Contract CR2005
Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Clementi Forest and Maju Forest)

Study Stage: Final

Volume 1 of 5

Submitted by:
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Abbreviations

Acronym	Definition
ABC	Active, Beautiful, Clean
AECOM	AECOM Singapore Pte. Ltd.
ALS	ALS Technichem (S) Pte. Ltd.
APCP	Air Pollution Control Plan
ASR	Air sensitive receptor
AVA	Agri-Food and Veterinary Authority of Singapore
BCA	Building Construction Authority
BIOME	NParks BIOME Biodiversity and Environment Database System
BOD_5	Biochemical Oxygen Demand
BS	British Standard
CCS	Central Control System
CCNR	Central Catchment Nature Reserve
COD	Chemical Oxygen Demand
COPPC	SS 593: Code of Practice for Pollution Control, 2013
CRL	Cross Island Line
CRL1	Cross Island Line Phase 1
D-walls	Diaphragm walls
DGPS	Differential Global Positioning System
DO	Dissolved Oxygen
EBS	Environmental Baseline Survey
ECM	Earth Control Measures
ECO	Environmental Control Officer
ECP	Erosion Control Plan
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIR	Environmental Impact Register
EIS	Environmental Impact Study
EMMP	Environmental Monitoring and Management Plan
ERP	Emergency Response Plan
ERSS	Earth Retaining Stabilisation Structures
ERT	Emergency Response Team
EU	European Union
GPS	Global Positioning System
HDB	Housing and Development Board
HDSM	High density slurry material
HDV	Heavy duty vehicles
HK EIAO TM	Hong Kong Environmental Impact Assessment Ordinance – Technical Memorandum
HLUS	Historical Land Use Survey
IAQM	UK Institute of Air Quality Management
IUCN	International Union for Conservation of Nature
JGP	Jet grouting pile rig
JTC	JTC Corporation (formerly Jurong Town Corporation)
LDSM	Low density slurry material
LTA	Land Transport Authority
LTH	Light Temperature Humidity
m bgl	Meter below ground level
MCCY	Ministry of Culture, Community and Youth
MLS	Marchwood Laboratory Services Pte Ltd
MND	Ministry of National Development
MOM	Ministry of Manpower
MRT	Mass Rapid Transit
MND	Ministry of National Development
MPA	Maritime and Port Authority
NAAQS	National Ambient Air Quality Standards

Acronym	Definition
NBSAP	National Biodiversity Strategy and Action Plan
NEA	National Environment Agency
NHB	National Heritage Board
NMDS	Non-metric Multidimensional Scaling
NParks	National Parks Board
NSR	Noise sensitive receptor
OJR	Old Jurong Railway
PHILMINAQ	Mitigating Impact from Aquaculture in the Philippines
PIE	Pan Island Expressway
PRO	Public Relation Officer
PME	Powered mechanical equipment
PPV	peak particle velocity
PSI	Pollution Standard Index
PUB	Public Utilities Board
QECP	Qualified Erosion Control Professional
QP	Qualified Professional
SAC	Species Accumulation Curve
SCDF	Singapore Civil Defence Force
SDS	Safety Data Sheet
SFA	Singapore Food Agency
SHE	Safety, Health and Environment
SICC	Singapore Island Country Club
SIDS	Silty Imagery Detection System
SLA	Singapore Land Authority
SO	Superintending Officer
SOP	Standard Operation Procedure
SRDB	Singapore Red Data Book
STC	Sound Transmission Class
SUSS	Singapore University of Social Sciences
TAQMMS	Telemetric Air Quality Monitoring and Management System
TBM	Tunnel boring machine
TDS	Total dissolved solids
TEL	Thomson-East Coast Line
TIA	Traffic Impact Assessment
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total suspended solids
UNECE	United Nations Economic Commission for Europe
URA	Urban Redevelopment Authority
UK	United Kingdom
US	United States
USEPA	United States Environmental Protection Agency
VES	Visual Encounter Survey
VSR	Vibration sensitive receptor
WHO	World Health Organisation
WSHE	Workplace Safety, Health and Environmental
WSHO	Workplace Safety and Health Officer

Glossary of Terms

Term	Explanation
Access Roads	Access roads are considered up to 500 m from the access point of the construction worksite area
Air Pollution Control Plan	Plan implemented to ensure implementation of air mitigation measures
Arboricultural Survey	Assessment of tree — is the cultivation, management, and study of individual trees, shrubs, vines, and other perennial woody plants. It involves the assessment of trees by certified arborists, in addition to the mapping of trees using a Differential Global Positioning System (DGPS).
Baseflow	This scenario/ case represents the original worksites status at the time of writing of the approved Inception Report, before being optimised with feedback from the impact assessment team or due to other design constraints as part of usual development of design.
Biodiversity Study Area or Study Area (Biodiversity)	Forested area identified in the vicinity of the Project to be studied for its biodiversity value as defined by LTA for the purpose of this EIS (i.e., Maju Forest and Clementi Forest).
dB(A)	A-weighted sound pressure levels (dB) – weighted to human hearing frequencies
Catchment Delineation	Based on topographic and river network information, the water catchment boundary to any required (usually gauged) point on the river network is defined by applying GIS tools to an appropriate digital elevation model.
Commissioning Phase	This phase is a short transitional period specified for EMMP purpose, where environmental monitoring works are proposed and to be conducted by the Contractor before handing over to the rail operator in operational phase.
Construction Phase	This phase includes ground improvement works, underpinning works, TBM works, rock breaking and excavation works, station box construction, concrete batching works (if any), construction of permanent vent shafts and MRT superstructures (if any), as well as general landscaping/finishing/reinstatement works.
Construction (Air Section)	Any type of construction activity involving new structures on construction worksite area involving powered mechanical machinery
Construction worksite area	Construction areas where surface impacts may occur due to construction footprint above ground level e.g. all areas excluding the parallel tunnels
Coverage-based rarefaction and extrapolation sampling curves	Computes diversity estimates for rarefied and extrapolated samples with sample completeness (as measured by sample coverage) up to an appropriate coverage. This type of sampling curve plots the diversity estimates with respect to sample coverage. (Hsieh et al, 2019)
Cryptogenic	Species with unknown origin.
Demolition	Any activity involved with the removal of an existing structure (or structures). This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time.
Dilapidation Studies	Studies to analyse impacts when a building/infrastructure/geological area is being demolished
Earthworks	This involves excavating material, haulage, tipping and stockpiling. This may also involve site levelling and landscaping
Emission Sources (Air Section)	Sources of air emissions for different activities such as earthworks, construction, trackout and demolition
Entire alignment	Station cut and cover area, construction worksite area, underground tunnels, tunnel portals viaduct, and ventilation shafts (vent shafts)
Exotic Species	Plant or animal species introduced into an area where they do not occur naturally, non-native species.
Ex-situ	Testing is carried out offsite, or away from the natural location.

Term	Explanation
Ground Absorption Factor *Ref: SoundPLAN*	This factor is given to describe the noise propagation with respect to ground effect. For example, G = 0 describes a 100% hard ground such as asphalt, water or industrial sites; G=1 describes 100% soft ground such as fields, forests or grass
Airborne Noise	Sound that is transmitted by the air e.g. speech. The term airborne noise and noise are used interchangeably in this report and mean the same
Heavy Duty Vehicle	Heavy duty vehicles defined as vehicles with a gross weight greater than 3.5 tonnes
Hydrology	The study concerned with the properties of the earth's water, and especially its movement in relation to land.
In-situ	Testing is carried out in the original place
ISO 9613-2:1996	Is the standard describing "Acoustics – Attenuation of sound during propagation outdoors – Part 2 : General method of calculation"
LAeq (1 hour)	Equivalent noise levels, averaged over a 1 - hour time period
LAeq (12 hours)	Equivalent noise levels, averaged over a 12 - hour time period
LAeq (5 mins)	Equivalent noise levels, averaged over a 5 - mins time period
Mitigated Scenario/ Mitigated Case	This scenario/ case represents the latest optimised worksites at the time of writing this report. It includes the incorporation of feedbacks from various environmental disciplines on the design and the usual design evolvement over time, as appropriate.
Non-metric Multidimensional Scaling (NMDS) Ordination	A way of visualising the level of similarity of individual cases of a data set. In this report, NMDS is used to compare the forest quality of the Study Area to the forest quality of the Central Catchment Nature Reserve.
Non-volant Mammals	Non-flying mammals, i.e., all mammals in Singapore, excluding bats
Operational Phase	This phase include the operations of vent shafts, railway, and tunnel in terms of this report context, while in general it also includes the operation of MRT station entrances/exits, station buildings and platforms.
Old Jurong Railway Corridor	A railway line from Bukit Timah to the Jurong industrial estate that ceased operations in mid-1990s. Portions of the lines remains intact and will be converted into a nature trail.
Peak Particle Velocity (PPV)	A vibration metric of displacement of a particle in a medium, over time.
Project/Operational Footprint	Station aboveground footprint, ventilation shafts footprints which will remain as permanent above ground features during operational stage of CR2005
Reactive Management Plan	Plan based on the real time situation of air impacts in an area.
Rock Breaking and Excavation	Indicating activity where rocks are blasted and broken into rock pieces which then be excavated and removed from the construction site. It does not represent hydraulic rock breaking. Rock breaking and excavation is only required at a confined area within a designated worksite where rock removal by normal earth excavation means cannot be performed.
Root Mean Square (RMS)	The square root of the mean of the of a certain set of values squared
Sound Power Level, Lw	Sound power is the total sound energy radiated by the source in a specified frequency band over a certain time interval, divided by the interval. In simple terms, a sound source produces sound power, and this generates a sound pressure fluctuation in the air.
Sound Pressure Level, Lp	Sound pressure is the difference between the pressure produced by a sound wave and the ambient pressure at the same point in space.
Species Abundance	The number of individuals per species in an area. Relative abundance refers to the evenness of distribution of individuals amongst species in the area.
Species Distribution	Refers to how a species is distributed throughout the area.
Species Group	Plants that could not be identified to species with certainty.
Species Richness	Number of distinct species recorded, per sampling point or area.

Term	Explanation
Study Area (Air)	Construction: 50m (Ecological Impact) from construction worksite areas as per IAQM Guidance; Operation: 250m from Project Footprint.
Study Area (Biodiversity)	See definition of *Biodiversity Study Area*
Study Area (Airborne Noise)	Construction: 150m from the construction worksite areas; Operation: Boundary of Project Footprint
Study Area (Ground-Borne Vibration)	Construction: 100m from the construction worksite areas and centreline of entire alignment; Operation: 100m from the Project Footprint
Study Area (Soil and Groundwater)	Construction and Operation: 250 m from the rail alignment/ station or other construction sites footprint
$L_{pA,S,max}$	Maximum A-weighted sound pressure level evaluated with a ‘Slow’ (1.0 second) time constant
Topography	The study of the shape and feature of land surfaces.
Trackout	The transport of dust and dirt from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when heavy duty vehicles (HDVs) leave the construction/demolition site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site.
Tree Mapping	Tree mapping is purely the mapping of trees using a Differential Global Positioning System (DGPS), without assessment by the arborists.
Trigger Value	The threshold value of a pollutant for which reactive management plan needs to be applied.
Vent Shaft	A shortened form of the term “Ventilation Shaft” used exchangeably for the complete term.
Vibration Dose Values (VDV)	A vibration metric that considers the magnitude of vibration and the time it occurs, calculated by taking the fourth root of the integral of the fourth power of acceleration after being frequency-weighted.

1. Executive Summary

AECOM Singapore Pte Ltd (AECOM) was appointed by the Land Transport Authority, Singapore (LTA), through the Letter of Acceptance dated 22 October 2019, to carry out the CR2005 Contract – Provision of Services to Conduct Environmental Impact Study (EIS). An EIS is required to be undertaken to assess the potential environmental impacts arising from, and associated with, the construction and operation of Cross Island Line (CRL) Phase 2 ('the Project') on the Biodiversity Study Areas abutting the Phase 2 alignment.

The current scope of work of this Contract will only focus on the direct alignment of CRL Phase 2 between Bright Hill and Clementi, excluding the alignment portion within the Central Catchment Nature Reserve (CCNR) which was covered under the *Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line* ("CCNR EIA") gazetted by LTA on 2 September 2019 which is available online from LTA website. Prior to the commission of this EIS, an Environmental Consultation Process was undertaken by LTA with the relevant technical agencies (i.e. MPA, SFA, NEA, NParks), as well as MND/URA. Thereafter, the scope of EIS was documented in the Inception Report Rev A [R-2] submitted to LTA on 3 March 2020.

Note that the methodology for vibration impact assessment was finalised only after NG engagement was carried out for the CRL Phase 2 near Windsor Nature Park on 23 March 2022.

The objective of this Report is to conduct environmental impact assessment from the construction and operation of railway line associated with CR16 station in the Biodiversity Study Areas, i.e., Clementi Forest, Maju Forest and Old Jurong Railway Corridor, identified nearby the construction and operational footprint of this Report context. The original CRL2 location and construction worksites (i.e., Worksite at Nursery and CR16 Worksites) are presented in Figure 3-1 as the base and mitigated plans. The indicative operational footprint of CR16 is presented in Figure 3-2.

This EIS provides an overview of the environmental baseline status along the route of the CRL2 alignment before the commencement of any actual pre-construction works (including site clearance) and construction of this Project. It consists of the construction impacts on the environment from above ground construction (i.e., biodiversity, hydrology and surface water quality, soil and groundwater, air, airborne noise, as well as ground-borne vibration impacts) and underground tunnelling activities (i.e. ground-borne vibration impact). It also comprises the operational impacts on the environment from train operation and maintenance activities (i.e., biodiversity, hydrology and surface water quality, soil and groundwater, air, airborne noise, as well as ground-borne vibration). The study impact assessment assumes that general good construction and operational practices will be adhered to, known as minimum controls, especially since the Project sites are in vicinity of sensitive receptors. Additionally, where the impacts are predicted to be "Significant" or "Moderate/Major", further mitigation measures to be implemented during the construction and operational works are also recommended. Thereby, residual impact assessment is assessed and presented in this Report.

It should be noted that this Report corresponds to the engineering design developed during preliminary design stage. As such, this EIS Final Report only presents the impact assessment on the environmental parameters from the preliminary engineering design. Pursuant to this Study, there are some recommendations as input to the design, which will be discussed and then re-evaluated when the design incorporates/develops/changes at the later stage of this Project.

Project Components and Schedule

According to current schedule of works at the time of writing this Report, the overall construction period of the entire CRL2 (including the construction worksite in this Report) is estimated to be from end of Year 2022 to end of Year 2032. The tentative construction timeline for the main construction of CR16 station and associated facilities, such as the station entrances/exits, is expected to last from early 2023 to mid-2032.

Generally, the construction activities of this Project include pre-construction activities and main construction activities. Pre-construction activities may require site clearance, tree clearance, temporary worksite establishment and monitoring instruments installation, while main construction activities could include ground improvement works, shaft construction and the installation of PPE-roofs at both sides of the CR16's subway. This will underpin the tunnelling works with Tunnel Boring Machine (TBM) at CR16 launching towards CR15 retrieval shaft (one of the concurrent developments for cumulative impact assessment) as illustrated in the schematic launch/retrieval plan in Figure 3-24. Main construction works will also include the construction of MRT superstructures for station boxes and permanent vent shafts, as well as landscaping works. The Worksite at Nursery will be required to support the construction of CR16.

For CR16 station worksite to reach its required platform level, rock breaking and excavation may be expected at a depth of approximately 27m below ground level. The need for rock breaking and excavation and associated impact assessments will be determined during the construction phase.

Furthermore, the vicinity of Old Jurong Railway Corridor is planned to be enhanced as a pedestrian walkway (utilising a 'light touch' or a natural theme) and there would be provision of ancillary facilities such as lifts, escalators, bicycle parking etc. where it exits at Maju Forest.

The targeted year of completion is expected to be 2032 at the time of writing this Report.

Design Optimisation for Construction Worksites

Throughout the Project, various design optimisations were conducted and discussed with AECOM to take into consideration of reducing environmental impacts. This includes but is not limited to:

- Reducing the construction footprint to avoid and minimise direct encroachment into Clementi Forest and Biodiversity Study Area, which minimises environmental impacts to the ecologically sensitive receptors.
- Splitting of CR16 worksites into several sites, including the cleared site in Clementi Forest (B1) and B2 worksite within the centre of Clementi Road for station construction, demolition worksite (B3) for the existing pedestrian overhead bridge (POB), and Worksite at Nursery (B4) for non-construction related activities (e.g., site offices) (refer to Figure 3-14). This minimises the land take of Clementi Forest and would still allow for Clementi Road to be operational during construction.
- Removal of the pedestrian walkway proposed to be constructed through Old Jurong Railway Corridor.

Apart from the base scenarios, all these design optimisation measures were assessed as mitigated scenarios in this Report (Figure 3-1).

Summary of Impact Assessment

The construction and operational activities as described in Section 3 would have impact towards the environment, therefore were assessed within the Study Area and the agreed scope of work.

Other key developments or projects identified in the vicinity of the Project have also been studied. As described in Section 3.4.1, there are five (5) major developments identified nearby CR16 where their construction activities might occur concurrently with this Project, including PUB DTSS2 link sewer (DTSS), Old Jurong Nature Trail, a new road development at Brookvale Drive, the CR15 worksite and the creation of the Clementi Nature Trail that will align across Clementi Forest and Maju Forest. As the details of construction and operational activities were not available at the time of writing this Report, only qualitative cumulative impact assessment was carried out in this Report.

The findings of the environmental impact assessment in this EIS Final Report are summarised as follows:

Biodiversity

Field surveys were conducted over an intensive five-month period (November 2019 – March 2020) to cover all known vegetation and habitat type and generate the floral and faunal baseline that will be reflective of each of the Study Areas. A total of approximately 300 floral species and 200 faunal species were recorded in all two Study Areas and the five different vegetation types were identified. It contained more interesting floral and faunal species than expected, especially along the Old Jurong Railway Corridor. It was observed that the slopes which flank both sides of the Old Jurong Railway Corridor are populated with numerous nationally threatened individuals of the stream-associated species in both Maju Forest and Clementi Forest. The waterlogged areas along Old Jurong Railway Corridor were also observed to support nationally threatened faunal species.

Areas of high conservation value were identified at both Clementi and Maju Forests during baseline studies. Following mitigation hierarchy, design optimization was applied to avoid or minimize impact to ecologically sensitive receptors. Where such impact could not be avoided, minimization and compensatory measures were applied.

The most severe impact from the construction phase at Clementi Forest is of major/moderate significance from habitats, floral and faunal species as for base scenario. This was mainly due to works resulting in loss of habitat and/or vegetation during site clearance, mortality to floral species and the loss of terrestrial and aquatic ecological connectivity for faunal species. After application of mitigation measures, major/moderate impact significance was mostly reduced to minor/negligible impact significance. This is largely due to the shifting worksite away from main streams (D/S1 and D/S2 streams) and the optimisation of worksite within Clementi Forest. Yet, there are still residual **moderate** impact significance due to worksite resulting in disturbance to tributary stream (D/S22) and habitat/vegetation loss are permanent and irreversible.

The most severe impacts from the operational phase at Clementi Forest are of major/moderate significance. This was mainly due to loss of ecological connectivity from the proposed pedestrian walkway along Old Jurong Railway Corridor for faunal species. After application of mitigation measures, moderate impact significance is mostly reduced to minor/negligible impact significance.

The most severe impact from the construction phase at Maju Forest is of major/moderate significance from habitats, floral and faunal species. This was mainly due to works resulting in loss of habitat and/or vegetation during site clearance to habitats, mortality to floral species and the loss of ecological connectivity for faunal species. After application of mitigation measures, major/moderate impact significance were all reduced to minor/negligible impact significance. This is chiefly due to the shift in worksite out of Maju Forest.

The most severe impacts from the operational phase at Maju Forest are of major/moderate significance. This was mainly due to loss of ecological connectivity from proposed pedestrian walkway along Old Jurong Railway Corridor. However, after the shift in worksite out of Maju Forest, major/moderate impact significance was reduced to minor/negligible impact significance.

The documentation of baseline, assessment of impacts and the recommendations of mitigating measures here aims to reduce the impacts of the proposed construction and set out mitigating measures that will achieve the best conservation outcome for the development. The above-mentioned optimised worksite design for CR16 was assessed as the CR16 Mitigated Scenario in the following hydrology and water quality, soil and groundwater, air quality, airborne noise, and ground borne vibration impact assessments.

Subsequently, cumulative impacts from concurrent developments in the vicinity were qualitatively assessed to ensure that impacts from these developments are considered. Five different concurrent developments were looked at. It was anticipated that significant cumulative impacts would occur to the habitats, flora and fauna of Clementi Forest as a result of the five concurrent developments i.e., Old Jurong Nature Trail, Clementi Nature Trail, DTSS, Brookvale Drive and CR15.

Hydrology and Surface Water Quality

The hydrological baseline study aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data, site survey as well as PUB water catchment map, eight (8) major watercourses were identified in Clementi Forest and Maju Forest. In Clementi Forest, the identified watercourses were two (2) natural streams (D/S1 and D/S22), two (2) earth drains (D/S2 and D/S21), one (1) concrete drain (D/S20). Three (3) natural streams (D/S23, D/S24 and D/S25) were also identified in the Maju Forest. Water from the identified drains/streams eventually flows into Sungei Pandan. The water from Sungei Pandan is pumped into Pandan Reservoir for drinking water purpose. Besides, some of the natural streams in Clementi Forest (i.e. D/S1, D/S2 and D/S22) and Maju Forest (i.e. D/S23, D/S24 and D/S25) are located within the areas of high ecological value and supports biodiversity life. Hence, it is important to understand potential environmental impacts of these drains/streams affected by the Project activities.

To study the water quality within the identified drains/streams, two (2) dry and one (1) wet weather samples were collected from twelve (12) water quality stations at the watercourses in Clementi Forest and Maju Forest. Water samples were tested for both physical and chemical parameters relevant for sustenance of aquatic life including temperature, pH, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), turbidity, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total phosphorus (TP), orthophosphate (PO_4-P), total nitrogen (TN), and nitrate (NO_3-N). Analysis of the water quality results have shown that the water quality of the watercourses is relatively consistent with its ecological significance.

In Clementi Forest, the water quality was good for aquatic life in terms of temperature, pH, TDS, turbidity, TSS, BOD_5, COD, TN, and NO_3-N in perennial watercourses. DO level at most of the stations met aquatic life criteria, except for drain D/S2 and midstream of stream D/S1 (lower than 4 mg/L) during dry and/or wet weather, due to their stagnant conditions. However, previous study also showed that at DO below 4 mg/L in Singapore natural streams, freshwater aquatic life may have adapted and therefore are found to thrive in these conditions in Singapore. Elevated TSS found at drain D/S2 indicated high sediments existed in the stagnant water condition. Relatively high phosphorus concentrations (i.e. TP and PO_4-P) were detected from all the tested water samples. This suggested that existing watercourses have high eutrophication potential, which is consistent with the site observation of greenish watercourses with algae. The overall baseline water quality of the perennial watercourses was likely to be suitable for aquatic life. This supports the biodiversity findings, especially the natural stream D/S1 to be of high ecological value. In Maju Forest, temperature, BOD_5, and NO_3-N at the natural streams met the limits of NEA guideline and aquatic life criteria. Lower pH and DO levels were found in stream D/S24 and stream D/S25 during dry and/or wet weather conditions. High TSS level was observed at stream D/S24 during dry weather and elevated turbidity were found at stream D/S23 and stream D/S24 during dry and/or wet weather conditions. COD levels at the natural streams during wet weather exceeded the limits of NEA guideline and aquatic life criteria. High phosphorus nutrient was found in the natural streams in Maju Forest, and this indicated high eutrophication potential all the time. It can be concluded that the overall baseline water quality of the natural streams in Maju Forest is poor and suggests possible unfavourable conditions for aquatic life. However, the aquatic life could have adapted to such existing conditions based on biodiversity findings, which considers the natural streams to be of high ecological value.

Based on the assessment of the hydrology and water quality related impacts on the various sensitive receptors, The proposed construction footprint (base scenario) was assessed to cause Major impact on stream D/S1, drain D/S21 and drain D/S22 while the operational footprint was assessed to cause Moderate impact on streams D/S1 and D/S22 in term of hydrology and water quality, even with implemented minimum controls. Hence, proposed mitigation measures included temporary diversion of the affected area of stream D/S22, and absolute stream D/S1 conservation with no disturbance on its water quality and hydrology within 30m from both embankments of the stream during construction phase in order to reduce impact from the worksites. Flow diversion of drains will require PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from the worksites to the diverted drain requires to meet NEA Trade Effluent Discharge Limits if applicable. For operational footprint, the mitigation measures included redesign and reduce proposed footprint areas, permanent diversion of the affected section of stream D/S22 and area reinstatement by providing greenery provisions to reduce the peak runoff resulting in reduction of flood risk at downstream area. Should these recommendations be successfully implemented during both construction and operational phases, the impact significance could be reduced to Minor.

For other watercourses in these forested areas which the construction or operational footprint are not within their catchment areas, they were assessed to have only Minor to Negligible impacts on hydrology and water quality during both construction and operational phases. Thus, apart from the minimum controls identified and those incorporated in the construction and operational plans, no additional management or mitigation measures would be required.

Therefore, given that the minimum controls and mitigation measures for the CRL2 construction and operational activities will be implemented, the significance of residual impacts from the potential hydrology and water quality impacts on the sensitive water receptors was assessed to be **Minor to Negligible**.

The cumulative impacts from concurrent developments identified in the vicinity of the CRL2 were assessed. It was concluded that the concurrent developments including PUB Deep Tunnel Sewerage System Phase 2 (DTSS2) manholes and pipeline along Clementi Road, proposed Brookvale Drive development, Clementi Nature Trail, Old Jurong Line Nature Trail and CR15 footprints (i.e. worksite and station) are unlikely to increase the impact extent on hydrology and water quality of identified watercourses in Clementi Forest and Maju Forest given best management practices and minimum controls provided by its developer are in place during both construction and operational phases.

<u>Soil and Groundwater</u>

The potential impacts on soil and groundwater of historical and current/potential land uses associated with the construction and operational phases of the Project were discussed with reference to LTA's HLUS reports, past soil and/ or groundwater studies, construction waste information and other best available data.

The soil and groundwater within the Project site were identified as Priority 3 sensitive receptors, as they were not for direct sensitive uses (e.g. agricultural/irrigation/drinking water purposes) and not directly extracted for industrial uses, therefore not posing unacceptable risks. Streams that support habitats and/or species of high conservation significance and those which are partly supported by groundwater were identified as Priority 2 sensitive receptors.

The potential sources of soil and groundwater impact during construction were expected to be mainly from pre-construction activities (e.g. site clearance, levelling, land grading works) and main construction activities of this Project such as tunnelling activities, which may cause decreased groundwater baseflow feeding into the streams, potential contamination from toxic chemical waste used or generated on site, as well as potential leakage from improper handling of hazardous chemical/substances on site.

