**Figure 2.180**). The types of fishes caught in the area are primarily dictated by the type of fishing gear that the fishers employ. There are two (2) general types of fishes caught in the area, the pelagic species and the demersal species (or soft bottom dwellers/feeders). Fishing gears target either the pelagic or demersal species. However, there are fishing gears targeting one (1) of the two (2) types but can also catch the other type. The fish and invertebrate species caught by the above gears are presented in **Table**

2.74. Photos of some of the different pelagic and demersal fish species caught are presented in **Plate 91** and **Plate 92**, respectively.

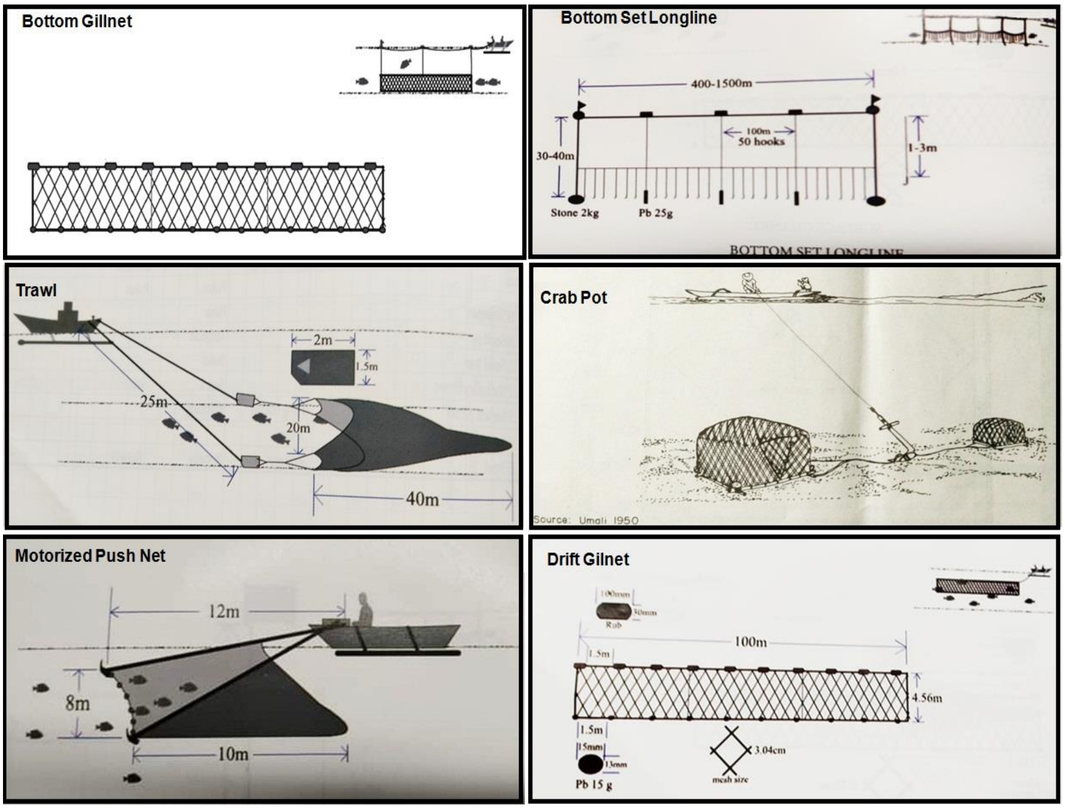


Figure 2.180 The major municipal fishing gears being used in Mariveles

Table 2.74 The species catch composition of the different fishing gears that unload their catch in San Carlos Fish landing site, Mariveles, Bataan

Species Catch Composition	Fishing Gears						
	Crab Pot	Crab Gillnet	Fish Trap	Squid Trap	Bottom Gillnet	Bottom Set Longline	Trawl
Portunos pelagicus (Alimasag - blue swimming crab)	√	√			√		√
Charybdis feriata (Alimasag red)	√	√					√
Epinephelus spp. (Lapu-lapu-Grouper)			√			√	√
Cepalopholis boenak (Brownbarred grouper)			√			√	√
Sepia spp. (Pusit – Cuttle fish)				√			
Loligo spp.(Pusit – Squid)				√			
Trichiurus lepturus (Espada – hairtail)					√		
Rastrelliger kanagurta (Alumahan)					√		
Rastrelliger brachysoma (Hasa hasa)					√		
Selar crumenophthalmus (Matambaka)					√		

Species Catch Composition	**Fishing Gears**						
	Crab Pot	**Crab Gillnet**	**Fish Trap**	**Squid Trap**	**Bottom Gillnet**	**Bottom Set Longline**	**Trawl**
Alepes djedaba (Salay-salay)					√		
Sphyraena putnamei (Barracuda)					√		
Sphyraena obstusata (Barracuda/Torsilyo)					√		
Pomadasys maculates (Bakoko)					√		√
Pomadays kaakan (Bakoko)					√		
Saurida tumbil (Kalaso)					√	√	√
Upeneus vittatus (Goatfish)					√		√
Priacanthus Sagittarius (Siga, Mata-hari)					√		
Caranx ignobilis (Talakitok)					√		
Geres filamentosus (Ayungin)					√		
Nemipterus japonicas (Bisugo)					√	√	
Leiognathus equulus (Sapsap)					√		
Eubleekeria jonesi (Bakagan)					√		
Eleuteronema tetradactylum (Mamali)					√		
Decapterus macrosoma (Galunggong)					√		
Psettodes erumei (Palad, Dapa)					√		√
Nemipterus nematophorus (Bisugo)						√	
Lysiosquillasp. (Mantis shrimp)						√	
Penaeus spp. (Shrimp)							√
Nemipterus spp. (Bisugo)							√
Sphyraena spp. (Barracuda)							√

Source: NFRDI Manila Bay Project

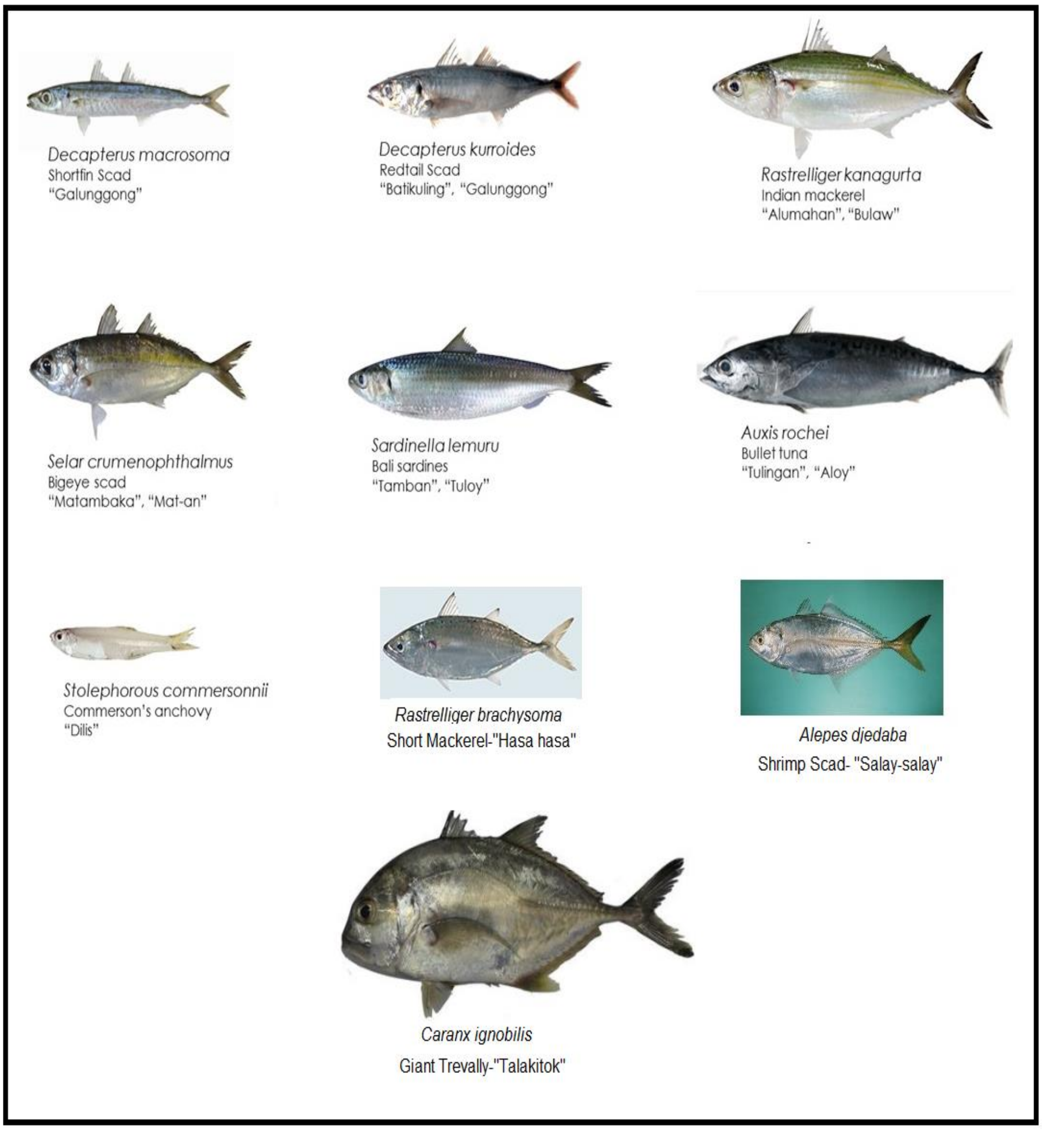


Plate 91 Photos of some of the common pelagic fish species caught in Mariveles

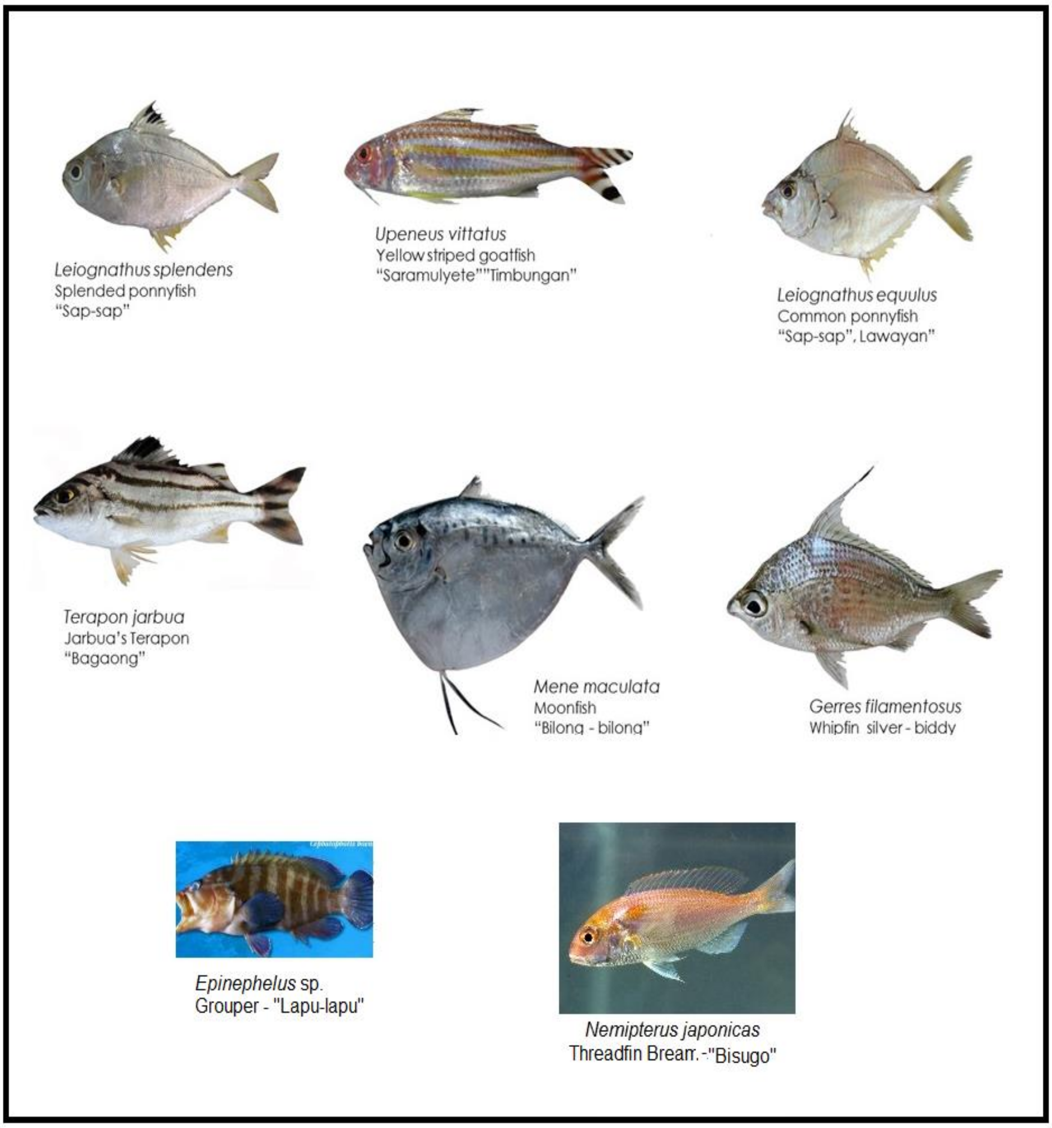


Plate 92 Photos of some of the common demersal fish species caught in Mariveles

Results of the baseline study also showed that the blue-swimming crabs (Portunus pelagicus) (**Plate 93**) and other marketable crabs Charybdis feriata are present and being exploited within the area (**Plate 94**). Based on interviews done in the area, the exploitation of crabs has been practiced since time immemorial. The demand for crabs is mainly for local consumption and domestic demand of nearby areas (including Metro Manila), for crab meat processing plant in Orion (Bataan), as well as for export. The fishing grounds of crab fishermen using passive gears like crab gill nets (for nighttime fishing) and crab pots (for daytime fishing) within the study area are concentrated along the shorelines of Alas-asin and adjacent barangays at approximately up to 20 meter-depth.

Plate 93 The blue-swimming crabs or “alimasag”, Portunus pelagicus (Photos by Ruben A. Estudillo, June 2002)

Plate 94 Crab pot fishing boat at Marina Beach in Alas-asin, Mariveles (a), landed crabs (b), and large-size crab specimen, Charybdis feriata (c) (Photos by Ruben A. Estudillo, 12 February 2020)

Despite the serious state of the blue crab resources in Manila Bay, the blue crab resource has been able to sustain the current rate of harvest probably because of the high recruitment rate (reproductive rate). The blue-swimming crabs Portunus pelagicus is highly fecund animal and grows very fast, with males grow faster than females (Agasen, 1999 and Ingles, 2000). The blue crabs attain sexual maturity in only 4.1 months, or at 9.60 cm carapace width, for males, and in only 8.52 months, or at 10.6 cm carapace width, for females (Ingles, 1988). Eggs varied between 180,000 to 774,000, depending on the size of the female. The average total fecundity of each female is about 3.46 million eggs (Ingles, 2000).

In the Philippines, spawning season of blue-crab, based on the occurrence of egg-bearing female occurs all throughout the year although peak times generally coincide with the intermonsoon periods, i.e., from February-March and October-November of each year (Ingles 1991). In Guimaras Strait, berried females were reported all year round with the peak months during May. In the Visayan Sea, ovigerous females were most abundant in May (Ingles, 1996). In Asid Gulf, Masbate, berried females were found all year round with the peak months during April-May (Agasen, 1999). Based on interviews of crab pot fishermen of Alas-asin (Marina Beach), month of August had the highest catch of swimming crabs, especially after the passage of a typhoon in the area.

v. Naic, Cavite

Timalan Balsahan

Naic is one of the Municipalities in the Province of Cavite. Naic is composed of 30 barangays. Of this, there are nine (9) coastal barangays. One of these coastal barangays is Timalan Balsahan with a total population of 9,754 reported in the 2015 census. The population is around 8.75% of the total population of Naic. Timalan Balsahan has a common border with Barangays Timalan Concepcion, Sabang and Munting Mapino. There are only 61 fisherfolks registered in Timalan Balsahan in 2019, with 34 fisherfolks are into capture fishing and 27 are into aquaculture. The numbers of registered fisherfolks by sector in the nine (9) coastal barangays of Naic are presented in **Table 2.75**.

Table 2.75 Number of registered fisherfolks by barangay in Naic by sector

Barangay	Fish Capture	Aquaculture	Vendor	Total
Timalan Balsahan	34	27		61
Bagong Kalsada	60		1	61
Munting Mapino	55		15	70
Sabang		9		9
Labac	30	1	12	43
Mabolo	11		16	27
Bancaan	48		1	49
Bancaan Malaki	18			18
Bucana Sasahan	74			74
Total	**330**	**37**	**45**	**412**

Source: Municipal Agriculture Office (MAO), Naic, Cavite

The 34 registered fish capture fisherfolks from Timalan Balsahan are using either bottom set or drift gillnet in fishing. The catch is mostly Rastrelliger brachysoma (“hasa hasa”) and Trichiurus lepturus (“espada”). There are also other fish species caught by the fisherfolks but in lesser quantities such as Terapon jarbua (“bagaong”), Pomadasys maculatus (“bakoko”), and Valamugil seheli (“aligasin”). The 27 registered aquaculture fisherfolks are into oyster farming along the Timalan River estuary (**Plate 95**).

Plate 95 Oyster farming (“talabahan”) at Timalan River, Barangay Timalan Balsahan, Naic, Cavite

There is no designated landing site in Timalan Balsahan so the catch is unloaded in nearby Barangay of Munting Mapino where there is a designated landing site located at Lat. 14°20’06.86” N and Long. 120°46’16.26" E (see **Figure 2.181**; and **Plate 96**). Fishing boats start to arrive at 2:00 am to 8:00 am. There are four (4) consignaciones in the area and the catches of municipal boats are brought directly to their respective consignacion. Aside from the fish, a lot of invertebrates (i.e., shrimps/prawns, squids, crabs) are also being landed in the area. Majority of the boats that land are gillnetters (drift gill net and encircling gill net) and trawlers. Commercial fishing vessels from neighboring barangays also unload their catch in Munting Mapino (Anit et al., 2017). There are no registered commercial fishing vessels from Timalan Balsahan.

Plate 96 The community fish landing center at Barangay Munting Mapino, Naic, Cavite

Fishing season is whole year round with peak season starting from June up to August and also during summer months March to May. The catch is around 15 kg for a three-hour fishing operation, while for a longer fishing operation time and during peak fishing season the catch can reach up to 300 kg in a day (**Table 2.76**). The fishing vessel can accommodate three (3) to four (4) fisherfolks. Figure 80 shows the municipal and traditional fishing grounds in Manila Bay for the province of Cavite.

Table 2.76 Catch by gear, species, volume, and price landed in Munting Mapino from fishermen of Timalan Balsahan

Fishing Gear	Major Fish Catch by Species	Volume	Price	Remarks
Bottom gillnet	Terapon jarbua (“bagaong”) Trichiurus lepturus (“espada”)	15kg-300 kg	No price was provided	Fishing is whole year round
Drift gillnet	Rastrelliger brachysoma (“hasa-hasa”) Rastrelliger kanagurta (“alumahan”) Selaroides leptolipes (“salay-salay”) Valamugil seheli (“aligasin”)	15kg-300 kg	No price was provided	Fishing is whole year round

Source: NFRDI Manila Bay Project

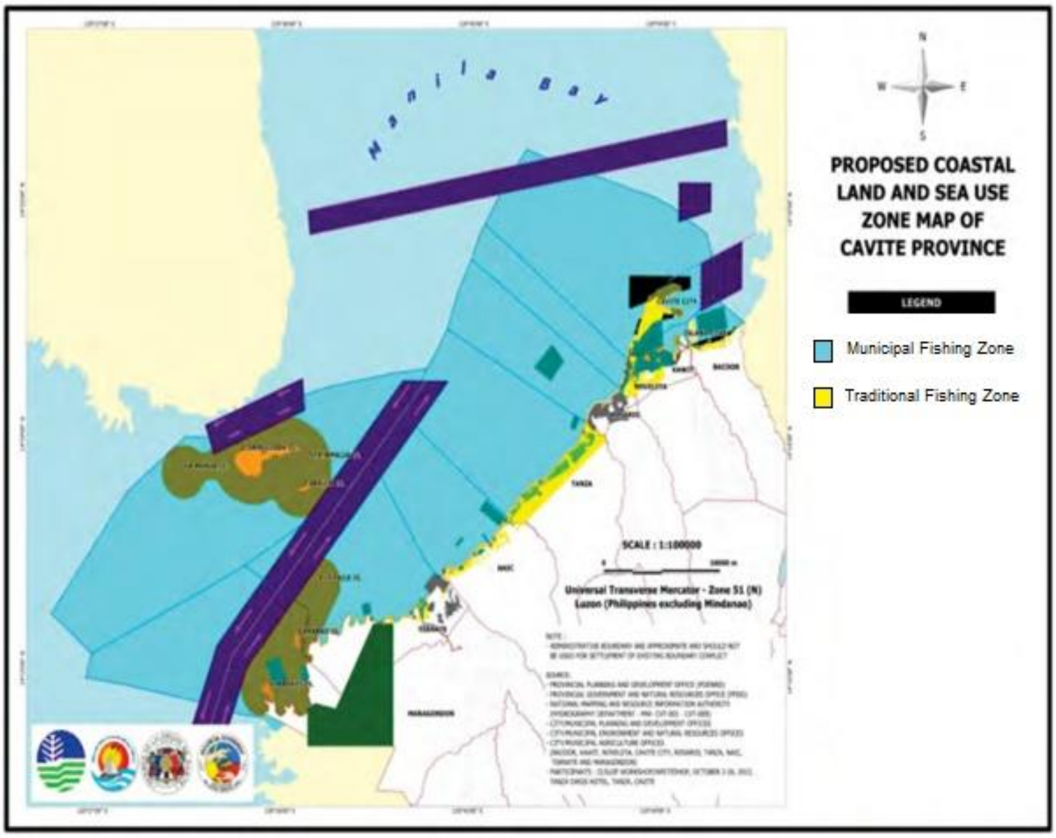


Figure 2.181 Proposed coastal and sea-use zoning map of Cavite Province showing municipal fishing zone and traditional fishing zone (Source: PEMSEA and Provincial Government of Cavite, 2017)

Timalan Concepcion

Timalan Concepion is one of the barangays in Naic wherein the proposed bridge project is to be constructed. This barangay is classified as urban barangay of Naic. Based on the 2015 population census, the population of Timalan Concepcion is 4,632. This represents around 4.16% of the total population of Naic. Timalan Concepcion has no registered fisherfolks based on the records from the Naic Municipal Agriculture Office (MAO), may be because of its limited shoreline. However, during the conduct of the baseline study on 8 February 2020, a total of about 18 motorized fishing boats were observed on the beach in the immediate vicinity of the proposed project site (**Plate 97**).

Plate 97 Municipal motorized fishing boats observed at the proposed bridge shore approach, Timalan Concepcion beach, Naic (8 February 2020)

The fishing ground of the fisherfolks from Timalan Concepcion is also in Manila Bay and within the waters surrounding the Corregidor and Caballo Islands (**Figure 2.181**). Fishing is also carried out the whole year round with peak season during the rainy months from June up to August and also during summer months March to May. There is also no designated landing site in Timalan Concepcion hence the catch is also unloaded in the nearby fish landing site of Barangay Munting Mapino (see **Figure 2.179** and **Plate 96**). Municipal catch are usually landed in small plastic bags (weighing about ½ to 1 kg/bag) or in small pails and are directly brought to the consignacion. There are fish retailers/vendors in the area who resell the fish to small buyers. The common fish species caught are Rastrelliger brachysoma ("hasa-hasa") and Trichiurus lepturus ("espada"). The common catches of trawl are shrimps/prawns (Anit et al., 2017).

As observed during the visit to the beach, the crab gill net is also one of the most common types of municipal fishing gears in Timalan Concepcion (**Plate 98**). The target species of the gill net is the blue-swimming crab, Portunus pelagicus. Other species that are taken by the gill net included the red crab Charybdis feriata and some fishes are considered as by-catch. Unfortunately, no information was gathered on the total number of motorized boats engaged in crab gill netting. Similarly, no information was gathered on crab fishing activities in the area using crab pots. Other gears in the area such as trawl also catch crabs, which catches both immature and adult crabs as by-catch.

Plate 98 Crab gill netters in Timalan Concepcion (Naic, Cavite) wherein the site for the bridge shore approach is proposed

For Naic commercial fishing activities, the total commercial fishing vessels registered is 11 units (**Table 2.77**). The 11 commercial fishing vessels are broken down into the following categories: (a) nine (9) units of handlines with GT ranging from 3.75 to 15.75 GT, (b) one (1) ringnet with 35.19 GT, and (c) one (1) encircling gill net with 9.33 GT (**Plate 99** and **Figure 2.182**). The operators and fisherfolks working in the commercial fishing vessels in Naic are from the other municipalities of Cavite.

The commercial fishing vessels are also mostly fishing within Manila Bay and within the waters surrounding the Corregidor and Caballo Islands. If the weather condition is favorable for fishing activities, the bigger commercial fishing vessels are fishing in the West Philippine Sea.

Table 2.77 Number of registered commercial fishing vessels by gear type in Naic

Fishing Gear	Number of Commercial Fishing Vessels	Gross Tonnage (GT)
Handline	9	3.75 - 15.75
Ringnet	1	35.19
Encircling Gill Net	1	9.33
Total	**11**	

Source: Provincial Fisheries Office (PFO), Cavite

Plate 99 Profile of commercial fishing vessels with 14.07 to 25.41 gross tonnage (225 to 285 horse power) operating in Manila Bay (Photo source: Abad et al., 2017)

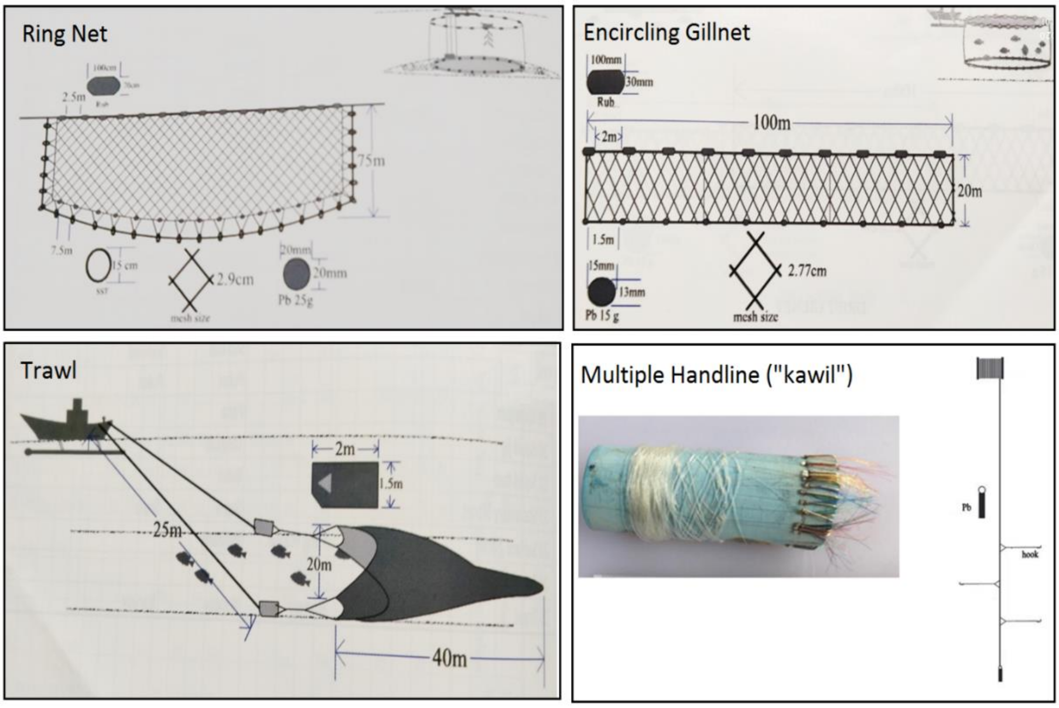


Figure 2.182 Profile of fishing gears being used by commercial fishing vessels in Manila Bay (Source: Abad et al., 2017)

vi. Open Waters of Manila Bay

An experimental trawl fishing survey by Bendaño et al. (2017) was conducted in the open waters of Manila Bay from March 2014 to October 2015 at sixteen (16) pre-established dragging stations near Pampanga, Bulacan, Metro Manila, Bataan, Cavite, and Corregidor Island (**Figure 2.183**). They reported that a total of 146 species of fish and invertebrate belonging to 48 families were caught during the survey. The most number of species was recorded in the trawling area near Cavite with 100 species, followed by station in the Pampanga-Bulacan area with 93 species while stations near Metro Manila have 80 species. Areas near Bataan recorded a total of 55 species while the waters near Corregidor Island have 42 species recorded. The dominant species such as devi's anchovies or "dilis" (Encrasicholina devisi) and fringescale sardinella or "tunsoy" (Sardinella fimbriata) including the shallowtail cardinalfish or "suga" (Rhabdamia cypselurus) exhibited higher biomass in the eastern portion (Metro Manila) of the bay (**Plate 100a**). In contrast, a higher distribution of gold stripe sardinella or "tunsoy" (Sardinella gibbosa) was recorded in the eastern (Cavite) and southern part of the bay (near Corregidor Island), while the swordtip squid or "pusit" (Photololigo edulis) is more prevalent in the western part (Bataan) (**Plate 100b**). The largehead hairtail or "espada" (Trichiurus lepturus), the black pomfret or "pampano" (Parastromateus niger) and the common ponyfish or "sapsap lawayan" (Leiognathus equulus) were more abundant in the southern part (near Corregidor Island) (**Plate 100c**) (**Table 2.78**). Majority of the fishes caught during the survey were immature individuals.

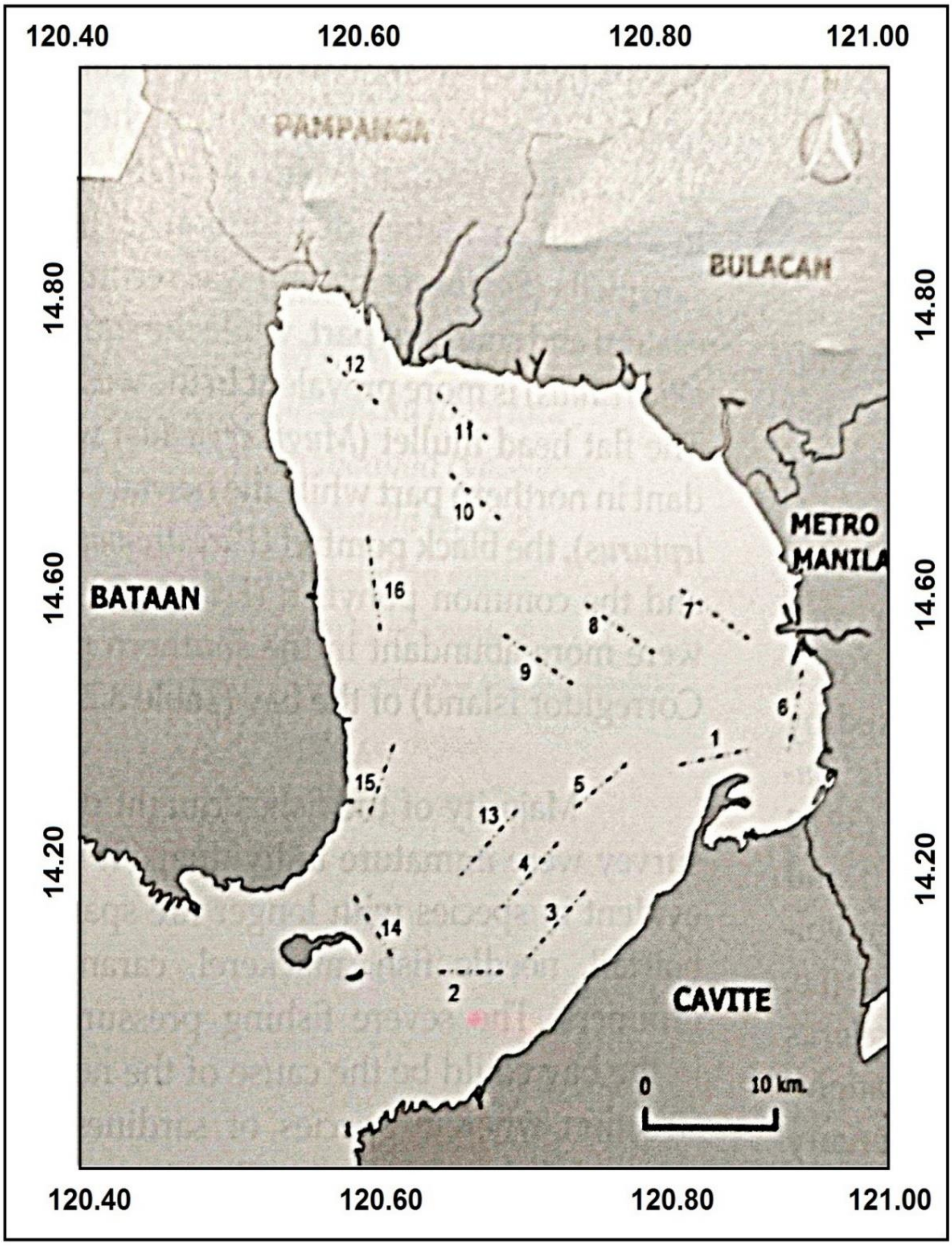


Figure 2.183 Location of the experimental trawl fishing stations in Manila Bay, 2014-2015 (Map source: Bendaño et al., 2017)

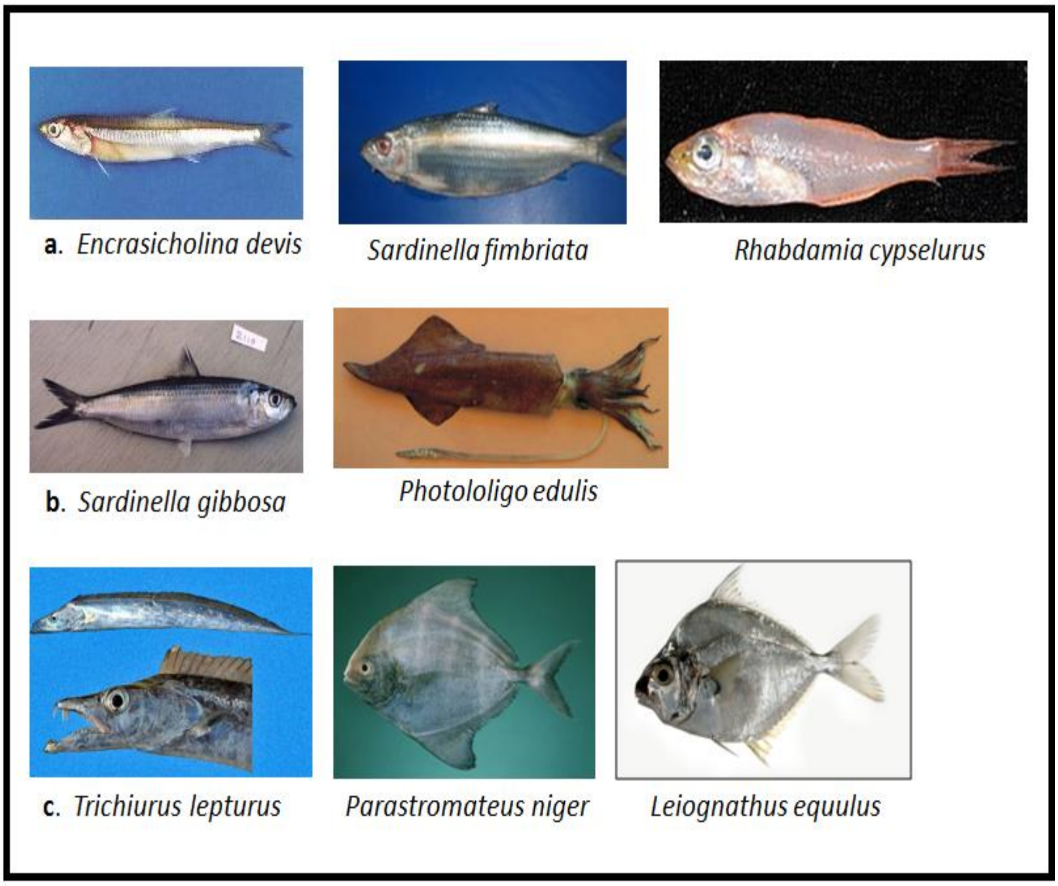


Plate 100 Photos of the dominant fish and invertebrate species by biomass abundance in Manila Bay (Photo source: Internet)

Table 2.78 Top 50 fish and invertebrate species caught in Manila Bay during the trawl fishing survey from 2014 to 2015 by biomass abundance

Species		**Province of Manila Bay**				
Demersal		**Bataan**	**Bulacan-Pampanga**	**Metro Manila**	**Cavite**	**Corregidor Island**
Arius maculatus	Spotted catfish	-	†	†	†	-
Eleutheronema tetradactylum	Fourthfinger threadfin	†	†	†	†	-
Elops hawainsis	Hawaiian Ladyfish	†	†	†	†	-
Gazza minuta	Toothpony	-	†	†	†	†
Gerres filamentosus	Whipfin silver buddy	†	†	†	†	-
Johnius belangeru	Belanger's croaker	†	†	†	†	-
Lagocephalus lagocephalus	Oceanic puffer	†	†	††	†	†
Leiognathus bindus	Orangefin ponyfish	†	†	†	†	††
Leiognathus elongatus	Slender ponyfish	-	-	†	†	-
Leiognathus equulus	Common ponnyfish	†	†	†	†	††

Species		**Province of Manila Bay**				
Demersal		**Bataan**	**Bulacan-Pampanga**	**Metro Manila**	**Cavite**	**Corregidor Island**
Leiognathus splendens	Splenden ponnyfish	†	†	†	†	-
Mene maculata	Moonfish	†	†	†	†	†
Mugil cephalus	Flathead mullet	-	†	†	†	-
Nematolosa nasus	Blosh’s gizzard shad	-	†	†	†	-
Parastromateus niger	Black pomfret	†	†	†	†	††
Rhabdamia cypselurus	Swallow tail cardinal fish	-	-	†††	-	-
Sarotherodon melanotheron	Black chin tilapia	-	†	†	-	-
Scatophagus argus	Spotted scat	†	†	†	†	-
Sphyraena obtusata	Obtuse barracuda	†	†	†	†	-
Sphyraena putnamae	Sawtooth barracuda	†	†	†	†	†
Terapon jarbua	Jarbua terapon	-	†	†	†	†
Valamugil buchanani	Bluetail mullet	-	-	†	†	-
Valamugil seheli	Blue spot mullet	†	††	††	†	†
Pelagic						
Alepes djedaba	Shrimp scad	†	†	†	†	-
Atule mate	Yellowtail scad	†	†	†	†	†
Caranx ignobilis	Giant trevally	†	†	†	†	†
Chanos chanos	Milkfish	-	†	-	†	-
Decapterus macrosoma	Shortfin scad	††	-	†	-	-
Dusumeiria acuta	Rainbow sardines	†	-	†	†	†
Encrasicholina devisi	Devi’s anchovy	†	†	††	†††	††††
Megalops cyprinoides	Indo-Pacific tarpon	†	†	†	†	†
Rastrelliger brachysoma	Short bodied mackerel	†	†	†	†	†
Rastrelliger kanagurta	Indian mackerel	†	†	†	†	†
Sardinella fimbriata	Fringescal sardinella	††	††††	††	††	†
Sardinella gibbosa	Goldstripe sardinella	††	†	††	††	††
Sardinella lemuru	Bali sardinella	†	†	†	†	-
Scomberoides lysan	Doublespotted queenfish	-	†	†	†	-
Scomberoides tala	Bared queenfish	†	†	†	†	†
Scomberomorous commerson	Narrow-barred spanish	†	†	†	†	†
Scomberomorous guttatus	mackerel	-	†	†	†	†

Species		**Province of Manila Bay**				
Demersal		**Bataan**	**Bulacan-Pampanga**	**Metro Manila**	**Cavite**	**Corregidor Island**
Selaroides leptolepis	Indo-Pacific king mackerel	†	†	†	†	†
Stolephorus commersonnii	Yellowtail stripe scad	†	††	†	†	†
Stolephorus indicus	Indian anchovy	-	†	-	-	-
Trichiurus lepturus	Largehead hairtail	††	†	†	††	††
Invertebrate						
Acetes spp.	Sergested shrimp	†	†	†	†	-
Photololigo chinensis	Mitre squid	†	†	†	†	-
Photololigo duvauceli	Indian squid	†	†	†	†	†
Photololigo edulis	Swordtip squid	†	†	†	†	†
Portunus pelagicus	Blue swimming crab	-	†	†	†	†
Squilla sp.	**Sea mantis**	†	†	†	†	-
No. of other species		**19**	**48**	**32**	**54**	**15**
No. of species recorded by province		**55**	**93**	**80**	**100**	**42**
Total no. of species recorded:146						

Symbols for commonness are; - : not found; † : less than 5% of the hauls; †† : 5-20% of the hauls; and ††† : 20-30% of the hauls (Source: Bendaño et al. (2017)

Bendaño et al. (2017) also reported a total catch of 8.14 metric tons of fish and invertebrates (3.24 mt in 2014; 4.9 mt in 2015) during the 10 fishing trips done from March 2014 to October 2015 with a mean Catch Per Unit Effort (CPUE) of 79.6 kg/hour. Higher demersal biomass was recorded in areas near Metro Manila, Bulacan and Pampanga while lower demersal biomass was recorded near Corregidor Island and Bataan followed by the waters near the mouth of the bay. The authors also concluded that the exploitation rates for the six (6) dominant species: Sardinella gibbosa, Sardinella fimbriata, Valmugil seheli, Mugil cephalus, Encrasicholina devisi and Stolephorus commersonii show signs of overfishing. The estimated demersal fish biomass of the bay revealed that the relative decline was about 90% from the 1947 baseline study. Apparently, this decrease in biomass is associated to the more serious problem such as increasing number of fishers, habitat destruction and water quality deterioration.

2.2.5.4 Conservation Status of Protected Marine Species (Threatened or Endangerd Species)

(a) Marine Turtles

The green turtle (Chelonia mydas), the hawksbill (Eretmochelys imbricata), and the olive ridley (Lepidochelys olivacea) have been found to occur nationwide with nesting recorded in the western coast of Luzon, particularly in Batangas, Cavite, Bataan up to Zambales. The International Union for the Conservation of Nature and Natural Resources (IUCN) list marine turtles as endangered using indices of abundance and levels of exploitation as criteria (Red List Standards and Petitions Subcommittee, 1996). Faced with potential extinction in the near future, marine turtles are included in Appendix I of the Convention on International Trade of Endangered Species of Wildlife Flora and Fauna (CITES) and protected by restrictions on international trade. Moreover, marine turtles are protected species under several Philippine laws (**Table 2.79**). The IUCN categorizes the olive ridley turtle and green turtle as "endangered" while the hawksbill turtle is "critically endangered" (**Table 2.80**). Additionally, DAO 2004-15 also classifies hawksbill turtles as "critically endangered".

Table 2.79 Pertinent Philippine Laws and Regulations providing protection to marine wildlife and corresponding penalties and provisions

Legal Title	Law/ Administrative Order Number	Year	Provisions
Wildlife Resources Conservation and Protection Act	Republic Act No. 9147	2001	Fines and Penalties for harming critically endangered species: imprisonment up to 12 years; fine up to PhP1,000,000
Fisheries Code	Republic Act No. 8550	1998	Fines and Penalties for harming CITES Appendix I and II species: forfeiture of catch; cancellation of permit; imprisonment up to 20 years; fine up to PhP 120,000
Establishing the list of terrestrial threatened species and their categories and the list of other wildlife species pursuant to RA No. 9147, otherwise known as the Wildlife Resources Conservation and Protection Act	Department of Environment and Natural Resources Administrative Order (DAO) No. 2004-15	2004	"critically endangered" marine turtle species: hawksbill turtle (Eretmochelys imbricata) "endangered" marine turtle species: green turtle (Chelonia mydas) olive ridley turtle (Lepidochelys olivacea) loggerhead turtle (Caretta caretta) leatherback turtle (Dermochelys coriacea)

Source: RA 9147, RA 8550 and DENR AO 2004-15)

Table 2.80 Species of marine turtles present in Manila Bay with the corresponding common English names, scientific names and IUCN Red List status

Common English Name	Scientific Name	IUCN Red List Status
Olive ridley turtle	Lepidochelys olivacea	Endangered
Green turtle	Chelonia mydas	Endangered
Hawksbill turtle	Eretmochelys imbricata	Critically endangered

Only the olive ridley turtle (L. Olivacea) was confirmed to nest in the project area during the baseline survey, particularly in two (2) nesting beaches of Mariveles in Bataan, namely: Hyatt Beach Resort in Brgy. Alas-asin and Pinagapugan Beachfront in Brgy. Cabcaben. The Labac Beachfront in Naic, Cavite was also known as an olive ridley nesting site.

In recent interview with Mang Manalo Ibias (Chairman Bantay Pawikan, Inc., Morong, Bataan, pers. comm., 25 July 2020), the eastern side (sandy coastline) of Corregidor Island was also known as an olive ridley turtle (*L. Olivacea*) nesting site. However, he further added that data and information are not available for this nesting site since systematic inventory of the nesting beaches for Corregidor Island has not yet been established. He also further mentioned that, the hawksbill turtle (E. imbricata) and the green turtle (Ch. mydas) are also present and proven to nest in Manila Bay but for low density of nesting.

Interestingly, a growing body of evidence from tag recoveries showing the olive ridley nesting in Subic Bay are affiliated with nesters in Manila Bay, Bagac and Morong (Bataan), Subic Bay up to Botolan (Zambales) (**Table 2.81**). **Figure 2.184** shows the locations of known nesting beaches of the olive ridley along the western coast of Luzon (from Naic, Cavite to Botolan, Zambales), a coastline of about 200 kilometers. When combined the annual nesting abundance in these beaches comprises the largest known rookery of olive ridley (*L. olivacea*) for the Philippines, and perhaps the whole South China Sea. However, the survival rate for the eggs to adulthood is very low, estimated at around one or two individuals per thousand (Frazer, 1986). Some estimates go even lower, at one individual reaching adult for every 10,000 eggs.

Table 2.81 Three notable tag returns with significant implications to the olive ridley (L. olivacea) in Subic Bay (Data source: PCP tag database)

Attached Tag	**Location and Date of Tag Recovery**	**Significance to Subic Bay Olive Ridley Population**
Homemade tag attached to an olive ridley released in Brgy. Calapacuan, Subic Bay, 25 June 2002	Retrieved 15 days later in Pier 2, Manila Bay	Olive ridleys in Subic Bay are affiliated in Manila Bay
P18448 (a tag code assigned to Morong, Bataan)	Retrieved in Sitio Agusuhin beachfront, after it had apparently nested	Nesters in Morong, Bataan also nest in Subic bay
P17137 and P17139 in Morong, Bataan, in 2001	Retrieved in Botolan, Zambales in 2004	Nesters in Morong, Bataan also nest in Botolan, Zambales

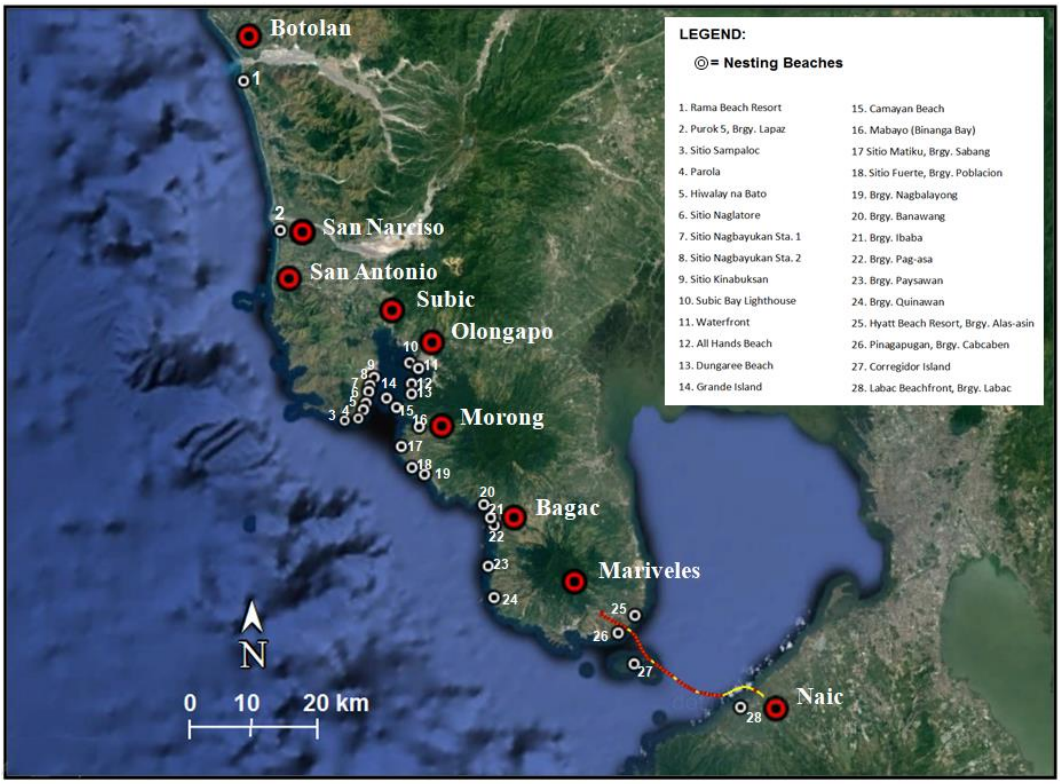


Figure 2.184 Locations of known nesting beaches of the olive ridley (Lepidochelys olivacea) at the project site (near mouth of Manila Bay) and neighboring areas in Bagac and Morong (Bataan), and Subic, San Narciso and Botolan (Zambales)

The data and information reviewed suggests that the project sites (Mariveles, Corregidor and Naic) are critical marine turtle habitats which could be classified into: (1) nesting habitats; and (2) foraging habitats. The common food/prey of olive ridley turtles (L. olivacea) are algae, lobsters, crabs, tunicates, mollusks, shrimps, and fish; green turtles (Ch. Mydas) graze on seagrass and algae; and hawksbill turtles (E. imbricata) graze on encrusting sponges.

(b) Cetaceans and Whale Sharks

Cetaceans (dolphins and whales) and whalesharks (“butanding”) are protected by virtue of their listing in the CITES Appendices I and II. Strandings of dolphins and whales have been reported in Manila Bay between 2006 and 2018 (**Table 2.82**). The species sighted in Manila Bay include: (1) “electra” dolphin or melon-headed whale, Peponocephala electra; (2) unidentified baleen whale; (3) dwarf sperm whale, Kogia sima; (4) Omura’s whale, Balaenoptera omurai; and (5) whalesharks Rhincodon typus. IUCN Red List classified melon-headed whale (P. electra) and dwarf sperm whale (K. sima) as low risk (LR), conservation dependent while Omura’s whale (B. omurai) was assessed as data deficient (DD). Furthermore, IUCN Red List reclassifies whalesharks (R. typus) as Endangered.

The whale sharks had the highest reported stranding frequency (4 sightings) with a total of four (4) dead individuals recorded (see **Table 2.82**). This was followed by the melon-headed whales with only two (2) sightings but recorded the highest total number of live individuals (over 350 individuals). The unusual mass stranding event (about 300-350 individuals) was reported by Aragones et al., 2010, while the media coverage of this stranding event reported more than 200 individuals. This event was observed in the Bataan side of Manila Bay on 10 February 2009. Another unusual stranding event (a school of about 12 live individuals) of melon-headed dolphins was observed the following year on 28 February 2010. According to Obusan et al.

(2016), most of the stranding events in the Philippines on cetaceans had northeast monsoon seasonality.

(c) Dugongs

Presently, there have been no reported sightings of dugongs (Dugong dugon) in Manila Bay. However, according to IUCN, Manila Bay was supposed to harbor some dugongs in the early 70's. Nishikawa et al. (1979), in fact reported that dugongs were present in Manila Bay. Manila Bay was previously fringed with mangrove trees and probably rich in seagrass. The dugong is classified by the IUCN-World Conservation Union as vulnerable to extinction since 1982. In 2003, 20 scientists considered the dugongs in the Philippines as Critically Endangered (https://maritimereview.ph/2016/11/01/the-disappearing-dugong/). CITES also lists the dugongs in Appendix I (except the Australian population which is listed in Appendix II) and likewise, the species is thus fully protected under RA 8550.

Table 2.82 List of stranded cetaceans and whale sharks in Manila Bay

Date of Sighting	Location	Species/ Condition	No. of Individuals	Scientific Name	Source of Information
17 May 2006	Brgy. Tambo, Paranaque City	Small injured dwarf sperm whale	1	Kogia sima	Philstar.com>headlineswhale-found-manila-bay Aragones et al. (2012)
Aug. 2007	Mouth of Manila Bay	Carcass of baleen whale	1	Unidentified	gmanetwork.com/news/news/naton/142303/hale-s-death-in-manila-bay-indicate-grim-problem-story
2008	Manila Bay	Omura's whale	1	Balaenoptera omurai	Aragones et al. (2010)
Jan. 2009	Manila Bay, Pier 13	Carcass of baleen whale	1	Unidentified	gmanetwork.com/news/news/naton/142303/hale-s-death-in-manila-bay-indicate-grim-problem-story
10 Feb. 2009	Manila Bay (Bataan side)	Live electra dolphin or melon-headed whales	300-350, or more than 200	Peponocephala electra	Aragones et al. (2010); https://www.theguardian.com/environment/gallery/2009/feb/10/wildlife-conservation
28 Feb. 2010	Manila Bay (near breakwater of Solaire) Hotel)	Live electra dolphin or melon-headed whales	12	Peponocephala electra	https://www.bworldonline/dolphins-swmming-near-mla-bay-coast-gided-sea

Date of Sighting	Location	Species/ Condition	No. of Individuals	Scientific Name	Source of Information
13 Apr. 2012	Near seawall across the Rajah Solaiman Park, Manila	Whale shark (butanding) with broken dorsal fin	1	Rhyncodon typus	https://www.philstar.com/headlines/2012/04/13/796112/whale-shark-spotted-manila-bay
05 Sept. 2013	Tanza, Cavite	Dead whale shark (butanding)	1	Rhyncodon typus	Rappler.com/nation/38205-dead-whale-shark-in-cavite
09 Sept. 2017	Tanza Bay, Cavite	Dead whale shark (butanding)	1	Rhyncodon typus	https://www.rappler.com/nation181660-dead-whale-shark-tanza-cavite
17 Aug. 2018	Navotas Fish Port, Manila	Dead whale shark (butanding)	1	Rhyncodon typus	https://philstar.comheadlines/2018/08/18/1843736/photos-dead-butanding-seen-navotas

(d) Sharks and Rays

IUCN Red List of Threatened Species classified great hammerhead shark (Sphyrna mokarran) under the Endangered category. This species of shark is confirmed present in Manila Bay along the coastal/marine waters of Bataan, Manila, Bulacan and Cavite. There are many species of sharks and rays present in Manila Bay. Most of the Philippine cartilaginous fishes have already been assessed for Red listing by the IUCN. The problem is the proper taxonomic identification of sharks and rays found in Manila Bay. Barangay Batangas II in Mariveles, Bataan, in fact, is one of the fishing grounds and landing sites being monitored with elasmobranch (shark and ray) catches in 15 coastal regions in the Philippines under the National Stock Assessment Program (NSAP) by the government. Some of the issues during data collection/compilation/reporting analysis encountered were: the mis-identification of species of sharks and other taxonomic concerns; the presence of new, unknown species, and still undescribed species; and the lack of voucher specimens to validate initial identification of species reported (BFAR-NFRDI. 2017).

An experimental trawl fishing survey by Bendaño et al. (2017) in the offshore/ open waters of Manila Bay from March 2014 to October 2015 showed a total of 146 species of fish and invertebrate belonging to 48 families. The most number of species was recorded near Cavite (100 species), followed by stations near Pampanga-Bulacan (93 species), near Metro Manila (80 species), near Bataan (55 species) while the least was in the stations near Corregidor Island (42 species).

2.2.5.5 Impact Assessment and Mitigation Measures

The purpose of this section is to identify the possible marine ecological impacts and their potential for contributing environmental degradation that could result from construction, operations and abandonment of the major structural components of the proposed bridge project, such as the

i. construction of South Channel Bridge,

ii. North Channel Bridge, and

iii. Marine Viaducts for Bataan and Cavite sides.

The construction of these structures could lead to potential impacts on the generation of turbidity plume and removal or loss of, or disturbance to, marine habitats, flora and fauna. Likewise, construction of marine structure will generate noise and vibration, particularly from pile driving activity at the proposed site for the construction of substructure foundation of the towers and anchor piers for navigation bridges and marine viaducts. Pile driving is a method used to install piles for marine and inland water construction projects using high-energy impact hammers. There is a growing concern about the potential effect of construction related underwater sounds and vibrations on sea turtles, marine mammals, and fishes (Dahl et al., 2015; Popper et al., 2014).

Moreover, the proposed bridge project has also the potential to impact the marine ecology through:

a. Accidental oil spills from marine construction vessels and barges, and the introduction of marine pest species and/or phytoplankton organisms involved in harmful algal blooms (HABs) from ships' ballast water;

b. The disruption on municipal or small-scale fishing operations and protected marine species (threatened or endangered species); and

c. The addition of substantial artificial hard substrates (solid structures) on the seafloor in the form of tower and pier steel/concrete piles, columns, and footings.

The impact classification used for the analysis of the proposed project is primarily based upon the United States and State of California guidelines (RI-KFUPM, 1990). Four classes of impacts are defined as follows:

d. **Class I** Significant impacts which cannot be mitigated to insignificant;

e. **Class II** Significant impacts which can be mitigated to insignificant;

f. **Class III** Adverse but insignificant impacts; and

g. **Class IV** Beneficial impacts, significant or insignificant.

Impacts are further classified as site, locally or regionally significant and as short-term or long-term based upon both spatial and temporal consideration, according to the following definitions:

Spatial Classification:

S = site, 1000 m radius from center of distribution

L = local, up to 60 km outside of the boundaries

R = region, beyond 60 km from site boundaries

Temporal Classification:

S = short term, less than or equal to 2 years

L = long term, greater than 2 years

2.2.5.5.1 Planktonic Communities

Potential impacts of the proposed project to the planktonic communities by project phases are summarized in **Table 2.83** below.

Construction

The potential impact of construction to plankton communities includes sediment re-suspension (turbidity) during pile driving. Impacts upon pelagic or water column planktonic organisms will be minimal for both primary production (phytoplankton), and secondary production (zooplankton). These construction impacts may temporarily interfere with phytoplankton productivity and zooplankton feeding and respiration within few meters around the pile driving area. All site specific impacts are classified as Class III (but insignificant).

The major impact of construction on plankton would be the expected increase in turbidity (levels of suspended solids) in the water column created by suspension of sediments around the pile driving area. Turbidity would tend to limit light penetration in the water column which is essential in photosynthesis, a vital process in phytoplankton primary production.

