Department of Transportation

Metro Manila Subway Project (MMSP) Phase 1

Environmental Performance Report and Monitoring Plan

Volume 1 Main Report

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Table of Contents

EXECUTIVE SUMMARY 1
Project Fact Sheet 1
EIA Process Documentation 3
EIA Summary 11
INTRODUCTION 35
Background 35
Proponent 35
EPRMP Report Structure 35

No table of figures entries found.

EXECUTIVE SUMMARY

Project Fact Sheet

About the Project

The Department of Transportation (DOTr) in partnership with the Japan International Cooperation Agency (JICA) is proposing to construct the Metro Manila Subway Project (MMSP). This railway project is part of the Build Build Build Program of the current Philippine administration.

This project has a total alignment length of 36 km running from its proposed depot Valenzuela City and to the proposed NAIA Terminal 3 Station and the interoperability area between the proposed FTI station and the Bicutan PNR Station. The project was given its Environmental Compliance Certificate (ECC) last October of 2017, **Annex ES.1-1**. However, due to a fault line discovered near the Cayetano Station, the alignment was shifted away from the fault line and thus was required to amend its ECC.

Including the additional components, the MMSP covers the following key components:

- Fifteen (15) subway stations including their corresponding;
    - Construction yards; and
    - Shield machine bases
- Underground sections in-between the stations;
- Valenzuela Depot;
- Interoperability area between FTI Station and Bicutan PNR Station; and
- Interconnections such as walkways, public utility vehicle (PUV) bays, etc.

The additional key components:

- Three (3) new subway stations;
    - Lawton East, Lawton West and NAIA Terminal 3 Stations
- The underground tunnels in-between the new stations; and
- The interoperability area between FTI Station and Bicutan PNR Station.

Name of the Project

Metro Manila Subway Project (MMSP) Phase 1

Project Proponent

Department of Transportation (DOTr)

Project Locations

Valenzuela City

- Barangay Ugong

Makati City

- Barangay East Rembo

Taguig City

- Barangay Fort Bonifacio
- Barangay Western Bicutan

Quezon City

- Barangay Talipapa
- Barangay Tandang Sora
- Barangay Bagong Pagasa
- Brgy. Project 6
- Barangay Pinyahan
- Barangay Bagumbuhay
- Barangay Blueridge A
- Barangay St. Ignatius

Pasig City

- Barangay Ugong
- Barangay San Antonio
- Barangay Oranbo
- Barangay Kapitolyo

Pasay City

- Barangay 183

Parañaque City

- Barangay San Martin de Porres
- Barangay Merville
- Barangay Bayanihan
- Barangay White Plains
- Barangay Santo Cristo
- Barangay Tandang Sora
- Barangay Malaya
- Barangay Sikatuna Village
- Barangay East Kamias
- Barangay Quirino 2A
- Barangay Quirino 3A
- Barangay Milagrosa
- Barangay Project 6

Nature of the Project

Railway Project with Depot

Total Alignment Length

36 km

Previous ECC

ECC CO 1709-0017 (Issued: 25 October 2017)

Project Components

Retained Old Alignment Components

- Valenzuela Depot
- Quirino Highway Station
  - Underground Tunnel Between Quirino Highway Station and Tandang Sora Station
- Tandang Sora Station
  - Underground Tunnel Between Tandang Sora Station and North Avenue Station
- North Avenue Station
  - Underground Tunnel Between North Avenue Station and Quezon Avenue Station
- Quezon Avenue Station
  - Underground Tunnel Between Quezon Avenue Station and East Avenue Station
- East Avenue Station
  - Underground Tunnel Between East Avenue Station and Anonas Station
- Anonas Station
  - Underground Tunnel Between Anonas Station and Katipunan Station

New Alignment Components

- Kalayaan Station
  - Underground Tunnel Between Kalayaan Station and Bonifacio Global City Station
- Bonifacio Global City Station
  - Includes the construction yards and shield machine bases for the aforementioned stations and underground tunnels
  - Underground Tunnel Between Bonifacio Global City Station and Lawton East Station
- Lawton East Station
  - Underground Tunnel Between Lawton East Station and Lawton West Station
- Lawton West Station
  - Underground Tunnel Between Lawton West Station and FTI Station
  - Underground Tunnel Between Lawton West Station and NAIA Terminal 3 Station
- NAIA Terminal 3 Station (Two Alignment Options for this Station)

- Katipunan Station
  - Underground Tunnel Between Katipunan Station and Ortigas North Station
- Ortigas North Station
  - Underground Tunnel Between Ortigas North Station and Ortigas South Station
- Ortigas South Station
  - Underground Tunnel Between Ortigas South Station and Kalayaan Station
- FTI Station
  - Alignment Between FTI Station and Bicutan PNR Station for interoperability with the North South Commuter Railway (NSCR) Project
- Includes the construction yards and shield machine bases for the aforementioned stations and underground tunnels

Indicative Project Cost

PhP 356,964.17 Million

Proponent Address

Sergio Osmeña Road, Clark Freeport, Mabalabat, Pampanga

Proponent Representative

Atty. Arthur P. Tugade, DOTr Secretary

Proponent Contact Details

(632) 790-8300

EIA Process Documentation

Process Brief

The ECC amendment and the EIA process undergone for the MMSP was conducted in accordance with Philippine EIA legislation:

- Presidential Decree 1586 (PD 1586)
- DENR Administrative Order No. 15 Series of 2017 (DAO 2017-15)
- DENR Administrative Order No. 30 Series of 2003 (DAO 2003-30)
- DENR Administrative Order No. 09 Series of 2001 (DAO 2001-09)
- EMB Memorandum Circular No. 005 Series of 2014 (EMB MC 2014-005)
- EMB Memorandum Circular No. 002 Series of 2010 (EMB MC 2010-002)

Based on the project screening guideline in EMB MC 2014-005, the proposed project is an Environmentally Critical Project that is located in a non-Environmentally Critical Area. The amendment of the ECC of the MMSP will require the conduct of an Environmental Performance Report and Monitoring Plan (EPRMP) and its submission to Environmental Management Bureau – Central Office (EMB-CO)

EIA Preparer

AECOM Philippines Inc.

Study Team Composition

Role/Specialization	Name	EIA Preparer Registration No.
Project Director/EIA Specialist/Peer Reviewer	Kathleen Anne Cruz	IPCO-164
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Socio-Economics Specialist/Social Impact Assessment Specialist	Wilfrido Palarca	
Environmental Risk Assessment Specialist	Richard Andal	IPCO-158

EIA Study Schedule

EIA Schedule 2017

Activity	Schedule	Venue / Area
Field studies		
Site survey	January to July 2017	Entire MMSP alignment
Landscape survey	May 5, 2017	Depot site in Brgy. Ugong, Valenzuela
Flora survey	April 28, July 5-18	Depot site in Brgy. Ugong, Valenzuela and all proposed stations
Ground vibration measurements	March 27 – May 4, 2017	MMSP alignment locations
Surface water quality sampling	March 1, 2017	All rivers along the MMSP alignment
Ambient air quality sampling	Dry season (March 27 – May 3, 2017) Wet season (July 10 – 27, 2017)	MMSP alignment locations
Noise measurements	March 27 – May 3, 2017 and July 10 – 27, 2017	MMSP alignment locations
Historical/Cultural heritage	May 18, 2017	BGC, Taguig City
Consultation[1]		
IEC meetings with LGUs for pre-scoping activity to introduce MMSP	December 6, 2016 – March 18, 2017	Quezon City, Caloocan City, Valenzuela City, Taguig City, Makati City, Pasig City and Parañaque City

[1] Full details included in Annex ES.1-1

Stakeholders' consultation meetings for environmental consideration and public scoping	March 9 – April 17, 2017	Makati City, Taguig City, Pasig City, Quezon City, Parañaque City and Valenzuela City
Public consultation for RAP	May 15 – 24, 2017	San Antonio, Blue Ridge, Bagumbuhay, Pinyahan, St. Ignatius, Talipapa, Tandang Sora
	April 18 – May 2, 2017	Quezon City, Makati City, Parañaque City, Pasig City, Taguig City, Valenzuela City
	June 5 – July 21, 2017	Bagumbuhay, Bayanihan, Blueridge, Kapitolyo, Merville, Oranbo, San Antonio, St Ignatius, Ugong, Bagong, Pinyahan, West Rembo, Quezon City, Makati City, Parañaque City, Pasig City, Taguig City, Valenzuela City
Public Hearings		
Public hearing – Pasig City, Makati City, Taguig City and Parañaque City	Sept 5, 2017	10th Flr. Kalayaan Hall, SM Aura Office Tower, Taguig City
Public hearing – Quezon City	Sept 6, 2017	3rd Flr., EPWMD Conference Room, Quezon City Hall
Public hearing – Valenzuela City	Sept 7, 2017	Roliing Hills Resort, Brgy. Ugong, Valenzuela City
ECC Granted	October 25, 2017	DENR- EMB Central Office