The potential sources of soil and groundwater impact during operational phase were expected to be mainly from maintenance of rail infrastructure, vent shaft and stations with potential contamination from toxic chemical waste used or generated, as well as potential leakage from improper handling of hazardous chemical/substances within the operational footprint of the project. According to preliminary planning at the time of writing this Report, this Project is assumed to have maintenance works for each station and rails within the tunnels to be carried out once a week. These activities could lead to generation of small quantities of toxic chemical waste (e.g. used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) as well as accidental leakages of hazardous chemicals/ substances due to improper handling/ management. These generated chemicals may seep into the wastewater drainage systems and/ or into the soil and groundwater, potentially impacting their quality. Furthermore, there is a potential for contamination of soil and/ or groundwater due to accidental spills and leaks in the storage areas of maintenance chemicals.

Minimum control measures for soil and groundwater which are commonly implemented in Singapore have been included in this Report. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site.

Hence, the significance from potential sources of soil and groundwater impacts during construction and operational phases such as decreased groundwater baseflow feeding into the streams, potential contamination from improper management of excavated soil and/ or extracted groundwater, toxic chemical waste generation and improper handling of hazardous chemicals/ substances was assessed to be Minor to the sensitive receptors, and no further mitigation measures were required for CRL Phase 2 Project (CRL2).

Cumulative impacts from concurrent developments identified in the vicinity of this Project during both construction and operational phases were assessed. It was concluded that the concurrent development of planned PUB DTSS link sewer along Clementi Road might increase the impact during construction phase only. Hence, appropriate mitigation measures should be proposed to minimise these adverse impacts by the project developer to avoid accidental spillage of chemicals for impacting the quality of soil and groundwater, and to ensure surface water streams are diverted with an equivalent capacity of stream if impacted and to minimise groundwater drawdown in line with best practice measures. The impact from other concurrent developments might not increase soil and groundwater impact in their construction or operational phases given best management practices and minimum controls are in place as the development might only have significant changes on the land use.

Air Quality

Air quality impact assessment for construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to which, a 50 m Study Area was considered for earthworks, construction and trackout activities due to ecological sensitive receptors in the vicinity of the worksites. Dust generated during construction works can have adverse effects upon vegetation – restricting photosynthesis, respiration and transpiration. Furthermore, it can lead to phytotoxic gaseous pollutants penetrating the plants. Overall, the deteriorated air quality can lead to a decline in plant productivity.

Air quality impacts from the construction and operation of the proposed Project were assessed on air sensitive receptors (ASRs) in the vicinity of the Project site. Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the earthworks, construction and trackout activities. During the operational phase, emissions from vehicle exhaust due to increased traffic in the vicinity of the proposed development is identified as the predominant air emission source. In order to assess the current baseline air quality in the Study Area, baseline air quality data was collected at one (1) representative monitoring location between 11-18 March 2020. All pollutant concentrations were found to be within the Singapore Ambient Air Quality Long Term Targets, except 1 out of 7 days at Singapore University of Social Sciences (SUSS) (A01) which recorded 24-hour average $PM_{2.5}$ concentrations of 26.5µg/m^3. However, the targets are met for the rest of the week at SUSS with average daily $PM_{2.5}$ concentration of 14.4µg/m^3 throughout the week.

The results of the assessment showed that unmitigated impacts are classified as Major and have the potential to affect the receptors near the construction footprint unless mitigation measures are put in place (see Section 10.7.1 for assessment details). This is largely because of the large extent of the construction worksite located very close to or within the areas with flora, fauna and habitat with high ecological value. This Report outlines mitigation measures that can be implemented by the Contractor as administrative or management measures, sourcing from best practice measures internationally, which are detailed Section 10.8.1. When the proposed mitigation measures are applied successfully, the significance of impacts is anticipated to be reduced to **Minor** (see Section 10.9.1 for details). The key control and mitigation measures include but not limited to development of air pollution control plan, dust control measures on site, site hoarding, planning of dust causing activities-location and timing, reinstating land upon completion of works amongst several others. Based on the assessment, “CR16 Mitigated Scenario” is preferred compared to “CR16 Base Scenario” due to its smaller footprint. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors. The construction Contractor is recommended to prepare an air quality management plan incorporating a range of monitoring and mitigation measures in line with Section 10.8.1, Section 13.9.1 and Section 13.13.1.

Air quality impacts were also qualitatively weighed for operational phase. Fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the Project is expected. It is assumed that all new vehicles to meet their Euro emission standard. Furthermore, there is currently a large traffic volume along the Clementi Road. The buffer from some green areas which will not be disturbed as part of the Project, will also help in terms of providing cleaner air from the impact from the vehicles. At a much higher level, trains are meant to replace substantial vehicles from roads, as passengers commute using trains, therefore in that scheme the Project may have a positive effect on road traffic. However, for immediate localised road traffic to and from the stations may see some increase. In this aspect with the information assessed at this stage, the air quality impact contributed from the proposed development is anticipated to be **Minor** during the operational phase. No mitigation measures are required during operational phase as no significant air quality impact is expected from Project operation.

Cumulative impacts from other major concurrent developments in the vicinity of each construction worksite are presented and detailed in Section 10.10. Due to the presence of these concurrent construction sites, the overall construction footprint is expected to be larger. With all these concurrent construction activities, the cumulative air quality impact during construction phase in the area might significantly increase.

Airborne Noise

Noise impact assessment was carried for the construction phase of the proposed worksite for CR2005. The construction noise Study Area was defined as combination of Maju Forest, Clementi Forest and 150m from the CR16 worksite. The noise impact assessment for the operational phase of the proposed CR16 worksite for CR2005 included providing boundary noise criteria for ACMV at the station and qualitatively assesses traffic noise to the noise sensitive receptors within Maju Forest and Clementi Forest. However, it is to be noted that LTA may not be designing in detail for the compliance to noise criteria at this stage, in which case the imposed criteria at boundary will form a mandatory requirement when the worksite is designed during detailed design stage. Baseline noise monitoring (recorded average $L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$ and $L_{Aeq(5\ min)}$) was carried out at four (4) locations. Uncorrected baseline noise was used as a more stringent criterion for assessment of ecological receptors in this Study.

For the assessment on construction phase, the noise levels generated from the equipment used during construction detailed in Section 11.3.1 was predicted using SoundPLAN ver 8.2. Topography played an important role in noise propagation and was included in this assessment. A quantitative assessment of the noise sensitive receptors (within Biodiversity Study Area) was carried out and compared with the stipulated *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.* The identified noise sensitive receptors were assessed in accordance with the impact evaluation matrix as shown in Section 6.4.2. Noise contours were provided. Based on the impact evaluation, mitigation to reduce airborne noise impacts was recommended for the affected ecological noise sensitive receptors.

The study on construction noise impact to the noise sensitive receptors focused on three (3) different construction base scenarios and six (6) different mitigated scenarios respectively. The three Base Scenarios are: Scenario 1: Cut and cover works and associated activities; Scenario 2: Tunnel Boring Machine (TBM) works; and Scenario 3: Construction of station entrances. Six (6) different Mitigated Scenarios are: Scenario 1: Advance work; Scenario 2: Construction of site office; Scenario 3: Demolition of POB; Scenario 4; Main civil work, Scenario 5; Tunnel Boring Machine (TBM) works; and Scenario 6: Construction of station entrances. It must be noted at this stage that worst-case assumptions on equipment usage, period of usage, and more conservative approaches for barrier heights were proposed to predict the worst impacts to these locations that are of highly sensitive nature.

Noise sensitive receptors were determined based on the species and habitats identified during ecological surveys undertaken within the Biodiversity Study Area. Data collected outlined how species utilise habitats within the Study Area; a habitat sensitivity map was created to indicate the airborne noise sensitivity of habitats and the species they support. Urban habitats and features, such as hardstanding areas, identified nearby the Biodiversity Study Area and Proposed Development, are considered unsuitable to support fauna, and thus were considered to be ‘Not Assessable’. As per NG Engagement held on 23rd March 2022, it was mutually agreed that habitat sensitivity map would be used for this Project to determine the probability of finding species within Study Area.

For the modelling undertaken as part of the impact assessments for construction Base Scenario 1 to Base Scenario 3, results indicated that an impact significance of Major is likely to occur, with a maximum exceedance of 33 dB(A) at Maju Forest and 33 dB(A) at Clementi Forest. Note that since the intensity of impact is much higher than the criteria, mitigation measures are proposed in Section 11.8 with residual impacts shown in Section 11.9. Efforts were also made to optimise the size of CR16 worksite within Clementi Forest as much as possible. The revised design was re-evaluated in this Report as the mitigated scenario.

Following the assessment of all design optimisation options, it is recommended that noise barriers, with a height of 6m, 12m respectively, are used for specific mitigated scenario i.e., use of LTA standard 15m fully enclosed noise barrier for TBM with one façade opening (as shown in Figure 11-8).

Based on the residual airborne noise impact assessment above, the proposed 6m and 12m noise barriers at CR16 main construction worksite will be beneficial by reducing the impact significance and area of major impact significance, from Major (Base Scenario) to Moderate-Major (Post Mitigated scenario), at Clementi Forest. This will also reduce the impact significance from Major (Base Scenario) to Minor-Major (Post Mitigated Scenario) at Maju Forest.

During Advance work construction, the proposed 6m noise barriers at the west and south-east construction boundary of CR16 Advance worksite will only reduce the noise level at the southern part of the Clementi Forest since there is no noise barrier along the northern part of the construction site; the resulting impact significance will therefore be Major at Clementi Forest and Maju Forest. Whilst the noise barrier will reduce the impact to ground level and low height noise sensitive receptors, said mitigation will not reduce the impact to arboreal receptors which utilise tree canopies. However, the total areas of “Major” impact significance are expected to be reduced significantly from base to mitigated worksite and can be seen obviously in the noise figures (refer to Figure 11-16 to Figure 11-21).

Given that the residual impact significance is **Major**, it is recommended that portable noise barriers are installed near to noisy equipment and/or activities. Furthermore, it is essential that no night works are carried out beyond 7pm for all non-safety critical activities as the site is situated next to sensitive receptors.

For rock breaking and excavation works proposed at the CR16 worksite, the approach taken was to provide a guideline to the criteria as set out in BS5228-2:2009+A1:2014. Based on assumptions made (rock breaking and excavation location, depth, breaking method) and known information (distance to nearest receptors), this assessment provides an estimate on the maximum amount of MIC (explosive charge mass, kg) that should be permitted in order to keep air overpressure within the stated criteria. Predictive methods in AS 2187.2-2006 Explosive – Storage and Use Part 2 were used to predict air overpressure based on constants recommended within the guideline. Based on the impact assessment, from CR16 worksite (Base Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Clementi Forest will potentially experience medium impact intensity with medium impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain and the resulting impact significance is Major. The Priority 1 ecologically sensitive receptors at Maju Forest will potentially experience low impact intensity, with a resulting impact significance of Moderate. The resulting impact significance for Priority 3 ecologically sensitive receptors at Maju Forest is Minor. After the mitigation measures within Section 11.8 are implemented, from CR16 Worksite (Mitigated Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Clementi Forest will potentially experience medium impact intensity with medium impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain and the resulting impact significance is Major. The Priority 1 ecologically sensitive receptors at Maju Forest will potentially experience low impact intensity, with a resulting impact significance of Moderate. The resulting impact significance for Priority 3 ecologically sensitive receptors at Maju Forest is Minor. Since the impact significance is Major in Clementi Forest, the further mitigation measures refer to Section 12.9 from vibration section and EMMP requirement from Section 13.11 need to apply to reduce the residual impact.

For the cumulative impact assessment with the concurrent projects, Manholes MH-4A and MH-4B near Old Jurong Railway as part of PUB DTSS2 project and construction of CR15 worksite near the Clementi Forest are planned in the vicinity of CR16 worksite. The impact significance before mitigation for CR16 ranges from Moderate to Major. Due to the presence of these concurrent construction sites, the construction footprint in this area is expected to be larger; for example, CR15 and CR16 will be undertaken concurrently, and both require some land take of Clementi Forest to undertake construction.

Much more extensive PME are required, and area excavated or impacted to Clementi Forest are more than that required by CR16 worksite only. It is expected that the cumulative impact from this construction will, therefore, be much more significant impact than the CR16 worksite alone in this area with an impact significance potentially increasing to Major. The detailed information associated with the CR15 construction, such as noise contour figures, equipment inventory and PMEs, were not included in this Report, however, were provided in a separated EIS report for CR15.

Concurrent project such as DTSS construction is restricted typically only in road reserve and may add little to cumulative noise owing to its location and smaller footprint than CR16 construction footprint. However, once CR16 is operational and largely noisy works would be underground, thus meaning that no significant noise impact will occur due to CR16 in operation.

Ground-borne Vibration

The study assesses the impact of construction ground-borne vibration on the impacted areas within the biodiversity areas such as Clementi Forest and Maju Forest.

AECOM reviewed several works of literature to gather information on vibration thresholds of fauna. Research shows that vibration thresholds for fauna are species-specific. There is a limited amount of information in this area for the indicator species for the study. The study uses the step threshold endured by humans as a basis to form a criterion for the vibration impact assessment.

The study assesses vibration impacts from construction and operational phases on the potential of burrow damage/collapse for fossorial species (i.e., structural impact assessment) and the ecological behaviour of the sensitive receptors. The biodiversity habitats/fauna species classifies in Priorities 1, 2 and 3 as ecologically sensitive receptors based on their ecological values and sensitivity towards vibration. The indicator species includes pangolins. The study assesses predicted vibration levels from the construction and operational phases of the Project. It evaluates against the impact assessment matrix for impact intensity, consequence, likelihood and impact significance on the ecological behaviours of the ecologically sensitive receptors.

The study predicted vibration levels for various construction equipment at the CR16 worksite for unmitigated and mitigated scenarios. The vibration levels are assessed according to the impact assessment matrix.

For the unmitigated scenario, the bulldozer causes minor – moderate vibration impact significance at Clementi Forest and negligible – moderate vibration impact significance at Maju Forest. Avoiding construction work at night could reduce the vibration impact significance from moderate to minor at Clementi Forest and Maju Forest.

Low and high amplitude vibratory compactor causes negligible – minor impact significance in the mitigated scenario. The contractor should use best available techniques (BAT) and control construction vibration levels to PPV, 8 mm/s at vibration sensitive biodiversity areas.

Tunnel boring vibration levels predicted using the BS5228-2:2009+A1:2004 method cause minor – major impact significance at Clementi Forest and Maju Forest. Hence mitigation measures are recommended for the mitigated scenario to reduce the impact significance to minor – moderate.

There is pipe jacking in the mitigated scenario during Advance Works for utility. The vibration levels may cause partial burrow collapse and cause negligible – major impact significance on the ecological receptors. As the depth of works (for the pipes) is very willow (7 m only), other construction methods are unlikely to mitigate vibration levels. The worksite needs to avoid exceedances at PPV, 8 mm/s, which is the threshold for burrow damage/collapse to control vibration impacts.

During Stage 2 in the mitigated scenario, there are rock breaking and excavation activities. This construction method produces high vibration levels, thus causing impacts on the structural integrity of burrows; and minor-major impact significance on ecological receptors. The rock breaking and excavation works must limit their vibration emission levels to PPV, 8 mm/s in areas with potential burrows to avoid damage/collapse of the burrow entombing the fauna. As high vibratory compactors produced PPVs exceeding 5 mm/s, it is recommended to use low vibratory compactors to reduce vibration impacts on burrows.

Temporary barriers (i.e. water barriers of 1 m height) should be implemented along Brookvale Drive and Clementi Road. Canvas sheets should also be used to cover the holes on the existing railings along Brookvale Drive and Clementi Forest. Hoardings must be ensured at the worksites and at the existing construction beside Maju Forest. These will potentially mitigate roadkills due to the impacted fauna trying to dash onto a road during the construction activities, reducing the impact significance to moderate.

Operational vibration impact assessment results indicate that standard track form and deep tunnel depth are sufficient to mitigate vibration impacts on sensitive fauna species. The residual impact significance on ecological behaviour with mitigation measures is **minor** in Clementi Forest and Maju Forest.

There are other significant concurrent developments during the construction and operational phase of CR2005. The study assesses cumulative vibration impacts qualitatively. During the construction phase of CR2005, there are ongoing construction works at PUB Deep Tunnel Sewerage System Phase 2 (DTSS) link sewer, road construction works, and residential development works. The ground-borne vibration caused by rock breaking and tunnel boring for CR2005 is the dominant vibration source within the vibration Biodiversity Study Area. The construction schedule of these ongoing works and the schedule of CR2005 for high vibration activities are drastically different in construction timelines. Therefore, overlapping schedule for high vibration works such as piling at both sites is unlikely to happen. The vibration levels caused by ongoing works at other sites are insignificant in the cumulative impact assessment.

During the operational phase of CR2005, the track works attenuate ground-borne vibration levels caused by moving trains. The levels are insignificant in the cumulative impact of other significant concurrent developments.

Overall, there are negligible – major residual impacts during the construction phase due to tunnel boring, pipe jacking, rock breaking and excavation at Clementi Forest and Maju Forest. The study recommends controlling vibration levels emitted to PPV, 8 mm/s where burrows of fossorial species are sighted to prevent damage/collapse of the burrows and entombing the species. Further mitigation measures include setting up temporary barriers (i.e. water barriers of 1 m height) along roads near the worksite and EMMP measures to reduce the impact significance to negligible – moderate. Concurrent construction activities at nearby works are unlikely to cause more impacts on the vibration Biodiversity Study Areas. Moving trains induce low ground-borne vibration levels and are insignificant to cause vibration impacts on the ecological receptors. Thus, there are no residual impacts for the operational phase.

Conclusions and Recommendations

In conclusion, the summary of unmitigated impact significance and potential residual impact significance of the assessed environmental aspects for both construction phases and operational phases are presented in the following tables. The recommended Environmental Monitoring and Management Program (EMMP) measures are summarised in Section 13.13. Note, that residual impact significance with mitigation measures, refers to the impact significance after mitigation has been applied.

Table 1-1 Summary of Potential Residual Impact Significance during Construction Phase

Environmental Parameter	EIS Section	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Biodiversity	Section 7	Negligible to Major	Negligible to Moderate (Note 1)
Hydrology and Surface Water Quality	Section 8	Negligible to Major	Negligible to Minor
Soil and Groundwater	Section 9	Minor	Minor
Air Quality	Section 10	Moderate to Major	Minor
Airborne Noise	Section 11	Negligible to Major	Negligible to Major (Note 2)
Ground-borne Vibration	Section 12	Negligible to Major	Negligible to Major (Note 3)

Note:

1. Though vegetation and habitat loss has been reduced by moving the station footprint away from Clementi Forest and main stream (DS/1 and DS/2), the loss of vegetation due to site clearance from the new worksite would still result in moderate impact for scrubland and herbaceous vegetation. Such vegetation and habitat loss are permanent and irreversible. After application of mitigation measures, **major/moderate** impact significance was mostly reduced to minor/negligible impact significance. This is largely due to the shifting worksite away from main stream (D/S1 and D/S2 streams) and the optimisation of worksite within Clementi Forest. Yet, there are still residual **moderate** impact significance due to worksite resulting in disturbance to tributary stream (D/S22) and habitat/vegetation loss are permanent and irreversible
2. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevated area which cannot be blocked by the proposed noise barrier.

Environmental Parameter	EIS Section	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
3. Despite minimum controls, the impact significance still reached Major at Maju and Clementi Forests during rock breaking and excavation, tunnel boring and pipe jacking. Thus, further mitigation measures and EMMP should be implemented to obtain a resultant impact significance to Moderate.			

Table 1-2 Summary of Potential Residual Impact Significance during Operational Phase

Environmental Parameter	EIS Section	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Biodiversity	Section 7	Negligible to Major	Negligible to Minor
Hydrology and Surface Water Quality	Section 8	Negligible to Moderate	Negligible to Minor
Soil and Groundwater	Section 9	Minor	Minor
Air Quality	Section 10	Minor	Minor
Airborne Noise	Section 11	Negligible	Negligible
Ground-borne Vibration	Section 12	Minor	Minor

This EIS Final Report only presents the impact assessment on the environmental parameters from the preliminary design stage of the Project, where the assessed worksite areas exclude detailed design elements such as locations of piezometers, utilities/ traffic diversion areas, and site elements (e.g. workers' dormitory, detention tank and site office). Should there be any changes to the design of the Project elements in this Report during detailed design stage or actual construction phase, the Contractor should take note of the design exclusions and update the findings of this EIS accordingly.

2. Introduction

AECOM Singapore Pte Ltd (AECOM) was appointed by the Land Transport Authority, Singapore (LTA), through the Letter of Acceptance dated 22 October 2019, to carry out the CR2005 Contract – Provision of Services to Conduct Environmental Impact Study (EIS). An EIS is required to be undertaken to assess the potential environmental impacts arising from, and associated with, the construction and operation of Cross Island Line (CRL) Phase 2 ('the Project') on the Biodiversity Study Areas abutting the Phase 2 alignment.

The LTA intends to construct Singapore's eighth and longest fully underground Mass Rapid Transit (MRT) line, the CRL, to provide an underground rail link to enhance connectivity between the east/northeast and west of Singapore and to meet future transport demands. The CRL will be approximately 50 km in length and span the length of Singapore to connect Changi in the east to the Jurong Industrial Estate in the west. CRL is planned to be developed in phases. Constructed in three phases, the 29 km CRL Phase 1 will comprise of 12 stations from Aviation Park to Bright Hill [W-1]. This phase is currently undergoing detailed design and build stage and is expected to be in operation by 2030.

However, this Project as part of CRL2 originally covered two optional routes of approximately 8 km (or Option 1 direct alignment) or 12 km (Option 2 skirting alignment) according to the *Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line* ("CCNR EIA") gazetted by LTA on 2 September 2019 which is available online from LTA website [R-1]. The CCNR EIA included environmental impacts from the two alignment options only for the extent of alignment either passing through or skirting around the CCNR area (8 km or 12 km stretch). Based on the findings of this CCNR EIA, and the approvals thereof during its gazette period, LTA announced in the news on 4 December 2019, the finalised alignment as Alignment Option 1 [W-2]. CR2005 was therefore advised to only assess the direct alignment of CRL2 between Bright Hill and Clementi. In addition, since the CCNR EIA has already covered the CCNR stretch, the scope of work for this CR2005 Contract only includes the changes and development made for the alignment portions outside the CCNR.

The objective of **this Report** is to conduct an environmental impact assessment that considers impacts on biodiversity within the Biodiversity Study Areas which may be impacted as a result of the construction and operation of a railway line associated with the CR16 station; the Biodiversity Study Areas being assessed include Clementi Forest, Maju Forest and the Old Jurong Railway Corridor, which are all situated nearby the construction and operational footprint of the Proposed Development.

The planning for the entire CRL2 alignment is still ongoing and a separate report will be provided for Windsor Nature Park and Eng Neo Avenue Forest, and Turf City and Holland Plain, respectively, to evaluate the remaining construction worksites. The original CRL2 location and construction worksites (i.e., Worksite at Nursery and CR16 Worksites), mitigated plan and operational footprint of CR16 are demonstrated in Figure 3-1.

This EIS also provides a pre-construction environmental baseline status along the route of the Project alignment. It covers the construction impacts on the environment from above ground construction (i.e. biodiversity, hydrology and surface water quality, soil and groundwater, air, airborne noise, as well as ground-borne vibration impacts) and underground tunnelling activities (i.e. ground-borne vibration impacts). In addition, it covers the operational impacts on the environment from train operation and maintenance activities (i.e. biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise, as well as ground-borne vibration). Other major concurrent developments are discussed in Section 3.4.1.

Additionally, where the impacts are deemed to be "Significant" or "Moderate/Major", appropriate mitigation measures to be implemented during the construction and operational works are also recommended. The study impact assessment assumes general good practice construction and operational practices will be followed mandatorily, known as minimum controls, especially since the Project sites are in vicinity of sensitive receptors. This Report also presents an Environmental Impact Register (EIR) as shown in Appendix A to be adhered to by the Contractors/operators during construction and operation.

It should be noted that this Report corresponds to the engineering design developed during preliminary design stage only. This EIS Final Report only presents the impact assessment on the environmental parameters from the preliminary engineering design. Pursuant to this study there are some recommendations as input to the design, which will be discussed and then re-evaluated when the design incorporates/ develops/ changes at the later stage of Design stage as well as this Project.

2.1 Scope of Work

Prior to the commission of EIS, an Environmental Consultation Process was undertaken by LTA with the relevant technical Agencies (i.e. MPA, SFA, NEA, NParks). Thereafter the scope of EIS was documented in the Inception Report Rev A [R-2] submitted to LTA on 3 March 2020, as summarised below:

- Definition of Study Area around the Project construction footprint, considered for the assessment of environmental impacts;
- Identification of sensitive receptors for biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise, as well as ground-borne vibration;
- Prediction and evaluation of impacts;
- Recommendation of mitigation measures;
- Assessment of residual impact; and
- Recommendation of Environmental Monitoring and Management Plan (EMMP), also in form of EIR (Appendix A).

This EIS has assessed design elements, construction methodology, Project components, and operational activities within LTA's preliminary design available at the time of writing. Understanding of the Project construction methods and operational activities have been clearly stated in Section 3.2 and 3.3, and detailed assumptions, if any, are described in individual assessment sections thereafter. Should the detailed design make alterations to these assumptions/approaches at later stage, a revised impact assessment will be undertaken by LTA to address these changes.

2.2 Report Structure

The structure of the report is as follows:

- **Section 3** – Description of the Project provides a general description of the Project components, construction activities, operational activities, schedule, Project resources, waste and emissions expected from the Project;
- **Section 4** – Description of the Environment provides a general description of the site setting, land use, historical features, topography, geology, water catchment and climate of the Project;
- **Section 5** – Environment Legislation, Policies, Plans, Standards and Criteria provides the legislative requirements relevant to the Project;
- **Section 6** – Description of Assessment Methodologies provides the overview of the methodology used for the assessment;
- **Section 7** – Biodiversity presents the methodology, baseline environment, sensitive receptors, and potential sources of impacts, minimum controls and evaluation of impacts to biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 8** – Hydrology and Surface Water Quality presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts to hydrology and surface water quality within the Study Area, along with recommendations for mitigation measures;
- **Section 9** – Soil and Groundwater presents the methodology, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts from construction and operational activities (e.g. general and toxic solid/ liquid waste generated, spoil handling, storage of bulk hazardous materials on site, etc.) to soil and hydrogeological conditions of the Study Area, and also to ascertain the presence of possible pollutants in the underlying soil and groundwater that may impact the local vegetation and downstream watercourses, along with recommendations for mitigation measures;
- **Section 10** – Air Quality presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts from the Project to air quality on the biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 11** – Airborne Noise presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of noise impacts on the biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 12** – Ground-borne Vibration presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of ground-borne vibration impacts on the biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 13** – Environmental Monitoring and Management Program (EMMP) details the organisational framework, stakeholder roles and responsibilities, monitoring program requirements and detailed EMMP; and
- **Section 14** – Conclusions provides a conclusive summary of the EIS's outcomes.