Increased turbidity would also lead to the irritation and clogging of gills of pelagic fish larvae and juveniles (ichthyoplankton) that could lead to their eventual smothering (Hirsch et al., 1978). This condition would slightly increase the mortality rates among pelagic fish larvae and juveniles including other planktonic organisms. These impacts would adversely but insignificantly impact planktonic organisms temporarily. Turbidity of the water column is expected to decrease to normal levels immediately following the completion of the construction activities.

Other source of impacts during construction relates to possibility of transport of some phytoplankton organisms associated with harmful algal blooms (HABs) or red tides via ships' ballast water discharges from construction/cargo/delivery vessels. For example, the results of 10 year of Australian research efforts on transport of toxic dinoflagellates via ships' ballast water as reviewed by Hallegraeff (1998), have shown that by 1990 toxic red tides and paralytic shellfish poisoning (PSP) outbreaks were documented throughout the Southern Hemisphere, including India, Thailand, Brunei, Sabah, and the Philippines. According to Hallegraeff (1998), the problem of transport of toxic dinoflagellates via ships' ballast water was raised by alarming observations of an apparent global increase in the frequency, intensity and geographic distribution of PSP. This human illness (15% mortality) results from the consumption of shellfish products contaminated with alkaloid toxins from some 11 species of plankton dinoflagellates (Hallegraeff, 1990). These species can be carried and spread by domestic traveling vessels and not just international traveling vessels (EPA, undated). Quarantine protocols to manage the possible contamination of ships' ballast water could be addressed through a Ballast Water Management Plan for all ships used on the bridge construction. Provided these measures are allowed the predicted impacts would likely be "low" or insignificant.

Bilge water discharges from construction vessels may also cause damage to plankton communities. Bilge water discharges contain polycyclic aromatic hydrocarbons (PAH). These are carcinogens and are implicated in diseases of aquatic organisms and subsequent human health problems (EPA, undated).

Information on the effects of oil on the pelagic environment taken directly from an EIA study (RI-KFUPM, 1990) reported that:

"photosynthesis is depressed in phytoplankton exposed to petroleum. One study examined the potential recovery of phytoplankton species after exposure to naphthalene (Vandermeulen and Ahern, 1976). On return to non-contaminated medium, the culture, *Monochrysislutheri*, showed a partial recovery of photosynthesis following initial inhibition."

The same EIA study (RI-KFUPM, 1990) also mentioned that:

"growth of phytoplankton is also readily depressed by wide range of petroleum hydrocarbons, including both whole oils as well as specific compounds. These included blue green algae, green algae, diatoms, dinoflagellates, and chrysophytes. Effects on growth vary widely, depending on the oil or compound used and on the algal species, but generally growth lag or lethality has been noted in the range of 1-10 mg/L (e.g., Mommaerts-Billiet, 1973; Pulich et al., 1974; Soto et al., 1975; Prouse et al., 1976; Batterton et al., 1978; Hsiao, 1978; Mahoney and Haskin, 1980). Recent works suggests that algal sensitiveness may not only be species specific but also clone specific depending on the environmental origin of the clone (Eppley and Weiler, 1979)."

The expected impacts are, as a whole, insignificant and Class III due to the transitory nature and short generation time of most plankton.

Another source of impacts to plankton communities during construction relates to possibility of accidental oil spills.The expected effects of accidental oil spills are similar to that of the effects of bilge water discharges from construction vessels in which, as a whole, insignificant (Class III) due to the transient nature and short generation time of most plankton.

In the EIA study (RI-KFUPM, 1990), it was concluded that to date, no mass toxicity to phytoplankton populations has been reported from the field, either from a spill or for chronic conditions. This is due in part, to the fact that very few field studies involving phytoplankton have been done during an oil spill.

Observations on phytoplankton biomass and primary productivity carried out following the Tsesis spill in Sweden during 1977 of no. 5 fuel oil, revealed no significant differences between non-contaminated and contaminated areas (Johanssen et al., 1980). Infact, if anything, for a brief postspill period, both primary productivity and cell numbers were found to be slightly higher in the contaminated areas, perhaps because of reduced grazing by zooplankton (RI-KFUPM, 1990).

Even if a large number of algal cells (9-12 hours), together with the rapid replacement by cells from adjacent waters, probably would readily obliterate any major impact on a pelagic phytoplankton community, and therefore impacts are classified as Class III (but insignificant).

RI-KFUPM (1990) mentioned that the impact of oil on zooplankton has been studied extensively since the 1975 NRC report, primarily because of the importance of zooplankton in marine ecosystems as secondary producers. Work has been carried out in both the laboratory and spill sites. Furthermore, RI-KFUPM (1990) noted that:

The responses of zooplankton to petroleum exposure are numerous (Kuhnhold, 1977; Corner, 1978). As individuals, most zooplankters studied to date in acute and chronic exposure experiments in the laboratory and the field appear to be highly vulnerable to dispersed and dissolved petroleum constituents, and less so to floating oils. The acute lethal toxicity of dispersion and water-soluble fractions (WSF), mostly expressed as 96-hr LC_{50} using initial measured concentrations, range between 0.05 and 9.4 mg/l, with few higher values. These values, based on measurements of actual rather than nominal concentrations, are very close to the lethality thresholds predicted, 0.1-10 mg/l, of soluble hydrocarbons for fish eggs, larvae, and pelagic crustaceans, derived from and earlier intensive survey of the literature (Moore and Dwyer, 1974). It must be emphasized that sublethal deleterious effects can set in well before these high concentrations are achieved.

Field observations on zooplankton have now been made at several spills and chronically polluted sites. Collectively, these studies have established biological effects (Spooner, 1978; Johanssen et al., 1980), these appear to be short lived; there are seldom significant prolonged changes in biomass or standing stocks of zooplankters in the open water near spills. Individual organisms in spills have been affected in a number of ways: direct mortality (fish eggs, copepods, mixed plankton), external contamination by oil (chorion of fish eggs, cuticles and feeding appendages of crustacea), tissue contamination by aromatic constituents, abnormal development of fish embryos, possible temporary inhibition of feeding in copepods, and altered metabolic rates (Longwell, 1977; Samain et al., 1980, 1981; Gilfillan et al., 1984). But zooplankton populations and communities experiencing spills or chronic discharges in open waters appear to recover eventually and maintain themselves; due largely to their wide distribution and rapid regeneration rates (Michael, 1977).

Operation

There will be no impact of operational activities to the surrounding water upon transient plankton.

Abandonment

Removal of the bridge structures (pier piles/columns/footings) will produce turbidity to plankton on temporary and localized basis. Therefore, expected impact to plankton communities is minimal (insignificant).

Table 2.83 Summary of impacts on planktonic communities by project phase

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Construction	- Turbidity due to pile driving	-Temporary turbidity with localized insignificant impact			+		+			+	
		-Tend to limit light penetration which is essential in photosynthesis			+		+			+	
		-Lead to irritation and clogging of gills of pelagic fish larvae and juveniles			+		+			+	
	-Ballast water discharges from construction/ cargo/delivery vessels	-Introduction of phytoplankton species known to trigger harmful algal blooms (HABs) or toxic red tides			+		+			+	
	-Bilge water discharges from construction vessels/tugboats/ barges	-Photosynthesis and growth of phytoplankton is depressed but impacts are insignificant due to transitory nature and short generation time of most plankton			+		+			+	
	- Accident (oil spills)	- Expected effects of oil spills are similar to that of the effects of bilge water discharges in which, as a whole, insignificant (Class III) due to the transient nature and short generation time of most plankton			+		+			+	

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Operations	- Bridge project operations	-None									
Abandonment	-Turbiddity due to removal of bridge structures	-Insignificant and site specific/short-term impact upon transient plankton may be expected			+		+			+	

2.2.5.5.2 Soft Bottom Benthos Communities

Benthic habitats are susceptible to impacts during all phases of development along the main bridge alignment. Soft bottom benthic habitat elements include sand/mud bottom epifauna and infauna.

Major categories of impact by project phase are indicated in **Table 2.84.** This table summarizes site specific effects of each development phase. Four (4) broad categories of impacts are as follows:

- Physical disturbance of the seabed, from pile driving and anchoring of construction barge and surface vessels;
- Localized water column turbidity from pile driving;
- Effects from possible accidental oil spills; and
- Permanent creation of hard/solid substrate on the seafloor.

Construction

Project construction involves pile driving which entail physical disturbance of substrate which would include soft bottom organisms. These activities will cause temporary impact and will crush benthic infaunal organisms and some epibenthic macroinvertebrates and cannot be mitigated. However, benthic organisms can easily recolonize in undisturbed areas.

Some seabed disturbance is also to be expected due to dragging of chains and setting of anchors of construction barge and surface vessels, and will temporarily disturb bottom areas resulting in the crushing or loosing of epifauna and infauna in small area.

The expected negative impacts of these construction activities are expected to be insignificant (Class III), short-term and/or restricted to a small area. Turbidity associated with sediment resuspension of loose to dense sands/muds will also impose insignificant (Class III) impact of short duration on the feeding activities and respiration of the soft bottom benthic community.

Another source of construction impact to benthic organisms is the possibility of accidental oil spills. Physical/chemical fates of released oil are determined by rates of mixing, spreading, advection, buoyancy, temperature, presence of suspended particulate matter, and mode of introduction in the water column. Effects upon benthic biota of oil leakage will be greatest in shallow (intertidal) areas where oil/water emulsion, “mousse”, or tar comes into contact with suspended sediment and sands, is trapped within seagrass beds, or is stranded on beaches and reworked by tidal and wave action into shallow sublittoral sediments. This could impact a high level and significant impact upon the sublittoral benthos. Oil leaks or spills that are released in offshore areas are less threatening to benthic organisms than spills from shallow water areas. For example, in the Santa Barbara Channel oil spill of 33,000 bbl in 1969, intertidal mortalities were significant, primarily by direct smothering from oil, while shallow subtidal habitats showed little evidence of direct damage (Jones, 1969; Fauchald, 1971; Foster et al., 1971).

Operation

The proposed bridge operation will impact marine organisms by means of the introduction of hard/solid substrate on the seafloor. Thousands of concrete/steel piles, columns and footings will be installed vertically extending from the seafloor to the surface. Estimated total areas of this introduced artificial solid/hard substrate are not available. This solid substrate could be provided as habitat for attachment by sessile invertebrates, fouling organisms, and as structural orientation of motile invertebrates.

Davis et al. (1982) have shown how by addition of hard substrata, artificial structures biologically enrich adjacent sediments. All investigations to date indicate a positive “artificial reef” impact upon resident marine biota. The pier piles/columns/footings will therefore most likely provide a beneficial impact for benthic organisms and invertebrates. This may be viewed as a beneficial impact from the introduction of habitat biota and rated as Class IV beneficial impact.

Abandonment

Removal of the bridge structures will temporarily disturb or displace and crush soft bottom (epifauna and infauna) communities and attached (fouling) organisms. The immediate localized impact will be adverse but insignificant (Class III).

Table 2.84 Summary of impacts on soft bottom benthos communities by project phase

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Construction	- Pile driving	- Destroy infauna and epifauna within the piling area and cannot be mitigated; however, benthic organisms can easily recolonized in undisturbed areas around the construction site			+		+			+	
	- Anchoring	-Crush or loose epifauna and infauna in small area			+		+			+	
	-Turbidity	- Disturb feeding activities and respiration of soft bottom benthos; insignificant (Class III) impact of short duration			+		+			+	

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
	- Accident (oil spills)	- Significant impact (direct smothering from oil) upon intertidal /sublittotal benthos but can be mitigated; while upon shallow subtidal and offshore benthos less threatening (insignificant impact)		+	+		+			+	
Operations	- Introduction of hard/solid substrate (pier piles/columns/ foolings) on the seafloor	- A positive “artificial reef” impact upon resident marine biota (benthic organisms and sessile invertebrates)				+	+				+
Abandonment	- Removal of bridge structures	- Temporarily disturb/displace/ crush epifauna and infauna and fouling/attached organisms; and temporary loss of habitat and source of food for invertebrate and fish species; adverse immediate localized impact but insignificant (Class III)			+		+			+	

2.2.5.5.3 Coral Reef

Impacts on coral reefs by project phase are summarized in **Table 2.85.**

Construction

(a) Physical Damage and Turbidity/Sedimentation (Pile Driving)

There are no coral reefs found along or within the footprint of the proposed main bridge alignment. The closest known reef area adjacent to the construction site is the small patch reef (Station RRSS) which is about 0.11 km away from the bridge alignment near the coast of Alas-asin. Therefore, no direct impacts (physical damage) are likely to occur on coral reef habitat as a consequence of project construction, except the fine sediments from sand-mud area during pile driving that could be re-suspended and could travel to adjacent coral reef. Coral reef is very susceptible to turbidity and sedimentation. Increase turbidity reduces the penetration of sunlight, thus inhibiting photosynthesis in primary producers such as the symbiotic microscopic algae (called zooxanthellae) of coral polyps that give its color and food or nutrition. This in turn slows coral growth. Sedimentation smothers living coral, and still hinders the settling of coral larvae. Even low levels of re-suspended fine sediment could affect benthic larvae and juveniles. However, the corals and associated benthic communities are expected to return to present condition following construction. These disturbances will cause temporary impact on the limited coral reef communities which occur in the project area. For these communities impacts will be insignificant (Class III) of short duration and site specific.

(b) Accidental Bumping and Disturbance from Dropping and Dragging of Anchors and Chains

A number of construction barge and surface vessels are expected to operate at the proposed construction of the bridge. Their operations could result in localized disturbance of the adjacent coral reef communities from dropping and dragging anchors and chains on the reef surface. When dropped onto the reef, anchors and anchor chains are dragged onto the reef surface, breaking, snapping and smashing corals before they finally become secure. The area of coral that may be damaged would be considerable. Accidental bumping of the coral formation by these vessels may also occur. These, however, are likely since the coral reef close to shore is of shallow type. These impacts are considered significant (Class II) but site specific, and can be mitigated.

(c) Accidental Oil Spills

Spillage can be due to a variety of reasons, including transferring/loading, bilge pumping, and ship collision. The impact from accidental oil spills could be a wide range of consequences depending on the amount and physical characteristics of spilled oil and the prevailing meteorological and sea conditions during the accident. Due to the proximity of the construction site to the shoreline of Corregidor Island and Alas-asin, any accidental spillage that may occur is likely to affect the nearby coral reefs. The extent of the affected area, however, will depend on the volume of spilled fuel oil. The coral reef resources in Corregidor and Alas-asin occupy subtidal zone (permanently submerged so that they are not susceptible to damage from oil spills). Since most of the spilled diesel fuel oil will evaporate, potential damage to coral reefs is considered minimal. Spills probably would have very minimal impact to deep reefs (Ray, undated).

Operation

There will be no impact of operational activities of the proposed bridge project upon adjacent coral reefs.

Abandonment

One of the potential impacts on the seafloor during actual removal of bridge structures include disturbance of the bottom due to increased turbidity which could travel along the shore and could affect the adjacent coral reefs in the area. However, for this community, impact will be temporary (short duration) and site specific during removal but insignificant (Class III).

Table 2.85 Summary of impacts on coral reef communities by project phase

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Construction	- Turbidity and sedimentation during pile driving	-No direct impacts (physical damage); fine sediments during pile driving could travel to adjacent coral reef; disturbance due to turbidity and sedimentation will cause temporary impact but insignificant (Class III) of short duration			+		+			+	

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
	- Accidental bumping of construction vessels/barges and localized disturbance from dropping and dragging anchors and chains	-Destroy/break and smash live corals; impacts are considered significant (Class II) but site specific and short term, and can be mitigated		+			+			+	
	-Accident (oil spills)	- Coral reefs in Corregidor and Alas-asin are not susceptible to damage from oil spills since they occupy subtidal zone (permanently submerged); since most spilled diesel fuel oil will evaporate, potential damage to corals is considered minimal (insignificant)			+		+			+	
Operations	- Bridge project operations	- None									
Abandonment	- Actual removal of bridge structures	- Impacts on the seafloor (disturbance of the bottom) due to increased turbidity which could travel and affect the nearest coral reef; however, impact will be of short duration and site specific but insignificant (Class III)			+		+			+	

2.2.5.5.4 Fish Sanctuary, Artificial Reef and Shipwreck

Fish sanctuary and artificial reef (AR) are not found at the proposed project site in Barangays Alas-asin and Mt. View, Mariveles. The only fish sanctuary found in the area is located in Barangay II which is approximately 7 km north from the project site.

Similarly, fish sanctuary and AR are also not found in Corregidor Island. However, shipwrecks which also assume the status of “artificial reef” are found around the island. The closest shipwreck to the proposed bridge alignment has a distance of about 0.7 km from the alignment.

Because of the distance of these existing artificial reefs and shipwrecks from the proposed bridge project, construction impact is judged to be insignificant (will not occur).

At present time the only designated marine protected areas (fish sanctuaries) found in the vicinity of the project area are located at Barangay II in Mariveles, Bataan, about seven (7) km north from the proposed bridge shore approach and at Barangay Karsada in Naic, Cavite, which is about 3.7 km southwest from the bridge shore approach and about 0.78 km southwest from main bridge alignment off Naic.

The bridge construction activities will not impact these distant fish sanctuaries. However, the only significant impacts to these marine protected areas are likely to be associated with accidental oil spills. The impact could be a wide range of consequences depending on the amount and physical characteristics of spilled oil and the prevailing meteorological and sea conditions during the accident.

2.2.5.5.5 Seagrasses

Seagrasses are not found along the entire main bridge alignment/shore approach and vicinity. Therefore, impact of bridge construction on seagrasses will not occur since no sensitive seagrass habitat is found in the area.

2.2.5.5.6 Mangroves

Mangrove stands in Alas-asin (Mariveles) are found almost 0.26 km away from the project site, while another mangrove stands are also found in the nearby Babuyan River located 0.14 km away from the project site.

For the Naic side (Cavite), mangrove stands are located at Timalan River in Barangay TimalanBalsahan and also at the mouth/outfall of a creek in Barangay Timalan Concepcion; however, these mangrove sites are located approximately 0.7 and 0.6 km away from the proposed bridge project, respectively.

Therefore, construction activities of the bridge project will not impact this sensitive habitat since there are no mangrove stands in the immediate vicinity of the proposed bridge project.

2.2.5.5.7 Protected Marine Species (Threatened or Endangered Species)

Within Manila Bay are several rare, threatened, or endangered species which are reported or sighted to be occurring or highly expected to occur in the bay. Species of concern include marine turtles, dolphins, whales, whalesharks, and dugongs. Expected project impacts are enumerated in **Table 2.86.**

Construction

(a) Marine turtles

Construction of the proposed bridge project is likely to impact the olive ridley marine turtles which are confirmed to nest in two (2) nesting beaches or egg-laying grounds along the coastline of Barangays Alas-asin and Cabcaben in Mariveles, and another nesting beach along the coastline of Barangay Bagong Kalsada in Naic (see **Section 2.2.5.3.13, Figure 2.173** and **Figure 2.174,** respectively). Nesting would occur between August and February, with an apparent peak season which occurs from November to February. The nearest nesting ground is located in Alas-asin of Mariveles, on a relatively small sandy beach (Hyatt Beach Resort), 1.28 km south of the project site while the nesting beach in Cabcaben (Pinagapugan beachfront) is 3.10 km north of the project site. The nesting ground in Bagong Kalsada (Labac beachfront) of Naic is the farthest from the project site (about 3.45 km from the proposed bridge shore approach in Barangay Timalan Concepcion and 2.81 km from the proposed main bridge alignment off Barangay Karsada). However, due to their high mobility, individuals could occur in the construction site. Sea turtles can migrate long distances in rather short time periods. For example, green sea turtles have been reported to travel 3,000 km in 58-73 days (Meylan, 1981). Fishermen have spotted olive ridleys over 4,000 km from land in the Pacific (oliveridleyproject.org/olive-ridley-turtle).

Noise and turbidity (pile driving)

Construction noise and turbidity are unlikely to cause effects other than possible disruption of orientation, and collisions with construction vessels may be lethal. They are likely to show behavioral responses and avoid the area. However, noise associated with pile driving during construction may be of more consequence. Very little is known about the source levels and associated frequencies that cause physical injury or behavioral responses in marine turtles (BHP Billiton, 2011).

Artificial light

Sea Turtle Conservancy noted that "nesting turtles depend on dark, quite beaches to reproduce successfully". The bridge project results in artificial lighting on the beach that discourages female marine turtles from nesting. Instead, turtles will choose a less-than-optimal nesting spot, which affects the chance of producing a successful nest. Also, nearshore lighting can cause sea turtle hatchlings to become disoriented when they are born. Instead, they will wander on land where they often die of dehydration and predation. However, the artificial lighting during the construction for the bridge project during is not expected to disrupt female marine turtles from nesting due to remoteness of the nesting grounds (1.28-3.45 km) from the construction sites. Therefore, construction impact of the proposed bridge project on marine turtles is likely to be insignificant (Class III).

Collisions/boat strikes/propeller hits

Due to the increased vessel traffic during construction, the possibility of accidental collisions or boat strikes and propeller hits for marine turtles are greater. Marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safety. Turtles can be hit when they come to surface to breath or when feeding or mating. Since severe injury/or mortality are the probable outcome from accidents, significant impacts are indicated (Class II) but can be mitigated.

Accidental oil spills

Oil is a mixture of chemicals, all of which may have different effects on marine animals. Marine turtles and dolphins are air breathers and all must come to the surface frequently to take a breath of air. They may be exposed to chemicals in oil (or used to treat oil spill like dispersants) in two (2) ways: internally (eating or swallowing oil, consuming prey containing oil based chemicals, or inhaling volatile oil related compounds) and externally (swimming in oil or dispersants, or oil or dispersants on skin and body) (NOAA Fisheries Service, undated).

Several aspects of sea turtles put them at risk including the lack of avoidance behavior of oiled waters and indiscriminate feeding in convergence zone. In an investigation of the Arabian Gulf's beaches, the National Commission for Wildlife Conservation and Development (NCWCD) determined that some turtles have died and that most Karan Island green turtles had lesions (Sadiq and MacCain, 1993). Tar has also been observed to block up turtles' mouth and nostrils, and studies of green and loggerhead turtles have shown that they are unable to distinguish between ball of tar and food (Poonian, 2003). Greenpeace reported in 1992 that a green turtle was found to contain 4,500 $\mu g g^{-1}$ oil in liver tissue and 3.10 $\mu g g^{-1}$ in stomach tissue (Poonian, 2003). Ingestion of petroleum compounds may cause injury to the gastrointestinal tract which may affect the animals' ability to absorb or digest foods. Absorption of petroleum compounds or dispersants may damage liver, kidney, and brain functions as well as causing anemia and immune depressions (NOAA Fisheries Service, undated).

Additionally, marine turtles may experience oiling impacts on nesting beaches and eggs through chemical exposure resulting in decreased survival to hatchlings and developmental defects in hatchlings (NOAA Fisheries Service, undated).

Significant effects on marine turtles such as disorientation, altered behavior, ingestion, disrupted breeding, and egg/juvenile/adult mortality would likely to result from oil spills.

However, in general, the impacts to marine turtles during construction are expected to be insignificant (Class III), short duration and site specific.

(b) Dolphins

<u>Noise (pile driving)</u>

Only the melon-headed whales (*Peponocephalaelectra*) was marked clearly as occurring within Manila Bay for having the highest stranding frequency among the marine mammals. Marine mammals use sound to locate prey, communicate with other members of their species, attract mates, and navigate through dark ocean waters (Jarvis, 2005).

The noise levels associated with pile driving during construction of the bridge project is likely to adversely impact the mammal. The piles will be driven into the seabed using a vibro hammer above water level. There may be dolphins that will swim near the proposed bridge construction site during calm weather conditions. However, they can easily move away if the piling noise bothers them. The maximum sound level expected from pile driving coupled with an increase in vessel traffic noise (range from 152 to 192 dB) expected during the construction phase, will likely result in a temporary avoidance of habitat by marine mammal (Nedwell and Howell, 2004 and USACE, 2004 as cited in Jarvis, 2005). For this marine mammal, the impacts during construction are expected to be insignificant (Class III), short-term duration and site specific; and marine mammals are likely to return to the area once construction activities are terminated (USACE, 2004 as cited in Jarvis, 2005).

<u>Collisions/boat strikes/propeller hits</u>

Increased boat traffic leads to an increased possibility of accidental collision and propeller hits. The probability of severe injury or mortality resulting from such accidents creates an adverse (Class III) but insignificant impact classification and can be mitigated.

<u>Accidental oil spills</u>

There have been numerous sightings of marine mammals such as dolphins (Greenpeace, 1992) and dugongs (Preen, 1991) swimming in oil slicks, even when clear water was nearby. Due to their position at the top of the food chain, cetacean predators are susceptible to the effects of bioaccumulation of some of the toxic substances within oil such as PAHs and heavy metals (Poonian, 2003).

The impacts of oil spills to cetaceans have been reviewed by RI-KFUPM (1990). The following summary is adapted from this source:

Oils spills can impact cetaceans by skin contact, eye contact, inhalation, ingestion, reductions in prey availability, denial of access to calving areas, obstruction of migratory pathways, harassment by vessels and personnel during clean-up operations, or any combination of these elements. The severity of the impact will depend upon multiple factors: areal extent of the spill, type of oil; weathered condition of the oil at time of contact; duration of contact; geographic location of the spill; water conditions; seasons of the year; and sea state. Cetaceans, because of their fusiform body shape and smooth, hairless skin are less likely than other marine mammals to have oil adhere for prolonged period. However, even brief direct contact with oil can result in irritation to the eyes, blow-hole and mucous membranes of the air sacs. Inhalation, absorption can lead to acute chronic inflammation, toxic bioaccumulation, and possibly industrial pneumonia. The physiological stress induced by exposure and hydrocarbon detoxification can contribute to mortality from secondary causes or reduced reproductive success (Cowles, 1981). Geraci and St. Aubin (1982) conducted experimental studies on bottlenose dolphins and their response to external contact with petroleum products. The results showed short-term local irritation and swelling which soon had disappeared. There is a dearth of studies considering the long-term, chronic effects upon cetaceans, of oil contact and exposure. This lack of information is due to the logistic and maintenance costs of a long-term study and the generally unacceptable necessity of sacrificing experimental animal to determine the results.

The hazards to cetaceans from oil spills are impossible to specify accurately because of numerous variables involved. The complexity of the oceanographic conditions and oil spill parameters when coupled with our lack of understanding concerning the behavioral, physical and physiological responses of the animals makes any assessment of impact highly speculative. In the majority of cases a low level impact would apply (Class III).

However, an unlikely worst case situation can be imagined with a massive oil spill and animals unable or unwilling to avoid the area while being exposed for a prolonged period. One or more fatalities in such a worst case situation would upgrade the effects to a significant impact (Class II).

(c) Whales, whalesharks and dugongs

Information gathered in this study showed that rarely or occasionally stranded dead or dying whales and whalesharks occur in Manila Bay, particularly along the mouth of the bay and shorelines of Cavite, Paranaque and Manila, and there is no concrete evidence to show that Manila Bay is a natural habitat for these marine animals. Likewise, presently there is no concrete evidence of the presence of dugongs in Manila Bay. Therefore, possible impacts of construction activities of the proposed bridge project on these protected marine species will not occur.

Operation

The impact to marine turtles and dolphins under the operational phase will not occur.

Abandonment

During the period of the actual removal of the bridge structures, insignificant level, Class III condition will exist.

Table 2.86 Summary of impacts on protected marine species by project phase

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Construction: Marine turtles	- Noise during pile driving	- Possible disruption of orientation; collisions with construction vessels may be lethal; significant impacts (Class II) but of short duration and site specific (but can be mitigated)		+			+			+	
	- Artificial light	-Disorientation of nesting turtles and hatchlings; impaci is likely insignificant			+		+			+	
	- Accidental collisions/boat strikes/propeller hits	-Severe injury/or mortality from accidents is greater (marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safety); significant impacts (Class II) but can be mitigated		+			+			+	
	-Accident (oil spills)	-Disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality and all other impacts (generally, impacts are insignificant short duration and site specific)			+		+			+	
Construction: Dolphins	- Noise/vibration impact during pile driving	- Temporary avoidance			+		+			+	
	-Collisions/boat strikes/propeller hits	- Probability of severe injury or mortality; adverse (Class III) but insignificant impact classification and can be mitigated			+		+			+	
	- Accident (oil spills)	- Highly speculative in the majority of cases; low (insignificant) level of impact			+		+			+	
		- However, when animals unable or unwilling to avoid massive oil spill while being exposed for a prolonged period; and with		+			+			+	

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
		one or more fatalities would upgrade insignificant impact to a significant impact (Class II)									
Construction: marineWhales, whalesharks, and dugongs	- Proposed bridge project	-None									
Operation **Marine turtles and dolphins**	Proposed bridge project	-None									
Abandonment **Marine turtles and dolphins**	- Removal of bridge structures	- Insigficant impact, Class III condition will exist			+		+			+	

2.2.5.5.8 Fisheries Resources

Impacts on fisheries resources are summarized in

Table 2.87.

Construction

a) Pile driving/noise and turbidity

The overall impacts of construction activities (pile driving) include sediment re-suspension (turbidity) and noise. These impacts upon pelagic fishes will be minimal because of their ability to avoid such disturbances. Therefore, impacts are classified as insignificant (Class III), temporary and site specific.

The major impact of construction would be the turbidity created by suspension of fine sediment. Most of this would be produced from pile driving procedures and could significantly impact demersal (bottom dwelling) fishes and invertebrates (e.g., the edible blue/red swimming crabs). However, pile driving will produce only localized turbidity plumes near the bottom. Hence, impacts are also classified as insignificant (Class III), temporary and site specific.

Likewise, there will be no turbidity impact on hard bottom reef fishes and it is expected since no coral reefs are present along or within the footprint of the proposed bridge project.

Increased suspended sediment levels and turbidity generated by pile driving activities would cause adult fish in the area to migrate to other suitable areas. However, pelagic fish larvae (ichthyoplankton) and smaller species that are unable to migrate would be chronically exposed to high turbidity and may suffocate as their gills become clogged with sediments. This impact is expected to occur within the radius of 0.1-0.2 km from the construction site. However, as the pile driving operations are not continuous, impact on the fish resources is expected to be minimal or insignificant (Class III), short duration and site specific.

b) Disruption of fishing activities

Impact associated with the construction activities that relates to disturbance or disruption of nearshore and offshore fishing activities of local fisherfolks in the area is expected. However, the fishing grounds along the proposed bridge alignment that will be temporarily disrupted by the construction is not the only fishing grounds in the bay. Local fishers look for richer areas in neighboring waters inside and outside of Manila Bay. For example, all fishers based in Baseco, Sisiman, Alas-asin, Mt. View, Cabcaben, Lucanin and Batangas II fish in the area of Manila Bay (Bataan side) and around Corregidor and Caballo Islands. Many of them, particularly the distant water fleets (bigger fishing vessels) go to distant places in search for fertile fishing grounds in the West Philippine Sea. Likewise, fishers based in TimalanBalsahan and Timalan Concepcion in Naic also fish in Manila Bay (Cavite side) and around Corregidor and Caballo Islands while some large commercial fishing vessels also fish in the West Philippine Sea. Therefore, expected impacts to fisheries around the project site, are as a whole, insignificant (Class III) short-term site specific.

Impact of bridge construction on the oyster farming along the brackishwaterTimalan River of BarangyBalsahan will not occur because of the remoteness of the river (around 0.75 km away) from the project site.

c) Accidental oil spills

Oil spills have low negligible impacts on fish population. Fish kills after oil spill are rare, especially in open waters (Scholz et al., 1992). Significant impacts on local populations generally occur only in shallow waters with poor water circulation. Although large and small spills often result in closure of fisheries by regulatory authorities, there is little or no evidence of tainting of fish or shellfish, even by major spills (GESAMP, 1993).

Assessment of oil spill effects upon motile pelagic fish populations is difficult because of inherent problem of accurately sampling population numbers. Most conclusions are derived from field observations of fish kills or subsequent determinations of sublethal effects. Extensive fish kills have been reported from few spill incidents, such as the Florida (Hampson and Sanders, 1969) and Amoco Cadiz (O'Sullivan, 1978). Lethal field doses are unknown. Laboratory studies showed that lethal toxicities of various crude oils typically are in parts per million range, and chronic sublethal effects (e.g., cellular damage, growth, feeding impairment, etc.) as low as one part per billion under exposure periods ranging from hours to days.

Heavy loss of pelagic eggs and fish larvae (ichthyoplankton) can occur if present in the area of an oil spill, although this is rarely observed directly (Baker et al., 1990). The literature suggests that mortalities among pelagic fish eggs and larvae are limited in size and usually have no measurable impacts on fish stocks (Neff, 1991).

Operation

(a) Creation of artificial hard substrates on the seafloor

Operations of the proposed bridge project are not expected to pose a threat to the local fishery resources around the project area. The introduction of solid/hard marine structures on the seafloor could, in fact, acts as artificial hard substrates (or "artificial reefs") that could attract colonization for a variety of marine life and provide shelter to a number of organisms. For example, the pier piles/columns/footings of the bridge project will provide food and protection for numerous and diverse marine organisms but will also serve as attachment or substrate for attached forms; thus, these artificial hard structures will enhance the marine habitat, biodiversity and productivity quite similar to natural coral reefs in the area. These artificial hard substrates will also provide habitat for an abundant and diverse fish fauna and may also contribute larvae, juveniles, and adult fishes to the fisheries around the project site. Therefore, impact of operations on the fisheries resources will be viewed as beneficial impact (Class IV).

Abandonment

Removal of the bridge structure will produce turbidity to fishes on a temporary and localized basis. Therefore, expected impact to fisheries resources is minimal (insignificant). However, immediate impact is significant because of the loss of hard substrata (“artificial reefs) but can be mitigated (Class II).

Table 2.87 Summary of impacts on fisheries resources by project phase

Project Phase	**Impact Agent**	**Impact**	**Impact Significance**				**Scope**			**Term**	
			I	**II**	**III**	**IV**	**S**	**L**	**R**	**S**	**L**
Construction **Pelagic fishes**	-Turbidity (pile driving)	-Minimal (insignificant) impact because of their ability to avoid such disturbances			+		+			+	
Demersal (soft bottom dwelling) fishes and edible invertebrates	- Turbidity plumes near the bottom due to pile driving	-Temporary avoidance of plume areas			+		+			+	
Hard bottom reef fishes	-Turbidity	-Impact insignificant due to absence of coral reefs along or within the footprint of the bridge project			+		+			+	
Fish larvae/juveniles and smaller species	- Increased suspended sediments/turbi-dity	-Species unable to avoid would be chronically exposed to high turbidity and may suffocate as their gills become clogged with sediments; impact within radius of 0.1-0.2 km from construction site; piling operations are not continuous, therefore, impact is minimal or insignificant			+		+			+	

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
Fiisheries resources	-Disruption/ disturbance to fishing activities	- Impact is insignificant (Class III) short-term site specific impact. Existing fishing grounds around project site are not the only fishing grounds in the area; local fishers fish both inside and outside of Manila Bay including the fishing grounds in West Philippine Sea			+		+			+	
	-Disruption to backishwater aquaculture (oyster farming) ("talabahan")	-No disruption is expected because of the very far distance of Timalan River wherein oyster farming is located, around 0.75 km away from the project site			+		+			+	
	-Accident (oil spills)	-Insignificant impacts on fish population (fish kills after oil spill are rare); avoidance by motile pelagic fishes			+		+			+	
		-Heavy loss of pelagic fish eggs /fish larvae can occur in the area of an oil spill (this is rarely observed directly); literature suggests that mortalities among fish eggs/larvae are limited in size and usually have no measurable impacts on fish stocks (Neff, 1991)			+		+			+	
Operation	-Creation of concrete/steel piles on the seafloor will act as artificial hard substrates or "artificial reefs"	-Provide habitat for abundant and diverse fish fauna, and may contribute larvae, juveniles and adult fishes to fisheries; serve as attachment or substrate for attached forms; thus will enhance the marine habitat, biodiversity and productivity; impacts of				+	+				+

Project Phase	Impact Agent	Impact	Impact Significance				Scope			Term	
			I	II	III	IV	S	L	R	S	L
		operations will be viewed as beneficial impact (Class IV) long-term site specific									
Abandonment	- Removal of bridge structures	-Turbidity during actual removal of the bridge to fishes on a temporary and localized basis; hence, insignificant impact (Class III)			+		+			+	
		-Impact to marine/fisheries ecology and biological resources of the area is significant because of the loss of hard substrata or “artificial reefs” (Class II)		+			+				+

2.2.5.6 Options for Prevention, Mitigation and Enhancement

Jahn (1979) urged that the National Environmental Policy Act or NEPA’s definition in Section 1508.20 be accepted as the universal definition of mitigation. Based upon the authority given in Title II of the NEPA, the Council on Environmental Quality (CEQ) broadly defined mitigation in the context of a management concept, i.e., mitigation includes:

- *Avoiding* the impact altogether by not taking a certain action or parts of an action;
- *Minimizing* impacts by limiting the degree or magnitude of the action and its implementation;
- *Rectifying* the impact by repairing, rehabilitating, or restoring the affected environment;
- *Reducing or eliminating* the impact over time by preservation and maintenance operations during the life of the action; and

- *Compensation* for the impact by replacing or providing substitute resources or environments.

Mitigation is a critical component of the EIA process. It aims to prevent impacts from happening and to find the best ways and means of avoiding, minimizing and remedying impacts, and ensure that residual impacts are kept within acceptable levels. It is therefore essential that a clear understanding of mitigation as a management tool should be established at the onset. Planktonic Communities

Construction

The construction phase will increase turbidity (sediment re-suspension) during pile driving and could cause a short-term, site specific, but insignificant or minor impact on plankton communities. To mitigate the impact among phytoplankton and zooplankton organisms, pelagic fish larvae/juveniles (ichthyoplankton) including phytoplankton photosynthetic activities (primary production), the use of geotextile silt curtains is recommended. Geotextile silt curtains should be used during the construction period to reduce turbidity and therefore, impact on adjacent marine communities.

To mitigate the impact of the introduction and spread of aquatic phytoplankton species (known to trigger harmful algal blooms or HABs/toxic red tides) due to discharge of ships' ballast water, the proponent must prohibit marine vessels used during contraction activities from discharging ballast water in the sea. A ballast water management plan (quarantine protocols) for all ships used during the construction to manage the possible contamination of ships' ballast water could be adopted.

Bilge water discharges from contraction vessels contains polycyclic aromatic hydrocarbons (PAH) and may also cause damage to plankton communities, particularly on the photosynthesis and growth of phytoplankton organisms. To minimize this impact on these pelagic communities, the proponent must also not allow vessels from discharging bilge water at the construction site, or possibly by establishing treatment for bilge water. There is a very effective technology currently available on the market to clean bilge water before it is discharged into the sea (https://www.oecd.org/sti/ind/48365856.pdf).

If there is an accidental oil spill it could not be mitigated. However, over time, new planktonic organisms will replace the population lost during the oil spill period. The extent and duration of the spill will also determine the extent of damage to plankton communities.

Operation

The operations of the bridge will not impact the plankton communities of the surrounding marine waters. Therefore, there is no need for mitigation of impacts.

Abandonment

The effects of turbidity on the removal of the bridge structures to plankton would be temporary and localized; therefore, any impacts to plankton communities is considered minimal (insignificant). Hence, there is no need for mitigation of impacts.

2.2.5.6.1 Soft Bottom Benthos Communities

Construction

Construction activities (pile driving and dropping/dragging of anchors and chains of construction barges and surface vessels) will cause insignificant but temporary and localized impact. Moreover, this will crush/destroy or loose of benthic infaunal organisms and some epibenthic macroinvertebrates in small area and thus, cannot be mitigated.

Except for the bottom areas around the pier piles and footings, the disturb bottom and its benthic biota are expected to return to its original benthic condition within a few months, or years after the completion of the construction, depending on the type of environment and biology of the animals affected (Hirsch et al., 1978). Recovery rates of soft bottom benthic communities are partly a function of habitat type and water depth. Benthic re-colonization should be quite rapid and could occur within a few months after construction. Complete recovery should be attained within a year or two.

Feeding activities and respiration of the benthos will also be impacted by turbidity plumes associated with sediment re-suspension of loose to dense sands/muds during the pile driving operation. Turbidity plumes can be reduced and the level of fine particles could also be greatly reduced by the use of geotextile silt screens during the construction activities. This could help in mitigating the impact on surrounding benthic communities not directly impacted by the construction activities.

A high level and significant impacts upon benthic biota of oil spill will be greatest in shallow subtidal water or intertidal areas. The impact of an oil spill event on shallow subtidal water/ intertidal benthic habitats might be reduced by controlling movement and/or dispersion at sea. Oil spill contingency plans should be prepared and made readily available.

Operation

The introduction of hard/solid substrate (pier piles/columns/footings) on the seafloor is a positive or beneficial “artificial reef impact” upon resident marine biota (benthic organisms and sessile invertebrates). Therefore, there is no need for mitigation of impacts.

Abandonment

Temporary localized adverse impact but insignificant on benthic fauna will occur when bridge structures are removed, and cannot be mitigated.

2.2.5.6.2 Coral Reef

Construction

Turbidity/sedimentation is the major problem for corals. Any reduction in the suspension of fine particles will reduce reef impact and will be a mitigative measure. Silt screens should be used for the pile driving activity to reduce turbidity and thereby, impacts on the adjacent coral reef of the area. Piling should be undertaken during the dry months, ideally when weather/sea condition is calm and water visibility is clear. A suitably qualified pollution control officer or equivalent should monitor the construction activities.

To prevent physical damage to adjacent coral reef during construction from dropping and dragging anchors and chains on the reef surface as well as accidental bumping by construction vessels, a marker buoy should be placed to indicate location of the adjacent coral formation. This will forewarn ship operators and aid them where they can only operate and anchor. If a ship ran aground on coral reef, the ship owners would be financially liable.

Information on the coral reefs at the Corregidor Island and Alas-asin (Mariveles) and neighboring areas occupy subtidal zone (permanently submerged and are not susceptible to damage from oil spills and surprisingly resistant to oil pollution). Since these reefs are essentially subtidal, and oil tends to float, evaporate, impact is normally minimal (insignificant); therefore, no need for mitigation of impacts. It is, however, worth mentioning that Contractor intends to have an Oil Spill Contingency Plan with the intent of giving guidelines as to the steps and actions to be taken when oil spill incident has occurred or is likely to occur.

Operation

No potential impacts of operational activities of the bridge project upon adjacent coral reefs are expected. Hence, there is no need for mitigation of impacts.

Abandonment

Turbidity due to disturbance of the bottom during actual removal of the bridge structures could travel and affect the adjacent coral reef formation; however, impact will be temporary and localized but insignificant. In addition, living corals are susceptible to even low levels of re-suspended fine sediments. Therefore, geotextile silt curtains should be used to reduce turbidity.

2.2.5.6.3 Fish Sanctuary, Artificial Reef and Shipwreck

Because of the remoteness of the existing fish sanctuaries, artificial reefs and shipwrecks from the project site, construction impact is judged to be insignificant or will not occur. However, the only significant impacts to these fish sanctuaries are likely to be associated with accidental oil spills. If there is an oil spill event on the marine environment it would not be mitigatable, but impacts to these sanctuaries could be minimized or reduced by controlling movement of any oil spill by containment and/or dispersion at sea. Oil spill contingency plans should be prepared and made readily available.

2.2.5.6.4 Seagrasses

Impact of bridge construction will not occur since no seagrass habitat is found in the project site and neighboring areas; therefore, there is no need for mitigation of impacts.

2.2.5.6.5 Mangroves

Construction activities of the bridge project will not impact the mangrove areas found in Alas-asin (Mariveles) and Naic (Cavite) since their geographical locations are quite far from the proposed bridge alignment. Hence, there is no need for mitigation of impacts.

2.2.5.6.6 Protected Marine Species (Threatened or Endangered Species)

(a) Marine turtles

Noise (pile driving)

Noise during pile driving may be of more consequence and could cause disorientation, injury or hearing loss while collisions with construction vessels may be lethal.

According to BHP Billiton (2011), the principal source of noise that considered to pose the most risk to marine turtles is produced during pile driving, although it is considered that the regular pulses from piling activities may result in avoidance behavior. However, little is known of the impact of noise on marine turtles.

Specific measures to manage noise during pile driving activities are found in a publication prepared by BHP Billiton (2011) entitled Marine Turtle Management Plan. Below are the following mitigating measures that could be adopted for the proposed project (BHP Billiton (2011):

- A trained personnel will be responsible for observing marine turtles during active piling at piling sites (e.g., on a jackup barge or adjacent support vessel).
- Vessel crew will undergo site inductions and clear briefings covering procedures to be undertaken, to minimize disturbance to marine fauna provided by appropriately qualities personnel.
- Existing acoustic control on noise-generating equipment (including vessel engines, drill and piling equipment) will be implemented to reduce notice at source.
- Noise-generating equipment (including vessel engines, drill and piling equipment) will be routinely maintained and inspected to reduce unnecessary increases in noise levels from the equipment. All vessels shall operate in accordance with appropriate industry equipment noise standards.
- Where practical the practice of leaving engines, thrusters and auxiliary plant on standby or running mode will be avoided.
- If marine turtles are sighted in the monitoring area, project vessels operating in the area will be notified.
- Trained vessel crew will monitor and report observations of marine turtles within a designated monitoring zone (250m radius of piling barge) around the pile driving operations. Observations are to be recorded on the Observation Record Form. In the event that a marine turtle is sighted within a designated exclusion zone (500 m radius of the piling barge), piling activities will cease until the marine turtle moves outside of the exclusion zone or is not sighted for 20 minutes. Note: for reference, a 2000-m exclusion zone applies for Marine Mammals (except dolphins).
- Carry out a “soft start” for piling by beginning a pile driving session with the lowest power possible and hammering at a low rate, then increasing hammer energy and rate to that desired. This should allow animals close to the source to move away and not be suddenly exposed to sound intensities sufficient to cause them serious injury.
- Any injuries or mortalities will be documented and reported.

For this proposed bridge project, a regular monitoring is recommended to assess compliance with noise and vibration levels during the construction phase of the bridge project.

Artificial light

Artificial lighting has the potential to reduce the reproductive success of marine turtles by deterring females from nesting beaches, and disorienting or misorienting hatchlings on the beach and at sea (BHP Billiton, 2011). Potential sources of light from the project site included the land-based project facilities, marine facilities as well as moored and construction/ barge/

cargo/ delivery vessels. However, assessment shows that the risk to female marine turtles will be in insignificant level impact (Class III) due to remoteness of the nesting grounds (1.28-3.45 km) from the construction sites. Therefore, there seemed to be no need for mitigation of impacts.

It is, however, worth mentioning that BHP Billiton (2011) has prepared key management measures and guidelines specific to managing light spill and potential impacts to marine turtles:

- Minimize light intensity to as low as reasonably particularly in nearshore areas.
- Avoid use of white lights (e.g. mercury vapour, metal halide, halogen, and fluorescent light) in proximity to turtle beaches. Use high pressure sodium lights where possible.
- Reduce lighting spill through shielding, directional alignment, window covering and other techniques.
- Reduce horizon glow through the use of downward facing luminaries, attention to reflecting surfaces and minimization of external visibility of indoor lighting.
- Lighting on moored vessels at night will be kept to a minimum for safe operations.
- Periodic monitoring of the waters by trained vessel crew around construction vessels and around the construction site for the presence of hatchlings.

Collisions/boat strikes/propeller hits

Boat strikes from construction vessels is considered more likely to occur to marine turtles during construction due to higher vessel traffic (smaller vessels that can travel at higher speeds) and less likely during operations with larger vessel moving slowly (BHP Billiton, 2011). The chances of collision with marine turtles might be reduced by minimizing vessel speed by incorporating routine visual reconnaissance efforts (RI-KFUPM. 1990 as cited by BSI, 2018). Hazel et al. (2007), however, emphasized that speed reduction appears to be the only way vessel operators can minimize collision risk when operating in turtle habitat. The Sea Turtle Protection Society of Greece described the speed limit of 6 knots to avoid collision with a sea turtle (http://www.archelon.gr/eng/habitat_zak.php).

Management measures for minimizing the interaction of marine turtles with vessels during construction and operations include (BHP Billiton, 2011):

- Vessel crew will undertake site induction by appropriately trained project personnel.
- Vessel speeds will be under the control of the Vessel Master who will ensure that all vessels operate in a safe manner with due respect to ongoing operations, navigational constraints and environmental considerations.
- The Vessel Master will be advised of environmental matters from on-site environmental staff, including trained vessel crew, as applicable.
- Trained vessel crew will monitor and report turtle sightings from project vessels during daylight hours during the construction phase.
- Any incidents or injuries to turtles will be documented and reported.

Accidental oil spills

If there is an oil spill, the impact would be significant and not mitigatable but might be reduced by controlling movement and/or dispersion at sea. Oil spill contingency plans should be prepared and made readily available.

(b) Dolphins

Noise/vibration impact (pile driving)

Management measures for marine noise and vibration impacts on marine mammals during construction are also similar to that of marine turtles (BHP Billiton, 2011).

Collisions/boat strikes/propeller hits

The management measures for minimizing boat strikes during construction at the project site are also similar to that of marine turtles except that "if a marine mammal is sighted within 300 m, a maximum vessel speed of 6 knots will be applied" (BHP Billiton, 2011).

Accidental oil spills

Mitigating measure of potential impacts for marine mammals if there is an oil spill event at the project site is also similar to that of marine turtles. Impacts from oil spill accidents could be reduced by controlling oil spills at sea.

2.2.5.6.7 Fishery Resources

Construction

The major impacts of construction upon pelagic and soft bottom demersal fishes would be turbidity and noise; however, impacts are classified as temporary or short-term but insignificant level since adult fishes has the ability to avoid such disturbances. Impact on hard bottom reef fishes is also insignificant since there is no coral reef within the pile driving sites. However, turbidity will be detrimental to both larval and juvenile fishes. Reduction of turbidity would reduce impact on these organisms. Therefore, geotextile silt curtains should be used to reduce turbidity.

Temporary impact or disturbance on fishing activities at the project site will occur. A required safety exclusion zone along construction area is recommended, that is 0.2 km.

Theconstructionofthe bridge willnotimpacttheoysterfarming in TimalanRiver (Naic) beingfar in distance (0.75 km) fromtheprojectsite. Therefore, thereis no needformitigationofimpacts.

Assessment shows that accidental oil spills during construction activities have generally minimal or insignificant impacts on fish population (significant impacts generally occur in shallow waters with poor water circulation). The probable capabilities of fishes to avoid toxic contaminants could reduce impacts. However, heavy loss of pelagic fish eggs/larvae can occur if present in the area of an oil spill. Modeling studies indicate that large numbers of fish larvae would have to be destroyed to affect recruitment (Reed et al., 1984 and Hurlbut et al., 1981 as cited in GESAMP, 1993). The possibility exists for impacts on stock spawning in the event of major spills in shallow water area having poor water circulation. However, only small proportions of any pelagic fish eggs and larvae population will likely to be impacted, with relatively small resource losses (GESAMP, 1993). The impact of an oil spill event on fishes and fish eggs/larvae might be reduced by controlling movement of any spill which originates from the project site by containment and/or dispersion at sea. Therefore, oil spill contingency plans should be prepared and made readily available.

Operation

A positive or beneficial impacts (Class IV) upon fish and fishery resources at the project site are expected because of the creation of artificial hard substrata ("artificial reef") on the seafloor. Therefore, no mitigation is required.

Abandonment

Significant impacts on reef fish and invertebrate populations will occur when bridge structures are removed because of habitat loss but can be mitigated.

Disposal of the bridge structures on land create a solid waste problem unless recycled as scrap metal. However, offshore disposal offers an attractive mitigative (compensation) option which bears consideration. Artificial reefs are popular throughout the world. Tires, pipes, car bodies, and concrete blocks are commonly used as basic components for these reefs, these components being placed together to form a group reef and ultimately a substantial artificial reef (Thierry, 1998 as cited by RI-KFUPM, 1990). Such artificial reefs have three (3) main functions as follows:

1. Concentrate species in an area for fisheries industry;
2. Protection of some species or young stages; and
3. Increasing the natural productivity based on establishment of a complete food chain.

Simply stated, the primary function of an artificial reef is to attract fishes and other marine organisms, and to encourage their establishment, temporarily or permanently.

2.2.5.6.8 Summary of Perceived Marine Impacts and Mitigating Measures

Summary of impacts and mitigating measures to the marine ecological and biological resources for the proposed bridge project is provided in **Table 2.88**.

Table 2.88 Summarized Impact Management Plan for Marine Ecology

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
Construction			
Plankton Communities	Increase turbidity (sediment resuspension) due to pile driving	May interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis; and may also irritate and clog the gills of pelagic fish larvae and juveniles that could lead to their eventual smothering. However, turbidity is expected to decrease to normal levels immediately	Use of geotextile silt curtains is recommended

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
		following pile driving activities; hence, these site-specific impacts are insignificant (Class III) and temporary	
	Ballast water discharges of construction/ cargo/delivery vessels	Introduction of some phytoplankton species known to trigger harmful algal blooms or HABS/toxic red tides that can alter the structure and function of aquatic ecosystems; if mitigating measures are allowed impact would likely be “low” or insignificant	Prohibit marine vessels from discharging ballast water in the sea; Quarantine protocols through a Ballast Water Management Plan could be adopted
	Bilge water discharges of construction/cargo/delivery vessels	Photosynthesis and growth of phytoplankton is depressed; expected impacts are, as a whole, insignificant (Class III) due to the transitory nature and short generation time of most plankton	Prohibit marine vessels from discharging bilge water, or possibly by establishing treatment for bilge water; a very effective technology currently is available on the market to clean bilge water before it is discharged into the sea
	Accidental oil spills	Impacts are classified as Class III (but insignificant) due to transient nature and short generation time of plankton; if there is an oil spill it would be not mitigatable (overtime planktonic organisms will replace populations lost during oil spill period)	No mitigation required

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
Soft Bottom Benthos Communities	Pile driving	Will crush or destroy benthic infaunal organisms and some epibenthic macroinvertebrates in small area and cannot be mitigated; benthic re-colonization should be quite rapid and could occur a few months after construction. Complete recovery should be attained within a year or two	No mitigation required
	Anchoring	Temporarily crush or loose infauna and epifauna in small area; insignificant impact (Class III) of short duration	No mitigation required
	Turbidity plumes, pile driving	Disturb feeding activities and respiration of benthos; insignificant impact (Class III) of short duration	Turbidity plumes can be reduced by the use of geotextile silt curtains; could help in mitigating the impact on surrounding benthic communities not directly impacted by the pile driving activities
	Accidental oil spills	Significant impact (direct smothering) on benthos in shallow water or intertidal/sublittoral areas; while in offshore areas less threatening (insignificant impact).	Impact on shallow water/intertidal or sublittoral areas might be reduced by controlling movement of oil spill and/or dispersion at sea. Oil Spill Contingency Plans should be prepared and made readily available
Coral Reefs	Accidental bumping of construction vessels and localized disturbance from dropping and dragging anchors and chains	Destroy/break and smash remaining live corals/associated communities and will cause significant impact (Class II) but site specific/short duration	To prevent to happen, a marker buoy should be placed to indicate location of the patch reef (this will forewarn ship operators and aid them where they can only operate and anchor)

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
	Accidental oil spills	Coral reefs of Mariveles, Corregidor and neighboring areas are permanently submerged and are not susceptible to damage from oil spills; therefore, impact is normally minimal (insignificant)	Contractor intends to have an Oil Spill Contingency Plan with the intent of giving guidelines as to the steps and actions to be taken when oil spill incident has occurred or is likely to occur
Protected Marine Species			
Marine turtles	Noise (pile driving)	Possible disruption of orientation, injury or hearing loss and collisions with constructioin vessels may be lethal; significant impacts (Class II) but can be mitigated	Mitigating measures to manage noise during pile driving activities can be seen in **Section 2.2.5.5.7o**n Marine Turtle Management Plan (BHP Billiton, 2011)
	Artificial light	Reproductive success of marine turtles may potentially be reduced because matured females could be deterred from nesting on sandy beaches; hatchlings may also be disoriented/misoriented and displaced on the beach	BHP Billiton (2011) has prepared key management measures and guidelines specific in managing light spill and potential impacts to marine turtles (see s can be seen in **Section 2.2.5.5.7** on artificial lighting)
	Accidental collisions/boat strikes and propeller hits from construction vessels due to higher vessel traffic	Severe injury and/or mortality from accidents is greater (marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safety); significant impacts (Class II) are likely to be expected but can be mitigated	Chance of collision might be reduced by minimizing vessel speed by incorporating routine visual reconnaissance efforts (RI-KFUPM, 1980 as cited in BSI, 2018). For management measures for minimizing the interaction of marine turtles with vessels, see BHP Billiton (2011) in s can be seen in **Section 2.2.5.5.7** The Sea Turtle Protection Society of Greece described the speed limit of 6 knots to avoid collision with a sea turtle
	Accident (oil spills)	Disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality; if there is an	Oil spill might be reduced by controlling movement and /or dispersion at sea; Oil Spill Contingency Plans should be

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
		oil spill, these impacts will be significant and not mitigatable but might be reduced. In general, impacts are considered insignificant short duration and site specific	prepared and made readily available
Dolphins	Noise/vibration impact (pile driving)	Temporary avoidance. Impact is expected to be insignificant (Class III), short-term duration and site specific	Trained vessel crew/marine observers to keep a watch during high noise/vibration activities
	Collisions/boat strikes/propeller hits	Probability of severe injury or mortality; adverse (Class III) but insignificant impact classification and can be mitigated	Management measures for minimizing boat strikes are similar to that of marine turtles except that “if a marine mammal is sighted within 300 m, a maximum vessel speed of 6 knots will be applied (BHP Billiton, 2011)
	Accidental oil spills	Highly speculative in the majority of cases (insignificant level of impact); however, when animals unable or unwilling to avoid massive oil spill while being exposed for a prolonged period, and with one or more fatalities would upgrade insignificant impact (Class III) to a significant impact (Class II)	Oil spill might be reduced by controlling movement and /or dispersion at sea; Oil Spill Contingency Plans should be prepared and made readily available
Fisheries Resources	Turbidity and noise, pile driving	Increase in turbidity and noise may temporarily drive away pelagic/demersal fishes; thus, impacts are classified as insignificant (Class III); also, impact on bottom reef fishes is insignificant since there is no coral reef along the project site. However, turbidity will be detrimental to both larval and juvenile fishes (reduction of	Geotextile silt curtains should be used to reduce turbidity

Project Phase/ Environmental Aspect	Project Activities/ Impact Agent	Potential Impact	Mitigation and Enhancement Measures
		turbidity would reduce impact)	
	Disruption/disturbance of fishing activities	Temporary impact and short duration will occur but minimal or insignificant (Class III) since fishing activities will still be allowed along the vicinity of the construction sites, but with a required safety exclusion zone. Moreover, existing fishing grounds around the construction sites are not the only fishing grounds in the area	A required safety exclusion zone along construction site is recommended (i.e., 0.2 km)
	Accidental oil spills	Generally, minimal or insignificant impacts (Class III) on fish populations are expected because of probable capabilities of fishes to avoid oil spills; however, heavy loss of pelagic fish eggs and larvae can occur in shallow water area with poor water circulation	Oil spill impact might be reduced by controlling movement of any spill; therefore, Oil Spill Contingency Plans should be prepared and made readily available
Operation			
Fisheries Resources	Creation of artificial hard substrates on the seafloor	Impact of operation is viewed as beneficial impact (Class IV); act as artificial hard substrates or “artificial reefs”.	A positive impact; therefore, no mitigation required
Abandonment			
Fisheries Resources	Removal of bridge structures	Significant impact on fish/invertebrate populations because of habitat loss (artificial hard substrata)	Offshore disposal of hard structures offers an attractive mitigative (compensation) option. These components being placed together will form a group reef and ultimately a substantial “artificial reef”

2.3 The Air

This section provides the potential impacts, options for prevention, mitigation and enhancement plans for the following sub-sections under the Air module:

- Meteorology and Climatology
- Ambient Air Quality
- Ambient Noise Assessment

These were conducted by a variety of methodologies being employed to determine baseline environmental conditions. These include:

a. Review of all available secondary information from PAGASA
b. Reconnaissance survey
c. Detailed field investigations
d. Air sampling and analysis
e. Noise sampling and analysis

The application of these methodologies is described in more details in the subsequent sections.