EIA Schedule 2019

Activity	Schedule	Venue / Area
Consultation		
IEC activities – Stakeholder consultation meetings	October 8 – 9, 2018	Training Room, Action Center, Brgy. Dalandanan, Valenzuela City
IEC activities – social preparation and scoping activities	May 16 – June 3, 2019	City Planning of Taguig, City Planning and Engineering of Pasay, Pasay Barangay 183, City Planning of Parañaque, Taguig Barangays (Bicutan and Fort Bonifacio) and Parañaque Barangays (San Martin De Porres)
Perception surveys	May 30 and June 4, 2019	Pasay City, Taguig City and Parañaque City
Public Scoping	July 1, 2019	Covered courts of United Hills Village, corner of Atis St. and Narra St, Parañaque
Technical Scoping	July 17, 2019	EMB Central Office
Field studies		
Ambient air quality and noise sampling	June 20-23, 2019	NAIA Terminal 3, Sitio Fort Bonifacio Health Center and Dr Arcadio Santos National High School
Wildlife surveys	June 29 – 30 and July 6 – 7, 2019	Bonifacio Global City, Lawton West and East and FTI
Perception surveys	May 30-31 and June 3, 2019	Barangay 183, Villamor (Pasay City), Barangay Fort Bonifacio (Taguig City) and Barangay San Martin de Porres (SMDP) (Parañaque City)
Vegetation surveys	June 18 – 20 and July 21, 2019	Bonifacio Global City, Lawton West and East and FTI

Traffic surveys	July 5 and July 8, 2019	NAIA Terminal 3 and FTI
Vibration surveys	July 4 – 7, 2019	Shrine of St. Therese of the Child Jesus, American Manila Cemetery and Administration building of United Hill Village
Technical Scoping	July 16, 2019	DENR – EMB Central Office
Submission of EPRMP to DENR for Procedural Screening	July 26, 2019	DENR – EMB Central Office
Public Hearings		
Public Hearing – Taguig City	August 30, 2019 (AM)	Taguig
Public Hearing – Pasay City	August 30, 2019 (PM)	Pasay
Public Hearing - Parañaque City	September 2, 2019	Parañaque
ECC completion	September 30, 2019	DNER – EMB Central Office

Study Area

This EPRMP will assess the environmental impacts and mitigations of the project throughout its 36 km alignment. However, particular focus will be given to the new shifted alignment. The succeeding presents a summary of the project components and the new components resulting from the shifting of the alignment.

As a whole, the alignment MMSP covers the following key components:

- Fifteen (15) subway stations including their corresponding;
    - Construction yards; and
    - Shield machine bases
- Underground sections in-between the stations;
- Valenzuela Depot;
- Interoperability area between FTI Station and Bicutan PNR Station; and
- Interconnections such as walkways, public utility vehicle (PUV) bays, etc.

EIA Methodology

The methodologies employed for the EIA are in accordance with the study guidelines stated in the Procedural Manual for DAO 2003-30 and the requirements set forth by the EIA Review Committee during the Technical Scoping Meeting for the ECC application process.

Module	Methodology	Source of Information / Data
Land Use and Classification	Review and analysis of secondary data on land use of the proposed project area	• Comprehensive Land Use Plans
	Georeferenced, digitized, generate and overlaid on Project Development using Geographic Information System and ground truthing. Extract lad cover data using GIS	• Open Source Satellite imageries (Google Earth, Open Street Map)

Geology, Geomorphology and Geomorphology	Assessment of geohazard susceptibility using secondary data, slope gradient analysis via ArcMap (v.10) software and historical earthquake records	• Academic studies and reports from the Philippine Institute of Volcanology and SEPRMPmology (PHIVOLCS) • Geological Hazard Maps released by PHIVOLCS, Mines and Geoscience Bureau (GMB) and National Operational Assessment of Hazards of the University of the Philippines.
	Review of historical geology of the project area	• National Mapping Resource Information Administration (NAMRIA) base maps
Pedology	Review and analysis of secondary data on soil types of the proposed project area	• Environmental Performance Report and Monitoring Plan(EPRMP) for Metro Manila Subway Project (MMSP; Phase 1) • Carating, R., Galanta, R., & Bacatio, C. (2014). *The Soils of the Philippines*. (A. Hartemink, Ed.) Madison, Wisconsin, USA: Springer. • BSWM. (2019, July). *Soil types of the Philippines*. (B. o. Management, Producer) Retrieved from Geoportal Philippines: http://www.geoportal.gov.ph/
Terrestrial Ecology	Review and analysis of secondary data on terrestrial ecology of the proposed project area Transect walk and walk-through survey Density, frequency and dominance calculation	• Environmental Performance Report and Monitoring Plan(EPRMP) for Metro Manila Subway Project (MMSP; Phase 1) • DENR Administrative Order No. 2017 – 11; Updated National List of Threatened Philippine Plants and Their Categories • Republic of the Philippines - Congress of the Philippines. Wildlife Act – Republic Act No. 9147 (2001). Metro Manila. • International Union for Conservation of Nature (IUCN) Red List of Threatened Species 2019 • AECOM. 2018 Rapid Site Assessment of Filinvest City as Part of LEED Accreditation Process. • Bajarias, A. (2016). A Field Guide to Flight: Identifying Birds on Three School Grounds (pp. 1-142). Quezon City: Ateneo de Manila University Press.

		• Birds of the Philippines - Ayala Alabang Birds. Retrieved 25 July 2019, from https://www.tonjiandsylviasbirdlist.com/Birds-By-Location/Ayala-Alabang-Birds/ • Cuyegkeng, A., Favis, A., Gotangco, K., & Tan, M. (2014). Ateneo de Manila University Sustainability Report - July 2014. • de Guia, M. 2018 (unpublished). Bird Watching Observations near the northern perimeter fence of Forbes Park • The Convention on International Trade of Endangered Species of Flora and Fauna| CITES. (2019). Retrieved 25 July 2019, from https://www.cites.org/eng/disc/species.php • Vallejo, B., Aloya, A., Ong, P., Tamino, A., & Villasper, J. (2008). Spatial Patterns of Bird Diversity and Abundance in an Urban Tropical Landscape: The University of the Philippines (UP) Diliman Campus. Science Diliman, 20(1), 1-10.
Hydrology and Hydrogeology	Review of secondary hydrologic data	• Hydro-meteorological and hydrological monitoring data from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA); • Groundwater availability map from Mines and Geosciences Bureau (MGB); • Data from the NWRB; • Data from the MMSP EPRMP (2017); • Data from available Comprehensive Land Use Plans (CLUP) of cities that will be traversed by the MMSP; • NWRB permit grantees data and • Data from other published technical information.
Water Quality	Review of secondary water quality data	• Water quality monitoring data from DENR for Tullahan River, San Juan River, Paranaque River, and Maricaban Creek;

		• Water quality monitoring data from the Pasig River Rehabilitation Commission; • Data from the MMSP EPRMP (2017); • Data from available Comprehensive Land Use Plans (CLUP) of cities that will be traversed by the MMSP; and • Data from other published technical information.
	Water quality sampling and analysis using AS/NZS 5667.1:1998 and US EPA (2007) standards	• Completed as part of MMSP EPRMP (2017)
Aquatic Ecology	Review and analysis of secondary data on aquatic ecology of the proposed project area	• Modified Visual Stream Assessment Protocol: A Field Guide. Magbanua et al. (2013) • The use of a Stream Visual Assessment Protocol to determine ecosystem integrity in an urban watershed in Puerto Rico. de Jesús-Crespo, R., & Ramirez, A. (2011). • Australian river assessment system: AusRivAS physical assessment protocol. Parsons, et al. (2002)
	Visual stream habitat field survey	
Climate and Meteorology	Analysis of weather station data	• PAGASA Climate and Agrometeorological Data Section (2018) Normals and Extremes from NAIA Terminal 3 and Science Garden Synoptic Weather Stations
	Analysis of general climate	• Climate Classification of the Philippines first established by Coronas (Coronas, 1920) and slightly modified by PAGASA (Flores & Balagot, 1969; Kintanar, 1984) • Tropical Cyclone Frequency Map (The Manila Observatory)
	Wind analysis using Windrose PRO	PAGASA Climate and Agrometeorological Data Section (2018) 30-year Daily Wind Data from NAIA Terminal 3 and Science Garden Synoptic Weather Stations
	Analysis of Climate Change Projections in	• PAGASA Climate Change Projections (2011)

