MAKATI PUBLIC RAIL TRANSPORT SYSTEM PROJECT

PROJECT DESCRIPTION

City Government of Makati

Philippine Infradev Holdings Inc.

Lichel Technologies, Inc.

March 2019

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1 BASIC PROJECT INFORMATION

Name of Project	:	**MAKATI PUBLIC RAIL TRANSPORT SYSTEM PROJECT**
Project Location	:	Makati City
Project Proponent	:	**Philippine Infradev Holdings Inc.**
Proponent's Address	:	35/F Rufino Pacific Tower, 6784 Ayala Avenue, Makati City
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Position/ Designation	:	President and CEO
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Name of Consultant	:	**Lichel Technologies Inc**
Consultant's Address	:	1403 Prestige Tower Condominium F. Ortigas Jr. Road, Ortigas Center, Pasig City.
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Estimated Project Cost	:	Php 151,857,675,296.23 (US$ 2,883,410,000.00) (Construction cost based on Feasibility Study, June 2018)

2 PROJECT DESCRIPTION

2.1 Project Location and Area

2.1.1 Project Location

The proposed Makati Public Rail Transport System is located in Makati City. The Project is composed of ten (10) stations beginning from near the intersection of Ayala Avenue and Epifanio de los Santos Avenue (EDSA), towards Paseo de Roxas, Metropolitan Avenue, and JP. Rizal Avenue. **Table 2-1** shows the location of the stations, while **Figure 2-1** shows the alignment of the proposed project. The proposed rail lines will be located underground accessible through the stations located at ground level.

Table 2-1: Location of the Stations in the Base Scheme

Station	Location	N	E
1	Near the junction of Ayala Avenue and EDSA	14°33'07.57"	121˚01'38.87"
2	At the junction of Ayala Avenue and Paseo de Roxas	14°33'23.25"	121˚01'17.26"
3	At the junction of Ayala Avenue and Metropolitan Avenue	14°33'49.45"	121˚00'58.37"
4	At the junction of J. P. Rizal Avenue and Sacramento Street	14°34'14.76"	121˚01'13.28"
5	Along J. P. Rizal Avenue between F. Zobel Street and Pertierra Street.	14°34'06.92"	121˚01'39.08"
6	Along J. P. Rizal between Estrella and Camia Street	14°34'01.92"	121˚02'18.40"
7	Near the junction of J. P. Rizal Avenue and Guadalupe Bridge	14°34'04.02"	121˚02'53.76"
8	Along J. P. Rizal Extension, near Gen Arellano Street. and Sir Balden Powell Road.	14°33'50.45"	121˚03'29.19"
9	Along J. P. Rizal Ext. between 4th Avenue and Kalayaan Avenue	14°33'20.30"	121˚01'53.63"
10	Along J. P. Rizal Ext. between 25th Avenue and Sampaguita Street	14°32'58.81"	121˚03'49.19"

2.1.2 Accessibility of Project Site

The project is located along major thoroughfares within Makati City (i.e., Ayala Avenue, Paseo de Roxas, and J.P. Rizal Avenue). The project is readily accessible as it is envisioned to connect to other existing transport nodes.

2.1.3 Direct and Indirect Impact Areas

Section 10 of the Department of Environment and Natural Resources Administrative Order 15 series of 2017 (DENR DAO 2017-15) provided guidelines on defining the Direct Impact Areas (DIA) for the impact on land, water, air and people. Based on these guidelines, the DIA and Indirect Impact Areas (IIAs) will be identified. For impacts on land, this includes areas that may be inundated and may experience disturbance. For water, this includes portions of water bodies that traverses the project (Pasig River, Ayala Creek, Amorsolo Creek, San Jose Creek, and Pinos Creek) and may be affected during construction.

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

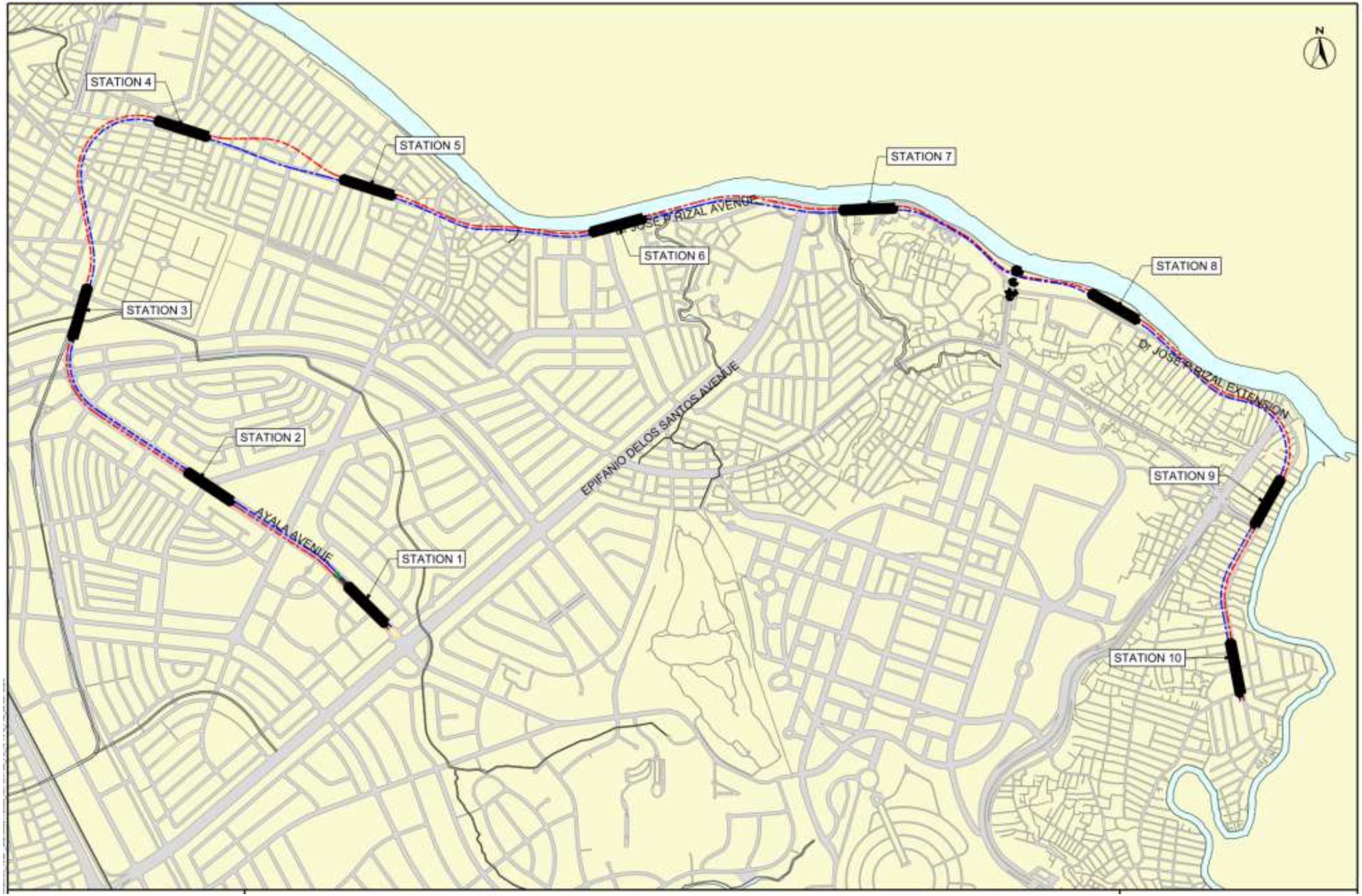

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FIGURE TITLE :

Location Map of the Project

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

2-1

2.2 Project Rationale

The project is envisioned to provide an alternative means of transport within the City of Makati. This will help reduce traffic congestion in the City. The project also foresees the development of areas along the alignment that can be tapped for development and will be linked by the operation of the project. As these sites generally form a series of development zones that sweep along the northern stretch of Makati, parallel to the Pasig River and J. P. Rizal Avenue, this will supplement the traditional Central Business District core of Makati.