2.3.1 Meteorology and Climatology

Natural disasters, such as rising sea levels, severity of storms, floods, and droughts, changing of landscapes, and loss of biodiversity have been increasing as the consequences of climate change, are all evident in the Philippines. As a solution, the Republic Act 9729, or the Climate Change Act of 2009, was implemented, which brought formulations of climate change into government policy, establishment of the Framework Strategy and Programme on climate change, and formation of Climate Change Commission (CCC).

The Department of Environment and Natural Resources - Environmental Management Bureau (DENR-EMB) issued the Memorandum Circular No. 2011-005 to incorporate the Disaster Risk Reduction and Climate Change Adaptation (DRR/CCA) in the Philippine Environmental Impact Statement Systems (PEISS). This will ensure that the submission of the Environmental Impact Statement (EIS) Report will include project's effects on human health and the environment will not be worsened by its possible impacts.

The collected historic and existing meteorological and climatological conditions of the Project are summarized in this section. The projection of the medium- to long-term climate change effects and projected climatic conditions use studies made by Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) were used in this assessment.

Study Area

The Project is located in two (2) provinces, Barangay Timalan Concepcion and Timalan Balsahan in Naic, Cavite and extends until Barangay Alas-asin and Mt. View in Mariveles, Bataan. The municipality of Bagac and Limay surround the northern part of the Bataan area, while the area of Cavite has Nasugbu and Bacoor to its south and east, respectively.

2.3.1.1 Methodology

The nearest PAGASA weather stations, where the meteorological data were taken, are located at the Naval Station Sangley Point, Cavite and Cubi Point, Subic Bay Olongapo City, Zambales.

The secondary data gathered at these weather stations provided information such as rainfall, ambient temperature, relative humidity, wind speed and wind direction in addition to the discussion of maps on climate and frequency of tropical cyclones. Medium and long-term climate change projections made by PAGASA were also added into the assessment.

A) Secondary Data Source

Long term meteorological data of the Bataan and Cavite are required by the Environmental Management Bureau (EMB) to represent the meteorological conditions at the project site. The climatological data were sourced from the nearest PAGASA weather stations: Sangley Point, which is located approximately 21 kilometers (km), and Cubi Point, which is approximately 47 km from the project alignment (**Figure 2.185**). Long term climatological data were based on PAGASA's latest available data collected from year 1981-2010: Sangley Point climatological normals were from 1981-2010, Cubi Point Average Values were from 1992-2010 and both weather stations climatological extremes were from 2018.

Listed below are the secondary data sources used to complete this sub-section:

- Sangley Point and Cubi Point Weather Stations from PAGASA- Climatology and Agrometeorology Data Section (PAGASA-CADS)
- Modified Coronas' Classification or the Climate Map of the Philippines.
- Tropical Cyclone data from Manila Observatory
- Climate Change in the Philippines, 2011
- Observed Climate Trends and Projected Climate Change in the Philippines, 2018

Table 2.89 Weather Station Details

Station	Location	Elevation	Coordinates
Sangley Point, Cavite	Naval Station Sangley Point, Cavite	3m	14°29'29.93"N 120°53'54.90"E
Cubi Point, Zambales	Cubi Point, Subic Bay Olongapo City, Zambales	19.087m	14°47'30.43"N 120°16'15.24"E

Source: Google Earth

Figure 2.185 Location of nearest weather stations

B) Analysis of Weather Station Data

Climatological normals are weather parameters computed over at least a 10-consecutive year period. Climatological extremes, on the other hand, are data matrix of the highest and lowest weather parameters recorded over a long period. These parameters include temperature, rainfall and wind speed. This climatological data, as presented in **Annex I**, was obtained from Sangley Point and Cubi Point weather stations.

Wind rose statistics that summarizes the distribution of wind in 16 speed and directions were analyzed using the 30-year (1988 to 2017) wind data from PAGASA Sangley Point Weather Station and 14-year (1994-2017) wind data from PAGASA Cubi Point Weather Station (**Annex I**). The color bands on the rose show the wind ranges while the direction of the rose with the longest spoke represents the direction with the greatest frequency.

Meteorological conditions will focus on the climate and tropical cyclone frequency maps collected from PAGASA.

C) PAGASA Climate Change Projections in the Philippines

A climate model done by PAGASA describes the possible changes in temperature, and amount of rainfall based on 2018 PAGASA Observed Climate Trends and Projected Climate Change in the Philippines report, and frequency of extreme events in a medium-range scenario for years 2020 and 2050, based on 2011 PAGASA Climate Change in the Philippines report. Climate projections for medium-range scenario are given more detail since current emissions of greenhouse gases in the atmosphere will influence and affect the climate in the next 30 to 40 years.

The seasonal variations are as follows:

- The DJF (December, January, and February or northeast monsoon locally known as *Amihan*) season;
- The MAM (March, April, and May or summer) season;
- The JJA (June, July, and August or southwest monsoon locally known as *Habagat*) season; and
- The SON (September, October, and November or transition from southwest to northeast monsoon) season.

D) Limitations of the Study

Limitations for the climate and meteorological assessment are listed below:

- The historic and existing climatological and meteorological data are limited to the secondary data as provided by Sangley Point and Cubi Point Weather Stations, which are approximately 21 and 47.5 km away from the Project alignment, respectively.
- Climate change projections are limited to those provided by the nearest weather station from the project site and are not sourced from local data.
- Moderate and high emission scenario projected rainfall and mean temperature are limited to projected mid-21st century based on the baseline period 1971-2000.

2.3.1.2 Baseline Environmental Conditions

A) General Climate

Climate Type

Based on the Modified Coronas Classification, the project location is under Type I category. This classification states that these areas experience two pronounced seasons, dry from November to April, and wet during the rest of the year (**Figure 2.186**), although it is likely that the project area will be affected by the *Habagat*, or the Southwest Monsoon, as it is located in Luzon. It general, Northeast Monsoon, or *Amihan* occurs during October to April while the *Habagat* occurs from May to September due to the Philippines' geographical location.

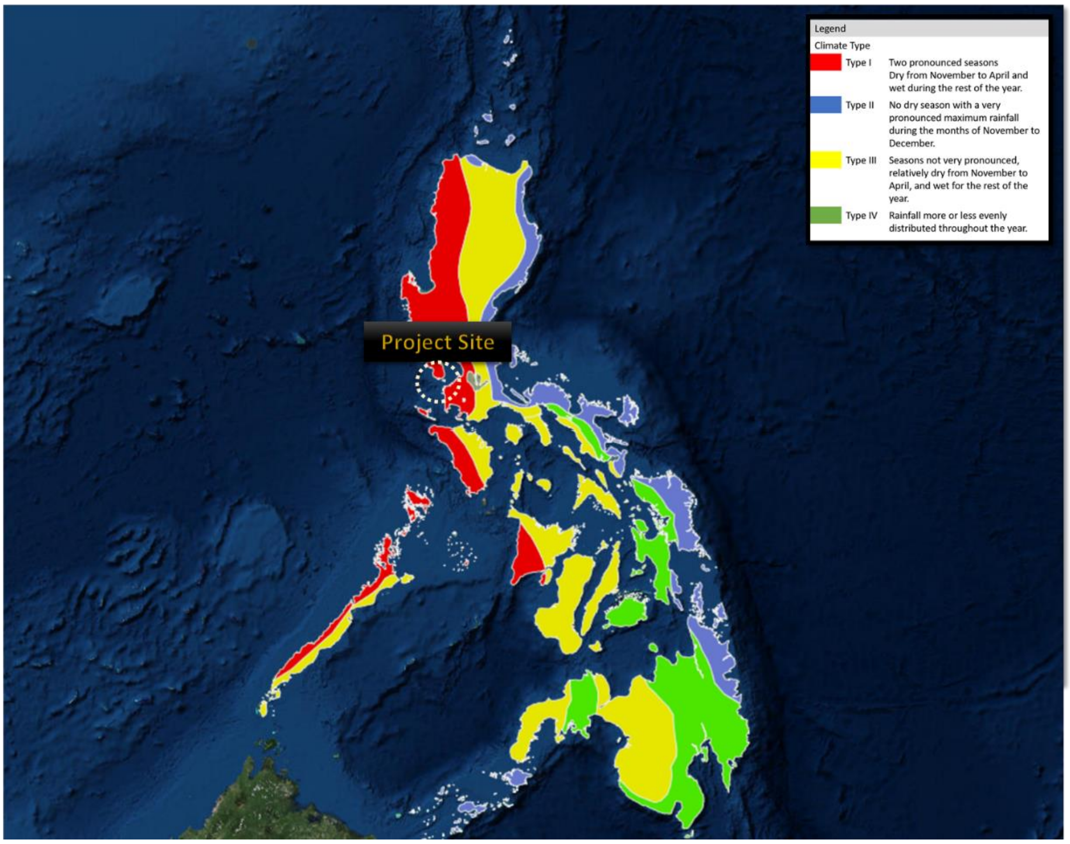


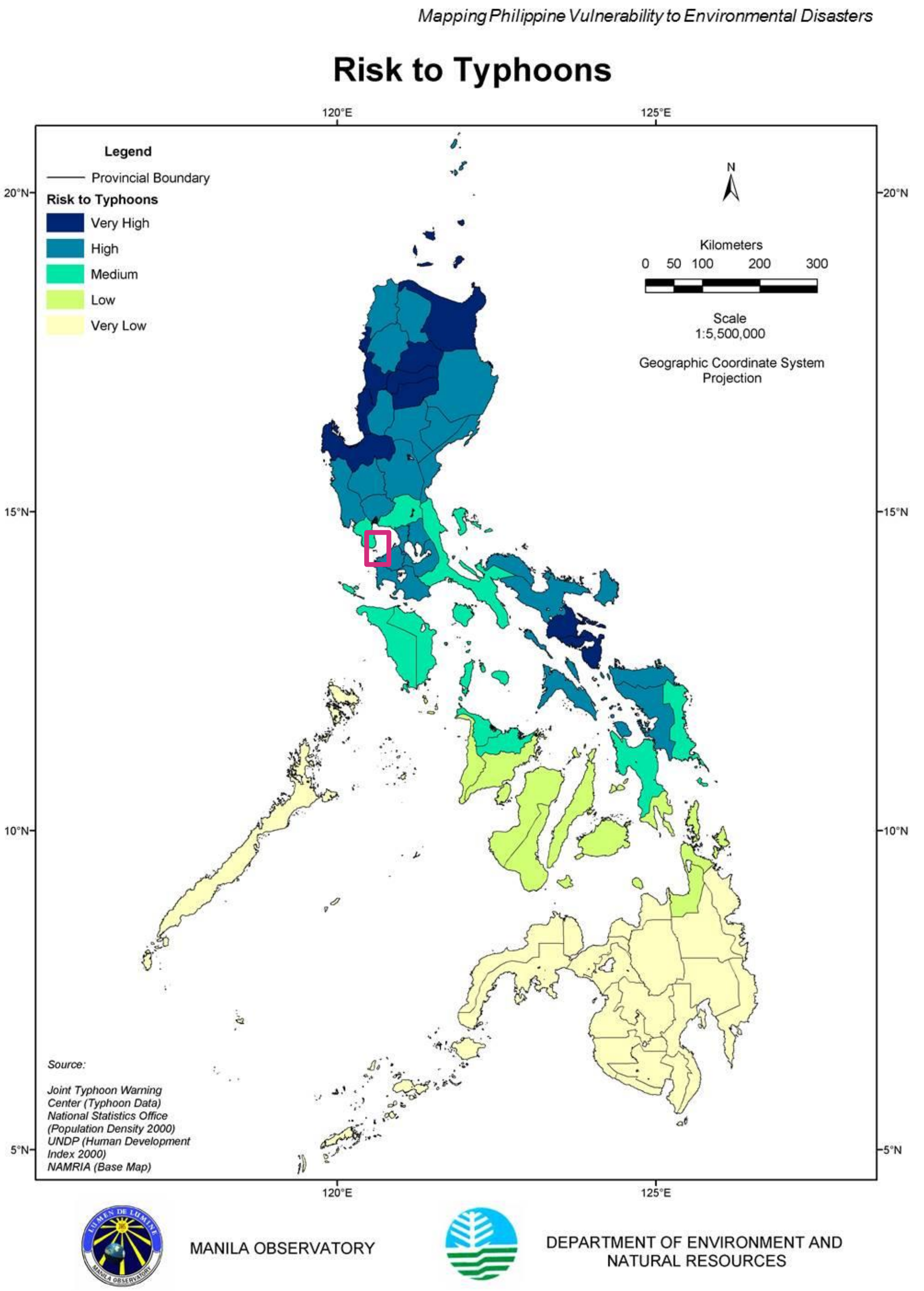
Figure 2.186 Climatological Map

Frequency of Tropical Cyclones

Tropical cyclones are non-frontal low-pressure system of synoptic scale with winds persisting at a minimum of six hours and a maximum average wind speed of 34 knots (62 kph). An average of 20 tropical cyclones form per year in the Philippine Area of Responsibility (PAR). The cyclones are categorized by PAGASA based on both the maximum winds, and its intensity as it enters PAR. In 2015, using strength, intensity, and impact to the affected communities, PAGASA categorized these cyclones into 5 public storm warning signals (PSWS).

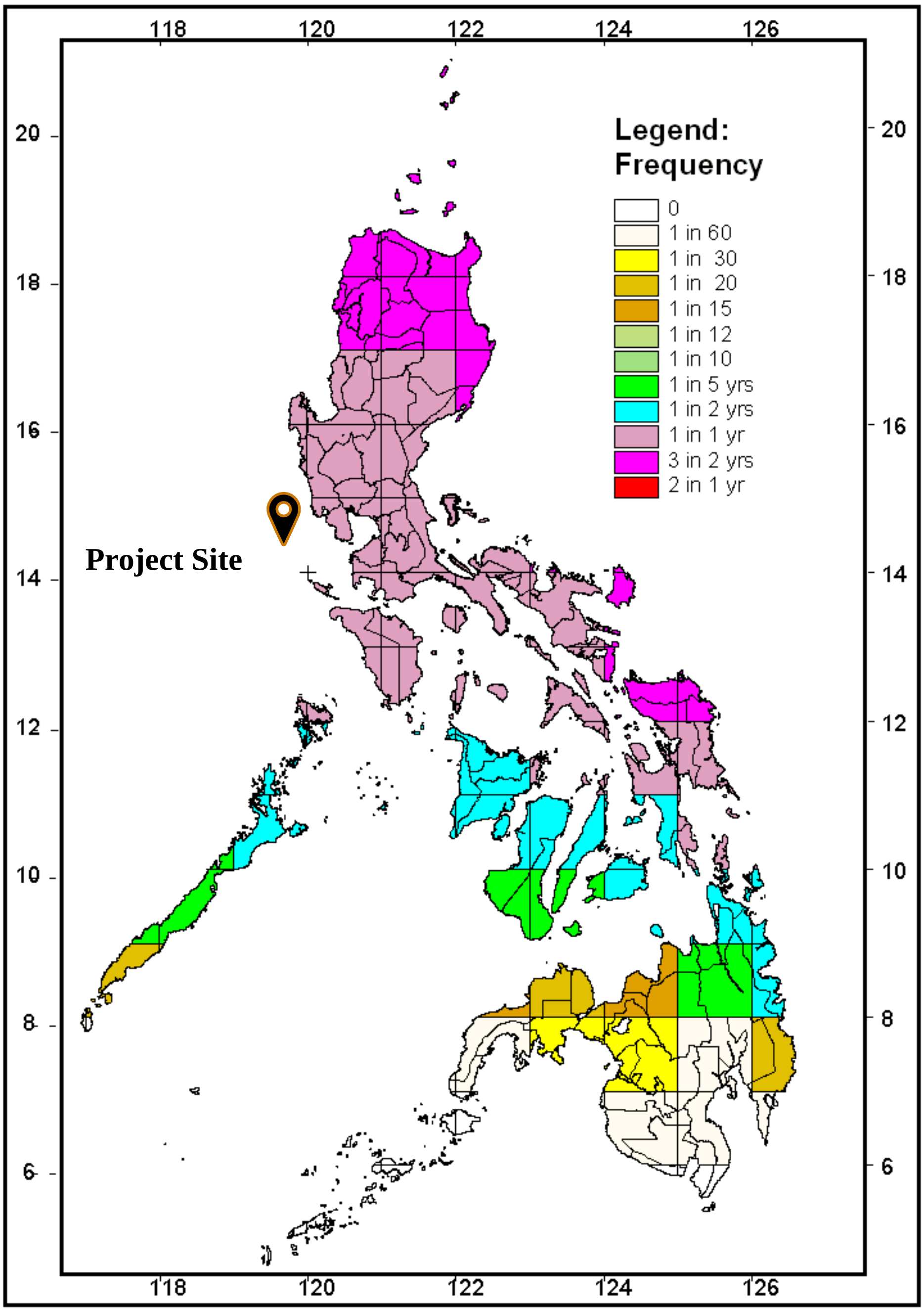
- **PSWS No. 1** - Tropical depression with maximum sustained winds up to 61 kph
- **PSWS No. 2** - Tropical storm with sustained winds 62 to 88 kph
- **PSWS No. 3** - Severe tropical storm with maximum wind speed of 89 kph to 117 kph
- **PSWS No. 4** - Typhoon with maximum sustained winds of 118 to 220 kph
- **PSWS No. 5** - Super Typhoon with maximum sustained winds more than 220 kph.

With a high to medium risk, Cavite and Bataan are hit by 1 typhoon per year (**Figure 2.187** and **Figure 2.188**). Recently in November – December 2019, typhoon Kammuri, with local name *Tisoy*, hit Central Luzon and Bataan with maximum sustained winds of 150 kilometers per hour (kph) and gustiness of up to 185 kph, which has caused moderate wind damage all over these provinces. Another noted tropical storm is in 2014 named *Glenda* that caused widespread flooding due to heavy downpours having a peak at 120 kph with gusts as strong as 165 kph.



Source: Joint Typhoon Warning Center (Typhoon Data 1945-2003) National Statistics Office (Population Density 2000) UNDP (Human Development Index 2000) NAMRIA (Base Map 1998)

Figure 2.187 Philippine Risk of Typhoons



Source: PAGASA (2012). Climate Trends in the Philippines. Retrieved from www.didah.org/.../01-PHILiphine_CLIMATE%20TRENDS%20APRIL%202012.ppt. Retrieved on February 2019

Figure 2.188 Typhoon Passage Frequency Map of the Philippines (1948-2010)

B) Climatological Data

Results at PAGASA weather stations consist of the latest dataset of climatological normal from Sangley Point in Cavite (1981 to 2010), and extremes from Sangley Point in Cavite and Cubi Point in Subic (2018). Daily data were also used, as the years recorded are recently updated from 1981 to 2017.

Rainfall, mm

The average rainfall from the PAGASA daily data indicates that the total monthly rainfall is constantly low during the first quarter of the year then escalates from May, reaching its highest value in August, then declines until December. The highest average monthly rainfall reaches 488 mm at Sangley Point and 837 mm at Cubi Point both in August, while the lowest recorded is 15 mm at Sangley Pt. in March and 4 mm at Cubi Point in February (**Figure 2.189**). This is found similar to the recorded climatological normals in 1981-2010, where trends consistently follow the description of the Type I climate category.

The total average rainfall from 1980-2017 recorded was 2,148 mm with an annual average number of 130 rainy days at Sangley Point, while the total average rainfall from 1994-2017 recorded at Cubi Point was 3,451 mm with an annual average number of rainy days of 125. The highest annual rainfall at Sangley Point was recorded in 2013 with 3,800 mm and on 19 August 2013 with 475.4 mm. While at Cubi Point, the highest recorded was in 2011 with 5,463 mm rainfall and on 5 July 2016 with 432.5 mm rainfall. The least annual rainfall was recorded at 1,008.8 mm in the year 1982 at Sangley Point and 505.8 mm at Cubi Point in 1994.

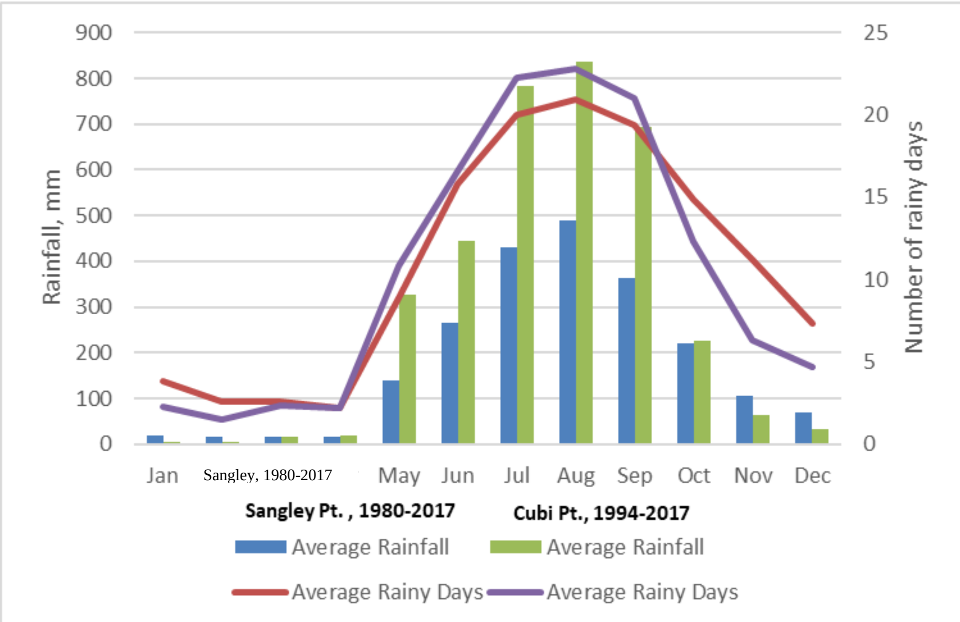


Figure 2.189 Average Monthly Rainfall from PAGASA Sangley Point and Cubi Point Weather Stations

Temperature, °C

The temperature recorded from Sangley Point and Cubi Point both have the lowest value during December then escalates from January to May (**Figure 2.190**). The data from the Sangley Point Weather Station recorded an average temperature at 24.6°C, with the highest temperature at 38.5°C on 13 and 16 May 1987, and lowest temperature at 18°C on 1 February 1982 and 14 December 1988. While the data from the Cubi Point weather station recorded an average temperature at 24.6°C, with the highest temperature at 38.9°C on 4 May 2016, and lowest at 18°C on 25 January 2014.

The annual average temperature from the Sangley Point Weather Station ranges from 21.7°C to 27.9°C. While Cubi Point temperature from 1994-2017 ranges from 24°C to 32°C.

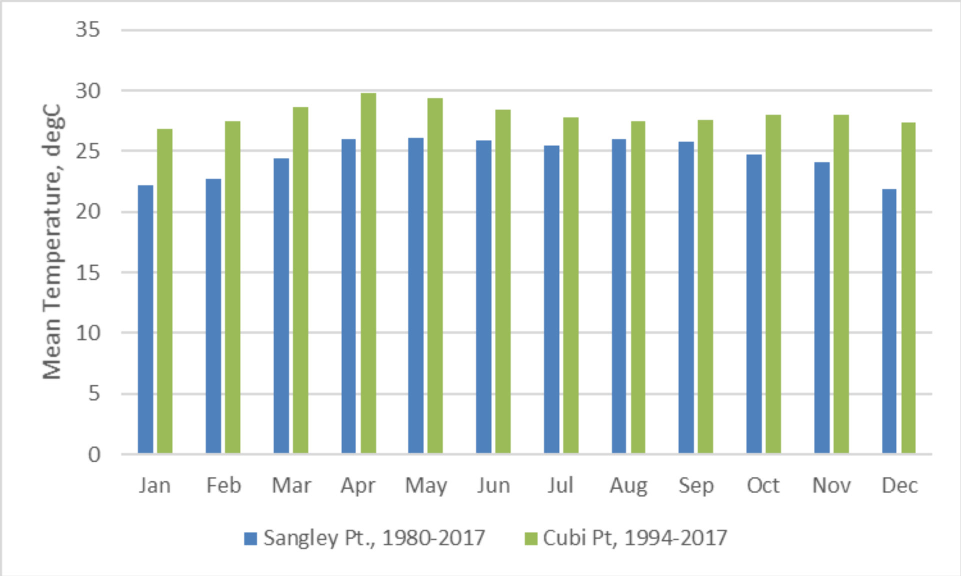


Figure 2.190 Monthly Mean Temperature from PAGASA Sangley Point and Cubi Point Weather Stations

Relative Humidity, %

Relative humidity describes moisture exchange processes of materials or also of people with their surroundings. It is the most important quantity for specifying a pleasant ambient climate and thus for well-being. Climatological normals recorded in the PAGASA weather station in Sangley Point shows that the average annual mean temperature and dew point are 28.4°C and 24.4°C, respectively. This translates to an annual average relative humidity of 78%. August is the most humid month of the year (83%) while April is the least humid (71%) (**Figure 2.191**).

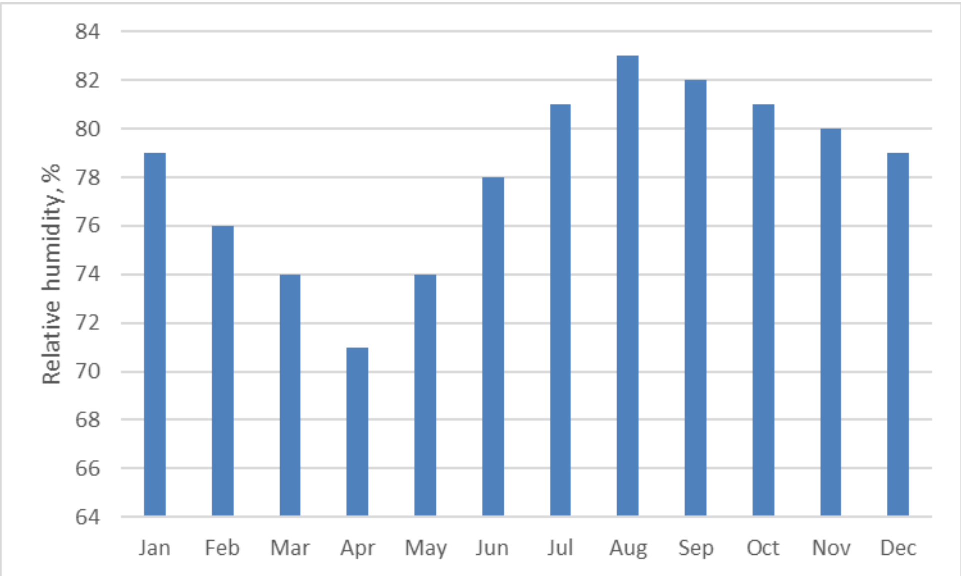


Figure 2.191 Monthly Relative Humidity from the PAGASA Sangley Weather Station from 1981-2010

C) Wind Regime

Wind vectors and stability conditions are the most important inputs to the assessment of material or pollutant dispersion in the atmosphere by modelling calculations. Generally, there are two (2) major air streams that influence the wind pattern of the region. These are the ESE wind and the W wind. The E wind prevails in the months of October to April. The W wind prevails in the months of May until September. The mean annual wind speed in the region is 3.0 m/s to 3.3 m/s.

The easterly wind has an average wind speed of 3.1m/s-3.5m/s, while the westerly wind has an average wind speed of 2.8m/s - 3.1m/s. For the rest of the year, the average monthly wind speed is uniform at 3.0 m/s to 3.3 m/s. The months of May to September, which is characterized by westerly winds, are normally the period when the amount of rainfall is significant, as enhanced by the southwest monsoon.

Wind Rose

Windrose analysis was done to describe the prevailing wind in the project area in the past 30 years (1988-2017) for Sangley Point and 14 years (1994-2017) for Cubi point, based on wind speed and direction from the PAGASA Weather Stations.

A windrose diagram is a graphical presentation that depicts a bi-variate frequency distribution table of wind speed and wind direction. It shows how much of the time (expressed in percent) that the wind speed is within a certain range, for each compass direction, using the 16 points of the compass. The windrose displays the frequency distribution data as spokes radiating from the central hub, and there is a spoke for each of the 16 direction points. The length of each speed group's segment of a spoke is related to its frequency, with longer segments representing higher frequencies.

The following legend shows the ranges of values of the mean wind speed, and their description, as used in the plot. The number of observations is used to calculate the frequency distribution.

Table 2.90 Wind speed range

Wind speed range (m/s)	Description
1-4	Light
5-8	Moderate
9-12	Moderate to Strong
13-16	Strong
17-24	Very Strong
Above 24	Violent

The windrose analysis was taken from the PAGASA daily wind data. For example, at Sangley Point, the windrose diagram for the month of January shows that 37.3% of the time, the wind direction comes from east southeast with 93.3% ranging from 1 to 4 m/s and 6.56% in the range of 5 to 8 m/s. Therefore, the prevailing wind direction for the month of January is east southeast, with average wind speed (mean) of 3.1 m/s (**Figure 2.192**).

ESE winds dominate the region during the months of October to April and shifts from the westerly direction from May to September. Average wind speed in *Amihan* ranges from 3.1m/s-3.5m/s, while in *Habagat* 2.8m/s - 3.1m/s. According to the Beaufort Wind Force Scale, this intensity of wind is described as light (**Figure 2.194** and **Figure 2.195**).

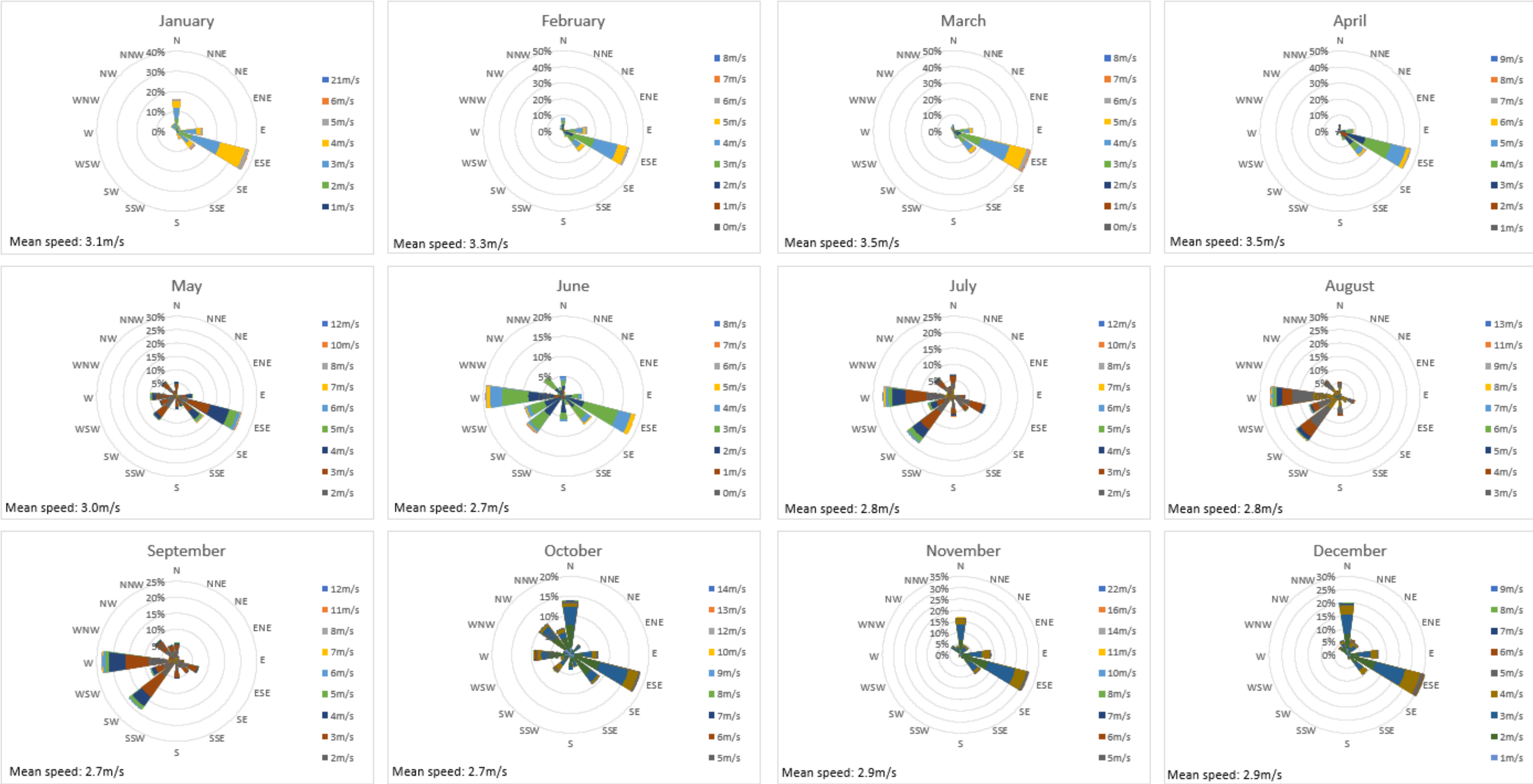


Figure 2.192 Monthly Windrose Diagrams from the PAGASA Sangley Point Weather Station in Cavite from 1988-2017

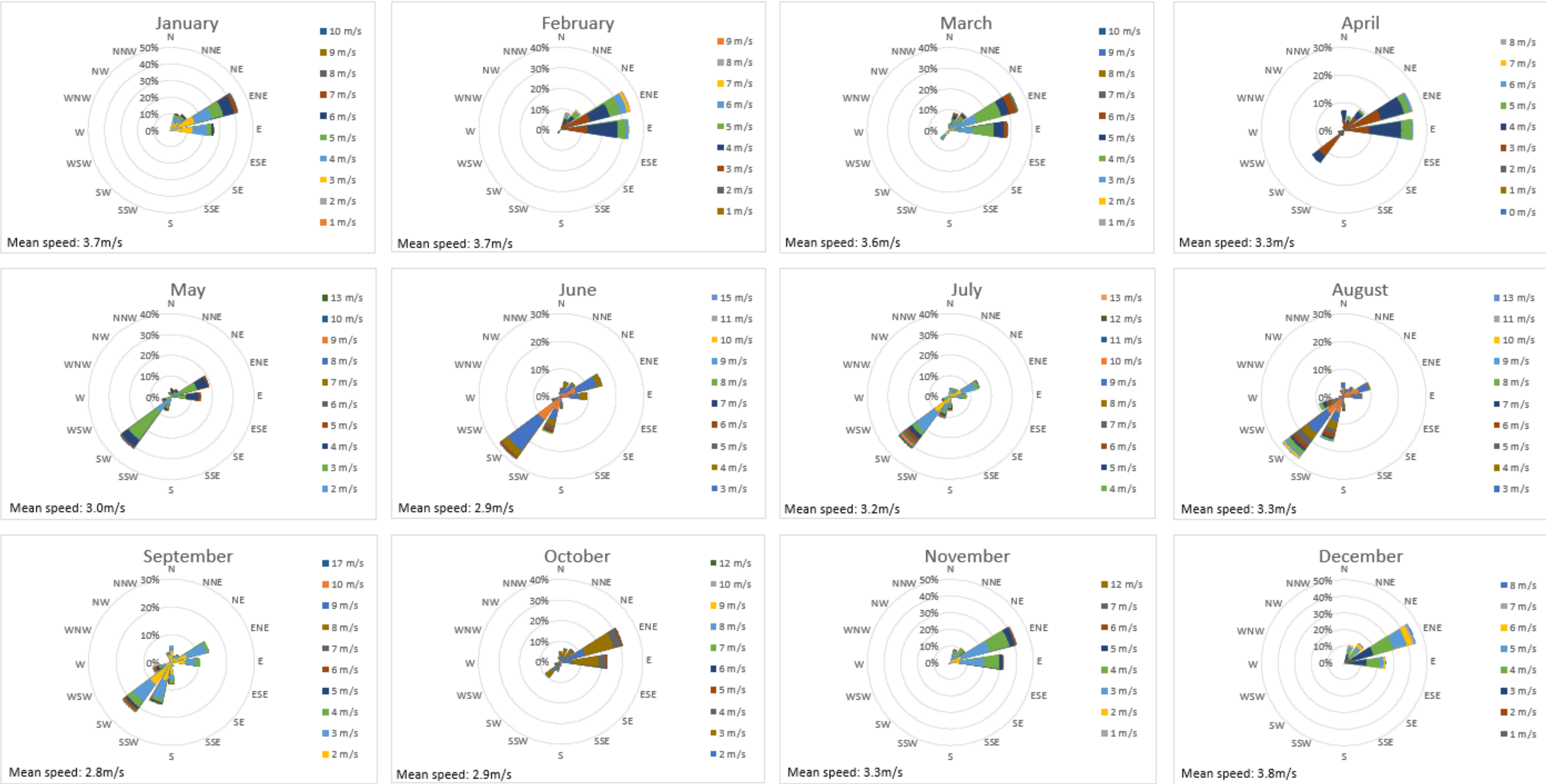
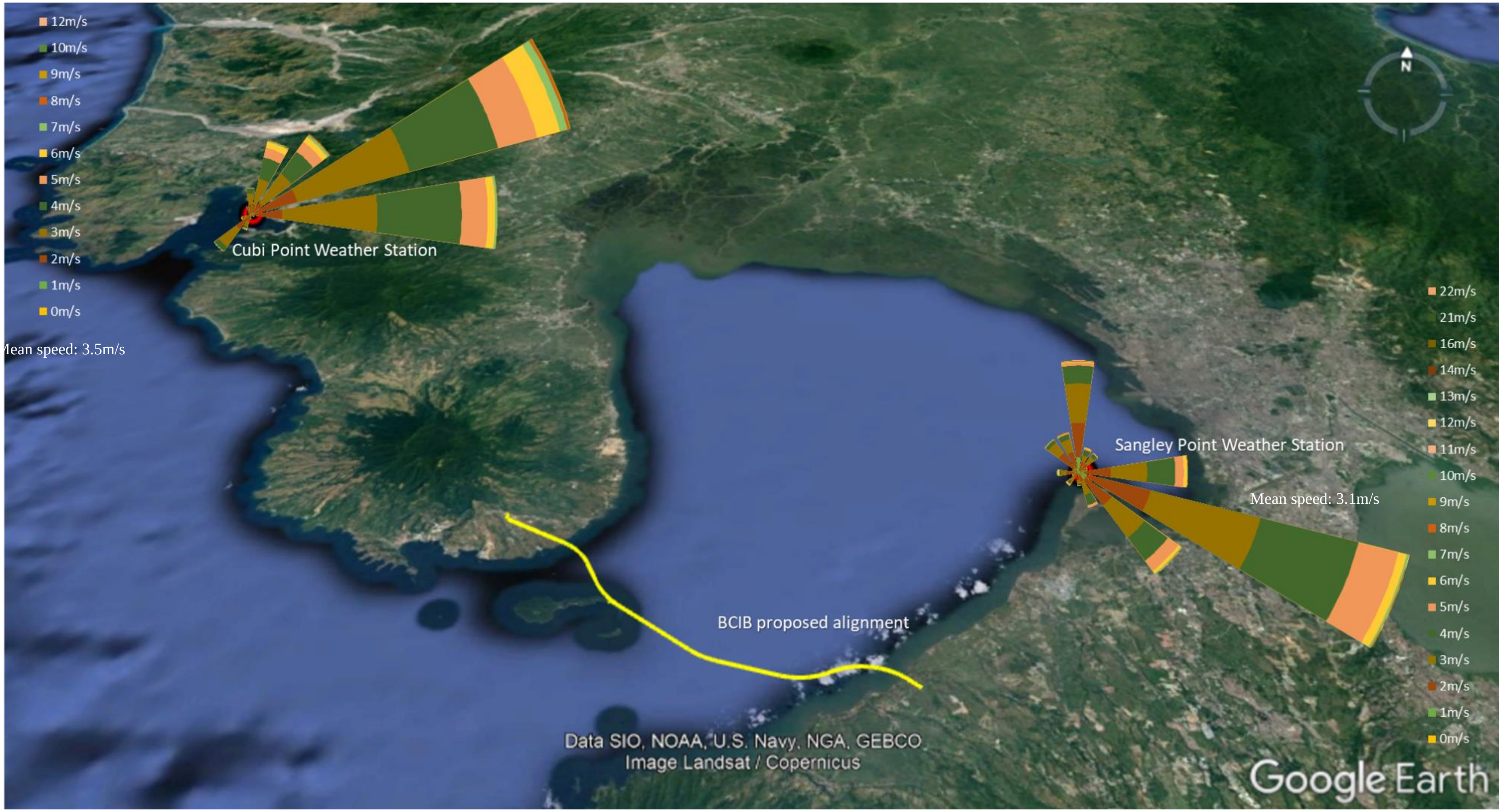
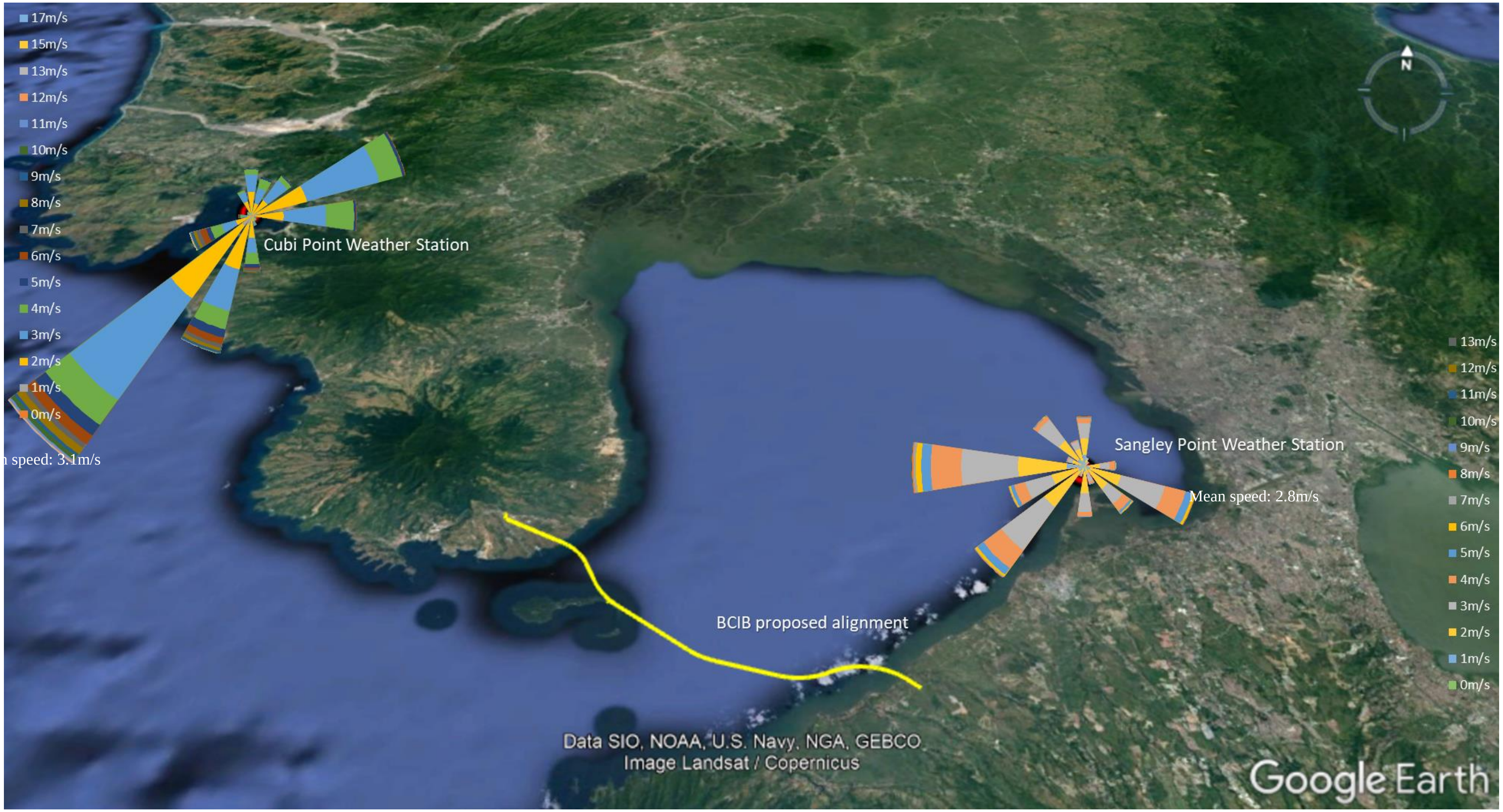


Figure 2.193 Monthly Windrose Diagrams from the PAGASA Cubi Point Weather Station in Subic from 1994-2017



Source: Google Earth, March 2020

Figure 2.194 Windspeed and direction during *Amihan* season



Source: Google Earth, March 2020

Figure 2.195 Windspeed and direction during *Habagat* season

D) Projection of Extreme Weather Events

The projected frequency of extreme weather events near the Project location under the medium-range scenario are presented in **Table 2.91**. The nearest available station is from Sangley, Cavite data.

Cavite is estimated to have an increase in the number of days with temperature exceeding 35°C, with a 169% increase for 2020 and 334% in 2050. It is also expected to have fewer dry days by 9.75% in 2020 and 10.7% in 2050. The number of days with extreme rainfall, downpour exceeding 200mm, increase by 50% for both 2020 and 2050 (**Table 2.91**).

Table 2.91 Frequency of Extreme Weather Events in 2020 and 2050 under medium-range emission scenario in Sangley, Cavite

Weather Event	Observed Baseline (1971-2000)	Projected in 2020	Projected in 2050
No. of Days w/ Tmax >35 °C	630	1,697	2,733
No. of Dry Days	7,352	6,635	6,565
No. of Days w/ Rainfall >200mm	6	9	9

Source: PAGASA Climate Change Projections, 2011

Frequency of Tropical Cyclones

In the past 65 years (1951-2015), a slight decrease in the number of tropical cyclones (TCs) and minimal increase in the frequency of very strong TCs (exceeding 170 kph) were observed and this will continue in the future. The tropical cyclone trend within the PAR shows no indication of an increase in frequency remaining at an average of 20 tropical cyclones per year. However, the number of stronger tropical cyclones has been slowly increasing as exhibited during El Niño events. High year-to-year variations in the frequency of occurence and intensity of tropical cyclones remain to be dominant in the future Philippine climate conditions.

E) PAGASA Climate Change Projections

Vulnerable countries, such as the Philippines, will experience warmer summer months based on PAGASA climate change projections. Climate models have developed climate change scenarios to predict future trends locally, and globally. PAGASA summarized a seasonal climate projection data for each province of the Philippines using Representative Concentration Pathways (RCPs) through DOST-PAGASA's new developed Climate Information Risk Analysis Matrix (CLIRAM), with the following scenarios:

- **RCP4.5 –** moderate level of GHG emission scenario, and
- **RCP8.5 –** high level of GHG emission scenario.

The CLIRAM provides the projected changes in climate variables (particularly for rainfall, mean, minimum and maximum temperature) in both the mid-21st century (2036-2065) or the late-21st century (2070-2099) relative to the 1971-2000 baseline period. Key findings on the effect of climate change to the Philippines include:

- Observed temperature in the Philippins is warming at an average of 0.1°/decade;
- Country-averaged mean temperatures s expected to rise by 0.9°C to 1.9°C (RCP4.5) and 1.2°C to 2.3°C (RCP8.5) in the mid-21st century;

- Warmer conditions are expected by the end of 21st century, which could range from 1.3°C to 2.5°C (RCP4.5) and 2.5°C to 4.1°C (RCP8.5) increase in mean temperature relative to the baseline climate;
- Extreme rainfall events were observed in many parts of the country. Multi-model projections suggest a range of increase and decrease in seasonal-mean rainfall exceeding 40% of its historical values. This projected changes estimates could be within the natural rainfall variations except for the projected rainfall reduction over the central sections of Mindanao that are beyond the observed rainfall variations in the past;
- Slight decrease in the number of tropical cyclones (TCs) and minimal increase in the frequency of very strong TCs (exceeding 170kph) will continue in the future. High year-to-year variations in the frequenct of occurece and intensity of tropical cyclones remain to be dominant in the future Philippine climate conditions;
- Sea level in the Philippines is expected to increase by approximately 20cm by the end of 21st century under RCP8.5 scenario. Such projected increase in sea level might worsen storm surge hazards particularly on coastal communities.

Rainfall

Based on the 2018 PAGASA Observed Climate Trends and Projected Climate Change in the Philippines, by the mid-21st century, Bataan is estimated to experience 12.7% (RPC4.5) and 20.2% (RPC8.5) more rainfall on DJF season, 12.2% (RPC4.5) and 4.6% (RPC8.5) more rainfall on MAM season, 17.7% (RPC4.5) and 1.9% (RPC8.5) less rainfall on JJA season, and 1.9% (RPC4.5) less and 3.1% (RPC8.5) more rainfall on SON season. While in Cavite, 12.5% (RPC4.5) and 12.8% (RPC8.5) more rainfall on DJF season, 6.9% (RPC4.5) and 3.7% (RPC8.5) more rainfall on MAM season, 18.0% (RPC4.5) and 10.4% (RPC8.5) less rainfall on JJA season, and 4.1% (RPC4.5) less and 0.9% (RPC8.5) more rainfall on SON season (**Table 2.92**). This change will result in increased flooding in low-lying areas such as the coastal areas of Cavite and Bataan, an increase in water-borne diseases, and further damage to properties due to frequent rainfall during some parts of the year.

Table 2.92 CLIRAM projected seasonal change in total median rainfall (in millimiters) in the mid-21st century (2036-2065) in Bataan and Cavite (PAGASA, 2018)

Season	Observed Baseline (1971-2000), mm	Projected Rainfall in mid-21st century (2036-2065), mm	
		Moderate emission (RPC4.5)	High emission (RPC8.5)
Bataan (Region III)			
DJF	71.7	80.8	86.2
MAM	368.7	413.7	385.6
JJA	1326.2	1,091.1	1,301.3
SON	872.6	856.0	899.3
Cavite (Region IV-A)			
DJF	124.9	140.4	140.9
MAM	242.8	259.6	251.8
JJA	985.7	808.1	883.2
SON	579.0	555.4	584.2

Temperature

The projection shows a temperature increase throughout the year for both ranges of emission. Mean temperature in the mid-21st century for Bataan shows that 1.0 – 1.2°C increase is expected under a moderate level of GHG emission scenario, while 1.5 –1.7°C increase is expected under a high level of GHG emission scenario. The same trend is expected in Cavite, where 1.1 – 1.3°C increase is expected under moderate emission scenario, and 1.5 – 1.6°C increase under moderate level of GHG emission scenario (**Table 2.93**).

Table 2.93 CLIRAM projected seasonal change in mean temperature (in degree Celsius) in the mid-21st century (2036-2065) in Bataan and Cavite (PAGASA, 2018)

Season	Observed Baseline (1971-2000), mm	Projected Temperature in mid-21st century (2036-2065), mm	
		Moderate emission (RPC4.5)	High emission (RPC8.5)
Bataan (Region III)			
DJF	26.4	27.6	28.0
MAM	28.7	29.9	30.4
JJA	27.6	28.8	29.1
SON	27.3	28.3	28.8
Cavite (Region IV-A)			
DJF	25.7	27.0	1,441.7
MAM	28.2	29.4	564.8
JJA	27.3	28.5	433.2
SON	26.9	28.0	872.5

F) Contribution in Terms of Greenhouse Gas Emissions (or GHG Mitigation Potential)

The Project implementation will inevitably generate greenhouse gases (GHG) through the consumption of fossil fuel during construction and operation phases. GHG are gases that trap the heat in the atmosphere and affect climate change. The major GHG include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases.

The transportation sector is a major contributor to GHG emissions, considering energy and fuel consumption as the main factors in the analysis. In this section, a quantitative GHG assessment was performed to estimate the potential emissions through the methodology of the Inter-governmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories and Asian Development Bank (ADB)'s 2016 Guidelines for Estimating GHG emissions of ADB Projects (Additional Guidance for Transport Projects).

Methodology

Emission scopes are defined by the Greenhouse Gas Protocol (World Business Council for Sustainable Development and World Resources Institute, 2004) for GHG accounting and reporting purposes to help delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organization and of climate policies and business goals. The three emission scopes include:

- **Scope 1: Direct GHG Emissions** - Emissions where the point of emission release is owned by the proponent, such as production of electricity, heat or steam; company owned vehicles used to transport materials, products, waste and employees; and fugitive emissions.
- **Scope 2: Indirect GHG Emissions** - Indirect emissions associated from the purchase / import of electricity, heat or steam which is consumed by the proponent.
- **Scope 3: Other Indirect GHG Emissions** - Indirect emissions that are a consequence of the activities of the proponent but occur from sources owned or controlled by another company or known as “sub-contractors”. Examples of such are: employee business travel; transportation of products, materials, and waste; and employees commuting to and from work.

The purpose of differentiating between the scopes of emissions is to avoid the potential for double-counting in which two or more organizations assume responsibility for the same emissions. It should be noted that GHG Protocol requires that organizations report Scope 1 and Scope 2 emissions, but not Scope 3 emissions, which may be reported voluntarily.

This GHG calculation is aligned with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, where three calculation methods were introduced, namely Tier 1, Tier 2, and Tier 3. Tier 1 approach uses default emission factors, while Tier 2 approach uses country-specific emission factors derived from national fuel characteristics, and Tier 3 approach takes into account the fuel type used, combustion technology, operating conditions, and control technology, quality of maintenance and equipment age.

The calculation of this GHG employs the Tier 1 approach, using Scope 3 indirect emission. Scope 3 emissions are consequences of the proponent’s activities but to which the proponent may have no direct control over. These are through the use of equipment during the construction and private/ public vehicles during the operation stage.

CO_2 emissions during construction

In order to compute for the CO_2 emission during construction, the number of equipment and its fuel consumption, for every work front throughout the construction period, should be provided. These, including the vehicle/ equipment size, capacity, and power consumption can be more accurately identified and computed during the procurement stage when the final design and contractors have already been selected. Hence, the Scope 3 GHG emission, during the construction period, can eventually be computed with higher certainty.

At this stage, a high-level assumption was used to compute GHG emissions. Total diesel consumption of 800,000 L per month at the peak of construction was assumed, as shown in **Table 2.94**. This was computed using **Equation 1**.

Equation 1:

$$\boxed{\boldsymbol{Emissions_{GHG,fuel} = Fuel\ consumption_{fuel}\ X\ EF_{GHG,fuel}}}$$

where:			units
Emissions $_{GHG,fuel}$	=	emission of a given GHG by type of fuel	(kg GHG)
Fuel consumption $_{fuel}$	=	amount of fuel combusted	(L/km)
EF $_{GHG,fuel}$	=	emission factor of GHG in consideration, based on the default EF by type of fuel (kg fuel/gal). Based on the Emission Factors for	(kg /gal)

Greenhouse Gas Inventories for mobile combustion of CO_2 for diesel fuel, 10.21 kg CO_2/gal is used.

1L = 0.26417 gallon (liquid, US)

Using this assumption, the Project is estimated to emit 25,900 tonnes of CO_2, annually during the construction phase.

Table 2.94 GHG emission impacts assumptions during construction

Fuel consumption	EF (kg/gal)	Calculated CO_2 Emission (tonnes/yr)
9,600,000	10.21	25,893.10

CO_2 emissions during operation

BCIB GHG Impact on NCR Transport Network

Based on the 2025 projected travel on the existing transport network, Manila's roads will support around 35 million trips made every weekday across the traffic zone sectors (**Figure 2.196**). Given the significant population growth, the number of trips is expected to increase to 40 million trips per day in 2035, where the largest share of travel is undertaken by car and jeepney. This analysis forecast overall traffic volume would increase up to 5 million trips between 2025 and 2035.

A Traffic Study Report has been prepared for the project to assess the traffic impact of the BCIB scheme. The traffic model output estimates that with BCIB in place, the proposed scheme will generate a total daily passenger time saving of 9.5 million person-minutes and 14 million person-minutes from the model network in 2025 and 2035, respectively.

Setting aside the considerable savings in direct journey time between Cavite and southern Bataan due to BCIB, the key observations of the transport model output shows that in 2025 the average journey time per car trip between the various sectors and Bataan is forecast to reduce by 14%, equivalent to a 6-minute reduction per car trip after the implementation of BCIB. By 2035, the average journey time saved increases slightly to 7 minutes per car trip to Bataan.

The conduct of this computation is based on the travel activity that relies on the trip distance (person km) data considering the NCR transport network model with travel sectors shown in **Figure 2.196**.

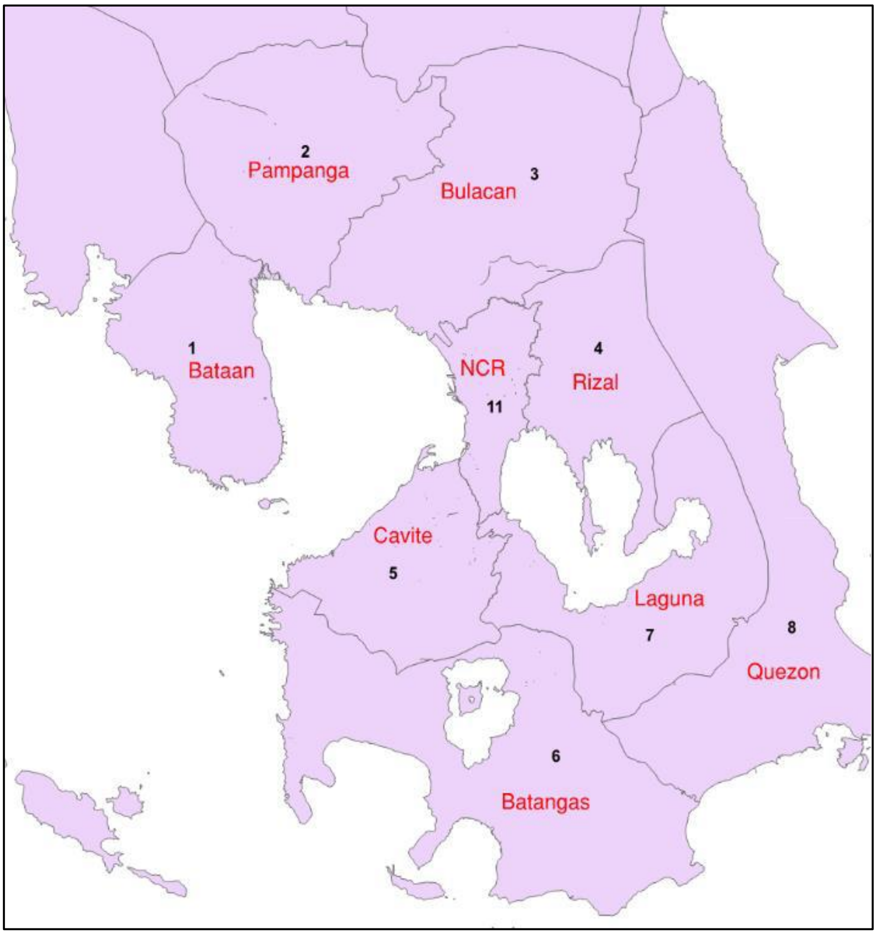


Figure 2.196 National Capital Region travel zones

The computation shows emissions in year 2025, 2035 and 2040, representing the proposed commencement year of BCIB, and 10 years and 15 years during implementation. The data were derived from the current traffic projections calculating the net difference of *with* and *without project* scenarios. **Table 2.95** and **Table 2.96** show the summary of all assumptions that were used in **Equation 2**.