2.3 Study Limitations, Assumptions and Constraints

The information contained in this document originally produced by AECOM Singapore Pte. Ltd. (“AECOM”) was produced solely for the use of the Client and was prepared to assist in the Environmental Impact Study for the Contract CR2005. The focus in this Report will be a portion of the direct CRL2 alignment and its associated worksites for CR16 station which are located at/nearby the Biodiversity Study Area (i.e. Clementi Forest and Maju Forest), but excluding the area within CCNR which has been covered separately under the CCNR EIA [R-1] published by LTA.

AECOM devoted normal professional efforts compatible with the time and budget available in the process of this Project. AECOM’s findings represent its reasonable judgments within the time and budget context of its commission and utilizing the information available to it at the time.

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3. Description of the Project

This section describes the Project location, Project components, proposed construction activities and operational activities, Project schedule, as well as the other major concurrent developments in the vicinity of the Project. The Project resources such as electricity, concrete, equipment used, and the waste produced during construction and operational phases have also been discussed.

3.1 Project Location and Components

The Project scope includes consideration of both the construction and operational phases for CR16 station which are located at/nearby the Biodiversity Study Areas (i.e. Clementi Forest and Maju Forest).

In order to objectively assess the Project at this stage, the locations of construction and operational footprint, the optimisation of the construction worksite design (comparing both base and mitigated scenarios), as well as the Project's activities or components during both phases are described in separate sections below.

3.1.1 Construction Phase

During construction phase, the Project will include the CR16 worksite, a pedestrian walkway through Old Jurong Railway Corridor, as well as the Worksite at Nursery to support CR16 construction activities. The Clementi Forest, Old Jurong Railway Corridor and Maju Forest are identified as the Biodiversity Study Areas in the vicinity. The locations of the original construction worksites (base scenario) and Biodiversity Study Areas (i.e., Clementi Forest and Maju Forest) are demonstrated in Figure 3-1. Section 3.1.1.1 also further elaborates on the design optimisation of the worksites in order to reduce the overall environmental impacts during the construction phase. Design optimisation plans are presented in Figure 3-1.

As mentioned in Section 2, the entire CRL2 direct alignment will pass through CCNR area, whereby the tunnel alignment will mostly be bored through bedrock strata at depths ranging between 23m to 90 m below ground level (bgl) along the whole alignment (average 70 m bgl under the CCNR). As per current planning, the CR2005 tunnel alignment (excluding CCNR area) in overall would not exceed -60m below Singapore Height Datum (SHD). The construction of launch shaft is planned at CR16 worksite where the TBM will launch towards the CR15 worksite (one of the concurrent projects) where the TBM will be retrieved.

As per the base scenario, the Worksite at Nursery near Clementi Forest is being expected to have only above-ground construction works (e.g., site office, stockpile, etc). Furthermore, the CR16 Worksite at OJR is intended for use as a pedestrian walkway underneath Clementi Road (refer to Section 3.2.2.11), where it will be incorporated with an at-grade structure as entrance/exit at Maju Forest, as well as pedestrian walkway at Clementi Forest leading to CR16 main station box. Other than that, a subway will be constructed to connect CR16 main station box to its opposite Entrance 3 near SUSS across Clementi Road.

3.1.1.1 Design Optimisation and Changes of Construction Worksites in Mitigated Scenario

In parallel to the EIS work, feedback was constantly provided to LTA and vice versa during the concept and preliminary design phases of the design development. During these meetings with the client, Agencies, and Nature Group representatives, various design optimisations and considerations to reduce environmental impacts were discussed with AECOM and the feedback was incorporated as design progressed. Apart from the base scenarios, all design optimisations discussed below were assessed as mitigated scenarios and consequently their impacts have been detailed in the individual sections of this Report. The difference between original worksites (i.e., base scenario) and optimised worksites (i.e., mitigated scenario) are shown in Figure 3-1.

The original worksite (base scenario) was situated predominantly within Clementi Forest, with a small proportion expanding across the Old Jurong Railway Corridor and adjacent hardstanding areas at Clementi Road. Various options were discussed with LTA, and relevant Agencies to mitigate the potential biodiversity impacts towards Clementi Forest. Thereafter, decision was made to adjust the worksite footprint to reduce the land taken within the forest to limit the impact on ecologically sensitive habitats, flora and fauna, whilst agreeing to the realignment of the northern section of the CRL railway alignment to accommodate lower land taken in Clementi Forest. In addition, the changes also ensure that development will not be undertaken within the proximity of the Old Jurong Railway Corridor.

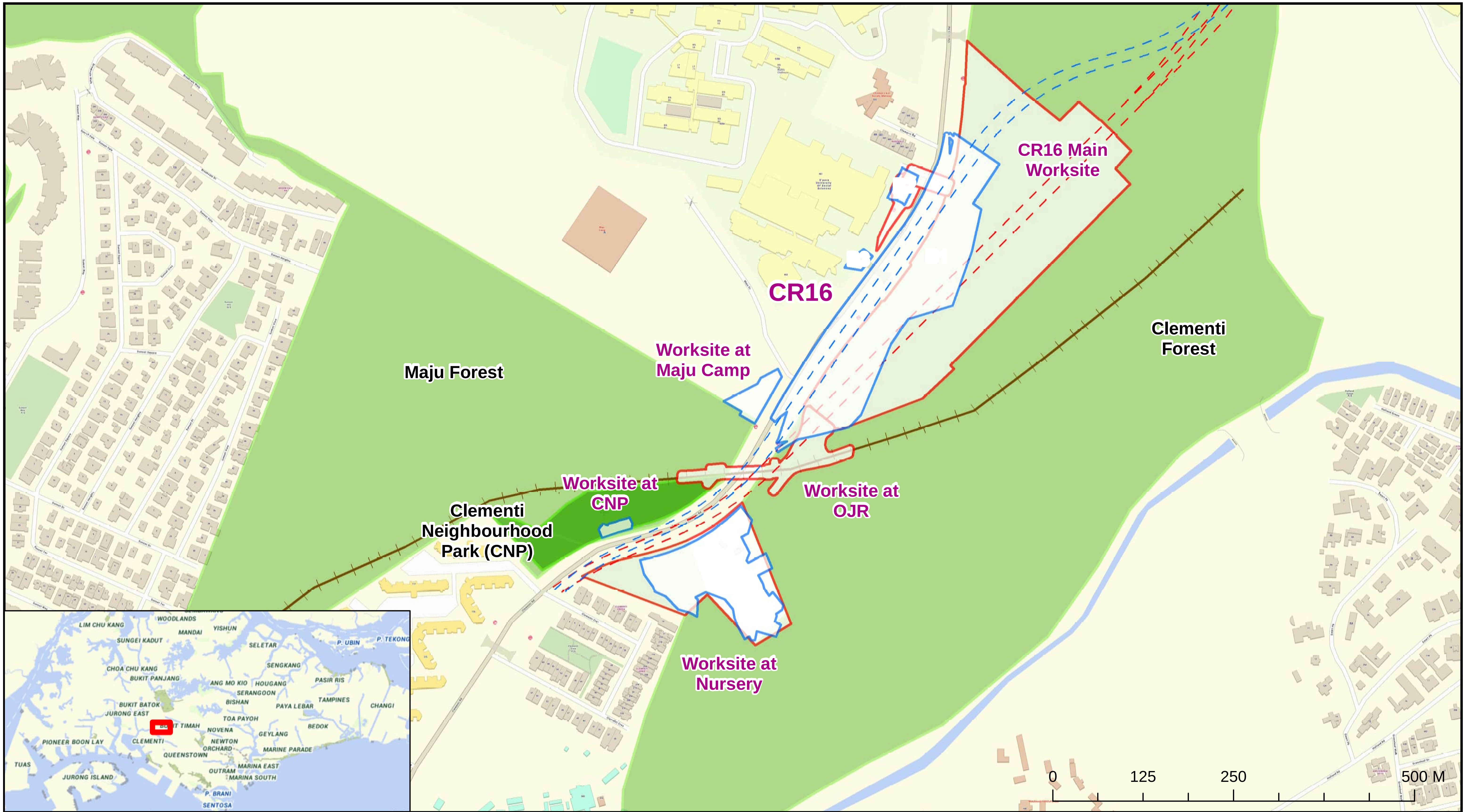
In order to fully utilise available spaces outside of Clementi Forest for construction works and to ensure development can be undertaken partially beneath Clementi Road, the mitigated scenario has been divided into three stages including Advance Worksite, Stage 1 and Stage 2 Worksites with details in Section 3.2.

This optimisation has greatly helped in avoiding direct encroachment into the Biodiversity Study Areas or its further fragmentation, hence minimising environmental impacts to the ecologically sensitive receptors in Clementi Forest. For example, CR16 construction worksites have been downsized, approximately, from a collective 124,058 sqm to 65,428 sqm and is partially shifted away from Clementi Forest, compressed, closer to Clementi Road.

3.1.2 Operational Phase

The indicative operational footprint for CR16 is demonstrated in Figure 3-1. During operational phase, CR16 will become an MRT station. For the base scenario, a pedestrian walkway is planned under Clementi Road utilising the Old Jurong Railway Corridor, which is planned to be enhanced for pedestrians (utilising a 'light touch' or a natural theme) and will provide ancillary facilities such as a lift, escalator, cycle parking etc., where it exits at Maju Forest. Furthermore, no permanent structure is proposed for the Worksite at Nursery during operational phase.

Following the optimised design of construction worksite, whilst the station and associated station entrances and subways were all originally situated within the western extent of Clementi Forest, the CR16 station is now proposed to be built below the Clementi Road with vent shafts and entrances (Figure 3-1). There will be three entrances, including entrances at Maju Camp, at SIM and at Clementi Forest side, with all subways between station to entrances becoming underground. Moreover, plans to use the Old Jurong Railway Corridor beneath Clementi Road as a pedestrian walkway were reconsidered as part of the Environmental Study.



Legend

- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Clementi Neighbourhood Park
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

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-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

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LTA Endorsement : NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
PROJECT LOCATION AND
CONSTRUCTION WORKSITES
(BOTH BASE AND
MITIGATED SCENARIOS)

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Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Underground Station (Base)
- Underground Station (Mitigated)
- Old Jurong Railway Corridor
- Biodiversity Study Area
- Above Ground Pedestrain Walkway
- Underground Pedestrian Walkway
- Vent Shafts (Base)
- Station Entrances/Exits (Base)
- Vent Shafts (Mitigated)
- Station Entrances/Exits (Mitigated)

N

Note: *This figure only shows indicative footprint of underground station box, above-ground entrances and ventilation shafts during operational phase, which these key features and others may subject to future changes.*

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
INDICATIVE OPERATIONAL FOOTPRINT AT CR16 STATION

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Figure No. : 3 - 2
Rev. : -
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3.2 Proposed Construction Activities

Each above ground Project construction worksite will require areas for site offices, equipment and material storage and worker's rest areas. The areas designated for the above ground components will also support the construction of the underground components of the Project. In terms of construction hours, it was recommended that in overall there will be no above-ground night works (not safety-critical) at CR16 worksites after 7pm due to the ecological sensitivity of Clementi Forest and Maju Forest (i.e., 7am to 7pm), except for D-wall trenching works and the underground TBM works which will be continuous for 24 hours due to safety considerations. The restriction of working hours was included as one of the proposed biodiversity and noise mitigation measures in this Report.

Construction phases includes the following phases:

3.2.1 Pre-Construction Activities (Advance Works)

The base scenario of advance worksites (refer to Figure 3-3) was situated predominantly within Clementi Forest, with a small proportion expanding across the Old Jurong Railway Corridor and adjacent hardstanding areas at Clementi Road. Various options were discussed with LTA, and other relevant Agencies to mitigate the potential biodiversity impacts towards Clementi Forest. Thereafter, decision was made to adjust the worksite footprint to reduce the land take within the forest to limit the impact on ecologically sensitive habitats, flora and fauna, whilst agreeing to the realignment of the northern section of the CRL railway alignment to accommodate lower land take in Clementi Forest. In addition, the changes also ensure that development will not be undertaken within the proximity of the Old Jurong Railway Corridor. Hence, the mitigated advance worksites (refer to Figure 3-3) consist of main worksite (A2) used for construction activities located within the Clementi Forest, and a small worksite (A1) for non-construction related activities (e.g. site office) in an existing turf area of the Clementi Neighbourhood Park (CNP). During the advance work stage, pre-construction activities include site investigation works to inform the geotechnical design of the tunnel and station box. Other pre-construction activities include road and utilities diversion works, site clearance, planning of laydown areas and worksites, creation of access roads, and the installation of instrumentation for the monitoring of tunnelling works. These stages are further discussed below:

3.2.1.1 Site Clearance

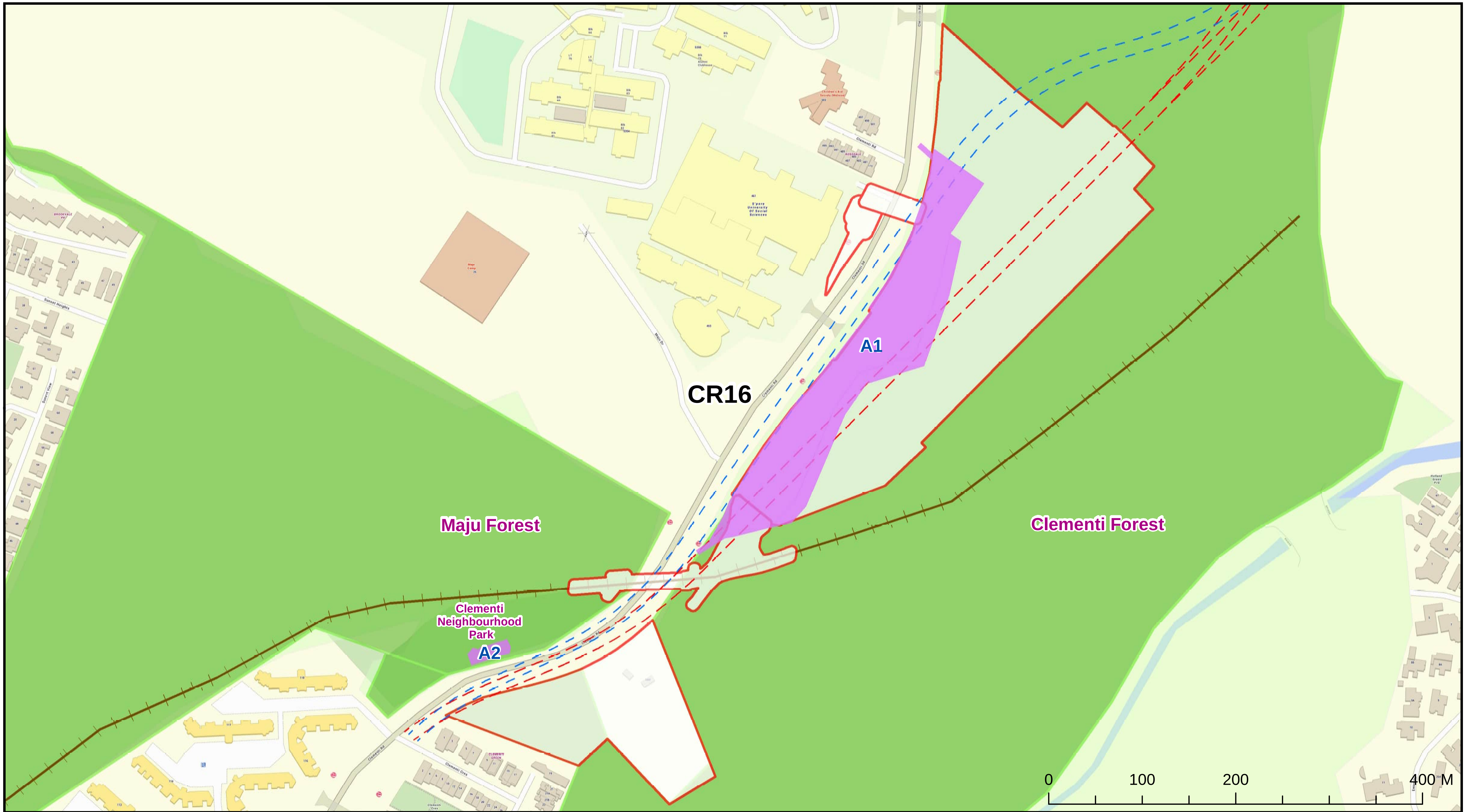
Pre-construction activities will involve clearance of trees, vegetation and levelling at the construction worksite areas as well as for the access roads. For this, the construction Contractor's Qualified Erosion Control Professional (QECP) will prepare Erosion Control Plan (ECP) and obtain approval from the Public Utilities Board (PUB). The Contractor also maps the trees on site and the trees planned for removal or retention and obtains National Parks Board (NParks) approval. The construction site debris, felled trees and spoil will be temporarily stored on site and then collected by licenced third parties for offsite disposal.

At this time, EIS report must be consulted by the Contractor for following requirements and therefore, plan of action:

- For any areas rich in trees of conservation interest where tree-felling of girth more than 1m is required [W-3], the Contractor should employ a certified arborist to map the trees carefully while applying for tree felling approval. This is to gauge the health, species, size and conservation significance of the tree;
- If there are trees that are required to be transplanted, this is done prior to commencing site clearance;
- If the area is rich in wildlife, the Contractor consults wildlife specialist and prepares a wildlife shepherding plan, obtains NParks approval and executes it prior to/ along the site clearance process. In this case, the direction of clearance is set by the Wildlife Shepherding plan. The site clearance is led by wildlife specialist(s), who helps shepherd, save, and relocate wildlife as necessary;
- It is best to avoid site clearance in migratory birds or breeding season, as many nests and therefore birds may be impacted upon. In such an event, the wildlife specialist not only assists in shepherding, but also to spot the birds' nests, and recommends on the spot measures to be taken to avoid disruption; and
- Site hoarding process and extent should also be governed by the above factors and the approved plans by NParks (see example in Figure 3-5 below).

The Safety, Health and Environmental (SHE) Personnel engaged by the Contractor during the construction phase will incorporate the above-mentioned requirements into the EMMP.

The construction site debris, felled trees and spoil will be temporarily stored on site and then collected by licenced third parties for offsite disposal (see Figure 3-10 and Figure 3-11 below for example). The indicative land area cleared and levelled with each worksite is 15,000 sqm for the ventilation buildings and over 100,000 sqm for the station boxes [R-4].



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Construction Worksite Footprint (Advance Worksite)
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

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-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
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Consultant :
AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
ADVANCE WORKSITE (BOTH BASE AND MITIGATED SCENARIOS)

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	Drawn: ASH	Date: MAY 2022

Figure No. :	Rev.	Sheet
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Note: Source of basemap - OneMap

Figure 3-4 Examples of Site Clearance, Tree Felling and Internal Access Roads [O-6]

Figure 3-5 Examples of Site Hoarding Erection [O-6]

In this process, the site is eventually levelled for construction to begin (See Figure 3-6 below). This may involve cutting and stabilising of slopes in areas such as Clementi Forest (See Figure 3-7 below). In this case, soil nailing will need to be done along the cut slope, while geotextile will be used for fill slope along the worksite boundary on Clementi Forest side. It is noted that the soil nails will be installed about 0.9m below the ground surface via micro piling. An ECO on site will need to take care of measures to prevent erosion of soil into the nearest drainage network at this stage. This may or may not accompany ground improvement works depending on the nature of the soil in the area.

Figure 3-6 Examples of Site Levelling Works [O-6]

Figure 3-7 Examples of Slope Cutting Works [O-6]

3.2.1.2 Traffic and Utilities Diversion Works

A key initial preparation activity will be traffic and utility diversion. Sections of selected roads, which will be affected by the construction, will be either temporarily diverted or access will be restricted to certain parts of the road. Works will include land clearing and tree feeling, road widening activities, construction of temporary roads to divert traffic and setting up of barriers around impending cut-and-cover works or around laydown areas. In addition, as the natural landscape will be replaced by impervious surfaces, it will reduce infiltration of water into the ground and increase water runoff. Besides, given in this case that road networks will be constructed, there is potential for the existing drainage network to be redesigned, where drainage works associated with temporary and permanent access roads might be expected.

Utilities which are willow and likely to cause impedance to cut and cover works will be diverted first, so that there is no disruption in usage of utilities by nearby human beings. If required, some of the utilities will be reinstated after underground station or tunnelling is completed and these utilities need to be restored at the same place. Depending on the utility to be diverted, this may involve tree felling, excavation, access road construction and concrete resurfacing works.

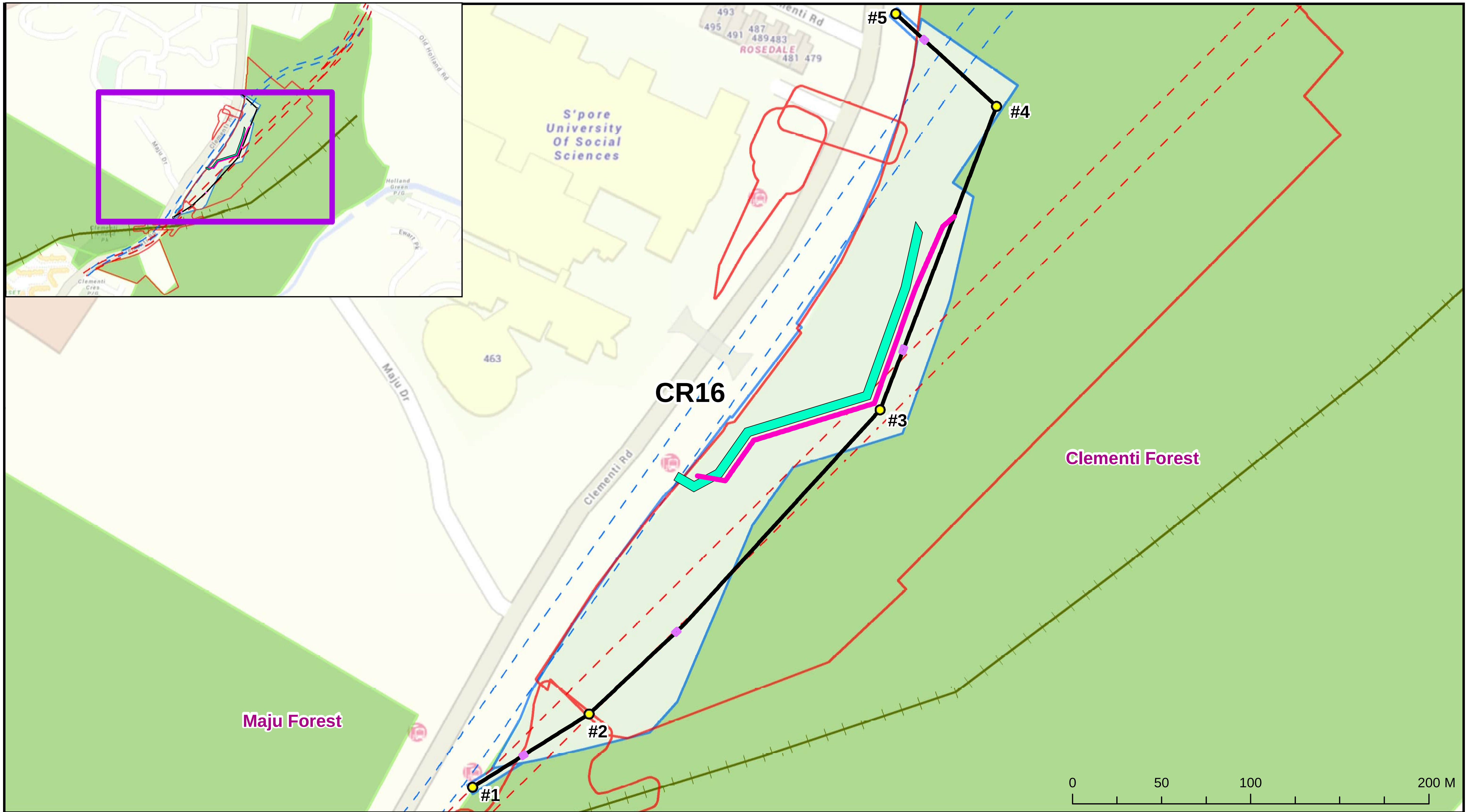
As shown in Figure 3-9, it is noted that there will be utility diversion, temporary and permanent drain diversion works, pumping main diversion, etc. at CR16 worksite for mitigated scenario. For utility diversion from Clementi Road, common utility trench will be constructed with 7.5 m width from inner boundary of worksite along the Clementi Forest side. After all construction works are completed, utilities will be diverted back to Clementi Road. As one of the road side main drain will discharge into the stream within Clementi Forest (refer to D/S22 in Section 8.5.1.1) and upstream of the stream will be occupied by the CR16 worksite, temporary drain diversion will be provided during construction to connect the road side drain and downstream of the stream within Clementi Forest. Before all construction works are completed, this will be converted to a permanent underground drain (as a box culvert) at the middle section of the common utility trench to replace the temporary drain.

Besides, the existing pumping main will be diverted from the Clementi Road to east of CR16 worksite. To construct the pumping main, five shaft worksites will be required along the pumping main alignment. From Shaft 1 to 2 and Shaft 4 to 5, the pumping main will be constructed via open-cut trench method with 3m width x 3m depth. From Shaft 2 to 4, to minimise disturbance on the forest area and avoid tree clearance in the section above ground, pipejacking will be used for the tunnelling as the depth of alignment could be deeper than 3m. Pipejacking generally is referred as microtunnelling in smaller diameters, a technique to install underground pipelines, ducts and culverts. Once construction of pumping main is completed, all the shafts will be converted to access chambers, which will be used for maintenance purpose during operation. It should be noted that PUB is currently constructing DTSS link sewer, a core water infrastructure that will support Singapore’s long-term need for used water collection. The diverted pumping main therefore serves to operate until the DTSS commissions.

Based on the current Project design, all temporary and permanent diversion works will be undertaken within the worksite boundaries (Figure 3-9).

The potential environmental impacts associated with utility diversion are qualitatively discussed in each respective chapter. If there are complaints received due to the utility diversion works (outside of current worksites in this Report), for example regarding noise and air nuisance, the Contractor will inform the Public Relation Officer (see roles and responsibility in Section 13.4.4.8 and conduct relevant on-site environmental monitoring to rectify the issues where possible.

Figure 3-8 Examples of Road Diversion and Traffic Realignment at Sin Ming Avenue End April 2016 [W-3]



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Advance Construction Worksite
- Main Pumping Shafts
- Permanent Drain Diversion
- Temporary Drain Diversion
- Pumping Main Access Chamber
- Pumping Main Alignment
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

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Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
UTILITY DIVERSION AT CR16

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3.2.1.3 Establishment of Temporary Worksites

Following the site clearance, the temporary worksite structures are set up at each worksite. The site features will include areas for offices, toilets, raw material storage area, equipment storage and workshop area, tunnel segment storage area, slurry treatment plant, detention tank, workers' dormitory, waste management facilities and storage, hazardous materials storage, U-turn area (where applicable), recharge wells, internal temporary roads for movement of vehicles and vehicle parking lot (see Figure 3-10 and Figure 3-11 below). All these site elements will only be provided in detailed design stage and are not available for assessment at the time of writing this Report.

According to the latest planning based on the optimised scenario, the total footprint at CR16 main worksite (which include launch shaft, station box, escape shafts, cooling tower, entrances/exits, subway to all entrances) is estimated around 47,853 sqm. For Worksite at Nursery at Clementi Forest and at Clementi Neighbourhood Park, have areas approximating 16,876 sqm and 700 sqm respectively.