	Metro Manila	
Greenhouse Gas Assessment	GHG Inventory Calculations	• Calculations based on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the Principles of GHG Accounting and Reporting in the Greenhouse Gas Protocol, and ISO 14064:2006 Parts 1 and 2
	Comparison to Philippine and global emissions	• Computed GHG emissions were compared to the global and Philippine Emissions data from: o Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectors; Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change o Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change o Philippines. Second National Communication to the United Nations Framework Convention on Climate Change
Air Quality	Review of baseline ambient air quality	• Baseline ambient air data were reviewed and collected from the project's previous EPRMP conducted by Delta Tierra Consultants, Inc. (2017)
	Primary sample collection of TSP, PM_{10}, SO_2, and NO_2 for additional sites	• The additional ambient air quality sampling was performed with reference to the ambient air sampling protocols and analytical procedures specified in DAO 2000-81 (Implementing Rules and Regulations (IRR) of the Philippine Clean Air Act of 1999): o TSP – High volume, gravimetric; o PM_{10} – High volume with PM_{10} inlet, gravimetric o SO_2 – Gas Bubbler – Colorimetric Pararosaniline o NO_2 – Gas Bubbler – Griess-Saltzman

Noise	Review of baseline noise measurements	• Baseline noise data were reviewed and collected from the project's previous EPRMP conducted by Delta Tierra Consultants, Inc. (2017)
	Primary noise measurements for new sites	• Noise levels were measured using a sound level meter meeting the requirements of IEC 61672-1
Socio-economics and Demographics	Review of secondary socio-economic data	• Comprehensive Land Use Plans (CLUPs) of host municipalities / NCR Regional Development Plan • Socio-Economic Profiles • Official websites (e.g. host LGUs)
	Conduct of IEC, focus group discussions (FGDs) and key informant interviews (KIIs)	
	Conduct of social perception survey	
Environmental Risk Assessment	Determination of Level of Coverage	• Annex 2-7e DAO 2003-30
	Determination of Risk Levels	• Risk Matrix

EIA Summary

Summary of Baseline Characterization

The schedule of activities conducted for the EIA of the Project is presented below.

Baseline Information	Key Findings and Conclusions
Land Cover	The whole region of Metro Manila is classified under the Land Cover type of Built-up areas and Arable lands crops mainly cereals and sugar. Parts of the MMSP alignment traverse across the land classification of Arable lands (7.5%) while majority of the alignment falls under the Built-up zone classification (74%).
Land Use	The identified Land Use of the MMSP disturbance footprint are Residential (40%), Mixed Use (17%), and Commercial (16%). This is based from the consolidated Zoning Plans from the different cities which will be affected by the project.
Land Utilization	Upon visual inspection of the Google Earth images, it can be concluded based from this study that the MMSP Components (construction yard, underground station boxes, and the interconnection between stations) that the actual land use in the ground would mostly affect Commercial lands and Institutional zones, in general. The area of the proposed depot can be generalized as an Industrial zone. While, the FTI Station is within the Medium-density Residential zone.
Protected Area	The nearest declared Protected Areas (PAs) from the MMSP is the Ninoy Aquino Parks and Wildlife Center (NAPWC), which is around 740 meters southwest north-east away from MMSP, and the Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) which is around 5.3 km south-west away from MMSP. The MMSP has no significant influence to both declared PAs.
Impact to the Land Use	The impact of the MMSP during pre-construction would be the displacement of the residents within the Residential zones especially in the construction the envisioned transportation hub in FTI Station. Also, rights-of-way of the villages (entrance and exit) along East Service Road

	would be a possible impact alongside with the potential vehicular traffic congestion during construction of the project. Furthermore, during the earl stage of the operation, the vehicular traffic would be displaced to the other roads/routes. The development of a Station within the vicinity of McKinley West Village (Lawton East Station) will be a threat to the amenities (e.g. solemnity and privacy of the place; and view value from the real estate properties) would eminent. Though, it is expected that land values would rise near the alignment of the project.
Topography	The MMSP alignment is located within the Central Plateau region of Metropolitan Manila, with elevations ranging from 6 – 54 masl and slope gradients of 0 – 8 %.
Hydrogeologic Setting	The MMSP alignment will cross at least 11 rivers and creeks, including major rivers like the Pasig River, San Juan River and the Tullahan River.
Geodynamic Setting	The MMSP alignment is located within a sEPRMPmically active region of the Philippines affected by active subduction (Manila Trench), fault movement (West Valley Fault), and Recent volcanism (Taal Caldera, Mt. Pinatubo and Laguna Caldera).
Local Geology	The MMSP track will burrow through mostly Guadalupe Formation tuff underlain with up to 10 m residual soil along its alignment. The Vs30 model from PHIVOLCS shows that the East Avenue to Ortigas Stations has shear-wave velocities ranging from 760 – 1500 m/sec, indicating NHERP Site Class B (rock) condition. The rest of the alignment has Vs30 ranging from 360 – 760 m/s, indicating Class C (hard soil) condition.
Structures	The MMSP alignment has been designed to avoid the known trace of the West Valley Fault. The alignment is closest to this fault along the segment from Ugong Norte to Capitol Commons in Pasig, with distances of 150 – 700 m. Initial borehole scan results show presence of structural defects such as joints, fractures, shears, etc. in each surveyed hole, indicating that the foundation is layered and non-massive.
SEPRMPmic Hazards	The MMSP alignment may experience ground shaking of 0.371 – 0.662 g caused by a Magnitude 7.2 movement of the West Valley Fault. This is equivalent to PEPRMP Intensity VIII (i.e. Very Destructive) shaking. Other potential strong earthquake generators are the East Valley Fault, Laguna – Banahaw Fault, Philippine Fault Zone (Infanta Segment) and the undetermined source of the 1863 Manila earthquake. Probabilistic SEPRMPmic Hazard Assessment, as presented in the Philippine Earthquake Model by PHIVOLCS, show 0.35 – 0.5 g shaking along the MMSP alignment with a 10% probability of exceedance in 50 years (i.e. 500-year return period). 0.45 – 0.7 g shaking along the alignment is predicted to have 5% probability of exceedance in 50 years (i.e. 2,500-year return period). The MMSP alignment avoids the known trace of the West Valley Fault, so ground rupture resulting from its movement is unlikely along the track. However, unmapped buried splays of the fault may possibly be encountered while drilling. The MMSP alignment is founded on soil that is generally not susceptible to liquefaction. The exception is along the Pasig River crossing, which is highly susceptible to liquefaction. Most of the MMSP alignment lies within areas that are not susceptible to earthquake-induced

	landslide, except for segments between the Katipunan Avenue in Pasig and McKinley Parkway in Taguig. The MMSP alignment is not susceptible to tsunami due to its distance (3.8 km at the NAIA T3 Station and 1.9 km from the Bicutan Interconnection) and elevation (13 and 37 masl, respectively) from the coast.
Pedology	The soils along the Depot to Ortigas South Station belong to the Novaliches series, except for the Katipunan Station which is underlain with Marikina series soil. From the Kalayaan Station down to the NAIA T3 Station and Bicutan Interconnection, the soil cover belongs to the Guadalupe soil series. Both Novaliches and Guadalupe series soils are derived from Guadalupe Formation tuffs (Diliman Tuff member), while the Novaliches series soil developed from alluvial deposits within the Marikina Valley.
Mass Movements	The MMSP alignment is located in areas that are not generally susceptible to landslide. A higher susceptibility rating (i.e. Low) is given to significant portions of the proposed alignment within Quezon City, from Quirino Highway Station down to Katipunan Station. The proposed stations in Pasig—Ortigas North Station and Ortigas South Station, also are within an area of Low rainfall-induced landslide susceptibility. The southern segment, from Kalayaan Station to FTI Station are not susceptible to landslide. The Depot is the component of the MMSP most susceptible to subsidence, as shown in the PSInSAR map indicating local subsidence in that area due to extensive groundwater extraction.
Hydrological Hazards	The MMSP alignment is located on areas that have generally No to Low flooding susceptibility, except along portions that intersect rivers and creeks where flooding susceptibility can be Moderate to High. Almost the entire segment from Ortigas North Station down to NAIA T3 and Bicutan are located in areas that have Low susceptibility to flooding. The MMSP alignment is not susceptible to coastal hazards such as storm surge, tsunami and sea level rise resulting from climate change or coastal subsidence due to its distance (3.8 km at the NAIA T3 Station and 1.9 km from the Bicutan Interconnection) and elevation (13 and 37 masl, respectively) from the coast.
Volcanic Hazards	The MMSP alignment can be affected by strong ground shaking, resulting from explosive eruptions of Taal Volcano. Being largely underground, it is not susceptible to ashfall.
Land Cover and Terrestrial Vegetation Community Structure	Two unique land cover types were identified from the most recent land cover map from NAMRIA, which includes (1) built-up areas and (2) arable lands for crops. Based on the vegetation surveys (EPRMP 2017 and additional studies (2019), vegetation communities were mainly comprised of arborescent species interspersed in the remaining green spaces in the NCR.
Flora Species Inventory	**EPRMP (2017)** Recorded a total of 217 plant species belonging to 88 genera and 69 Families along the proposed 13 stations and train depot. Taxa richness were as follows: 86 species of trees, 43 species of herbs, 39 species of shrubs, 16 species of climbers, 13 species palms, 12 species of fodder grasses, 3 species of ferns, 2 species of erect bamboos, one (1) species of sedge, one (1) species of pandan, and one (1) species of orchid.