To calculate the net change in emissions, the following formula was applied:

Equation 2:

$$\boldsymbol{Total\ Transport\ GHG\ Emission = Activity\ X\ Modal\ Structure\ X\ Intensity\ X\ Fuel\ Carbon\ Content}$$

where:			units
Activity	=	the total network vehicle kilometres have been used for a with and without scheme scenario. Computed based on the Manila traffic model study.	(vkm, pkm, tkm)
Modal structure	=	Estimate of the % share of petrol and diesel vehicles by mode	
Intensity	=	litres of petrol/diesel used per kilometres and has been included for each mode considered in this analysis	(L/pkm, kJ/pkm)
Fuel carbon content	=	determined for both, petrol and diesel with kg CO_2 / litre of 2.32 and 2.70, respectively	(g/L, g/kJ)

Table 2.95 GHG emission impacts assumptions

Vehicle	% Fuel used per vehicle type		Consumption (L/km)
	Diesel	Petrol Gas	
Motorcycle	0% [1]	100% [1]	0.02 [4]
Car	10% [2]	90% [2]	0.08 [4]
Jeepney	100% [3]	0% [3]	0.18 [5]
Bus	80% [2]	20% [2]	0.28 [4]
Truck	90% [2]	10% [2]	0.30 [4]

Note:

[1] http://dotr.gov.ph/images/front/other_matters/nip.pdf

[2] Estimates based on: http://dotr.gov.ph/images/front/other_matters/nip.pdf

[3] http://www.neda.gov.ph/wp-content/uploads/2015/03/FR-MAIN-TEXT.-12149605_01.pdf

[4] https://cleanairasia.org/wp-content/uploads/portal/files/documents/Guidelines_for_AP_and_GHG_Indicators_2012_Edition.pdf

[5] https://businessmirror.com.ph/2018/05/05/political-will-drives-puv-modernization/

Table 2.96 Activity based on trip distance (person km)

Vehicle	Activity 2025 (vkm)	Activity 2035 (vkm)	Activity 2040 (vkm)
Motorcycle	184,539,887	234,872,737	234,872,737
Car	81,603,530	194,615,614	194,615,614
Jeepney	14,396,045	30,266,310	30,266,310
Bus	7,327,629	20,211,218	20,211,218
Truck	-25,665,240	66,487,608	66,487,608

Note: *Computation based on the net change of the activity used for a with and without project scheme scenario. Computed based on the total network vehicle kilometres from the Manila traffic model study.*

One of the objectives of BCIB is to improve the inner-city urban road network by diverting traffic and reducing the pressure in the existing transport network. The construction of a new bridge usually increases travel speed and which contributes a reduction in CO_2 emission. As the computation has followed the basic structure of ADB's formula to calculate GHG emission impacts, the only parameter that changes is due to the 'Activity' - vehicle kilometers traveled (vkt). Since vkt increase due to BCIB, there is an increase in the GHG emission.

As a result, in **Table 2.97**, it is estimated that the Project will lead to an increase in GHG emission of 14,867 tonnes CO_2, 128,931 tonnes CO_2 and 128,931 tonnes CO_2 in 2025, 2035 and 2040, respectively, due to additional capacity (i.e. increase in population and additional capacity).

Table 2.97 GHG emission impacts during operation

Vehicle	GHG emission (tonnes)		
	2025	2035	2040
GHG based on petrol gas			
Motorcycle	7,706	9,808	9,808
Car	13,631	32,508	32,508
Jeepney	0	0	0
Bus	952	2,625	2,625
Truck	-1,786	4,627	4,627
GHG based on diesel			
Motorcycle	0	0	0
Car	1,763	4,204	4,204
Jeepney	6,880	14,464	14,464
Bus	4,432	12,223	12,223
Truck	-18,710	48,469	48,469
TOTAL	**14,867**	**128,931**	**128,931**

Road improvement schemes in the Project can moderate congestion. As the project reduces congestion in Metro Manila, it also generates new trips that travel longer distances (e.g. new trips for commuting from Bataan to Metro Manila), and hence an increase in distance traveled (vkm). This computation has not taken into account the reduction in travel time due to decongestion nor the increase in traffic flow speed, hence expected to lead to less GHG emission, if travel distance is unchanged.

2.3.1.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Potential Impacts

Change in local microclimate

Microclimate is a set of atmospheric conditions in an area that is different from its surroundings. This difference may be a slight or a drastic difference, but both have substantial effects on the environment and the ecosystem.

The ambient temperature is mostly measured by the amount of solar radiation and different factors may affect this. Latitude, cloud, canopy and structural cover, and wind speed of an area can drastically affect the local temperature. Moisture, wind speed, soil type and composition, slopes, and presence of vegetation are all examples of factors that may change the local microclimate. These explain why the effect of climate change is more prominent in some areas.

The air quality of an area can be affected by changes in local microclimates of a given area. Higher temperatures in urban areas lead to an increased rate in smog formation, as photochemical reactions involving volatile organic carbons (VOCs) produce ground-level ozone. In drier and heavily vegetated areas, an increase in temperature may lead to bush or forest fires. These natural and anthropogenic phenomena release ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and particulate matter, resulting in an increase in air pollutant concentrations in the atmosphere.

A change in microclimate may greatly affect the ecosystem, depending on its species composition. An increase or decrease in mean temperature will alter the environment, making some populations of species either strive or struggle for survival, depending on the resources relied on the most. The slight or drastic, increase of temperature will tremendously affect organisms with narrow thermal limits. These creatures are unable to withstand and adapt to temperature changes, resulting in death when temperatures exceed their limits.

Adverse health effects may occur from shifts in microclimate. Health hazards from higher temperatures, paired with formed ozone at ground-level can cause more frequent heat strokes and heart problems. Illnesses may be more prominent with higher temperatures favoring the survival of disease-carrying insects like mosquitoes.

During construction, variations in microclimate will affect the schedule of construction works, potentially delaying the progress of construction.

Material selection and technologies will consider the effects of microclimate variations and the effects of extreme temperature changes to operating conditions of Project components.

Enhancement of climate change impacts

Flooding, landslides and typhoons are possible causes of construction delays because of environmental and construction hazard it imposes on the project. When extreme rainfall during typhoons occur, water can get inside the heavy construction equipment and make friction-based mechanisms, such as the breaks, clutches, and others, inoperable and faulty. Heavy rainfall can also delay the transport of materials and goods to the project site as flooding, landslides and low visibility are possible hazards to drivers and passengers. Puddles of water may also be used as a breeding ground for disease-carrying insects, increasing the risk of illnesses such as malaria.

Drought and extreme heat can affect the project during the construction phase when water starts depleting. Water is vital to construction and when resources start depleting, the building of infrastructures may be delayed.

Operational phase may also be affected by extreme heat and drought if the construction of road contains bitumen, a component of pavement, melts from over-exposure to solar radiation and heat. This causes difficulty in operating the vehicles' melted bitumen can stick to the mechanism of the tire, and it can lose its traction.

The operation phase of the project can also be affected by extreme rainfall. Poorly planned roads can retain water over the ground when water is not able to exit the soil. Wet roads pose a hazard to the passengers as control of the vehicle may be influenced by the lack of friction with the wet road. This can make the road temporarily untraversable by transport vehicles.

Enhancement of climate change to the Project

Climate change is earth's natural occurrence over thousands of years, however, we are speeding the process up so fast with, our air pollution emission into the atmosphere, that this change occurs in a span of a few decades. This phenomenon causes a change in downpour and drought intensity and frequency and alters the normal weather patterns.

The Project is heavily affected by climate change. Increased rainfall can hinder the progress of construction as flooding may worsen and be more frequent on-site and can lower the accessibility of the roads during operation.

In addition to construction, the workers' safety and health are also affected by climate change. More frequent flooding will put their health at risk as debris, strong currents, and high levels may be a threat to their lives. As an increase of downpour occurs, more puddles of water will form around the area and may become breeding grounds for disease-carrying parasites such as mosquitoes, increasing the risk of illnesses. Increased exposure to more intense heatwaves and droughts can also cause dehydration and heat strokes in the construction site.

B) Options for Prevention, Mitigation and Enhancement

Change in local microclimate

Prevention of the change in microclimate must be taken into consideration as it may affect the health and safety of the workers on site, and may affect the ecosystem of the area. Cutting of trees in and around the area must be brought to a minimum or replanting of trees should occur if no other option is possible. This enhances the evapotranspiration from the trees resulting in lower temperatures in the area. Installing mist sprays on site can also help to cool the area. Installing roofs and roads that reflect incoming solar radiation or green roofs can help lower the temperature of the area, inevitably reducing the health and ecosystem risk of the project.

Enhancement of climate change impacts

During the planning phase, unexpected heavier downpour should be taken into consideration, requiring extra drainage and durability to be installed for the construction and operation phase. The durability to heat must be reinforced as droughts and higher temperatures should be expected. The location must be thoroughly discussed as flood prone areas may experience higher waters.

Prevention of breeding grounds of mosquitoes and other insects must also be taken into consideration during the construction phase.

Enhancement of climate change to the Project

In consideration of the possible impacts stated above, the bridge will be designed robustly to climate change and related extreme events including drainage, construction facilities and structures (viaduct, embankment, and interchanges) based on the geology and hydrological studies. Emergency planning practices, through climate-resilient economic growth with the local authorities and development agencies and Emergency Response Plan will also be implemented in case of extreme events.

2.3.2 Ambient Air Quality

Ambient air quality is defined by the Republic Act No.8749 or the Philippine Clean Air Act of 1999, which is an act the provides a comprehensive air pollution control policy to protect the people to a balanced and healthful ecology. The responsibility under R.A. 8749 has been further emphasized through its Implementing Rules and Regulations under the DENR Administrative Order 2000-81.

Compliance of the ambient air quality results in this assessment is compared to the limitations provided under R.A. 8749, which includes the National Ambient Air Quality Standards (NAAQS) for Source Specific Air Pollutants from Industrial Sources/ Operations. These standards are maximum concentration used for one-hour averaged ambient air quality results to avoid adverse health effects. While the National Ambient Air Quality Guideline Value (NAAQGV) of DAO 2000-81 are values typically used for 24-hour ambient air monitoring assessment in a region or locale prior to the implementation of the project. The classification of the ambient air quality in the environment are then further evaluated based on the air quality index (AQI) of the DAO 2000-81.

This section discusses the ambient air quality in the vicinity of the project alignment, to set the baseline conditions at the project area, identify and assess the air pollutants and possible impacts, and recommend management strategies to prevent and mitigate these possible impacts during the project implementation.

2.3.2.1 Methodology

A) Study Area

The sampling points were chosen to represent sensitive receptors, within the project area, that may be affected by the construction and operational phases of the project. Sensitive receptors identified in this study include the schools, hospitals, day-care centers, and other areas that may have individuals with health conditions and may be more vulnerable to the exposure to air quality changes.

B) Sources Identification

Air pollution is a complex mixture of various gases, particulates, hydrocarbons and transition metals. This can be natural (i.e. forest fires and volcanic eruptions) and anthropogenic (i.e. combustion of fuel and wastes) sources of various gases, particulate matter, hydrocarbons, and transition metals. Overexposure to these pollutants may cause adverse health effects, specifically affecting the heart and the lungs.

Air pollutants that are associated with the project construction can be attributed to congestion of people, and the use of high-volume equipment, earthmoving vehicles and diesel generator. These parameters such as particulate pollutants (i.e. Total Suspended Particles (TSP) and particulate matter (PM10 and PM2.5)), and gaseous pollutants (i.e. NO_2, and SO_2), may cause adverse effects when exposed in excessive amounts.

Particulate pollutants are characterized based on the particle diameter:

- Total Suspended Particles: <50 – 60 µm
- PM10: < 10 µm
- PM2.5: < 2.5 µm

Depending on the size of the particles, these pollutants can inflict various health effects as PM10 can penetrate the nose, while PM2.5 can penetrate the lungs.

SO_2 is a colorless pungent gas when concentration is low, while NO_2 is odorless but the color of the gas is reddish-brown. These gaseous pollutants have the capacity to chemically react to the air, forming SOx and NOx, compounds posing a threat to human health and potentially forming O_3 through photolysis.

During the demolition of existing structures and materials, earthworks, grinding operations, and stockpiling of soil, TSP and PM10 are produced as fugitive dust. Diesel-powered transport vehicles and construction equipment emit fine particles, such as PM2.5 or black carbon, from their exhaust. Emissions from excavators, industrial trucks, cranes, and stationary engines, such as generators and pumps, include PM2.5, NO_2, and SO_2.

C) Field Surveys and Sampling Areas

Eleven stations were identified for ambient air quality sampling and were strategically positioned to be close to the proposed alignment and sensitive receivers. The coordinates of each sampling site are shown in **Table 2.98** and the sampling map in **Figure 2.197** and **Figure 2.198**.

Table 2.98 Ambient air and noise monitoring sites

Station ID, Location	Coordinates	Description and Observations	Picture
A1, Santiago Residence, Mariveles, Bataan	14°27'42.74"N, 120°32'32.43"E	Hard soil ground and open area was dusty and surrounded by trees. 20m away from main road, 30m away from residential area. Sunny weather with light wind. Noise source was mostly vehicles passing the main road and crickets at night. Moderate then light traffic was observed.	
A2, Near Godspeed Garden Memorial Park, Mariveles, Bataan	14°27'32.98"N 120°32'41.90"E	Open field trees and grass surrounded the area. Sunny weather condition with strong winds. Around 50m away from main road and 30m from residential area. Noise came from insects during nighttime. Light traffic was observed.	
A3, Front of Garcia Residence Mariveles, Bataan	14°27'11.43"N 120°33'0.28"E	Slash and burn agriculture is evident in this area. Grassy ground surrounded by banana trees. Sunny weather with light winds. Around 30m away from access road. Source of noise from crickets and other insects at night.	
A4, Amando Residence, Mariveles, Bataan	14°26'57.80"N 120°33'34.04"E	Land near the station contained cows. Grassy ground surrounded by banana trees. Sunny weather with light winds Around 20m away from Maharlika St. Source of noise mainly animals and insect during nighttime. Light traffic was observed.	

Station ID, Location	Coordinates	Description and Observations	Picture
A5, Along Maharlika St., Mariveles, Bataan	14°26'25.93"N 120°34'11.04"E	Slash and burn agriculture is evident in this area Grassy area surrounded by trees and grass. Sunny weather with strong winds. Main road 3km away from sampling point. Source of noise from insect during nighttime. No observed precense of residents. Light traffic was observed.	
A6, Near Aroma Resort, Naic Cavite	14°20'28.68"N 120°46'38.08"E	Slash and burn agriculture is evident in this area Grassy open area surrounded by trees and grass. Sunny with strong winds. Around 150m from access road. Cows observed within the area. Source of noise from noise and vehicles.	
A7, Purok 7, Naic Cavite	14°20'11.74"N 120°46'47.01"E	Grassy area s urrounded by trees and grass. Cloudy to sunny weather with moderate winds and frequent rainfall. Around 50m away from access road. Burning of leaves around 1800H-1900H was observed Source of noise mainly from vehicles passing the road and insect at nighttime. Moderate then light traffic was observed.	
A8, Tramo St., Naic Cavite	14°20'15.85"N 120°46'54.56"E	Grassy open area surrounded by trees and grass. Cloudy weather with light to moderate winds and frequent rainfall. Around 20m away from road. Animals such as goats, cows and dogs were observed. Sources of noise were mostly from residential noise, and crickets and insects at night. Light traffic was observed.	

Station ID, Location	Coordinates	Description and Observations	Picture
A9, Near Northdale Villas, Naic Cavite	14°20'12.96"N 120°46'57.42"E	Concrete ground in access road inside private property. Grass cutting occurred during 0800H-0900H. Sunny to partial cloudy weather with light to moderate winds and frequent rainfall. 20m away from road and 5m away from nearest house Source of noise from vehicles and insect at nighttime. Trucks observed passing access road. Light traffic was observed.	
A10, St. Clair Homes, Naic Cavite	14°20'1.79"N 120°46'28.55"E	Concrete ground near main gate of a private property surrounded by trees and grass. Burning of leaves were observed. Dogs and cows were observed. Sunny weather with light to moderate winds Around 10m away from road Sources of noise were birds, cows, dogs, chicken, vehicles, residents, and insects at night Light traffic was observed.	
A11, Timalan Elementary School, Naic Cavite	14°20'13.23"N 120°46'44.26"E	Grassy ground in the middle of quadrangle and beside stage area. Near a debris lot. Sunny to cloudy with occasional rainfall. Kids playing basketball. Sources of noise were mainly vehicles passing the road.	

Figure 2.197 Ambient Air and Noise Sampling Locations, Bataan February 2020

Figure 2.198 Ambient Air and Noise Sampling Locations, Cavite February 2020

D) Sampling Methodology

Ambient air quality sampling was conducted at eleven sampling sites for 24-hour and 1-hour measurements. These were performed in accordance with the protocols and sampling procedures specified in the DAO 2000-81, DAO 2013-13, USEPA and World Health Organization (WHO) Guidelines, which are all summarized in **Table 2.99**.

Table 2.99 Methods of air sampling and analysis

Paramters	Sampling Scheme	Method of Collection	Method of Analysis	Source*
TSP	24-hour and 1-hour	Tisch High Volume Sampler	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix B
PM10		Tisch High Volume with 10 micron particle-size inlet	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix J
PM2.5		Tisch High Volume with 2.5 micron particle-size inlet	High Volume Gravimetric Method	USEPA 40 CFR, Part 50, Appendix L
SO_2		NOSHOK RAC3 Gas Sampler	Tetra-chloromercurate (TCM) Absorber-Pararosaniline Colorimetric	USEPA 40 CFR, Part 50, Appendix A
NO_2		NOSHOK RAC3 Gas Sampler	Impinger Griess-Saltzman Reaction Method	Methods of Air Sampling and Analysis-3rd ed./James O. Lodge, Jr

Source: DAO 2000-81, DAO2013-13

Figure 2.199 Ambient Air Sampling Set-up

E) Data Analysis

Following the Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental - Air Emissions and Ambient Air Quality under the International Finance Corporation (IFC) guidelines, emissions should not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards.

In the Philippines, RA 8749 and DAO 2000-81 provide the air quality standards for air pollutants including total suspended particulates (TSP), respirable suspended particulates (RSP/ PM10), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). DAO 2013-13 provides the provisional NAAQGV for particulate matter 2.5 (PM2.5). **Table 2.100** summarizes the ambient air quality standards and values relevant to this study.

Table 2.100 National Ambient Air Quality Guideline Values and Standards

DAO 2000-81	TSP (µg/Ncm)	PM10, (µg/Ncm)	PM2.5, (µg/Ncm)	SO_2 (µg/Ncm)	NO_2 (µg/Ncm)
24-hour Sampling (NAAQGV)	230	150	50	180	150
1-hour Sampling (NAAQS)	300	200	--	340	260

The project's ambient air quality sampling results are compared to these standards to verify its compliance. The quality of the pollutants is evaluated through the Air Quality Indices (AQI) in **Table 2.101**. The AQI is used to classify the conditions of ambient air quality in the project area.

Table 2.101 Air quality indices

Type/ Classification	TSP, µg/Ncm (24-hour average)	PM_{10}, µg/Ncm (24-hour average)	SO_2, µg/Ncm (24-hour average)*	NO_2, ppm (1-hour average)*
Good	0 to 80	0 to 54	0 to 88.8	--
Fair	81 to 230	55 to 154	91.4 to 376.2	--
Unhealthy for sensitive groups	231 to 349	155 to 254	378.8 to 627.4	--
Very unhealthy	350 to 599	255 to 354	587.8 to 794.2	--
Acutely unhealthy	600 to 899	355 to 424	796.8 to 1577.9	1,220.5 to 2,328.3
Emergency	900 and above	425 to 504	1580.5 to 2100.3	2,347.0 to 3,079.3

*Conversion factor for SO_2: 1 ppm = 2,612.4 µg/Ncm; NO_2: 1 ppm = 1,877.6 µg/Ncm; Annex A of DAO 2000-81.

F) Air Modelling

Air Quality Modelling by CALINE4

California Line Source Dispersion model version 4 (CALINE4) is a roadway dispersion model developed by California Department of Transportation. This software is commonly adopted in many highway projects in different parts of the world for air quality assessment. Therefore, it is used to predict the air quality impact from the road traffic emission in this study. The input data of CALINE4 includes surface roughness, meteorological data, receiver coordinates, hourly traffic flows, and vehicular emission factors.

Assessment Area

The assessment area should cover a 500m radius from the project boundary. As there are no Air Sensitive Receivers (ASRs) in the vicinity of the segments within the marine area (including Corregidor Island), only the residential areas in Bataan and Cavite where the BCIB lands are considered in the quantitative model. Hence the model area is divided into two parts: the northern assessment area (Bataan) and the southern assessment area (Cavite), as shown in **Figure 2.200** and **Figure 2.201**. The main road alignment and the corresponding slip roads are also shown in **Figure 2.202** and **Figure 2.203**, respectively.

Figure 2.200 Air Quality Assessment Area in Bataan

Figure 2.201 Air Quality Assessment Area in Cavite

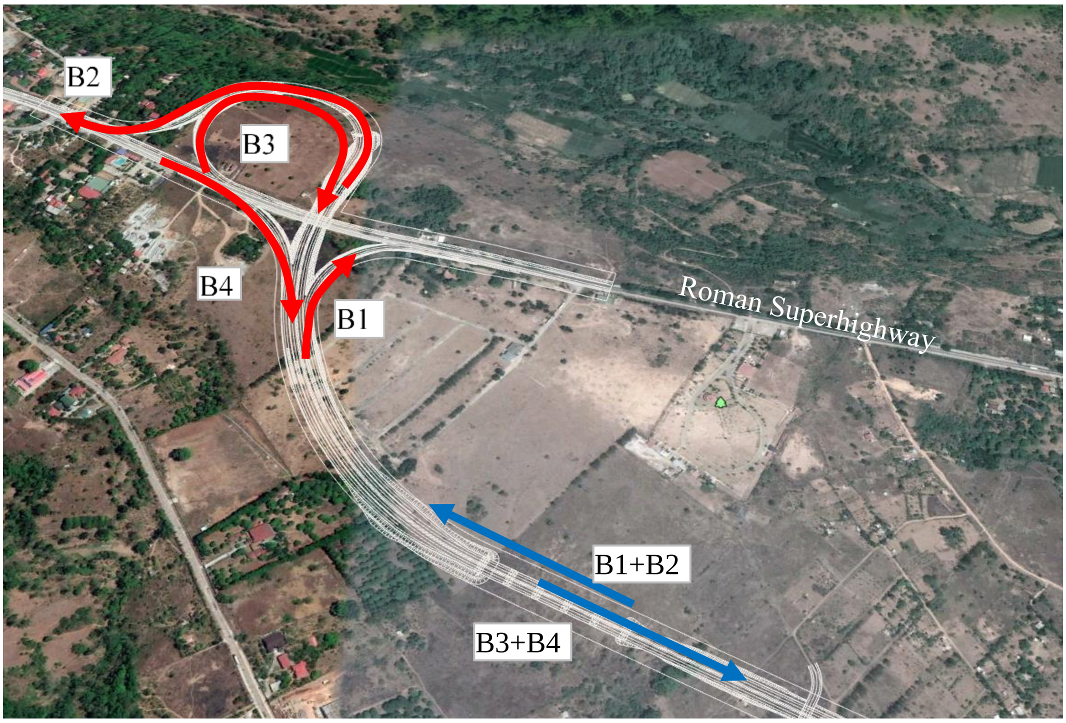


Figure 2.202 Road ID in Bataan

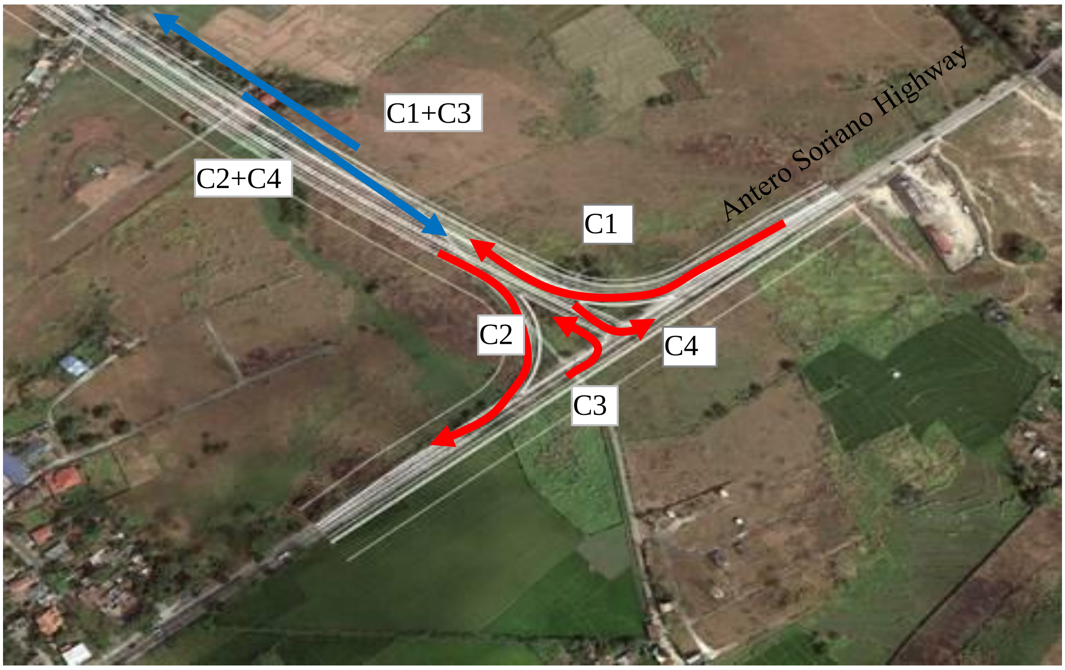


Figure 2.203 Road ID in Cavite

The existing land uses in Bataan and Cavite are mainly rural types with low density and low-rise buildings (with 1 or 2 storey). Existing roads are mainly village type roads with very low traffic volume. Most segments of the proposed BCIB are far away from the existing ASRs.

The vehicular emission impacts are modeled for ASRs at 1.5m and 5m above ground. A 100 × 100m grid is used to generate the pollution contours to present the pollution dispersion.

G) Surface Roughness

According to Table 6 in CALINE4 Manual, the surface roughness would be set at 15% of the typical average canopy height (Benson, 1984). Since the existing buildings are 1 or 2 storeys and it is anticipated that there would be more developments to be established in the future, surface roughness of 45cm (i.e. 15% × 3m) is therefore adopted in this CALINE4 modeling for both assessment areas to represent the existing rural area.

H) Meteorological Data

The meteorological data for CALINE4 input includes wind angle, wind speed, Pasquill-Gifford (P-G) stability class, mixing height, wind direction standard deviation and ambient temperature. The nearest weather station that would best represent the assessment areas is the Sangley Point, which is approximately 21 km away and can present the existing circumstances in both Bataan and Cavite (**Figure 2.185**).

As the hourly meteorological data of the nearby weather station is not available, the worst-case meteorological condition is adopted to predict the maximum hourly concentration.

In order to predict the maximum hourly concentration, the worst wind angle search (i.e. run type 3 in CALINE4) is adopted. Other input data is shown in **Table 2.102**. It can be seen that atmospheric stability classes have been varied from Pasquill-Gifford stability class 1 to 6, associated with the reasonable wind speeds (1 – 6 m/s) and typical ambient air temperatures (i.e. annual average temperature 28.4ºC in Sangley Point, Cavite from 1981 -2010).

Table 2.102 Meteorological Input Data

ID [1]	Wind Speed (m/s) [2]	P-G Stability Class	Mixing Height (m)	Wind Direction Standard Deviation (°) [3]	Temperature (°C) [4]
1	1	1	571	28.0	28.4
2	2	1	571	28.0	28.4
3	3	1	571	28.0	28.4
4	1	2	571	28.0	28.4
5	2	2	571	28.0	28.4
6	3	2	571	28.0	28.4
7	4	2	571	28.0	28.4
8	1	3	571	21.8	28.4
9	2	3	571	21.8	28.4
10	3	3	571	21.8	28.4
11	4	3	571	21.8	28.4
12	5	3	571	21.8	28.4
13	6	3	571	21.8	28.4
14	1	4	571	15.6	28.4
15	2	4	571	15.6	28.4
16	3	4	571	15.6	28.4
17	4	4	571	15.6	28.4
18	5	4	571	15.6	28.4
19	6	4	571	15.6	28.4
20	2	5	571	9.3	28.4
21	3	5	571	9.3	28.4
22	4	5	571	9.3	28.4
23	5	5	571	9.3	28.4
24	1	6	571	4.7	28.4
25	2	6	571	4.7	28.4
26	3	6	571	4.7	28.4

Note:

[1] Weather condition index.

[2] Refer to the Table 4-2 of PCRAMMET User's Guide by USEPA, varied wind speed (1 - 6 m/s) is adopted for the various P-G stability class.

[3] Wind direction standard deviation is calculated from surface roughness and P-G stability class refer to Section 6.4 in "Meteorological Monitoring Guidance for Regular Modeling Applications" by USEPA 2000.

[4] The CALINE4 modelled results are less sensitive to the ambient temperature, and hence the past 10 years average temperature is adopted as a typical temperature in the modelling.

For the estimation of mixing height in **Table 2.102**, due to the lack of measured mixing height around the assessment area, the mixing height has been calculated via the following equation, based on CALINE4 Manual:

$$MIXH = \frac{0.185\ \mathrm{U\ K}}{\ln\left(\frac{\mathrm{Z}}{\mathrm{Z0}}\right) \mathrm{f}}$$

Where,
U =Wind speed (m/s),
Z =Height U measured at (m)
Z0 = Surface roughness (m)
K= von Karman constant (0.35)
F = Coriolis parameter
= 1.45×10^{-4} cosϴ (radian/Sec)
ϴ = 90 – site latitude

I) Traffic Forecast

The year with the highest emission strength from the Project within the next 15 years upon commencement shall be typically considered as the assessment year. Generally, the traffic flow is anticipated to grow progressively, while the emission factor per vehicle would gradually decrease due to the phasing out of vehicles with older emission standards. As the vehicular emission factor for a particular year is not available, as a conservative approach, it is proposed to adopt the highest traffic flow (in the 15th year after the road operating) and the highest emission factor (in the 1st year) as the worst-case scenario. Since the proposed BCIB is planned to commence in year 2025. The traffic forecast in 2040 is therefore adopted for this CALINE4 modeling.

The traffic forecast for a different road segments of AM peak hour and PM peak hour in 2040 are listed in **Table 2.103** and **Table 2.104**, respectively. Since the AM peak hour traffic flow is generally higher than that of PM traffic flow, the AM peak hour is adopted as the worst-case hourly traffic flow.

Table 2.103 AM Peak Hour Traffic Forecast in 2040 (Vehicle/hour)

Road ID	MC	Car	Jeepney	Bus	Truck	Total
B1	720	650	40	80	40	1,530
B2	160	410	0	10	60	640
B3	620	450	50	80	110	1,310
B4	170	420	0	10	50	650
C1	700	890	40	80	90	1,800
C2	60	100	0	10	0	170
C3	190	170	0	0	10	370
C4	730	760	50	70	160	1,770

Table 2.104 PM Peak Hour Traffic Forecast in 2040 (Vehicle/hour)

Road ID	MC	Car	Jeepney	Bus	Truck	Total
B1	530	500	30	50	10	1,120
B2	100	250	0	0	30	380
B3	450	500	40	50	90	1,130

Road ID	MC	Car	Jeepney	Bus	Truck	Total
B4	130	310	0	0	40	480
C1	620	700	30	50	40	1,440
C2	20	40	0	10	0	70
C3	10	40	0	0	0	50
C4	560	770	40	50	130	1,550

J) Emission Factors

The DENR tightened the pollution emission standard of a vehicle from EURO II to EURO IV since 1st January 2016 and only EURO IV vehicles are allowed to be registered since 1st January 2018. It is anticipated that more vehicles with higher emission standards will be registered. However, there are no published information /statistics on the replacement program for existing vehicles. Hence, in order to be conservative, the vehicular emission factors for EURO II vehicles are adopted in this assessment.

The emission factors are referred to "Air Pollution and GHG Emissions Indicators for Road Transport and Electricity Sectors. Guidelines for Development, Measurement, and Use" and "Emission Factors 2009: Report 3 – exhaust emission factors for road vehicles in the United Kingdom" Version 6. The calculations of emission factors are detailed in **Annex J**. The emission factors used in this study are listed in **Table 2.105**.

Table 2.105 Emission Factors

Pollutants	Emission Factor (g/mile)				
	Car	**Jeepney**	**Truck**	**Bus**	**MC**
PM	0.010	0.118	0.589	0.241	0.048
NO_X	0.151	0.994	10.378	10.040	0.547
SO_2	0.010	0.011	0.040	0.037	0.004
PM10	0.013	0.145	0.373	0.231	0.059

Notes:
[1] Refer to **Annex J** for further details.

K) Total Emissions

Considering the traffic forecast for 2040 and EURO II emission factor, the emission rates for each road segment are summarized in **Table 2.106**.

Table 2.106 Combined Emission Rate for Each Road Segment

Road ID	Pollutant Emission Rate (g/mile)			
	TSP	**NO_X**	**SO_2**	**PM10**
B1	0.0581	1.1439	0.0094	0.0589
B2	0.0774	1.3634	0.0116	0.0616
B3	0.0950	1.8333	0.0114	0.0834
B4	0.0681	1.1935	0.0110	0.0560
C1	0.0665	1.2747	0.0104	0.0615
C2	0.0371	0.8725	0.0094	0.0420
C3	0.0453	0.6308	0.0077	0.0464
C4	0.0903	1.6538	0.0113	0.0768
B1+B2	0.0638	1.2086	0.0101	0.0597
B3+B4	0.0860	1.6211	0.0113	0.0743
C1+C3	0.0629	1.1649	0.0099	0.0589
C2+C4	0.0856	1.5853	0.0112	0.0738

The ratio of NO_X to NO_2 is dependent on the ambient ozone concentration. Referring to the nearby air quality monitoring station, which is about 50 km away from the project site, the daily average ozone concentrations measured at Subic Bay Metropolitan Authority (SBMA) Station, Zambales ranges from ~10 to 77 $\mu g/m^3$ and are below 50 $\mu g/m^3$ for most of the time (the past 29 months air quality record). Hence, the amount of NOx converted to NO_2 in the presence of O_3 would not be significant as compared to the DAO 2000-81 criteria. According to “A New Approach to Deriving NO_2 from NOx for Air Quality Assessment of Roads”, the NO_2 to NOx ratio ranges from 20% to 37.5%. Therefore, the daily average NO_2 contour maps use 37.5% of NOx to NO_2 as an illustration.

L) Averaging Time Conversion

A total of 26 modeling scenario has been considered using CALINE4 to predict the worst-case 1-hour pollutant concentrations.

In order to estimate the 8-hour average, 24-hours average and annual averages, the conversion factors recommended in the "Guidelines for Air Dispersion Modelling" has been adopted. **Table 2.107** presents those conversion factors. The 1-hour concentrations, 8-hour concentrations, 24-hour concentration and the annual concentration estimated are then compared with the DAO 2000-81 criteria to identify the adverse impact that may be caused by the potential phase of the Project.

Table 2.107 Averaging Time Conversion Factors

Convert from \ Convert to	10 min	1/2hour	1 hour	8 hour	24 hour	Annual
10 min	1	1/1.36		-	-	-
1/2hour	1.36	1	1/12	0.5	1/3	1/15
1 hour	1.65	1.2	1	0.6	0.4	1/12.5
8 hour		1/0.5	1/0.6	1		
24 hour		3	2.5		1	0.2
Annual		15	12.5		5	1

Note:

[1] Referred to Table B1 in Appendix B of "Guidelines for Air Dispersion Modelling" by Department of Environmental and Natural Resources of Philippines and reviewed with Table 4-1 in Air Dispersion Modelling Guidelines for Ontario Version 3.0 by Ministry of the Environment 2017.

2.3.2.2 Baseline Environmnetal Conditions

A) Baseline Sampling

Ambient air quality monitoring has been conducted in Bataan and Cavite on 14 - 17 February 2020. There are 11 background monitoring locations as shown in **Table 2.98**, **Figure 2.197** and **Figure 2.198**. Monitoring locations 1-5 (A1 to A5) are in Bataan, while monitoring locations 6-11 (A6 to A11) are in Cavite. The results of the baseline conditions for 24-hr and 1-hr sampling air pollutants are summarized in **Table 2.108** and **Table 2.109**.

Table 2.108 24-hr ambient air monitoring results

ID Stations	Date	Time	Pollutants (μg/Ncm)				
			TSP	PM10	PM2.5	SO_2	NO_2
A1	15-16 February 2020	2255H – 2255H	28.2	21.0	15.2	BDL	BDL
A2	14-15 February 2020	2005H – 2005H	23.5	13.9	9.44	BDL	BDL

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	PM10	PM2.5	SO_2	NO_2
A3	13-14 February 2020	1725H – 1725H	19.9	13.5	10.0	BDL	3.91
A4	12-13 February 2020	1430H – 1430H	17.2	16.0	16.3	BDL	3.11
A5	11-12 February 2020	1110H – 1110H	33.6	19.2	19.2	BDL	3.59
A6	09-10 February 2020	2030H - 2030H	25.4	21.8	21.8	BDL	4.82
A7	7-8 February 2020	1620H - 1620H	11.3	10.5	BDL	BDL	3.89
A8	6-7 February 2020	1400H – 1400H	18.9	14.2	14.5	BDL	3.66
A9	5-6 February 2020	1130H – 1130H	44.4	25.3	18.5	BDL	BDL
A10	4-5 February 2020	0915H – 0915H	34.6	30.5	28.1	BDL	5.55
A11	8-9 February 2020	1825H – 1825H	12.2	11.8	12.1	BDL	3.19
DAO 2001-81			**230**	**150**	**50**	**180**	**150**

BDL - Values below the laboratory's Method Detection Limit or pollutant minute enough to be 0 or have a slight mechanical error.

Table 2.109 1-hr ambient air monitoring results

ID Stations	Date	Time	Pollutants (µg/Ncm)				
			TSP	**PM10**	**PM2.5**	**SO_2**	**NO_2**
A1	16-17 February 2020	2315H – 0015H	51.6	46.4	BDL	BDL	BDL
A2	15 February 2020	2020H - 2120H	61.1	49.2	BDL	BDL	BDL
A3	14 February 2020	1735H – 1835H	69.2	BDL	BDL	BDL	BDL
A4	13 February 2020	1445H – 1545H	63.6	51.7	BDL	BDL	BDL
A5	12 February 2020	1120H – 1220H	64.7	BDL	BDL	BDL	BDL
A6	10 February 2020	2040 – 2140H	31.6	42.3	BDL	BDL	BDL
A7	8 February 2020	1630H – 1730H	36.1	BDL	BDL	BDL	BDL
A8	7 February 2020	1420H – 1520H	BDL	BDL	BDL	BDL	10.0
A9	6 February 2020	1140H – 1240H	53.8	51.4	50.1	BDL	BDL
A10	5 February 2020	0926H – 1026H	102.0	70.4	55.9	BDL	BDL
A11	9 February 2020	1835H – 1935H	53.7	37.8	BDL	BDL	BDL
DAO 2001-81			**300**	**200**		**340**	**260**

BDL - Values below the laboratory's Method Detection Limit or pollutant minute enough to be 0 or have a slight mechanical error.

TSP

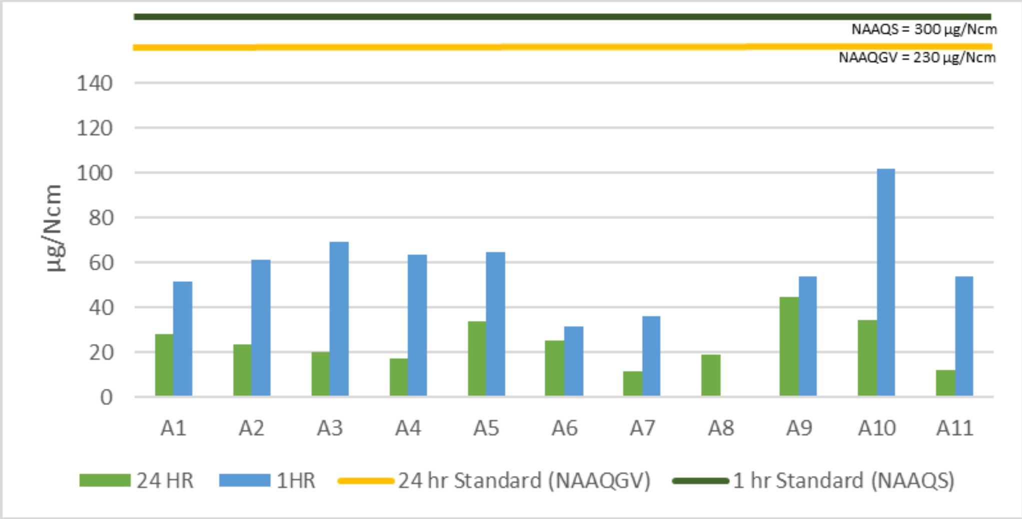


Figure 2.204 Ambient TSP Levels

PM10

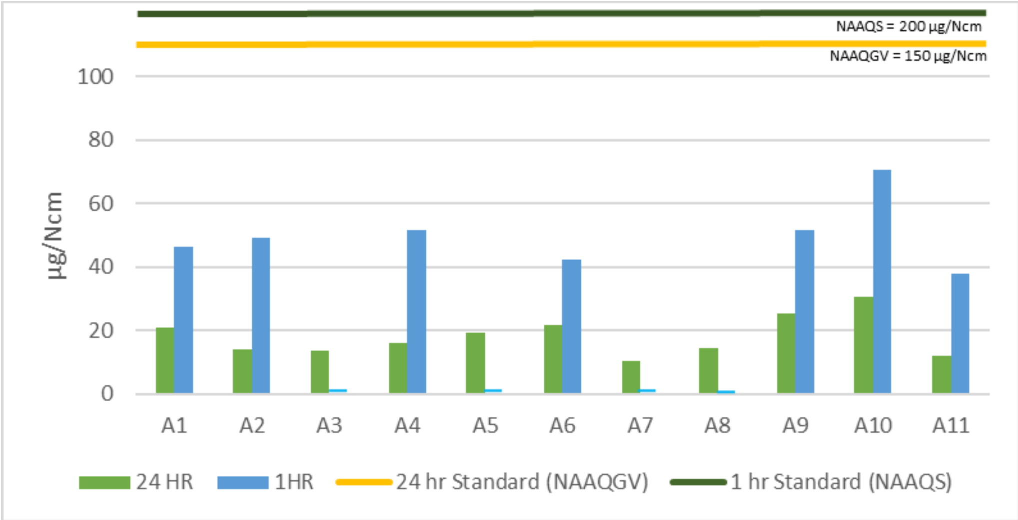


Figure 2.205 Ambient PM_{10} Levels

PM2.5

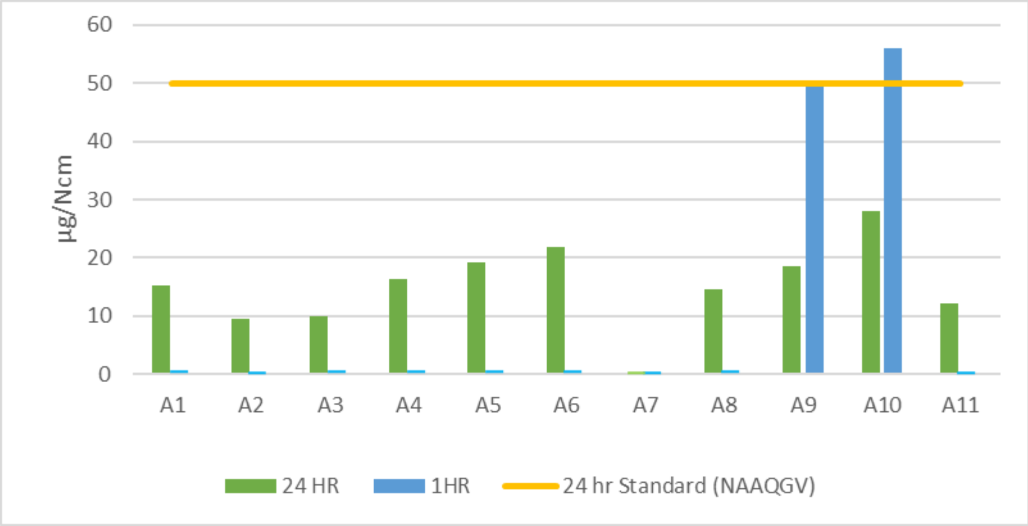


Figure 2.206 Ambient $PM_{2.5}$ Levels

The results for particulate pollutants for 24-hr and 1-hr monitoring conform to the guideline values and standards of DAO 2000-81. The highest particulate pollutants, both for 24-hr and 1-hr sampling, were observed in A9 and A10 due to road dust that get disturbed whenever vehicles passed the near access roads during the time of sampling (e.g. motorcycles/ tricycle, private cars and trucks). The air quality surrounding the project site in terms of particulates is "good", based on the DAO 2000-81 AQI.

<u>Gaseous Pollutants</u>

NO_2

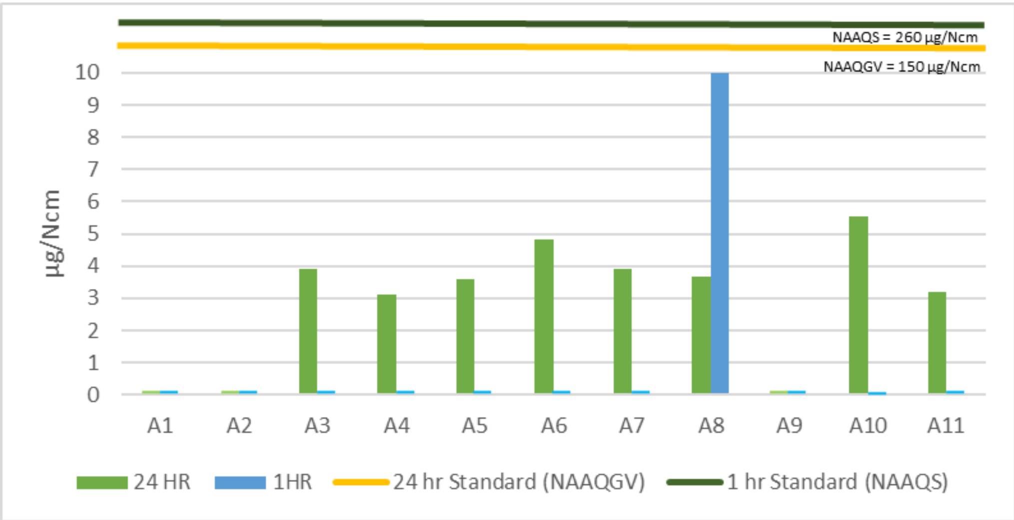


Figure 2.207 Ambient NO_2 Levels

The gaseous pollutant concentrations in the monitoring stations generally comply with the standards for both 1-hr and 24-hr monitoring. Results for SO_2 are all below the detection limit (**Table 2.108** and

Table 2.109). The highest gaseous pollutants for 24-hr NO_2 sampling results were observed in A10, and 1hr sampling results in A8 due to gaseous pollutants emitted by few vehicles that passed the nearby access roads during the time of sampling (e.g. motorcycles/ tricycle, trucks and private cars) (**Figure 2.207**). The air quality surrounding the project site is "good", based on the DAO 2000-81 AQI.

Vehicular traffic, aside from congestion of people, is the most common source of particulate and gaseous pollutants in the area. These particulates are found minimal and do not cause adverse health risks. Moreover, these particulates should frequently be monitored based on the DENR standards to prevent exceedances, which may cause toxicity in the environment and human health.

B) Cumulative Air Quality Impact

According to the EMB MC 2008-005 Guidelines for Air Dispersion Modelling, the estimation of the cumulative air quality impact can be provided by incorporating the background air quality data, which may be obtained by on-site measurement, with the model results.

There are 11 background monitoring locations conducted in Bataan and Cavite. The summary of the maximum measured air quality is given in **Table 2.110** below.

Table 2.110 24-hour Maximum ambient air auality c oncentrations (μg/m³)

ID	Location	Background Pollutant Concentrations			
		NO_2	**SO_2**	**TSP**	**PM10**
Max. in Bataan		3.91	10.5	33.6	21
Max. in Cavite		5.55	10.2	44.4	30.5
NAAQGV (24-hour ave.)		**150**	**180**	**230**	**150**

Note:

[1] Refer to **Annex J** for the measurement report.

For all of the pollutants, the 24-hour average concentrations at the eleven (11) monitoring locations complied with the NAAQGV criteria. The maximum 24-hour concentrations in Bataan and Cavite measured are aggregated to the modeled results from CALINE4 to generate both daily average and the annual average for the estimation of the cumulative pollutant concentrations. Contour maps are prepared to illustrate the cumulative air quality impact to the surrounding ASRs at 1.5m and 5m above local ground (see **Figure 2.208** to **Figure 2.235**).