2.3 Project Alternatives

2.3.1 Siting and Number of Stations

Alternative Scheme without Station 4. To avoid a tight turning curve between Stations 3 and 4, an alternative alignment has been studied by running straight along the cemetery after leaving Station 3 before turning the J. P. Avenue; therefore, this alignment is without Station 4. The length of this alignment is approximately 9.7 km with only 9 stations.

2.3.2 No Project Option

If the project is note realized, the existing traffic situation on the City will continue to be felt. In addition, the development along the alignment will not be realized, hence, impeding the additional employment that these developments will entail.

2.4 Project Components

The summary of the project component is shown below. Details are described in the succeeding sections.

Table 2-2: Summary of Project Components

Operation Details		
	Day 1	**Ultimate Phase**
Passenger Demand (pphpd- passenger per hour per direction)	21,000 pphpd	31,300 pphpd
Operating Hours	18 hours	
Maximum Train Speed	80km/h	
Train Capacity	6-car train (approximately 140 meters (m) long, 225 passenger/car)	
Journey Time (Round Trip)	33.4 minutes	
Peak Headway	3 min	2 min
Off-Peak Headway	6 min	4 min
Train in service	12	18
Train Dimension		
	DM-car (mm)	**M-car/T-car (mm)**
Length	24,400	22,800
6-Car Train Length	140,000	
Width (at door threshold)	3,000	
Height (from top of rail)	3,810	
Nominal car floor height (from top of rail)	1,130	
Door Opening Width	1,400	
Tunnels		
Preferable Minimum Radius	300 m	
Absolute Minimum Radius	250 m	
Difficult Situation Radius	225 m	
Preferable Gradient	3%	
Difficult Gradient	3.50%	
Minimum Radius at Station	2000 m	

2.5 Process Technology

2.5.1 Train Services

Trains will run between the terminus stations on an 18-hour operating day, 365-day year basis. The first passenger trains dispatched from the depot will commence service at around 0600 h every morning from the two terminus stations. Thereafter, trains will call at every intermediate station. Services will continue until around 0000 h of the next morning when trains will be withdrawn one-by-one back to the depot for stabling and maintenance.

Trains will normally be dispatched from the depot stabling area to join revenue service according to the Working Timetable. However, in order to build up the morning service more efficiently, it may consider to outstable a certain number of trains on the running line subject to confirmation at the operation stage. At the end of the traffic hours, or the scheduled withdrawal as per the Working Timetable, trains will automatically be withdrawn from the running line to the designated stabling tracks inside the depot.

Trains will be dispatched at different frequencies, or service headways, during different time periods of the day; however, actual implementation will be subject to confirmation at the operational stage with due consideration being given to passenger demands.

Regulations of normal train services will be managed centrally from the control center located at the depot. Trains will be designed to be driven by a driver on the main lines and the depot in/out tracks.

Track diagram of this subway alignment is shown in **Figure 2-2.** A turnout section will be provided to tracks before approaching terminus stations (Stations 1 and 10) to allow trains to be stopped at either side of the platform for passenger to alight and board, and then depart at the correct right-hand running track.

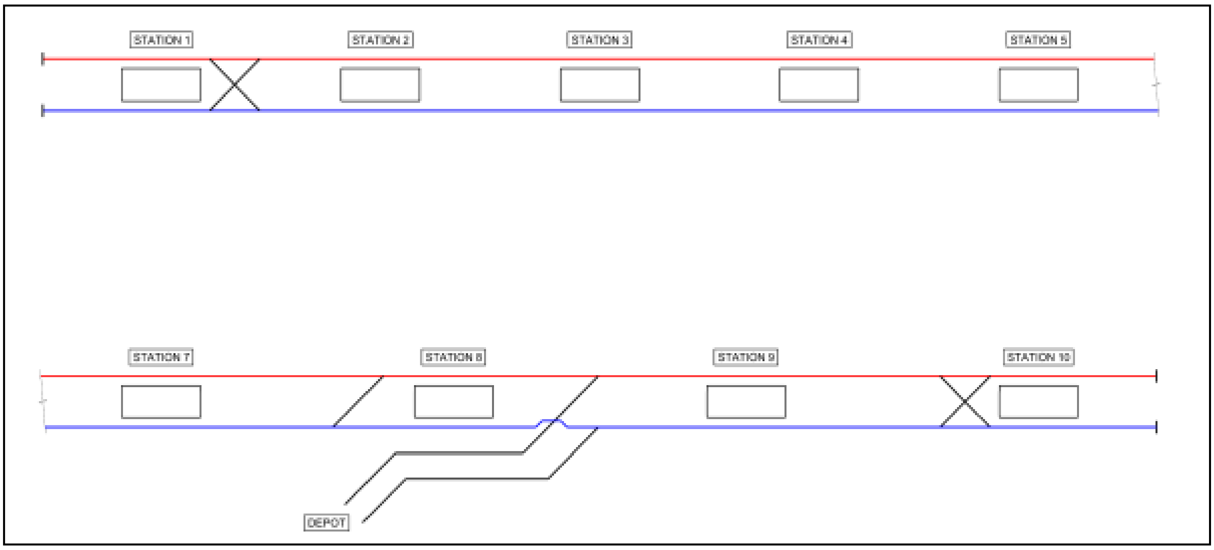

Figure 2-2: Track Diagram

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

Refuge sidings are typically provided in approximately 8km spacing to allow failed trains to be pushed into it and clear the running line during operation hours. As the proposed alignment is only approximately 10km with depot approximately in between the two ends, it can be assumed that failed train can be pushed into the depot to avoid a stalled train from blocking the normal service and no need for additional refuge siding.

Whenever normal service is affected for a certain period, a decision may be made to implement a degraded service plan to minimize the adverse impact on passengers.

Train services will have to be suspended whenever a certain part of the running line is declared not safe, or not able to pass through. An appropriate contingency plan will be prepared and exercised to minimize or to contain the “suspended area” by implementing some partial services. When a short “degraded operation” service is implemented, consideration, such as running of emergency buses over the suspended section, may be given subject to further analysis and justification.

A degraded operation is also possible with two possible short loops by providing a single turnout in the cut and cover tunnel section between Station 7 and Station 8, in the event that one section is blocked.

Detrainment (i.e., evacuation of passengers) from an incident train in the tunnel will always be treated as the last resort. All possible attempts will be considered to move the train into the station platform, where detrainment will be much safer and more efficient.

2.5.2 Stations

2.5.2.1 Stations Description

There will be nine (9) stations along the subway alignment. All of these stations will be underground and the construction of stations will be carried out by cut and cover method.

The stations in general, comprise two levels, concourse and platform. Typical station section is shown in **Figure 2-3.** Stations will also consist of entrances, ventilation shafts, traction substation, heat rejection plant room, and other facilities.