	Additional Assessment (2019) A total 98 morpho-species in 82 genera and 36 Families were recorded along the four (4) transects. Dominant families were Fabaceae (13 species), Moraceae (10 species), Arecaceae (6 species), and Myrtaceae (5 species). The most frequently occurring species were *Pterocarpus indicus* (Narra; 272 individuals), *Swietenia macrophylla* (Big leafed mahogany; 97 individuals), *Terminalia catappa* (Talisai; 77 individuals), *Albizia saman* (Akasya; 66 individuals), and *Delonix regia* (Fire tree; 35 individuals).
Endemicity and Conservation Status of Plants	**EPRMP (2017)** Of the 217 species, only three (3) species were Philippine endemic, namely *Ficus ulmifolia* (Is-is), *Artocarpus blancoi* (Antipolo), and *Caryota mitis* (Pugahang Sui). Sixty-three species (29%) were considered indigenous/native to the Philippines, with existing natural distributions extending beyond the region. The remaining 151 species (70%) are all introduced/exotic. A total of nine (9) species were categorized under IUCN 2019 and DAO 2017-11. Noteworthy among the list were *Adonida merrillii* (Manila palm), *Dypsis lutescens* (Butterfly palm), *Hyophorbe lagenicaulis* (Champagne palm), *Pterocarpus indicus* (Narra), *Vitex parviflora* (Molave), *Swietenia macrophylla* (Big leafed mahogany), *Artocarpus blancoi* (Antipolo), *Ficus ulmifolia* (Is-is), and *Nephelium lappaceum* (Rambutan). **Additional Assessment (2019)** Of the 98 morpho-species, only four (4) species were endemic to the Philippines. These include *Ficus balete* (Balete), *Ficus pseudopalma* (Niog-niogan) and *Ficus ulmifolia* (Is-is). The other endemic species is a Batanes-endemic gymnosperm called *Podocarpus costallis* (Arius). There were eight (8) species recorded that are classified as threatened under the updated national list of threatened Philippine plants and their categories (DAO 2017-11) and/or the IUCN Red list of threatened species (2019-1). These are *Podocarpus costalis* (Arius), *Pterocarpus indicus* (Narra), and *Ficus ulmifolia* (Is-is). *Podocarpus costalis* (Arius), an endemic species from Batanes is categorized as endangered under DAO 2017-11 and IUCN 2019-1. *Pterocarpus indicus* (Narra) is categorized as endangered in IUCN 2019-1 and vulnerable in DAO 2017-11. Lastly, *Ficus ulmiforlia* (Is-is), an endemic species recorded during opportunistic survey is categorized as vulnerable under IUCN 2019-1.
Density, Frequency and Dominance of Plants	Summary of the computed species diversity index values for EPRMP (2017) and the additional assessment (2019) are presented in the tables below: **EPRMP (2017) and Additional Assessment (2019)**

Station	Diversity Index (H)
Quirino Highway Station	2.57
Tandang Sora Station	1.23
North Avenue Station	2.33
Quezon Avenue Station	2.07
East Avenue Station	2.31

	Katipunan Avenue Station	2.39
	Ortigas North Station	2.21
	Ortigas South Station	2.18
	Kalayaan Avenue Station	0.89
	Bonifacio Global City Station	0.00
	FTI Station	2.57
	Transect 1 (T1)	3.35
	Transect 2 (T2)	0.97
	Transect 3 (T3)	1.93
	Transect 4 (T4)	2.17
Vulnerability to Climate Change of Plants	Expected sporadic increases in terms of ambient temperatures and extreme weather conditions (i.e., high precipitation events, strong typhoon-mediated winds, intense irradiance) in the coming decades could potentially impact the optimal growth rate, mortality rate, and survival rate of various tree species found within and near the surveyed areas.	
Hydrology and Hydrogeology – Drainage system of the project	The entire MMSP project site is located within the Manila Bay Catchment Area, and straddles seven catchments that form part of the Pasig-Marikina-Laguna de Bay Basin. The Laguna de Bay Basin is one of the four major river basins of the Manila Bay Catchment Area. The seven catchments traversed by the MMSP alignment include the Tullahan River Catchment, San Juan River Catchment, Marikina River Catchment, Pasig River Catchment, Pateros River Catchment, Paranaque River Catchment, and Muntinlupa River Catchment. The alignment will cross at least 9 rivers/creeks, albeit underground, except for the unnamed creek that will be directly crossed by the Quirino Highway Station.	
Flooding	The MMSP alignment traverses areas along Metro Manila that have moderate to high flooding susceptibility. These areas include the Valenzuela Depot, Quirino Highway Station, Tandang Sora Station, Quezon Avenue Station, East Avenue Station, Katipunan Station, Anonas Station, Lawton East Station, Lawton West Station, and FTI Station.	
Groundwater Environment	The area traversed by the MMSP consists of Class I (B) and Class I (C) aquifers. Class I (B) aquifers are fairly extensive and productive aquifers with moderate to high permeability while Class I (C) aquifers are considered local and less productive aquifers, with well yields mostly about 2 L/s but as high as 20 L/s in some sites. A total of 46 deep wells have been granted by the NWRB within a 1 km radius of the MMSP realignment site. As per the NWRB water listing, the static water level and drawdown of deepwells with available pumping test data located within the 1 km radius of the subway alignment ranged from 21.31 to 141.73 meters below ground level (mbgl) and 5.30 to 21.34 mbgl.	
Water Users	Metro Manila's water supply is provided by the Manila Water Company, Inc. (MWCI), and Maynilad Water Services, Inc. (MWSI). Individual houses in Metro Manila not connected to MWCI's or MWSI's distribution system have their own wells or get their water from communal	

	wells. A walkthrough survey of some of the host communities of the MMSP expansion site in Taguig City and Pasay City identified at least 20 perennial wells with approximate depths ranging from 9 to 20 m (based on information from well owners). These wells are used by residents for domestic purposes such as drinking (boiled prior to consumption), cooking, bathing, and cleaning.
Surface water quality	Tullahan River, San Juan River, Pasig River, and Maricaban Creek are currently heavily polluted and have poor water quality, with elevated concentrations of BOD, DO, phosphates, and fecal coliform that exceed the DAO 2016-08 Class C WQG
Groundwater quality	Water from the two groundwater deep wells sampled during the 2017 EPRMP meet the PNSDW except for fecal coliform levels in the Valenzuela City deepwell. Both deep wells are rarely used by the community and are used only as a back up source of water supply (Delta Tierra Consultants, Inc., 2017).
Water quality - Existing sources of pollution	Sources of pollution that contribute to the degradation of Tullahan River, San Juan River, Pasig River, Maricaban Creek and Paranaque River include solid wastes from domestic, commercial, and industrial activities, and wastewater discharges from households, commercial/institutional establishments, and industries
Aquatic ecology	• Maricaban Creek Channel flow across the waterway is apparently low. Coupled with altered stream channel as a result of built-up concrete structures (i.e., perimeter walls, concrete ledges, bank reinforcements), having reduced channel flow entails less available microhabitat for resident aquatic biota. stream velocity and depth regime is somehow complex, as evidenced by the mixture of slow-deep and slow-shallow areas. Bank stability is good due to the observable bank strengthening components from both banks. Observed bank vegetative zone was relatively good. Notable riparian species include different varieties of figs (Ficus sp.) along the majority of the creek margin, which are important food sources for various insect and pollinator species thriving in the area. Sediment deposition was not common for the most part of the creek and canopy cover was variable. Overall, stream health in Maricaban Creek falls under the poor condition rating. • Don Galo Creek Low gradient stream courses through a highly residential area, with characteristic bank fortification structures along the entire surveyed stream channel. Channel flow was relatively good and comparatively higher in that the volume of water present in the channel reaches the majority of the stream cross-sectional area. Sparse vegetation communities was interspersed along the margins of the creek, as the bank vegetative zone width is reduced as a result of the construction of concrete-enriched stream banks. Canopy cover was relatively fair and could be attributable to the patchy distribution and dispersed orientation of the vegetation species in the immediate riparian buffer, whereas the vegetation zone width was low. Overall, the stream health in Don Galo Creek falls under the poor condition rating.