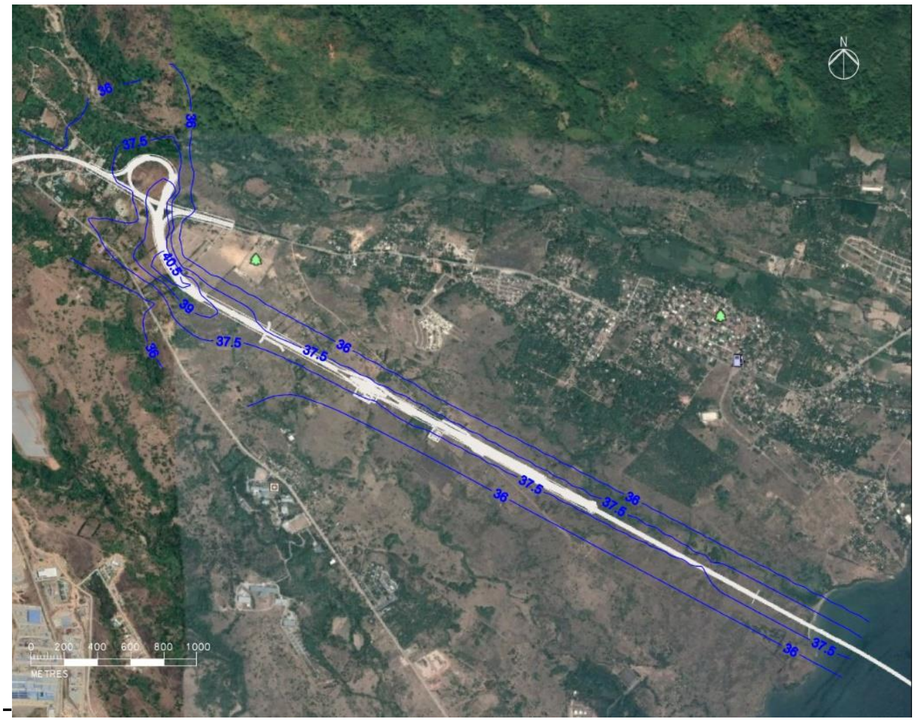


Figure 2.208 Contours of Cumulative 24-hour TSP at Bataan (1.5m above ground)

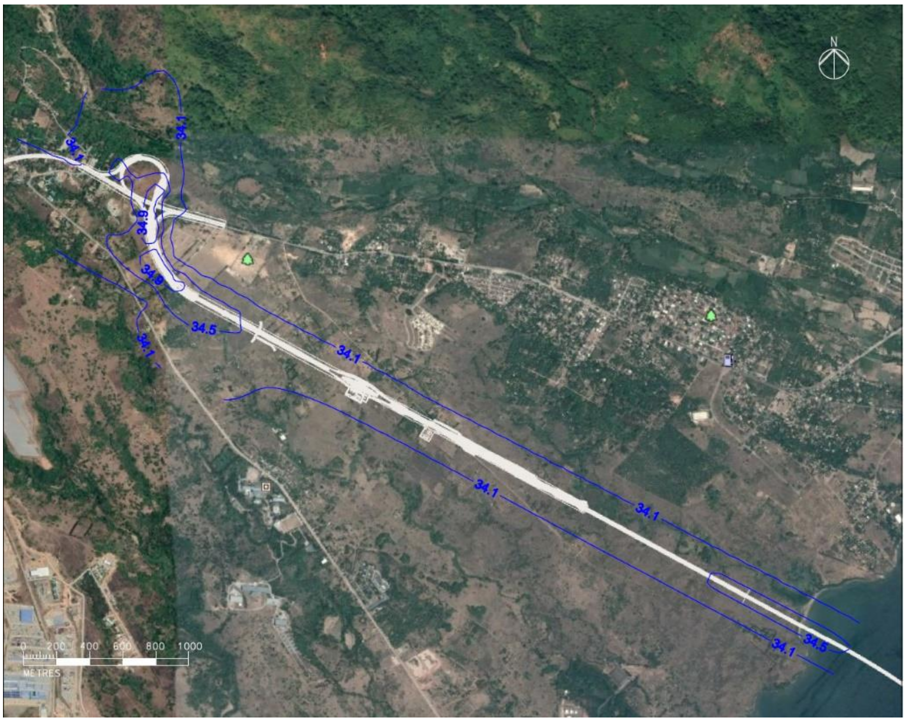


Figure 2.209 Contours of Cumulative Annual TSP at Bataan (1.5m above ground)

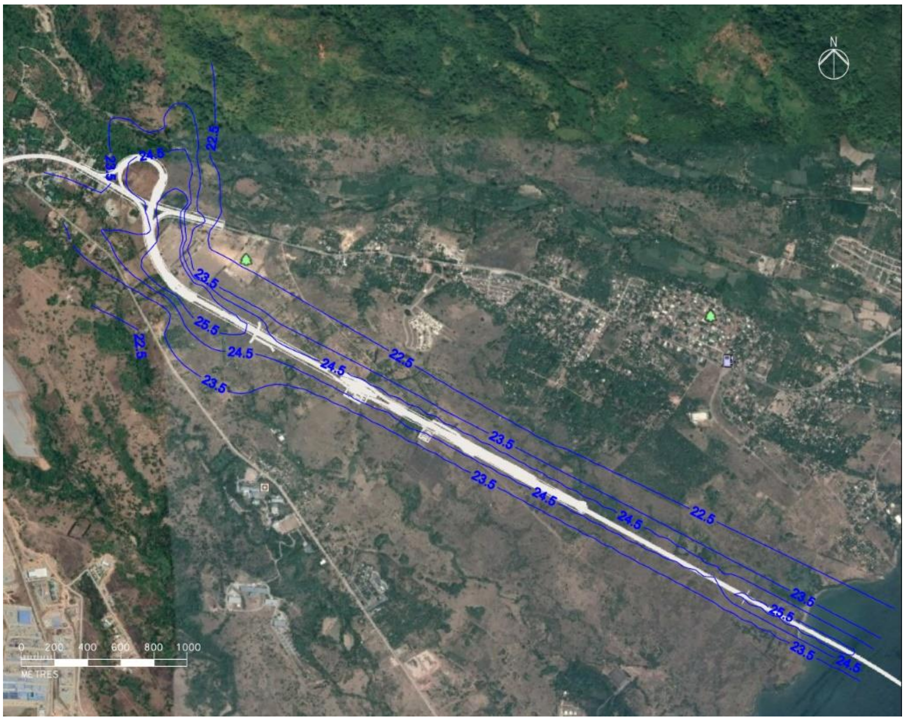


Figure 2.210 Contours of Cumulative 24-hour PM10 at Bataan (1.5m above ground)

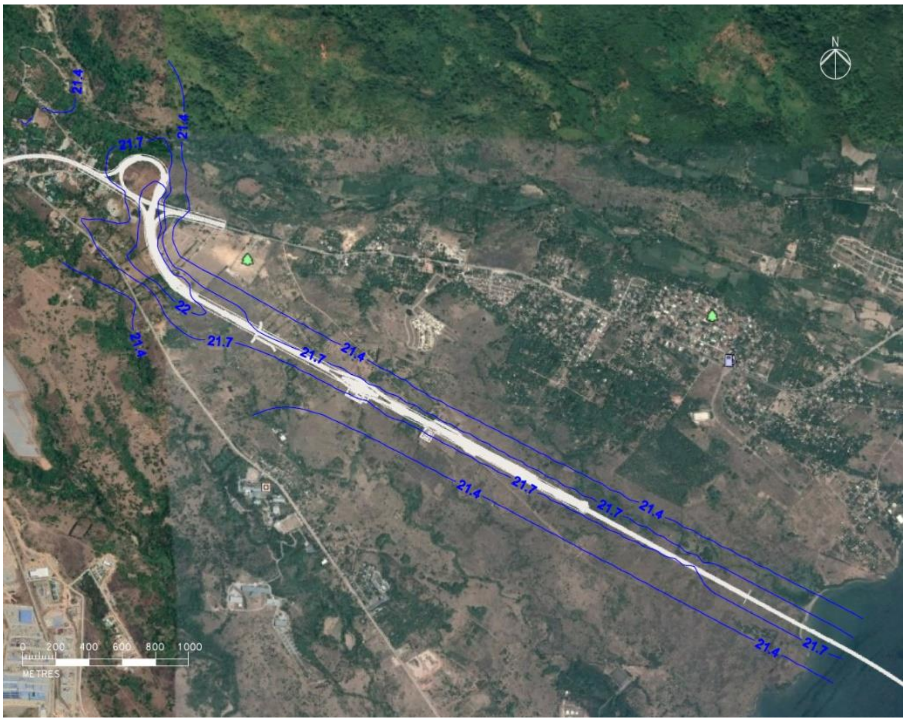


Figure 2.211 Contours of Cumulative Annual PM10 at Bataan (1.5m above ground)

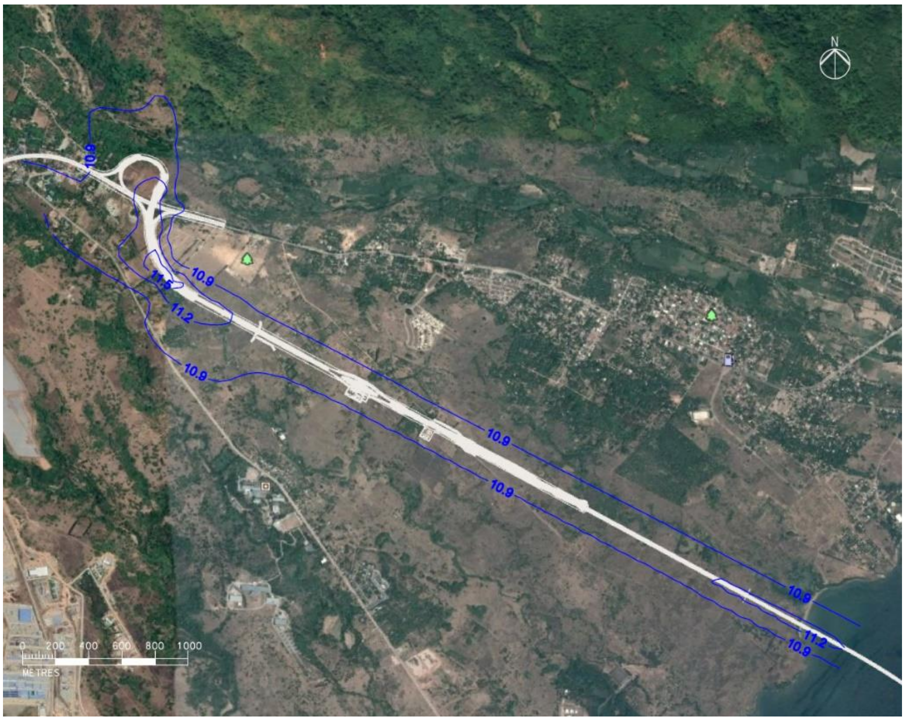


Figure 2.212 Contours of Cumulative 24-hour SO2 at Bataan (1.5m above ground)

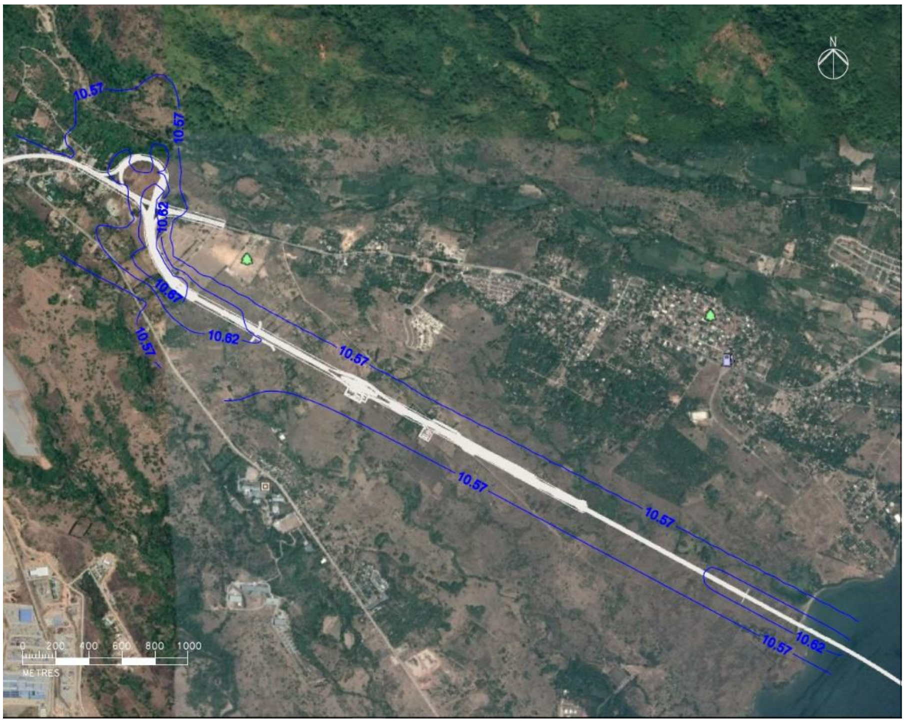


Figure 2.213 Contours of Cumulative Annual SO_2 at Bataan (1.5m above ground)

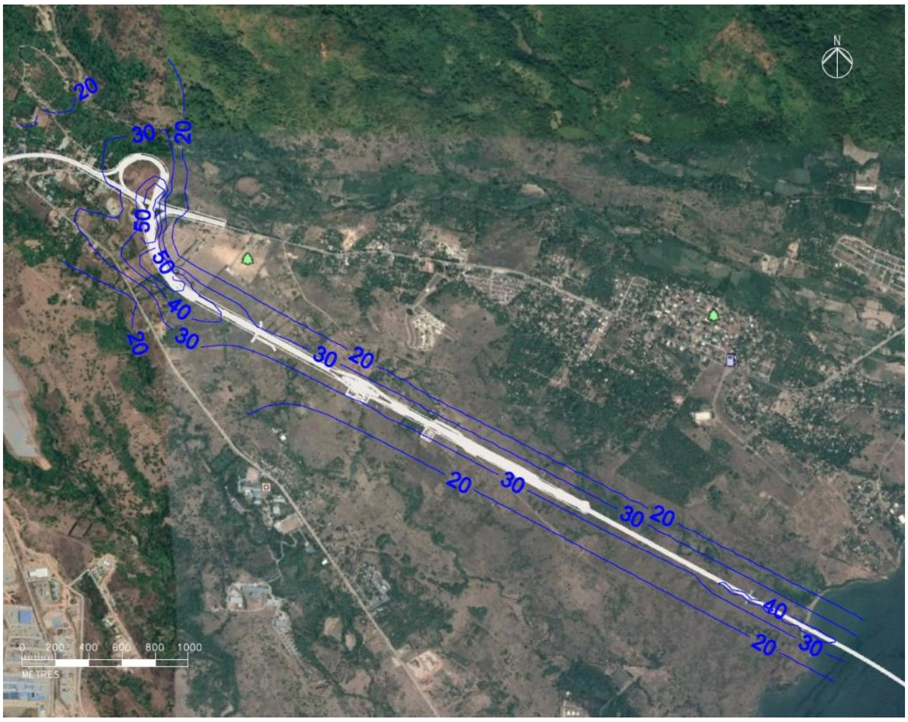


Figure 2.214 Contours of Cumulative 24-hour NO2 at Bataan (1.5m above ground)

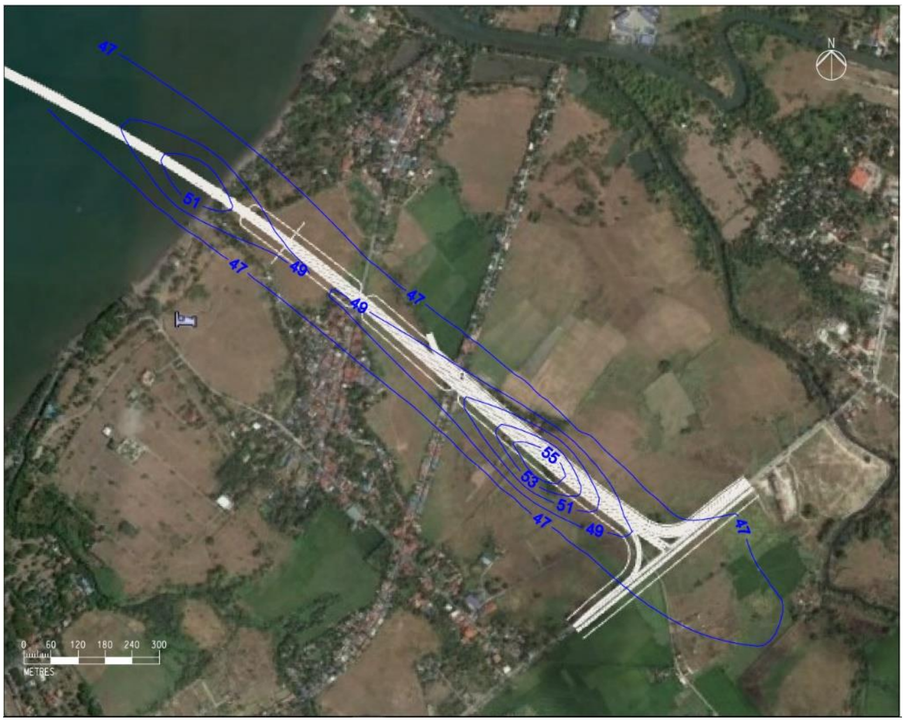


Figure 2.215 Contours of Cumulative 24-hour TSP at Cavite (1.5m above ground)

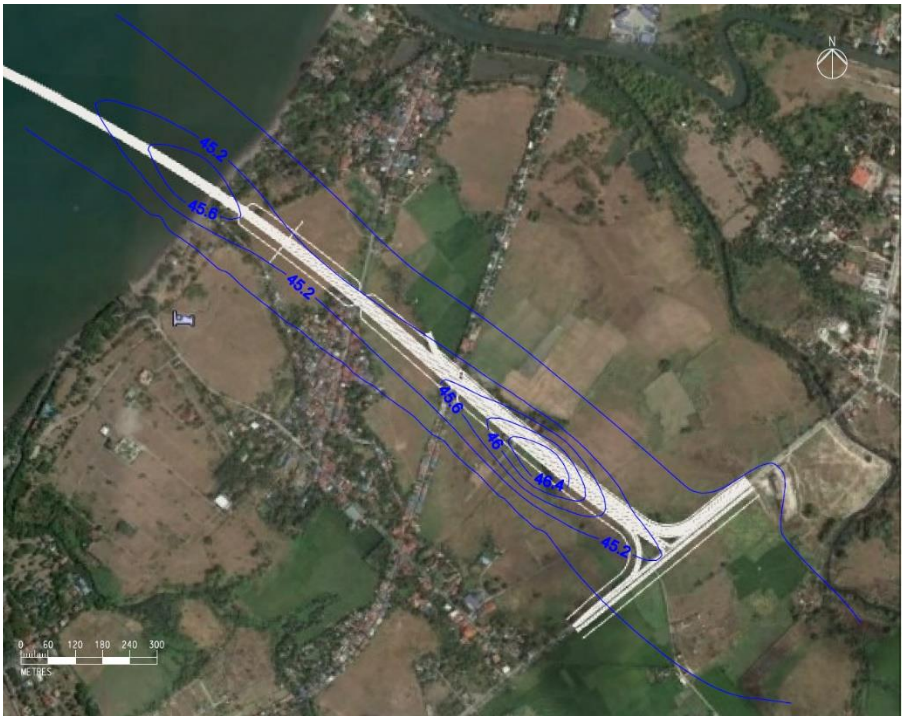


Figure 2.216 Contours of Cumulative Annual TSP at Cavite (1.5m above ground)

Figure 2.217 Contours of Cumulative 24-hour PM10 at Cavite (1.5m above ground)

Figure 2.218 Contours of Cumulative Annual PM10 at Cavite (1.5m above ground)

Figure 2.219 Contours of Cumulative 24-hour SO2 at Cavite (1.5m above ground)

Figure 2.220 Contours of Cumulative Annual SO_2 at Cavite (1.5m above ground)

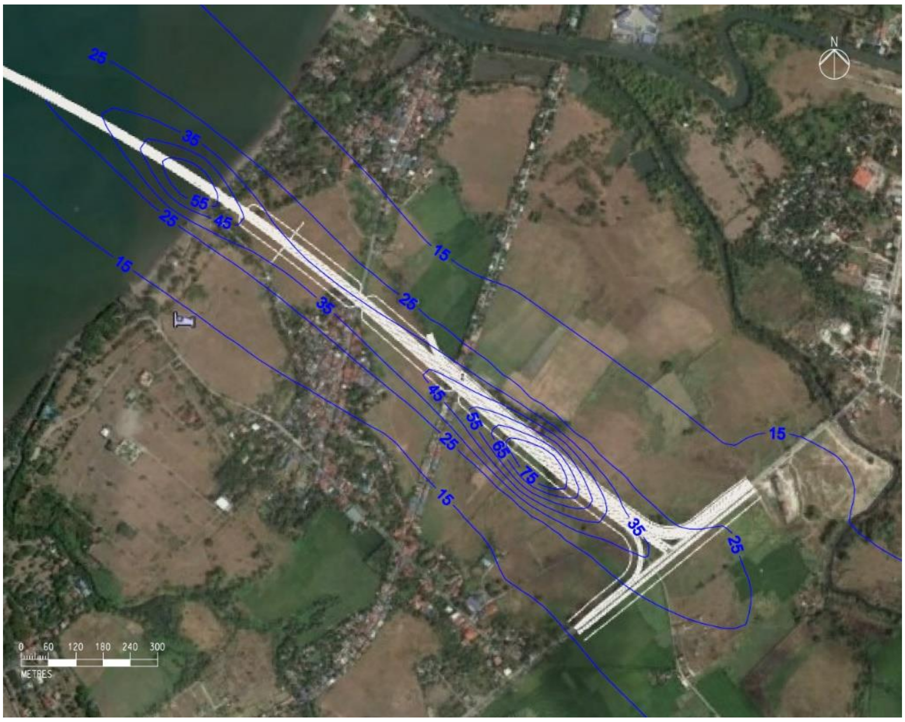


Figure 2.221 Contours of Cumulative 24-hour NO2 at Cavite (1.5m above ground)

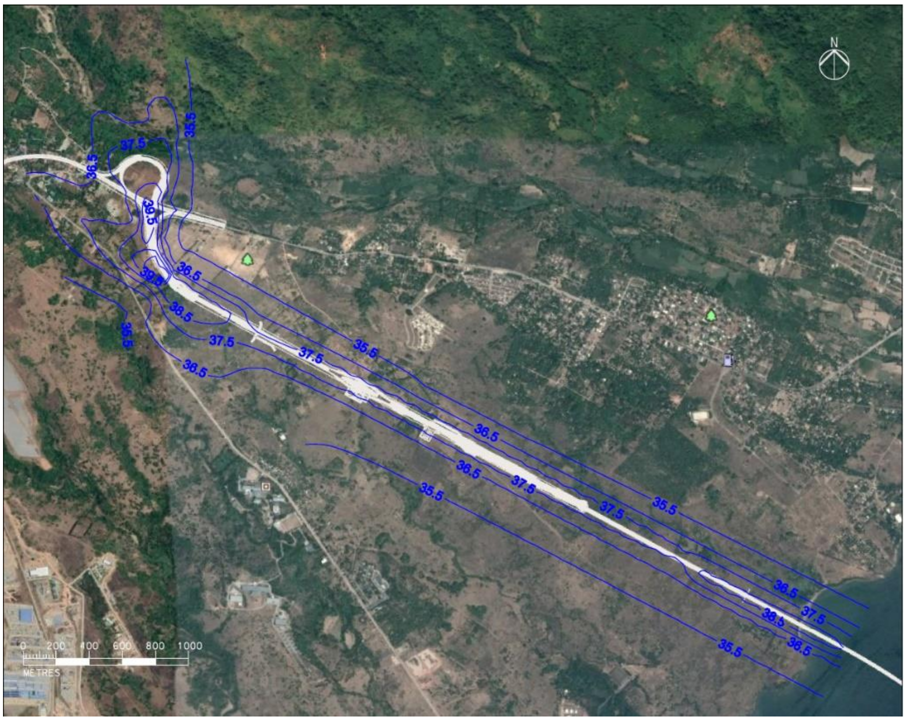


Figure 2.222 Contours of Cumulative 24-hour TSP at Bataan (5m above ground)

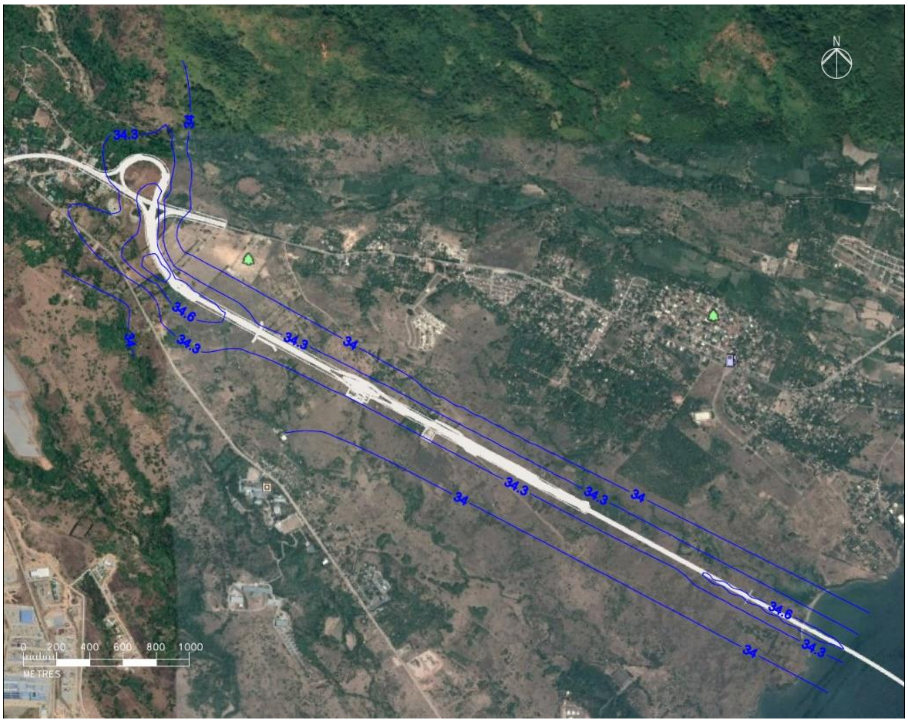


Figure 2.223 Contours of Cumulative Annual TSP at Bataan (5m above ground)

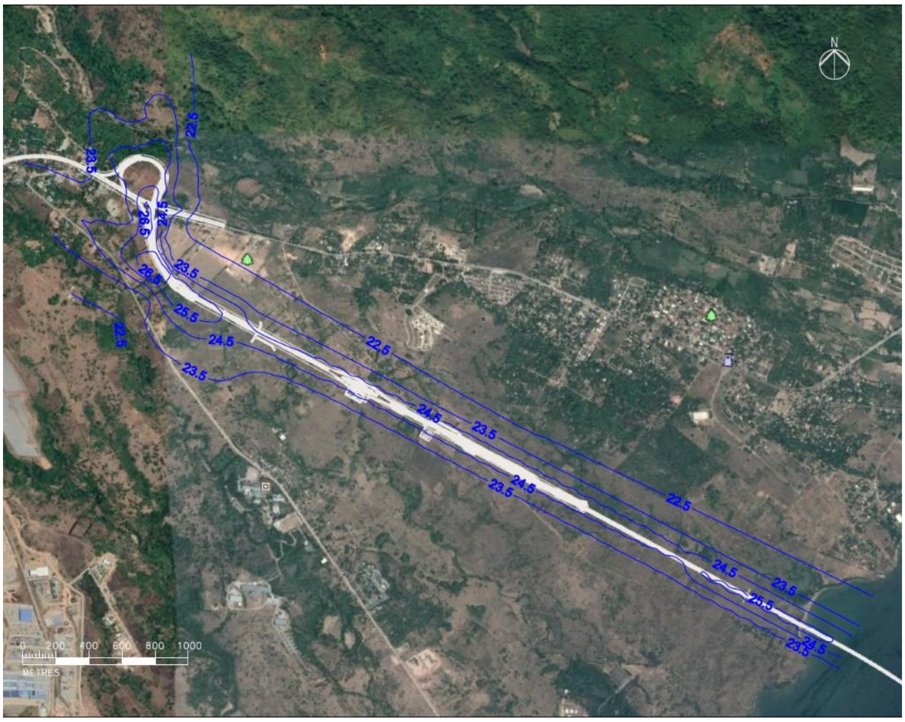


Figure 2.224 Contours of Cumulative 24-hour PM10 at Bataan (5m above ground)

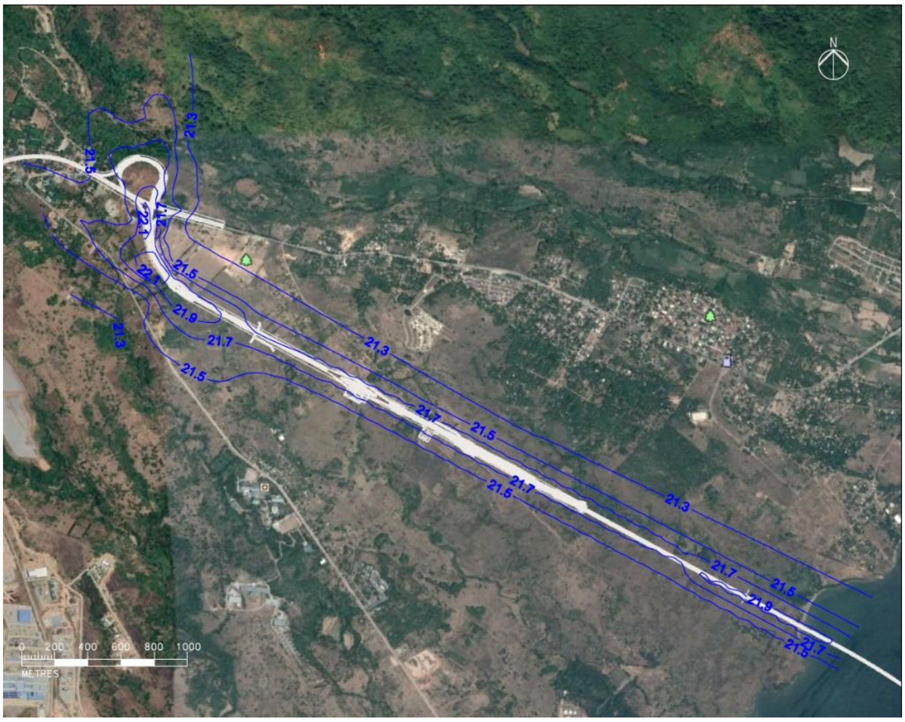


Figure 2.225 Contours of Cumulative Annual PM10 at Bataan (5m above ground)

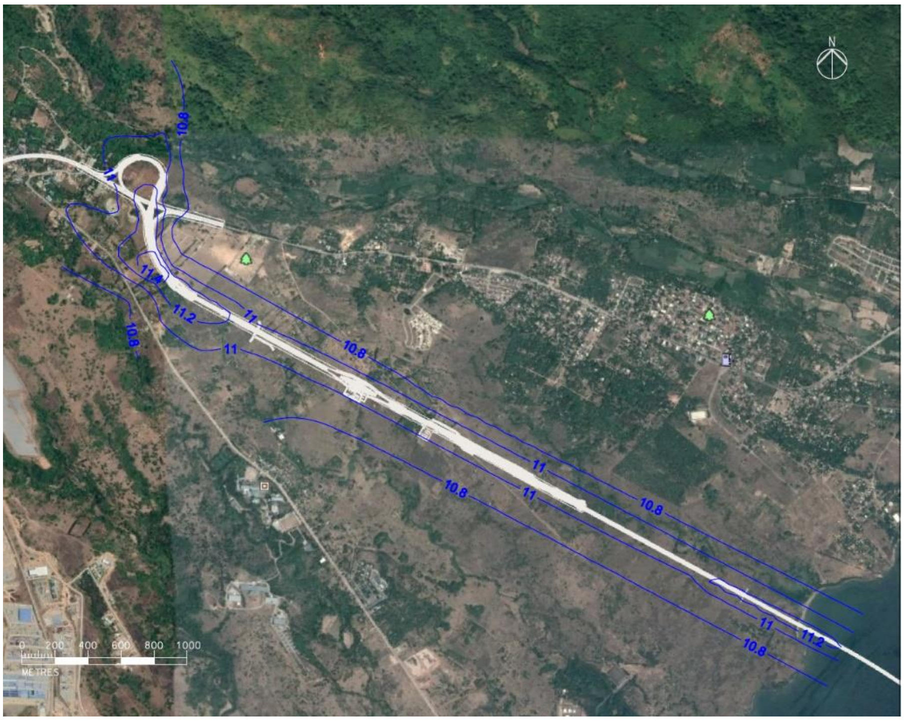


Figure 2.226 Contours of Cumulative 24-hour SO2 at Bataan (5m above ground)

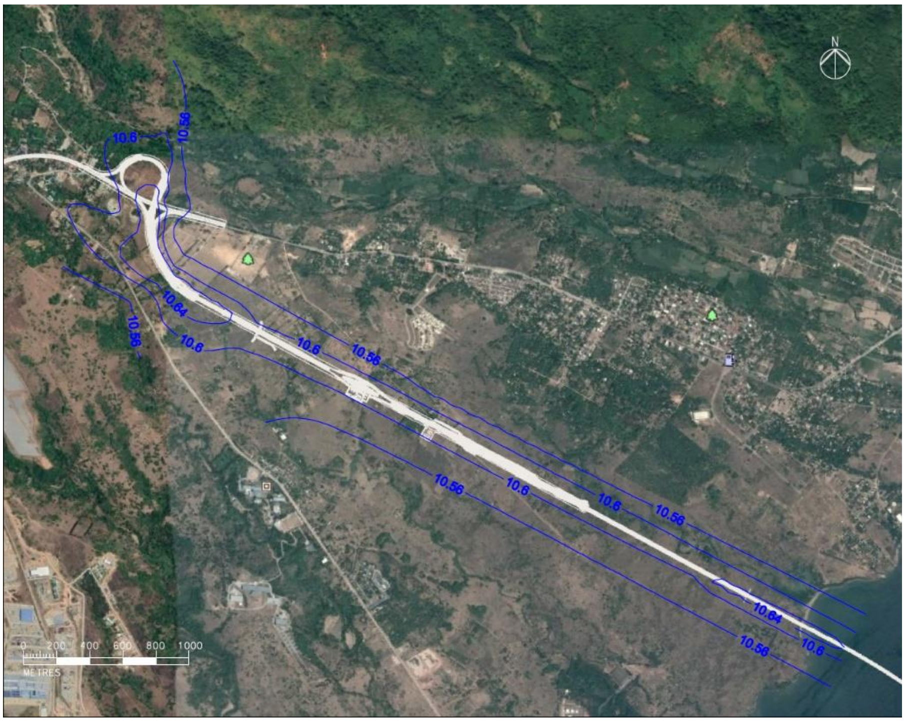


Figure 2.227 Contours of Cumulative Annual SO2 at Bataan (5m above ground)

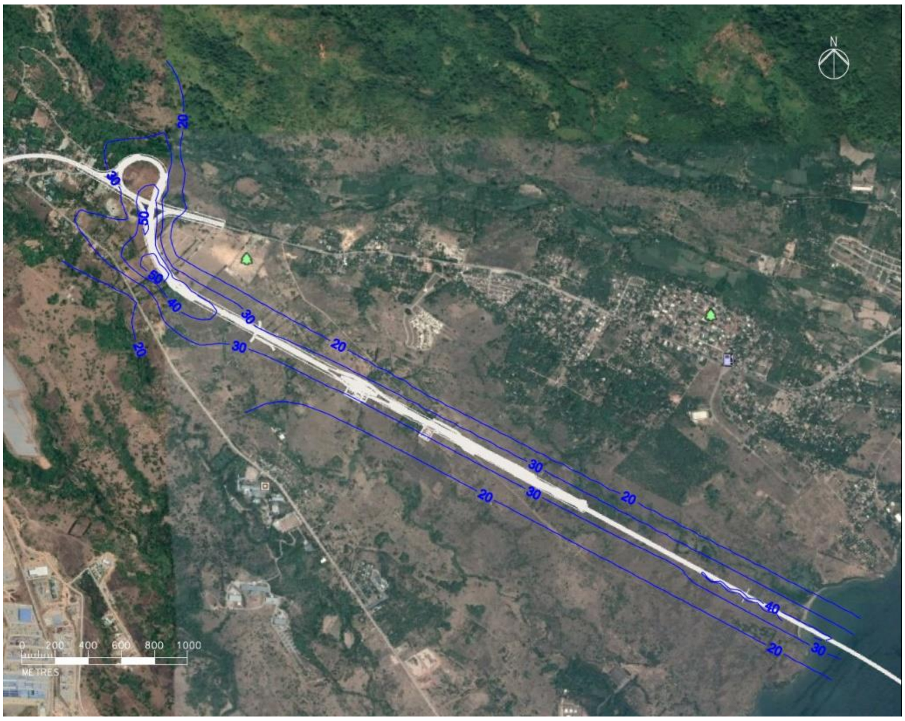


Figure 2.228 Contours of Cumulative 24-hour NO2 at Bataan (5m above ground)

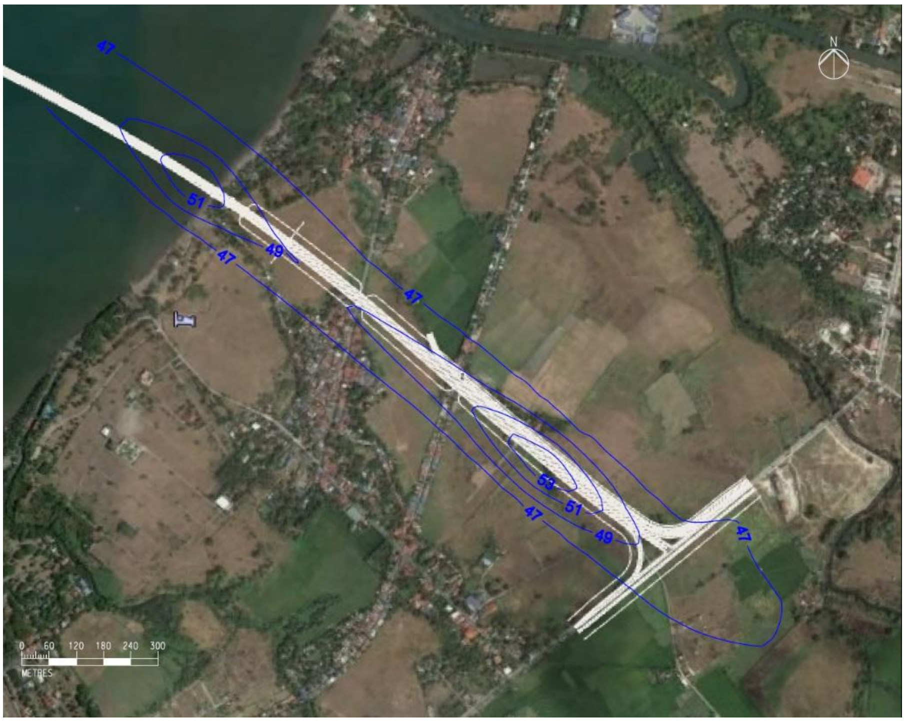


Figure 2.229 Contours of Cumulative 24-hour TSP at Cavite (5m above ground)

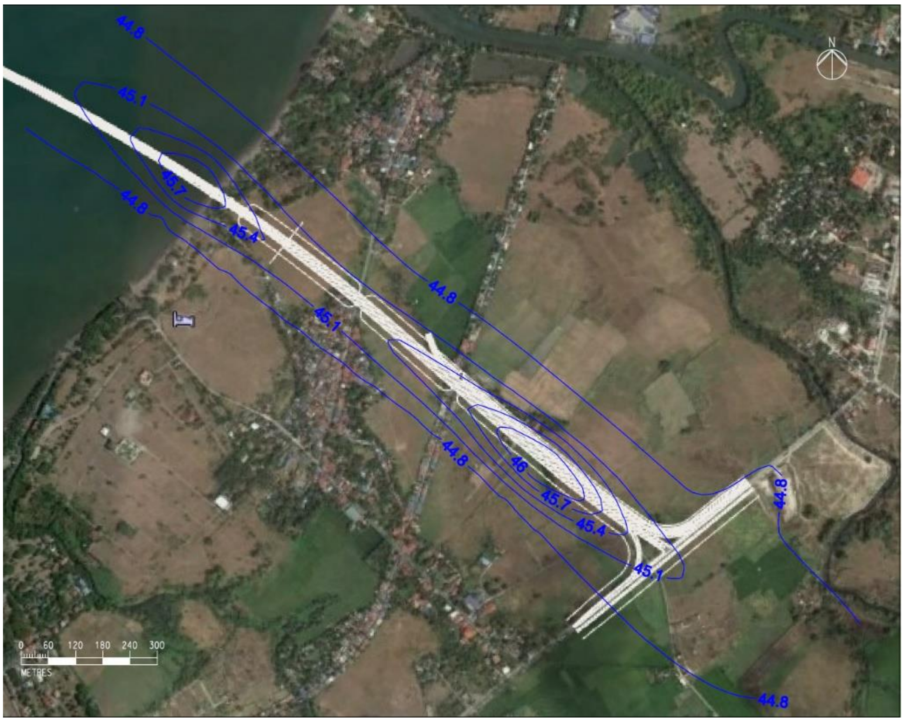


Figure 2.230 Contours of Cumulative Annual TSP at Cavite (5m above ground)

Figure 2.231 Contours of Cumulative 24-hour PM10 at Cavite (5m above ground)

Figure 2.232 Contours of Cumulative Annual PM10 at Cavite (5m above ground)

Figure 2.233 Contours of Cumulative 24-hour SO2 at Cavite (5m above ground)

Figure 2.234 Contours of Cumulative Annual SO2 at Cavite (5m above ground)

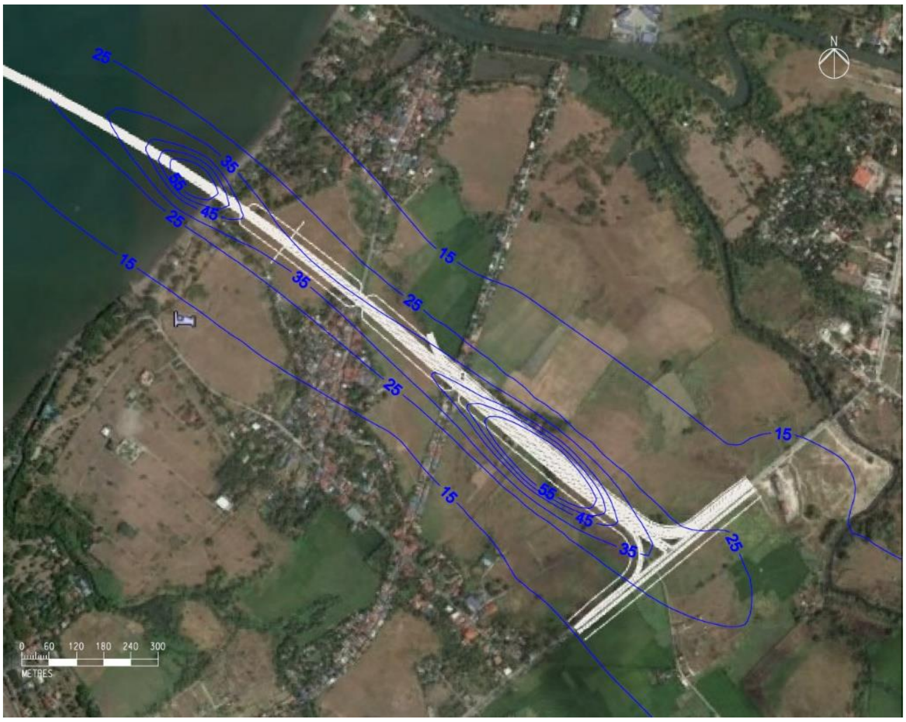


Figure 2.235 Contours of Cumulative 24-hour NO_2 at Cavite (5m above ground)

The predicted cumulative 24-hour average TSP concentrations range from 35 to 46 µg/m³ in Bataan and 45 to 59 µg/m³ in Cavite. Both are below the NAAQGV criteria of 230 µg/m³. For the predicted annual average, the concentrations range from 34 to 36 µg/m³ in Bataan and 45 to 47 µg/m³ in Cavite. Both are below the NAAQGV criteria of 90 µg/m³ and are mainly contributed from background concentration.

For PM10, the predicted 24-hour concentrations range from 22 to 32 µg/m³ in Bataan and 31 to 44 µg/m³ in Cavite. Both are less than half of the NAAQGV criteria of 150 µg/m³. The annual average PM10 concentrations are in the range of 21 to 23 and 30 to 33 in Bataan and Cavite, respectively. Both are lower than NAAQGV criteria of 60 µg/m³.

For SO_2, daily average concentrations range from 10 to 12 µg/m³ in both study areas and are much lower than NAAQGV criteria of 180 µg/m³. Similarly, the predicted annual average SO_2 concentrations are less than 11 µg/m³, and thus are lower than NAAQGV annual criteria of 80 µg/m³.

The predicted daily average concentrations of NO_2 range from 11 to 91 µg/m³ in Bataan and from 8 to 61 in Cavite. The major NO_2 emission sources would be traffic emissions due to the proposed BCIB. As mentioned in the air modeling methodology, the daily average NO_2 contour maps used 37.5% of NOx to NO_2 as an illustration. However, the predicted cumulative NO_2 concentrations are well below the NAAQGV daily criteria of 150 µg/m³.

Generally, the pollutant concentrations at the level 1.5m above ground are slightly higher than that at 5m above ground. The background concentration is the major contribution of the cumulative concentrations for TSP, PM10 and SO_2. The predicted cumulative concentrations at the level 1.5m and 5m above ground for daily average and the annual average of TSP, PM10 and SO_2, as well as the daily average of NO_2, are below the NAAQGV criteria.

C) Climate change impacts without the project

Climate change is attributed to direct and indirect human activities that alter the composition of the global atmosphere or in land use. To assess the climate change on the project, current climate conditions are established through the relevant historical data and climatological background of Bataan and Cavite.

As discussed in **Section 2.3.1**, changes in rainfall and temperature may affect the area, since it is expected to increase in the mid-21st century (2036-2065). These changes may have a critical influence on altering air pollutant dispersal and the formation of inversion layers. Inversion layers happened when dense low temperature air trap the warmer air, potentially leading to trapping of ground-level pollutants for longer times. In addition, sulfur dioxides (SO_2) and nitrogen dioxides (NO_2) released into the atmosphere by vehicular exhaust may react with water and oxygen, forming acid rain. During the wet season, wet deposition of acidic rain may occur more frequently. During decreased rainfall in the dry periods, acid chemicals in the atmosphere may be incorporated into dust and fall to the ground through dry deposition. Dry deposited gases may be washed by rainstorms, which may lead to increased runoff.

2.3.2.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Potential Impacts

Fugitive Dusts

Fugitive dusts are fine air particles, ranging from 2 μm to 10 μm that can escape into the air because of its size. Wind is the main cause of the spreading of this pollutant as its lightweight allows it to float easily and spread to its surroundings. Industrial processes that break down and crush material emit these fugitive dusts into the environment. During the construction phase, the concentration of pollutants in the air will increase. This is due to land clearing, loading and unloading of materials, and the use of construction and transportation vehicles.

Depending on the size, composition, and length of exposure to the particles, fugitive dust can be detrimental to workers and nearby communities. Exposure to this pollutant can cause eye and even skin irritation upon repeated contact. Individuals who experience asthma will have can have more frequent asthma attacks as these particles are small enough to enter your nose and lungs. Long-term effects from over-exposure to fugitive dust can be illnesses to the lungs and to the heart.

Emissions due to the combustion of fossil fuels

Vehicle and equipment emissions are one of the primary sources of air pollution as these create particulate matter, such as smoke and dust, and other and other gaseous pollutants. Gaseous pollutants such as NO_2 and SO_2, are emitted from the combustion of fossil fuels by vehicles and equipment. Along with these emissions, fine particulates are produced from the exhaust of vehicles. Combustion of fossil fuels result in the emission of TSP, PM10, and PM2.5, specifically black carbon. As previously mentioned, the particles have diameters so small that it can bypass human defense systems, such as nasal hair and filia in the lungs. This can produce adverse health effects as the particles are able to enter the lungs, causing respiratory diseases like asthma, or cardiovascular disease during long-term over-exposure.

NO_2 and SO_2 are released during fossil fuel combustion. The gaseous pollutants mix and react with water, making it more acidic. In addition to this, this pollutant can react to rain and result in acid rain. This can pollute bodies of water and nearby soil, changing their chemical properties. This has an ecological effect as many organisms, especially plants and aquatic creatures, have a narrow pH limit, dying once basicity or acidity exceeds these limits.

Another by-product released by the combustion of fossil is carbon dioxide (CO_2). CO_2 is considered a greenhouse gas (GHG) and these are the main cause of climate change and global warming. CO_2 can react with O_3, otherwise known as ozone, which is of the gases responsible for the degradation of the ozone layer in the stratosphere. The result of this is global warming and climate change, causing habitat loss, species extinction, and resource depletion. On a local level, over-exposure to CO_2 can lead to carbon dioxide poisoning. This kind of intoxication can lead to loss of oxygen, or anoxia, or an elevated level of CO_2 in the blood and tissue and may lead to death. Nearby communities may experience nuisances by the odor of the combustion of fossil fuels.

The release of pollutants into the atmosphere during the operation phase will rise as the public will be permitted to utilize the highway. The resulting increase of vehicles passing through the highway, and the roads connecting to it, will increase the emission of air pollutants, imposing health hazards to the area, especially on the locals situated in the immediate surroundings of the roads.

Enhancement of climate change impacts

BCIB may increase the ground level concentration of air pollutants during construction and operation phases. Particulate pollutant emission can have significant impacts on climate. The direct effects come from particles' ability to absorb and scatter light. These particles absorb heat from the sunlight preventing the dispersion of heat thus, cause an increase in temperature in the atmosphere. Other causes of climate change include the change in reflectivity of the scattered particles, which influence cloud lifetime and precipitation. Changes may also increase influence in altering air pollutant dispersal and formation of inversion layers.

Gaseous pollutants such as emission of NO_X from the combustion of fossil fuels, from use equipment and vehicle use, may contribute to the formation of ozone, which is a significant contributor to climate warming. SO_2, when combined with water, formed harmful compounds, such as sulfuric acid, sulfurous acid and sulfate particles. This may be dispersed in air and forms acid rain that may damage plants and crops, and may even affect human health.

B) Options for Prevention, Mitigation and Enhancement

A procedural approach is needed for mitigating and preventing hazards. The utilization of mitigation plans must comply with standards set by laws. These include proper maintenance of construction and machines for repair, personnel work safety and guidelines, equipment usage training, transport, storage, and other rules.

Fugitive Dusts

Listed below are ways to control and mitigate fugitive dusts, pollutants caused by combustion of fuels and other particulate matter:

- Water spraying to apply dust suppression, especially during transportation of materials.
- Cement paths and roads humans and vehicles use.
- Provide washing areas for construction vehicles to remove mud and dirt from tires before leaving the project site.
- Add rumble grids in the entrances and exits to remove dust stuck on the wheel.
- Control speed in which the transport vehicle is driving at to prevent chunks of material to break on the pavement and become dust.
- Cover vehicles when not in use to keep dust and particulates from sticking to its walls when it leaves the site.
- Regularly conduct maintenance for construction vehicles and machines.
- Constantly monitor air quality in the area and strictly follow set mitigation plans. Prioritize sensitive receivers, strictly implementing buffer zones.
- Publicize the information of the project and activities to communities nearby.
- If possible, immediately plant trees in-between the roads and the residential areas in order to have a buffer for air pollutants and to prevent erosion and dust dispersion. This will help lower the air pollution experienced by the local communities.
- Add wind breakers in areas upwind to prevent wind from disturbing the dust.
- Conduct training, which includes:
    - Proper and efficient use of fuel-powered equipment for air pollution reduction.
    - Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines.
    - Guidelines to manage traffic.

Emissions due to the combustion of fossil fuels

Mitigation approaches and ways to control the emissions of particulate matter and gaseous pollutants from combustion of fossil fuels are:

- Conduct regular inspection and maintenance for construction and transport vehicles, and machine in order to avoid incomplete combustion of fuels.
- Use cleaner fuel such as biofuel or diesel if possible.
- Use renewable energy to power equipment or appliances found on site.
- Construction plans for temporary buildings and rest areas should consider cooling effects by different roofs, such as green roofs and energy star roofs, and interior design to lessen the use of cooling systems such as air conditioners and heavy-duty electric fans.
- Plant trees in between project site and local communities to reduce their exposure to these emissions as the vegetation act as a buffer.
- Conduct training to inform the workers proper and efficient use of construction equipment and vehicles transport
  - Proper and efficient use of fuel-powered equipment for air pollution reduction.
  - Safety briefings, giving importance to personal and environmental implications. Ensure the proper use of personal protective equipment (PPE) based on Occupational Safety and Health Association (OSHA) guidelines.
  - Guidelines to manage traffic.
- Turn off the engine of idling vehicles to prevent wasting fuel.

Enhancement of climate change impacts

In addition to minimizing any negative impacts on the community, good sustainable development practices should be implemented to have environmental sustainability targets. The project implementation may generate significant amounts of air pollution. The changes in seasonal rainfall and temperature that are projected to occur in a changing climate may harm species, habitat and ecosystem. Measures to minimize the Projects' contribution to the effects of climate change are the same as the above.

2.3.3 Ambient Noise Level

Noise impact assessment aims to protect people from the adverse effects of noise in human health and the environment. The study aims to identify the baseline condition at the project vicinity, conduct the ambient noise impact assessment and propose mitigation measures.

Ambient noise results are compared to the Philippine Noise Standards (1978 National Pollution Control Commission (NPCC)) Memorandum Circular No. 002 Series of 1980, Section 78 – Ambient Noise Quality and Emission Standards for Noise. Noise standards were developed with the aim of protecting the people from the adverse effects of noise. These were set according to the category of the area and time range of sampling.

The assessment is also compared to the Environmental, Health, and Safety Guidelines on Noise Management set by the International Finance Corporation (IFC) to ensure that noise will always comply with its acceptable limit.

2.3.3.1 Methodology

A) Study Area

The eleven noise sampling sites were selected to represent the sensitive receptors in the vicinity of the project area and were located coincident with the ambient air sampling stations. The most common category in the study is category A for the purpose of obtaining the most accurate representational data experienced by the residents. One location, A11, is classified as AA as it is located at the nearest school. This station was an additional sampling location as requested during one of the project's consultation activities.

B) Sources Identification

Decibel (dB) is a unit used to measure the intensity of sound. Various components may affect the sound level produced such as power, sound pressure, distance, voltage, and many more. Measuring dB is important as over-exposure to this pollutant may lead to sleeping disorders, and irritation, while exposure to high levels can cause hearing loss.

Sources of noise pollution can be found throughout the site. From heavy transport trucks to construction machinery, many of the necessary equipment produce loud and unsettling noises.

During the construction phase, the two main sources of noise pollution are from construction and from transport. The sound from construction mainly occurs from heavy machinery. Excavators, bulldozers, track loaders, and cranes are a few of the common equipment that can produce large amounts of noise because of their purpose to move earth, soil, and rock. Because high numbers of rock and soil require large amounts of energy to be displaced, engines and its parts need to be bigger and stronger to do enough work. This increases the noise the machine makes as larger parts are at work and grinding against each other.

Vehicles going to the area also emits a significant amount of noise. Construction workers are brought to the site and this constant transport to and from the area may result in loud noises depending on the shift of the workers. Trucks carrying material to the construction site are not necessarily as common as transport vehicles, but their sizable engines cause louder noises. Conversations from construction workers near the edge of the site may also be loud enough to bother nearby communities.

The main source of noise pollution during the operational phase of the projects is the transport vehicles that will utilize the bridge and the roads. As locations are more accessible, travel to and from these areas will be simpler, increasing the number of cars, motorcycles, trucks, and others. Neighboring communities may be affected by the loud noises these vehicles produce.

C) Sampling Methodology

Noise monitoring was conducted on 4-17 February 2020. Sampling was stationed at eleven (11) noise level sampling stations, consistent with the ambient air sampling stations, using the Lutron Sound Level Meter. The meter used for noise level monitoring was an A-weighted, dB (A), frequency filter to approximate the sounds humans hear. This digital sound level meter was calibrated using Extech 407766 Sound Level Calibrator. Sampling was obtained for 24 hrs with an interval of a second.

D) Data Analysis

Noise level standard used at sampling sites varies depending on the category of each locations. The noise sampling station category is shown in **Table 2.111**.

Table 2.111 Noise Sampling Station Category

Category	Description
AA	A section of contagious area, which require quietness such as area within 100m from school sites, nursery schools, hospitals and special home for the aged.
A	A section or contagious area primarily used as residential purposes.
B	A section or contagious area primarily used as commercial purposes.
C	A section primarily reserved as light industrial area.
D	A section primarily reserved as heavy industrial area.

Source: Rules & Regulations of the National Pollution Control Commission (1978), Section 78, Table 1. Environmental Quality Standards for Noise in General Areas (maximum allowable noise levels in general areas)

The sampling sites used in this assessment belong to Category AA, which requires quietness and Category A, which is located in residential areas.

To prevent possible complaints from nearby communities and institutions, noise levels during construction and operation stages should be monitored. As part of the baseline sampling, a continuous 24-hr measurement divided into four time periods was the method used to note any predominant noise sources. These four time periods with standards corresponding to the sensitivity in receiving noise levels are summarized in **Table 2.112**.

Table 2.112 The Philippine Noise Standards

Category	Noise levels (dBA)			
	Morning 5:00am- 9:00am	**Daytime 9:00am-6:00pm**	**Evening 6:00pm-10:00pm**	**Nighttime 10:00pm-5:00am**
AA	45 dB	50 dB	45 dB	40 dB
A	50 dB	55 dB	50 dB	45 dB
B	60 dB	65 dB	60 dB	55 dB
C	65 dB	70 dB	65 dB	60 dB
D	70 dB	75 dB	70 dB	65 dB

In accordance with Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental – Noise Management under IFC guidelines, noise impacts should not exceed the levels presented in **Table 2.113**, or result in a maximum increase in the background level of 3dB at nearest receptor location off-site.

Table 2.113 IFC Noise Level Guidelines

Receptor	One Hour L_{Aeq} (dBA)	
	Daytime (07:00-22:00)	**Night time (22:00-07:00)**

Residential; institutional; educational	55	45
Industrial; commercial	70	70

E) Road Traffic Noise Modeling

Soundplan is the software adopted for road traffic noise modelling. The calculation methodology would be based on the Federal Highway Administration's (FHWA) Traffic Noise Model version 3.0 (TNM3.0), developed by the U.S. Department of Transportation. This methodology is commonly adopted in many highway projects in different parts of the world for road traffic noise assessment. Therefore, it is used to predict the road traffic noise impact during the operational phase in this study. The model has taken into account various corrections, such as distance correction, view angle correction and barrier correction, etc. The input data of TNM includes topography, geographic data, receiver coordinates, ground absorption, road surface, hourly traffic flows and speed.

TNM 3.0 relies on a database of maximum A-weighted sound pressure levels for pass by events and corresponding one-third octave-band spectra to determine vehicle noise levels. This database includes a noise measurement of approximately 6000 vehicles. The measurements were conducted over relatively flat ground, with the microphone at height of 1.5m and with the microphone horizontal distance at 15m. The ground between the roadway edge and the microphone was acoustically absorptive.

Assessment Area

The assessment area should cover approximately 300m from the project boundary. As there are no Noise Sensitive Receivers (NSRs) in the vicinity of the marine viaduct section (including Corregidor Island), only the residential areas in Bataan and Cavite, where the BCIB lands, are considered in this quantitative road traffic noise assessment model. Hence, the model area is sub-divided into two parts: the northern assessment area for Bataan and the southern assessment area for Cavite, as shown in **Figure 2.200** and **Figure 2.201**, respectively. The main road alignment and the corresponding connecting roads are also shown in **Figure 2.202** and **Figure 2.203**, respectively.

Existing Landuses

The existing land uses in Bataan and Cavite are mainly rural types with a combination of low density and low-rise residential buildings (with 1 or 2 storeys) and agricultural land. Existing roads are mainly village type roads with very low traffic volume. Most segments of the proposed BCIB are far away from the existing NSRs, although some existing NSRs could be relatively closer to the alignment.

Noise Sensitive Receivers

As there is no confirmed information on the details of any future urban planning for Bataan and Cavite, the first layer of those existing NSRs along the proposed BCIB alignment has, therefore been selected as representative NSRs for this road traffic noise impact assessment. These NSRs are currently village type residential houses of 1 to 2 storeys. The assessment points are set at 1.5m above ground. Representative NSRs in Bataan and Cavite are shown in **Figure 2.236** and **Figure 2.237**, respectively.

Figure 2.236 Location of Representative NSRs in Bataan

Figure 2.237 Location of Representative NSRs in Cavite

Topography

Bataan is located on hillside, while the Cavite is located on a relatively flat terrain. Therefore, the topography of the northern assessment area in Bataan has been modelled. The topographical information is extracted from Google Earth.

On top of the existing topography information, some modifications of topography such as construction of berms and supressed roads, have also been taken into consideration for both northern assessment area in Bataan and southern assessment area in Cavite.

Geographic Data

Apart from the topography, the surrounding environment has been modelled. The land section of the proposed BCIB is located in the vicinity of some rural residential buildings, which are mainly 1 – 2 storeys. The structures of these residential buildings are included in the model, which provide screening effect along the propagation paths of road traffic noise.

Ground Absorption

Reflection creates extra propagation paths that can result in increased noise level at the receivers. As both the road segments and receivers are located close to the ground, the impact of ground reflection shall be taken into consideration. As the land section of BCIB is located on rural area with majority of lawn area, lawn is assumed to simulate the ground reflection.

Traffic Forecast

The year with the highest traffic flow from the project within the next 15 years upon commencement shall be typically considered as the assessment year. Since the proposed BCIB is planned to commence in 2025, the traffic forecast in 2040 is therefore adopted for this road traffic noise assessment.

For the purpose of comparing with the hourly noise criteria for daytime (07:00 – 22:00) and nighttime (22:00 – 07:00), the average hourly traffic for daytime and nighttime are adopted for the road traffic noise assessment, listed in **Table 2.114** and **Table 2.115**.

Table 2.114 Daytime Average Hourly Traffic Forecast in 2040 (Vehicle/hour)

Road ID	MC	Car	Jeepney	Bus	Truck	Total
B1	303	299	18	39	47	705
B2	78	192	0	4	27	302
B3	289	252	32	38	88	699
B4	92	223	0	4	27	346
C1	358	449	18	41	73	938
C2	11	32	1	4	4	51
C3	24	42	0	2	1	68
C4	370	443	32	39	112	995

Table 2.115 Night-time Average Hourly Traffic Forecast in 2040 (Vehicle/hour)

Road ID	MC	Car	Jeepney	Bus	Truck	Total	
B1	120	127	9	24	39	319	
B2	31	82	0	2	23	138	
B3	114	107	16	24	74	335	
B4	36	95	0	3	23	156	
C1	142	191	9	26	61	428	
C2	4	14	0	2	3	24	
C3	9	18	0	1	1	29	
C4	147	188	16	24	94	468	

For Bataan, the design speed for the free flow slip road of the trumpet interchange is 80km/hr. Only the loop of the trumpet interchange is designed at 60km/hr. For Cavite, the design speed of the mainline is 80km/hr.

Road Surface

The noise emission levels for vehicles database of TNM includes the following pavement types:

- Dense-graded asphaltic concrete (DGAC)
- Portland cement concrete (PCC)
- Open-graded asphaltic concrete (OGAC)
- An “Average” composite pavement type consisting of data for DGAC and PCC combined.

As the design of the pavement is yet to be finalized at the early stage of the study, an “Average” composite pavement type consisting of data for DGAC and PCC combined is assumed.

2.3.3.2 Baseline Environmnetal Conditions

A) Baseline Sampling

The results of the four-time period for NPCC and two-time period for IFC noise monitoring are presented in **Table 2.116**. Most of results from all stations exceeded the NPCC and IFC standards in all time periods.

Table 2.116 Results of Noise Level Measurements

ID Stations	Date	NPCC Standards					IFC Noise Level Guidelines	
		Class/ Category	Morning	Day time	Evening	Night-time	Day time	Night-time
A1	15/02/2020-16/02/2020	A	63	64	63	54	63	56
A2	14/02/2020-15/02/2020	A	57	57	55	49	57	51
A3	13/02/2020-14/02/2020	A	46	49	53	42	50	49
A4	12/02/2020-13/02/2020	A	49	49	47	45	48	47
A5	11/02/2020-12/02/2020	A	53	50	52	54	51	54
A6	09/02/2020-10/02/2020	A	56	55	52	54	54	55
A7	07/02/2020-08/02/2020	A	57	62	63	55	62	56
A8	06/02/2020-07/02/2020	A	50	59	57	53	58	52
A9	05/02/2020-06/02/2020	A	57	55	54	52	55	54
A10	04/02/2020-05/02/2020	A	54	55	51	53	54	53
A11	08/02/2020-09/02/2020	AA	52	56	52	47	54	48

Note: Noise readings in red exceeded the NPCC and IFC Standards.

The 24-hour noise monitoring at location A1, A2, A7, A8, and A11 had median values that exceeded the NPCC standards for all time zones. Apart from the evening results of A3 and all results from A4, all other locations have the majority of its noise levels from different time periods above the allowable standards.

For the IFC Standards, locations A3, A4, A5, A6, A10, and A11, or six out of eleven locations had values lower than the daytime standard. The night-time standard, however, had values exceeding the limit for all locations.

The common contributors of noise in these monitoring stations are vehicles, mainly tricycles, motorcycles, and some heavy trucks, residential noise, weather occurrences, and animal noises, from cows, chicken, dogs, birds, and crickets and insects at night.

It should be noted, however that a power generator for the sampling machines was set up for all stations apart from stations A1, A4, A6, and A11. All generators were placed 20m away from the sampling point except for the set located in station 10, as this is placed 5m away.

B) Background Noise Levels and Noise Criteria

According to Environmental, Health, and Safety Guidelines – General EHS Guidelines: Environmental – Noise Management, noise monitoring may be carried out for the purposes of establishing the existing ambient noise levels in the area of the proposed facility. Eleven background noise monitoring has been conducted in both Bataan and Cavite in February 2020. The monitoring locations A1-A5 all in Bataan while monitoring locations A6-A11 in Cavite.

For the area in Bataan, the noise monitoring station at the Santiago Residence, Mariveles, Bataan (A1) is located close to a typical residential area in the vicinity. Therefore, background noise measurement at A1 is considered representative of NSRs in the northern assessment area at Bataan.

For the area in Cavite, the noise monitoring station at Purok 7, Naic, Cavite (A7) is located close to a typical residential area along an existing road. Therefore, background noise measurement at A7 is considered representative of the southern assessment area at Cavite.

As the background noise measurement levels at both A1 and A7 are higher than the noise criteria of IFC for both daytime and night-time, the background noise measurement levels at A1 and A7 are adopted as the noise criteria. The noise criteria are presented in **Table 2.117** below.

Table 2.117 Noise Criteria for Representative NSRs

Representative NSRs	**Corresponding Noise Monitoring Station**	**Noise Criteria, dB(A)**	
		Daytime	**Night-time**
Representative NSRs in Bataan (the northern assessment area)	A1	67.9	63.2
Representative NSRs in Cavite (the southern assessment area)	A7	67.0	57.5

The TNM model has been set up to represent two scenarios, including the Basecase Scenario for the without mitigation measures, and the Mitigated Scenario for the case with mitigation measures. The predicted road traffic noise levels under Basecase Scenario is presented in **Table 2.118**.