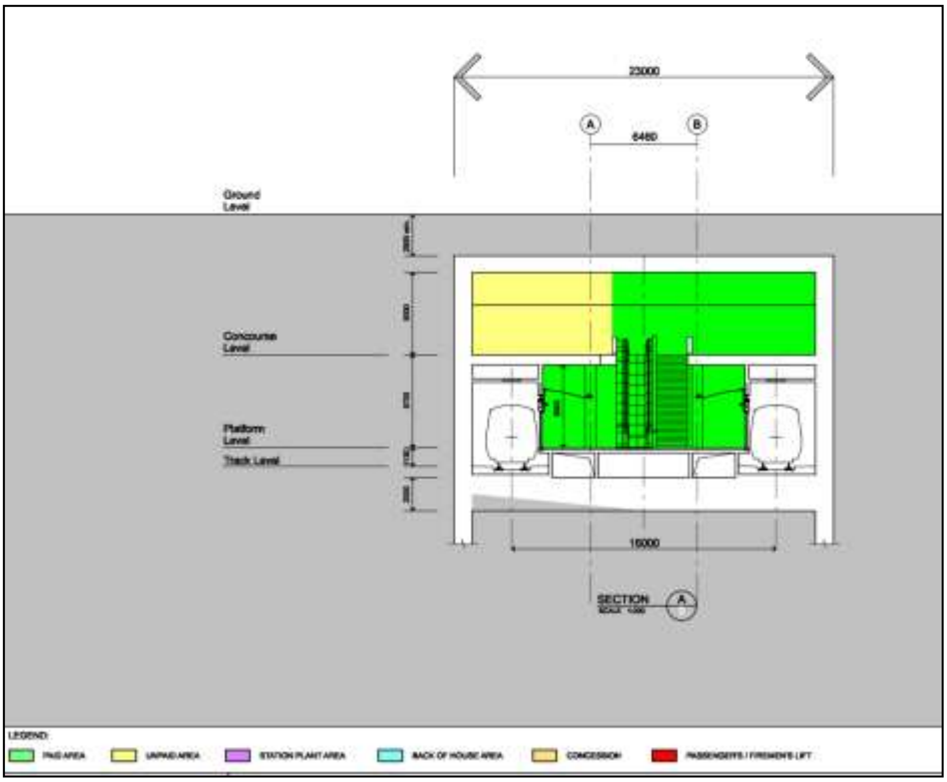

Figure 2-3: Station Cross Section

Source: Makati Public Rail Transport System Technical Component Report Philippine Infradev Holdings Inc. (July 2018)

A cross turnout section with length of approximately 150m will be provided at the 2 island platform terminus stations (i.e., Stations 1 and 10) before approaching the station which allow the trains to board passengers at both side of the island platform. An overrun section with length of approximately 80m will be provided beyond the station. The turnout section, same as the station box, will be carried out by Cut and Cover Method.

2.5.2.2 Station Plans

Stations with island platform are proposed for all the nine stations of this subway alignment. Island platform station reduces the confusion of passengers; they only need to make decision to choose the right platform at the platform level. It also reduces the number of vertical links and reduces the overall width of the station box. Furthermore, it is ideal for Tunnel Boring Machine (TBM) tunnels construction as the island platform configuration allows enough separation between the two TBM bores at approaches to the station.

There are 5 types of station layout developed to suit specific constraints and requirements at various station sites. Width of all 5 types of station is typically 23 m, but some may have to be increased slightly to allow bigger column size.

- **Type 1** station layout: This is a typical island platform station with length of 240m. Type1 station layout applies to Stations 4, 7 and 9, layout is presented in **Figure 2-4**;
- **Type 2** station layout: This layout is developed for those stations with traction power substation (TPSS) providing 2 TPSS rooms located at the platform level; station length is slightly increase to 253m to cater to these extra plant rooms. Type 2 station layout that applies to Stations 3, 5, and 8, and layout is presented in **Figure 2-5**;

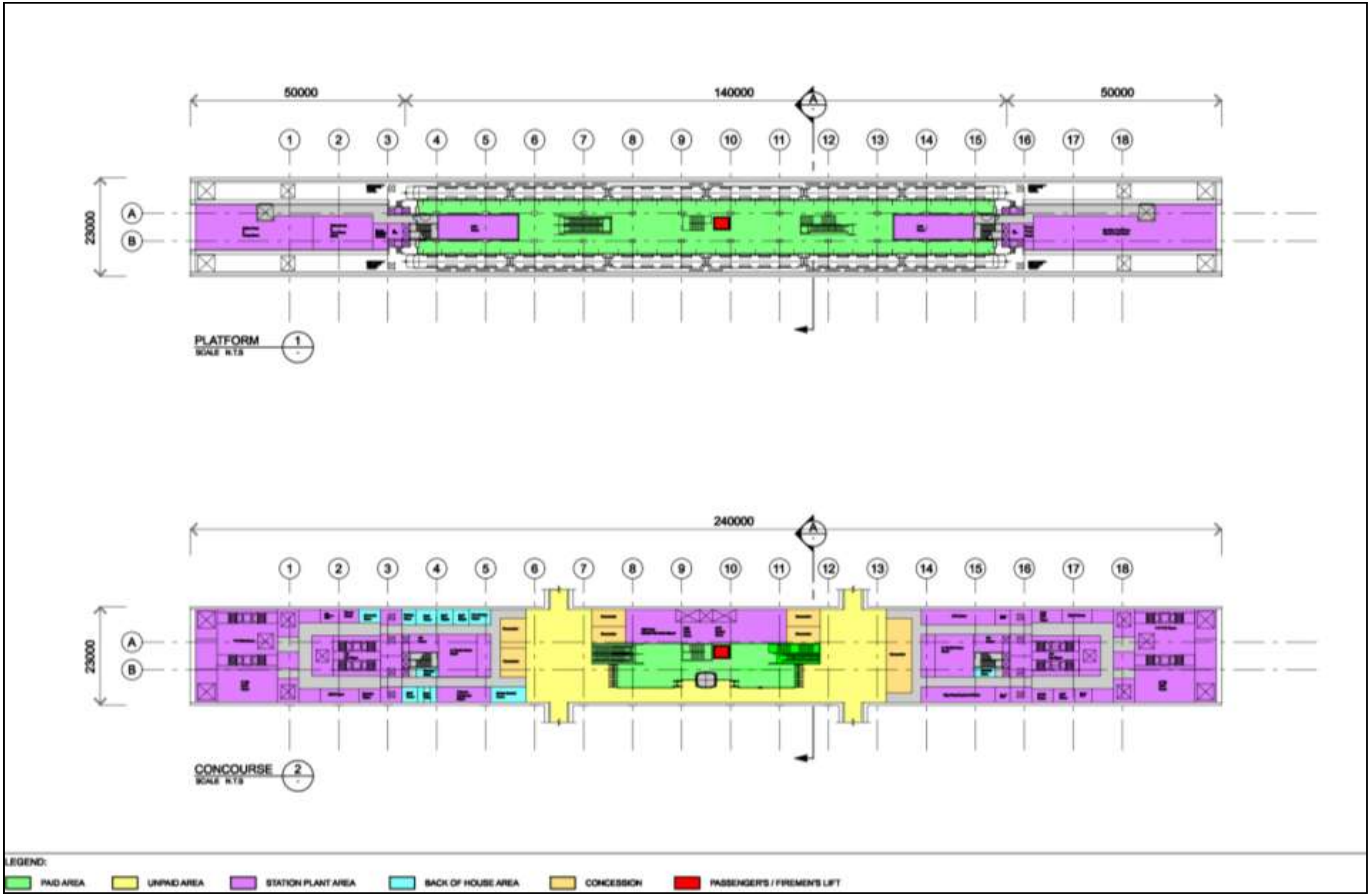

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FIGURE TITLE :