General Climate	• The project site is in an area classified as Type I based on the Modified Coronas' Classification. This climate type is characterized as having two pronounced seasons: dry from November to April and wet during the rest of the year. Maximum rain period is from June to September.
Monthly Rainfall	• The total monthly raindfall at the PAGASA synoptic weather station in NAIA Terminal 3 ranges from 4 mm (March) to 418.4 mm (August). The total annual rainfall amounts to 1,767.90 mm with an annual number of rainy days of 105 days or approximately 29% of the year. The rainfall in the PAGASA synoptic weather station in Science Garden were higher. The total rainfall ranges from 14.6 mm (February) to 504.2 mm (August) with a total annual rainfall of 2,574.30 mm. The annual number of rainy days is 151, corresponding to 41.4% of the year. • The highest daily rainfall recorded at the NAIA Terminal 3 was 472.4 mm on July 20, 1972. For the PAGASA Science Garden weather station. The highest daily rainfall was 455.0 mm on September 26, 2009 during Typhoon *Ondoy* (International name Ketsana)
Temperature	• At NAIA Terminal 3, the mean temperatures ranged from 26.1 °C (January) to 29.7 °C (May), with an annual average mean temperature of 27.8 °C. Although the temperature ranges (difference between maximum and minimum temperatures) are higher in Science Garden, the average annual mean temperature is similar (27.7 °C). The coldest month is January (25.7 °C) while May is the hottest (29.7 °C). In both weather stations, temperatures are usually higher the MAM period and lower during the DJF period. • The highest temperature recorded in NAIA Terminal 3 was 38.2 °C on May 18, 1969, while the coldest was 14.6°C on February 1, 1962. At the PAGASA Science Garden, the highest temperature was 38.5 °C on May 14, 1987, while the coldest was 14.9 °C on March 1, 1963
Relative Humidity	• The annual average relative humidity are 76% (NAIA Terminal 3) and 78% (Science Garden). August and September are the most humid months with average relative humidity of 76% and 79%, respectively, while the month of April is the least humid at 67% in both weather stations.
Wind	• Long-term wind data indicate that the average wind speeds in NAIA Terminal 3 and PAGASA Science Garden ranges from approximately 2.2 m/s to 3.2 m/s, and 1.9 m/s to 2.3 m/s, respectively. Based on the Beaufort Wind Force Scale, these wind speeds are classified as 'light breeze.' • Wind rose analysis of the 30-year daily wind data at the PAGASA synoptic weather station in NAIA Terminal 3 shows that the prevalent wind direction is to the west, east, and southeast directions. The wind directions are to the east and southeast directions during the months of October to April and starts to shift to the west in May, lasting until September. At the PAGASA synoptic weather station in Science Garden, the wind direction throughout the year is predominantly to the north. From October to April, the predominant wind direction is to the north, and shifts to the south and southwest directions from May to

	September. These characteristics are consistent with the two principal airstreams that dominate the Philippines: the Northeast Monsoon (*Amihan*) which prevails from October to April and the Southwest Monsoon (*Habagat*) which is prevalent from May to September. • Polynomial trend analysis shows that the average monthly wind speed in NAIA Terminal 3 based on the 1989 to 2018 dataset is highest during the MAM season and lowest in SON. In Science Garden, the windspeeds were highest during the JJA season and lowest during the DJF season.
Tropical Cyclone	• The project site is in an area traversed by 24 tropical cyclones in 12 years (two tropical cyclones per year)
Climate Change Projection for Rainfall	• The simulations indicate that for the medium-range emission scenario, rainfall is expected to decrease during the dry seasons (DJF and MAM) and increase during the wet seasons (JJA and SON) in both time-slices, making the dry season drier and the wet season wetter.
Climate Change Projection for Temperature	• The results of the simulation show that ambient mean temperatures have an increasing trend in 2020 and 2050 from the baseline. For the medium-range emission scenario, the temperature will range from 27.1 °C to 29.9 °C in 2020 and 29.3 to 30.9 °C 2050. In both 2020 and 2050 time slices, MAM is projected to be the warmest season every year.
Global Greenhouse Gas Profile	• Total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute decadal increases toward the end of this period. • CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emission increase from 1970 to 2010, with a similar percentage contribution for the period 2000-2010. • About half of cumulative anthropogenic CO_2 emissions between 1750 and 2010 have occurred in the last 40 years. • Annual anthropogenic GHG emissions have increased by 10,000 million tonnes of CO_2-e between 2000 and 2010, with this increase directly coming from energy supply (47%), industry (30%), transport (11%), and buildings (3%) sectors. Accounting for indirect emissions raises the contributions of the buildings and industry sectors. • Globally, economic and population growth continue to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply. • The IPCC Fifth Assessment Report (AR5) estimated that the worldwide anthropogenic greenhouse gas emissions totaled nearly 49 billion tonnes of CO_2-e in 2010.
Philippine Greenhouse Gas Profile	• An inventory of GHG emissions conducted in 2000 showed that the Philippines emitted approximately 21.767 million tonnes of CO_2 -e (including LULUCF[2]). • The Philippine GHG emissions in the year 2000 due to fuel consumption was estimated to be at 69.67 million tonnes of CO_2 –e (excluding LULUCF[6])

[2] *Land Use, Land Use Change, and Forestry- is the subset of Agriculture, Forestry and Other Land Use (AFOLU) emissions and removals of GHGs related to direct human-induced land use, land-use change and forestry activities excluding agricultural emissions and removals*

Particulate Pollutants	• The 24-hour ambient air quality monitoring along the MMSP's alignment ranges from 57.5 µg/NCM (Station A1) to 204.3 µg/NCM (Station A13) during the dry season, and 51 µg/NCM (Station A14) to 521 µg/NCM (Station A1). All ambient air quality monitoring stations are within their DAO 2000-81 NAAQGV (230 µg/NCM) except for Stations A1 (521 µg/NCM), A2 (248 µg/NCM) and A10 (265 µg/NCM). Based on Annex A of DAO 2000-81. The ambient air quality along the Project's alignment in terms of TSP is 'good' to 'acutely unhealthy.' • The 1-hour TSP in the three stations were 25 µg/NCM, 31 µg/NCM, and 32 µg/NCM, respectively. All monitoring stations are within the DAO 2000-81 NAAQS (300 µg/NCM). • PM_{10} concentrations ranged from 37.2 µg/NCM (Station A6) to 81.4 µg/NCM (Station A13) during the dry season and 25.2 µg/NCM (Station A14) to 209 µg/NCM (Station A1) during the wet season in the stations along the MMSP. All ambient air quality monitoring stations are within their DAO 2000-81 NAAQGV (150 µg/NCM) except for Stations A1 (209 µg/NCM), A2 (191 µg/NCM), and A12 (193 µg/NCM). Based on Annex A of the DAO 2000-81, the ambient air quality in the stations along the MMSP alignment in terms of PM_{10} is 'good' to 'unhealthy to sensitive groups.' • The 1-hour PM_{10} concentrations in Stations AN1, AN2, and AN3 where 19 µg/NCM, 21 µg/NCM, and 25 µg/NCM, respectively. All stations are within the DAO 2000-81 NAAQS (200 µg/NCM).
Gaseous Pollutants	• The 24-hour NO_2 concentrations in all monitoring stations ranged from 15.7 µg/NCM (Station A1) to 37.3 µg/NCM (Station A11) during the dry season and 4.5 µg/NCM (Station A3) to 86 µg/NCM (Station A10) during the wet season. All stations were within the DAO 2000-81 NAAQGV (150 µg/NCM). • The1-hour NO_2 concentrations in Stations AN1, AN2, and AN3 were 17 µg/NCM, 64 µg/NCM, and 20 µg/NCM, respectively. All stations are within the DAO 2000-81 NAAQS (260 µg/NCM). Annex A of DAO 2000-81 has no prescribed index for NO_2 concentrations below 1,220.5 µg/NCM. • The concentrations of 24-hour SO_2 ranged from below detection limit (<4 µg/NCM) (Stations A9 and A13) to 5.3 µg/NCM (Station A1) during the dry season and below detection limit (<4 µg/NCM) (Stations A2, A3, A4, A5, A7, A9, A11, AN1, and AN2) to 17.1 µg/NCM (Station A1) during the wet season. All stations are within the DAO 2000-81 NAAQGV (180 µg/NCM). Based on Annex A of the DAO 2000-81, the ambient air quality in the monitoring stations along the MMSP alignment is 'good.' • The 1-hour SO_2 concentrations were 16 µg/NCM, 20 µg/NCM, and 23 µg/NCM, respectively. All stations are within the DAO 2000-81 NAAQS (340 µg/NCM).
Lead and Ozone	• Lead (Pb) and Ozone (O_3) were monitored for the dry season in 2017 in Stations A1, A5, A6, A9, A11, and A13. The concentrations of Pb and O_3 were undetected in all monitoring stations and below the DAO 2000-81 NAAQGV for Pb (1.5 µg/NCM) and O_3 (140 µg/NCM)