Table 2.118 Predicted Noise Level at Representative NSRs (Basecase Scenario)

NSRs ID	**Predicted Noise Level, dB(A)**		**Compliance [Y/N]**	
	Daytime	**Nighttime**	**Daytime**	**Nighttime**
Bataan (the northern assessment area)				
N101	63.3	47.5	Y	Y
N102	60.0	44.3	Y	Y
N103	63.6	47.9	Y	Y
N104	54.9	39.4	Y	Y
N105	55.8	40.2	Y	Y
N106	51.1	35.5	Y	Y

NSRs ID	Predicted Noise Level, dB(A)		Compliance [Y/N]	
	Daytime	Nighttime	Daytime	Nighttime
N107	48.1	32.4	Y	Y
N108	51.5	35.8	Y	Y
N109	51.2	35.5	Y	Y
N110	49.9	34.1	Y	Y
N111	58.7	43.1	Y	Y
N112	59.5	43.9	Y	Y
N113	60.8	45.0	Y	Y
N114	53.8	37.8	Y	Y
N115	56.2	40.3	Y	Y
N116	53.2	37.1	Y	Y
N117	62.4	46.6	Y	Y
N118	60.3	44.5	Y	Y
N119	59.1	43.2	Y	Y
N120	61.3	45.4	Y	Y
N121	59.5	43.4	Y	Y
N123	54.1	38.1	Y	Y
N124	66.5	50.7	Y	Y
N125	65.0	49.2	Y	Y
N126	67.4	51.6	Y	Y
N127	65.1	49.3	Y	Y
N128	46.1	30.1	Y	Y
N129	42.9	26.9	Y	Y
N130	56.5	40.7	Y	Y
Cavite (the southern assessment area)				
N001	66.6	64.3	Y	N
N002	66.9	64.6	Y	N
N004	67.4	65.0	N	N
N005	59.8	57.4	Y	Y
N006	56.3	53.9	Y	Y
N007	54.3	51.8	Y	Y
N008	55.1	52.7	Y	Y
N009	52.6	50.2	Y	Y
N010	66.1	63.7	Y	N
N011	57.6	55.2	Y	Y
N012	52.8	50.5	Y	Y
N013	59.0	56.3	Y	Y
N014	60.9	58.4	Y	N

NSRs ID	Predicted Noise Level, dB(A)		Compliance [Y/N]	
	Daytime	Nighttime	Daytime	Nighttime
N015	59.8	57.1	Y	Y
N016	61.6	59.1	Y	N
N017	62.8	60.3	Y	N
N018	63.8	61.3	Y	N
N019	65.8	63.3	Y	N
N020	66.2	63.8	Y	N
N021	66.4	64.0	Y	N
N022	64.6	62.2	Y	N
N023	60.4	57.9	Y	N
N024	62.0	59.4	Y	N
N025	65.3	62.6	Y	N
N026	66.2	63.5	Y	N
N027	67.4	64.7	N	N
N028	66.6	64.0	Y	N
N029	66.8	64.1	Y	N
N030	68.7	65.9	N	N
N031	69.0	66.2	N	N
N032	69.5	66.6	N	N
N033	71.6	69.4	N	N
N034	71.2	68.4	N	N
N035	69.8	66.9	N	N
N036	69.2	66.2	N	N
N037	68.0	65.1	N	N
N038	63.3	60.9	Y	N
N039	64.2	61.8	Y	N
N040	55.4	52.9	Y	Y
N041	57.5	55.0	Y	Y
N042	53.2	50.6	Y	Y
N043	54.9	52.4	Y	Y

As shown in **Table 2.118**, some representative NSRs located close to the alignment of the proposed BCIB in the northern assessment area in Bataan comply with the respective criteria and hence mitigation measures are not required.

For the southern assessment area in Cavite however, a number of the NSRs would exceed their respective noise criteria and hence noise mitigation measures are therefore required. The effectiveness of installing noise barriers of different height has been proposed along the alignment in Cavite to protect the NSRs in the vicinity. The extent and height of noise barriers are shown in **Figure 2.238**.

Figure 2.238 Location of Proposed Noise Barriers in Cavite

With the proposed noise barriers, the predicted road traffic noise levels under Mitigated Scenario are presented in **Table 2.119**.

Table 2.119 Predicted Noise Level at Representative NSRs (Mitigated Scenario)

NSRs ID	Predicted Noise Level, dB(A)		Compliance [Y/N]	
	Daytime	Nighttime	Daytime	Nighttime
Cavite (the southern assessment area)				
N001	57.7	55.7	Y	Y
N002	57.8	55.6	Y	Y
N004	58.3	56.5	Y	Y
N005	55.9	54.0	Y	Y
N006	53.8	51.8	Y	Y
N007	51.8	49.6	Y	Y
N008	54.6	52.3	Y	Y
N009	50.9	48.7	Y	Y
N010	56.8	54.8	Y	Y
N011	51.9	50.0	Y	Y
N012	49.0	47.1	Y	Y
N013	53.9	51.7	Y	Y
N014	55.4	53.4	Y	Y
N015	54.3	52.3	Y	Y

NSRs ID	Predicted Noise Level, dB(A)		Compliance [Y/N]	
	Daytime	Nighttime	Daytime	Nighttime
N016	55.7	54.0	Y	Y
N017	56.3	54.5	Y	Y
N018	56.9	54.9	Y	Y
N019	57.9	55.9	Y	Y
N020	57.3	55.3	Y	Y
N021	57.4	55.3	Y	Y
N022	56.5	54.6	Y	Y
N023	54.1	52.3	Y	Y
N024	55.7	53.7	Y	Y
N025	58.4	56.2	Y	Y
N026	58.7	56.6	Y	Y
N027	59.3	57.1	Y	Y
N028	58.3	56.2	Y	Y
N029	58.7	56.5	Y	Y
N030	59.6	57.1	Y	Y
N031	59.7	57.2	Y	Y
N032	59.4	56.8	Y	Y
N033	58.3	55.8	Y	Y
N034	59.0	56.4	Y	Y
N035	59.6	57.0	Y	Y
N036	59.5	56.8	Y	Y
N037	58.2	55.7	Y	Y
N038	55.3	53.3	Y	Y
N039	56.0	54.0	Y	Y
N040	51.6	49.5	Y	Y
N041	53.1	51.0	Y	Y
N042	49.2	46.9	Y	Y
N043	50.9	48.7	Y	Y

It can be seen from **Table 2.119**, with the proposed noise barriers, the predicted noise levels at the representative NSRs would fall within their respective noise criteria. Nevertheless, it should be noted that the proposed noise barriers are based on a number of assumptions including the following:

- The traffic forecast adopted in the assessment is based on the forecast for 2040 (i.e. 15 years after the commissioning of the Project). For a large highway infrastructure as the BCIB, there would be lot of planning initiatives / developments (e.g. LGU planning, infrastructure etc) for the areas in and in the vicinity of both Bataan and Cavite. Any such initiatives / developments that may be further studied or materialised would have significant bearing on the traffic forecast and hence the noise impacts as well.

- As discussed previously, the noise criteria are dependent on the ambient noise levels. However, the existing landuses are rural area mixed with lot of agricultural lands. Hence, the prevailing noise levels measured are relatively low as compared to other more developed areas in the Philippines. As the development of Bataan and Cavite are getting mature in the future especially when the BCIB comes into operation, which would definitely stimulate economic growth, there would inevitably be regeneration in both Bataan and Cavite. As in other cities, such a process would reshape the cities and hence change background noise levels.
- The current study has only considered the ROW that is anticipated at this stage. During the actual construction phase, any need for further temporary construction works areas would be further identified. In case there are residential buildings within these temporary works areas, they would need to be cleared for land resumption. This would also change the landuses immediately next to the alignment after the completion of the project.

In view of the above, the Project Proponent is recommended to consider conducting regular reviews on the need and extent of the proposed noise barriers after the commissioning of the Project. The reviews shall take into account all the latest available information at that time and recommend the next strategy for noise abatement.

2.3.3.3 Potential Impacts and Options for Prevention, Mitigation or Enhancement

A) Potential Impacts

Increase in ambient noise level

Heavy machinery, construction equipment, and transport vehicles are possible sources of noise during the construction phase. Transportation vehicles are the main source of noise during operation phase as cars and trucks will begin their passage through the area. Added noise during the operation will come from heavy machinery when maintenance is needed. The overexposure to the noise may result in nuisances, sleep deprivation, stress, and other physical, physiological, and psychological effects, experienced by nearby residents.

Listed below are some of the anticipated sources of noise during implementation of the project:

- Earth moving and land clearing activities.
- Ingress and egress of vehicles, heavy equipment, and transportation and placement of material.
- Engines from different kinds of vehicles, since the road will be open for public use.
- Other anthropogenic activities.

Potential impact of noise in sensitive receivers

Sensitive receivers are typically defined as schools, hospitals, residential care facilities, or day-care centers, or other facilities that may house individuals with health conditions that would be adversely impacted by changes in the environment. This may include individuals who are disabled, elderly, children, etc. These people experience greater impacts when exposed to the same pollution as compared to the average person. Because of their sensitivity towards pollution, the impacts such as sleep deprivation, stress, and nuisances are still possible, but will most likely be experienced and lower levels of exposure. Over-exposure to noise may lead to a lack of rest, hindering their natural healing systems. This may worsen their conditions and even lead to fatalities of the people in hospitals who are in critical status.

B) Options for Prevention and Mitigation

Increase in ambient noise level

During the construction period, adequate orientation is recommended to discourage construction workers to generate unnecessary noise i.e. shouting or making disturbing noise especially in places near residential areas and schools. In cases of activities and situations where the generation of noise cannot be avoided, noise barriers, fences and warning signs should temporarily be installed at the representative NSRs that would fall within their respective noise criteria.

Regular reviews should be conducted by the proponent on the need and extent of the proposed noise barriers after the commissioning of the Project. The reviews shall take into account all the latest available information at that time and recommend the next strategy for noise abatement.

Workers should be prescribed to wear appropriate personal protective equipment (PPE) to conform to OSH guidelines, if necessary. Since traffic is one of the major sources of noise, the implementation of an efficient Traffic Management Plan within the project area should be established and implemented. This has the objective of ensuring a smooth flow of traffic because this generates less sound compared to stop-and-start flow.

Summary of the prevention and mitigation plans for noise impacts are listed below:

- Proper scheduling and limiting loud activities during construction and maintenance of the road.
- Conduct orientation during construction phase and maintenance to include:
    - Rules regarding noise level to prevent disturbing local communities, giving more importance to areas near sensitive receivers.
- Conduct training during construction phase and maintenance, which includes:
    - Proper and efficient use of equipment during construction and maintenance, minimize the noise.
    - Safety briefing for personal and environmental implications, which includes proper use of personal protective equipment (PPE) for workers based on Occupational Safety and Health Association (OSHA) guidelines.
    - Traffic management guidelines.
- Place fences and warning signs to remind workers of noise guidelines and act as noise barriers.
- Plant trees in-between the roads and the residential areas in order to have a buffer to lessen the noise experienced by the locals.
- Ensure that all machinery used are regularly maintained and properly used in order to avoid noisier sounds from unmaintained machines.
- Regularly monitor the noise during construction and maintenance.
- Strictly implement vehicle speed limits.
- Install mufflers in construction vehicles and heavy equipment.

Potential impact of noise in sensitive receivers

In controlling noise at the receiver's end, several action plans may be taken into account. This includes the scheduling and limiting of loud activities at nearby settlements and institutions. It can also be recommended that insulating noise, use of noise screens, and the control of noise be implemented near the receiver's end.

Continuous monitoring is required to check and plan how to minimize the effect of noise pollution. Increase levels of noise may be due to traffic since it is used as a major thoroughfare in the area.

Mitigation efforts to avoid effects on sensitive receivers must be done properly as impacts are greater during the exposure of these individuals. The following are mitigation efforts specifically for sensitive receivers:

- Install fences and noise barriers near sensitive areas.
- Schedule use of roads passing through these areas, finding alternate routes when the time is too late in the evening or too early in the morning.
- Install larger numbers and more noticeable "No blowing of horn" signs.
- Provide buffer area that will enforse noise mitigating procedures.
- Maintain vehicles and equipment regularly.
- Conduct regular noise monitoring are sensitive receptor areas to prevent effects on human health.
- Prevent workers from loitering in these areas by conducting orientations.

2.4 The People

2.4.1 Methodology

Primary Data

Household survey was conducted in the primary impact areas to gather baseline information and stakeholders' perception of the proposed project.

Secondary Data

Secondary data were gathered from the following sources:

- Comprehensive Land Use Plan of Mariveles, Bataan
- Comprehensive Land Use Plan of Naic, Cavite
- Comprehensive Land Use Plan of Cavite City, Cavite
- 2015 Census of Population from the Philippine Statistics Authority

2.4.1.1 Demographic Data

Among the five provinces comprising Region 4A (CALABARZON), Cavite had the biggest population in 2015 with 3.68 million. As the fastest growing province in terms of population, Cavite recorded an average annual population growth rate (PGR) of 3.37 percent during the period 2010 to 2015. It was also the second most densely populated province of the country with 2,410 persons per square kilometer.

According to the results of the 2015 Census of Population and Housing, Naic had a total population of 111,454 and a household population of 110,970. For the same census year, Cavite City registered a total population of 102,806 and a household population of 102,508. The PSA defines household population as *“the population enumerated in private households during a census.”*

Table 2.120 shows the total population and household population of Naic by age and gender, while

Table 2.121 shows the total population and household population of Cavite City by age and gender.

Table 2.120 Total population and household population by age and gender in Naic

Age Group	Total Population by Age Group, and Sex			Household Population by Age Group, and Sex		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All Ages	111,454	56,160	55,294	110,970	55,799	55,171
Under 1	2,214	1,171	1,043	2,214	1,171	1,043
1 - 4	9,217	4,879	4,338	9,215	4,878	4,337
5 - 9	11,564	6,091	5,473	11,532	6,077	5,455
10 - 14	11,189	5,716	5,473	11,113	5,674	5,439
15 - 19	10,286	5,239	5,047	10,237	5,218	5,019
20 - 24	9,991	5,031	4,960	9,940	4,994	4,946
25 - 29	9,836	4,859	4,977	9,795	4,825	4,970
30 - 34	9,027	4,473	4,554	8,977	4,430	4,547
35 - 39	8,520	4,272	4,248	8,466	4,224	4,242
40 - 44	6,794	3,440	3,354	6,748	3,397	3,351
45 - 49	6,110	3,081	3,029	6,074	3,049	3,025
50 - 54	4,907	2,505	2,402	4,877	2,475	2,402
55 - 59	4,051	1,940	2,111	4,044	1,934	2,110
60 - 64	3,150	1,514	1,636	3,145	1,509	1,636
65 - 69	2,019	923	1,096	2,016	920	1,096
70 - 74	1,107	451	656	1,105	449	656
75 - 79	785	324	461	785	324	461
80 years and over	687	251	436	687	251	436

Source: PSA, 2015.

Based on Naic's total population, there were slightly more males (56,160) than females (55,294). The proportion of the working age population was also greater (65%) than the dependents' (35%). The PSA defines the working age population as those 15-64 years old at a specified time while dependents would be those below 15 years and over 64 years.

Table 2.121 Total population and household population by age and gender in Naic

Age Group	Total Population by Age Group, and Sex			Household Population by Age Group, and Sex		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All Ages	102,806	51,232	51,574	102,508	51,012	51,496
Under 1	1,653	864	789	1,652	863	789
1 - 4	7,289	3,758	3,531	7,286	3,755	3,531
5 - 9	9,393	4,880	4,513	9,392	4,880	4,512
10 - 14	9,631	5,047	4,584	9,628	5,045	4,583
15 - 19	9,996	5,046	4,950	9,960	5,026	4,934
20 - 24	9,269	4,685	4,584	9,213	4,650	4,563
25 - 29	8,540	4,290	4,250	8,501	4,259	4,242
30 - 34	7,765	3,842	3,923	7,713	3,801	3,912
35 - 39	7,379	3,741	3,638	7,336	3,712	3,624
40 - 44	6,243	3,110	3,133	6,221	3,090	3,131
45 - 49	6,189	3,037	3,152	6,173	3,022	3,151
50 - 54	5,391	2,675	2,716	5,377	2,663	2,714
55 - 59	4,436	2,194	2,242	4,429	2,187	2,242
60 - 64	3,484	1,629	1,855	3,481	1,627	1,854
65 - 69	2,688	1,191	1,497	2,686	1,189	1,497
70 - 74	1,341	550	791	1,341	550	791
75 - 79	1,078	390	688	1,078	390	688
80 years and over	1041	303	738	1041	303	738

Source: PSA, 2015.

In Cavite City, the situation is reversed as there were slightly more females (51,574) than males (51,232) from the total population. The dependents were almost half (34,114) of the total number (68,692) of 15 to 64-year olds.

Literacy for household population 10 years old and over was slightly higher among females (44,079) than males (43,436) in Naic. In Cavite City, there were 42,548 literate females compared to 41,395 literate males.

For the same census year, Bataan registered a total population of 760,650, one of the lowest among the seven provinces in Region 3 (Central Luzon), but recorded the second highest average annual population growth rate during the period 2010 to 2015 at 1.94%.

Among the 11 municipalities and one city that make up the province of Bataan, Mariveles recorded the highest total population at 127,536. Its household population stood at 125,027 for the same census year.

Table 2.122 shows the total population and household population of Mariveles by age and gender.

Table 2.122 Total population and household population by age and gender in Mariveles

Age Group	Total Population by Age Group, and Sex			Household Population by Age Group, and Sex		
	Both Sexes	Male	Female	Both Sexes	Male	Female
All Ages	127,536	64,277	63,259	125,027	62,233	62,794
Under 1	2,335	1,236	1,099	2,334	1,235	1,099
1 - 4	9,430	4,914	4,516	9,426	4,914	4,512
5 - 9	11,977	6,161	5,816	11,959	6,155	5,804
10 - 14	12,146	6,248	5,898	12,089	6,221	5,868
15 - 19	13,835	7,355	6,480	12,869	6,471	6,398
20 - 24	13,389	6,928	6,461	12,820	6,417	6,403
25 - 29	11,529	5,827	5,702	11,317	5,661	5,656
30 - 34	10,282	5,185	5,097	10,111	5,064	5,047
35 - 39	9,897	4,925	4,972	9,758	4,833	4,925
40 - 44	7,633	3,792	3,841	7,520	3,728	3,792
45 - 49	6,875	3,419	3,456	6,799	3,370	3,429
50 - 54	5,834	2,769	3,065	5,765	2,725	3,040
55 - 59	4,866	2,202	2,664	4,807	2,165	2,642
60 - 64	3,356	1,587	1,769	3,333	1,571	1,762
65 - 69	2,031	933	1,098	2,010	915	1,095
70 - 74	934	390	544	927	384	543
75 - 79	647	238	409	645	237	408
80 years and over	540	168	372	538	167	371

Source: PSA, 2015.

There were slightly more males (64,277) than females (63,259) from the total population. The dependents were almost half (40,040) of the total number (87,496) of 15 to 64-year olds.

Literacy for household population 10 years old and over was slightly higher among females (51,228) than males (49,732).

Poverty and Food Poverty Indices

Poverty incidence among families in Cavite was estimated at 6.0 percent in the first semester of 2018. This translates to six out of 100 families that did not have sufficient income to meet their basic food and non-food needs in the first half of 2018. This was estimated at 9.7 percent in the same period in 2015.

Poverty incidence among individuals was estimated at 7.9 percent, which means that eight out of 100 Caviteños did not have sufficient income to meet their basic food and non-food needs in the first half of 2018. During the same period in 2015, the poverty incidence among individuals in Cavite was estimated at 13.0 percent.

Poverty data for Mariveles based on the 2014 community-based monitoring system (CBMS), indicated that there were 7,495 households with income below the poverty threshold, 5,902 households with income below the food threshold, 42 households who experienced food shortage, and 2,078 unemployed members of the labor force.

2.4.1.2 Potential Impacts and Options for Prevention and Mitigation and/or Enhancement

A) Potential Impacts

Among the project's potential impacts on demographics include the displacement of some families and individuals along the project alignment. Influx of workers and other individuals seeking to benefit from the potential economic gains from the project are also expected.

B) Options for Prevention and Mitigation

Locals will be prioritized in hiring for the project.

Concerned LGUs may also check their respective policies when it comes to business registration to ensure that businesses and establishments are compliant with relevant national and local policies. These include regulations on sanitation, structure (building), and employees.

2.4.2 Basic Services / Public Resources

2.4.2.1 Baseline Information

A) Water Supply

The Naic Water Supply Company, a private corporation, supplies domestic water in the poblacion and selected adjacent barangays. The rest of the households in Naic consisting of the majority of population rely on privately or communally operated shallow and deep wells.

Water distribution in the Municipality of Mariveles is primarily administered by the Mariveles Water District (MARIWAD), which serves 14 out of Mariveles' 18 barangays, namely: Balon Anito, San Isidro, Ipag, Poblacion, San Carlos, Camaya, Baseco, Sisiman, Alas-asin, Mt. View, Cabcaben, Townsite, Lucanin, and Alion (Mariveles CLUP, 2017-2026). For the Bataan Export Processing Zone (BEPZ), currently known as the AFAB, it has its own water dam, water treatment plant (WTP), and water distribution system to serve its locators and residents. The SALINTUBIG Program 2013 of the DILG, in the meantime, implemented several water supply and distribution projects in the poor and waterless communities in Mariveles.

B) Power Supply

Naic's electric power is being supplied by the Manila Electric Company (MERALCO). It is being augmented by a power sub-station intended for Naic residents but located at adjacent Trece Martires City.

Electric power in Mariveles is provided by the Peninsula Electric Cooperative, Inc. (PENELCO), which distributes electricity to 11 other municipalities in Bataan Province.

PENELCO gets its bulk supply from the state-owned National Power Corporation (NPC). Transmission lines that bring power to the municipality are operated and maintained by the National Grid Corporation of the Philippines (NGCP).

C) Communications

The Philippine Long Distance Telephone Company (PLDT), Globe Telecom, and Digital Telecommunication Philippines (DIGITEL) provide landline connection in Naic. Mobile connection is Smart, Mobiline, Globe, and Extelcom.

According to Mariveles' Updated CLUP (2017-2026), results of the 2014 CBMS survey revealed that 7,722 households in Mariveles owned cellphone devices, while only 257 remain connected to telephone lines. There were 1,694 households with internet connections. Of the 18 barangays, Barangay Camaya had the most number of households connected to communication devices, mainly by mobile phones, followed closely by Barangay Alas-asin, then by Barangay Ipag. All barangays, except Barangay Biaan, have telephone lines. The CLUP found no available data regarding the type of communication system dominant in AFAB, especially with its locators.

D) Transportation

According to data from Naic's CLUP (2011-2020), there is a total of 3,040 registered tricycles, 384 units of jeepneys, 260 units of minibuses, 100++ units of FX Vans, 69 units of MAZDA, and 125 units of aircon buses. Small boats, medium-built boats, and municipal fishing vessels also serve Naic's transport needs. Boats ply between Naic and the neighboring towns of Tanza, Rosario, Cavite City, and other coastal towns of Cavite and Manila. Landing terminals could be found at barangays Balsahan and Bucana Sasahan along the Balsahan River and other coastal barangays.

Tricycles dominate the public transportation mode in Mariveles. According to Mariveles' Updated CLUP (2017-2026), data from 2011 to 2014 indicate that tricycles comprise 89 percent of the total public transportation vehicles, generally serving local trips within the municipal center area and nearby barangays. It further says that as of 2014, there are close to 4,650 motorized tricycles operating in Mariveles, which has grown increasingly for the past 4 years. Public utility jeepneys (PUJ) comprise 6%, or 300 units, of the total public transport vehicles in 2014. The number of registered jeepneys increased from 2011 to 2013 but remained constant in 2013 through 2014. Buses follow at 5%, or 240, of the total public transport vehicles in 2014, serving long-distance inter-regional and intra-regional transport. Air-conditioned buses from Metro Manila regularly travel to Mariveles (and vice-versa), as well Baguio City. There are currently two (2) private bus companies operating in Bataan, both providing trips to and from Metro Manila. Genesis Transport Service provides a one-way trip to Baguio City. Minibuses provide inter-provincial trips between the Municipality of Mariveles and the provincial capital of Balanga. There are currently 149 units of minibuses that take two round trips between these two LGUs.

E) Peace and Order / Crime

Peace and order in Naic is being maintained by the Naic PNP Force with a total of 44 personnel, based on data from Naic's CLUP (2011-2020). It is assisted by more than 300 barangay tanods, different NGOs, the Traffic Management Unit of the LGU, and the Local Disaster Risk Reduction Management Council. The Naic PNP uses two (2) service vehicles, a detention cell at the Naic PNP Building at Ibayo Silangan and a sub-station located at the Poblacion. The highest proportion of crimes recorded in 2011 involved physical injuries. There were no recorded activities of any kind which could be attributed to organized groups (CPP/NDF/NPA) and there were also no indication of infiltrated nor influenced barangay.

Mariveles PNP is composed of 42 personnel serving 125,167 persons in 2014 for a police-population ratio of 1:2,980, or almost 1:3,000. This is below the ideal 1:500 police-population ratio. Most index crimes recorded by the Mariveles PNP in 2015 involved physical injuries followed by theft. Most crimes recorded by the PNP at the Mariveles Police Station in 2015 were cleared and solved, giving the Mariveles PNP a crime solution efficiency of 82%.

2.4.2.2 Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

A) Potential Impacts

Competition for basic utilities and services are to be expected as the local population increases due to the influx of workers and other individuals seeking to benefit from the expected expansion of the local economy.

The water and power needs of the project may also impact on the local supply of the host LGUs.

B) Options for Prevention and Mitigation

Aside from prioritizing locals in hiring for the project, the contractor can also set up facilities that would look after some of the basic needs of its employees, such as a clinic and housing for migrant employees.

The contractor should also look into the project requirements and activities and ensure that local supply will be sufficient and that project activities will not cause unnecessary disruptions to local services.

2.4.3 Health and Safety

2.4.3.1 Baseline Information

A) Public Health and Safety

Peace and order in Naic is maintained by the Naic PNP Force with a total of 44 personnel, based on data from Naic's CLUP (2011-2020). It is assisted by more than 300 barangay tanods, different NGOs, the Traffic Management Unit of the LGU, and the Local Disaster Risk Reduction Management Council. The Naic PNP uses two (2) service vehicles, a detention cell at the Naic PNP Building at Ibayo Silangan and a sub-station located at the Poblacion. The highest proportion of crimes recorded in 2011 involved physical injuries. There were no recorded activities of any kind which could be attributed to organized groups (CPP/NDF/NPA) and there were also no indication of infiltrated nor influenced barangay.

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B) Public Services

The standard public services provided by local government units in the country are present in the project areas. Social welfare services are available for vulnerable sectors, there are public schools for elementary and high school, and health services are provided through municipal and barangay health centers.

C) Environmental Health and Sanitation

The Naic Water Supply Company, a private corporation, supplies domestic water in the poblacion and selected adjacent barangays. The rest of the households in Naic consisting of the majority of population rely on privately or communally operated shallow and deep wells.

Water distribution in the Municipality of Mariveles is primarily administered by the Mariveles Water District (MARIWAD), which serves 14 out of Mariveles' 18 barangays, namely: Balon Anito, San Isidro, Ipag, Poblacion, San Carlos, Camaya, Baseco, Sisiman, Alas-asin, Mt. View, Cabcaben, Townsite, Lucanin, and Alion (Mariveles CLUP, 2017-2026). For the Bataan Export Processing Zone (BEPZ), currently known as the AFAB, it has its own water dam, water treatment plant (WTP), and water distribution system to serve its locators and residents. The SALINTUBIG Program 2013 of the DILG, in the meantime, implemented several water supply and distribution projects in the poor and waterless communities in Mariveles.

2.4.3.2 Potential Impacts and Options for Prevention, Mitigation and/or Enhancement

A) Potential Impacts

The influx of migrants during the construction phase of the project may cause temporary strain to the host LGUs. There may be competition for resources, services, and commodities, and communities may be at increased risk of exposure to diseases and outbreaks.

B) Options for Prevention and Mitigation

Potential impacts may be lessened, if not prevented, with better preparation from both the host LGUs' and contractor's end.

The host LGUs may undertake the necessary preparations of its frontline departments in anticipation of the influx of migrants during the project's construction stage. The contractor, for its part, may note the number of workers it will be hiring from outside the host LGUs and consider the establishment of basic facilities within the construction camp to prevent competition between the migrant workers and local residents. These facilities may include health clinics and temporary housing. The contractor may also provide prior orientation to its workers on health and safety, including the observance of sanitary practices.

2.4.4 Income and Employment

2.4.4.1 Baseline Information

A) Main Sources of Income and Livelihood

Farming, fishing, and livestock are the major economic activities in Naic. About 60% (5,194.23 ha) of its total land area is devoted to rice and various crops. Residents also engage in backyard livestock and poultry production. Piggeries and cattle breeding stations could be found in the barangays of Sabang and Palangue 2 & 3. Being a coastal municipality also means that fishing is another major source of livelihood of the people in the municipality. Naic has three (3) fish landing areas and as of 2011, there is a total of 1,696 fishermen. Aside from deep sea fishing, fishpond operations are another source of fish and fishery products. According to its CLUP 2011-2020, Naic has seventeen (17) fishpond locations occupying a total area of 9.49 hectares. The same document also indicates that there are 704 fishing bancas in the municipality, with 553 (78.55%) motorized and 151 (21.44%) non-motorized.

Table 2.123 shows the area, location, and production of fishing grounds in Naic.

Table 2.123 Area, location, and production of fishing grounds in Naic

LOCATION	**AREA IN HECTARES**		**VOLUME OF CATCH**					
	TILAPIA	**BANGUS**	**Average (kls)**		**Total**		**Value (P/)**	
			TILAPIA	**BANGUS**	**TILAPIA**	**BANGUS**	**TILAPIA**	**BANGUS**
Bucana Sasahan	1.5		1.39		0.277		9730	
Calubcob	0.05		89		0.089		6230	
Halang	0.3		248		0.248		17360	
Ibayo Silangan	0.07		102		0.102		7140	
Labac	2.15	0.3	75	204	0.972	0.408	5250	18360
Latoria	0.1		42		0.084		2940	
Mabolo	1.65	1	128	31	1.2744	0.062	8960	2790
Malainen Bago	1.05		44		0.922		3080	
Malainen Luma	0.1		155		0.31		10850	
Molino	0.3		7		0.037		490	
Muzon	0.62		153		1.53		10710	
Palangue Central	0.2		72		0.287		5040	
Palangue 2/3	0.3		90		0.447		6300	
Sabang	0.3		90		0.448		6300	
San Roque	0.05		32		0.032		2240	
Sapa	0.2		75		0.225		5250	
Tim Balsahan	0.55	2.5	83	406	0.165	0.812	5810	36540
	9.49	3.8						

Source: Naic's CLUP 2011-2020.

In Cavite City, industries are classified into four, namely: shipyard, furniture, garments, and construction materials. Cavite City used to be well-known in manufacturing export quality rattan furniture, which gradually vanished after the global recession. The city's garment industry has survived though its market has been limited to local customers who preferred customized clothes.

In Mariveles, the local economic sector is made up of three (3) important categories of economic activities, which are clustered into primary, secondary, and tertiary sectors. The primary sector, made up of agriculture and fishing, encompasses activities that involve the utilization, production, and processing of raw materials into primary goods and basic food. The secondary sector covers the manufacturing and processing of raw materials and inputs generated from the primary sector. The tertiary sector refers to industries that are engaged in manufacturing activities, which consume massive quantities of energy.

B) Employment profile

Based on 2010 data, Naic's economically active (labor force) comprised 66.96% of the total population of 15 years old and above. Out of this, 45.44% are employed while 4.78% are "unemployed." **Table 2.124** shows the number of employed and unemployed household population 15 years old and over in Naic in 2010.

Table 2.124 Household population 15 year old and over, employed and unemployed, Naic, 2010

AGE GROUP	IN THE LABOR FORCE					NOT IN THE LABOR FORCE	%
	HOUSEHOLD POPULATION	(ECONOMICALLY ACTIVE)					
		EMPLOYED	%	UNEMPLOYED	%		
Both Sexes	**59,023**	**26,819**	**45.44**	**2,822**	**4.78**	**29,382**	**49.78**
15-19	8831	1,361	2.31	408	0.69	7,062	11.96
20-24	8387	3,189	5.40	805	1.36	4,393	7.44
25-29	7984	3,911	6.63	569	0.96	3,504	5.94
30-34	6764	3,978	6.74	282	0.48	2,504	4.24
35-39	6222	3,854	6.53	152	0.26	2,216	3.75
40-44	5033	3,354	5.68	167	0.28	1,512	2.56
45-49	4213	2,482	4.21	47	0.08	1,684	2.85
50-54	3785	2,106	3.57	178	0.30	1,501	2.54
55-59	2719	1,508	2.55	70	0.12	1,141	1.93
60-64	1786	781	1.32	33	0.06	972	1.65
65-69	1250	493	0.84	48	0.08	709	1.20
70-74	914	292	0.49	0	0	622	1.05
75-79	565	131	0.22	0	0	434	0.74
80 & over	570	42	0.07	0	0	528	0.89

Source: Naic's CLUP 2011-2020.

Many skilled workers are assumed to be located in Cavite City, as evidenced by the number of registered tailoring and dressmaking shops. There are also plenty of bakers, electrical workers, mechanic, machine sheet metal workers, and carpenters in the city and a few who are handicraft artists whose specialties are precision equipment repair, jewelry making, embroidery, and shoemaking. A small number possess expertise in boat building. Majority of the labor force consists of semi-skilled and unskilled workers. Most are employed either in service industries locally, in Metro-Manila, or in neighboring cities and municipalities (Cavite City CLUP).

In 2010, the labor force, or working population, in the city totaled to 64,484, which was 63.76% of the total population. The Public Employment Services Office, at the time, registered a total of 2,500 job applicants, representing only 3.87% of the working population. The data, however, did not signify the total number of unemployed individuals in the city.

2.4.4.2 Local Benefits of the Project

From the pre-construction up to the construction stages, the project is expected to result to an increase in business and other income generating opportunities. It may lead to more investors coming to the host LGUs. The increase in demand for supplies and services may also lead entrepreneurial individuals and groups to maximize this opportunity. The expansion of the local economy will open doors for greater participation and inclusion. More micro and small entrepreneurs may be able to take part in the local economic activities that the project may present.

During the construction stage, the project may also provide temporary employment to locals. It also presents an additional income source for the host LGUs for the taxes and other permits that the project will require.

2.4.5 Perception Survey and Public Participation Activities

Household Survey

Survey among households was conducted on both sides of the proposed bridge. From the total of 107 respondents, 29 (27%) are from Naic. More than half (57%) are from Mariveles.

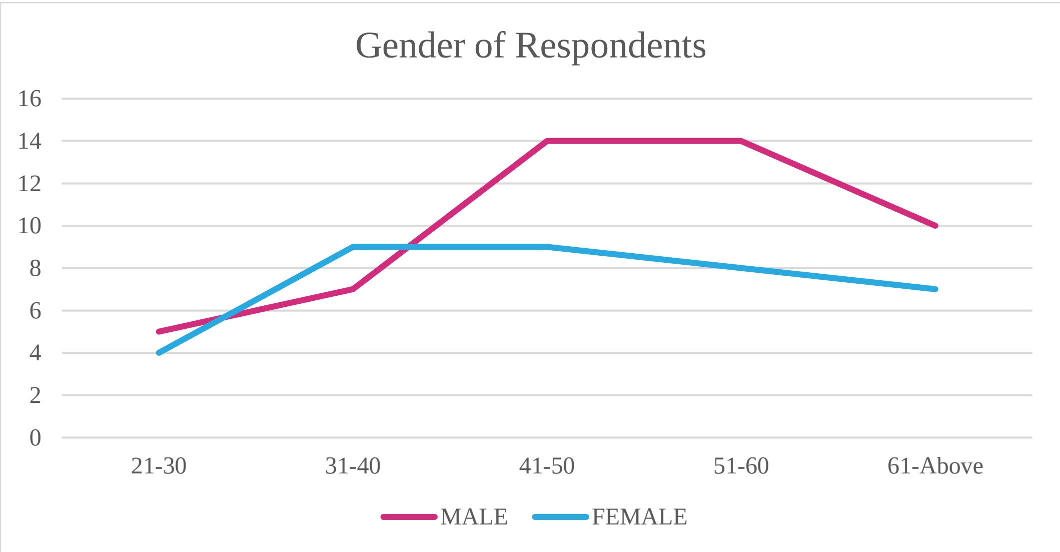

Figure 2.239 Gender of household respondents

More than half (57%) of the respondents are male, with mmore than half of them between 41 to 60 years old (28% are age 41-50 and 28% are 51-60).

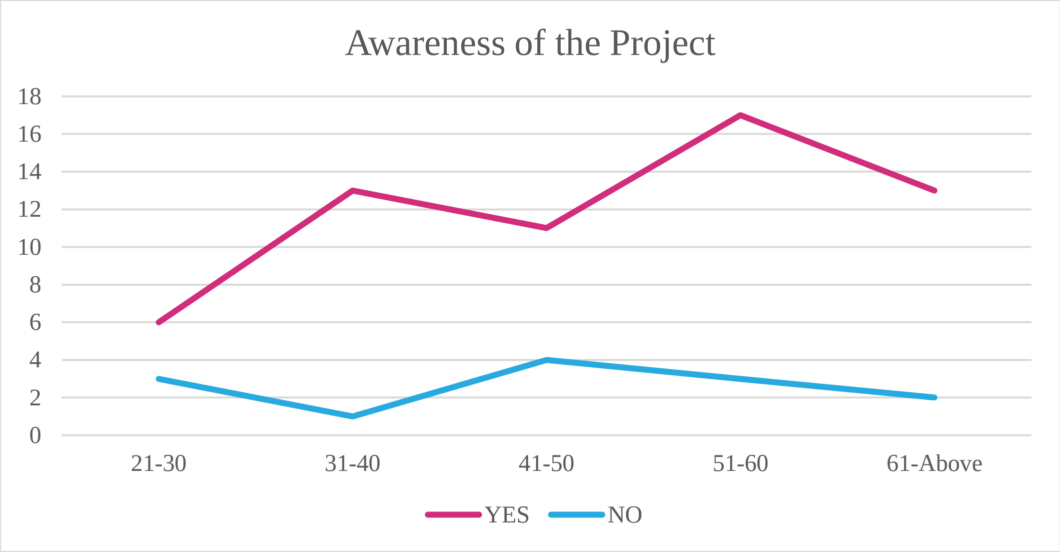

Figure 2.240 Awareness of the project among household respondents

Most (82%) of the respondents said they are aware of the project. Almost a third (28%) of those who said they are aware of the project are between 51-60 years old.

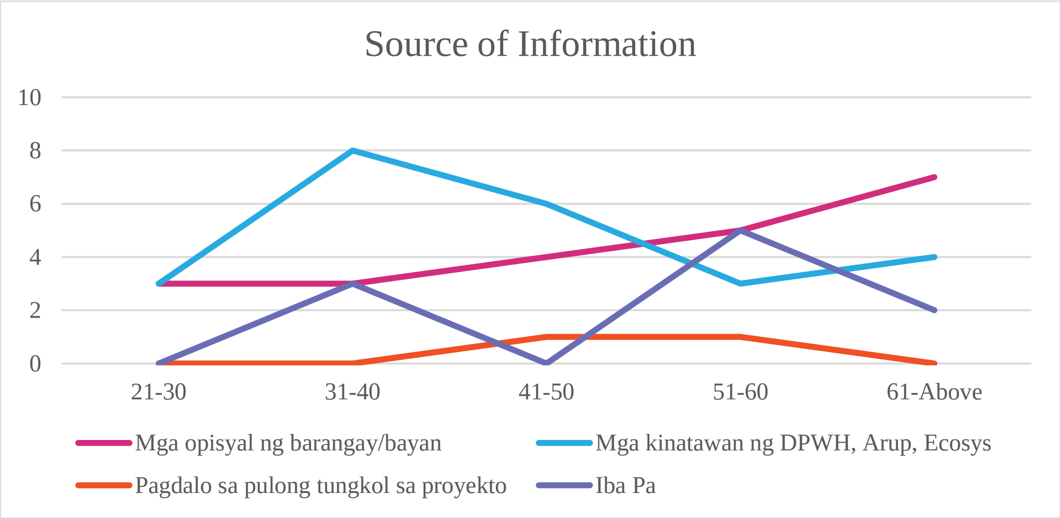

Figure 2.241 Source of information among household respondents

Almost half (41%) of the respondents learned about the project from representatives of DPWH/ARUP/ECOSYS, closely followed by those who got informed through local government officials (38%).

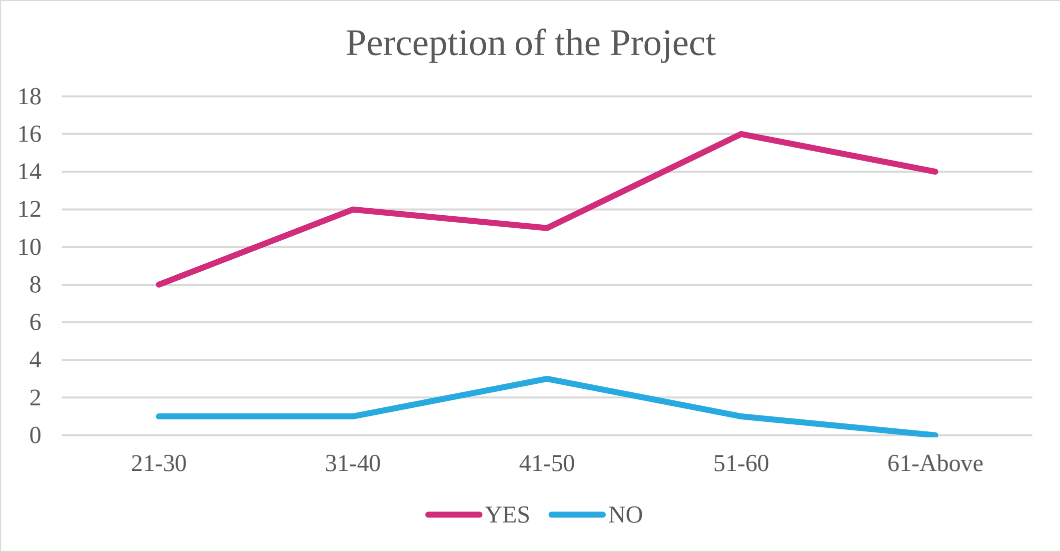

Figure 2.242 Perception of the project among household respondents

Most (70%) of the respondents also believe that the project will be beneficial to them and tp their community. Almost half (49%) of those who believe that the project will be beneficial belong to the 51-60 (26%) and 61 and above (23%) age range.

Survey Among fisherfolks

Survey was also conducted among fisherfolks from both sides of the proposed bridge.

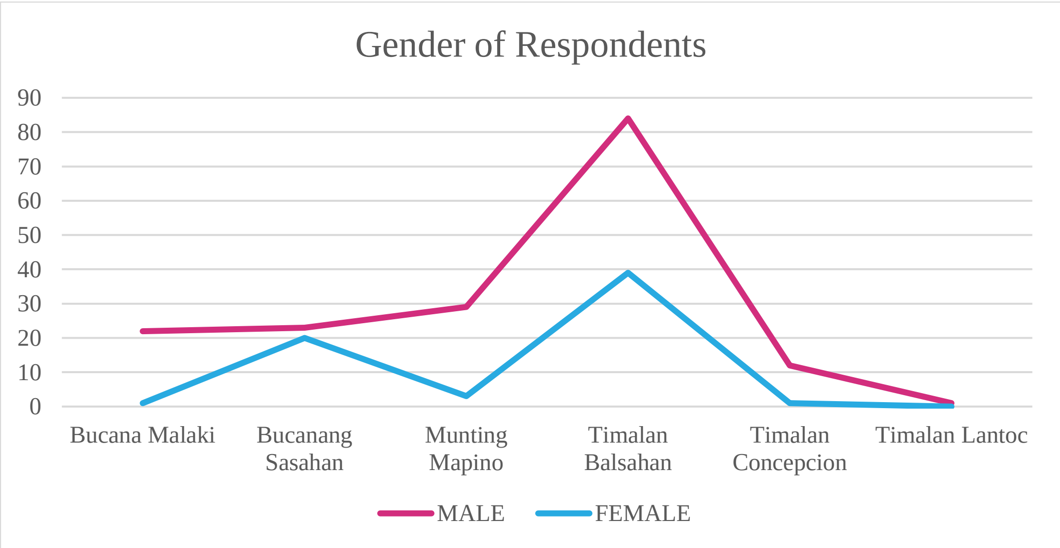

Figure 2.243 Age and gender of respondents in Naic, Cavite

In Naic, a total of 256 fisherfolks participated in the survey. Of this, 73 percent are male and 49 percent of them are from Barangay Timalan Balsahan. There are also respondents from Barangay Bucana Malaki, Bucanang Sasahan, Munting Mapino, Timalan Concepcion, and Timalan Lantoc.

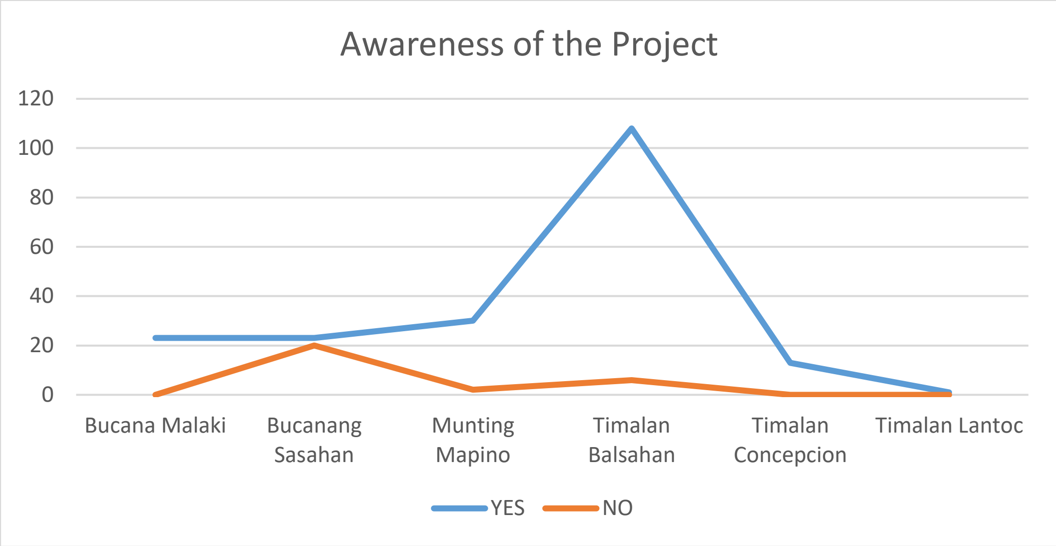

Figure 2.244 Awareness of the project among respondents in Naic, Cavite

Most (84%) of the respondents said they are aware of the project. Most (50%) of the respondents who said they are aware of the project are from Barangay Timalan Balsahan.

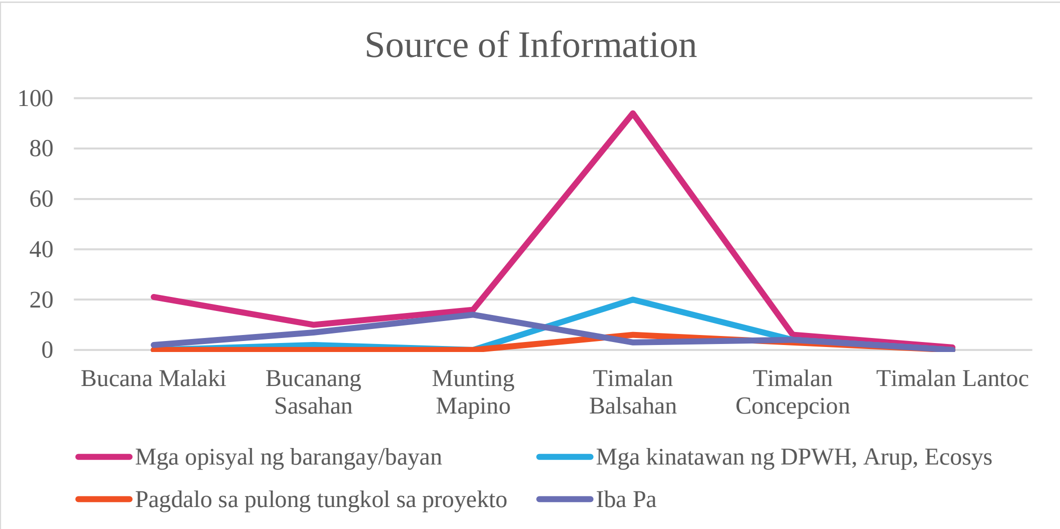

Figure 2.245 Source of information of respondents in Naic, Cavite

Majority (60%) of the respondents tagged local government officials as their main source of information.

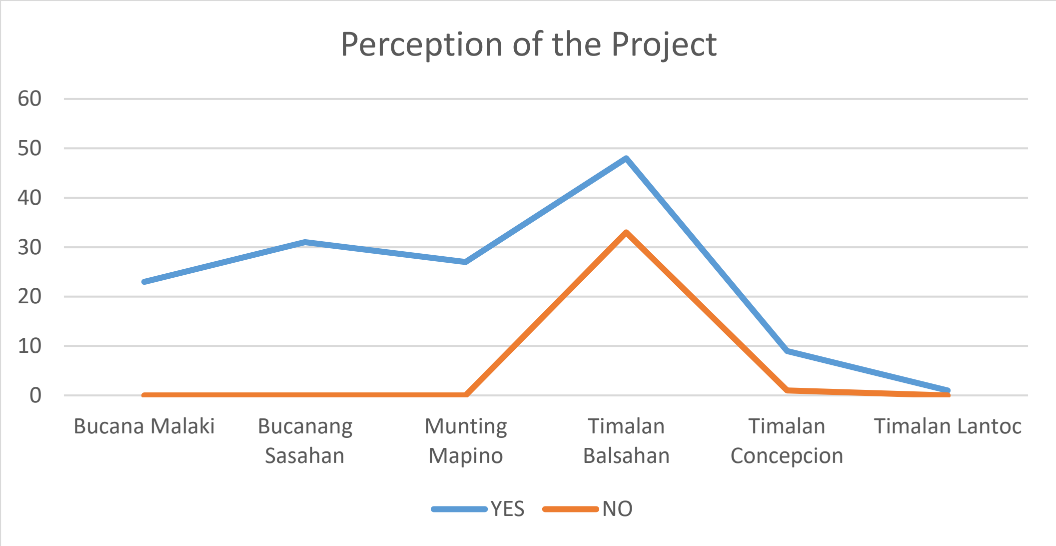

Figure 2.246 Perception of the project of respondents in Naic, Cavite

More than half (59%) of the respondents said they believe that the project will be beneficial to them.

In Mariveles, a total of 383 fisherfolks were surveyed. Respondents came from the affected barangays of Alas asin and Mt. View as well as from Cabcaben, Lucanin, Poblacion, and Town Site.

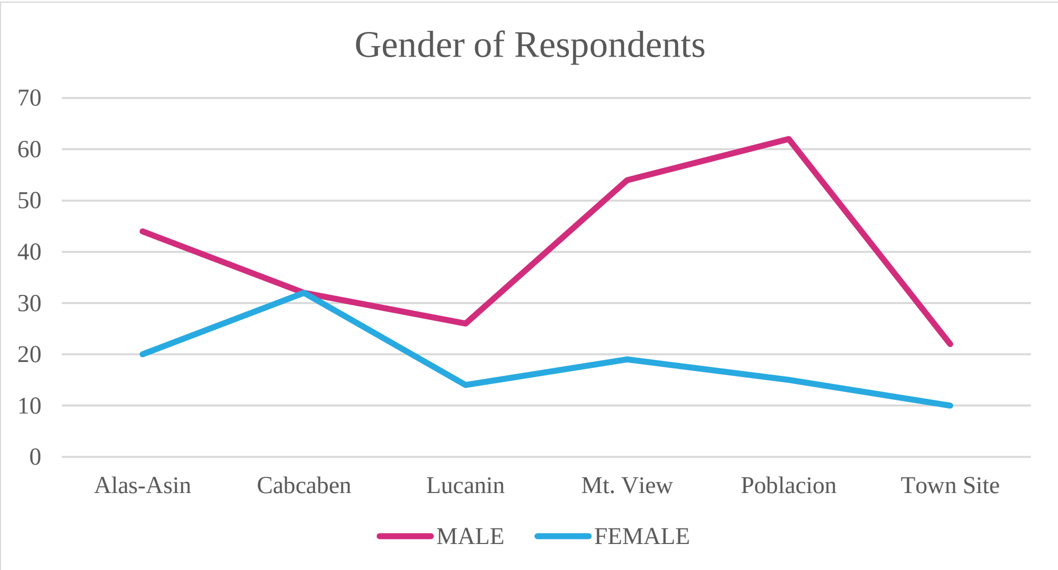

Figure 2.247 Gender of respondents in Mariveles, Bataan

Males comprise 69 percent of the respondents. The most numbers (26%) of male respondents are from Barangay Poblacion.

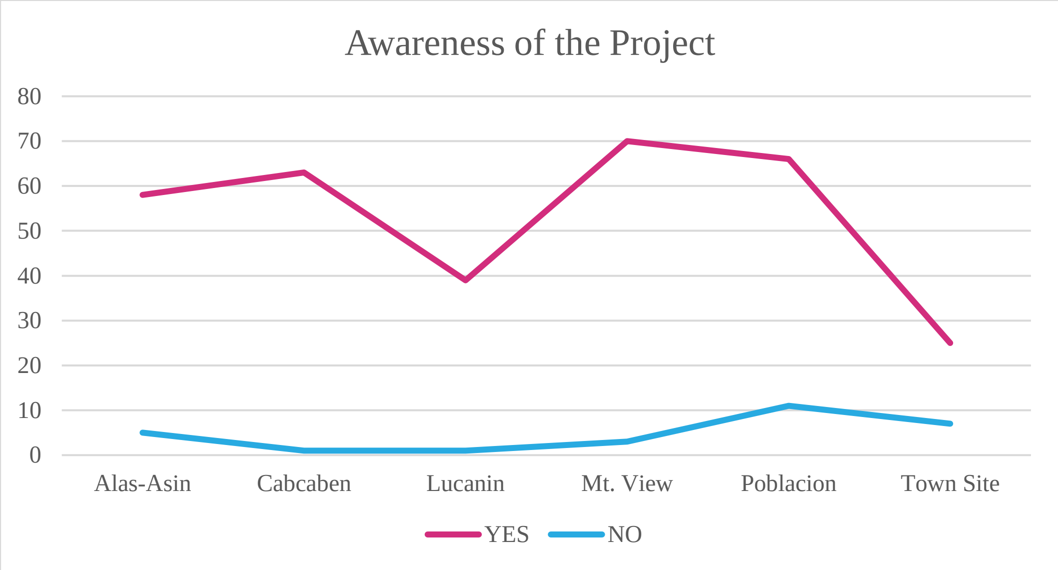

Figure 2.248 Awareness of the project among respondents in Mariveles, Bataan

Most (92%) of the respondents said they are aware of the project, with the biggest proportion coming from Barangay Mt. View (20%).

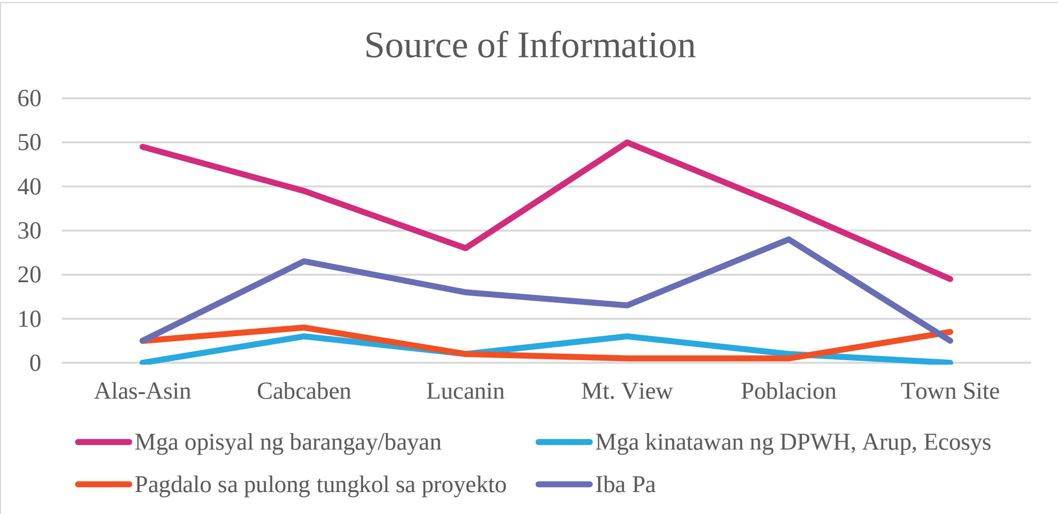

Figure 2.249 Source of information of respondents in Mariveles, Bataan

Majority (60%) of the respondents said they got their information from local government officials. Only seven percent said they received information from attending meetings.

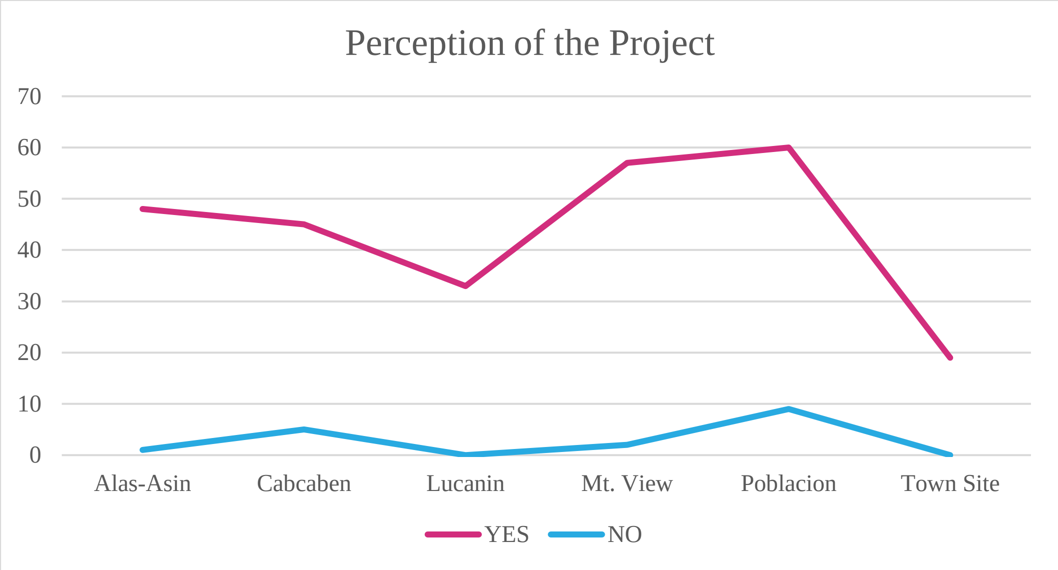

Figure 2.250 Perception of the project of respondents in Mariveles, Bataan

Most of the respondents (75%) believe that the project will be beneficial to them and to their community. The biggest proportion (22%) of those who answered yes are from Barangay Poblacion, followed by 20% from Barangay Mt. View.