A typical layout of construction site with some basic features is shown in the building worksite picture below. It shows site office, internal access roads, equipment laydown area, concrete batching plant, etc. Roads around the site boundary will be also constructed before the commencement of site work, where necessary. For air quality trackout purposes, the access road is defined as a 500m line from the potential access point to the site (i.e., along the Site length of Clementi Road, in addition to 500m north and south of this area). Nonetheless, at this preliminary design stage, relevant assumptions would be made by selecting potential access roads as shown in Figure 10-6.

Figure 3-10 Typical Worksite Layout [O-6]

Figure 3-11 Bright Hill MRT Temporary Worksite Area [W-5]

3.2.1.4 Installation of Monitoring Instrumentation

Instruments such as piezometers and settlement markers will be installed at regular intervals within the designated construction worksite area. A piezometer is usually spaced at 25m and includes an arrangement of settlement marker installed in a 100 mm borehole.

- **Piezometer**: Surface monitoring of groundwater pressure serves as a secondary source of pre-empting the onset of excessive groundwater ingress at the tunnel cutterhead. It is recommended that the SI boreholes be used as future piezometer boreholes, so that additional boreholes may be avoided.

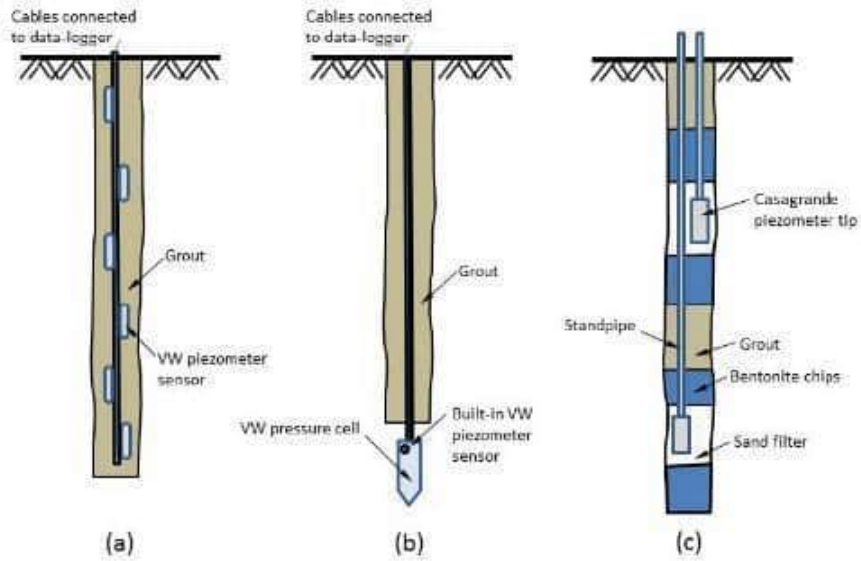


Figure 3-12 Schematic of Piezometer [P-62]

- **Settlement markers**: A settlement marker is a steel rod of approximately 20 mm diameter, which is installed in the ground to record vertical settlement of the ground surface using an inclinometer or equivalent digital level equipment mounted on a tripod. In soft ground, the settlement marker can be a nail shaped rod less than 20cm in length, hammered directly into the ground. This is marked by visual markers such as reflective tape. Where the ground is concrete, the marker is a steel rod at least 1 m long which penetrates the concrete layer to reach the soil. A concrete coring drill and handheld drill will be used to install each settlement marker.

Figure 3-13 Settlement Markers [W-12]

The frequency of such measurements is typically not more than once a day and is only necessary during the period the TBM approaches or passes under the piezometer/marker. In the event of abnormal readings, the TBM operator increases the frequency of measurements at the piezometers/markers and may alter the operational parameters of the TBM to mitigate to once in every 4 hours.

For this Project, the installation of the above-mentioned monitoring instruments will be constrained within the respective worksites to avoid additional site clearance beyond of the worksites. This is to minimise disruption to the Biodiversity Study Areas located nearby. If installation of monitoring instruments has to be conducted outside of the worksites, it will only be conducted on existing footpaths nearby where no additional land clearance is required, provided with approval from the Client and/ or relevant parties/ Agencies (if necessary).

3.2.2 Main Construction Activities (Stage 1 and Stage 2)

In order to fully utilise available spaces outside of Clementi Forest for construction works and to ensure development can be undertaken partially beneath Clementi Road, the mitigated scenario has been further divided into two additional stages after the Advance Worksite i.e., Stage 1 and Stage 2 Worksites. The main purpose of undertaking staged worksites within the new footprint is to avoid direct encroachment into the Biodiversity Study Area and increasing fragmentation of the forest to minimise environmental impacts to the ecologically sensitive receptors in Clementi Forest. The construction activities to be undertaken for Stage 1 and Stage 2 worksites are outlined below.

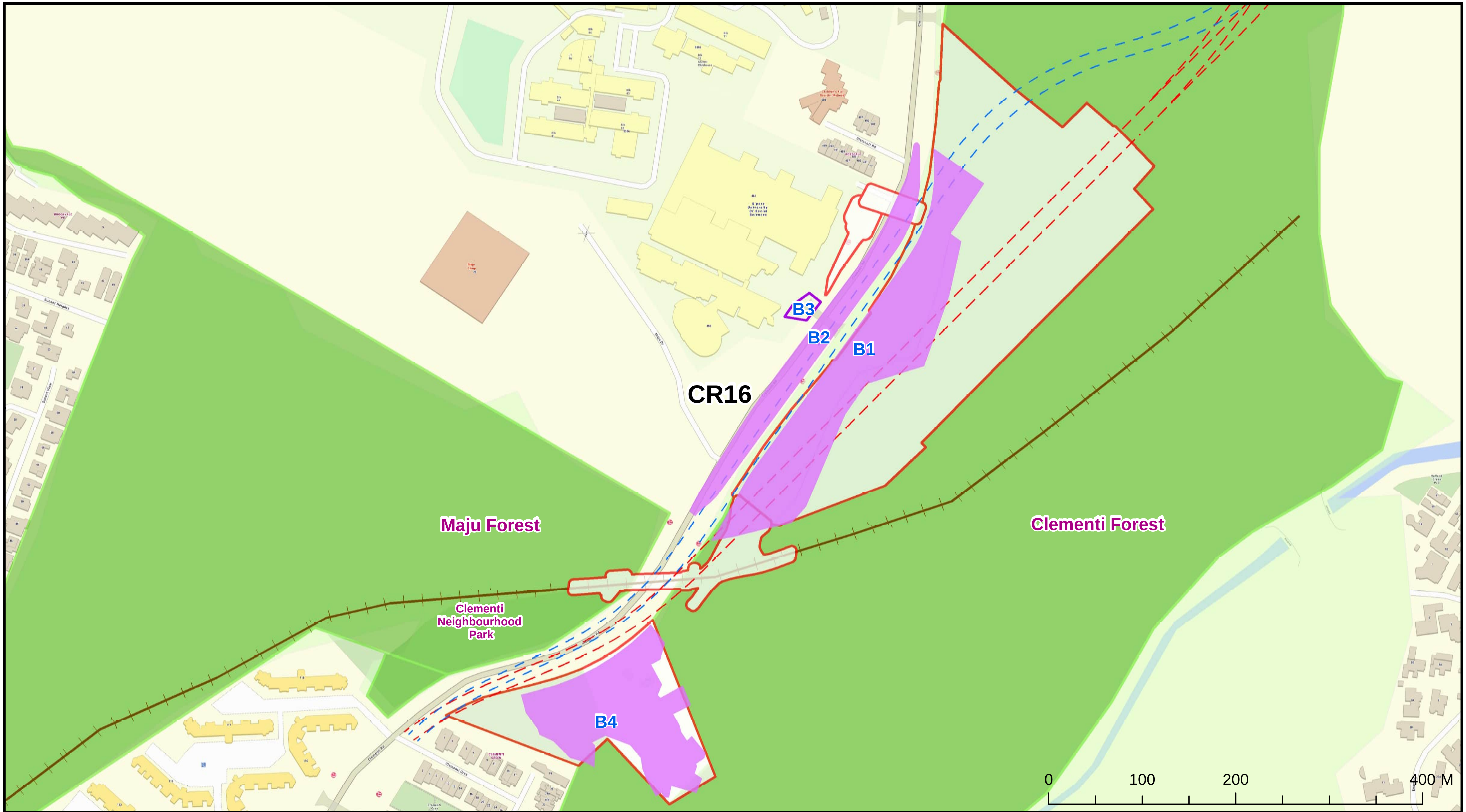
Construction of this Project will involve ground improvement works, underpinning works, rock breaking and excavation works, shaft construction, temporary road access, tunnelling or TBM launch/retrieval works, concrete batching works (if any), as well as the construction of superstructures such as MRT stations, vent shafts, as well as general landscaping/ finishing works.

Stage 1 Worksite

Once advance works are completed, the Stage 1 Worksite (Figure 3-14) for main CR16 construction works will be split into a few sites, including the cleared site in Clementi Forest (B1) and B2 worksite within the centre of Clementi Road for station construction, demolition worksite (B3) for the existing pedestrian overhead bridge (POB), and Worksite at Nursery (B4) for activities required to support the construction of CR16 (e.g. site offices). In order to reduce impact to Clementi Forest, the CR16 station box will be partially situated underneath Clementi Road. A staged traffic diversion of Clementi Road is therefore necessary, resulting in the splitting of worksite into worksite B1 and B2. As shown in Figure 3-14, the CR16 worksite (base scenario) was initially planned to be predominantly situated within Clementi Forest. For the same reasons outlined for the Advance Worksite, the footprint was reduced to limit the impact on sensitive ecological habitats and receptors within Clementi Forest. Given the significant reduction in footprint, a separate site, situated in a garden centre south of the original worksite area which is connected to Clementi Road. Furthermore, the demo worksite has been situated to the west of Clementi Road, situated in a parcel of land between Singapore University of Social Sciences and the road, within the mitigated scenario.

Stage 2 Worksite

After the station construction works are completed within the centre of Clementi Road (i.e. at B2 worksite), Stage 2 Worksite (refer to Figure 3-15) will be further changed to the C1 worksite for station construction and TBM launch shaft, C2 and C3 worksites for construction of entrance and vent shaft. The traffic along Clementi Road will be diverted to west of C1 worksite. In addition, resulting from the changes due to design optimisation of construction worksites, the Stage 2 Worksite also differs from the base scenario. Not only does it also consider the same main worksite footprint as the Advance Worksite and Stage 1 Worksite, the mitigated worksite now considers small fragments of land. This includes a triangular parcel between Maju Forest and Maju FCC, and a small roadside verge situated between Clementi Road and Singapore University of Social Sciences.



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint (Stage 1 Worksite)
- Demolition Worksite for POB
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

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Figure Title : STAGE 1 WORKSITE (BOTH BASE AND MITIGATED SCENARIOS)

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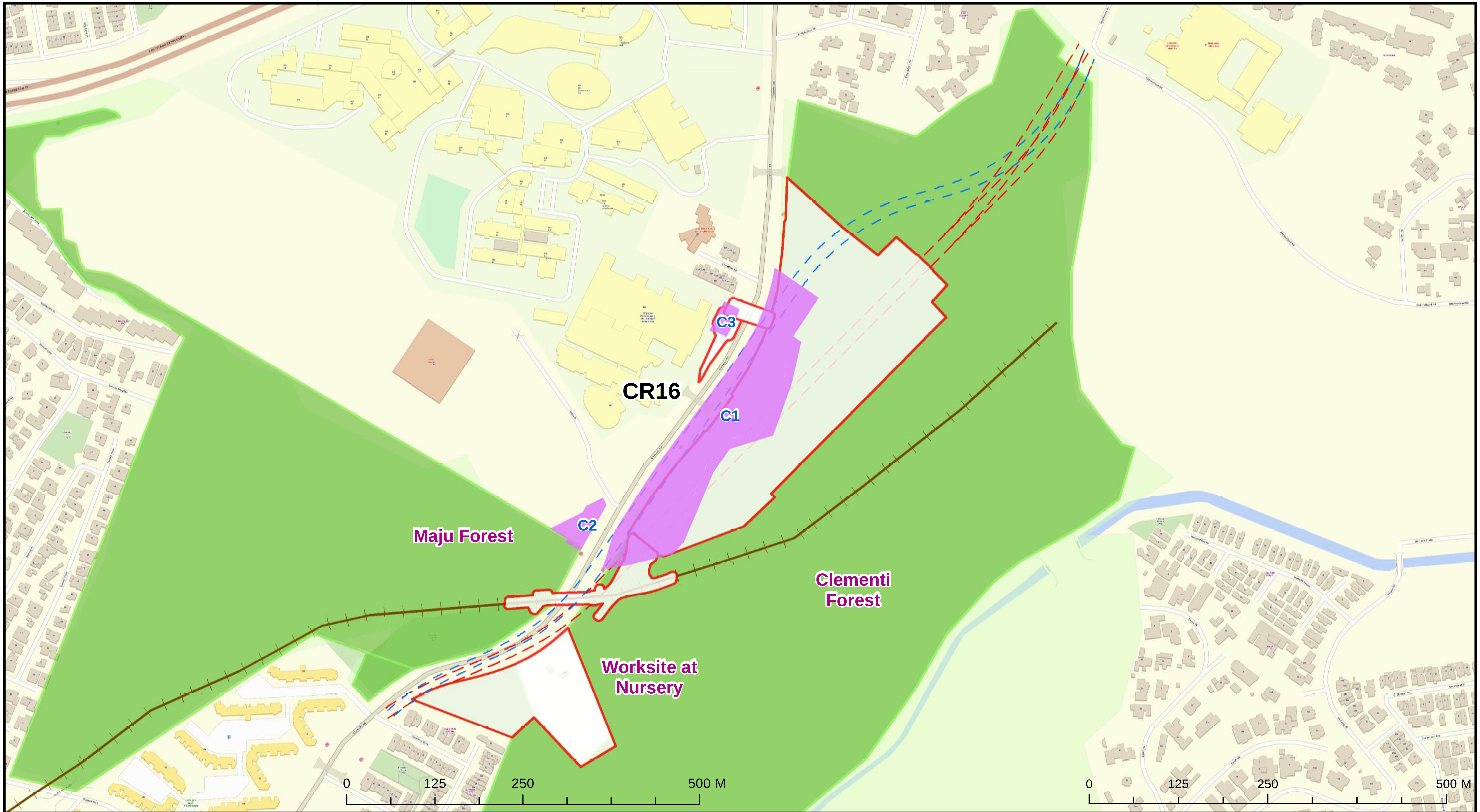

Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint (Stage 2 Worksite)
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
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CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
STAGE 2 WORKSITE (BOTH BASE AND MITIGATED SCENARIOS)

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Note: Source of basemap - OneMap

3.2.2.1 Ground Improvement Works

Ground improvement works will be carried out at each station worksite where the soil condition requires ground improvement before excavation. According to the preliminary design planning at the time of writing this Report, ground improvement with a size of 15m (width) x 15m (length) and a 2m – 3m thickness will be required for the PPE-roof installation at both sides of the CR16's subways which connects its entrances to the main station box.

Typically, the ground improvement works may include a variety of methods as shown in figure below.

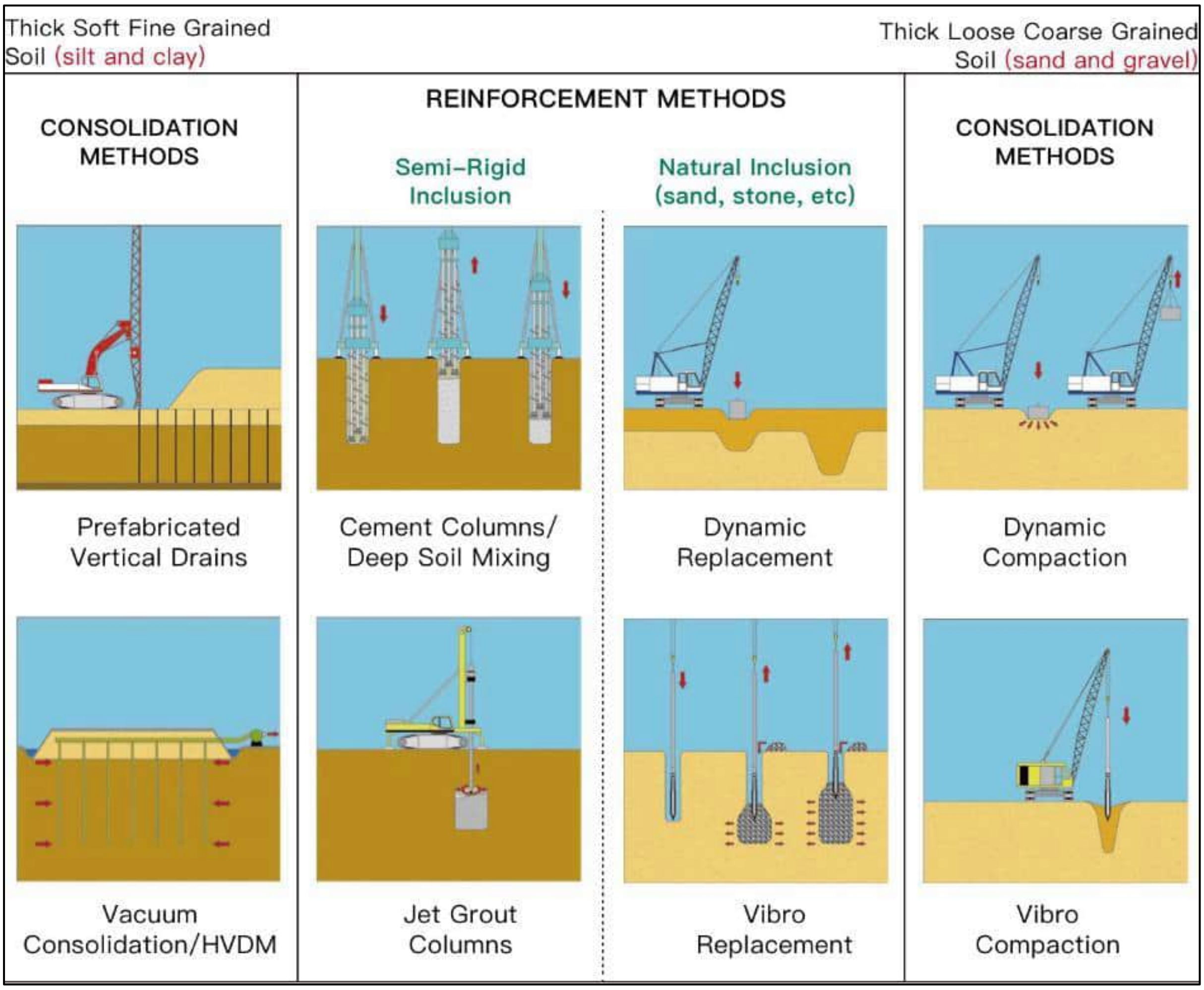


Figure 3-16 Common Ground Improvement Techniques Prior to Excavation [W-16]

On the other hand, in soil conditions ahead of the TBM where there is potential for mixed face conditions to be encountered (exact locations to be determined by Soil investigation by LTA), ground improvement works may be required ahead of TBM cutter head. Construction equipment required for ground improvement works include jet grouting pile rig (JGP) high pressure pump, air compressor, power generator, and a vertical silo wet cement. The cross-sectional area of the ground requiring grouting is assumed to be a corridor extending approximately 3 m out from the circumference of each tunnel [R-1]. Various steps of ground improvement are as below:

- Concrete breaking of the asphalt/ concrete covering the surface, where necessary;
- A 250mm – 300mm diameter casing is driven by vibratory driving method, up to 3m into the ground, to act as guide for the JGP drill probe;
- The JGP drills down to tunnel depth and uses a jet system at the end of the drill probe to erode the surrounding soil column using high pressure water and/ or air;
- The slurry formed from eroded soil and water is pushed up to the surface where it is initially contained within a 1.5m by 1.5m metal box installed around the bore site, and subsequently pumped out into a tote tank for collection and off-site disposal; and
- A grouting mix is pumped into the rill probe and injected into the soil column to form a concrete column within the soil strata [R-1].

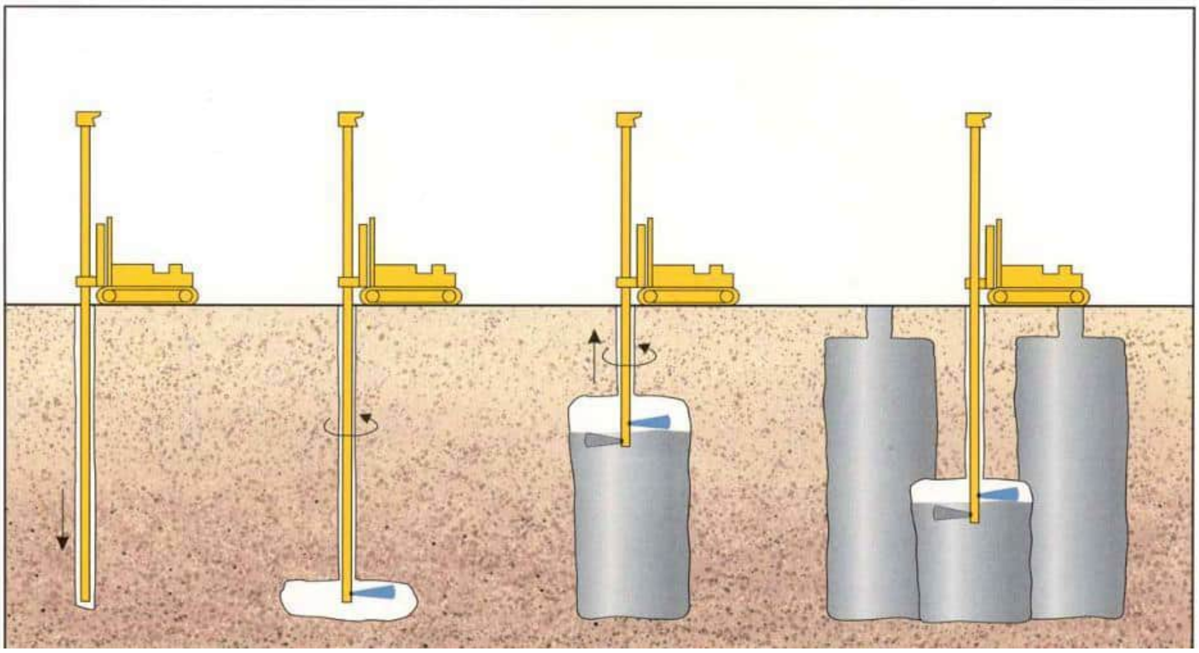


Figure 3-17 Schematic of jet grouting rig operational process [W-17]

3.2.2.2 Underpinning Building Foundations

During early stage of design, LTA usually studies the geology of the tunnelling alignment, and recommends (if required) to obtain a critical mass of data for additional soil investigation so that the geology of the tunnelling depth is known. In addition, all the buildings above the tunnel alignment and in its vicinity are studied for their foundation types, age, depths and conditions. A combination of above determines if original foundation of certain buildings is not stable enough to withstand the tunnel boring or any other construction works in close vicinity or if the building has a potential to undergo settlement due to tunnel boring underneath. The foundations of these buildings are then strengthened by underpinning works prior to commencement of construction in its vicinity.

At the time of writing this Report, no underpinning works are expected for CR16 worksites in this Report, however it is mentioned here for comprehensiveness of the study.

3.2.2.3 Launch/Retrieval and Vent Shaft Construction

Launch/Retrieval or Vent shaft construction typically involves similar construction methods but with different area sizes. The construction of CR16 launch shaft under this Project would averagely require an estimated area of 5,000 sqm to allow TBM to be launched within. It is worth noting here that launch shaft will be constructed before the tunnelling commences.

Construction of a shaft begins with the installation of perimeter walls using sheet piling, or ERSS, before the strutted excavation is carried out to form the opening of the launch shaft. This ERSS helps to support the adjacent soil and prevents water ingress and caving in, thereby limiting ground movement to ensure integrity of nearby buildings, structures and utilities. The ERSS will be designed to comply with Building and construction Authority (BCA)'s requirements and relevant standards and codes of practice, as stipulated in the *LTA's Civil Design Criteria for Road and Rail Transit Systems, September 2019 Edition* [R-5]. The ERSS will be waterproofed in accordance with the standards for underground structures, as detailed in *LTA's Materials and Workmanship Specification for Civil and Structural Works, September 2020 Edition* [R-6] to ensure minimal groundwater ingress into the shaft.

3.2.2.4 Rock Breaking and Excavation Works as part of Shaft Construction

In case of hard underlying ground like Jurong Formation Granite, rock breaking and excavation works may be required. During rock excavation, relief holes will be drilled near the ERSS walls to prevent damage to the retaining walls. In the event that rock breaking is used, relevant protection measures will be undertaken prior to releasing of the charges and will comprise the laying of protection mats over the shaft flow and the covering of the shaft opening with a temporary metal deck. The rock breaking and excavation works will be overseen by a licensed operator, and measures will be undertaken in accordance with the Arms and explosives Rules, 2007 to ensure public health and safety during rock breaking and excavation works [R-1].

At CR16 Study Area, the rock level is expected to be above formation level at the western end of the CR16 station box based on the available boreholes data from site investigation results, therefore is estimated to require one (1) rock breaking per day over a span of eight (8) months with six (6) working days per week. The depth of rock breaking is estimated to be around 27 m below ground level. As per current planning, electronic rock breaking may be adopted. Details of noise and vibration impacts caused by breaking at CR16 worksite are discussed in Section 11 and Section 12 respectively.

3.2.2.5 Station Box Construction

The station box for CR16 and its associated cripple sidings, overrun tunnels and TBM launch shaft will be constructed using the cut and cover construction method. For the station area construction, it may be top down or bottoms up approach, to be decided by the ERSS plan by LTA. In general, for cut and cover construction, the structure is built inside an excavation and covered over with backfill material when construction of the structure is complete. Excavation includes piling, earthworks, D-wall construction for the retaining wall as part of the ERSS plan, ground improvement works, roof slab formation, etc., as well as groundwater control works (e.g. Tam grouting, curtain grouting, etc.).

A brief introduction of the two approaches is detailed below:

Top Down with Island Methods

In top-down construction, typically the tunnel walls (retaining walls) are first constructed to support the excavation. The retaining wall can be a concrete diaphragm wall, a concrete bored pile wall or a steel sheet pile wall, depending on the site condition, soil type and the excavation depth. Thereafter, secondary finishing walls are provided upon completion of the construction followed by the construction of the roof which is tied into the support of excavation walls. The surface will then be reinstated before the completion of the construction. The remainder of the excavation will be completed under the protection of the top slab. Once the excavation is complete, the floor will then be completed and tied into the walls.

Where the tunnels are wide, temporary or permanent piles or wall elements are sometimes installed along the centre of the proposed tunnel to reduce the span of the roof and floors of the tunnel. Diaphragm walls (also referred to as D-walls) will be constructed to support excavation at the site. A D-wall is constructed using a narrow trench excavated in ground and supported by an engineered fluid (typically a bentonite mud) until the mud is replaced by the permanent material. D-walls allow for deep excavation without requiring a large site area to provide stable slope and minimise groundwater flow. The diaphragm walls are anticipated to be approximately 1.5 m thick.