Existing Sources of Pollutants	• TSP and PM_{10} are generated when fossil fuel is consumed by vehicles. In addition, fugitive emissions of these particulate pollutants are released into the environment through wheel entrained dusts from roads. Dust kicked up by vehicles traveling on roads may make up 33% of air pollution. Road dust consists of deposits of vehicle exhausts and industrial exhausts, particles from tire and brake wear, dust from paved roads or potholes, and dust from construction sites. Road dust is a significant source contributing to the generation and release of particulate matter into the atmosphere. Control of road dust is a significant challenge in urban areas, and in other locations with high levels of vehicular traffic upon unsealed roads, such as mines and landfill dumps. • SO_2 and NO_2 are generated from the combustion of fossil fuel by vehicles.
Noise Levels	• For dry season, areas with relatively more residential areas have lower noise pollution levels compared with other stations. However, as some of these stations are situated near major roads, the application of correction factor showed that some of these stations exceeded their respective standards, except for a few residential and parking lot areas. For wet season, the survey sites generally had elevated noise levels except for some residential areas. Across seasons, some survey sites still exceeded the maximum tolerable noise standards, while only two (TriNoma and Brgy. Blue Ridge sites) among the common monitoring stations had significant changes.
Existing Sources of Noise	• Based on the land use categories and the results, noise associated with commercial, residential, and industrial activities can be considered as existing sources of noise pollution.
Wildlife species inventory	• A total of 213 species comprised of six (6) amphibians, 12 reptiles, 184 birds, and 11 mammals was recorded along the MMSP (original and revised) alignment, and nearby major greenspaces. • Recorded birds (184 species) represent approximately 37% of the known total for Luzon mainland (493 species).
Summary of range distribution	• Range distributions was dominated by native but non-endemics/ resident breeding non-endemics with 92 species or 43% of the total. • Other range distributions noted were: migratory birds with 67 species or 31% of the total, endemics with 29 species or 14% of the total, introductions with 19 species or 9% of the total, and migrants with resident breeding populations with six species or 3% of the total. • Endemics were relatively high despite the available habitat.
Conservation Status (Threatened, Near Threatened, and Least Concern)	• Majority of recorded wildlife are Least Concern with 182 species or 85% of the total based on IUCN 2019 and RA 9147/ CITES 2019. • At least 28 species or 13% of the total (composed of four reptiles and 24 birds) are included in various conservation listings based on IUCN 2019 and RA 9147/ CITES 2019. • Five (5) of these threatened species are introduced or not originally from the Philippines. • Three (3) species are Near Threatened based on IUCN 2019.

Hindrance to wildlife access, historical occurrences of pest infestation, forest/grass fire, and/or similar incidences	• The MMSP (original and revised) alignment and surrounding areas are highly urbanized and the original vegetation therein have long been removed and converted into development areas. • Wildlife access across the entire MMSP alignment is fragmented due to the absence of original vegetation and various development. Remaining wildlife habitats are limited within the 27 major greenspaces. • Major disturbances are growing human population, pollution, and conversion of natural habitats and remaining greenspaces to built-up areas.
Vulnerability to Climate Change	• As the NCR area is extra vulnerable to the effects of climate change due to high pollution levels, absence of good vegetation cover, and increased flooding incidents, these may add-up to the projected sporadic increases in terms of ambient temperatures and extreme weather conditions. Said conditions may potentially impact the already limited wildlife populations in the NCR and overall health of the few remaining greenspaces.
Vibration	•
Demographic Profile	In all three cities, about half the population is less than 27 years old with the largest population group in age 20 – 29; the lowest, 80 and over. There are about 40 – 45% young (0-14) and old (65 and over) people who are dependent on the working age population (15 – 64). Population growth rate ranges from 1.12% (Pasay, the lowest) to 4.32% (Taguig, the highest and almost four times the rate of Pasay).
Socio-Economic Profile	**Taguig City** • Highly Urbanized City • 53.67sqkm (5,367ha) land area; 8.66% of NCR • 28 barangays • First Class City: PHP5.56 Billion regular revenue (fiscal 2016) • Annual Population Growth Rate: 4.32% (2010-1015) **Barangay Fort Bonifacio** • 2.4sqkm (240ha); 4.47% of City Includes within its jurisdiction Fort Bonifacio (military camp), Bonifacio Global City (business, financial, and lifestyle district) **Pasay City** • Highly Urbanized City • 13.97sqkm (1,397ha) land area; 2.25% of NCR • 201 barangays • First Class City: PHP3.53 Billion regular revenue (fiscal 2016) • Annual Population Growth Rate: 1.12% (2010-2015) **Barangay 183** • 53 hectares; 3.79% of City Formerly part of military base (Philippine Airforce). Includes Newport City (lifestyle district), NAIA Terminal 3

	Pasay City • Highly Urbanized City • 13.97sqkm (1,397ha) land area; 2.25% of NCR • 201 barangays • First Class City: PHP3.53 Billion regular revenue (fiscal 2016) • Annual Population Growth Rate: 1.12% (2010-2015) **Barangay 183** • 53 hectares; 3.79% of City part of military base (Philippine Airforce). Includes Newport City (lifestyle district), NAIA Terminal 3
Public Health Services	Primary, secondary and tertiary health care and services are available in Taguig, Pasay and Paranaque. Primary health care is available in all barangays through the health centers of the municipal government. A world class and internationally accredited tertiary facility, St Luke's, is located in Bonifacio Global City, Taguig. Each city maintains a city-owned hospital.
Cultural Heritage	There are three cultural heritage sites near the project alignment; Bonifacio War Tunnel, the American War Memorial and Cemetery and the Nutrition Center of the Philippines (Interior Design). The closest to the alignment is the Nutrition Center of the Philippines at 25 meters.
Transport and Traffic	The existing transport systems near the project include road, railway, mass rapid transit, light rail transit, air transport, water transport and other modes of public transportation such as Public Utility Jeepneys, Asian Utility Vehicles and tricycles. Due to the road capacities and volume of traffic some nearby roads currently have a low level of service.
Perception of the Project	**Barangay 183** • The respondents constituted household members, property owners, tenants, and business owners. A total of 98 respondents were surveyed, 53 of which were female (54 %) and 45 were male (46 %). • Majority of the respondents (54 % or 52 individuals) in Barangay 183 answered that they do not have prior knowledge about the project, while 44 individuals (46 %) responded that they were aware about the project **Barangay Fort Bonifacio** • Targeted respondents were office workers near the direct impact areas, vendors, and residents. A total of 100 respondents were interviewed in the barangay, 58 of which were male (58 %) and 42 were female (42 %). • In general, respondents of the barangay were aware about the project (72 %), primarily sourcing the information from mass media (73 %). Others were aware of the project from the government and barangay officials (15 %), while others from relatives, neighbors, and friends (12 %). **San Martin de Porres** • The respondents were a diverse group of property owners, tenants, business owners and their employees. The survey was conducted upon the IEC to the Barangay Chairman and officials, as well as to the officials of the Homeowners' Association of the affected village.

		• Majority of the respondents from SMDP stated that they have prior knowledge about the project (76 %)	

Key Impacts and Mitigation

The key impacts of the Project and proposed mitigation measures are presented below.

Project Phase	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention, Mitigation or Enhancement
Pre-construction, Construction, Operation, Closure	Land Use	*Change or inconsistency in land use and potential tenurial issues*	
		Some of the locations of the MMSP Station is within Residential zones, and most of the areas are within Commercial zones. Displacement of the residents within the Direct Impact Area of the station developments (transport hubs and station plazas) will be done.	• Doing the right practices with regards to the negotiations with the concerned parties pertaining to land acquisition should be done. Fair market value should be determined by providing a clear reference to the applicable legal instrument.
		Potential impact of the project to the other Subway Projects in Metro Manila (e.g. Makati Subway Project), such as intersection of the alignments.	The DOTr should continuously coordinate with the LGUs and other related government agencies (e.g. DPWH, MMDA) and secure the necessary permits, endorsements, and clearances required for the construction. • The depth of the underground activity of the project should closely coordinated with the authorities handling the other Subway Projects within Metro Manila.
		Land disputes	• Secure easement agreements with the owners of the properties in the vicinity to have safety net in response to tenurial issues over the development area for the project.
Construction, Operation,	Land	*Change in land values of areas near and within the alignment of the project*	
		The land values of the area within the vicinity of the station development is expected to increase.	• Limit/control the commercialization of the planned mixed-use developments within the planned Station Plazas to some of the stations
Pre-	Subsurface	*Change in sub-surface / underground conditions*	

construction, Construction, Operation	Conditions	Tunneling will alter existing underground stress distributions	• Perform tunnel deformation analysis to determine how the hollowing of ground will affect underground stress regimes
Construction, Operation, Closure	Subsurface Conditions	Installation of buried facilities and introduces new material types to the ground which can react with the soil	• Use non-reactive materials for pipes and other buried components to ensure that soil contamination is prevented.
Pre-construction, Construction, Operation,	Subsurface Conditions	Solid wastes generated can be cause of pollution that would impact the quality of surrounding soil / ground	• Implement proper waste management and disposal system to prevent contamination of surrounding soil and water.
Pre-construction	Subsurface Conditions	Excavation and tunneling may accidentally hit buried facilities such as pipelines that could spill contaminants to the groundwater and soil.	• Perform due diligence and utilities survey. Adjust design to avoid utilities or coordinate with utility owner on how to transfer these to another location.
Construction, Operation,	Subsurface Conditions	Buried pipeline may leak water underground	• Use strong and durable materials for pipes to prevent leakage.
Pre-construction Construction, Operation	Geohazard Susceptibility	*Inducement of subsidence, liquefaction, landslides, mud / debris flows, flooding, etc.*	
		Tunneling will leave an underground void which will affect pore water pressure of overlying materials, leading to possible ground subsidence	• Perform tunnel deformation analysis to determine how the hollowing of ground will affect underground stress regimes • Install piezometers to monitor groundwater pressure around the tunnel, • Ensure that the tunnel is sufficiently supported and lined to prevent failure and ingress of groundwater.
Construction, Operation,	Geohazard Susceptibility	Leakage from pipes may saturate the ground, causing it to soften and subside.	• Use strong and durable materials for pipes to prevent leakage.
Pre-construction Construction, Operation	Geohazard Susceptibility	Continuous operation of heavy machinery produces vibration that may induce liquefaction.	• Perform liquefaction tests on segments found to have indications of liquefiable soil. • Use vibration dampers, if necessary.
Pre-construction Construction, Operation	Geohazard Susceptibility	*Inducement of flooding*	
		Excavation and tunneling sites may collect rainfall and groundwater, creating pools of water.	• Do not let excavation pits and trenches collect water. • Provide necessary drainage (e.g. pumps) in excavated components.
Pre-construction, Construction,	Geohazard Susceptibility	Burst pipes can leak significant amounts of water to the surface, which could cause flooding.	• Use strong and durable materials for pipes to prevent leakage.