Type 1 Station Layout

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

2-4

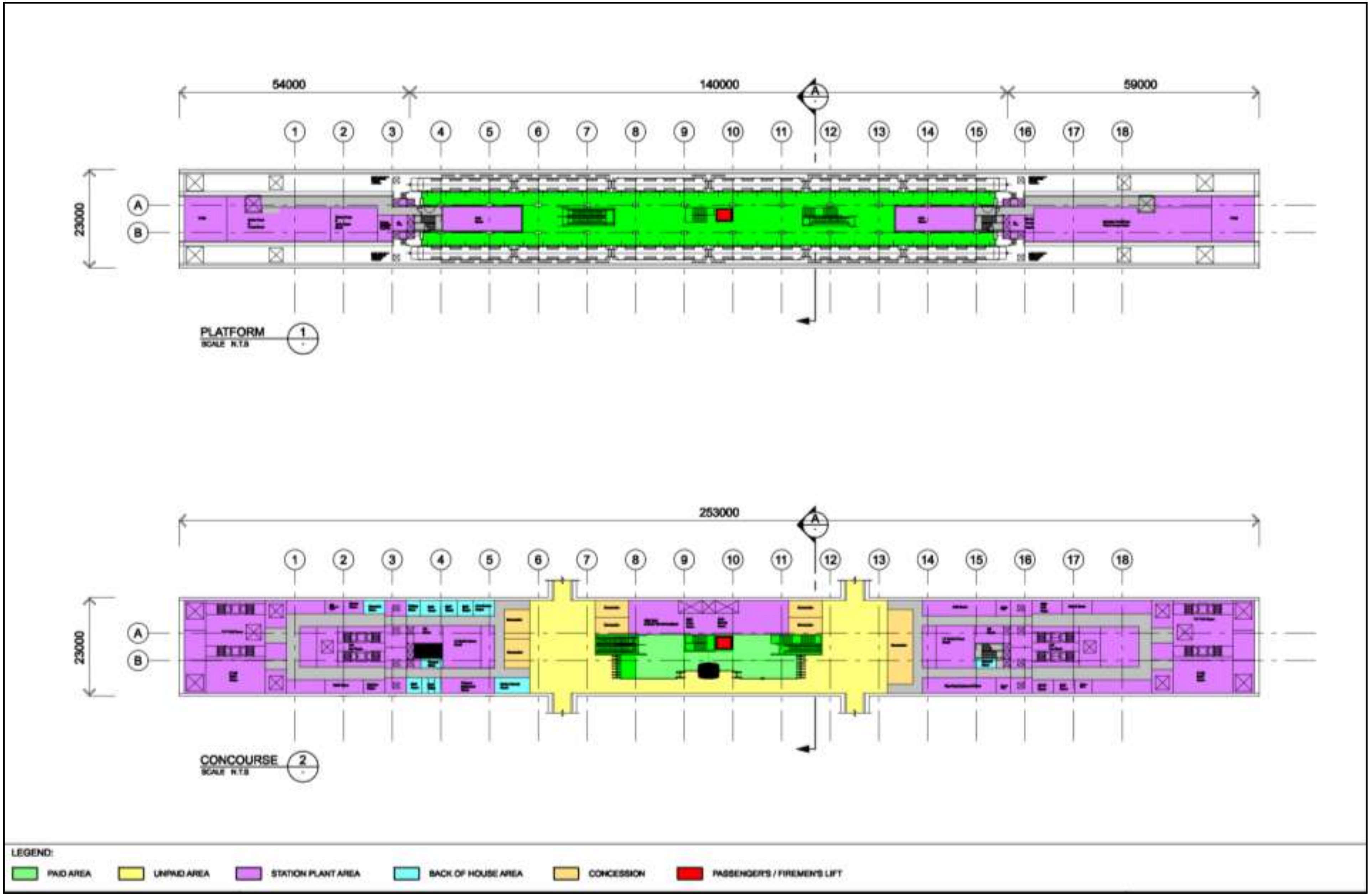

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FIGURE TITLE :

Type 2 Station Layout

Source: Makati Public Rail Transport System Technical Component Report
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FIGURE NO.:

2-5

- **Type 3** station layout: This layout is developed for terminus Station 10 with a 122m long turnout section in front. Commercial area linking to the station concourse level will be provided above the turnout section. There will also 2 TPSS rooms provided in this station. This station layout is presented in **Figure 2-6;**
- **Type 4** station layout: This layout is developed for terminus Station 1 with a 122m long turnout section in front. Commercial area linking to the station concourse level will be provided above the turnout section. There will also be 2 TPSS rooms provided in this station. This station layout is presented in **Figure 2-7**;
- **Type 5** station layout: This is a typical island platform station with length of 240m. Type 5 station layout applies to Station 2, layout is presented in **Figure 2-8;**
- Typical sections for all types of stations are shown in **Figure 2-9**.
- Station 1 and Station 7 can interchange with MRT's Ayala Station and Guadalupe Station, respectively. The estimated travelling time for these two interchanges (from platform to platform) are approximately 8 minutes and 7 minutes respectively, which is marginally tolerable in rail planning.

2.5.2.3 Station Operations

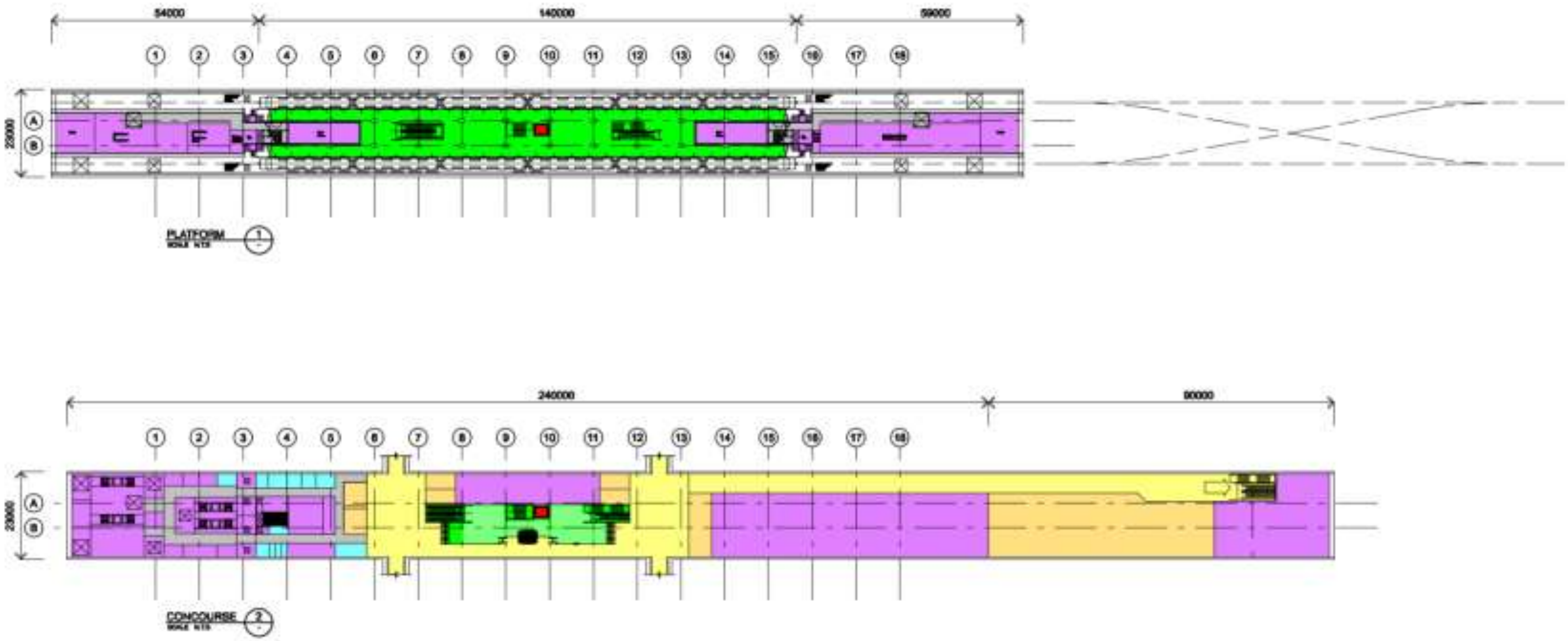
To enhance passenger perception, stations will be designed in a customer-friendly manner. They will be modern and simple structures offering an open and bright travelling environment conducive to easy and direct accessibility. Whenever it is technically and commercially viable, grade-separated pedestrian links will be provided connecting the stations with nearby buildings.

Full-height platform screen doors will be installed at the station platforms in respect of passengers' safety and to provide a fully air-conditioned environment at the platform.

To assist passengers, a system of information and direction signage will be well-planned and installed in public areas of the stations.

Stations will be equipped with provisions including station control room, customer service center, real time CCTV, centralized public announcement system, etc. for daily operation and maintenance.

Fare collection system will be convenient and user-friendly, and will be designed to achieve a high level of security to protect revenue from being lost through the misbehaviours of both passengers and staff.