Following establishment of the D-walls, excavation will commence for construction of the cut and cover tunnel and TBM launching shaft. The cut and cover construction method is typically used for willow structures such as station boxes, interfaces with existing MRT lines, turn-backs and supporting structures, such as underground pedestrian walkways (subways) and escape routes.

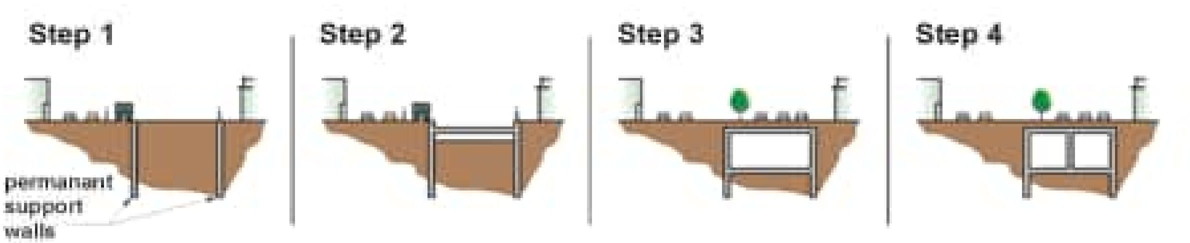


Figure 3-18 Top-down Cut and Cover Construction [P-33]

Figure 3-19 Example of Top Down Construction at Lentor MRT Worksite [W-23]

Bottom Up Construction

In the bottom-up construction, tunnel construction takes place in a trench which is excavated from the ground surface at the willow depth [Figure 3-20]. The trench is formed either using open cut (sides sloped back and unsupported), or with vertical faces using an excavation support system. The trench is then backfilled, and the excavated surface restored. In the bottom-up type of construction, the tunnel is completed before it is covered up and the surface reinstated. The steps for a bottom-up construction are depicted in the figure below.

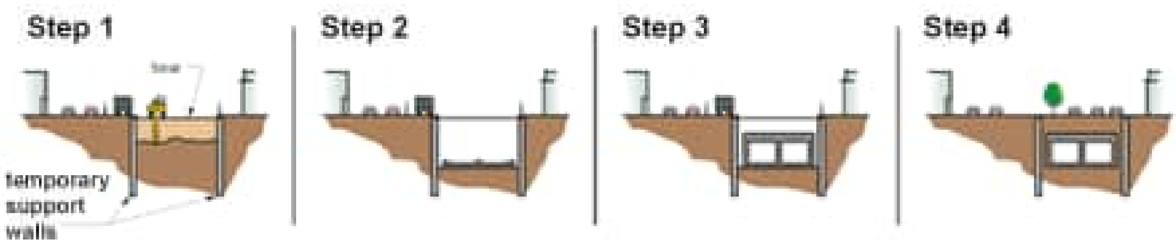


Figure 3-20 Bottom up Cut and Cover Construction [P-33]

Figure 3-21 Example of Bottom Up Construction at Woodlands South Worksite [W-7]

3.2.2.6 Construction of Tunnel/Rail Alignment

The tunnel or rail alignment of this Project will be constructed typically via the tunnel boring machine (TBM).

TBM is specially designed for excavating and constructing tunnels and is typically used to build a passage under an urban settlement, where access from above is difficult. With a large rotating steel cutter head at the front of the shield, TBMs can pass through different types of soil, rock or a mixture of both. The TBM can excavate and remove excavated materials, and at the same time install the reinforced concrete or precast tunnel segments, forming a permanent lining of the tunnel as it progresses. The use of a TBM requires relatively less work area than the cut-and-cover method, thus reducing the impact to public facilities and nearby traffic. A shaft is built for delivering the components of the TBM from ground level to the tunnel level for assembly. Tunnel segment linings are fabricated offsite, waterproofed, in accordance with relevant LTA standards, where they will be lined with High Density Polyethylene (HDPE) to provide additional protection from the corrosive underground environment [W-73]. TBM gantries will be provided in front of the secondary lining system for the removal of provisions left by the TBM after the tunnel boring works, such as working platforms, rails and pipes [W-74].

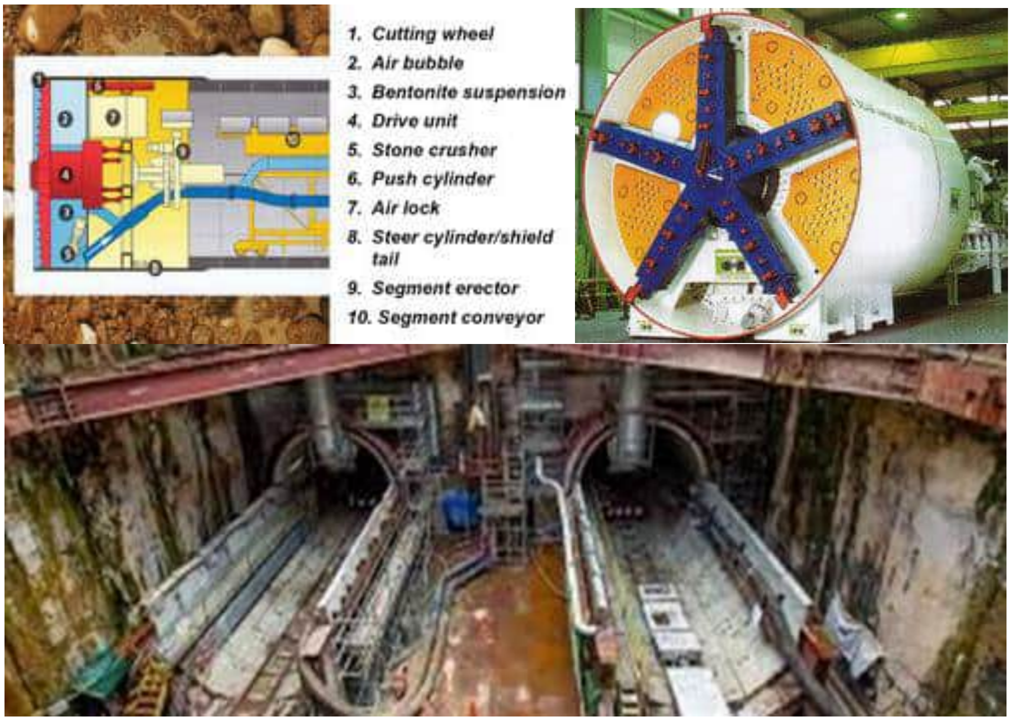


Figure 3-22 An Example of Slurry TBM [W-60] and Twin Tunnels Bored at A Station Site in Singapore [W-22]

A slurry TBM is used, which is a close shield TBM that pressurises boring fluid or a suspension of bentonite or a clay and water mix (slurry) inside the cutterhead chamber, which then forms the filter cake for tunnel face support. By using the slurry shield technology, support pressure is directly controlled by regulating the inflow and outflow of the suspension; when using mixed shield technology, it is controlled by using compressed air. This slurry TBM is most suitable in unstable or soft grounds with high groundwater pressure or groundwater inflow. Before advancing TBM works, offsite prefabricated tunnel segments must be kept ready on standby in a nearby location to make sure the TBM is constantly fed with the segments. As the TBM pushes forward, the excavated materials will be transported from the cutter head to the back of the TBM for removal via the vertical shaft. The excavated materials are transported through the pipelines along the tunnels via the fluid conveying system, into the slurry treatment plant above ground in the temporary worksite area. Slurry treatment plant above ground uses settling tanks to settle the solids, and the waste is sent for offsite disposal.

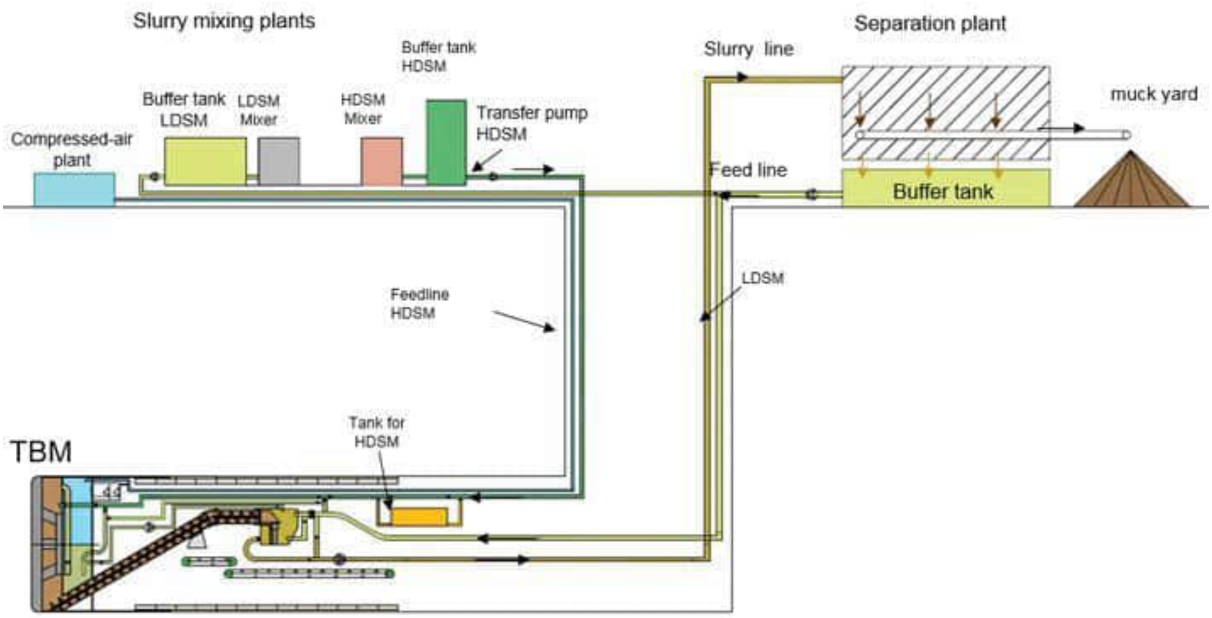


Figure 3-23 Schematic Showing TBM Operating below Ground and Treatment of Extracted Slurry at Above Ground Plant [W-13]

(HDSM- High density slurry material, LDSM- Low density slurry material)

Under this Report, it is planned that the TBM launching from CR16 to CR15 will be twin-bored tunnels, where each tunnel has a diameter of 6.9m and will house 1 track with an excavated cross passageway in between tunnels. Tunnel alignment will mostly be bored through bedrock strata at depths ranging between 11 and -20 (Singapore Datum Level). The TBM will construct tunnel one by one for the twin-bored tunnels. A schematic launch/retrieval plan is shown in figure below.

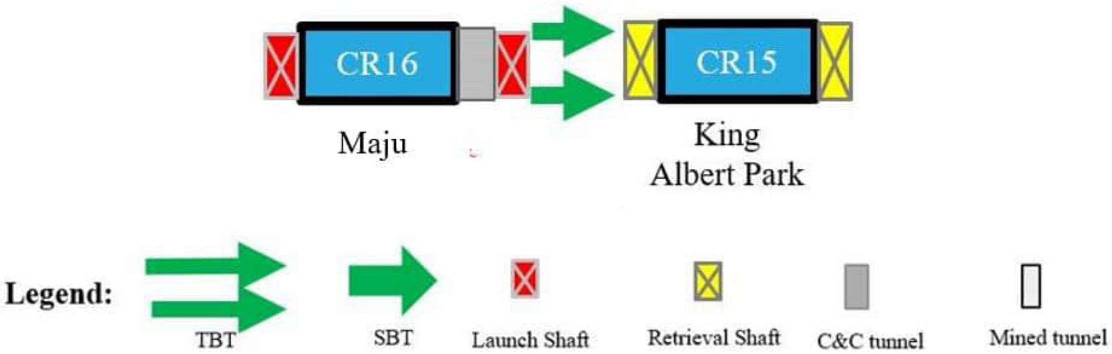


Figure 3-24 Schematic Plan of CR16 TBM Launching

Once the TBM has advanced and tunnel linings have been installed for the twin tunnels, cross passageways between railway tunnels and escape staircases are typically constructed once every 250 m for emergency preparedness in the tunnels in line with Singapore Civil Defence Force (SCDF) requirements. This may again involve traffic and utilities diversion before the cross passages can be mined or constructed.

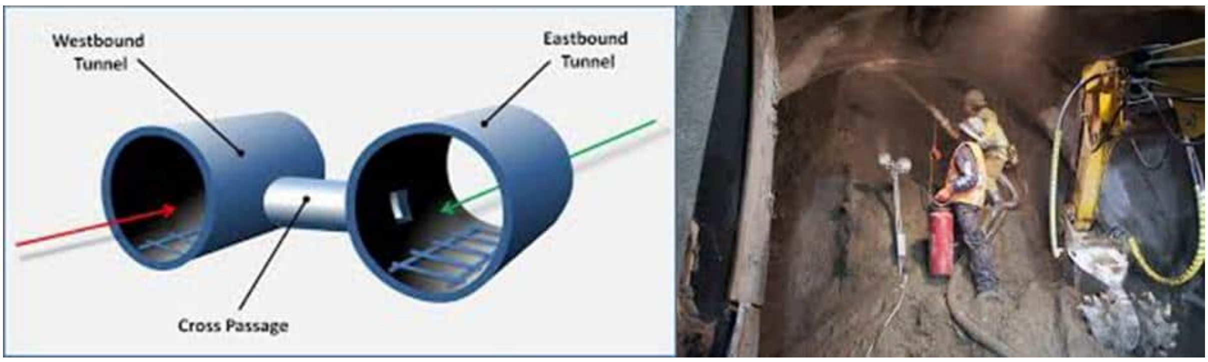


Figure 3-25 Cross-Passages between the Twin Tunnels for Emergency Preparedness Purposes [W-14, W-15]

Post construction of the tunnels, the trackwork engineers complete the trackwork, mechanical and electrical installations in the tunnels, and test run trains before the tunnels are declared complete.

Overall, the TBM has the advantage of not causing significant disturbance to surrounding soil and produce a smooth tunnel wall, however a key disadvantage is its high cost. In addition, for safety considerations, all works associated with TBM works are undertaken 24 hours a day until the work is completed, averaging up to 7 m per TBM per day. Placing TBM equipment on standby is not considered economically viable. Besides, the impacts from TBM operation are usually on ground-borne noise and vibration only, and therefore, unless this is a major issue, the operation of this machine is not stopped till the work is completed. Associated aboveground non-critical works such as delivery of long tunnel segments, may be carried out at night to avoid traffic disruptions associated with movement of these carriers.

Where required, sometimes ground improvement works may precede the TBM movement to stabilise the ground ahead of the cutter head. These measures also minimise the risk of groundwater drawdown or loss of tunnel pressure to the surface to as low as reasonably practicable [R-1]. As mentioned before, the groundwater ingress and ground settlement are constantly monitored ahead of TBM progress (see Section 3.2.1.4 for details about installation of monitoring instrument).

3.2.2.7 Concrete Batching Plant

Construction of MRT station will be normally associated with the need of concrete batching plant to supply its daily concreting needs.

A concrete batching plant is an equipment that combines various ingredients to form concrete. Some of the ingredients used in concrete plant include water, air, admixtures, sand, aggregate (rocks, gravel, etc.), fly ash, silica fume, slag, and cement. A concrete batching plant is equipped with various accessories, including mixers, cement batchers, aggregate batchers, conveyors, radial stackers, aggregate bins, cement bins, heaters, chillers, cement silos, batch plant controls, and dust collectors. There are mainly two types of concrete batching plant, i.e. Dry Mix Plant and Wet Mix Plant. A Dry Mix Plant first mixes the above-mentioned ingredients without water at a factory, which then being loaded into a mixer truck with water added and being mixed while being transported long distances to the worksite; whereas a Wet Mix Plant (can be mobile or stationary) mixes all necessary ingredients including water directly at the worksite or a central location near the worksite, where the ready-mixed concrete is simply transported using a ready mix truck or hauled using an open-bodied dump truck within worksite. [W-56, W-57]

A generalised diagram of a typical concrete batching process flow is included in Figure 3-26.

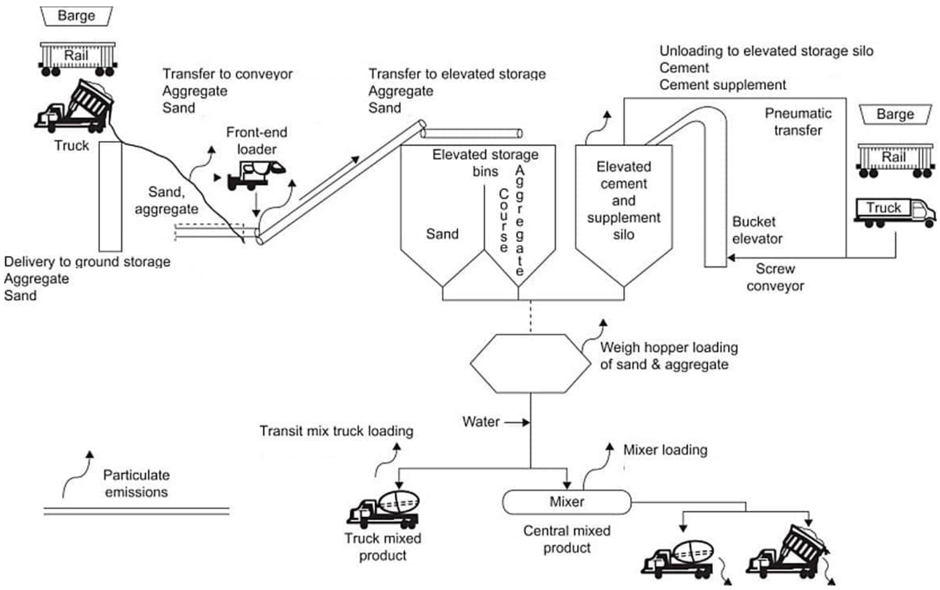


Figure 3-26 Generalised Concrete Batching Process Flow Diagram [P-74]

The raw ingredients (e.g. aggregate, sand, etc.) are first delivered by truck to the ground storage area or stockpile area, then transferred to the elevated storage bins through front-end loader. The other important raw ingredient, i.e. cement, is delivered by truck to site, which then being transferred to the elevated cement and supplement silo pneumatically or by bucket elevator. From these elevated bins, the constituents are fed by gravity or screw conveyor to a weigh hopper which combines the proper amount of the ingredients. Water is then added into the process and mixed together with the weighed ingredients in a central mixed drum or mixer to form ready-mixed concrete.

According to the preliminary design planning at the time of writing this Report, there will be one (1) concrete batching plant at CR16 worksite. For MRT construction in Singapore, it is common to have a Wet Mix concrete batching plant to support the concrete needs directly on site, in which the concrete volume required for this Project is estimated in Section 3.5.1.3. An example of the concrete batching plant is as shown in Figure 3-27.

Figure 3-27 Batching Plant at Marina South for Tunnel and Station Box Construction [W-8]

Based on the information by LTA , it is assumed that a concrete batching plant would create a sound power level of 106 dB(A) at source. Besides, the transport process (e.g. sand, rocks, ash, dust, etc.), stockpile area and batching or mixing process would cause emissions of particulate matters which may affect the air quality. Furthermore, the concrete batching process may produce wastewater on site, where inappropriate discharge of wastewater generated from concrete batching plant can result in calcium hydroxide contamination on surface watercourses nearby due to the potentially large amount of cement handling on the construction sites. Therefore, the potential impacts from concrete batching plant were considered and discussed in the water quality, air quality, airborne noise impact assessment in Section 8, Section 10 and Section 11, respectively.

3.2.2.8 Construction of Permanent Facility Buildings

Following the completion of TBM retrieval and completion of the tunnelling works, the launch and retrieval shafts are converted to facility buildings. Typically, each facility building is an above ground structure over the shaft and will include an aboveground 2 storey structure housing an electrical substation, tunnel ventilation system and other electrical and mechanical installations, e.g. fire detection and alarm system [R-1]. It is also serving the purpose of vent shaft for rail/tunnel operation during operational phase.

However, for CR16 launch shaft, it will be constructed into part of the station box during operational phase, excluding the construction of other facility structures associated with the station box.

3.2.2.9 Construction of MRT Superstructures

Construction of the MRT superstructure or the concourse level is like any other building superstructure construction over the roof slab built after either the top down or bottom up station box construction (Refer to Section 3.2.2.5).

These construction works will include ticket vending machines or/and offices, passenger service office, office spaces such as station master room, technical rooms, stores and shops, and other station facilities, access routes (entrance and exit passageways), and other station facilities such as, electrical and mechanical installations, fire detection and alarm systems etc.

Figure 3-28 Completion of Station Concourse [W-6]

3.2.2.10 General Landscaping and Finishing Works

Facility buildings are provided with façade cosmetics with theme decided for a rail line. Landscaping around these buildings for the CRL2 stations in the Biodiversity Study Areas will follow *NParks Guidelines on Greenery Provision and Tree Conservation for Developments* [R-10], as part of finishing works. For the worksites where the existing topography has been altered during land grading works, it is mandatory for the finishing works to include reinstatement and stabilisation of the area.

Figure 3-29 Example of Reinstatement and Landscape Works at TEL1 Worksite [W-11]

3.2.2.11 Construction of Access across Clementi Road to CR16 Station

3.2.2.11.1 *Underpass to Maju Forest and Subway Access to Entrance to SIM Campus (Base Scenario)*

Originally in base scenario, an underpass was proposed while making use of the existing Old Jurong Railway to cross Clementi Road. The underpass was planned to be constructed by enhancing the existing underpass along the old Jurong Railway, and construction of the ancillary structures in Maju Forest. An at-grade structure of minimal footprint above ground was planned to be constructed at the end of this connection at Maju Forest for access to this underground pathway. Following this underground access will then lead to the Clementi Forest pedestrian footpath at road level, which is also connected to the CR16 station's entrance/exit. This proposed underpass may disturb the ecologically connectivity of the existing Old Jurong Railway Corridor which is known to be part of the Rail Corridor with rich biodiversity values, hence potentially resulting in adverse biodiversity impact. Therefore, an alternative was proposed as described in the following Section 3.2.2.11.2.

For the underground subway access from CR16 Station to the entrance/exit to SIM Campus, a trenchless method of construction is proposed. Trenchless construction method is described as a type of subsurface construction work that requires few trenches or no continuous trenches with minimal excavation [W-72], which requires lesser surface works if compared to open cut method. It is classified into 3 main categories, which includes the horizontal earth boring method where usually worker entry is not required, as well as pipe jacking method and utility tunnelling method where worker entry may be required to carry out excavation or spoil removal [W-72].

3.2.2.11.2 *Clementi Forest Subway Access to Entrance at Maju Camp and SIM (Mitigated Scenario)*

As mentioned in Section 3.1.1.1, the design of this access was then optimised to reduce construction footprint and the associated potential environmental impacts on Maju Forest and Old Jurong Railway by replacing with subway access to entrance at both Maju Camp and SIM on the other side of Clementi Road. Construction method will be similar as mentioned above for the construction of underground subway.

3.2.2.12 General Landscaping and Finishing Works

Both MRT Station superstructures and facility structures are provided with façade cosmetics with theme decided for an MRT line. Landscaping around these buildings for the CRL stations in Biodiversity Study Areas will follow *NParks Guidelines on Greenery Provision and Tree Conservation for Developments* [R-10], as part of finishing works.

For the worksites where the existing topography has been altered during land grading works, such as Clementi Forest, it is mandatory for the finishing works to include reinstatement and stabilisation of the area.

Figure 3-30 Example of Reinstatement and Landscape Works at TEL1 Worksite [W-11]

3.3 Proposed Operational Activities

Following the reinstatement period, CR16 station will be fully operational as part of the entire Cross Island Line which is expected will make at least 600,000 trips per day [W-47]. The Study Area will see an associated increase in human activity such as traffic movement, lighting, and general activities increase in the vicinity of the development. This section describes these operational activities in general both for the underground alignment (Tunnels, cripple sidings) and above ground features (Station entrances/exits, station building, vent shafts). The indicative operational footprint for CR16 is presented in Figure 3-1.

According to LTA's preliminary planning at the time of writing this Report, all stations in this Project are assumed to be operational from 5.30am to 12.00am daily with maintenance works of MRT and the relevant operational supporting systems are expected to be undertaken during engineering hours (from 1am to 4am depending on rail operators) once per week for each station, as well as in cases of emergency or when necessary during non-engineering hours (operational hours of the trainline).

3.3.1 Station Entrances/Exits

The primary purpose of the station is designed as a facility for the movement of people, hence adequate space needs to be given to the main station entrance/ exit or drop-off area for access to and from the station, and designed according to the Projected passenger flow during peak period together with the necessity for rapid evacuation of passenger from the station in an emergency. Operation of station buildings will attract more public, as well as more vehicles for dropping off / pickup of the public travelling via MRT.

However, in addition to the main entrance/ exit, typically a station has a few additional entrances and exits for passengers to reach the station from the other side of the road or junctions. These relatively smaller entrances/ exits are mainly for pedestrians but may be accompanied with bicycle parking lots aboveground.

All station entrances are provided with canopies or roof to adequately protect them from the weather. Canopies and roof are constructed with adequate Projection and fascia or parapets to cover the structural elements of the roof and provide enough upstand against rainwater spillage which will be collected and discharged to the surface drains. For rainwater runoff collected by drains at the sides of the station, it will be channelled to discharge into public storm drains [W-36].

The locations of station entrances/exits of CR16 station, including entrances which connects via subway to CR16 main station box, are presented in Figure 3-1. A typical example of station entrance/exit is illustrated in Figure 3-31 below.

Figure 3-31 TEL Mayflower Station Entrance G [W-37]

3.3.2 Station Buildings and Platforms

During operational phase of the MRT line, the stations are assumed to be operational from 5.30am to 12.00am and therefore have an increase in activities in terms of human activities and light/ temperature changes in and around the stations during these hours. The typical example of an MRT station and platform is as shown in Figure 3-32.