Operation			
Pre-construction, Construction,	Soils	*Inducement of soil erosion*	
		Erosion of stockpiled excavated or burrowed soil due to exposure to rainfall and air can lead to dust generation and increased siltation of water bodies.	• Regular hauling of excavated materials and storage in pads with appropriate soil protection facilities or management systems
Pre-Construction	Terrestrial Vegetation	*Vegetation removal and loss of habitat*	
		The Project will be constructed in a highly urbanized area, with interspersed green spaces supporting numerous diverse arborescent tree species. Approximately 63.23 ha of above ground land area will be cleared of vegetation prior to the subway construction.	• Clear delineation of the extent of vegetation removal on plans and on the ground prior to removal activities • Development and implementation of a pre-clearing plan prior to construction. The plan should contain detailed clearing and cutting protocols to reduce impacts to the surrounding areas. • Generation of a Biodiversity Management Plan (BMP) prior to the start of the development activities, as this document outlines the conservation objectives of the Project and will detail the perceived impacts in biodiversity • Securing both tree cutting and earth balling permits from the Department of Environment and Natural Resources (DENR). Replacement of cut trees should be in accordance with the DENR Memorandum Order (DMO) 2012-02. • Provision of offset sites for all areas that will be cleared. These designated areas should be approximately equivalent to the land area affected by the Project; and must be jointly identified by DOTr and DENR
Pre-Construction, Construction	Terrestrial Vegetation	*Vegetation removal as a threat to local existence of endemic and/or threatened plant*	
		Noted threatened species, including but not limited to, *Pterocarpus indicus* (Narra), *Adonidia merrillii* (Manila palm), *Diospyros discolour* (Kamagong), Vitex parviflora	• Securing earth balling permits from DENR prior to vegetation removal activities

		(Molvae), *Podocarpus costalis* (Arius within and in the immediate vicinity of the Project could be removed and displaced from their natural habitats.	• Guided transplanting and earth balling activities with the supervision of an expert horticulturist / agriculturist to facilitate high survival rate of transplanted trees. • Appropriate maintenance activities should be conducted to ensure high survival rates of earth balled tree species
Pre-Construction, Construction	Terrestrial Vegetation	*Indirect effects*	
		Dust – the accumulation of dust on the leaf laminae could inhibit come major physiological processes of plants (i.e., photosynthesis, transpiration, respiration, phenology) and could even contribute to physical abrasion. Such may lead to decreased plant fitness and mortalities. **Increased weed infestation** – weeds prefer disturbed areas, which may be likely to occur in among the sites especially during construction phase.	• Implementation of regular water sprinkling, especially during the dry season along dusty areas to reduce the harmful effects of dust emissions. • Inclusion of weed control measure in the Biodiversity Management Plan (BMP) of the Project
Construction, Operation	Hydrology	*Change in drainage morphology / inducement of flooding / reduction in stream volumetric flow*	
		Ground disturbance during construction activities may temporarily disrupt natural drainage flow which may result to the development of new surface runoff paths	• All trench and foundation will be backfilled and ground restored to its original condition • Tunnelling works using TBM are not anticipated to impact river/stream waterflows
Construction, Operation, Closure	Hydrology	*Inducement of flooding / reduction in stream volumetric flow*	
		Some sections of the MMSP alignment will traverse areas with moderate to high flooding susceptibility	• Temporary drainage and detention cum siltation ponds will be constructed in construction areas if necessary to mitigate localized flooding. Temporary bund walls will also be provided as necessary

			• Stations will be provided with permanent bund walls along with water-sealed panels, tempered glass and waterproof iron doors, and drainage pumping stations • The Depot will be provided with a drainage system to collect surface runoff to designated outfalls • A Construction Waste Management Plan will be prepared for the project in order to appropriately handle and dispose excavated materials and demolition debris that may clog drainage systems and waterways
Construction	Hydrology	*Change in stream depth*	
		Temporary cofferdams will be required during the construction of the Quirino Highway Station, which will encroach on top of an unnamed creek. Cofferdams constrict waterways and reduce flow area, which may cause a minimal increase in water surface level upstream of the construction area	• Construction activities along the waterway will be done during the drier months of the year or during low flows whenever practicable. Diversion channels that are designed to adequately convey design flows with minimum if any backwater effect will be used • Tunneling works are not anticipated to induce changes in stream depth given that the tunnel will be located about 16 m underground on average
Construction, Operation	Hydrology	*Depletion of water resources and water competition*	
		Fresh and potable water will be required during the construction and operation phase of the project which may strain existing water sources used by the community	• Considering that the proposed project will not be extracting water from existing surface waters crossed by the MMSP or construct new wells, potential water competition as a result of the project activities is unlikely • Potable water will be sourced from the local water utility providers.
Construction, Operation	Hydrology	*Groundwater drawdown*	
		Groundwater dewatering during the tunnelling works could potentially induce groundwater drawdown	• Conduct detailed hydrogeological/ groundwater study in the detailed design stage.

			• Installation of monitoring wells for observation along the subway tunnel and monitor change of the surrounding groundwater levels • If water supply of people relying on groundwater along the alignment decreases, DOTr shall make arrangements to supply affected people with water. • DOTr should coordinate with NWRB regarding tunneling activities along the alignment and its potential effects on the water table • A Dewatering Permit may have to be secured from NWRB prior to tunneling activities.
Construction, Operation	Water quality	*Siltation and sedimentation of waterways*	
		Earth moving activities during the construction phase have the potential to increase turbidity and sedimentation in surface runoff which may eventually flow and discharge to nearby rivers and creeks	• Erosion and sediment control measures and spill prevention techniques including silt screens, drain channels, diversion dams, sumps and/or settling ponds will be provided in construction areas as necessary • Spoil and building material stockpiles will be provided with physical barriers and/or bunds to minimize silt-laden runoff • Surplus soil from tunneling will be used as backfill; remaining surplus soil after construction will be disposed appropriately in five identified sites within Metro Manila • Conduct of regular water quality monitoring
Construction, Operation	Water quality	*Contamination of groundwater as a result of tunneling activities*	
		Dewatering as part of borehole drilling and tunnelling may potentially contaminate groundwater resources	• Dewatered groundwater from tunneling activities should meet DAO 2016-08 standards prior to disposal • Conduct of regular water quality monitoring

Construction, Operation	Water quality	*Contamination of waterways with hydrocarbons and project wastes*	
		Liquid and solid wastes generated by the project including lime slurry wastes that may be produced during the tunnel boring process may contaminate waterways if disposed improperly. Accidental spills of fuel and other hydrocarbon and chemical products may contaminate waterways.	• A Waste Management Program for the construction and operations phase will be developed and implemented for the MMSP. Contractors will also be required to submit a wastewater management plan. • Fuel storage facilities will be provided with adequate spillage protection
Pre-Construction, Construction,	Aquatic Ecology	*Sediment influx in waterways*	
		Delivery of sediments and other debris into the water column of the stream channel, originating from the activities during the pre-construction and construction phase.	• Designation of buffer zones approximately 5 m from each bank to dampen the rapid entry of sediments and organic debris • Development and implementation of a construction plan during earth moving activities which ensures that the potential delivery of sediments and other particulate matter into the stream channel is kept at minimum.
Construction, Operations	Climate	*Climate change impacts*	
		The Project will be constructed in a highly urbanized area. The project's above ground disturbance footprint is 120 hectares in high density built-up areas and is not expected to significantly affect the local climate.	• Monitoring of any changes in local climate will still be performed, following the frequency of ambient air monitoring.
Pre-construction, Construction, Operations, Closure	Climate	Being in Metro Manila, the MMSP is vulnerable to sea level rise, increased intensity of storms, increased temperatures, and exposure to climate change-induced flooding and storm surge. Projected changes in temperature could potentially cause track expansion which can lead to train delays, and in the most extreme cases can lead to derailments Increase in ambient temperatures may require additional electricity usage for temperature regulation for MMSP. Electricity	• Establishment of comprehensive management systems to address climate adaptation; • Preparation of risk-identification processes to include climate risk and opportunities; • Integration of climate-related risks and mitigation measures into business decisions throughout the project life; • Ensuring robust engineering design and construction standards for facilities; • Design of comprehensive management measures;