LEGEND:

PAID AREA | UNPAID AREA | STATION PLANT AREA | BACK OF HOUSE AREA | CONCESSION | PASSENGER'S / FIREMEN'S LIFT

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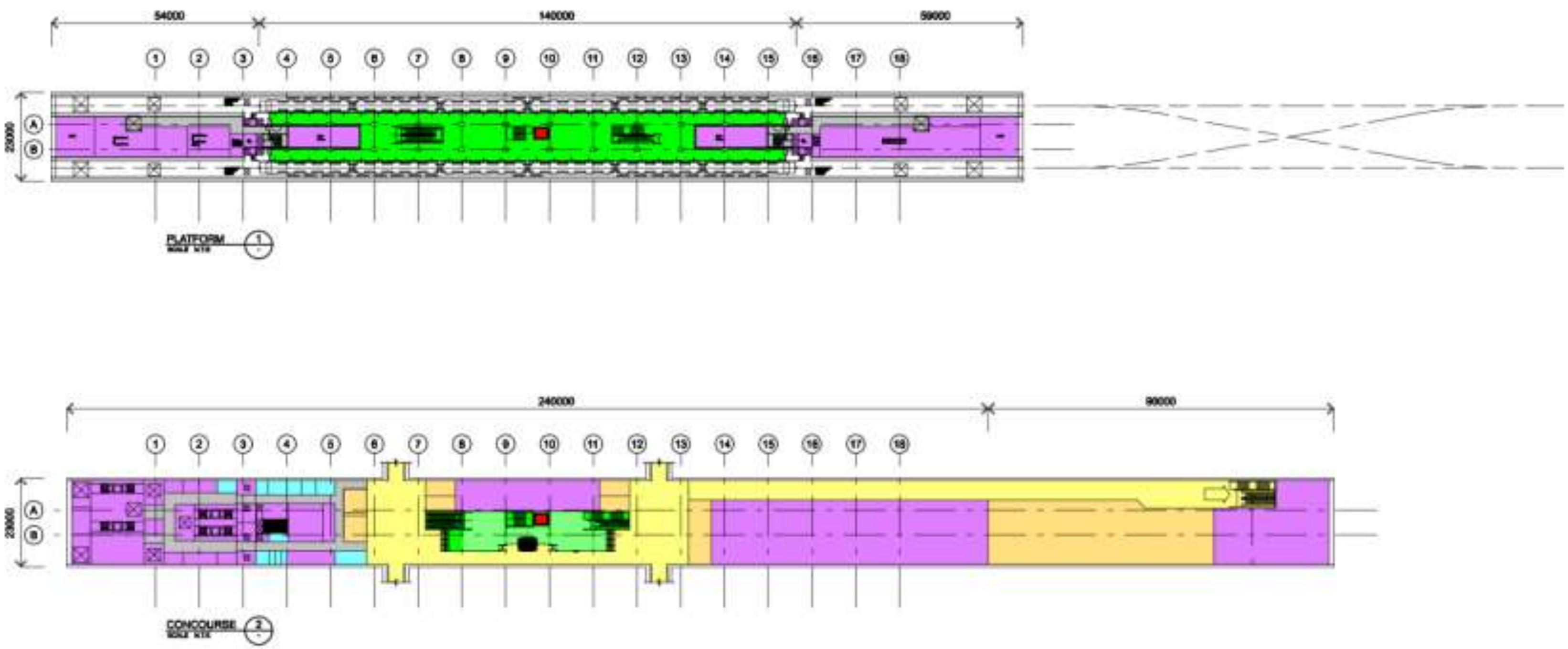
FIGURE TITLE :

Type 3 Station Layout

Source: Makati Public Rail Transport System Technical Component Report
Philippine Infradev Holdings Inc. (July 2018)

FIGURE NO.:

2-6



LEGEND:

PAID AREA | UNPAID AREA | STATION PLANT AREA | BACK OF HOUSE AREA | CONCESSION | PASSENGER'S / FIREMEN'S LIFT

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FIGURE TITLE :

Type 4 Station Layout

Source: Makati Public Rail Transport System Technical Component Report
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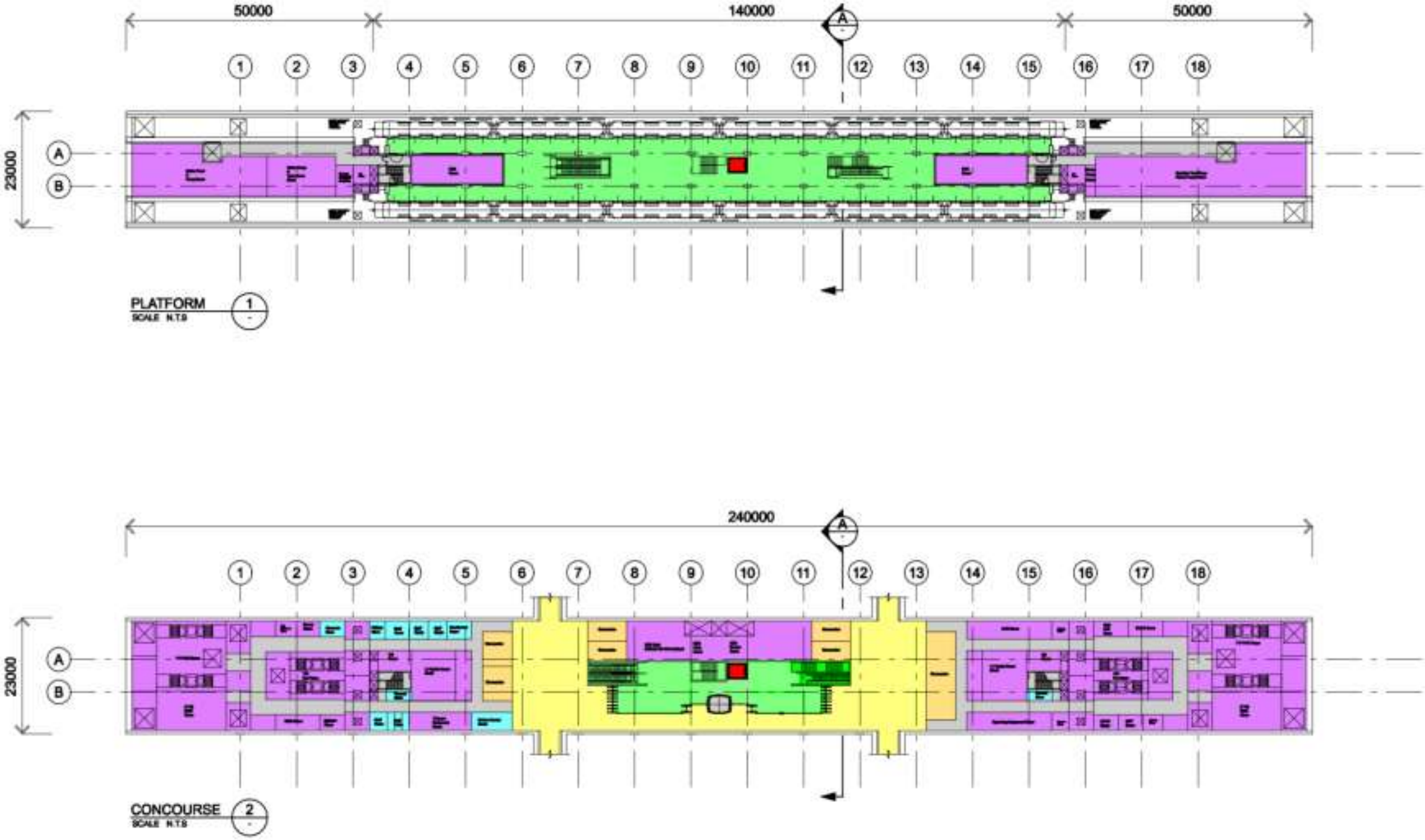
FIGURE NO.:

2-7



LEGEND:

PAID AREA | UNPAID AREA | STATION PLANT AREA | BACK OF HOUSE AREA | CONCESSION | PASSENGER'S / FIREMEN'S LIFT

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FIGURE TITLE :