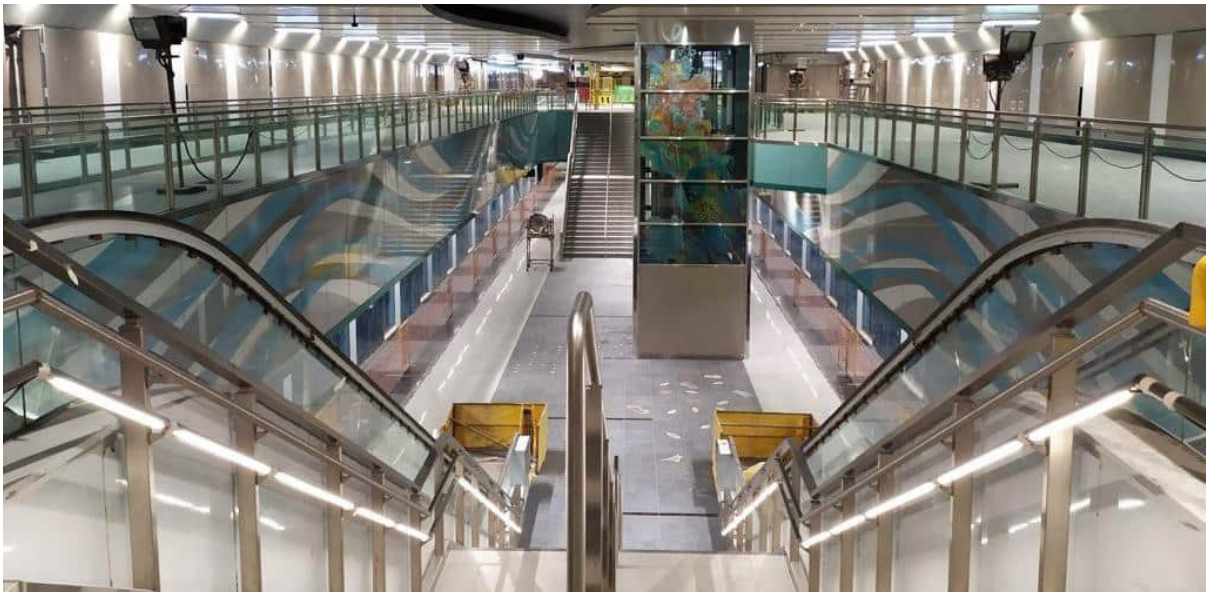


Figure 3-32 Interior of TEL Bright Hill Station [W-37]

Besides, in order to keep the station cool and ventilated, air-conditioning systems and mechanical ventilation systems are used, where mechanical ventilated systems may be used during non-revenue hours and air-conditioning equipment during revenue hours [W-36]. The proposed ACMV system (e.g. air-conditioning equipment, exhaust, condenser etc.) in stations has several equipment housed in the outer façade of the building, either on the roof or the façade, thus the noise levels have to be controlled such that it meets the noise levels at the boundary of the building in accordance with *NEA Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-industrial Buildings*.

An MRT station will also be equipped with sanitary facilities, where waste or foul water from the station is discharged through the sanitary pipes from the station to the public sewer. Passengers who undertake rail transport service will be accessing and waiting at the platform within the station building. The stations CR16 in this Project are designed to be island-type platforms. An example of preliminary concept design of CR16 station's island platform with cripple sidings is demonstrated in Figure 3-33.

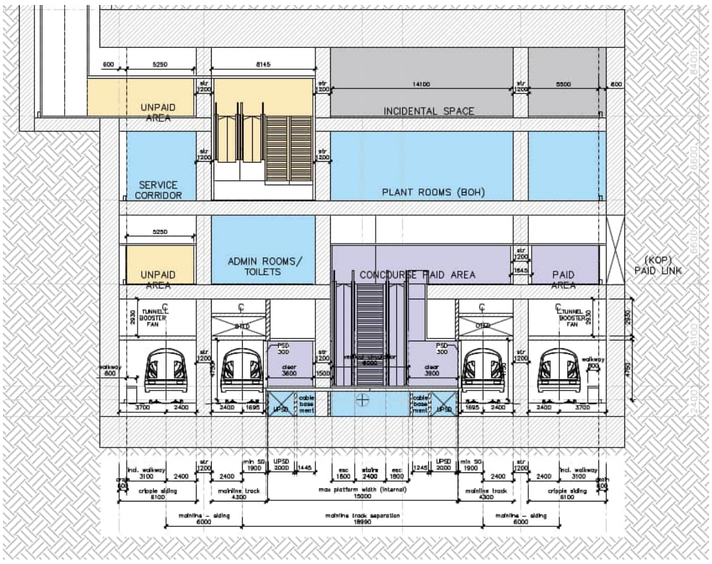


Figure 3-33 Concept Design of CR16 Station [O-2]

3.3.3 Tunnel Alignment

As per current planning, the CR2005 tunnel alignment (exclude CCNR) in overall would not exceed -60m below Singapore Height Datum (SHD). The tunnels will be designed with twin tracks for the trains to operate in both directions with a design lifetime of up to 120 years. These tracks sometimes run parallel to each other and at places can be stacked one above the other depending on the engineering constraints (e.g. geological constraints or existing underground utilities/ existing services nearby). The track form for this Project is expected to be non-ballasted type where its potential ground-borne vibration impacts have been discussed in Section 12 of this Report.

During the Commissioning phase, test trains will run and extensive track testing will be completed before the MRT line is opened to public for safety reasons. However, with regular maintenance and correction during operational phase, the useful life of tunnels can go beyond 120 years, and there should be no need to replace the tunnels. The periodic maintenance works for the rails within the tunnels will be carried out once a week, typically between 0100 hrs and 0400 hrs when the trains are not operating, or whenever the need arises. The list of maintenance equipment is provided in Section 3.5.2.3. Typically, a diesel-operating wagon/ vehicle may be used for mobility for maintenance work in the tunnels in the night.

During the operational phase, since the trains are powered by electricity, they do not emit air emissions as a direct impact to environment. Besides, it is required for tunnels and train operations to minimise the impact of ground-borne vibration to cater to the comfort of the human receptors above ground, which was studied by LTA under a separate study, whose findings were incorporated and discussed as part of the ground-borne vibration impact assessment of this Report.

In addition to the regular two-way track forms, an MRT station may be associated with a pair of cripple sidings in parallel to the tunnel alignment alongside the island-type platform. A cripple siding is an extra track needed to facilitate withdrawal or storage of impaired/ crippled train that is not fit for passenger service. The cripple siding will also be used to store trains that are on standby as evacuation trains during operational phase [W-40]. For example, the existing Mattar MRT Station (DT25) along Downtown Line (DTL) with an island platform arrangement has a pair of cripple sidings located parallel to the running tracks and separated by a concrete wall [W-42] as illustrated in figure below. The impact of cripple sidings is only due to the fact that this area is usually constructed by cut and cover method, along with a station box, hence the worksite footprint for this purpose tends to be larger than usual.

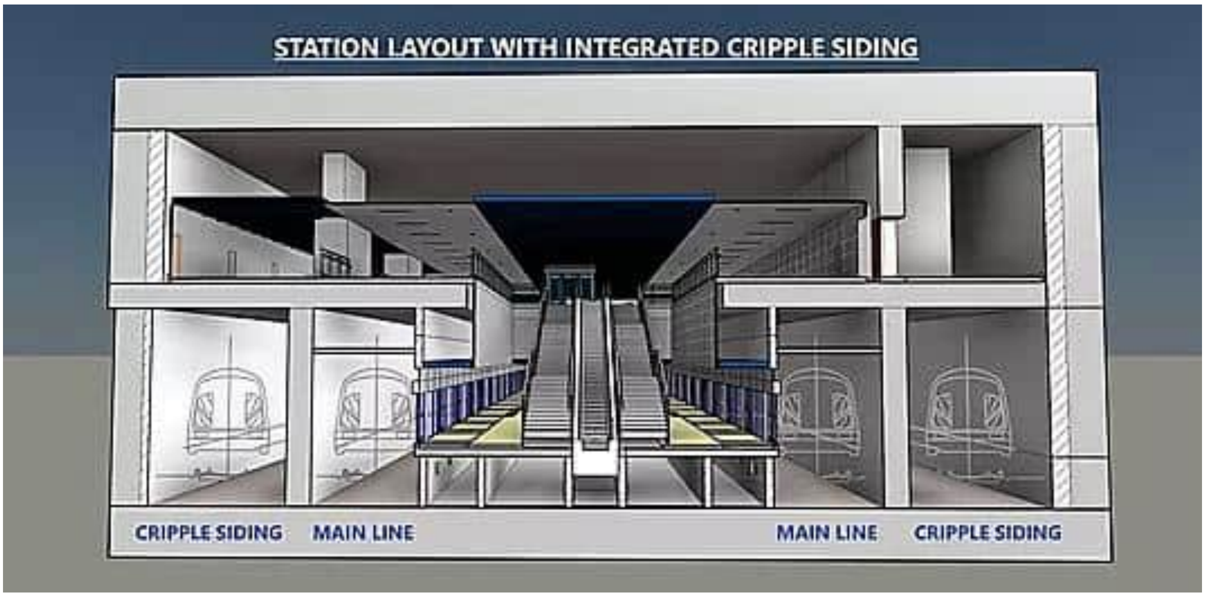


Figure 3-34 Example of Station Layout (Island Platform) with Integrated Cripple Sidings [W-40]

3.3.4 Ventilation Shafts at Stations, Tunnels and Facility Buildings

For the purpose of air ventilation in the tunnels and underground structures, ventilation shafts (vent shafts) are provided intermittently in order to exchange air from the atmosphere via an intake and exhaust stack above ground. Since the train is operated electrically and there are no vehicles or industrial process emissions, these stacks are purely meant for airflow and movement enhancement with fans to facilitate the air exchange. Mechanical engineers calculate the air exchange requirement and determine the intervals of the placement and sizing of the fans. Computational fluid dynamics modelling is conducted during design stage for strategizing the location and purpose of vent shafts in consideration of fire events and the need to evacuate smoke from the tunnels. These are separate reports and go through SCDF's scrutiny and approval separately. Since fire events are emergency events, and meant for safety of public, these are exempted from this EIS assessment.

During the operational phase, therefore, there will be vent shafts associated with each station box [W-36] and/or its supporting facility building/structure. In order to ventilate the tunnels with fresh air and in the event of fire emergency, to prevent recirculation and re-entrance of smoke into the stations, these vent shafts are installed. The vent shafts are connected from the station box/ tunnels to the vent, and lastly to the atmosphere. The ventilation supply (VS) shafts take in fresh air from the atmosphere, while the ventilation exhaust (VE) shafts exhaust air from the stations. Tunnel Ventilation (TV) shafts are for the ventilation of tunnels through the piston effect brought about by the train movements through tunnels. In case of fire emergency, the VE shafts and TV shafts will purge smoke and hot gases from the station and tunnel. In addition, TV shafts may also act as intake shafts supplying air into the tunnel during congested/ peak hour operations and tunnel maintenance activities. Replacement air for the station smoke purging system and trackway emergency ventilation system will be supplied from the station entrances. [W-36]

Gratings, grilles or louvres will be fitted to these shafts to prevent rainwater seepage, entry of birds and unauthorised personnel. Where vertical discharge is proposed for the vent shafts, the developer will provide a drainage system, including pumping system where necessary, to prevent accumulation of water in the shaft bottom. [W-36]

In future, any potential construction activities in the vicinity of the vent shaft will generate dust pollution, smoke and exhaust fumes and other environmental pollution which will affect the performance of the environmental control equipment as well as the fire and smoke detection system of the stations and facility buildings. Care should be taken to ensure no restriction to free flow of air around the vent shafts, hence effective measures to minimise dust pollution, etc. will be implemented during operational phase. [W-36]

Facility buildings usually do not see as extensive visitors as the stations, however, it will require maintenance staff to access the site periodically, whose frequency ranges from 1-monthly to 1-yearly, depending on the maintenance needs of the relevant system/ equipment as listed in Table 3-3.

Access roads will be constructed for this purpose to lead to the facility building entrances. Facility buildings may generate airborne noise due to the air-conditioning and mechanical ventilation (ACMV) at the rooftops of relevant buildings, such as air-conditioning units, exhaust air fans, intake air fans and cooling towers. These buildings will be built to comply to relevant NEA's mechanical buildings noise regulations at boundary. Besides, the tunnel may accumulate wastewater during heavy rainfall, which will be pumped out to proposed detention tank and disposed properly according to NEA's *Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse* [W-18].

Figure 3-35 Ventilation Shaft at Bedok North MRT Station within an open park setting [O-7]

3.4 Project Schedule

According to current planning at the time of writing this Report, the overall construction works of the entire CRL2 alignment, and the associated worksites of this Project would tentatively commence around end of Year 2022 and target to complete around end of Year 2032. This timeline may be subject to changes while the Project progresses from time to time according to the actual situation.

The tentative construction timeline generally includes periods for pre-construction activities (e.g., site clearance and preparation, temporary worksite establishment) and main construction activities (e.g., shaft construction, boring works, superstructure construction, landscaping etc.), but might exclude architectural and M&E works at each worksite.

3.4.1 Other Major Concurrent Developments

It is known that construction activities are planned to occur in the vicinity of the Project as identified below. The duration and overlapping period these concurrent developments are detailed as below.

a) PUB Deep Tunnel Sewerage System (DTSS) Phase 2 manholes and pipeline along Clementi Road:

As part of DTSS, a core water infrastructure targeted to support Singapore’s long-term needs for used water collection and reclamation for reuse. DTSS Phase 2 will extend to serve the western part of Singapore. Works will entail pipe jack of underground sewer lines and manholes along Clementi Road including the crossing of Old Jurong Railway Corridor near CR16. Construction is anticipated to take place from 2H 2022 and to be completed in 2025. This development will coincide with CR16 development between Q4 2022 and 2025.

Cumulative impacts from the proposed manhole MH-4A and MH-4B near Old Jurong Railway were considered in this Report. Cumulative impacts from the proposed manholes MH-4A and MH-4B near Old Jurong Railway were considered in this Report.

b) Proposed Brookvale Drive (Dr) Project:

A new road is being constructed along Brookvale Drive that includes cut and fill works (predominantly cutting). In addition, along Clement Road a new junction configuration / resurfacing works, traffic light and other related works are proposed. Construction is set to be complete in 2024, with some overlap occurring between this project and CR16 considering that construction at Brookvale Drive is expected to be complete in 2024.

c) Old Jurong Nature Trail

NParks are to undertake works along Clement Drive and Old Jurong Line which will eventually become part of Singapore's Park Connector Network (PCN). This may involve minor cut and fill. Construction is expected to take place between Q4 2023 and Q1 2026. Construction will therefore overlap with CR16 construction within this period.

d) Clementi Nature Trail:

NParks are creating a nature trail that will pass alongside Clementi Stream and Old Jurong Line, which will eventually become part of Singapore’s Park Connector Network (PCN). This may involve minor cut and fill. Construction is expected to take place in Q2 2023 to Q4 2023. Construction will therefore overlap with CR16 within this period.

e) CR15 worksite and station:

Construction of CR15 is expected to take place between 2023 and 2032, the same timeframe outlined for CR16. The projects will therefore be constructed concurrently.

The cumulative impacts of the concurrent developments above were assessed qualitatively in each individual section of different environmental disciplines.

3.5 Project Resources

This section is to generally discuss about typical resources which might be required in the construction and operational phases of this Project, including electricity and water supply, concrete requirement, and equipment application.

3.5.1 Construction Phase

3.5.1.1 Electricity Supply

During the construction phase, electricity supply is required for the lighting and operation of construction equipment. The Project will be supplied with power from the Singapore power grid. For the purposes of electrification, a 25kV alternating current system will be fed to the overhead line equipment.

Nonetheless, in case where connection to the electrical substation or power grid is not available for operation of site equipment during construction phase, portable generators may be required. It is assumed that up to six portable generators might be used at each worksite [R-1]. The Contractor will obtain approvals from relevant authorities if usage of electricity from nearby mains is needed and ensure compliance with requirements to ensure that there is no disruption to the local electrical supply.

3.5.1.2 Water Supply

Water supply is essential throughout all phases of the Project, where water will be drawn from the mains for the construction activities (e.g., concreting, recharging of groundwater, dust suppression, wheel washing, etc.). In such cases where water supply is not easily accessible from construction site, temporary water tanks will be provided on site to support construction activities, as well as potable use and temporary sanitary facilities (e.g. portable toilet on site).

3.5.1.3 Concrete

Generally, there will be no concrete required during operational phase, thus only the construction phase is considered in this section. Based on the preliminary assumptions at current stage, a rough estimation of concrete volume used for the construction of above-ground structure and below-ground structure is provided in Table 3-1 below.

Table 3-1 Project Concrete Requirements

Worksite	Total Concrete Required for Above-Ground Structure	Total Concrete Required for Below-Ground Structure
CR16 *(including Worksite at Nursery near Clementi Forest)*	20,000 – 100,000 m^3	> 30,000 m^3

3.5.1.4 Equipment

Table 3-2 provides an indicative list of equipment and/or facility which may be required during construction phase of the Project, where construction of MRT station and superstructures is listed for the comprehensiveness of the study. Fuel and other chemical materials (e.g., cement additives, etc.) are the common inputs to operate the equipment for construction works, which will be stored at a designated temporary stockpile location or laydown area. For example, diesel fuel for the refuelling of construction equipment and other flammable or non-flammable chemicals required for construction works will be labelled and stored in accordance with requirements stipulated in LTA's Construction Safety Handbook [W-76].

Table 3-2 Project Indicative Equipment/Facility List during Construction Phase

Activity	Indicative Equipment
Site Clearance and Preparatory Works (e.g. hoarding setup, site levelling, tree removal, debris removal, etc.) including Traffic Diversion Works and Excavation to Work Platform Level	Lorry Cranes Hand Held Breaker Front End Loader Hand Held Chainsaw Dump Truck Generator
Temporary Earth Retaining Structure works at CR16 (e.g. continuous bored piling, sheet piling, decking installation, etc.)	Generator Lorry Cranes 40 ft Trailer Excavator Mounted with Vibrator Pile Driver Crane Mounted with Vibrator Pile Driver Hydraulic Foundation Drill Excavator

Activity	Indicative Equipment
	Crane Crane
Earth Retaining Structure Systems (e.g. installation of D-Wall) and Concrete Batching Plant at station worksites, as well as other temporary works for all worksites (e.g. wall casting, earth removal, spoil and slurry disposal, concreting works etc.)	Concrete Pump Dump Track D-Wall Rig with Grab Excavator Mobile Crane Ready Mix Concrete Truck Truck Mounted Crane **Concrete Batching Plant** Bentonite Slurry Tanks Clean Water Tanks Colloidal Mixer (Bentonite) Compressor Generator Measuring Tank & Agitator Ripple Screen (included in sewage treatment plant) Slurry Pump
Installation of Wallers and Struts, as well as Excavation and Reinforced Concrete Works	Welding Equipment 40 ft Trailer Mobile Crane Crane Excavator Mini Excavator Dump Truck
Tunneling/TBM Launching and Retrieval	Air Chiller Air Compressor Air Receiver Cranes (200 tonne and 500 tonne) 30T Excavator Grout Mixing Plant Muckaway Truck TBM with Precast Segment Erector TBM & Gantries TBM Gantry Crane Tunnel Segment Rings Delivery Segment Delivery Shaft Hoist Slurry Separation Plant Ventilation Air Cooling Plant Ventilation Supply Fans Water Chiller Plant
Construction of Permanent Structures for Stations (e.g. Vent Shafts, MRT Entrances/Exits, CR16 Underpass and Subway Access)	Compressor Concrete Pump Crane Mobile Crane Dump Truck D-Wall Rig with Grab Excavator Excavator mounted with Vibrator Pile Driver Forklift Generator Mini Excavator Ready Mix Concrete Truck

Activity	Indicative Equipment
	Temporary Water Pump Trailer (40 feet)
Reinstatement and Finishing Works	Asphalt Paver Dump Truck Excavator Front End Loader Generator Grader Roller

3.5.2 Operational Phase

3.5.2.1 Electricity Supply

During operational phase, electricity will be required to operate the train services, which also include the associated operational activities at the station, as well as periodic maintenance activities. The Project will be supplied with power from the Singapore power grid during the operational phase. For the purposes of electrification, a 25kV alternating current system will be fed to the overhead line equipment.

3.5.2.2 Water Supply

In Singapore, water supply is governed under Singapore's National Water Agency PUB with robust and diversified sources known as "Four National Taps", which comprises water from local catchment, imported water, highly purified reclaimed water known as NEWater and desalinated water, from where it reaches the public through water mains and taps. Water supply is essential throughout all phases of the Project, where water will be drawn from the mains for the operational activities (e.g., cleaning, washing, drinking).

3.5.2.3 Equipment

Table 3-3 provides an indicative list of equipment and/or facility associated with rail tunnel operation and maintenance works during operational phase of the Project, where station activities are also included for comprehensiveness of the Study [W-36].

Table 3-3 Project Indicative Equipment/Facility List during Operational Phase

Activity	Indicative Equipment/Facility/System
Rail operations and associated supporting systems/services	**<u>E&M System (all Railway Systems required for railway operations)</u>** Rolling Stock Signalling System Platform Screen Doors (PSD) Station Travel Information System (STIS)/Rail Travel Information System (RATIS)/Visual Information System (VIS)/Passenger Information System (PIS) Integrated Supervisory Control System (ISCS) Access Management System (AMS) Maintenance Management System (MMS) Fence Intrusion Detection System Power Supply System Communications System Video Surveillance System Automatic Fare Collection System Travel Information System **Lifts, Escalators, Travellators & Passenger Conveyers Water Handling Equipment (WHE) Plant rooms for relevant systems
Railway Maintenance Works	**<u>Common Equipment [W-35]</u>** Track Tamping Vehicle Multi-Function Vehicle Rail Grinding Vehicle

Activity	Indicative Equipment/Facility/System
	Viaduct Inspection Wagon Diesel Locomotive Tunnel Cleaning Wagon Heavy Crane Vehicle Rail-Road Vehicle
Building Services *(Applicable for station)*	Private/Public Fire Hydrant System Water Services, Sanitary & Pumped Drainage System (e.g. public toilet, water tap and floor traps, etc.) Irrigation System
M&E Services *(Applicable for station)*	**Environmental Control System (ECS) (e.g. chillers, cooling towers, pumps, dampers, air compressors, Air Handling Unit (AHU), Tunnel Ventilation Fan (TVF), Package Condensing Unit (PCU), Package Evaporator Unit (PEU), etc.) Tunnel Ventilation System (TVS) – permanent TVS and Temporary Tunnel Ventilation System (TTVS) for Trackworks and Track Related Installation Programme (TRIP) Fire Protection System (FPS) Electrical Services (ES)
Other supporting activities at Mid Tunnel Vent Shaft (MTVS)	Radio and PA (Public Address) System Communications Backbone Network (CBN)/Synchronous Digital Hierarchy (SDH) System Closed Circuit Television (CCTV) Trainborne Communication System Electronic Private Automatic Exchange (EPAX) System Uninterruptible Power Supply (UPS)/Emergency Power Supply (EPS) System, Battery and Charge Over Panel Virus Scan System Main Switch Board (MSB)/Emergency Main Switch Distribution Board
Human activities (e.g. commercial, community) when accessing station buildings	Offices Service counter Retail space/shops Normal and emergency lighting Storerooms with cleaning equipment and chemicals (e.g. oil/diesel) Bicycles parking space outside station building
Note: ** The replacement of this equipment might involve heavy vehicle.	

3.6 Project Wastes

Wastes can be defined as unwanted material produced directly and indirectly as a result of construction and operational works. In general, the wastes expected to be generated from the Project activities will be hazardous (e.g., toxic industrial wastes, organic wastes), non-hazardous wastes (e.g., general waste, inorganic waste) and recyclable wastes (e.g., excavated soil).

3.6.1 Construction Phase

Typically, hazardous wastes produced from construction activities can include oil, grease, sludge, solvents, empty containers of insecticide, paint, solvents, contaminated soil and groundwater etc., while non-hazardous waste can include paper, cardboard, etc. Recyclable wastes generated from the Project will comprise of excavated spoil material, construction debris from demolition sites, plastics and metals.

Construction activities will generate large amounts of spoil material which will require disposal or reuse. A total of 2,519,400 m^3 of spoil may be excavated during the construction phase of the entire CRL2 alignment, which is estimated based on the spoil generated from the cut and cover excavation works and tunnel boring works from all the associated construction worksites, including the CR16 worksites of this EIS. Within the estimated total spoil volume, it is assumed about 357,100 m^3 of spoil will be generated from all CR16 worksites. The total spoil volume includes cut and cover excavation works and TBM spoil volumes. TBM from CR16 will launch to CR15 where excavated waste will be conveyed to CR16 worksite for disposal.

A large proportion of this spoil will be used as construction backfill, but exact spoil balance figures will only be available during the detailed study for the construction phase by the Contractor.

Recyclable wastes generated from the Project will comprise of excavated spoil material. As there will be minor demolition works associated with the Construction of the Project, other recyclable waste generated is expected to be minimal e.g., plastics from food and beverage generated at construction sites.

Table 3-4 Estimated Spoil Disposal from CR16 Worksite

Project Activity	Disposal Required (m^3)
Bored Tunnels	29,900
Station	327,200
Total	357,100

Liquid effluents generated from the construction activities will generally include extracted groundwater, sanitary discharges, effluent from bentonite slurry treatment, surface runoff and trade effluent from tunnelling activities. Sanitary effluents will be released to the PUB's sewerage system while extracted groundwater (not contaminated with construction wastes) and surface water runoff will flow into the stormwater drains within the Project area which will then be channelled to watercourses if they meet required discharge standards. The trade effluent from tunnelling activities will be treated and discharged separately from stormwater runoff. Bentonite slurry treatment system/plant will be established accordingly within the Project site. Contractor will need to seek approval from relevant authorities (i.e., PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. Further discussion on water and/or effluent discharge was provided in Section 8.

3.6.2 Operational Phase

It is anticipated that there will be limited sources of impacts during the operational phase. Typically, hazardous wastes produced from operational activities can include oil, grease, sludge, solvents, empty containers of insecticide, paint and others. The activities associated with the production of the hazardous waste includes maintenance of rail infrastructure and stations associated with the station. The operation and/or maintenance of the trains on the alignment and at stations could potentially result in oil leakage on the ground surface which could potentially cause surface runoff pollution in the event of rain.

Non-hazardous waste can include paper, cardboard, plastics from wrapping/bottles, styrofoam and others generated from the site staff. It is to be noted that operation waste data was not readily available during the time of writing this Report and non-hazardous waste was assumed to be generated from station staffs (5 persons) only. The domestic waste production of one person in Singapore is approximately 0.86 kg per day [W-69]. It can be assumed that each typical station would produce a total of 4.3 kg of general waste (staffs only) in a day.

Liquid waste effluent may be generated during operational phase which mainly consists of sanitary discharge from MRT station and seepage from station and tunnel facilities. According to current planning, sanitary discharge will enter PUB's public sewer, while station and tunnel seepage will be properly discharged to the designated drain during the operational phase of an MRT station and rail.

4. Description of the Environment

This section is to describe the existing environment in the vicinity of the Project, which includes the introduction to Study Areas, current land uses, URA's land zones, historical land uses, heritage features, topographical and geological conditions, water catchment area and climate.