Public Participation Activities

Consistent with the Guidelines on Public Participation under the Philippine Environmental Impact Statement System (PEISS) of DAO 2017-15, stakeholder's consultation has been continuously conducted for the BCIB Project. Information and Education Campaigns (IEC) were completed in Barangay Timalan Conception, Sabang and 53B in Naic and Cavite on 21 January 2020 and Barangay Mt. View and Alas-Asin in Mariveles on 22 January 2020. The complete Public Participation Reports are attached in **Annex C**.

Public scoping is not held due to the restrictions of the COVID-19 pandemic. DPWH sent a letter to EMB requesting for an advice for the conduct of Public Scoping and should EMB agree to waive this activity and resume the moment its safe to conduct public gatherings (**Annex D**). EMB advised to temporary hold the activity due to the restrictions of the current health situation and proceed with the preparation of this EIS Report. Hence this report initially contains the summary of IEC and FGD issues and concerns and their corresponding measures conducted before the start of the Enhanced Community Quarantine (ECQ).

Table 2.125 Summary of Issues and Corresponding Measures

Issues Raised	Proposed Measures
Municipality of Mariveles	
Accuracy of the project maps shown and the barangays that will be affected	• Project disclosure through IEC
Impact of the project on fisherfolk	• Conduct IEC and FGD with affected boat owners/fisherfolks • (Details of compensation included in RAP)
Identification of those who will be resettled	• Included in RAP
Resettlement plans for those who will need to be relocated and the accompanying compensation scheme	• Included in RAP
Installation of toll fees on the proposed bridge	• Project disclosure through IEC
Impact on Bataan's security (public safety) concerns given the accessibility that the bridge will provide and the lack of toll gates on the bridge	• Project disclosure through IEC

Issues Raised	Proposed Measures
Brgy. Alas-asin, Mariveles	
Project alignment	• Project disclosure through IEC
Pollution resulting from the project	• Adoption of commensurate measures to minimize pollution incidence • Regular monitoring of air and water quality
Installation of toll gates	• Project disclosure through IEC
Brgy. Mt. View, Mariveles	
Exit to Corregidor Island	• Project disclosure through IEC
Traffic congestion	• Provide traffic aides to make sure smooth flow of traffic to and from project site; • Request assistance from LGUs to minimize delays in vehicular traffic; • Install signage in the entrance to the • project site and around 100 meters on both sides of the road to alert motor vehicles of possible ingress and egress of site vehicles and delivery trucks • Continuous coordination with the LGUs and affected barangays • Implementation of traffic management plan
Fishing activities near the bridge	• Continuous coordination with the LGUs and affected barangays • Conduct of IEC with affected fisherfolks
Allowing fishermen to use the bridge when their boats break down	• Continuous coordination with the LGUs and affected barangays • Conduct of IEC with affected fisherfolks
Right-of-way of fisherfolks vis-à-vis the bridge	• Discussions on displacement are included in RAP
Municipality of Naic	
Accuracy of the project maps shown and the barangays that will be affected	• Project disclosure through IEC
Impact of the project on fisherfolk	• Conduct of IEC with affected fisherfolks • Provision of compensation for PAPs • (Further discussions on displacement and compensation are included in RAP)
Identification of those who will be resettled	• Discussions on displacement are included in RAP
Resettlement plans for those who will need to be relocated and the accompanying compensation scheme	• Discussions on displacement and compensation are included in RAP.
Brgy. Timalan Concepcion, Naic	
Displacement of fisherfolks	• Discussions on displacement are included in RAP
Project impacts to nearby elementary school	• Conduct of baseline environmental sampling and analysis • Stakeholder mapping • (Discussion on asset inventory is included in RAP)
Safety of students during construction	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents

Issues Raised	Proposed Measures
	• Regularly monitor presence/absence of complaints from PAPs • Immediate action on stakeholder complaints through the implementation of GRM.
Participation of all affected parties	• Public scoping will be conducted where all potential project-affected persons (PAPs) will be invited.
Allowed vehicles on the bridge	• Project disclosure through IEC
Priority hiring of locals	• Existing guidelines on priority hiring for qualified residents shall be followed. Adequate public information for jobs available to local residents in the affected areas will be posted in the Barangay. The project will comply with the conditions and requirements of the Labor Code of the Philippines.
Brgy. Sabang, Naic	
Identification of PAPs and compensation	• Discussions on displacement and compensation are included in RAP.
Noise and air pollution as well as the people that will be affected by the project once the construction starts	• Conduct of noise and air quality sampling prior, during, and after the project has been constructed. • Regular monitoring of air quality and noise levels during construction.
Valuation of land to be acquired	• Included in separate activity on RAP.
Hiring of workforce/laborers.	• Existing guidelines on priority hiring for qualified residents shall be followed. Adequate public information for jobs available to local residents in the affected areas will be posted in the Barangay. The project will comply with the conditions and requirements of the Labor Code of the Philippines.
Cavite City	
Number of posts that will be erected on Corregidor Island	• Project disclosure through IEC
Clarification on the optional ramp leading to the Island; CPDO clarified that the latest information on the airstrip in the Island is that it will be maintained for its historical value but will not be operational	• Project disclosure through IEC
Project's alignment with the Sangley viaduct leading to Cavitex	• Project disclosure through IEC
Clarification on whether the alignment will directly lead to Cavite City	• Project disclosure through IEC
Clarification on whether the alignment will be connected to Calax	• Project disclosure through IEC
Timeline for commencing the project	• Project disclosure through IEC • Close coordination with LGU on project activities
Naic, Cavite	
Inclusion of vulnerability assessment of coastal erosion in Naic and indicate the Manila Bay source and sink	• Conduct of marine survey
Project disclosure	• Conduct of IEC
Mariveles, Bataan	

Issues Raised	Proposed Measures
Schedule and other logistical details of marine sampling	• Close coordination with LGU on project activities
Presence of artificial reefs near the pier in Brgy. Alas-asin	• Conduct of marine survey
Support to affected fisherfolks	• Conduct of IEC with affected fisherfolks • Provision of compensation for PAPs • (Further discussions on displacement and compensation are included in RAP)
Compensation for PAPs	• Discussions on compensation for PAPs are included in RAP
Conduct of public consultations	• Conduct of IEC and public consultations
Traffic congestion	• Provide traffic aides to make sure smooth flow of traffic to and from project site; • Request assistance from LGUs to minimize delays in vehicular traffic; • Install signage in the entrance to the • project site and around 100 meters on both sides of the road to alert motor vehicles of possible ingress and egress of site vehicles and delivery trucks • Continuous coordination with the LGUs and affected barangays • Implementation of traffic management plan
Awarding of supplemental projects to Mariveles as well as to other surrounding municipalities.	• No mitigating measures needed.

2.4.6 Traffic

A) Methodology

The JICA transport model developed using the STRADA software was referred to in the traffic study. The model adopts the conventional 4-stage modelling approach, including Trip Generation, Trip Distribution, Modal Split, and Trip Assignment. Only the Trip Assignment Model was converted to the CUBE platform (a commercial modelling software). The CUBE model was obtained from DOTr for this study. The CUBE Trip Assignment Model could show changes in route choice of each origin-destination trip pair if a new infrastructure is incorporated into the transport network. Daily traffic flow on the road network and travel speed of each road link in the model network could also be generated. CUBE Model elements are summarised in the table below.

Table 2.126 Trip Assignment CUBE Model Elements

Element \ Year	2014	2020	2025	2035
Bare Network	X		X	X
Loaded Network	X	X[5]		
Daily Demand Matrices		X	X	X
Daily Assignment Matrices	X	X		

Note:

1. Bare network means pure model network without traffic assignment result
2. Loaded network means the model network with traffic assignment results
3. Daily demand matrices are person trip matrices by walk, private, public, truck, and other modes. These are not matrices for transport model assignment
4. Daily assignment matrices are person trip matrices by motorcycle, private car, jeepney, bus, and truck. These are matrices for transport model assignment

5. Based on the assignment of the 2020 daily assignment matrices onto the 2025 bare network. There is no bare network for 2020

Model limitations and input assumptions adopted into the transport model are discussed in detail in **Annex K.** In general, the model was adjusted to account for:

- City/municipality population changes at night-time and day-time
- Planned road infrastructure projects determined by the model, updated to include missing information: (i) NLEX-SLEX Connector Road; (ii) NLEX Harbour Link (Segment 8.2); (iii) Cavite-Tagaytay-Batangas Expressway; (iv) Tarlac-Pangasinan-La Union Expressway; (v) Molino Link; (vi) Calamba-Los Banos-Bay Bypass Road; and (vii) Connections between BCIB and CALAX
- Toll assumptions
- Value of time (VOT), based on the JICA Model, projected to account for GDP per capita (used for Base Case); and DPWH VOT and a derived VOT based on a recently endorsed study (used for Test Cases).

Table 2.127 Value of Time of Different Sources (PHP/min/person in 2014 price)

Source	JICA Model (GDP/capita adjusted)		DPWH		SIDC Project	
Vehicle Type \ Year	2025	2035	2025	2035	2025	2035
Motorcycle	8.8	12.4	2.7	3.8	4.3	6.1
Private Car	8.8	12.4	10.7	15.1	3.0	4.2
Jeepney	8.8	12.4	2.7	3.8	3.0	4.2
Bus	6.3	8.9	2.7	3.8	3.0	4.2
Truck	6.3	8.9	2.7	3.8	3.0	4.2

- Passenger car unit (PCU) and occupancy by vehicle classes

Table 2.128 PCU Factor and Occupancy

Vehicle Type	PCU Factor[A]	Occupancy[B]
Motorcycle	0.75	1.20
Private Car	1.0	1.58
Jeepney	1.5	8.8
Bus	2.0	34.19
Truck	2.5	2.17

[A] Based on DPWH typical classifications, except for motorcycles, which are adjusted referencing international practice, such as Hong Kong's Transport Planning and Design Manual
[B] Based on JICA's traffic count and occupancy survey

- Design speed and capacity of road links based on the JICA CUBE Model

Table 2.129 Design Speed and Capacity by Road Type

Area	Road Category	Carriageway Type	Capacity 1-Way (pcu/day/lane)	Maximum Speed (km/h)
Inside EDSA	Local Road	Single	2,200	30
	Secondary	Single	4,400	40
	Primary	Single	6,600	45
	Secondary	Single	7,700	50

Outside EDSA, Inside Metro Manila	Primary	Single	8,250	60
	Secondary	Divided	14,000	70
	Primary	Divided	16,500	80
Outside Metro Manila	Local Road	Single	8,000	30
	Secondary	Single	11,000	55
	Primary	Single	15,400	60
Urban / Intercity	Access/Egress	Single	15,000	80
	Expressway	Single	17,000	80
	Expressway	Divided	20,000	100

- Speed-flow relationship based on CUBE model, which assumes a constant relationship and that as roads reach their maximum capacity, speed is at 0.2 km/h.

The model was validated based on the 2014 traffic count by JICA and further revalidated based on latest traffic count survey data conducted under this project.

A 24-hour vehicle classified count survey along key roads and junctions in Bataan and Cavite was conducted by the Transport and Traffic Planners Inc (TTPI). Survey locations are provided in **Table 2.130**. Other traffic survey details are provided in **Annex K.**

Table 2.130 Survey Sites

Screenline code	ID	Location
W-W	W1	Aguinaldo St
	W2	Roman Superhighway
	W3	National Road
X-X	X1	Olangapo-Bugallow Road
	X2	SCTEX
	X3	Angeles-Porac-Floridablanca-Dinalupihan Road
	X4	Jose Abad Santos Ave, Dinalupihan
Y-Y	Y1	Magalang-Arayat Road
	Y2	Jose Abad Santos, Mexico, Pampanga
	Y3	Radial Road 8, San Fernando Pampanga (NLEX)
	Y4	McArthur Highway, San Matias, Santo Tomas, Pampanga
Z-Z	Z1	Calatagan Highway, Lian, Batangas
	Z2	Palico-Balayan, Batangas Road
	Z3	Diokno Highway, Lemetry Batangas
Key Roads	P1	McArthur Highway, Bamban Central Luzon
	P2	North Luzon Highway, Mabalacat, Central Luzon (SCTEX)
	P3	Magalang Concepcion Road, Concepcion
	P4	Antero Soriano Highway, Naic
	P5	Emilio Aguinaldo Highway, Dasmarinas
	P6	Governor’s Drive, Carmona
	P7	9094 Governor’s Drive, Carmona
	P8	E3 near Binakayan Kawit Toll Plaza (CAVITEX)
	P9	Tirona Highway, Bacoor
	P10	Emilio Aguinaldo Highway Bacoor
	P11	Alabang Zapote Road, Las Pinas

2.4.6.2 Traffic Model Trip Assignment Matrix

The trip matrix is a key component of the traffic forecast on the road network as it presents the number of trips between one zone to another zone, which would find the most suitable route from origin zone to destination zone in the trip assignment process. The assignment of trips of every origin-destination zone pair would form the total traffic on each major corridor. The sector (zone) definition is illustrated in the figure below.

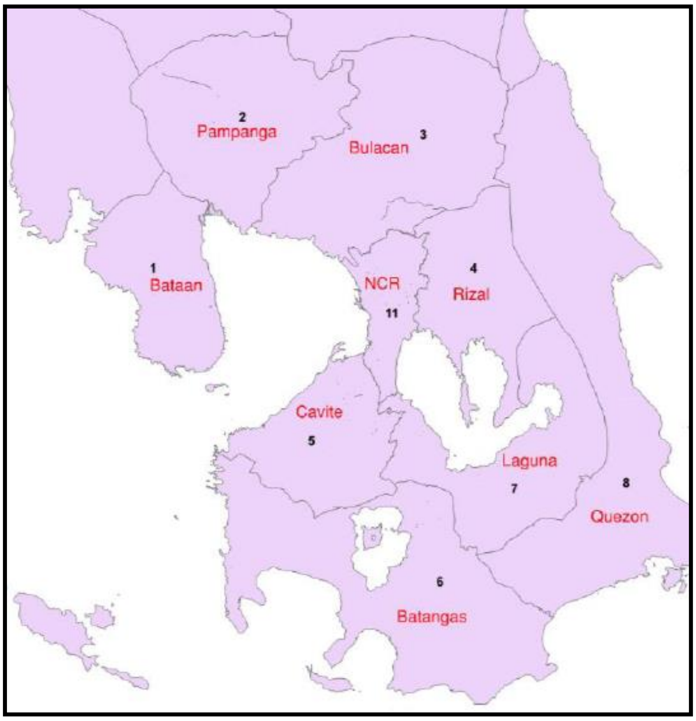

Figure 251 Sector Definition of Trip Matrix

The CUBE Model only provides daily demand matrices for years 2020, 2025, and 2035 and daily trip assignment matrices for 2014 and 2020. Conversion factors were derived from the CUBE 2020 demand and assignment matrices and applied to CUBE demand matrices of 2025 and 2035 to develop 2025 and 2035 daily assignment matrices. PSA population projection data was also used to estimate total province trip ends and supplement missing trip data in the daily assignment matrices. The table below shows the updated 2020 assignment matrix.

Table 2.131 Updated Total Daily Sector-Sector Person Trips (‘000) for 2020 Assignment Matrix

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	596	66	35	9	4	0	0	0	14	**723**
2: Pampanga	66	2,014	133	44	15	0	0	0	57	**2,330**
3: Bulacan	35	128	2,677	11	7	0	9	73	363	**3,302**
4: Rizal	9	44	11	1,835	7	37	58	64	425	**2,490**
5: Cavite	4	15	4	5	2,682	145	62	0	346	**3,264**
6: Batangas	0	0	0	37	145	2,084	192	43	38	**2,539**
7: Laguna	0	0	9	58	65	177	3,004	134	165	**3,612**
8: Quezon	0	0	73	64	0	43	131	1,740	21	**2,072**
11: NCR	13	56	337	411	365	56	151	29	12,588	**14,005**

Sector	1	2	3	4	5	6	7	8	11	Total
Total	**723**	**2,323**	**3,279**	**2,474**	**3,290**	**2,543**	**3,606**	**2,083**	**14,015**	**34,338**

Note:

1. Sector-sector trip numbered zero in orange box is absolute zero, while for sector-sector trip numbered zero in white box is a number rounded to zero
2. Figures in red represent self-containment (intra-sector) trips.

Assumptions, detailed methodology, and resulting developed CUBE 2025 and 2035 initial trip assignment matrices are provided in **Annex K**.

As the transport model is only an Assignment Model, the model was revalidated mainly to adjust trip matrices to match with traffic survey count data. In addition, truck trips have been derived from the validated 2019 truck matrix based on GDP growth. The adjustments made to the trip matrices were carried forward to the CUBE 2025 and 2035 initial trip matrices.

Table 2.132 Total Daily Sector-Sector Person Trips (‘000) for 2025 Assignment Matrix (without BCIB)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	601	23	13	2	1	0	0	0	8	**648**
2: Pampanga	22	2,034	77	15	3	0	0	0	20	**2,171**
3: Bulacan	12	75	2,808	10	6	0	4	39	399	**3,354**
4: Rizal	2	15	14	1,963	7	8	45	76	535	**2,664**
5: Cavite	1	3	7	3	2,905	51	104	0	460	**3,535**
6: Batangas	0	0	0	8	51	2,128	177	49	9	**2,422**
7: Laguna	0	0	3	43	120	171	3,815	157	138	**4,448**
8: Quezon	0	0	40	76	0	44	175	1,780	14	**2,129**
11: NCR	8	21	390	546	431	13	140	18	12,375	**13,942**
Total	**646**	**2,323**	**3,352**	**2,666**	**3,524**	**2,416**	**4,460**	**2,119**	**13,959**	**35,314**

Note:

1. Figures in red represent self-containment (intra-sector) trips.

Table 2.133 Total Daily Sector-Sector Person Trips (‘000) for 2035 Assignment Matrix (without BCIB)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	652	47	26	5	2	0	0	0	13	**746**
2: Pampanga	46	2,214	123	31	9	0	0	0	38	**2,461**
3: Bulacan	25	119	3,247	15	13	0	6	68	560	**4,054**
4: Rizal	6	32	19	2,274	11	22	60	101	665	**3,190**
5: Cavite	3	9	10	6	3,430	112	127	0	649	**4,344**
6: Batangas	0	0	0	22	112	2,343	233	66	16	**2,791**
7: Laguna	0	0	6	58	145	227	4,287	202	167	**5,093**
8: Quezon	0	0	69	101	0	61	220	1,970	20	**2,443**
11: NCR	13	39	538	692	641	20	167	26	12,977	**15,112**
Total	**744**	**2,460**	**4,038**	**3,205**	**4,362**	**2,786**	**5,100**	**2,434**	**15,105**	**40,233**

Note:

1. Figures in red represent self-containment (intra-sector) trips.

With BCIB incorporated into the CUBE transport network, travel cost for some origin-destination pairs, especially Bataan and Cavite, would change. Trip distribution pattern changes were based on derived trip distribution curves applied to the trip assignment matrices in **Table 2.132** and **Table 2.133** through a matrix balancing process. New developments in the Freeport Area of Bataan (FAB) were considered for scenarios with BCIB in place, including: a proposed international container port terminal with an annual capacity of 950,000 TEUs; and the FAB Commercial Strip, with five floors of office and commercial space and six floors of dormitel, with 6,000 sq.m. per floor. The 2025 and 2035 daily person trip assignment matrices revised for scenarios with BCIB and incorporating new development traffic are provided in the tables below.

Table 2.134 Total Daily Sector-Sector Person Trips ('000) for 2025 Assignment Matrix (with BCIB)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	601	9	8	2	16	0	0	0	20	656
2: Pampanga	9	2,034	82	16	6	0	0	0	25	2,171
3: Bulacan	7	79	2,808	10	7	0	4	39	398	3,352
4: Rizal	2	17	14	1,963	6	7	45	76	533	2,662
5: Cavite	15	6	7	3	2,905	51	104	0	447	3,537
6: Batangas	0	0	0	7	51	2,128	177	48	10	2,421
7: Laguna	0	0	3	43	119	171	3,815	157	138	4,447
8: Quezon	0	0	40	75	0	44	174	1,780	14	2,128
11: NCR	19	26	389	544	416	14	139	18	12,375	13,940
Total	653	2,171	3,351	2,664	3,525	2,415	4,458	2,118	13,959	35,315

Note:

1. Figures in red represent self-containment (intra-sector) trips.

Table 2.135 Total Daily Sector-Sector Person Trips ('000) for 2035 Assignment Matrix (with BCIB)

Sector	1	2	3	4	5	6	7	8	11	Total
1: Bataan	652	25	22	5	21	0	0	0	29	754
2: Pampanga	25	2,214	117	38	16	0	0	0	51	2,460
3: Bulacan	24	121	3,247	15	10	2	6	68	559	4,052
4: Rizal	5	38	19	2,274	12	14	60	101	664	3,188
5: Cavite	17	15	19	5	3,430	112	126	0	619	4,343
6: Batangas	0	0	1	16	112	2,343	232	66	21	2,790
7: Laguna	0	0	6	58	145	227	4,287	202	167	5,091
8: Quezon	0	0	69	101	0	61	220	1,970	20	2,442
11: NCR	27	48	537	690	617	26	167	26	12,977	15,113
Total	751	2,459	4,037	3,203	4,362	2,785	5,098	2,433	15,107	40,234

Note:

1. Figures in red represent self-containment (intra-sector) trips.

2.4.6.3 Traffic Forecast and Impact Assessments

Person trips were converted into vehicle trips expressed in PCUs, referenced in **Table 2.128**. Volume-to-capacity (V/C) ratios, indicating the proportion of road capacity used by peak hour traffic volume (in PCU) were further determined to assess the current performance of the road network and to determine the level of improvements needed to accommodate future travel. Road capacity is defined by road type, road width, and roadside friction, referenced from **Table**

2.129. Any road performance at or above 1.2 V/C is considered unacceptable. The peak hour traffic flow and V/C ratio under Base Case is provided in the table below.

Table 2.136 Peak Hour Performance (Base Case)

Year	Direction	Capacity (PCU/hr)	Traffic Flow (PCU/hr)	V/C Ratio
2025 AM	Eastbound	4,000	1,140	0.3
	Westbound	4,000	1,290	0.3
2025 PM	Eastbound	4,000	1,050	0.3
	Westbound	4,000	920	0.2
2035 AM	Eastbound	4,000	1,980	0.5
	Westbound	4,000	2,090	0.5
2035 PM	Eastbound	4,000	1,640	0.4
	Westbound	4,000	1,420	0.4

BCIB will operate satisfactorily within its capacity in 2025 and 2035. The most critical V/C ratio will be about 0.5 in 2035 AM peak hour, given 2 traffic lanes per direction.

Daily and peak hour traffic comparisons of "without project" and "with project" scenarios at screenline level for 2025 and 2035, are respectively provided in **Table 2.137** and **Table 2.138**.

Table 2.137 Screenline Traffic Change between "without project" and "with project" scenarios in 2025

Screenline	Direction	Capacity (PCU/hr)	Traffic Flow (PCU/hr)	V/C Ratio
Daily				
W-W	Southbound	26,900	31,900	1.2
	Northbound	26,400	31,000	1.2
X-X	Southbound	51,000	51,200	1.0
	Northbound	50,500	50,700	1.0
Y-Y	Southbound/ Westbound	95,100	93,100	1.0
	Northbound/ Eastbound	100,300	98,300	1.0
Z-Z	Southbound	18,700	18,800	1.0
	Northbound	18,900	19,300	1.0
AM Peak				
W-W	Southbound	2,060	2,430	1.2
	Northbound	1,920	2,430	1.3
X-X	Southbound	2,980	2,870	1.0
	Northbound	3,550	3,610	1.0
Y-Y	Southbound/ Westbound	5,110	5,110	1.0
	Northbound/ Eastbound	5,670	5,550	1.0
Z-Z	Southbound	1,220	1,220	1.0
	Northbound	1,290	1,290	1.0
PM Peak				
W-W	Southbound	1,780	2,190	1.2
	Northbound	1,840	2,200	1.2
X-X	Southbound	3,550	3,660	1.0
	Northbound	2,730	2,780	1.0
Y-Y	Southbound/ Westbound	5,800	5,750	1.0

Screenline	Direction	Capacity (PCU/hr)	Traffic Flow (PCU/hr)	V/C Ratio
	Northbound/ Eastbound	5,270	5,240	1.0
Z-Z	Southbound	1,160	1,160	1.0
	Northbound	1,150	1,150	1.0

Note:
Daily traffic flow is rounded to the nearest hundred for presentation
Peak hour traffic flow is rounded to nearest ten for presentation

Table 2.138 Screenline Traffic Change between "without project" and "with project" scenarios in 2035

Screenline	Direction	Capacity (PCU/hr)	Traffic Flow (PCU/hr)	V/C Ratio
Daily				
W-W	Southbound	37,700	49,100	1.3
	Northbound	36,100	46,100	1.3
X-X	Southbound	78,300	82,300	1.1
	Northbound	77,100	80,000	1.0
Y-Y	Southbound/ Westbound	121,900	121,700	1.0
	Northbound/ Eastbound	125,200	125,800	1.0
Z-Z	Southbound	31,700	31,800	1.0
	Northbound	31,400	31,600	1.0
AM Peak				
W-W	Southbound	3,100	4,110	1.3
	Northbound	2,810	3,890	1.4
X-X	Southbound	5,410	5,690	1.1
	Northbound	5,880	6,220	1.1
Y-Y	Southbound/ Westbound	8,940	9,090	1.0
	Northbound/ Eastbound	9,550	9,720	1.0
Z-Z	Southbound	2,580	2,580	1.0
	Northbound	2,560	2,580	1.0
PM Peak				
W-W	Southbound	2,540	3,430	1.4
	Northbound	2,530	3,290	1.3
X-X	Southbound	5,280	5,660	1.1
	Northbound	4,480	4,770	1.1
Y-Y	Southbound/ Westbound	8,100	8,330	1.0
	Northbound/ Eastbound	7,710	7,790	1.0
Z-Z	Southbound	2,080	2,070	1.0
	Northbound	1,980	2,000	1.0

Note:
Daily traffic flow is rounded to the nearest hundred for presentation
Peak hour traffic flow is rounded to nearest ten for presentation

For daily traffic, screenline W-W will increase by about 20% and 30% in 2025 and 2035, respectively, indicating a considerable amount of traffic in Northern Bataan would cross the screenline to the southern part for access to BCIB. Screenline X-X will have similar traffic between "with project" and "without project" case in 2025, through traffic will increase by about 10% in 2035 under "with project' case. Traffic increase will be from outside Bataan to use BCIB. Screenline Z-Z will have similar traffic between "with project" and "without project" case in both 2025 and 2035. Peak hour traffic shows similar trends with daily traffic when comparing "without project" and "with project" scenarios.

Overall, the result indicates that BCIB implementation will not sigificantly affect traffic pattern in the model area.

With more traffic loaded on the road network, the following are key findings in terms of road network performance:

- Without the project case, Road R301 on the Bataan side will be within a V/C ratio of 1.0 in 2025 and 2035. Road R-1 on the Cavite side will be in within a V/C ratio of 1.0 in 2025 and 2035, with some localized sections over 1.2. Road R-1 V/C ratio was assumed to only have 1 effective traffic lane based on site observations and considering roadside friction. With the BCIB connection, Road R301 (Bataan Provincial Highway) and Road R-1 in Cavite should have 2 traffic lanes by direction to cater to traffic.
- In 2025 AM under "with project" scenario, key roads in Bataan and Cavite will generally operate under V/C ratio of 0.7. Road R-1 will reduce its V/C ratio from over 1.2 in "without the project" case to below 1.0 under "with project" case if 2 traffic lanes are implemented.
- In 2035 AM under "with project" scenario, key roads in Bataan and Cavite will generally operate with a V/C ratio below 1.0, indicating manageable traffic. However, with 2 traffic lanes at Road R-1, a short section at the BCIB landing point will still operate at V/C ratio of over 1.2, indicating considerable congestion. Road R301 in Bataan will experience a V/C ratio less than 1.2, indicating traffic delays.
- Comparing "with project" case and "without project" case, V/C ratio is similar in Cavite and therefore, project does not cause more traffic congestion. Further road improvement measures however, in both Cavite and Bataan are necessary with or without the project.

Assumptions, detailed methodology and results are provided and discussed in detail in **Annex K**.

2.4.6.4 Travel Time Savings

The transport model is capable of estimating zone-to-zone travel time and travel distance along the assigned path of each origin-destination movement in the validated assignment matrix. Network daily person time savings from the transport model are shown below.

Table 2.139 Estimated Time Savings with BCIB (daily person minutes, 000s)

Year	Total	MC	Car	Jeepney	Bus	Truck
2025	9,500	500	1,700	2,900	4,200	200
2035	13,900	1,700	2,600	4,300	4,900	400

The results estimate that with BCIB in place, the proposed scheme will generate a total daily passenger time saving of 9.5 million person-minutes and 13.9 million person-minutes in 2025 and 2035, respectively.

Setting aside considerable journey time savings between Cavite and Bataan due to BCIB, the transport model shows that in 2025, average journey time per car trip between various sectors and Bataan is expected to reduce by 14% (equivalent to a 6-minute reduction per car) with the implementation of BCIB. By 2035, average journey time saved increases sligthly to 7 minutes per car trip to Bataan.

Traffic congestion cost during construction was found to be negligible as majority of the bridge will be constructed over water and on land where there are no existing roads. Construction material will also be transported mainly by sea transport.

Detailed methodology, assumptions, and monetization of benefits are discussed in detail in **Annex K.**

3 Environmental Management Plan

The summary of potential environmental impacts and proposed mitigation measures with details on duration, institutional responsibilities, cost estimates, and financial arrangements during the project's pre-construction, construction, operation, and demobilization phases are presented in **Table 3.1.**

Table 3.1 Environmental Management Plan for BCIB Project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
Pre-Construction						
A1. Preparation of the project site for construction	People	Issues and concerns of the stakeholders will be identified	• Undertake consultation meetings with stakeholders including IEC, FGD and other consultation meetings	DPWH LGU	P200,000	Pre-operational expenses
		Public resistance on development	• Conduct FGD and consultation meetings with LGU, directly affected people, and key stakeholders	DPWH LGU	P150,000	Pre-operational expenses
	Terrestrial Ecology	Cutting down of trees along the road right-of-way Displacement of animals, insects and avifauna	• Identification of site for replacement tree planting • Compliance with conditions of DENR/LGU, Tree Cutting Permit, ROW • Provide temporary fencing to vegetation that will be retained • Delineation on the ground of the areas to be cleared should be implemented to avoid and minimize unnecessary clearing.	DPWH LGU DENR		Pre-operational expenses
	Water Quality	Inconsistency on DENR and LGU's current mandate to rehabilitate and improve the water quality of Manila Bay	• Integrate the Manila Bay Rehabilitation plan in the project • Regular coordination with LGUs, DENR and Manila Bay Coordinating Office (MBCO) • Regular water quality monitoring	DPWH LGU DENR		Pre-operational expenses
A2. Procurement and planning	Economy	Increase business opportunities due to purchase of construction materials	• Purchase from local suppliers whenever possible • Secure services of residents whenever possible	DPWH		Pre-operational expenses

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
A3. Land acquisition and resettlement	People	Loss of land within the project affected area; Displacement of residents and structures in the project site and within its vicinity	• Implementation of the approved Resettlement Action Plan (RAP) of the Project • Provide relocation / compensation to affected landowners, households, and owners of other establishments • Regularly monitor of presence/absence of complaints from PAPs. • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism (GRM)	DPWH LGU		Pre-operational expenses
A4. Acquisition of applicable permits and licenses	People/ Terrestrial Ecology	Disclosure of project components and activities Cutting down of trees along the road right-of-way	• Submission of complete project requirements and processing of all permits • Identification of site for replacement tree planting	DPWH LGU		Pre-operational expenses
Construction						
B1. Erection of temporary facilities for workers and field office, storage sheds, and workshops	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Implement appropriate operating hours • Provide noise barriers, such as site fencing, during the construction stage • Properly operate and maintain all noise sources	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site • Use covered vehicles to deliver materials that may generate dust	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Regular monitoring of the concentrations of PM2.5, PM10, TSP, SO_2 and NO_2 shall be done to ensure that the levels of these pollutants will still be within the NAAQS. • Workers will be provided with the appropriate PPEs and will practice standard occupational health and safety pursuant to BWC-DOLE Occupational Safety and Health Standards			
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
	Water Quality	Degradation of water quality due to generation of domestic wastewater	• Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to ensure continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • Locate motor-pool area at least 500 meters away from any body of water;	DPWH DENR LGU	Part of development cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• The contractor will be required to comply with the Civil Works Guidelines; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment.			
	Community health and safety	Increased risks to community due to increase in vehicular movement Disturbance to nearby residents and resort operators	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents • Regularly monitor of presence/absence of complaints from PAPs • Immediate action on the stakeholder complaints through the implementation of GRM	DPWH LGU	Part of develop ment cost	Incorporated part of the project
		Possible spread of diseases due to workers' unsanitary practices	• Observe proper sanitation practices in the construction area and workers' barracks to avoid generation and spread of diseases. • Regular conduct of health and safety awareness to all construction employees.			
	Solid waste	Generation of solid waste from construction activities	• Implement solid waste management plan • Proper waste management and housekeeping measure	DPWH LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; and • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.			
		Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility.	• Implement an organized waste storage, collection, and management system; • Proper waste management and housekeeping measures can also prevent possible contamination in soil and water in compliance with RA 6969; • Used oil, spillages and other hazardous waste should be collected, contained and disposed by a 3rd party accredited hauler and treater; • Maintenance and proper use of construction materials and heavy vehicles; • The contractor shall be provided with training and should ensure that hazardous waste is collected on a daily basis from the site.	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Local economy	Temporary employment for the locals during the construction stage Increase in economic opportunities.	• Prioritize locals when hiring laborers. Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; and • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs. • Enforcement of RA6685	DPWH	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
B2. Mobilization of equipment and supplies to project site	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Air quality	Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Traffic	Transport of construction materials from source to casting yard	• The project will not cause congestion, however, should be necessary, traffic management plan will be prepared and implemented. • Coordination with LGUs is proposed to provide traffic enforcers for safe and organized traffic flow.	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Community health and safety	Increased risks to community due to increase in vehicular movement	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Regular coordination with the LGUs and barangays with regards to project plans and concerns of the residents • Regularly monitor of presence/absence of complaints from PAPs	DPWH LGU	Part of develop ment cost	Incorporated part of the project
		Disturbance to nearby residents and resort operators				

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Immediate action on the stakeholder complaints through the implementation of GRM.			
B3. Setting up of casting yard	Terrestrial flora	Cutting down of trees within the proposed casting yard	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site			
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
	Traffic	Transport of construction materials from source to casting yard	• Traffic Management Plan will be prepared and implemented • Coordination with LGUs is proposed to provide traffic enforcers for safe and organized traffic flow.	DPWH LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
	Water Quality	Degradation of water quality due to oil, fuel or other lubricant agents leaks	• Locate motor-pool area at least 500 meters away from any body of water; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring to ensure continuous conformance of the water bodies to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase. • The contractor will be required to comply with the Civil Works Guidelines; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; • Emergency and contingency plan in case of spills (health and safety management plan must be in place); • The contractor shall ensure that solid and hazardous waste is collected on a daily basis from the site.	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
B4. Establishment of dry dock and works area for navigation bridge	Terrestrial flora	Cutting down of trees within the proposed dry dock and works area	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only;	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Provide noise barriers, such as site fencing, during the construction stage			
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site			
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
	Transportation/ Occupational Health and Safety	Sea Traffic	• Proper coordination with the Maritime, PPA, Coast Guard, LGUs and other related government offices regarding the following: -Schedule of shipping -Coordinates of alternative route of ships passing through North and south Passage • Ships/barges will be fitted with proper lighting during nighttime • Continuous coordination with the LGUs and affected barangays, PPA and other related government-offices • Assign a ship crew to assist the helmsman during nighttime steering • Designated exclusion zones should be defined and vessels not related to the	Contractors; DPWH; Engineer's Representative; Philippine Coast Guard (PCG) Representative; Philippine Port Authority (PPA) Representative; Philippine Navy Representative; Relevant LGUs	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	**Environmental Aspect**	**Potential Environmental Impacts**	**Option for Prevention or Mitigation or Enhanceent**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
			construction works shall be prohibited from entering these areas in order to minimize impacts from marine traffic. Exclusion zones shall be defined and clearly marked by the contractors such that non-construction vessels navigating in the vicinity of the works area are kept clear of the area and transit at slow speed. Contractors should liaise with the PPA, PCG, LGUs and other related government offices to patrol the exclusion zone to maintain traffic order. • Flexible rules and mitigation measures should be developed by the contractor according to different working stages (i.e. special yellow marker buoys fitted with yellow lights should be laid to mark the extents of particular exclusion zone as required). • It is proposed that a Marine Liaison Group is established prior to construction to co-ordinate and expedite the construction of the BCIB while maintaining safe marine activities in Manila Bay. • The purpose of the Marine Liaison Group is as outlined below: -To provide a forum for the sharing of vessel activities to assist planning of construction activity. -To co-ordinate marine traffic management requirements between the Contractors, Marine Department			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			and other relevant Government Authorities. -To review and discuss the experience of implementation measures to optimise the safety and efficiency of construction and marine activities. -To advise the Engineer with respect to the phasing of construction operations. -To agree on the precise timing and setting out of exclusion zones required for construction activities above North and South Navigational Channel. • -To resolve conflicts that may arise from the implementation of the works.			
	Water Quality	Degradation of water quality due to construction, and water contamination due to fuel, oil and other hazardous materials leakages	• Apply appropriate siltation control measures such as well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea; • Soil debris and other excavated materials should be hauled out from the site; • Regular monitoring of the affected and adjacent water bodies prior, during and even after the construction phase to monitor the water quality and ensure the continuous conformance to their respective water quality criteria. Water quality monitoring will be conducted on a monthly basis during the construction phase;	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• The contractor will be required to comply with the Civil Works Guidelines; • The contractor shall ensure that solid and hazardous waste is collected on a daily basis from the site; • Compliance in of MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14; • Ensure compliance to PCG Memorandum # 07-14; • Implement an organized waste storage, where bulk waste oils and lubricants are placed in impermeable area with appropriate secondary containment; and • Emergency and contingency plan in case of spills (health and safety management plan must be in place).			
	Marine ecology	Increase turbidity which may interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis May also irritate and clog the gills of pelagic fish larvae and juveniles that could lead to their eventual smothering Ballast water discharges of construction/cargo/deliver	• Use of geotextile silt curtains is recommended • Prohibit marine vessels from discharging ballast water in the sea; quarantine protocols through a Ballast Water Management Plan could be adopted • Prohibit marine vessels from discharging bilge water, or possibly by establishing treatment for bilge water; a very effective technology currently is available on the market to clean bilge water before it is discharged into the sea	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		y vessels may introduce some phytoplankton species known to trigger harmful algal blooms or HABS/toxic red tides that can alter the structure and function of aquatic ecosystems Bilge water discharges of construction/cargo/delivery vessels may depress photosynthesis and growth of phytoplankton Pile driving will crush or destroy benthic infaunal organisms and some epibenthic macroinvertebrates in small area and cannot be mitigated; benthic re-colonization should be quite rapid and could occur a few months after construction Anchoring will crush or loose epifauna in small area Turbidity plumes (pile driving) will disturb feeding activities and respiration of benthos Accidental oil spills- significant impact (direct smothering) on benthos in shallow water or intertidal/ sublittoral areas; while in	• Impact on shallow water/intertidal or sublittoral areas might be reduced by controlling movement of oil spill and/or dispersion at sea. Oil Spill Contingency Plans should be prepared and made readily available • Compliance to marine protocols by PPA and PCG requirements • Avoid or reduce the potential for the introduction of HABs/ toxic phytoplankton species • Avoid or reduce the potential to cause damage to phytoplankton communities • Lessen or avoid complaints received on oil spills of nearshore/coastal waters from residents, fisherfolks, and resort owners/operators			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		offshore areas less threatening (insignificant impact)				
	Marine ecology (Coral Reefs)	Turbidity (sediment resuspension), pile driving -resuspended fine sediments could travel to a neighboring coral reef in Corregidor Island; might cause temporary impact of short duration (insignificant level) Accidental bumping of construction vessels and localized disturbance from dropping and dragging anchors and chains may destroy/break and smash live corals	• Use of geotextile silt curtains is recommended • To prevent physical damage to adjacent patch reef during construction from dropping and dragging anchors and chains on the reef surface as well as accidental bumping by construction vessels, a marker buoy will be placed to indicate location of the adjacent reef formation. This will forewarn ship operators and aid them where they can only operate and anchor.	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project
	Protected Marine Species i.e. Marine turtles	Artificial light-reproductive success of marine turtles may potentially be reduced because matured females could be deterred from nesting on sandy beaches; hatchlings may also be disoriented/ misoriented and displaced on the beach Accidental collisions/ boat strikes and propeller hits from construction vessels due to higher vessel traffic- severe injury and/or mortality from accidents is greater	• Use of geotextile silt curtains is recommended • <u>Artificial light</u> Minimize light intensity to as low as reasonably particularly in nearshore areas. • Avoid use of white lights (e.g. mercury vapour, metal halide, halogen, and fluorescent light) in proximity to turtle beaches. Use high pressure sodium lights where possible. • Reduce lighting spill through shielding, directional alignment, window covering and other techniques.	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		(marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safet Accident (oil spills) - disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality; if there is an oil spill, these impacts will be significant and not mitigatable but might be reduced. In general, impacts are considered insignificant short duration and site specific	• Reduce horizon glow through the use of downward facing luminaries, attention to reflecting surfaces and minimization of external visibility of indoor lighting. • Lighting on moored vessels at night will be kept to a minimum for safe operations. • Periodic monitoring of the waters by trained vessel crew around construction vessels and around the construction site for the presence of hatchlings. • Protected Marine Species Trained personnel will be responsible for observing marine turtles during active piling at piling sites (e.g., on a jackup barge or adjacent support vessel). • Vessel crew will undergo site inductions and clear briefings covering procedures to be undertaken, to minimize disturbance to marine fauna provided by appropriately qualities personnel. • Existing acoustic control on noise-generating equipment (including vessel engines, drill and piling equipment) will be implemented to reduce notice at source. • Noise-generating equipment (including vessel engines, drill and piling equipment) will be routinely maintained and inspected to reduce unnecessary increases in noise levels			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			from the equipment. All vessels shall operate in accordance with appropriate industry equipment noise standards. • Where practical the practice of leaving engines, thrusters and auxiliary plant on standby or running mode will be avoided. • If marine turtles are sighted in the monitoring area, project vessels operating in the area will be notified. • Trained vessel crew will monitor and report observations of marine turtles within a designated monitoring zone (250m radius of piling barge) around the pile driving operations. Observations are to be recorded on the Observation Record Form. In the event that a marine turtle is sighted within a designated exclusion zone (500 m radius of the piling barge), piling activities will cease until the marine turtle moves outside of the exclusion zone or is not sighted for 20 minutes. Note: for reference, a 2000-m exclusion zone applies for Marine Mammals (except dolphins). • Carry out a “soft start” for piling by beginning a pile driving session with the lowest power possible and hammering at a low rate, then increasing hammer energy and rate to that desired. This should allow animals close to the source to move away and not be suddenly exposed to			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			sound intensities sufficient to cause them serious injury. • Any injuries or mortalities will be documented and reported. • <u>Collisions/boat strikes/propeller hits</u> Vessel crew will undertake site induction by appropriately trained project personnel. • Vessel speeds will be under the control of the Vessel Master who will ensure that all vessels operate in a safe manner with due respect to ongoing operations, navigational constraints and environmental considerations. • The Vessel Master will be advised of environmental matters from on-site environmental staff, including trained vessel crew, as applicable. • Trained vessel crew will monitor and report turtle sightings from project vessels during daylight hours during the construction phase. • Any incidents or injuries to turtles will be documented and reported. • <u>Accidental oil spills</u> Oil spill contingency plans should be prepared and made readily available.			
	Fish and Fishery resources	Disruption/ disturbance of fishing activities - temporary impact and short duration will occur but minimal or insignificant since fishing activities will still be allowed along the vicinity	• A required safety exclusion zone along construction site is recommended (i.e., 0.2 km) • Oil spill impact might be reduced by controlling movement of any spill; therefore, Oil Spill Contingency Plans should be prepared and made readily available	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		of the construction sites, but with a required safety exclusion zone. Moreover, existing fishing grounds around the construction sites are not the only fishing grounds in the area Accidental oil spills - generally, minimal or insignificant impacts on fish populations are expected because of probable capabilities of fishes to avoid oil spills; however, heavy loss of pelagic fish eggs and larvae can occur in shallow water area with poor water circulation	• Geotextile silt curtains should be used to reduce turbidity • Regular coordination with the LGU and affected fisherfolks • Regularly monitor of presence/absence of complaints from affected fishers • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism			
B5. Setting up of dumping/ storage areas	Terrestrial flora	Cutting down of trees within the proposed dumping/storage area	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
	Solid waste	Generation / Increased in solid waste from the activity	• Implement solid waste management plan • Proper waste management and housekeeping measure • Waste will be collected daily by a 3rd party contractor to ensure cleanliness in the workplace; and • Trainings will be provided to site workers to improve the awareness on proper solid waste management practices.	DPWH LGU	Part of develop ment cost	Incorporated part of the project
B6. Setting up of haul roads	Terrestrial flora	Cutting down of trees within the proposed haul roads	• Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Noise	Increased noise level due to use of heavy equipment and other vehicles	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers, such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
	Air quality	Dust re-suspension from earthworks and other construction activity	• Water spraying of the area during dry days; • Fencing the area to contain the dust within the project site			
		Increased vehicular emission	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
B7. Development of landing site	Terrestrial flora	Removal of vegetation on the proposed landing site and along the proposed alignment leading up to the existing highway (Antero Soriano Highway for Naic and Roman Superhighway for Mariveles)	• Compensatory planting will be done as per requirements of PD 705 • Identify and limit the area within the proposed alignment • Initiate the possible tree earth-balling option instead of tree cutting • Compliance with conditions of DENR/LGU, Tree Cutting Permit	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Noise	Increased noise level due to use of heavy equipment	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Livelihood	Removal of structures, including neighborhood sundry stores, backyard piggeries, and tricycle terminals, will lead to reduced income or income	• Conduct of IEC with displaced individuals • Provide compensation options, including alternative livelihood options to project affected micro, and small entrepreneurs	DPWH LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		loss to affected residents/business owners	• Implementation of the approved Resettlement Action Plan of the Project • Provide just relocation / compensation to affected landowners, households, and owners of other establishments • Regularly monitor of presence/absence of complaints from Project-Affected-Persons • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism			
	Occupational health and safety	Increased accident risks to workers due to the construction works Potential risks from natural hazards	• Provision for PPE to all workers • Training and safety drill to be given to workers • Conduct regular toolbox meeting • Record health and safety incidents on site	DPWH LGU	Part of develop ment cost	Incorporated part of the project
B8. Placement of precast segments	Coastal water	Siltation of coastal water may affect growth of coral reefs	• Installation of silt and sediment traps to localize the movement of silt and sediments to within the cable laying route	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project
	Water quality	Ships/barges may discharge sewage to the sea Ships/barges may discharge its ballast water which may contain oil and contaminate marine waters	• Ships/barges will be required to have its own treatment facility • Ships/barges will not be allowed to discharge its sewage or ballast water to the sea. The ship will make use of existing facilities that accept discharge of sewage and ballast water from ships • Regular water quality monitoring	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		Placement of precast segments may disturb seabed sediments which may have accumulated heavy metal content	• Installation of silt and sediment traps to localize the movement of silt and sediments to within the cable laying route • Regular water quality monitoring • The contractor will be required to comply with the Civil Works Guidelines; and • Compliance in of MARPOL 73/78 - Prevention of Pollution by Sewage from Ships and PCG Memorandum # 10-14.			
	Marine Ecology	Increase turbidity which may interfere with phytoplankton productivity and zooplankton feeding and respiration; tend to limit light penetration essential in photosynthesis; and may also irritate and clog the gills of pelagic fish larvae and juveniles that could lead to their eventual smothering Anchoring will crush or loose infauna and epifauna in small area Accidental oil spills-significant impact (direct smothering) on benthos in shallow water or intertidal/sublittoral areas; while in offshore areas less threatening (insignificant impact)	• Use of geotextile silt curtains is recommended • Prohibit marine vessels from discharging ballast water in the sea; quarantine protocols through a Ballast Water Management Plan could be adopted • Prohibit marine vessels from discharging bilge water, or possibly by establishing treatment for bilge water; a very effective technology currently is available on the market to clean bilge water before it is discharged into the sea • Impact on shallow water/intertidal or sublittoral areas might be reduced by controlling movement of oil spill and/or dispersion at sea. Oil Spill Contingency Plans should be prepared and made readily available	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
	Coral Reef	Accidental bumping of construction vessels and localized disturbance from dropping and dragging anchors and chains may destroy/break and smash live corals	• Use of geotextile silt curtains is recommended • To prevent physical damage to adjacent patch reef during construction from dropping and dragging anchors and chains on the reef surface as well as accidental bumping by construction vessels, a marker buoy should be placed to indicate location of the adjacent reef formation. This will forewarn ship operators and aid them where they can only operate and anchor. If a ship ran aground on coral reef, the ship owners would be financially liable.	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project
	Protected Marine Species i.e. marine turtles	Artificial light- reproductive success of marine turtles may potentially be reduced because matured females could be deterred from nesting on sandy beaches; hatchlings may also be disoriented/ misoriented and displaced on the beach Accidental collisions/ boat strikes and propeller hits from construction vessels	• Use of geotextile silt curtains is recommended • <u>Artificial light</u> Minimize light intensity to as low as reasonably particularly in nearshore areas. • Avoid use of white lights (e.g. mercury vapour, metal halide, halogen, and fluorescent light) in proximity to turtle beaches. Use high pressure sodium lights where possible. • Reduce lighting spill through shielding, directional alignment,	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
		due to higher vessel traffic- severe injury and/or mortality from accidents is greater (marine turtles have poor hearing and vision, and often times will not notice an approaching boat in time to move to safety) Accident (oil spills) - disorientation, alter behavior, ingestion, disrupt breeding, egg/juvenile/adult mortality; if there is an oil spill, these impacts will be significant and not mitigatable but might be reduced. In general, impacts are considered insignificant short duration and site specific	window covering and other techniques. • Reduce horizon glow through the use of downward facing luminaries, attention to reflecting surfaces and minimization of external visibility of indoor lighting. • Lighting on moored vessels at night will be kept to a minimum for safe operations. • Periodic monitoring of the waters by trained vessel crew around construction vessels and around the construction site for the presence of hatchlings. • <u>Protected Marine Species</u> Trained personnel will be responsible for observing marine turtles during active piling at piling sites (e.g., on a jackup barge or adjacent support vessel). • Vessel crew will undergo site inductions and clear briefings covering procedures to be undertaken, to minimize disturbance to marine fauna provided by appropriately qualities personnel. • Existing acoustic control on noise-generating equipment (including vessel engines, drill and piling equipment) will be implemented to reduce notice at source. • Noise-generating equipment (including vessel engines, drill and piling equipment) will be routinely			

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			maintained and inspected to reduce unnecessary increases in noise levels from the equipment. All vessels shall operate in accordance with appropriate industry equipment noise standards. • Where practical the practice of leaving engines, thrusters and auxiliary plant on standby or running mode will be avoided. • If marine turtles are sighted in the monitoring area, project vessels operating in the area will be notified. • Trained vessel crew will monitor and report observations of marine turtles within a designated monitoring zone (250m radius of piling barge) around the pile driving operations. Observations are to be recorded on the Observation Record Form. In the event that a marine turtle is sighted within a designated exclusion zone (500 m radius of the piling barge), piling activities will cease until the marine turtle moves outside of the exclusion zone or is not sighted for 20 minutes. Note: for reference, a 2000-m exclusion zone applies for Marine Mammals (except dolphins). • Carry out a “soft start” for piling by beginning a pile driving session with the lowest power possible and hammering at a low rate, then increasing hammer energy and rate to that desired. This should allow animals close to the source to move			

Project Phase/ Project Activity	**Environmental Aspect**	**Potential Environmental Impacts**	**Option for Prevention or Mitigation or Enhanceent**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
			away and not be suddenly exposed to sound intensities sufficient to cause them serious injury. • Any injuries or mortalities will be documented and reported. • Collisions/boat strikes/propeller hits Vessel crew will undertake site induction by appropriately trained project personnel. • Vessel speeds will be under the control of the Vessel Master who will ensure that all vessels operate in a safe manner with due respect to ongoing operations, navigational constraints and environmental considerations. • The Vessel Master will be advised of environmental matters from on-site environmental staff, including trained vessel crew, as applicable. • Trained vessel crew will monitor and report turtle sightings from project vessels during daylight hours during the construction phase. • Any incidents or injuries to turtles will be documented and reported. • Accidental oil spills Oil spill contingency plans should be prepared and made readily available.			

Project Phase/ Project Activity	**Environmental Aspect**	**Potential Environmental Impacts**	**Option for Prevention or Mitigation or Enhanceent**	**Responsible Entity**	**Cost**	**Guarantee/ Financial Arrangements**
	Fish and Fisheries resources	Disruption/ disturbance of fishing activities - temporary impact and short duration will occur but minimal or insignificant since fishing activities will still be allowed along the vicinity of the construction sites, but with a required safety exclusion zone. Moreover, existing fishing grounds around the construction sites are not the only fishing grounds in the area Accidental oil spills - generally, minimal or insignificant impacts on fish populations are expected because of probable capabilities of fishes to avoid oil spills; however, heavy loss of pelagic fish eggs and larvae can occur in shallow water area with poor water circulation	• A required safety exclusion zone along construction site is recommended (i.e., 0.2 km) • Oil spill impact might be reduced by controlling movement of any spill; therefore, Oil Spill Contingency Plans should be prepared and made readily available • Geotextile silt curtains should be used to reduce turbidity • Regular coordination with the LGU and affected fisherfolks • Regularly monitor of presence/ absence of complaints from affected fishers • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project
	Air quality	Increased vehicular emission from use of heavy equipment	• Heavy equipment and other vehicles to be used on site should have passed the emission testing; • All vehicles and heavy equipment should have undergone preventive maintenance to reduce emission • Fuel efficiency will be maximized through scheduling of vehicle, and	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			equipment movements in order to minimize both idle time and distances travelled and use of low sulfur fuel, where possible.			
	Noise	Increased noise level due to use of heavy equipment	• Limit the use of noise-emitting machines and equipment to daytime only; • Provide noise barriers such as site fencing, during the construction stage	DPWH DENR LGU	Part of develop ment cost	Incorporated part of the project
	Employment	Temporary employment for the locals during the construction stage	• Positive impact and does not require mitigation; • Prioritize locals when hiring laborers. Contractors to adopt strict policy requiring the contractor to source workforce from qualified locals; and • Contractors to develop scheme of prioritization in local hiring with equal opportunities for men and women, skilled and unskilled, and PWDs. • Enforcement of RA6685	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Economic Development	Additional income taxes for the LGU	• Positive impact and does not require mitigation • Continuous coordination with the LGUs and affected barangays	DPWH		Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
	Transportation	Traffic congestion due to trucks delivering supplies to site and movement of staff vehicles to and from the site	• Provide traffic aides to make sure smooth flow of traffic to and from project site; • Request assistance from LGUs to minimize delays in vehicular traffic; • Install signage in the entrance to the project site and around 100 meters on both sides of the road to alert motor vehicles of possible ingress and egress of site vehicles and delivery trucks • Continuous coordination with the LGUs and affected barangays • Implementation of traffic management plan	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Religious practices	Disturbance to church activities in the nearby chapel	• Proper scheduling of construction activities to minimize impact • IEC with church, community and LGU • Posting of notices on church bulletin board to inform the community	DPWH LGU		Incorporated part of the project
	Occupational Health and Safety	Increased accident risks to workers due to the construction works Potential risks caused by natural hazards	• Provision of PPE to all workers • Training and safety drill to be given to workers • Conduct regular toolbox meeting • Record health and safety incidents on site	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Community Health and Safety	Increased risks to community due to increase in vehicular movement	• Proper scheduling of construction activities to minimize impact • IEC with community and LGU • Posting of safety signage to warn motorists • Continuous coordination with the LGUs and affected barangays			
		Disturbance to nearby residents and business owners				

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
	Fisheries	Docking areas within the alignment may no longer be available for boat owners. Docking and fishing areas near the alignment will be temporarily unavailable due to construction activities	• Conduct IEC and FGD with affected boat owners/fisherfolks • Provide alternative docking areas for permanently occupied docking areas • Provide temporary docking areas for temporarily unavailable docking areas • A navigable channel will be maintained, as required, to ensure safe and convenient passage of fishing boats and sea-craft in the vicinity of the project area • Continuous coordination with the LGUs and affected barangays • Immediate action on the stakeholder complaints through the implementation of Grievance Redress Mechanism	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Livelihood	Fisherfolks from the area will temporarily be prohibited from fishing within the area of the submarine cable route	• Provide an alternative livelihood program for affected fisherfolks • Continuous coordination with the LGUs and affected barangays • Implementation of the approved RAP of the Project • Regularly monitor of presence/absence of complaints from PAPs • Immediate action on the stakeholder complaints through the implementation of GRM			
	Maritime safety	Small fishing boats may accidentally collide with the ships/barges, especially during nighttime	• Ships/barges will be fitted with proper lighting during nighttime • Continuous coordination with the LGUs and affected barangays, PPA and other related government-offices	DPWH DENR LGU PCG	Part of develop ment cost	Incorporated part of the project

Project Phase/ Project Activity	Environmental Aspect	Potential Environmental Impacts	Option for Prevention or Mitigation or Enhanceent	Responsible Entity	Cost	Guarantee/ Financial Arrangements
			• Assign a ship crew to assist the helmsman during nighttime steering			
Operation / Maintenance						
Operation of the BCIB bridge	Marine Ecology	Creation of artificial hard substrate on the seafloor – impact of operation is viewed as beneficial impact; act as artificial hard substrates or "artificial reefs"	• A positive impact; therefore, no mitigation required	DPWH LGU		Incorporated part of the project
Operation of the BCIB bridge	Community Health and Safety	Increased probability of road accidents due to increased traffic and higher speed limit on the bridge	• Post appropriate signage along the alignment to warn both residents and motorists; • Widely disseminate information on allowed vehicles on the bridge and speed limit • Provide a crew to monitor traffic on the bridge • Continuous coordination with the LGUs and affected barangays	DPWH LGU	Part of develop ment cost	Incorporated part of the project
	Occupational Health and Safety	Accidents may befall workers as they maintain the bridge	• Regularly site safety drills • Use of prescribed PPEs			
Operation of the BCIB bridge	Local economy	Accessibility as well as traffic will be increased, increasing opportunities as well for businesses due to more people coming to and /or passing through the host LGUs.	• Positive impact.	DPWH	Part of develop ment cost	Incorporated part of the project
Decommissioning/Abandonment						
Disintegration of the demobilized structure	Water Quality/ Contamination	Impacts on existing water quality of Manila Bay	• Implementation of approved decommissioning plan by the EMB			

4 Environmental Risk Assessment (ERA) & Emergency Response Policy and Guidelines

Emergencies are unforeseen events or episodes that may be caused by natural forces or human actions or inactions which may result to negative effects to people, property, and the surrounding environment. As a preliminary step in developing an effective emergency response policy, it is important to identify the potential emergency scenarios that would most likely occur.