Type 5 Station Layout

Source: Makati Public Rail Transport System Technical Component Report
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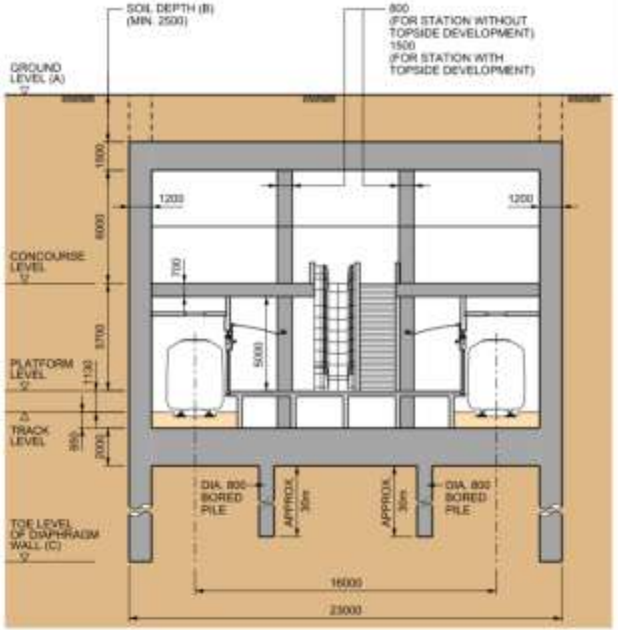
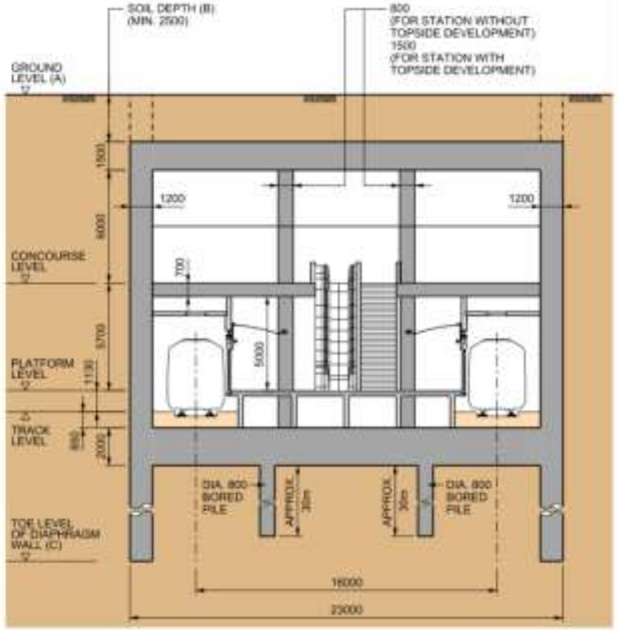
FIGURE NO.:

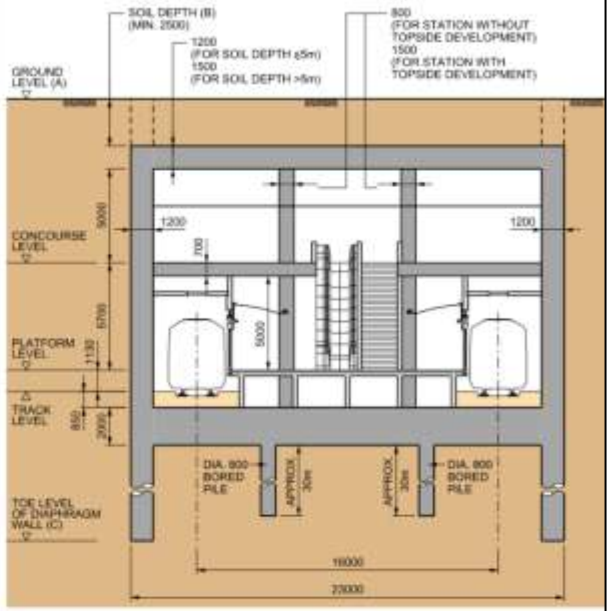
2-8



TYPICAL STATION SECTION (TYPE 4)



TYPICAL STATION SECTION (TYPE 5)



TYPICAL STATION SECTION (TYPE 1, 2, 3)

STATION	STATION TYPE	TRACK LEVEL (mPD)	TENTATIVE GROUND LEVEL (mPD)	TENTATIVE SOIL DEPTH (m)	TENTATIVE TOE LEVEL OF DIAPHRAGM WALL (mPD)
			A	B	C
1	TYPE 4	-14.33	14.20	11.00	-49.16
2	TYPE 5	-14.33	10.00	11.00	-44.96
3	TYPE 2	-15.46	4.12	6.24	-41.31
4	TYPE 1	-15.49	2.83	4.96	-40.10
5	TYPE 2	-15.12	3.91	5.70	-40.44
7	TYPE 1	-12.46	5.25	4.68	-36.47
8	TYPE 2	-11.86	4.50	3.33	-34.52
9	TYPE 1	-14.67	6.17	7.41	-41.62
10	TYPE 3	-14.26	6.19	7.12	-40.01

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FIGURE TITLE :

Typical Station Section

Source: Makati Public Rail Transport System Technical Component Report
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FIGURE NO.:

2-9

Ticket gates will be provided to separate the paid and unpaid areas at the Station concourse level. Both contactless smart card and single-ride magnetic/contactless ticket for multiple and single journeys will be used as the medium to travel. There will be sufficient number of Card Validators, Automatic Ticket Vending Machines, operating through a user-friendly man-machine interface, provided at each station.

2.5.3 Central Control Operations

The centralized control centre for the subway is proposed to be located with the depot. This control center, combining both running line and depot train operations control functions, will be the central hub, the overall command unit, responsible for the whole subway operations.

The control center will be manned by appropriate controllers throughout the day. It will operate on a 24-hour/365-day basis to manage the daily train services as well as maintenance activities during non-traffic hours. A team of controllers will be expected on duty on a shift basis to cover the 24-hour operations.

The main control center will be responsible for the following activities:

- Monitoring and controlling the daily running lines and depot train operations to ensure safe and timely services in accordance with the working timetable.
- Acting as the fault management center for all system/equipment, be system-wide or station-based;
- Preventing and reacting to incidents, or service disruptions, to ensure an efficient recovery of service with the support of Roving Teams;
- Monitoring and controlling all trackside engineering works during non-traffic hours, or during traffic hours in case of emergencies, to ensure safe and efficient operations.

The control center will be able to monitor the real time status of every station via CCTV and disseminate information to the stations via a Centralized Public Address System. When there is a need, passengers in stations will be able to communicate the duty controllers in the control center.

2.5.4 Trains and Railway System

Grade GoA 2 will be employed for the Makati Subway Operation, which is a semi-automatic train operation (STO) where starting and stopping is automated, but a driver operates the doors, drives the train if needed and handles emergencies. The trains will draw power from a nominal 1,500 V DC Overhead Contact System via roof mounted pantograph. The proposed train formation is shown in **Figure 2-10** below:

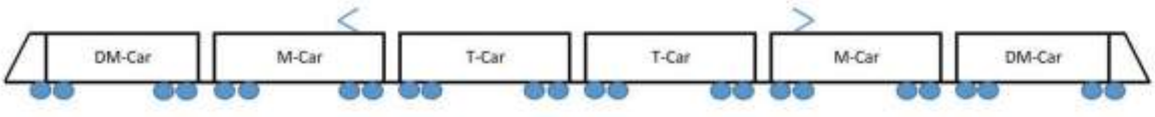

Figure 2-10: Proposed 6-Train Formation

Whereas DM is Motor Car with Driving Cab, M is Motor car and T is trailer car. Each M car will be equipped with one roof mounted pantograph for power collection. In line with GoA 2 operation, the trains will be provided with a fully equipped driver cab at each end. The key dimensions of the trains are provided in **Table 2-3** below.

Table 2-3: Key Train Dimension

	DM-car (mm)	M-car/T-car (mm)
Length	24,400	22,800
6-Car Train Length	140,000	
Width (at door threshold)	3,000	
Height (from top of rail)	3,810	
Nominal car floor height (from top of rail)	1,130	
Door Opening Width	1,400	

2.5.4.1 Design Life

The trains will be designed to operate for at least 30 years, with an average annual running distance of 145,000 km.

2.5.4.2 Train Design

The car body will be made of aluminium alloy or stainless steel. The passenger saloon will be provided with stanchions, handrails and wheelchair space with ergonomic consideration. To allow speedy boarding and alighting of passengers, five pairs of doors will be provided on each side of a car.