4.1 Study Area

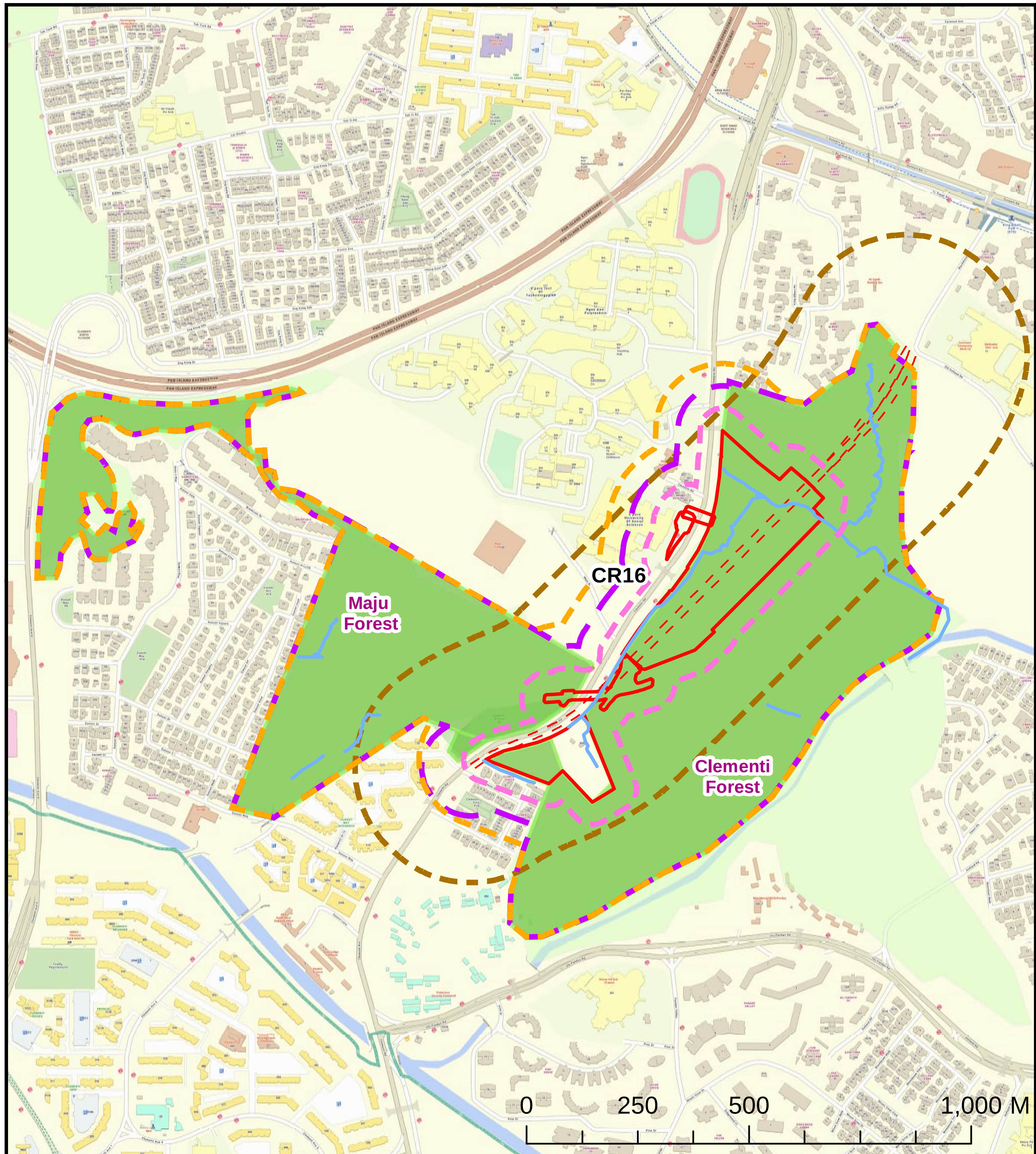
The Study Area is a representative area covering the construction/ operational footprint of the defined Project that is used for the assessment of environmental impacts. The purpose of identifying a Study Area is to determine any potential environmental impacts to the nearby sensitive receptors due to construction and operational activities in the vicinity of the Project.

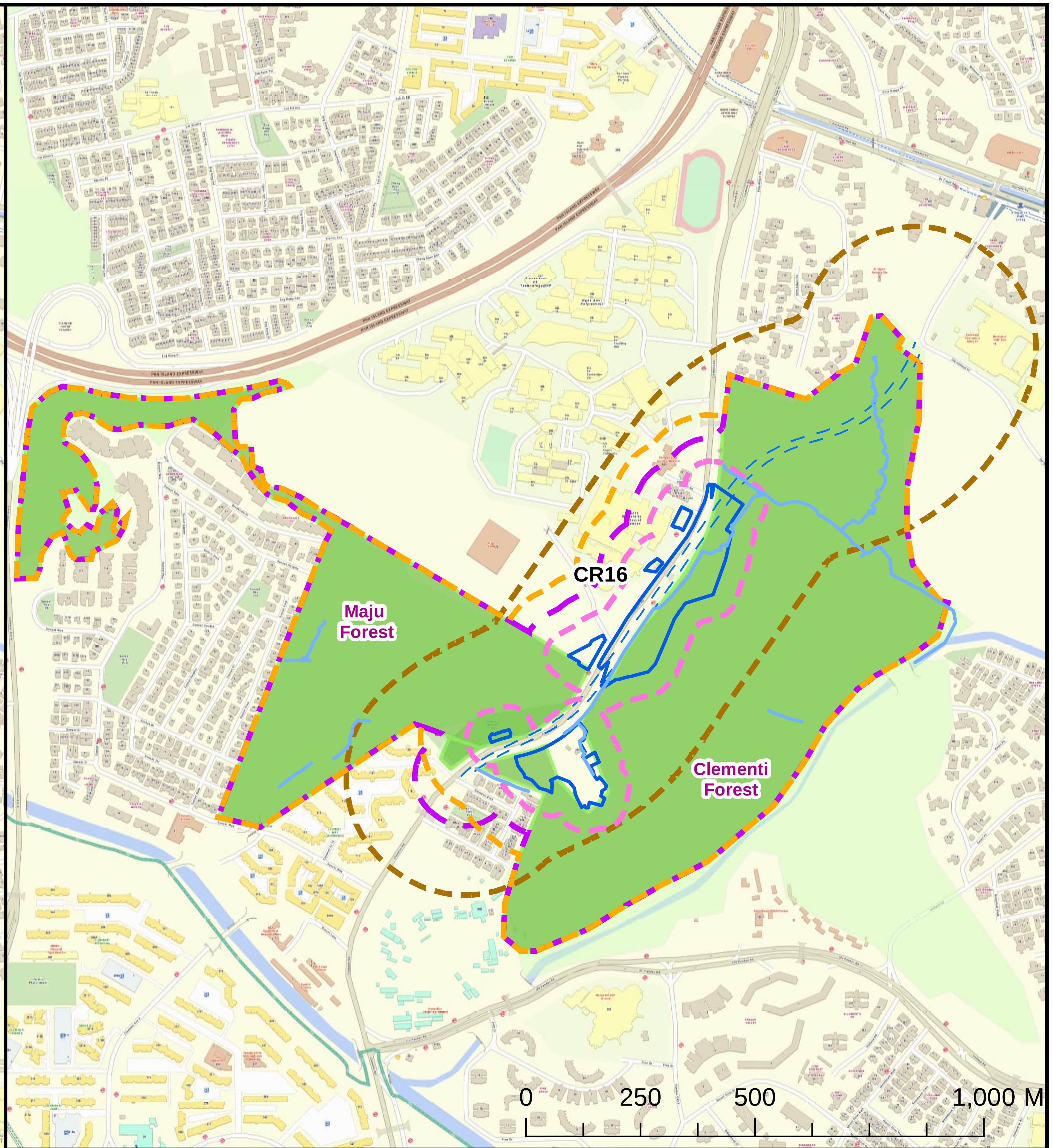
A varying size of Study Area is required for each environmental parameter based on the relevant legislation or international guidelines, which are justified and summarised in Table 4-1, and presented collectively in Figure 4-1. Further details of Study Areas will be discussed for each impact in the respective chapters.

Table 4-1 Summary of Study Areas for EIS CR2005 Clementi Forest and Maju Forest

Environmental Impacts	Study Area (Construction Phase)	Study Area (Operational Phase)	Justifications
Biodiversity	Forested area identified in the vicinity of the Project to be studied for its biodiversity value as defined by LTA for the purpose of this EIS, i.e. Clementi Forest, Maju Forest, Old Jurong Railway Corridor.		Construction and operational activities of the Project has potential to affect biodiversity and ecosystems.
Hydrology and Water Quality	Any major watercourses with direct impact from the Project within the Biodiversity Study Area.		Construction and operational activities of the Project has potential to impact hydrology and water quality of the watercourses affected by the Project.
Soil and Groundwater	250 m from the rail alignment/ station or other construction sites footprint		Based on typical Study Area in Historical Land Use Survey (HLUS) under separate study by LTA.
Air Quality	Up to 50 m around the construction worksites (i.e., earthworks activity, above-ground structure, trackout).	Up to 250 m around the operational footprint.	Construction phase: Based on UK IAQM Guidance [R-45] Operational phase: Based on other project experiences.
Airborne Noise	For Clementi Forest: Clementi Forest and 150 m from the construction worksite. For Maju Forest: Maju Forest and 150 m from the construction worksites.	Immediate boundary of the operational footprint and access roads.	Construction phase: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-50] Operational phase: NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 [R-51], NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 [R-22]
Ground borne vibration	For Clementi Forest: Clementi Forest and 100 m from the	For Clementi Forest: Clementi Forest and 100 m from the construction worksite and alignment,	Based on extensive technical experiences on similar rail projects.

Environmental Impacts	Study Area (Construction Phase)	Study Area (Operational Phase)	Justifications
	construction worksite and alignment, whichever is greater. The area can be extended beyond if significant impacts are greater. For Maju Forest: Maju Forest and 100 m from the construction worksites and alignment.	whichever is greater. The area can be extended beyond if significant impacts are greater. For Maju Forest: Maju Forest and 100 m from the construction worksite and alignment.	





Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Old Jurong Railway Corridor

Study Area

- Study Area (Air-Construction)
- Study Area (Noise-Construction)
- Study Area (Vibration-Construction)
- Study Area (Soil and Groundwater)
- Waterbodies/ Study Area (Water)
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title : SUMMARY OF STUDY AREAS

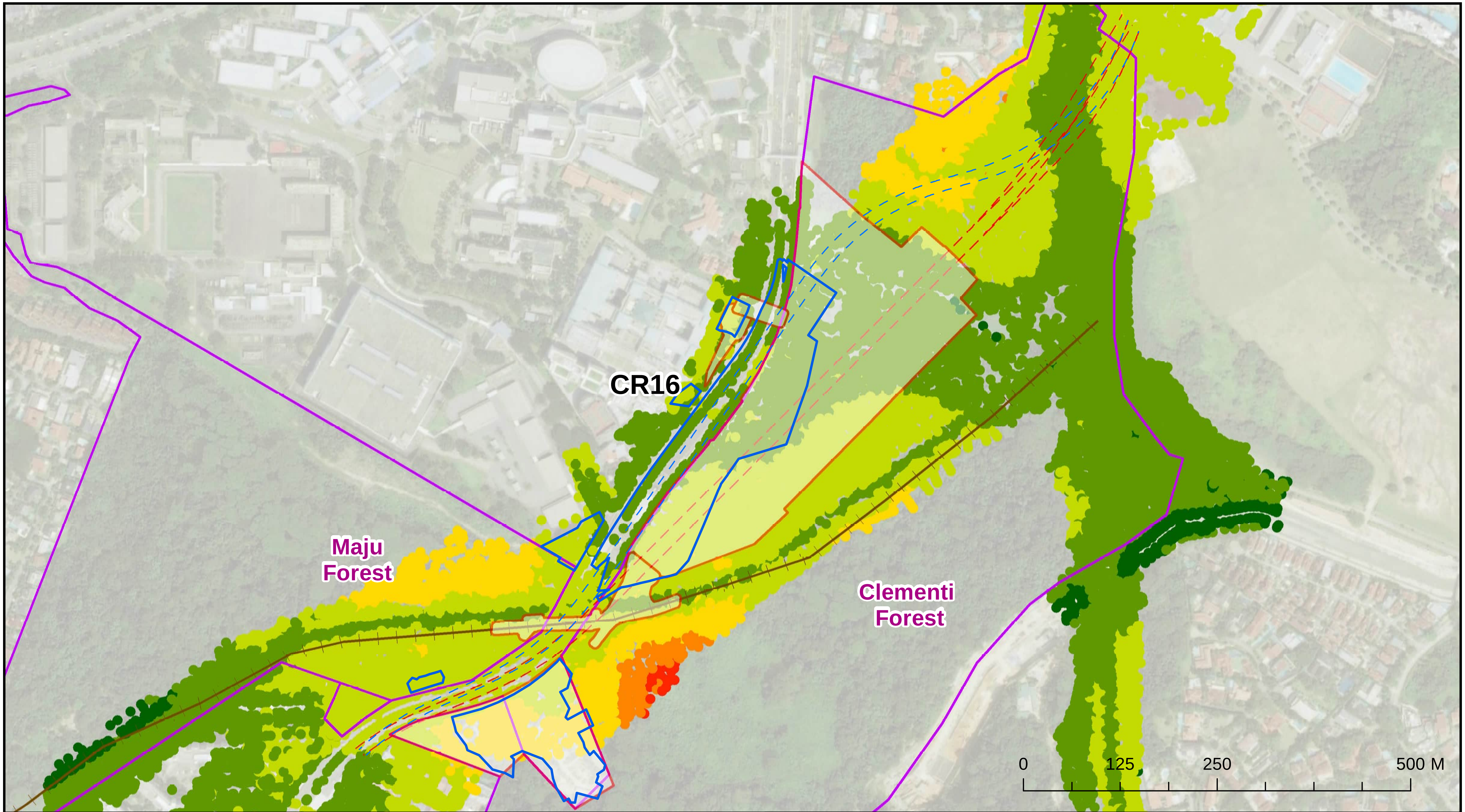
Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	JAG/NHT	JAG	4 - 1	-	1 of 1

	Drawn	Date	CAD File Name :	A3
	ASH	MAY 2022		

Note: Source of basemap - OneMap

4.2 Topography of the Study Area

The topographic survey data of year 2019 and year 2022 within the Study Area was provided by Client. Based on the review of this topographic survey data and observations from the site visit, the alignments of base and mitigated scenarios are located at the undulating terrain which the elevation up to 40 mSHD (Figure 4-2). The footprints of CR16 base and mitigated scenarios are located at the top of the hillock area with relative high elevation (up to 40 mSHD) in Clementi Forest. The hillock area slopes down from southwest towards the northeast (lower than 10 mSHD). The Worksites at Nursery will be located in the relatively flat terrain areas along the west of Clementi Forest with the elevation up to 30 mSHD. Further details about hydrological conditions of Study Area are provided in Section 8.5.1.1.



Legend

- - Proposed CRL Alignment (Base)
- - Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Old Jurong Railway Corridor

Elevation (mSHD)

- < 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- > 50

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
TOPOGRAPHIC MAP
OF THE STUDY AREA

Designed	Checked	Approved
ASH	NHT	JAG
	Drawn ASH	Date MAY 2022

Figure No. : 4 - 2 | Rev. - | Sheet 1 of 1

CAD File Name : | A3

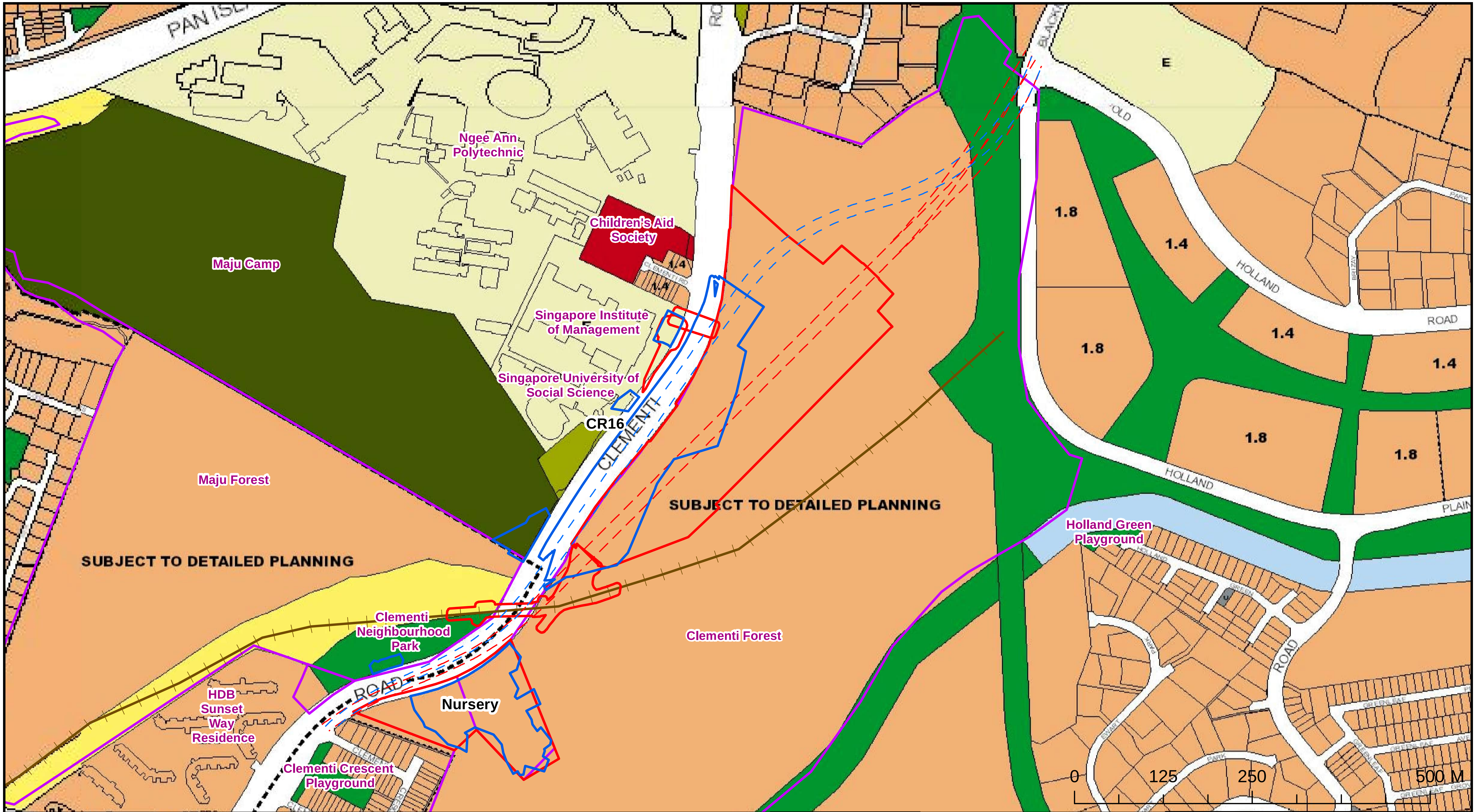
Note: Source of basemap - Google Earth Map

4.3 Current Land Zoning

According to the current Urban Redevelopment Authority of Singapore (URA) Master Plan 2019, the alignment passes through a variety of land zoning such as residential, educational, commercial etc. The current buildings or areas situated within and/or across different URA's land zoning were identified through 2020 Street Directory Map and/or Google Map, as listed in table below and presented in Figure 4-3.

Table 4-2 Land Zoning within the Study Area

URA Master Plan 2019		Street Directory
Land Zones	**Description**	**Current Land Uses**
Civic & Community Institution	These are areas used or intended to be used mainly for civic, community or cultural facilities or other similar purposes.	Children's Aid Society
Educational Institution	These are areas used or intended to be used mainly for educational purposes including tertiary education.	Singapore Institute of Management, Singapore University of Social Sciences (SUSS), Ngee Ann Polytechnic
Reserve Site	These are areas intended for specific use of which has yet to be determined. Interim uses that are compatible with the uses in the locality may be allowed subject to evaluation by the competent authority.	Maju Forest
Special Uses	These are areas used or intended to be used for special purposes.	Maju Camp
Open Space	These are areas used or intended to be used as open space.	Unknown structure on open space at 435A Clementi Road
Park	These are areas used or intended to be used mainly for parks or gardens for the enjoyment of the general public and includes pedestrian linkages.	Clementi Forest, Maju Forest, Clementi Neighbourhood Park, Clementi Crescent Playground
Residential	These are areas used or intended to be used mainly for residential development.	Clementi Forest, Maju Forest, Old Jurong Railway Corridor (Underground);
Road	These are areas used or intended to be used for existing and proposed roads.	Clementi Road



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Old Jurong Railway Corridor
- Biodiversity Study Area

- Residential
- E Educational Institution
- U Utility
- Waterbody
- Commercial & Residential
- Commercial
- Hotel
- Business 1
- Business 2
- C Conservation Area
- Road
- NR Nature Reserve
- Civic & Community Institution
- H Health & Medical Care
- W Place of Worship
- Residential with Commercial at 1st Storey
- Sports & Recreation
- Park
- Special Use
- Open Space
- Cemetery
- Reserve Site
- Mass Rapid Transit
- 2.8 Maximum Permissible Plot Ratio

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	NHT/JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :

Land Transport Authority
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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
LAND USE MAP

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT/JAG	JAG	4 - 3	-	1 of 1
	Drawn ASH	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - URA Master Plan 2019

4.4 Historical Land Use

The historical land uses of a site can indicate potential contamination which has occurred at certain stage in its history. The nature of these historical activities can be in the form of materials storage, handling, utilization and improper disposal/ discharge from the past, which may potentially contaminate soil and groundwater resources in the vicinity of this Project which will be further discussed in Section 9. Therefore, similarly to the Study Area of soil and groundwater impact assessment, the historical land uses within 250m from both sides of the Project alignment were reviewed based on the details from Historical Land Use Survey Report (HLUS) [R-3, R-4] under a separate study by LTA to give context to potential contamination considerations associated within the 250m Study Area. The HLUS study suggested that there is a potential for underground buried structures such as building foundations to be encountered during construction excavations. It is assumed that any buried foundations and piling associated with these structures will be cleared as part of the Project.

Furthermore, it is worth to further discuss about the land history at the identified Biodiversity Study Area in terms of its richness in biodiversity and heritage values at the same time, as follows:

4.4.1 Maju Forest

As Maju Forest and Clementi Forest are located adjacent to each other, their land use histories likely show some similarities. It is not known what the vegetation type constituted the two sites in 1914, though it is likely to be plantations typical in most of Singapore at that time (Corlett, 1988). Back then, all the major roads were already built (i.e., Upper Bukit Timah Road, Clementi Road, Ulu Pandan Road, and Holland Road), including Lorong Gaung which runs through the Maju Forest (Figure 4-4A). Lorong Gaung served as the entrance to Maju Camp until Maju Drive was constructed, after which Lorong Gaung became defunct and overgrown, becoming popular with geocachers seeking to explore the old road (Geocaching, 2018).

An aerial photograph dated 1950 shows that Maju Forest was cleared and was covered predominately by grassland (Figure 4-4B). There were no large-scale developments in the area then. The Keretapi Tanah Melayu (KTM) railway, which commenced operations in the early 1930s and ran from Malaysia to Tanjong Pagar cutting through Clementi Forest (Figure 4-4B). The Jurong spur of the KTM Malayan Railway (Old Jurong Railway Corridor) was incorporated in 1963 to enhance connectivity and transport goods to the rural Jurong Industrial estate (The Straits Times, 1963). The line begins from the KTM in Clementi Forest, passes under Clementi Road and runs through the valley in the southern section of Maju Forest and towards Jurong (Figure 4-4C). Construction of the railway likely introduced large disturbance to both Clementi Forest and Maju Forest. Development, in the form of low-density settlements, began to encroach into both sites (Figure 4-4C).

Between 1975 and 2005, Maju Forest and Clementi Forest appear to have matured into abandoned-land forest (Figure 4-4C & D), which is forest typified by plantation trees and exotic plant species (Yee et al., 2016). Over the years, land works in Maju Forest reduced the highest elevation on-site to 57 m a.s.l. (Figure 4-4D). Due to low usage, operation of the Jurong spur railway ended in the early 1990s and the line was abandoned. Presently, the line in Maju Forest and Clementi Forest is overgrown with vegetation. On the other hand, the rest of the KTM railway line remained in operation until 2011. Presently, the defunct rail line is progressively being converted into the Rail Corridor, an approach to have the rail line serve as a biodiversity, recreational, and heritage corridor (NParks, 2019).

Figure 4-4 Topographical (A, C–D) and aerial (B) maps of Maju Forest and Clementi Forest. (A) 1914; (B) 1950; (C) 1975, (D) 2005. Source: NUS Libraries (2019).

4.4.2 Clementi Forest

Between the 1920s and 1940s, Clementi Forest persisted as a rubber plantation that is presumed to have been abandoned during World War II (Neo et al., 2012). As mentioned above in Section 4.4.1, the Keretapi Tanah Melayu (KTM) railway, also cuts through the south of Clementi Forest and thus is also likely to have introduced large disturbance to both Clementi Forest and Maju Forest. Development, in the form of low-density settlements, began to encroach onto both sites (Figure 4-4C). Despite impacts from the development and railway, the hilly topology of the site still remains largely intact, giving rise to the today's hilly topology (Figure 4-4).

The floristic study by Neo et al. (2012) at Clementi Forest found 98 species of plants from 54 families. The most dominant species was Para Rubber (*Hevea brasiliensis*). The most interesting find was the rediscovery of a presumed locally extinct ground orchid species, *Dienia ophrydis* (Ibrahim et al., 2011).

4.5 Heritage Features

According to Singapore's Planning Act (Chapter 232) Section 9, *"any area of special architectural, historic, traditional or aesthetic interest"* can be designated as a conservation area, which may comprise of an area, a single building or a group of buildings. Any individual must not conduct any works within the conservation area without obtaining conservation permission. As governed by the Planning Act, *"competent authority may, from time to time, issue guidelines for the conservation of buildings or land within a conservation area and for the protection of their setting"*. [R-11] The two main competent authorities responsible for heritage conservation in Singapore are National Heritage Board (NHB) and URA, where the former is governed under Ministry of Culture, Community and Youth (MCCY) and the latter is under Ministry of National Development (MND). Besides, according to NParks, "*mature trees are the natural heritage of Singapore and serve as important green landmarks of our City in Nature*", hence a Heritage Tree Scheme was announced on 17 August 2001, which advocates the conservation of Singapore's mature trees [W-77].

Based on the desktop review of heritage features via OneMap SG [M-2] with NHB's/NParks' contributed sources, there were no NHB-governed heritage features (i.e. museums, monuments, historical sites and heritage trees) within the Study Area of this Project.

URA takes into account the conservation of built heritage or historic buildings as an essential part of Singapore's development and urban planning. Based on the desktop review of URA's Master Plan 2019 [M-3], no conservation areas were identified within the Study Area of this Report.

4.6 Ecological Connectivity

Small forest patches in Singapore, such as the Study Areas, provide stepping stones for wildlife moving across the fragmented landscape. Landscape-level habitat connectivity is crucial in maintaining the viability of populations and important ecological processes (Nor et al., 2017).

Maju Forest and Clementi Forest are connected to the Bukit Timah Nature Reserve (BTNR) and Central Catchment Nature Reserve (CCNR) via Toh Tuck Forest and Bukit Batok Nature Park to its west (Figure 4-5). Maju Forest is connected to the Toh Tuck Forest to its east and Clementi Forest to its west via the Old Jurong Railway Corridor, both of which eventually link up to the BTNR. The Toh Tuck Forest is also part of the Important Biodiversity and Bird Areas in Singapore (Singapore Bird Group, 2016).