Table 4.1 below presents the emergency scenarios for the project with details on possible causes and potential effects.

With the different emergency scenarios identified for the project, **Table 4.2** then presents the corresponding emergency response procedures that can be followed.

Table 4.3 presents the roles and responsibilities of personnel concerned in the emergency plan.

Table 4.1 Emergency scenarios for the BCIB Project

Type of Emergency Situation	Possible Causes	Potential Effects
Fire	• Electrical short-circuits, overloading of equipment • Accidental ignition of combustible materials (e.g. diesel/fuel for machineries and oil for maintenance)	• Partial or total loss of equipment and property • Injuries and fatalities to personnel and commuter
Earthquakes	• Movement/rupture of nearby fault lines • Volcanic eruption	• Failure of gantry • Injuries and fatalities to personnel and commuter • Damage to bridge
Occupational safety accidents	• Improper training and supervision of personnel • Equipment and facility failure • Possible collapse of steel structures during gantry installation	• Injuries and fatalities to personnel • Partial and total loss of equipment
Tsunami	• Movement/Rupture of nearby fault lines • Volcanic eruption • Intense earth movement	• Failure of gantry • Injuries and fatalities to personnel and commuter • Damage to bridge
Flooding	• Location of the Philippines as a typhoon prone area • Complex weather systems • Topography of the area	• Minimal impact is expected to facility structures
Storm Surge	• Location of the Philippines as a typhoon prone area • Complex weather systems • Intense rainfall, wind, and high tides	• Injuries and fatalities to personnel and commuter • Damage to facilities/bridge
Vehicular accidents	• Human error • Faulty machines (vehicles) • Road obstructions	• Injuries and fatalities to personnel and commuter • Damage to bridge

Table 4.2 Emergency Response Procedures for Different Scenarios

Preparation	Response	Recovery
A. Fire ● **Orientation and training of personnel on fire safety** ● **Conduct regular fire drills** ● **Installation and regular testing of fire-fighting devices (i.e. fire hoses, fire extinguishers)** ● **Regular inspection of electrical equipment and lines, and replacement as necessary, for any defects or malfunctions** ● **Proper storage of all flammable items in secured and proper containers and storage facilities** ● **Implementation of a 'no-smoking' policy when on duty** ● **Placement of emergency numbers and communication equipment in conspicuous areas for easier notification** ● **Emergency exits and evacuation procedures shall be put in place, and kept free from any obstructions** ● **Regular maintenance of electrical equipment**	● Personnel are advised not to panic to prevent further injuries. ● Personnel are advised to follow emergency evacuation procedures. ● Immediately report any presence of smoke, sparks, or open flame to authorized personnel. ● If the fire can still be contained, use fire extinguishers immediately. ● Disconnect electrical or fuel connections, and shut-down all affected equipment. ● If possible, remove all flammable materials from the fire scene to avoid further contact. ● For responders, wear the proper fire protection attire (i.e. fire suit, boots, breathing apparatus). ● Avoid using or pouring water over fuel or alcohol fires, and electrical fires.	● Avoid returning to the fire scene, as long as necessary, unless declared for safe entry. ● Check personnel and find out if there are injuries or trapped/injured persons that may need assistance. ● Report any important incidents that require immediate attention. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry. ● If the fire damage is minimal, or facility is recoverable, make necessary corrective measures to prevent the accident from re-occurring.
B. Earthquakes ● **Make necessary preparations, which includes equipment and facility checks to prevent injuries in an event of an earthquake** ● **All loose items must be secured to prevent falling** ● **Placement of heavy materials near the ground** ● **Storage of flammable items in designated safe areas** ● **Personnel/tenants are familiarized to safe locations, emergency response equipment and evacuation routes**	● Personnel are advised not to panic to prevent further injuries. ● Personnel are advised to protect themselves by getting under sturdy structures. ● Personnel are advised to stay away from sharp, flammable, or heavy items. ● Personnel are advised to prepare immediate evacuation of the facility if necessary ● All gas and electric equipment are shut down	● If there are no threats of aftershocks, check other personnel that may be trapped, injured, or needs further assistance. ● Avoid returning to the facility if it is deemed structurally unstable, or declared unsafe. ● Conduct thorough inspection of the facility's premises for any possible damage to the bridge and other electrical equipment. ● Check for possible fires and advice authorities for appropriate response. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry.

Preparation	Response	Recovery
		● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards. ● If the earthquake damage is minimal, or facility is recoverable, make corrective measures to prevent the further hazards from affecting personnel and property.
<u>**C. Release of Toxic Substances**</u> ● **Regular visual inspection for potential leaks and corrosion** ● **Inspection of facilities, containers, and equipment for any signs of leaks or spills**	● Report immediately to supervisor. ● Stop operations in the area affected by spillage and stop appropriate source. ● Stop engines of vehicles in the affected area. ● Follow strictly instructions of supervisor in charge of cleaning operations. ● Do not resume operations or any movements until the supervisor has given clearance.	● All spills should be cleaned up immediately using proper conditions, which include stopping and containing the spill or leak. ● Arrest the spill and take steps to prevent repeat.
<u>**D. Occupational Hazards**</u> ● **Formation of emergency response teams for each department** ● **Provision of first-aid kits and emergency equipment on critical workstations** ● **Training of personnel on proper equipment handling and other safety practices** ● **Posting of safety reminders on workstations** ● **Provision of safety features such safety signage**	● Report immediately any accidents, especially those considered life-threatening ● Immediate application of first aid ● Removal of the affected personnel from the accident site. ● Bring the affected personnel to the nearest first aid station or hospital, if necessary.	● Perform corrective measures on equipment and procedures. ● Provision of additional safety procedures, equipment, and training.
<u>**E. Tsunami**</u> ● **Loose articles, which may be subject to movement by wind force or earth movement, will be secured in such areas as necessary to prevent them from becoming hazards.** ● **Remove obstructions to the drainage system**	● Personnel are advised not to panic to prevent further injuries. ● Personnel are advised to stay away from sharp, flammable, or heavy items. ● Personnel are advised to prepare for immediate evacuation of the facility, if necessary. ● All gas and electric equipment will be shut down.	● Avoid returning to the facility if it is deemed structurally unstable or declared unsafe. ● Secure important items and equipment from unauthorized access from outsiders after the premises have been declared safe for re-entry. ● Make corrective measures to prevent further hazards from affecting personnel and property.
<u>**F. Flooding**</u> ● **Prior to the incoming storm, secure all loose items (i.e. lamp post, roofs, loose planks, and**	● Personnel are advised to follow evacuation procedures. ● Personnel are advised to stay away from items that may be	● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards.

Preparation	Response	Recovery
other light materials) by adding extra guy wires or reinforcing materials. ● **Remove obstructions to the drainage system.** ● **If there is a storm warning from PAGASA, monitor any possible developments, especially for the expected path and intensity of the storm, and other important weather parameters.**	blown away by strong winds and electrical mains. ● Continuous monitoring of the weather conditions. ● All gas and electric equipment will be shut down.	● If necessary, repair broken power lines, fuel lines, and other utilities. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry.
F. Storm Surge ● **Prior to the incoming storm, secure all loose items (i.e. lamp post, roofs, loose planks, and other light materials) by adding extra guy wires or reinforcing materials.** ● **Remove obstructions to the drainage system.** ● **If there is a storm warning from PAGASA, monitor any possible developments especially for the expected path and intensity of the storm and other important weather parameters.**	● Personnel are advised to follow evacuation procedures. ● Personnel are advised to stay away from items that may be blown away by strong winds and electrical mains. ● Continuous monitoring of the weather conditions. ● All gas and electric equipment will be shut down.	● Inspect the facility for any major structural defects, cracks, unstable items, and other potential hazards. ● If necessary, repair damaged cables and electrical equipment. ● Secure important items and equipment from unauthorized access from outsiders, after the premises have been declared safe for re-entry.
G. Vehicular Accidents ● **Strictly impose speed limits.** ● **Strictly impose limit to types of vehicles allowed on the bridge.**	● Report immediately any accidents, especially those considered life-threatening. ● Immediate application of first-aid. ● Removal of the vehicle and victims from the accident site. ● Bring the affected personnel to the nearest first aid station or hospital, if necessary.	● Perform corrective measures on procedures. ● Provision of additional safety procedures, equipment, and training. ● Inspect the premises for any damage and potential hazards.

Table 4.3 Roles and Responsibilities in the Emergency Plan

Emergency Response Personnel	Roles and Responsibilities
Incident Commander	● Overall in-charge of operations during an event of an emergency ● Gives direction and orders to the response teams in managing the emergency
Safety Officer	● Supervises the daily safety performance of operations and maintenance procedures, including emergency response procedures
Liaison Officer	● Secures the necessary permits and training certification for the personnel
Public Information Officer	● Performs communication duties in behalf of NGCP to the media, government officials, and the local population ● Issues relevant warnings and advisories to concerned authorities
Operations Team	● Performs the actual response, rescue, and retrieval of personnel and equipment during an event of an emergency
Planning/Intelligence Team	● Devices programs and policies for proper response procedures ● Informs the operations team regarding the nature and type of response procedure for the Operations Team ● Identifies potential hazards and performs recommendations to authorities
Logistics Team	● Provides the necessary supplies and equipment for the Operations Team ● Provides additional support/assistance to the Operations Team
Finance and Administration Team	● Provides the assessment of expenses and allocates the necessary financial resources for the other Teams ● Performs the disbursement of claims and compensation for affected personnel, property and the community

5 Social Development Program (SDP) and Information and Education Campaign (IEC) Framework

5.1 Social Development Program

The formulation of the project Social Development Program (SDP) was based on priority issues and concenrs identified in the EIS study of the project and through a series of IEC and consultation activities in the affected communities.

Table 5.1 oresents the proposed social development programs for the project benefitting the host barangays with consideration to vulnerable persons such as senior citizen, women and children.

Table 5.1 Social Development Framework for the BCIB Project

Concern	Target beneficiary	Responsible entity	Possible programs	Indicative timeline	Source of fund
Displacement	Project affected families	M/CPDO M/CSWDO Local housing offices/ agencies PESO DOTr	Skills inventory and job matching Creation of livelihood programs that is anchored on a clear understanding of supply and demand and value chain	Pre-construction	LGU, NHA, DPWH
Transparency and community involvement	Project affected people in affected areas	BLGUs M/CLGU DOTr	Bi-monthly conduct of barangay consultations Development of audience-specific IEC materials Establishment of grievance redress mechanism	Pre-construction Construction Operation	BLGUs M/CLGU DPWH
Gender responsive livelihood/ **Employment and credit facilities**	Qualified project affected men, women, youth, and elderly	M/CPDO M/CSWDO GFPS (GAD Focal Point System) PESO (Public Service Employment Office) M/CCDO (Credit Development Office)	Conduct of gender analysis Mainstreaming of gender in livelihood programs Skills inventory and job matching Creation of livelihood programs that is anchored on a clear understanding of supply and demand and value chain	Pre-construction Construction Operation	LGU, DPWH

Concern	Target beneficiary	Responsible entity	Possible programs	Indicative timeline	Source of fund
Health and safety	Project affected families	M/CHO M/CDRRMO BDRRMO	Dissemination of traffic advisories Road safety orientation among schoolchildren	Pre-construction Construction Operation	LGU, DPWH
Environment and sanitation	Project affected families	M/CENRO M/CHO	Conduct of monthly medical missions in affected barangays Strengthening of TB-DOTS programs at the barangay level Strengthening of reproductive health and family planning programs and activities in barangays and workplaces	Pre-construction Construction Operation	LGU, DPWH
Peace and order	Project affected families	LGU PNP PCG	Registration of non-residents who conduct business in the barangay Capacity building for barangay tanods on peace keeping	Pre-construction Construction Operation	LGU, DPWH
Spiritual	Project affected families	Religious Leader and/or religious organization	Pre-arranged counselling sessions	Pre-construction Construction Operation	Local church

5.2 Information and Education Campaign (IEC)

The conduct of Information, Education and Communication (IEC) campaign serves as a venue for the exchange of feedback between the project proponent and the community. The contents of the IEC campaign should contain information about the project based on the proponent's understanding of the community's right to know.

The IEC campaign should have a supporting strategic communication plan that clearly identifies target audience, their interest, and the corresponding message (information disclosure) and approach or medium to be used. Broadly, the communication plan for this Project can cover the following concerns:

- The need for the project;
- The potential benefits of the project;
- The project phases and possible impacts; and
- The social development plan of the proponent and corresponding LGUs.

Table 5.2 presents the proposed IEC Framework for this project.

Table 5.2 IEC Framework for the BCIB Project

Stakeholder	Interest	Method	Indicative Timeline and Frequency
Residents of affected barangays	Potential impacts and proposed mitigation measures during construction and operation Priority hiring for workers and employees	Briefing sessions Group consultations Barangay bulletins	At least two months prior to start of construction Semi-annually during construction Annually during operation
Fisherfolks	Potential impacts and proposed mitigation measures during construction and operation	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction Semi-annually during construction Annually during operation
Parents and schoolchildren	Potential impacts and proposed mitigation measures during construction and operation Access and road safety	Group consultations School bulletins	At least two months prior to start of construction Semi-annually during construction Annually during operation
Municipal governments of Naic and Mariveles, Cavite City government	Preparation for construction Completion of construction Preparation for operation	Leadership briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation
Religious sector	Potential impacts and proposed mitigation measures during construction and operation	Group consultations Notices/Briefings	At least two months prior to start of construction Semi-annually during construction (notices only, unless necessary) Annually during operation
Transport sector	Avoid disturbances, like traffic congestion and inconvenient re-routings, as much as possible that may lead to lesser earning/income; Access and road safety	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction Semi-annually during construction Annually during operation
Business owners within and along the alignment	Avoid disturbances (air pollution, traffic noise, flooding, waste accumulation) as much as possible; access to their shops from the road/highway; better and safer roads; fair compensation; same or better livelihood condition to get new location	Group consultations Posting of bulletins in strategic areas for important announcements	At least two months prior to start of construction Semi-annually during construction (notices only, unless necessary)

Stakeholder	Interest	Method	Indicative Timeline and Frequency
			Annually during operation
Corregidor Foundation, Inc.	Avoid or minimize adverse effects to the physical resources of Corregidor Island	Executive briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation
Municipal/City Fisheries and Aquatic Resources Management Councils (FARMCs)	Enforcement of fishery laws, rules, and regulations in municipal waters	Executive briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation
Shipping associations Association of International Shipping Lines, Inc. (AISL) Filipino Shipowners Association (FSA) Philippine Liner Shipping Association (PLSA) Philippine Inter-Island Shipping Association (PISA)	Avoid disturbances Better and safer maritime transport	Executive briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation
Philippine Coast Guard	Better and safer maritime transport	Executive briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation
Maritime Industry Authority (MARINA)	Better and safer maritime industry	Executive briefings Provision of briefing notes	At least two months prior to start of construction Semi-annually during construction Annually during operation

6 Environmental Compliance Monitoring

This Environmental Compliance Monitoring and Management Plan (EMMP) has been prepared to ensure that the proposed project by the government through the Department of Public Works and Highways (DPWH) will be undertaken in a manner that minimizes the environmental effects of the site preparation and construction works.

As a framework to minimize the environmental effects of the pre-construction, construction and up to operation works, all activities that need to be undertaken will have to meet the conditions laid down in the Outline Plan, Land Designations, Resource Consents and relevant By-laws, Acts and Regulations.

This EMMP will be a ‘live’ document and will be reviewed and updated throughout the life of the project to make sure that environmental protection is achieved at all times.

6.1 Objectives

The objectives of the project, in regard to environmental management and protection are:

(a) To take the necessary steps to prevent or mitigate any adverse environmental effects caused by the pre-construction, construction and up to operation works, or by related activities;

(b) To take the necessary steps to prevent or mitigate any nuisance to adjacent properties during the conduct of various activities.

(c) To maintain to a reasonable standard any land taken or held for the works until the physical works commence.

(d) To ensure that, at all times, reasonable and useable access is maintained to private properties, particularly those directly affected by the pre-construction, construction and up to operation works or related activities;

(e) To provide protective fencing to sites of ecological sensitivity that are identified before construction works and any that are discovered during construction.

(f) To ensure that the requirements of the EMMP are complied with throughout the duration of the project including but not limited to contract works by all parties involved with the construction works, including subcontractors.

6.2 Designation and Resource Consents

A designation approval and several resource consents have been granted for the project. These documents have been reviewed and the EMMP has been prepared to address the conditions and requirements detailed within these documents.

6.3 Environmental Legislation

There are various Government Acts and Regulations including environmental specific acts that are applicable to the worksite, these include but are not limited to:

- PD 856 – Code of Sanitation

- PD 1067 – Water Code of the Philippines
- PD 1586 – The Philippine Environmental Impact Statement System
- RA 8749 – The Philippine Clean Air Act of 1999
- RA 6969 – Toxic Substances, Hazardous and Nuclear Waste Act
- RA 9275 – The Philippine Clean Water Act of 2004
- RA 9003 – Ecological Solid Waste Management Act

Compliance to these and any other regulations, by-laws, etc., will be achieved proper implementation of appropriate site and environmental monitoring and management plan presented herein.

6.4 Environmental Management Contacts

The potential environmental effects as a result of the construction of this project are to be minimized through careful planning, adherence with the requirements of this Environmental Monitoring and Management Plan (EMMP). This EMMP utilizes the existing DPWH Procedures as a basis for environmental management on site. These procedures have been modified, as maybe required, to address the specific issues on site. The procedure also specifies the responsibilities of the various staff in the implementation, which is summarized below:

6.4.1 Project Manager

The Project Manager is responsible for ensuring that environmental risk management processes are implemented throughout the duration of the project. The Project Manager is to nominate key personnel to carry out risk assessments on all potential environmental aspects and develop specific risk control measures to eliminate or minimize risks to an acceptable level. The Project Manager is also responsible for ensuring that changes to personnel or the work environment that may impact on the effectiveness of risk control methods are identified.

The risk management process is to involve relevant personnel directly involved with the work. Risk control measures are to be regularly monitored and reviewed to ensure continuing effectiveness.

6.4.2 Project Health, Safety and Environmental (HSE) Manager

The HSE Manager is responsible for providing the support necessary for the successful implementation of this procedure.

6.4.3 Safety Supervisor, Engineers and Officer

All Safety Officers are responsible for the maintenance of safety in their respective units by ensuring the implementation of risk management processes and associated risk control methods.

6.4.4 Project Environmental Officer

The Project Environmental Officer (EO) is responsible for ensuring that this procedure is known and implemented by all relevant supervisory personnel. The responsibility of the

Environmental Officer also includes the inspection of the Site for any possible issues, monitoring of the area and implementation of the EMMP and the corresponding mitigation measures. The Environmental Officer also acts as the Pollution Control Officer (PCO).

6.4.5 Supervisors/ Foremen

Supervisors and Foremen have key responsibility in the planning and coordinating of work activities and assessing potential environmental aspects on the job and instructing employees in risk control methods to accomplish the work without harming the environment.

6.4.6 Contractor's Responsibility and Environmental Programs

This section discusses the responsibility of employees and subcontractor's employees in health, safety, and environmental issues related to the project.

6.4.6.1 Employees and Subcontractors

Throughout this procedure "employee" shall refer to both **DPWH** direct employees and subcontractor employees. Employees are responsible for complying with environmental controls on the project. Employees are required to be active in awareness on the job by reporting inadequate conditions or practices to supervision. Relevant employees are to be consulted during the risk management process.

6.4.6.2 Environmental Chain of Responsibility

The first point of contact for any safety and environmental issues on site is the Health, Safety and Environmental (HSE) Manager and the Environmental Officer (EO)**.** In the event that the HSE and EO are unavailable, all issues are referred to the Project Manager. He will then designate who among the remaining Safety Officers will take charge of the issues. Should there be environmental issues outside the control of the **DPWH** or in the event that the response or performance of **DPWH** is not considered appropriate, **the Construction Management** is to be contacted. Below is the sample contact list of key personnel responsible for ensuring that all healthy, safety, and environmental issues related to the project.

Table 6.1 Sample contact list of key personel

Name	Position	Company	Contact Number	Email
	Project Manager	**DPWH**		
	HSE/ Environmental Manager	**DPWH**		
	Safety Supervisor	**DPWH**		
	Safety Engineer	**DPWH**		
	Safety Engineer	**DPWH**		
	Safety Officer	**DPWH**		
	Environmental Officer	**DPWH and Construction Management Rep**		
	Safety Officer	**Construction Management.**		
	Safety Officer	**Construction Management**		

6.5 Monitoring

The regular monitoring, excluding the specific monitoring, will be undertaken in accordance with the Safety & Environmental Inspections & Monitoring Procedure (Environment) of DPWH. The results of this regular monitoring will be utilized to prepare the required environmental compliance reports. In addition to the internal environmental monitoring, it is expected that there will be a degree of regular external monitoring from **the Proponent (DPWH), Construction Management and the Environmental Management Bureau (EMB)**.

6.5.1 Self- monitoring Plan

As per Annex 2-20 of the Revised Procedural Manual (RPM) from DAO 2003-30, the self-monitoring plan is summarized in **Table 6.3** in the next page. On the other hand, the description of the EQPL is provided in the table below.

Table 6.2 EQPL Definition

EQPL Level	Description
Alert or Red Flag	Early warning
Action Level	Point where management measures must be employed so as not to reach the regulated threshold or limit level, or to reduce deterioration of affected environmental component to pre-impact or optimum environmental quality
Limit Level	Regulated threshold of pollutant (standard that must not be exceeded); point where emergency response measures must be employed to reduce pollutants to lower than standard limit.

It is worth noting that the EQPL component of the EMoP is filled out only if they are willing to be committed by the proponent at the pre-ECC stage. Otherwise, the proponent may opt to have EQPLs established post-ECC, which are then mutually agreed upon by the Proponent, EMB and other MMT members. Otherwise, only the Limit Level shall be the reference for regulatory compliance. This means that formulated environmental measures are not to exceed this regulated threshold.

In the case of the project, the EQPL component will be established post-ECC.

Table 6.3 Summary of Monitoring Plan (EMoP) with Environmental Quality Performance Levels (EQPLs)

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
								Environmental Quality Performance Level			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION PHASE													
General													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	2,000,000.00	One near miss accident	One recorded accident	Two recorded accidents	Assess the source of accident	Investigate the root cause of injuries	Temporary stoppage of work until incident properly assess and mitigated
General Construction works	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	1 no lost time injury	>1 no lost time injury	1 lost time injury	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Preparation and Construction of Temporary Facilities													
Site preparation, clearing, and/ or tree cutting activities	Displacement and loss of livelihood of residents and business owners during ROW land acquisition.	Resettlement Action Plan	Technical Review	Once	Project Management Office (PMO)	DPWH, Design Contractor;	Part of construction cost	Not applicable					
		Affected residents and land owners and corresponding compensation packages	Inventory and Survey	Quarterly	Direct and Indirect Impact Areas	DPWH, LGU	Part of construction cost	Not applicable					
		Employment records	Number of locals hired	Monthly	At construction site	Social Safeguard Specialist, PMO-DPWH	Part of construction cost	Increased number of unemployed affected people					
	Temporary disruption of public services, such as water and electric supply	Affected communities and businesses	Ocular inspection	Daily during preparation and construction	Direct Impact Areas	Project Contractor Proponent	Not Applicable	Formal complaint					
	Loss of topsoil due to vegetation clearing may trigger soil erosion and may induce landslides in some areas.	Soil and bedrock components	Geologic Investigation	After every major earthquake and during pile driving	At construction site	Project Engineer	Part of contract cost	Presence of cracks, vertical displacement and mass movement					

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Loss of vegetation during clearing operation (i.e. fruit bearing trees, and forest trees);	Terrestrial habitat and trees removed and planted making sure loss has been compensated; survival rate of introduced species	Ocular inspection; Tree count	Monthly	At construction site	PCO of the Contractor, DPWH-PMO, Biodiversity Management Bureau	Part of Contract Cost	Degradation/reduction of vegetative cover relative to the project site					
	Disturbance or loss of habitat and will affect existing wildlife	Inventory of lost habitats and affected population of certain fauna species	Fauna inventory and habitat logging	Quarterly	Bataan and Cavite	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
	May trigger siltation	Volume of sediments stored or disposed	Volume estimation	Weekly	At construction site	Proponent	Part of contract cost	Degradation on its physical aesthetics due to accumulation of suspended sediments.					
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction and installation of site facilities – Temporary Facilities (field	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
offices and barracks)			accredited service provide										
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Degradation of water quality: Impacts on groundwater and freshwater quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
	Degradation of water quality: Impacts on marine water quality	Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100mL		Provision and repair of proper sanitary facility	
		Total coliform								10,000 MPN/100mL			
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quartlerly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Construction, bore piling and installation of piers and columns on land and marine – Permanent Structure													
Dredging and excavation on land and water; Earthmoving through use of heavy equipment; Operation of vessels; Installation of columns/ foundations and construction of interchanges and bridge structure.	May trigger soil erosion and induce landslides in some areas (including impacts on Earthquakes, Ground settlement and lateral spread, Mass movements)	Detailed Engineering Design	Technical Review	Once	Project site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Geohazards	Measurement of displacement caused by geohazards in an area; Size of flooded areas and flood heights	Geohazard survey	Quarterly	Project site	DENR-MGB/ DPWH Environment Officer	300,000.00	Not applicable					
	Liquefaction	Ground vertical displacement	Geologic Investigation	After every major earthquake and during pile driving	Project site	Project Manager	300,000.00	Not applicable					
	Ground subsidence	Dissolution cracks and volume of solution cavities	Geologic Investigation	Quarterly	Project site	Project Manager	300,000.00	Not applicable					
	Change in sub-surface geology and underground conditions due to the project, inducement of subsidence, karst subsidence, liquefaction and mass movements; Damage or collapse due to strong ground shaking	Detailed Engineering Design	Technical Review	Once	Project Management Office	DPWH and Design Contractor	Incorporated as part of the design cost	Not applicable					

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Soil contamination from leaks of lubricants, reagents and used oil	Presence of lubricants, reagents and oil	Visual inspection	Daily	Project site	Environment Officer	100,000.00	Not applicable					
	Accumulation of solid wastes	Volume and type of solid wastes generated	Segregation and weighing; disposal thru a DENR-accredited service provide	Daily	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
	Generation of hazardous materials in land (i.e. disposal of busted lamps, batteries, empty chemical containers, used oil etc. (from casting yard and storage areas); generated from the operation of construction machinery and office facility	Proper management and disposal of wastes; Volume and type of hazardous materials generated	Checking compliance to RA 9003 and RA 6969; Segregation and weighing	Weekly	At construction site	Environment Officer	200,000.00	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper transport and disposal of solid waste
	Impairment of visual aesthetics	Final Project Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
	Increase in flooding susceptibility	Detailed Engineering Design	Technical Review	Once	At construction site	DPWH and Design Contractor	Part of contract cost	Not applicable					
		Size of flooded areas and flood heights	Geohazard survey	After every flooding event	At construction site	Proponent	Part of contract cost	Exceeded the carrying capacity of flood mitigating measures applied					
	May trigger siltation; Degradation of water quality due to oil, fuel or other lubricant agents leaks; Water Quality	pH	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	10,000.00 per parameter	6.5-8.0	8.0-8.5	6.5-8.5	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		DO						5 mg/L	5.1-5.5 mg/L	8 mg/L			
		Oil and grease	DENR- EMB Water Quality Monitoring Manual	Monthly	Project site	Environment Officer	500,000.00	1.8 mg/L	2.4 mg/L	3 mg/L	Investigate and identify non-point sources	Investigate and identify non-point sources	Investigate and identify non-point sources, repeat analysis
		TSS						62 mg/L	71 mg/L	80 mg/L			
		Fecal coliform						200 MPN/100mL	1000 MPN/100mL	9,200 MPN/100mL		Provision and repair of proper sanitary facility	
		Total coliform								10,000 MPN/100mL			

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
	Traffic congestion	Traffic Management Plan	Monitoring and evaluation of TMP implementation	Daily during onshore construction	Project site	Project Contractor Proponent	Not Applicable	Formal complaint			Coordinate with LGUs on Traffic Management Reassess Traffic Management Plan		
	Alteration of air quality from vehicles, fugitive dust and from equipment use	$PM_{2.5}$	Air quality sampling: Refer to DAO 2000-81 Analysis Methods	Quarterly	Project site	Environment Officer	840,000.00	25 ug/Ncm	30 ug/Ncm	50 ug/Ncm	Check of APCD	Conduct maintenance and operation works on APCD	Inspect condition of engines; Repair damages/ defects, repeat analysis
		PM_{10}						120 ug/Ncm	130 ug/Ncm	150 ug/Ncm			
		TSP						180 ug/Ncm	200 ug/Ncm	230 ug/Ncm			
		SO_2						120 ug/Ncm	150 ug/Ncm	180 ug/Ncm			
		NO_2						65 ug/Ncm	70 ug/Ncm	150 ug/Ncm			
	Noise Generation; Disturbs people and areas	Noise levels	Noise monitoring	Daily during onshore construction	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects
Dredging and excavation on water; Operation of Vessels; Installation of columns/ foundations and construction of bridge structure													
	Local loss and disturbance of natural sedimentary habitats due to introduction of hard substrates and increase in sediment loads from construction materials; Deterioration, destruction and disruption of fish habitats	Monitoring and evaluation of benthic habitats to capture changes; Should there be any affected corals and seagrasses, coral translocations/ seagrass mitigation / translocation of any benthic species should be undertaken by a suitably qualified marine ecologist.	Ecological inventory	Semi-annual	Bataan and Cavite	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					
	Changes in channel beds and impacts on fish and aquatic life	Monitoring and evaluation of benthic habitats to capture changes based on	Ecological inventory	Semi-annual	Bataan and Cavite	PCO of the Contractor, DPWH-PMO, BMB	Part of Contract Cost	Degradation/reduction of native species cover relative to the project site					

Project Activity	Impact	Parameter to be Monitored	Sampling & Measurement Plan			Lead Person	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			Environmental Quality Performance Level			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		Biodiversity Protection Plan											
OPERATION PHASE													
Hiring of local workers	Opportunity for employment and livelihood; Competition with local and migrant workers; Reduction of poverty and food poverty.	Number of locals hired	Employment records	Monthly	Project site	Project Contractor Proponent	Part of project cost	40% of on-site employees are migrant workers			Freeze hiring of migrant workers		
Hiring of local workers	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily	Project site	Health and Safety Officer	2,000,000.00	One near miss accident	One recorded accident	Health and Safety of construction workers	Accident-free man hours	Timesheets and incident reports	Daily
Operation of the bridge	Potential threat to health and safety of people / communities	Number and nature of incidents	Records from Clinics Safety Records	Monthly	At construction site	Project Manager Proponent	Part of construction cost	1 no lost time injury	>1 no lost time injury	1 lost time injury	Assess the source of accident	Investigate the root cause of injuries	Provide EHS monthly report and plans
Movement of passengers	Increase in solid waste generation from passengers and operational works	Proper management and disposal of wastes	Checking compliance to RA 9003 and RA 6969	Weekly	Project site	PMO	Part of the operation cost	50% maximum storage capacity	80% maximum storage capacity	Maximum storage capacity	Ensure proper storage and segregation of wastes	Monitoring of trash bins	Proper disposal of solid waste
Movement of vehicles along the bridge	Noise from vehicles may exceed national standards for noise in general areas	Noise levels	Noise monitoring	Daily	Project site	Environment Officer	400,000.00	50 dB(A)	60 dB(A)	65 dB(A)	Investigation of noise generating equipment	Provide maintenance and operation works on equipment	Inspect condition of engines; Repair damages/ defects

6.6 Reporting

The reporting of the environmental monitoring will be undertaken as follows:

• Copies of the daily inspections, with the prescribed Form, will be kept on site and will be available for inspection at the request of the Environmental/Safety Officers of DPWH and the Environmental Management Bureau (EMB).

• These daily inspections and the weekly inspection, with the prescribed Form, will be the basis for the **Monthly Environmental Compliance Report (MECR)**. The monthly report will be submitted to the Project Manager by the second working day of the month. A copy shall also be forwarded to the HSE Manager.

• Any environmental incidents or emergencies will be reported immediately to the Safety and Environmental Officers of **DPWH**, the **Construction Management.**, Barangay Captain and the Barangay Councilor for Environment and the Environmental Management Bureau (EMB). Efforts must be made to contact the appropriate person(s) by phone as well. This notification and the remedial works and or actions will be recorded on the **Environmental Incident Report,** with the prescribed Form.

• Also the **Quarterly Self-Monitoring Report** will be submitted as mandated by the Environmental Management Bureau (EMB). This report will be accomplished by the Pollution Control Officer (PCO), or in this case, the Environmental Officer (EO). The report covers the DENR Permits and Clearances issued; inventory of chemical and hazardous wastes generated and their storage, treatment and disposal; water pollution data, and, the air pollution source equipment (APSE) and air pollution control facility (APCF).

6.7 Environmental Compliance Meetings

Regular Environmental Compliance Meetings will be held to discuss environmental issues. These meetings will be held at the site offices and will include representatives from **DPWH**, **Construction Management**, Barangay Captain and the designated Barangay Councilor for Environment. These meetings will be held monthly, however once the initial controls and methodologies have been installed and implemented it is expected that the frequency of these meetings will be reduced.

6.8 Environmental Education Programmes

To ensure that the requirements of the EMMP is being followed it is critical that all personnel on site are aware of the requirements of these documents and are aware of why the requirements are in place. All personnel working on it will be inducted by the Safety Officers prior to performance of work assigned. The site induction will include health and safety, traffic management, quality and environmental procedures and potential issues. At the initial site induction, environmental issues that will be discussed will be of a general nature but will include discussions on why issues exist and the general nature of the controls utilized to mitigate the effects. To continue this awareness the regular site toolbox meetings will include a monthly environmental component. This component will be site orientated to include specific issues relating to the area of work undertaken by those attending the meeting. As much as possible, these toolbox meetings will be practically-based rather than theoretical. They will include issues such as the correct installation of silt fences, contour drains and other erosion or sediment controls for areas near water bodies, taking note of wind direction and property location in regard to noise and dust control, general 'housekeeping' requirements, etc. These safety and environmental toolbox meetings will be undertaken once a week (every Friday) by the Environmental Officer.

6.9 Complaints/Inquiries

Due to the size and nature of the project, it can be expected that there will be complaints and or inquiries relating to various issues. Complaints or inquiries will be recorded on the **Complaint/Enquiry sheet.** The inquiries will be directed to the engineer-in-charge of the area or other responsible personnel. When the complaint is identified as serious or critical, the notification will be acted upon immediately. The completed complaint or enquiry sheets will be kept in the complaints register, which will be kept in the site office. A summary of complaints received and actions taken will be included in the Monthly Environmental Compliance Reports.

6.10 Construction Management Plan

6.10.1 Overview

Project component are mostly discussed in **Section 1.4** of this EIS Report. The summary of the bridge construction activities, including the navigation span bridge, and marine and land viaducts, as well as all support facilities is discussed in **Section 1.7.1.2**.

Site specific environmental requirements will be further specified by the DED consultant during the detailed design when the final construction details can be confirmed. Further details of the actual mitigation measured shall be proposed by the Contractor before the implementation of the project. The Contractor must comply with all requirements of the site-specific work of the Construction Environment Management Plan (CEMP), in addition to general requirements set out in this EIS Report.

As influx of workers are expected during the construction phase, DPWH will ensure that contractors will adopt strict policy to require and prioritize workforce from qualified locals with equal opportunities for men and women, skilled and unskilled, and PWDs. Hence DPWH will guarantee that employment will be in compliance with RA 6685 and provide trainings for hired workers. The summary of initial manpower requirements for the project is discussed in **Section 1.8** of this EIS.

6.10.2 Hours of Operation

The complete plan for the construction will be identified during DED stage, ensuring pursuant to BWC-DOLE Occupational Safety and Health Standards. The entire project alignment is 35km long and majority of it would be away from residential area. Considering the ambitious implementation programme and the offshore construction methods, it is likely that Contractor will need to work outside normal hours to achieve the programme. Such works shall be limited to the marine portion of the site where sensitive receivers are not in proximity.

On the other hand, for land based construction works on Bataan and Cavite, due consideration has to be considered as some of the land based site is close to existing residents. Work involving handling of noisy and/or vibrating power tools/ equipment shall be with maximum of 2 hours per day (for 8-hour work, duty cycle should be 1:4) in conformity to the requirements of BWC DOLE DO 1998-13 and the Occupational Safety and Health Standards (As Amended, 1989).

6.10.3 Parking of site vehicles

Works Areas will be specified in the construction contracts by the DED consultants on the possible land that the Contractor can use. The Contractor shall manage his works and workers and ensure that any activities related to the contract, including the transportation of materials, equipment and workers shall only be parked within the extent of his Works Areas, which shall be separated from the public area by hoarding. The Contractor shall carry out good site practice to minimise the impact of the dust and pollutants from the site to the public area. The Contractor may use carpool system to minimise the number of vehicles that need to be parked at the site.

6.10.4 Storage of Construction Equipment

Casting yard as discussed in **Section 1.4.2.7** will be located during the DED stage. Based on recent project experience, it is anticipated that an area of 105,000m^2 will be required on the Bataan side with access to Manila Bay, and similarly on the Cavite side, such that the two areas can be utilised for the construction of the long marine viaduct.

Both the North Channel Bridge and South Channel Bridge would require works area for storage of construction material, site office etc, similar to a normal construction work site (**Section 1.4.2.8**). In addition to the normal function and requirements for works area, this works area would also include land with easy access to Manila Bay. This is required for the construction of the foundation which would need to be constructed firstly in a dry dock. Once the precast construction is complete and ready to be floated out, the dry dock would need to be flooded. The prefabricated structural component would then be floated out for construction.

Based on recent project experience, it is anticipated that an area of 120,000m^2 and 240,000m^2 would be required for the North Channel Bridge and South Channel Bridge, respectively.

All materials needed for the concrete structures will be transported and stored in casting yard. Materials will be transported through freight or vessel. Specific procedure will be prepared as part of the project management and traffic management plan during DED.

6.10.5 Contractor's Environmental Management Plan

The complete design and methodology for the construction will be identified during DED stage. Prior to commencement of construction activities at the site, the Contractor and DPWH will undertake a briefing and joint site inspection that must include, as a minimum:

- Review of scope of works proposed for the site and conduct site familiarisation inspection;
- Review of pre-clearance site assessments, and other site environmental values;
- Review of all site-specific environmental management requirements and regulatory approvals; and
- Review and coordination for any outstanding approval requirements; and
- Coordination and action for any "no go" areas.

Detailed technical instructions or environmental procedures will be developed by the DPWH and its contractor to further enhance and alter the purpose or intent of a control measure of the CEMP. This will be complied by the contractor as approved by the executing agency.

6.11 Vegetation Removal Management Plan

This Landscape plan addresses the landscaping of areas disturbed by the permanent and temporary works. This area is the Camp Site area, including Lay Down and Car Park Area. At the completion of the works the site establishment area will be reverted to a grassed area.

The project requires approximately 5 hectares of vegetation removal; this vegetation ranges from grass through to trees. This vegetation is also located in varying topography ranging from relatively flat to moderately steep areas.

The design of the project, the resource consents and designation conditions have determined the areas of vegetation requiring removal.

6.11.1 Potential Environmental Impact

The physical works involved in vegetation removal can also result in adverse environmental effects. These effects include:

- Damage to vegetation outside those areas to be cleared
- Washing of organic material into watercourses
- Disturbance of soil resulting in sediment discharge
- Discharge of leachate from mulch stockpiles
- Noise generation from landscaping equipment
- Spillage of oils, etc from heavy equipment
- Loss of habitat and aesthetic qualities

6.11.2 Mitigation Measures

Issues such as these have been addressed and mitigated by the consents granted and the design, including final re-vegetation and landscaping design.

To minimize adverse environmental effects of vegetation removal the following measures are to be utilized when undertaking vegetation removal.

- In all planting areas, the Contractor shall break up or shatter the surface of the subsoil by ripping or harrowing to ensure that compaction is alleviated and to prepare for the installation of topsoil. The topsoil layer shall key into the surface of the subsoil. All areas shall be free draining.
- Topsoil shall be transported and handled in dry conditions only. No work shall be carried out when there is a likelihood of excess compaction and loss of soil.

- Topsoil shall be spread over the prepared subsoil evenly in one layer to a lightly consolidated depth of 150mm that preserves the friable granulated structure of the topsoil.

6.11.3 Monitoring and Inspection

Prior to commencement of vegetation removal in an area the area will be inspected, and the appropriate controls and methodologies determined. These controls and methodologies will include:

- Identification of access points to the area
- Tree inventory
- Inventory of flora species and its volume to be removed
- Perimeter definition
- Designation of stockpile areas
- Stabilization methods for exposed surfaces
- Appropriate sediment controls required

6.12 Fuel and Oil Spill Management Plan (Part of Land and Water Management)

6.12.1 Overview

The construction of the project will require the use of many items of large and small construction plant. The majority of this plant will be motorized and as such will require regular supply of fuels and oils. Motorpool and refilling station

6.12.2 Water Pollution and Wastewater Management

Anticipating the water pollution and wastewater that may be generated from varying project activities and in consideration with the project site's proximity to the water body and the marine area, the following water pollution and wastewater management system will include:
Treatment and collection of wastewater from construction activities by a third-party contractor accredited by the Department of Environment and Natural Resources Environmental Management Bureau (DENR-EMB).
Installation of a drainage system to collect rainwater

- To prevent water pollution, the drainage area will contain a filter to separate water contaminants such as oil and grease, which will be drained and collected in sump
- Installation of a well-designed silt curtain control scheme
- Separation of oil and water mixtures into separate components using oil and water separator (OWS)

All construction materials and chemicals will be properly stored and managed in secured storage area with provision of secondary containment. Silt traps will be installed for all nearby water bodies. Regular domestic waste disposal will be collected daily by a third-party

contractor to ensure cleanliness in the workplace and avoid possible water quality impacts to drainages and waterbodies.
The project will employ well-designed marine silt curtain scheme installed within the buffer of construction areas to prevent any pollution and silt disturbance due to construction activities at sea. This will also be regularly checked and monitored to avoid any significant environmental incidents.

Furthermore, as discussed in **Section 1.5.2** of this EIS Report, the proponent will ensure that the contractor will abide the Marine Pollution (MARPOL) 73/78 and Philippine Coast Guard (PCG) marine vessel operations guidelines particularly on the Regulations for the Prevention of Pollution by Garbage and Sewage from Ships (MARPOL), Prevention of Pollution from Garbage (PCG Memorandum # 07-14) Prevention of Pollution from Sewage (PCG Memorandum # 10-14) and Rules on Prevention, Containment, Abatement of Oil Marine Pollution (PCG).

6.13 Air and Noise Quality Management Plan

6.13.1 Overview

The potential air pollution will generally come from the construction and operation of back-up diesel-fueled generator sets. Construction activities associated with this project have limited potential to result in vibrations that have adverse effects on properties.

6.13.2 Air Pollution Control

Emission of air contaminants/ pollutants due to construction activities such as earthworks on site, use of heavy equipment and machineries, and other possible sources shall be minimized and if possible, avoided.

The proposed use of the following air pollution correction methods to reduce emissions or limit to a manageable range include:

- Use of well-maintained equipment, machineries, and vehicles
- Use of low sulfur fuel and ensuring fuel efficiency of equipment and vehicles
- Air pollutant concentrations will be monitored via regular sampling to ensure conformity with the National Ambient Air Quality Guideline Values (NAAQGV)

6.13.3 Noise Pollution and Vibration Control

Temporary noise barriers will be installed accompanied with monitoring of ambient noise level within the perimeter of the project and near the sensitive receptors. The management of noise pollution will be integrated with strategic scheduling of construction working hours to limit and control noise. Construction of marine structure will generate noise and vibration at the proposed site for the construction of substructure foundation of the towers and anchor piers for navigation bridges and marine viaducts. Pile driving is a method used to install piles for marine and inland water construction projects using high-energy impact hammers. Other proposed noise pollution control methods are:

- Use of hydraulic oscillator piling equipment to reduce noise and vibration

- Oscillator rigs will be specified to reduce vibrations
- Installation of air bubble curtains in the sea to reduce underwater acoustic disturbance
- Use of movable noise barriers in areas where exceeding noise levels are expected to be generated by machineries/equipment
- Regular monitoring is recommended to assess compliance with noise and vibration levels during the construction phase of the bridge project.
- Management measures for marine noise and vibration impacts on marine mammals during construction

In addition, construction vessels that will be used will have on-board noise reduction to protect construction workers from excessive noise exposure. This will be in accordance with the International Convention for the Safety of Life at Seas (SOLAS) and would limit ambient noise from on-board machineries and other noise generating equipment. Furthermore, propeller of vessels will be cleaned or polished regularly. Vessels that will be used will observe speed restriction and follow routing clearance to avoid sensitive marine areas.

6.14 Solid Waste Management Plan

The project will require a large workforce and site facilities, smoke sheds etc. Anywhere that there is a concentration of activity there is potential for an increase in litter.

6.14.1 Potential Environmental Impact

Litter is unsightly and can also result in adverse environmental effects such as:

- Contamination of watercourses.
- Blockage of culverts or watercourses and subsequent flooding.
- Can create a fire hazard.
- Can promote infestation of rodents and or insects.
- Can result in Health and Safety deficiencies.

6.14.2 Mitigation Measures

- All solid used materials will be stored in a designated Material Recovery Facilities (MRF);
- Solid wastes will be placed in a designated area with proper labeling and regular hauling to the designated disposal area

To minimize the above potential effects one of the major controls will be maintaining a tidy site, other specific controls include:

- Coordinate with the concern LGUs to integrate with their localize Solid waste Management Plan

6.14.3 Monitoring and Inspection

- Daily environmental inspections will check that the site amenities are being maintained in a tidy manner.
- Volume and type of wastes generated will be track recorded
- Hauling and Disposal

6.15 Hazardous Waste Management Plan

6.15.1 Potential Environmental Impact

- Form oils
- Concrete retarders / accelerants / adhesives / paint

6.15.2 Mitigation Measures

- The contractor shall provide and maintain a list of all hazardous and toxic substances stored and used on site.
- All hazardous materials will be stored in a separate container so they will not cause leaks or spills
- Hazardous wastes will be contained in a manner that they are properly labeled
- Material safety and data sheets (MSDS) must be displayed in the immediate vicinity of these substances.

To minimize the above potential effects one of the major controls will be maintaining a tidy site, other specific controls include:

- Providing specific areas for the disposal of surplus concrete, etc.
- Apply form oils, etc sparingly.
- Containers of paint, adhesives etc are not to be left open unless being actively used.
- Bins are to be provided for the disposal of nails, tie wire, welding rods and other sundry construction waste including packaging and containers.
- Store construction chemicals in a secure, bunded, covered facility when not in use.

6.15.3 Monitoring and Inspection

Environmental inspections will check that the site amenities are being maintained in a tidy manner.

- Volume and type of Hazardous wastes generated will be track recorded
- Hauling and Disposal by EMB accredited third party

7 Decommissioning/ Abandonment/ Rehabilitation Policy

The abandonment plan is not applicable in this type of project. This abandonment plan would mean abandonment or decommissioning of the construction team and all construction related facilities during the end of construction period.

Once the Environmental Compliance Certificate (ECC) is issued, among the conditions will be the abandonment plan. This shall be prepared ninety (90) days prior to abandonment of the area and will be submitted to DENR-EMB Central Office. Activities will include the following:

1. On-site inspection of the project site;
2. Pull out construction equipment and remaining supplies and materials;
3. Dismantling and pull out of temporary construction facilities;
4. Disposal of waste generated during construction.
5. Clean-up, remediate (if any) contaminated areas (soil or water) cause by the project during construction; and
6. Revegetation or rehabilitation of environment disturbed by the construction support facilities

8 Institutional Plan for EMP Implementation

The Institutional Plan is the establishment of a body that will implement the proposed Environmental Management Plan (EMP) whose main thrust is to ensure that environmental, socio-economic, political and public health issues are properly address in a timely manner. It provides necessary mechanism that will strengthen the organizational relationship of the proponent with the host community, concern government agencies and other stakeholders.

8.1 Environmental Unit

One condition of the project's ECC is the creation of the Environmental Unit (EU) to monitor the environmental compliance of the project. During the construction of the project the proponent must initiate the creation of the project's Environmental Unit (EU) which will be primarily composed of the proponent's Environmental Officer (EO) or Pollution Control Officer (PCO), contractors PCO or Environmental Health and Safety Officers (EHSO), subcontractors' representatives, and project engineers. The proponents' designated EO/PCO will lead the EU and coordinate with DENR-EMB CO.

The project engineers and EHSOs shall be responsible in the monitoring of the project in coordination with the DPWH - Environmental and Social Safeguards Division (ESSD), under the Planning Service. Enough resources/budget shall be appropriated to support the different environmental programs.

The created EU shall implement the Construction Environmental Management Plan (CEMP) and monitor the project's compliance with the ECC conditions of the project. The proponent's EO/PCO should be given enough authority and competence on decision-making with reference to environmental management.

The Managers, PCOs, Safety Officers, and Security Officer should have appropriate educational background and/or experience and training on environmental, community organization and development, health and safety and security risk regulations and practices.

8.2 ECC Compliance Monitoring and Reporting

The Proponent will commit to comply with the environmental laws, particularly on the conditions stated in the project's ECC.

During the pre-construction phase of the project, the DED contractor shall be required, thru their contract agreement, to incorporate in the project's design all the gathered data from the environmental baseline study, listed environmental impacts and formulated mitigation plans, and issues and concerns.

The same will be done during the construction phase of the project. The Contractor's Agreement will include the implementation of the applicable conditions of the ECC and implementation of the EMP and EMoP. The Contractor's environmental compliance will be monitored by the hired Project Management Consultants (PMC) and by the corporate PCO.

The created Environmental Unit will ensure that regular reporting of compliance to DENR standards and other regulatory agencies will be undertaken. The Self-Monitoring Reports (SMR) and Compliance Monitoring Reports (CMR) detailing status of compliance with ECC and other environmental regulations shall be submitted to DENR – EMB CO on quarterly and semiannually, respectively.

8.3 Multi-Partite Monitoring Team (MMT)

The proponent shall initiate the creation of the Multi-partite Monitoring Team (MMT). The MMT shall be responsible for the conduct of quarterly environmental monitoring of the project, as well as drafting of the Compliance Monitoring and Verification Report (CMVR) to be submitted to DENR-EMB CO on a semiannual basis.

Budget to implement the Environmental Management Plan (EMP) and for the Environmental Monitoring Fund (EMF) will be prepared during the Detailed Engineering Design (DED) and will be included in the Civil Works Contract. The budget will cover the following items:

a. All mitigation cost which includes dust suppression, installation of movable noise barriers, cutting of trees, waste management, etc.
b. Monitoring cost which includes air, water, noise, soil quality, etc.

In lieu of the Environmental Guarantee Fund (EGF), the Contractors' All Risks (CAR) Insurance will be used to compensate aggrieved parties for any damages to life or property.

8.4 Organizational Structure for Implementation

Figure 8.1 to **8.2** shows the proposed organizational structure with respective roles for the environmental monitoring and reporting.

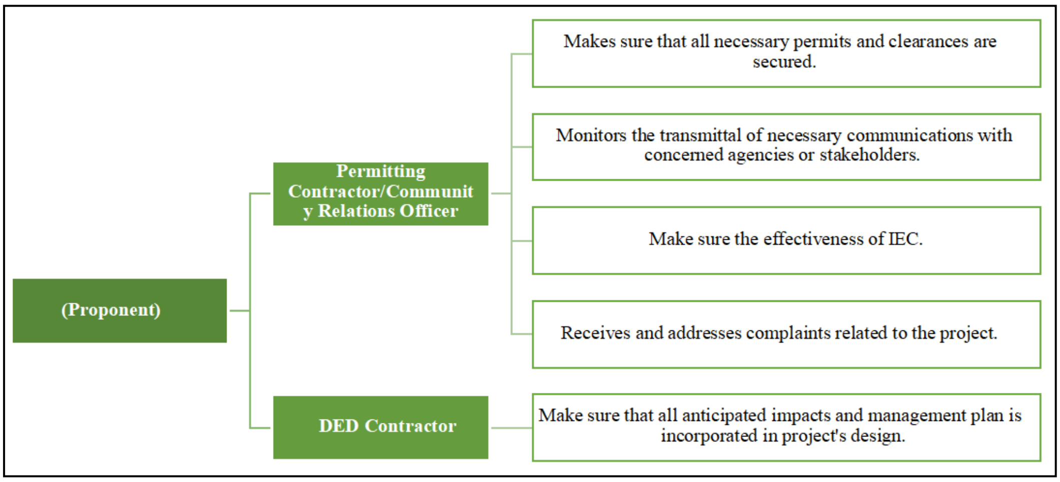

Figure 8.1 Organizational Structure for EMP Implementation during the Pre-Construction Phase

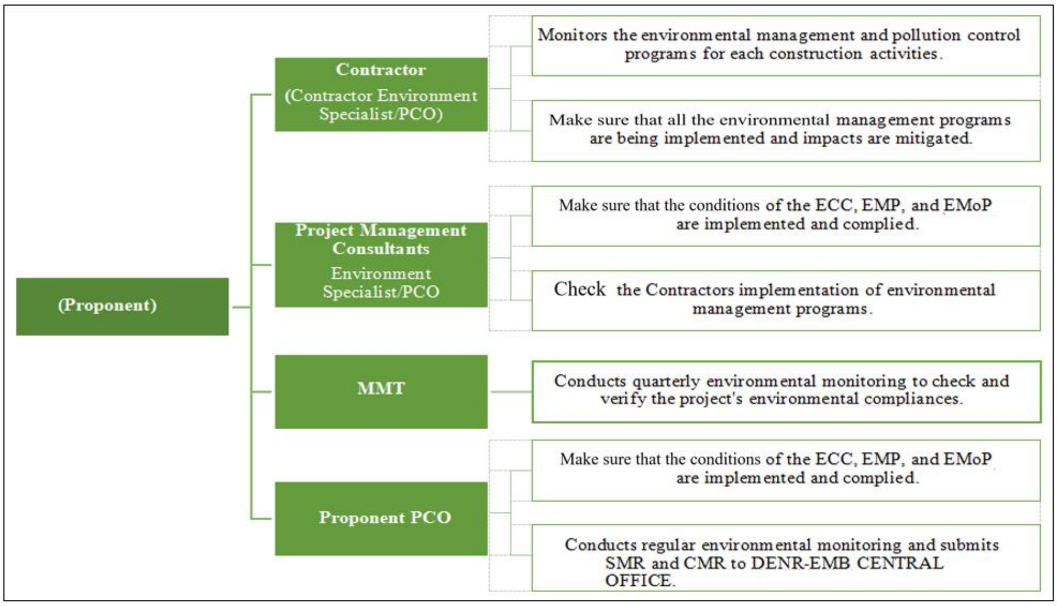

Figure 8.2 Organizational Structure for EMP Implementation during the Construction Phase

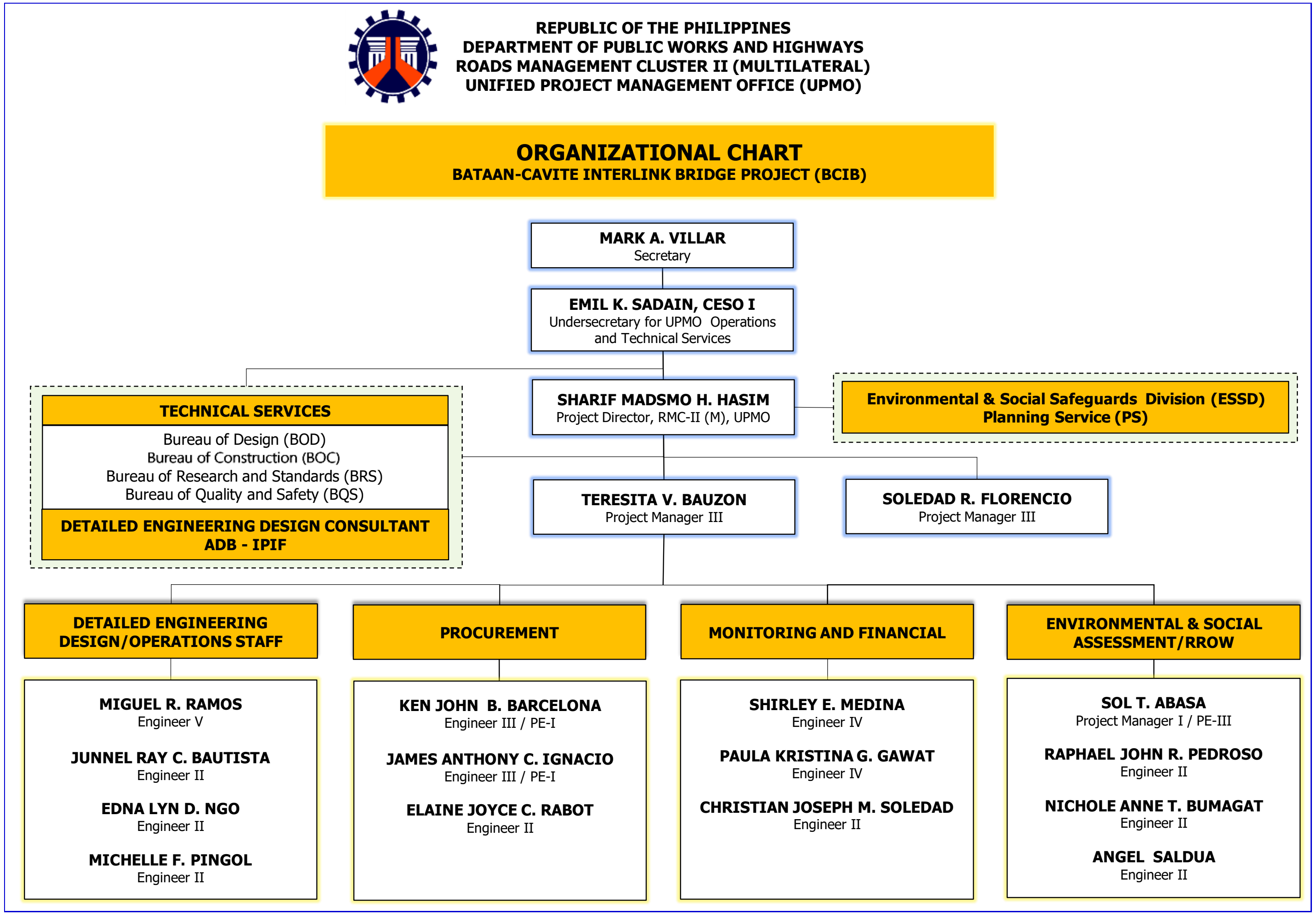

Figure 8.3 The Initial Organization Chart

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