		rationing and rotating blackouts may lead to challenges in subway operations and efficiency. Rising temperatures may increase the risk of heat-related illnesses and inhibit decision-making, increasing the likelihood of injuries, accidents, and fatalities and decreasing worker productivity Flooding may also affect employee safety on-site and on roads. Climate change induced flooding and storm surges could potentially flood subway tunnels, severely impacting mobility and economic activity	• Integrate climate-compatible development into initiatives for sustainable local benefit from Project operations; and • Initiate cross-industry collaboration on regional adaptation strategies.
Construction, Operations	GHG	*Contributions in terms of GHG emissions* • Carbon dioxide (CO_2) accounts to the highest GHG emission share (9,352.79 tonnes of CO_2-e per year) among the three common GHGs associated with the combustion of fossil fuel during the construction phase. This is followed by nitrous oxide (N_2O) and methane (CH_4) with GHG emission shares of 20.07 tonnes of CO_2-e and 10.60 tonnes of CO_2-e per year, respectively. • Scope 1 emissions (direct GHG emissions) total 9,383.46 tonnes of CO_2-e per year due to the combustion of fossil fuel. Scope 2 emissions (indirect GHG emissions) total 14,497.89 tonnes of CO_2-e from the purchase of electricity. For the operations phase, the total annual GHG emissions are	• consideration of fuel and equipment efficiency prior to construction and operation activities; • maximising fuel efficiency through scheduling of vehicle and equipment movement to minimise both idle time and distances travelled; • optimization of equipment and vehicle loadings through accurate monitoring and calculation of fuel and electricity requirements to reduce fuel weight and improve fuel efficiency; • regular maintenance of vehicles and construction equipment will be done to increase efficiency, reduce fuel and electricity use, and help reduce costs associated with equipment downtime; • close monitoring of equipment dispatches to eliminate unnecessary use and to increase efficiency of use; • Compensate the release of GHG during construction and operation by means of implementing carbon dioxide capture and sequestration through progressive

		109,021.00 tonnes of CO_2-e per year.	rehabilitation (within or outside the project site). This will be undertaken as soon as areas for rehabilitation become available. Rehabilitation areas will at least be equivalent to the areas cleared of vegetation through the established National Greening Program, and/or the carbon sequestration program as discussed in **Section 2.1.4** of this EPRMP; and • Monitoring of carbon release by following the frequency of ambient air monitoring as discussed in **Section 2.3.3** of this EPRMP.
Construction	Air Quality	*Degradation of air quality*	
		Fugitive emissions generated from wheel entrained dusts, dusts generated from unpaved roads, storage and handling of construction material, and wind erosion from exposed surfaces and construction material stockpiles may increase the ground level concentration of dusts (TSP and PM_{10}) in the area. The project is not expected to significantly affect the air quality during its operations phase.	• Fugitive dust from vehicular traffic and material handling activities will be controlled by management of vehicle speeds and application of regular water suppression to unpaved roads and stockpiles whenever visible dust is observed; • Trucks and vehicles that deliver construction material should be covered to prevent potential fugitive emissions of dust; • Regular ambient air quality monitoring will be performed in all monitoring stations as shown in Error! Reference source not found.; and • Workers will be provided with the appropriate personal protective equipment pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989) to protect them from disease associated with dusts.
Construction	Air Quality	Particulates and gaseous pollutants may be emitted through fossil fuel consumption of construction equipment which may	• Requiring sub-contractors to undergo and pass the government vehicle emission tests prior to contract award;

	increase the Ground Level Concentrations (GLCs) of the identified pollutants.	• Exhaust fumes from vehicles, construction equipment, and other fuel burning equipment will be managed through the use of low sulphur fuel where possible; • Traffic management guidelines will be incorporated in worker's and subcontractor's induction seminar. Guidelines will include control in vehicle speed and spraying of road routes and work sites as well as transport routes near the host communities; • Fuel efficiency will be maximised through scheduling of vehicle and equipment movements in order to minimise both idle time and distances travelled; • Equipment and vehicle loadings will be optimised through accurate monitoring and calculation of fuel requirements in order to reduce fuel weight and improve fuel efficiency; • Vehicles and construction equipment will be regularly maintained in order to increase efficiency, reduce fuel use, and help reduce costs associated with equipment downtime; • Equipment dispatch will be monitored closely in order to eliminate unnecessary use and to increase efficiency of use; • Standard occupational health and safety practices will be implemented pursuant to BWC-DOLE Occupational Safety and Health Standards (Department of Labor and Employment, 1989); and • Regular ambient air quality monitoring will be performed in all monitoring stations as shown in Error! Reference source not found..

Construction	Ambient Noise	*Increase in ambient noise level*	
		Increase in noise level and ground vibration due to operations of construction machinery, which may cause disturbance to construction workers and nearby communities.	• Using equipment or machines that produce lesser noise, or considerations in using mufflers to minimize noise. • Strategic scheduling of activities per period within a day to minimize effects of noise on nearby residents/public areas. • Maintenance of equipment or machineries used during construction to minimize possible loud noises due to equipment damage. • Conducting a construction noise assessment during the preconstruction stage to determine the noise levels on the areas surrounding the construction site, and the predicted noise levels coming from equipment and machineries. • Construction of wall enclosures on areas that produce a lot of noise to minimize disturbance within the immediate area. • Continuous monitoring of ambient noise levels on the monitoring sites for impact mitigation purposes.
Construction	Noise	May cause hearing problems to workers who operate nearby machineries or equipment that produce extremely loud noise.	• Strictly implementation of Personal Protective Equipment (PPE), such as ear muffs and ear plugs, during work hours for the safety of the workers. • Taking note of equipment/machines that produce extremely loud noises (beyond tolerable levels – 85 decibels (Fink, 2017)) and keeping these areas off limits from workers for their safety. • Implementing permissible noise levels for construction workers as suggested by Department of Labor and Employment (DOLE).
Construction	Noise	May cause hearing problems to nearby residents who are a part of the vulnerable	• Active response of LGU through necessary health programs for

		groups, and the public.	vulnerable groups, and massive public information for those areas that can produce noise level beyond tolerable limits of human ears.
Operations	Noise	May inadvertently cause mental stress to residents near the project location due to the noise from structures and ground vibration.	• Considerations in the design and operations of the subway to minimize vibration, such as noise barriers. • Continuous monitoring and survey for complaints from residents nearby the areas to assess the extent of the disturbance coming from the vibrations during operations.
Construction, operation	The People	*Displacement of setter/s / disturbance of properties*	
		Impacts on people displaced along the East Service Road	• Resettlement Action Plan development and implementation
Operation	The People	*Community safety and security*	
		The sheer amount and diversity of passengers using the Entrance / Exit Points suggest that some of them could intrude into the vicinities and areas beyond with no legitimate purpose and even engage in anti-social activities thereby posing a risk to legitimate residents and workers.	• Installation of security cameras at strategic places and instituting visible police presence. • Local residents and workers engaged to be more security and safety conscious • Development of quick response emergency teams drawn from office workers and residents
Construction, Operation	The People	*Change / conflict in land ownership*	
		Displacement of their constituents; break-up of communities; diminution of community amenities; transparency of information.	Transparency of Information; consider Use Value and Exchange Value orientation of stakeholders in engaging them
Construction, Operation	The People	*Impacts on cultural heritage*	
		Although the alignment passes near cultural heritage sites the construction and operation is not likely to impact these sites	• Assessment of "interior Design' aspects of the Nutrition Center of the Philippines • A photo-documentation of the entire 'interior design' should also be made to serve as a historical memory.
Construction	The People	*Traffic congestion during construction*	
		Because of the mobilization of heavy vehicles and equipment, construction activities, and staging of construction works, restriction on some roadways and sidewalks will be unavoidable. This will lead to	• Development and implementation of a Traffic Management Plan (TMP) • Rerouting/diverting traffic where possible

		increased traffic congestion and changes in traffic patterns during construction. Motorists, cyclists, and pedestrians might alter their trip routes to their inconvenience in order to avoid heavy traffic in the construction areas.	• Use of construction methods to limit the disturbance to existing roadways during the construction of stations
Operation	The People	*Increase in roadside friction along road adjacent to stations*	
		Commuters are likely to wait, load and unload to and from other modes of road transport, impeding the flow of traffic.	• Conversion of the construction yard areas into facilities with sidewalks, taxi bays, loading and unloading stations or intermodal central terminal stations for interconnectivity with mass transit and public utility vehicles.