The doors will be electrically driven bi-parting doors, and will have an interior release handle for emergency evacuation purpose. Audible and visual indication for door closing and opening will be provided. The doors will be equipped with obstruction detection to minimize possibility of passenger or other objects being trapped between a pair of door leaves.

The train interior will follow the most common arrangement in Asia, i.e., longitudinal seats along both sides of the trains. Longitudinal seats will be provided along the window bays of each car. Wheelchair space will be provided at some or all cars. Seats will either be made of stainless steel or fire resistant Glass Reinforced Fiber (GFR). Suitable stanchions, handrails and strap hangers with ergonomic considerations will be provided along the car for passenger’s use.

Passenger Emergency Communication (PEC) will be provided by means of a duplex communication system for communication between passengers and the train driver, or in between the passenger and the Operation Control Center (OCC) via the train radio if the emergency call is not attended by the train driver.

LCD type passenger information displays will be provided in the saloon area for displaying of operational messages including dynamic route map, and other infotainments including news and advertisements.

Train borne public address (PA) system will be provided to support the following functions:

- automatic broadcasting of pre-recorded messages during normal, abnormal and emergency operation;
- direct broadcast of messages by the train driver or from OCC; and,
- broadcast of selected pre-recorded or ad-hoc messages by the train driver from the driving console.

The trains will be equipped with a video surveillance system comprising in-car CCTV cameras, train end CCTV camera, video recording system, and video transmission system to enable real time viewing by the train operator and the OCC, when necessary. Each train will have event recorders with a capacity sufficient for storing data for a desired period.

Each car will be equipped with two roof mounted package type air-conditioning units, one at each end, with adequate cooling capacity commensurate with Manila’s climate. Cooling air will be evenly distributed along a car using ceiling mounted air ducts. These air-conditioning units will also provide ventilation to the train using the on train battery for a fixed period in the event that the traction power is not available.

A walk-through gangway will be provided at all intermediate car ends to allow free movement of passengers between cars. A fully equipped driver cab will be provided at each end of a train. The driver cab will be provided with power operating side sliding door for getting access from a platform, as well as a manual operated cab/saloon hinged door for getting access from the saloon.

The driver cab will be equipped with a driving console, all required operating buttons, switches and indicators. Additionally, all operational information and health status, as well as certain control functions of the train will be provided to the driver through a touch-screen type LCD display of the Train Management System.

An ergonomically designed driver seat will be provided inside the driving cab. Additionally, a foldable instructor seat will also be provided. The bogies will be of a proven design with suspension stiffness optimized to achieve various performance requirement including derailment resistance, ride quality, curving and running stability. Motor and trailer bogies will have identical wheelbase and as many identical parts as possible for interchangeability. Flange lubrication system will be provided on the bogies and wheels will have noise damping device to mitigate wheel squeal on tight curves. Obstacle detector/defector and derailment detector will be installed on the end bogies.

Power collection will be through roof mounted pantographs. The pantographs will be equipped with auto-drop functions to minimize damage to the pantographs and the overhead wire in case of failure. The propulsion system and associated components will use AC driven, rotary motors technology with wheel slip/slide protection function.

The braking system will comprise of regenerative braking to be implemented by the propulsion system, friction brake to be implemented by the electro-pneumatic (EP) friction brake system, and the spring applied park brake system. The pneumatic friction brake system will adopt tread brake and will have wheel slide protection function. Dual pipe compressed air system will be adopted to facilitate the implementation of rescue brake design.

Static inverters will be provided for auxiliary power supply. Backup batteries will have sufficient capacity to maintain emergency ventilation and operation of other essential loads such as lighting, communication, door control, etc., for fixed periods.

Train Management System (TMS) will be used in the trains to provide real-time control and monitoring, diagnostic and reporting of the train-borne equipment. The TMS will control and monitor all non-safety critical systems and will only monitor vital or safety critical systems. The TMS stores data on train performance, equipment conditions, distance covered and fault history which will be used for corrective and preventive maintenance planning purpose. This information can be downloaded manually from the train onto maintenance computers and can also be uploaded automatically onto the Computerized Maintenance Management system (CMMS) via a wireless data communications network.

Couplers will be installed for all car ends. Train ends will be equipped with automatic couplers and all other car ends will be equipped with semi-permanent couplers.

2.5.5 Power Supply

Traction power supply for metros can be AC or DC. However, apart from metros in India, almost all other metros use DC. The major disadvantage of an AC system is that heavy transformers have to be installed on the trains to convert the AC power to DC. The transformers can also be perceived as a major fire risk by the railway regulator. Since the Makati Subway is entirely underground, fire safety is of utmost importance. Therefore, DC traction power will be adopted.

For DC traction power system, it can be 750V using third rail, or 1,500V using overhead line. There is no distinct advantage of one system over the other and in many cases the selection is based on precedence or aesthetic consideration. In the case of Makati subway, since all existing transit systems in Manila use the overhead line system, it is considered appropriate to use the same to minimize any potential regulatory issue. Training for operation and maintenance staff will also be simpler as a pool of personnel familiar with the overhead line system is available locally.

Therefore a 1,500 V DC Overhead line system is selected for the Makati subway. The Power Supply and Distribution (PS&D) system will comprise the following: an AC power supply and distribution network and a DC power supply and distribution network.

2.5.5.1 AC Power Supply and Distribution Network

The AC power supply and distribution network will be a 33kV 3-phase system. It will consist of a 33kV internal ring network running through the up and down track of the complete alignment. Infeed to the 33kV network will be derived from the 33kV system of the local power supply company.

The network will be designed to maintain regular train services under the outage of any major component in the system. This includes the infeed from the local power supply company system and individual 33kV substation. In general, an (N – 1) security criteria need to be fulfilled.

The alignment will be divided into two electrical sections the power supply of which will be fed from two separate 33kV open ring circuits. Each open ring will consist of two main feeder circuits running along the two tracks in opposite direction along the alignment. Each feeder will be turned in and out of a 33kV board at each passenger station which will supply all E&M services (including traction power supply) in that station. The feeders of the two tracks will be connected together at the ends of the ring via separate normally–open interconnectors.

Infeed to each 33kV ring will be connected to two different and independent 33kV sources at a Bulk Feeder Substation (BIS) to be established by the local power supply company. Normally open points will be established such that the two 33kV substations at each passenger stations will be fed from different sources. This will ensure the security criteria mentioned above to be accomplished.

Detailed operational requirements of the 33kV network need to be discussed and agreed with, the local power supply company in particular, the switching / interlocking arrangements under normal and emergency situations. The available capacity of the local power supply company's network will affect the back-up arrangement between the two 33kV rings via the two interconnectors. All associated 33kV/415V transformers and the downstream equipment are not considered as part of the PS&D System mentioned in this section.

2.5.5.2 DC Power Supply and Distribution Network

The trains to be adopted will be designed to operate at 1,500V DC and supplied via an Overhead Contact System (OCS). To provide traction supply to the OCS, Traction Power Substations (TPSS) will be established at a number of selected passenger stations. At each selected passenger stations, there will be two rectifier substations which supply traction power to the two tracks. Each DC traction power substation will include a rectifier transformer, a rectifier, DC switch board, negative busbar and the associated protection equipment. The rectifier transformers will be fed from one of the two 33kV substations at that passenger station.

The negative return will make use of the running rails connected back to the negative busbars of the TPSS. For stray current consideration, the running rail will be insulated from earth. As a second line of defense for stray current containment, a stray current collection mat will be included in the trackwork system.

2.5.6 Water Supply

Water supply needs of the Project during construction and operation will be sourced from the local water utility provider.

2.5.7 Waste Management System

2.5.7.1 Generation of Construction Debris and Solid Waste

Construction activities may generate various types of solid waste, including debris from clearing activities, cut soil, building waste, construction debris, and domestic waste and recyclables from the construction camp. In order to effectively manage waste materials that will be generated during the construction of the Project, a Construction Waste Management Plan should be prepared and implemented. The Construction Waste Management Plan will focus on the waste management hierarchy of avoid, reuse, recycle, and disposal, and will be disseminated and explained to all construction personnel of the Project.

Approximately 430,000 m^3 of soil is estimated to be excavated by the Tunnel Boring Machine during the construction of the subway track. Cut soil may be sold, donated to individuals or companies requiring backfill, or may be used as soil cover in landfills. Prior to use however, soils along the tunneling route should be characterized (through drilling) for potential contamination. Contaminated soils should be disposed in a treatment, storage, and disposal facility, consistent with the requirements of Republic Act 6969.

A Waste Management Plan for the operations phase of the Project will also be developed and implemented to ensure the proper management and disposal of general refuse and wastes that will be generated once the subway is operational. The Project’s Waste Management Plan should be aligned with the Makati City Government’s own solid waste management plan.

2.5.7.2 Generation of Fugitive Dust and Gaseous Pollutants

During the construction phase of the Project, activities such as excavation works and earthmoving activities, vehicle and heavy equipment movement, delivery to and unloading of materials in the site, cement mixing, and the use of generator sets may generate fugitive dust and gaseous pollutants (SOx and NOx). Since the project site is located in a heavily built-up area, majority of the stations is surrounded by populated locations (termed sensitive receivers) which may be impacted by dust and vehicle and plant emissions.

Construction activities may also contribute to the already elevated recorded TSP and PM10 concentrations in Makati City. While these air quality impacts associated with the construction phase are expected to be localized and temporary, the following mitigating measures are recommended to be implemented to minimize the generation of fugitive dusts and gaseous pollutants:

- Properly operate and maintain all emission sources pursuant to the Philippine Clean Air Act of 1999 (R.A. 8749) and its Implementing Rules and Regulations (DAO 2000-81);
- Install when applicable, the appropriate air pollution control device/s such that air pollution sources would conform to the Philippine Clean Air act of 1999 (R.A. 8749) and its Implementing Rules and Regulations (DAO 2000-81);
- Maintain and service vehicles and heavy equipment according to manufacturer recommendations through a regular vehicle maintenance and repair program;
- Strictly enforce good housekeeping practices to minimize/control emission of air pollutants;
- Implement dust suppression measures (e.g. apply water on unpaved roads and work areas whenever visible dust is observed) to reduce dust during construction activities;
- Maintain access roads in good working order;
- Minimize earthmoving activities during adverse meteorological conditions;
- Minimize the area of disturbed land as far as practicable;
- Re-vegetate construction areas as soon as practicable;
- Cover stockpiles or provide physical barriers around stockpiles wherever practicable;
- Locate stockpiles away from sensitive receivers as much as practicable;
- Prohibit burning of waste materials onsite;
- Clean and seal trucks before coming out of the construction site;
- Schedule earthwork and material transport preferably at night, to make full use of
- vehicles and minimize heavy traffic;
- Instruct drivers on the benefits of driving practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits;
- Maintain positive relations with the community through a continuing stakeholder engagement program; and
- Provide construction workers with appropriate personal protective equipment (PPE) (e.g. face mask) as necessary.

2.5.7.3 Wastewater Management

The operation of the subway will generate stormwater runoff and sanitary wastewater streams. It is recommended that these two wastewater streams are separated to reduce the volume of wastewater requiring treatment. Stormwater runoff from the site will be collected by an onsite drainage system. If deemed necessary, collected stormwater will be treated prior to discharge to nearby creeks. Effluent from the subway stations and various establishments will be treated as required to ensure compliance with the DENR Administrative Order 2016-08 General Effluent Standards prior to discharge to public sewers or surface waters.

2.6 Project Size

The total length of the project alignment is 10.1 km with 9 stations. The passenger capacity of the project ranges from 21,000 pphpd to 31,300 pphpd.

2.7 Description of Project Phases

2.7.1 Pre-Construction Phase

This phase will include the completion of all regulatory requirements and acquisition of all land requirements for the project. The Pre-construction Phase includes selection and awarding of contracts to contractors for the construction of the project.

2.7.2 Construction/ Development Phase

All nine underground stations and the two terminal crossover boxes will be constructed by cut and cover techniques because their design and the track arrangement do not permit them to be constructed by mining methods. As with all large, open excavations, extensive use will be made of temporary decking to provide local traffic crossings of the excavation and working platforms for construction. Buried utilities will be diverted or suspended under the decking or both.

Construction of Station 1 in Ayala Avenue uniquely requires temporary closure of a flyover at the south end of the station box that occupies the central portion of the Avenue. Overrun tunnels are mined parallel to the remaining portion of the viaduct with a mined connection to a draught relief shaft in a nearby car park. The south station ventilation shaft is also situated in the car park, connected to the station with a shallow, cut and cover duct under the east bound carriageway of Ayala Avenue. To the station and crossover box in front of it are constructed in two or three, narrow, longitudinal strips. Extensive use of temporary traffic decking will be made. A portion of the station will be constructed by a Top Down method so as to maintain the necessary number of traffic lanes and minimise the duration of flyover closure.

Construction of Stations 4, 5, 9, and 10 requires site clearing to create space for the temporary traffic diversions essential for building the station (and crossover box at station 10). Less site clearing is required at Station 3, which has fewer buildings surrounding it, and no site clearing at all at Station 2, where the street (Ayala Avenue) appears to be wide enough to accommodate both the excavation for the station and the required number of traffic lanes. (The positions of existing basements have yet to be verified to confirm the location of station external walls.) Stations 7 and 8 are large, cut and cover excavations lying just outside the depot boundary. The running tunnels between Stations 7 and 8 are more efficiently constructed by cut and cover techniques, as are the depot approach tracks which pass Station 8 in tunnel from their connection with mainline east of the station. The spoil generated by cut and cover excavations will be removed using the barging point planned for tunnel spoil disposal at the river frontage of the site.

Because depot facilities (workshops; plant building) are largely framed structures and stabling tracks are simply ballasted tracks, they can be built and equipped relatively quickly. The depot area has therefore been used to initially re-route the existing road, under which the stations are to be built, well away from station construction.

The station and crossover walls are constructed in vertical concrete panels, reinforced with steel bars lowered into pre-excavated trenches excavated along the alignment of the walls. Where TBMs are to pass through the diaphragm wall (and if ground conditions permit) the normal steel reinforcement in the wall may be replaced by steel-fibre reinforced concrete or glass-fibre bar reinforcement (GFRP).

Where running tunnels are not deeply buried below streets, it can be cost-effective to construct them by a cut and cover technique. This technique has not been used for the majority section of Makati Subway running tunnels because alternative traffic routes via existing roads are unavailable without greatly increasing traffic congestion. Where construction does take place in existing roads, extensive site clearing is undertaken to construct temporary roads into which traffic may be diverted. In ground conditions such as found here, bored tunneling is much faster and far less disruptive.

Bored tunneling has been adopted to construct running tunnels between: Stations 1 and 5; Stations 5 and 7; and Stations 8 and 10, using four TBMs of the Earth Pressure Balance Machine (EPBM) type.

TBMs operate most efficiently with long tunnel drives, a large area at the launching point to support their operations and a reliable supply of electrical power. If TBMs are to be operated 24/7 either the excavated spoil must be constantly removed from the launching point (but this may be forbidden in certain hours by noise control regulations or traffic controls) or it must be temporarily stored at the site and then removed at an accelerated rate during permitted hours.

2.7.3 Operation Phase

Details of the Station Operation are described in Section 0 above.

2.7.4 Abandonment Phase

Initially, the project concession period is 30 years after which Revolving concession renewals at 30 year intervals would be an alternative to maintain operational responsibility outside of the City, and would require consideration of asset replacement expenses. If the project is to be abandoned, a detailed abandonment plan would be submitted a year before abandonment.

2.8 Manpower Requirements

The estimated manpower requirements are shown in **Table 2-4**.

Table 2-4: Manpower Requirements

	2019	2020	2021	2022	2023	2024
Station and Depot	776	2260	1015			
Tunnel		422	482	181		
Rail				447		
Electromechanical				154	370	51
Total	**776**	**2682**	**1497**	**782**	**370**	**51**