Both Maju Forest and Clementi Forest lie along the Old Jurong Railway Corridor, which serve as an important ecological corridor between the two Study Areas. Along the northeast perimeter of Clementi Forest, the Rail Corridor runs parallel through the Study Area. The Rail Corridor "constitutes the longest belt of existing greenery in Singapore that is relatively well-connected" (Ho et al., 2019), and facilitates the movement and dispersal of wildlife through northern, central and southern parts of Singapore. It links nodes of greenery between Woodlands in the north, as well as Jurong and Tanjong Pagar in the west and south of Singapore, respectively.

Legend

- Study Area
- Important Bird Areas
- Green Rail Corridor
- Old Jurong Railway Corridor
- Base Scenario Construction Worksite Footprint and Proposed CRL Alignment (Base)

N

Rev.	Date	By	Description	Chk'd	App'd
	JUL 2022	ASH	EIS (Clementi Forest and Maju Forest)	NHT/JAG	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
PACKAGE 1
(VOLUME I)

Figure Title :
ECOLOGICAL CONNECTIVITY OF THE STUDY AREAS WITH OTHER FORESTS IN PROXIMITY

Designed	Checked	Approved
ASH	NHT/JAG	JAG
	Drawn ASH	Date JUL 2022

Figure No. : 4-5
Rev.
Sheet 1 of 1

CAD File Name : NA
A3

Note: Source of basemap - Google Earth Map

4.7 Local Geology

Information relating to the geology is provided in the geological publication published by the Defence Science and Technology Agency (DSTA) of Singapore entitled “Geology of Singapore” (2009) with the information below extracted from *Historical Land Use Survey for the Advanced Engineering Study for Cross Island Line Phase 2 (CRL2)* done by LTA.

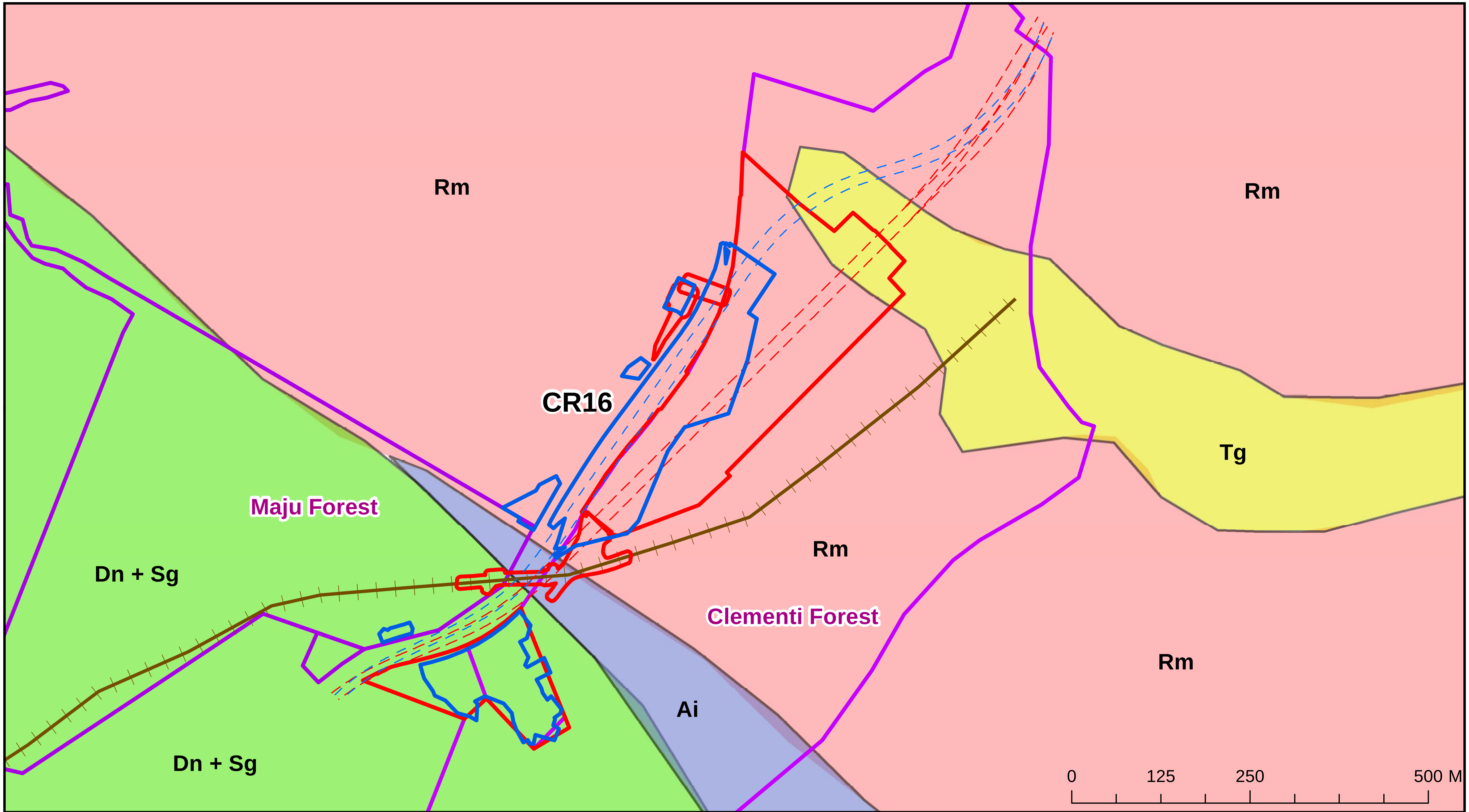
The geology of Singapore largely consists of three (3) formations: (i) igneous rocks of granitic composition (i.e. Bukit Timah Granite) in the central and northwest of Singapore, (ii) deposits of Tertiary to early mid-Pleistocene age (i.e. Old Alluvium) which masks older rock units located beneath the eastern part of Singapore, and (iii) sedimentary rocks (i.e. Jurong Formation) in the west.

Based on LTA’s HLUS study [R-3] and geology maps from DSTA, the local geological profile along the CR16 alignment and worksites is shown in Table 4-3 and Figure 4-6. Whilst it appears that the location of the TBM sits within Bukit Timah Granite, LTA’s latest survey data, the location comprises Jurong Formation (Tengah Facies and Queenstown Facies) (Drawing Number: CRLw-SK0001).

Table 4-3 Geological Information in the Vicinity of Project

Formation	Composition	Occurrence within the Alignment and its vicinity
Bukit Timah Granite	An array of acid rocks including granite, adamellite, granodiorite and the acid and intermediate hybrids which resulted from the assimilation of basic rock within the granite	• Exists as a comparatively large land area across from Bukit Timah Road to a point along Clementi Road
Jurong Formation (Tengah Facies)	Muddy marine sandstone with occasional grit beds and conglomerate	• Underlies forested areas and residential development along a section of Clementi Road
Jurong Formation (Queenstown Facies)	Red to purple mudstone and sandstone with minor conglomerate, with occasional minor tuffs	• Exists along Clementi Road from Maju Camp towards Clementi Avenue 5 which is mainly located outside of the Study Area. o By comparing the Geological Map of Singapore 1851 from National Archives of Singapore) [W-75] with the Geological Map of Singapore (after Lee and Zou (2009)) [P-34], the Air Terjun Facies and Durian+Sendang Facies (see Figure 4-6) were historically located as part of the Queenstown Facies which is now one of geological distributions under Jurong Formation in Singapore.

Sources:
- *Historical Land Use Survey for the Advanced Engineering Study for Cross Island Line Phase 2 (CRL Phase 2) – by LTA.*
- *National Archives of Singapore*



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Old Jurong Railway Corridor
- Biodiversity Study Area

Bukit Timah Granite

SOILS ON IGNEOUS ROCKS

- Rm — Rengam Facies

Jurong Formation

SOILS ON ALLUVIUM

- Tg — Tengah Facies

SOILS ON SEDIMENTARY ROCKS

- Ai — Air Terjun Facies
- Dn + Sg — Durian+Sendang Facies

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	ASH	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :

GEOLOGICAL MAP
OF STUDY AREA

Designed	Checked	Approved
ASH	JAG/NHT	JAG

	Drawn	Date
	ASH	MAY 2022

Figure No. :	Rev.	Sheet
4 -6	-	1 of 1

CAD File Name :

A3

Note: Source of basemap - National Archives Singapore

4.8 Catchment Area

As Singapore does not have extensive natural aquifers or lakes and has limited land to collected stormwater, it aims to maximise stormwater harvesting. Stormwater is collected through a network of rivers, canals and drains and channelled to seventeen (17) reservoirs, after which it is treated, filtered and disinfected at the water treatment plants. Stormwater is one of Singapore's main sources of drinking water and industrial water. As shown in Figure 4-7, the proposed CR16 worksites will be located with the catchment area of Pandan Reservoir. This indicates that the stormwater runoff within the Study Area is collected for drinking water purposes in this reservoir. The detailed hydrology baseline information will be further discussed in Section 8.

Due to the paucity of sufficient topographical data to carry out the catchment analysis for Maju Forest and Clementi Forest, only hydrological analysis was conducted based on elevation data, site observation and available information. The detailed hydrological analysis for Maju Forest and Clementi Forest is provided in Section 8.5.2.1 of this Report.

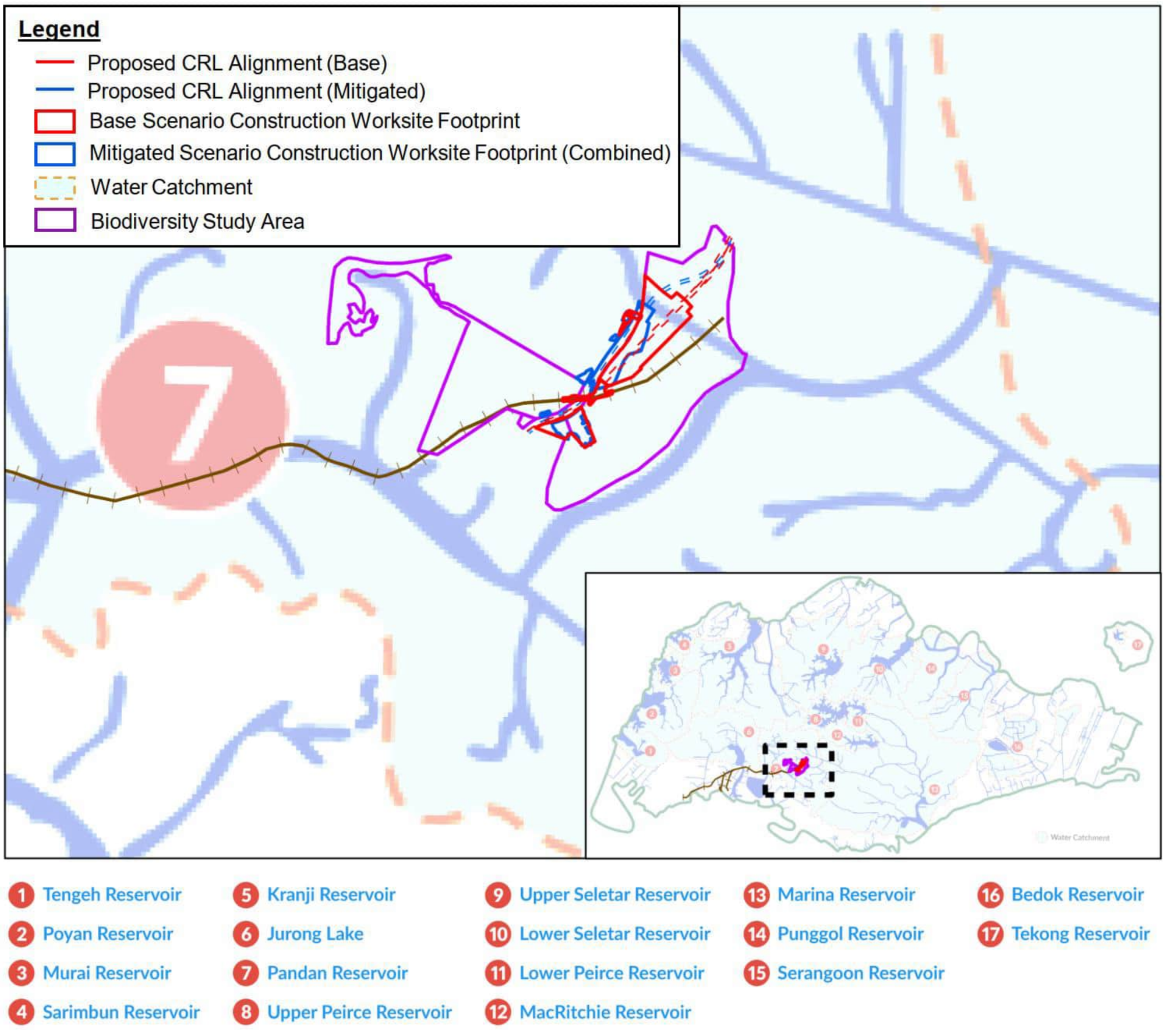


Figure 4-7 Singapore Water Catchment [W-20]

4.9 Climate

4.9.1 Rainfall

Singapore is situated near the equator and has typically tropical climate. Singapore's year-to-year rainfall is highly variable. Based on the 30-years long-term climate information (1981 – 2010) by the Meteorological Service Singapore (MSS), it rained an average of 167 days of the year [W-27]. The long-term mean annual rainfall total is 2534.4 mm when averaged across island-wide stations with long-term records [W-28]. Based on the findings from MSS, the annual rainfall total has increased at an average rate of 67 millimetres (mm) per decade, and hourly rainfall increased at the rate of 0.8 days per decade for heavy rain (>40 mm) and 0.2 days per decade for very heavy rain (>70 mm) from Year 1980 to 2019 (see Figure 4-8) [W-29].

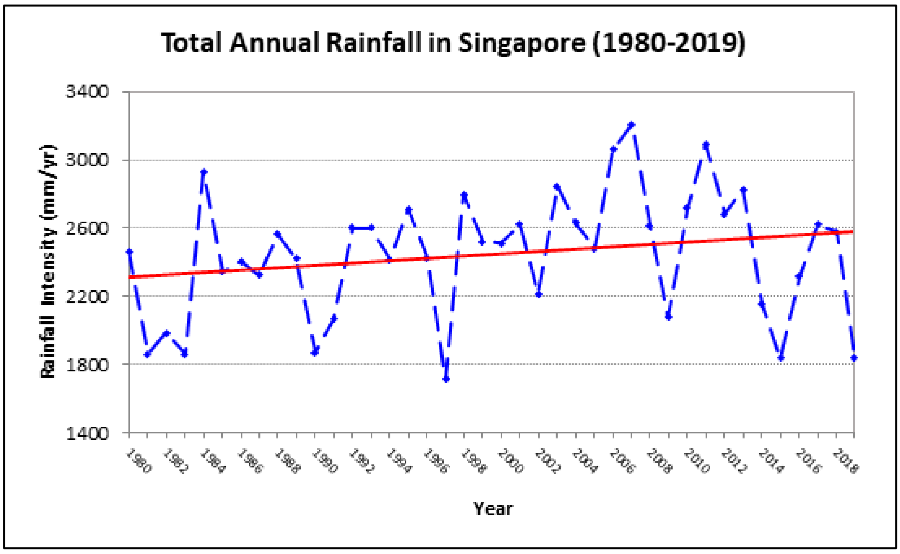


Figure 4-8 Annual Rainfall Total in Singapore from 1980 to 2019 [W-29].

In terms of spatial distribution, rainfall is higher over the northern and western parts of Singapore and decreases towards the eastern part of the island [W-27]. The figure also shows that the Central Catchment possibly receives the maximum rainfall in Singapore. The annual average rainfall in the Project Site is anticipated to be approximately 2,800 to 3,000 mm. Furthermore, the recent findings from MSS had shown an overall upward trend in total annual rainfall at increased average rates ranging from 3.3 to 12.2 mm/year, during the period from 1980 to 2019 (refer to Figure 4-10) if compared to the 30-years long-term basis, except for the areas near Changi and Queenstown climate stations at the east and south of Singapore respectively [W-29].

Figure 4-9 Annual Average Rainfall Spatial Distribution (1981-2010) [W-27]

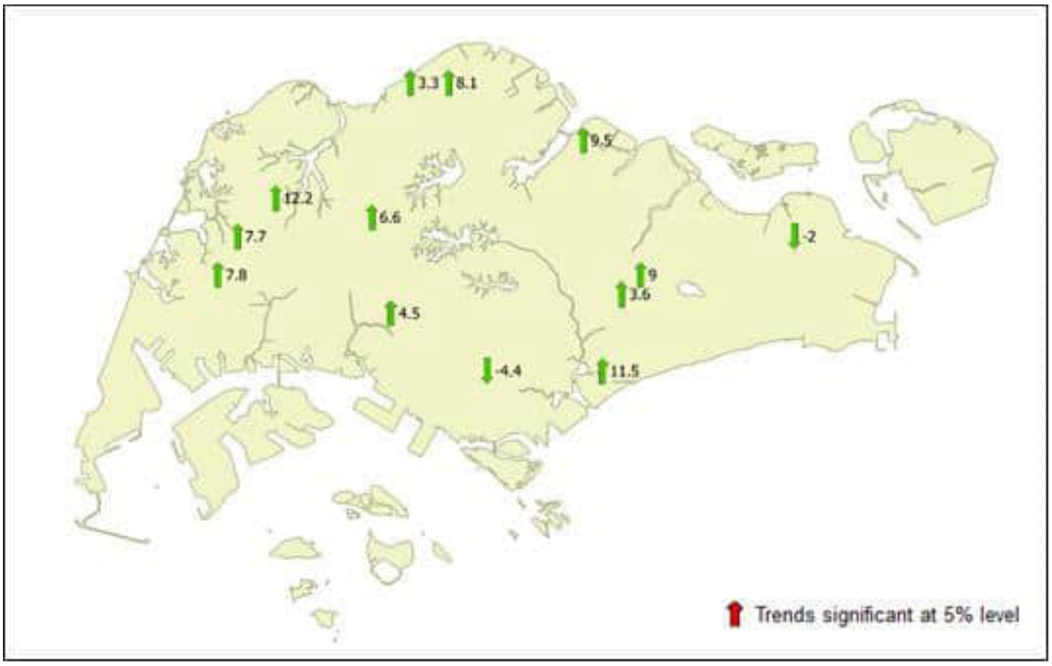


Figure 4-10 Past Trends of Annual Rainfall Total at Indicative Stations (1981-2019) [W-29]

Singapore has two monsoon seasons separated by inter-monsoonal periods, where the Northeast Monsoon occurs from December to early March and the Southwest Monsoon from June to September. It also has abundant rainfall all the year round with relatively higher mean rain days (more than 13 days) and mean rainfall amount (more than 230 mm) from November to January every year. The average rainfall in Singapore is approximately 200mm and 150mm during Northeast and Southwest monsoon respectively. Most months in 2021 had rainfall that was above average.

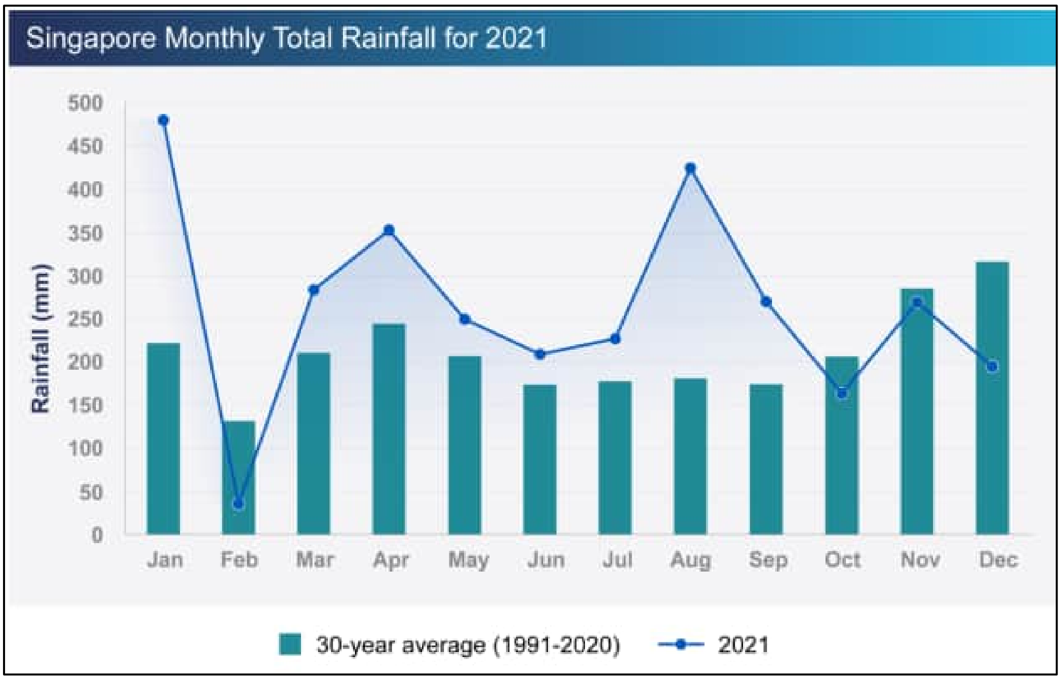


Figure 4-11 Monthly Rainfall in Singapore for 30-year Average over Island-Wide Stations with Long-Term Records (bars, 1992 – 2020) Compared to 2021 (solid line) [W-28]

4.9.2 Temperature

Singapore's continuous temperature records since 1948 show that the island has warmed by an average of 0.25°C per decade, with a visible and sudden rapid increase after the mid-1970s. This may have been due to the rapid economic development and urbanization that took place after Singapore's political reformation, as well as due to the influence of anthropogenic global warming effects. Eight (8) out of the ten (10) warmest years recorded in

Singapore have occurred in the 21st century and all ten (10) occurred after 1997. This increasing trend has led to an increase in warm days and warm nights, and a decrease in cool days and cool nights.

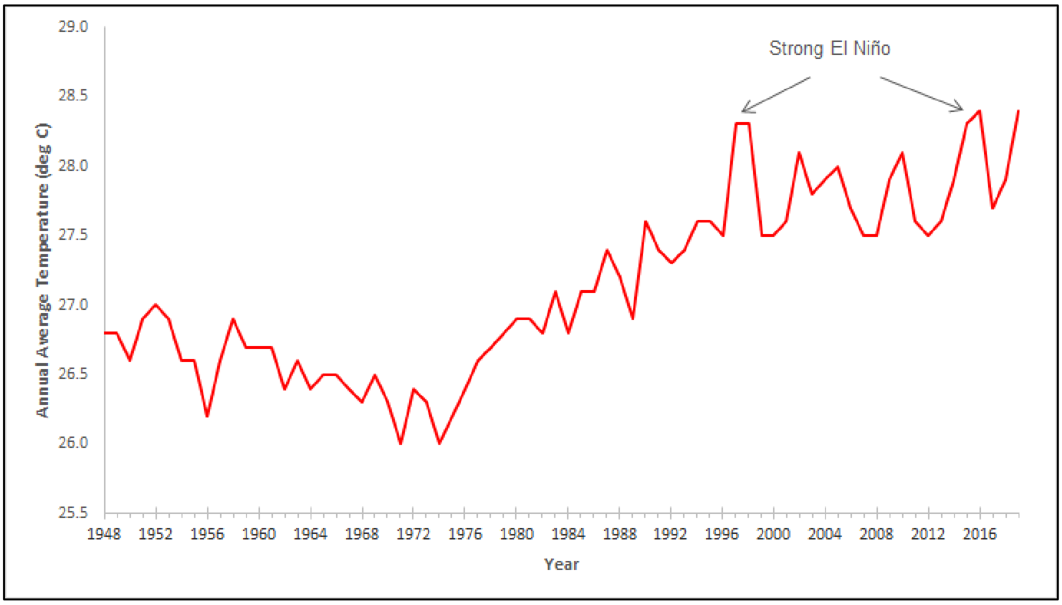


Figure 4-12 Annual Mean Temperature in Singapore from 1948 to 2019 [W-27]

Generally, the temperature variation throughout the year is relatively small as compared to the mid-latitude regions [W-28]. The mean temperature from 2012 to 2021 was 27.97°C, which is 0.02°C higher than the previous record of 27.95°C for the decade from 2010 to 2019. In Year 2021, the annual mean temperature in 2021 was 27.9°C, with May 2021 being the warmest month at 28.7°C and January 2021 being the coolest month at 26°C. Overall, the annual mean temperature of Year 2021 is 0.1°C above the long-term average of 27.8°C, however, it has not exceeded the long-term monthly temperature records [W-28] as shown in figure below.

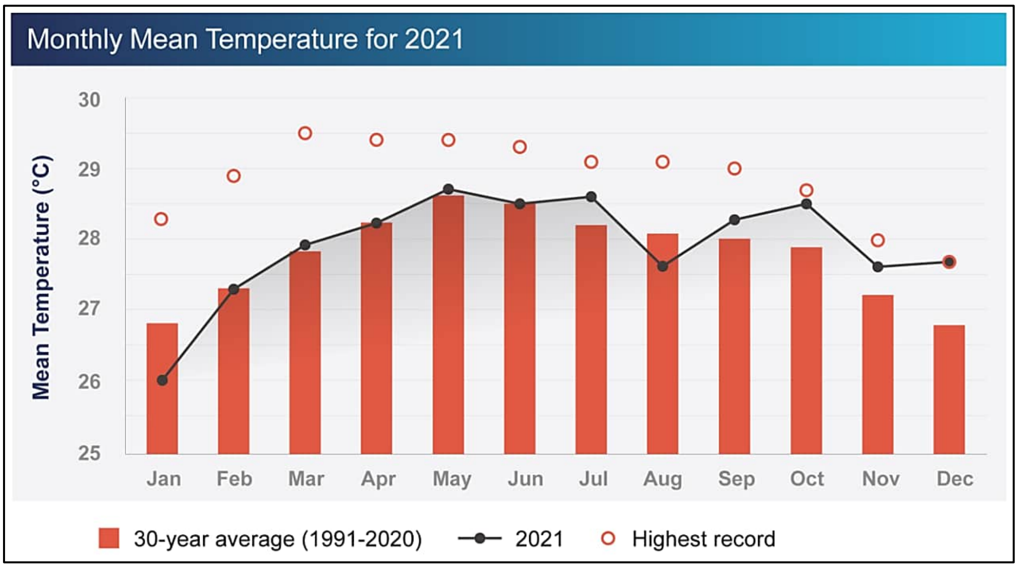


Figure 4-13 Singapore Monthly Mean Temperature for 30-years Average from Changi Climate Station with Comparison to Year 2021 Monthly Mean Temperature [W-28]

Although there is no distinct borderline between 'urban' and 'rural' areas in Singapore, maximum temperature difference of 4.01°C was observed between well planted area, such as Lim Chu Kang area, and the Central Business District (CBD) area [P-91]. This shows the presence of Urban Heating Island (UHI) effect in Singapore. Green areas in cities have been considered as potential measure in mitigating the UHI effect. This finding is also supported by a study conducted by Jusuf et al (2007), which shows different daytime temperature at different type of land use areas in Singapore. As observed in Figure 4-14, the daytime temperature in park areas is considerably lower compared to other type of land use areas [P-43].

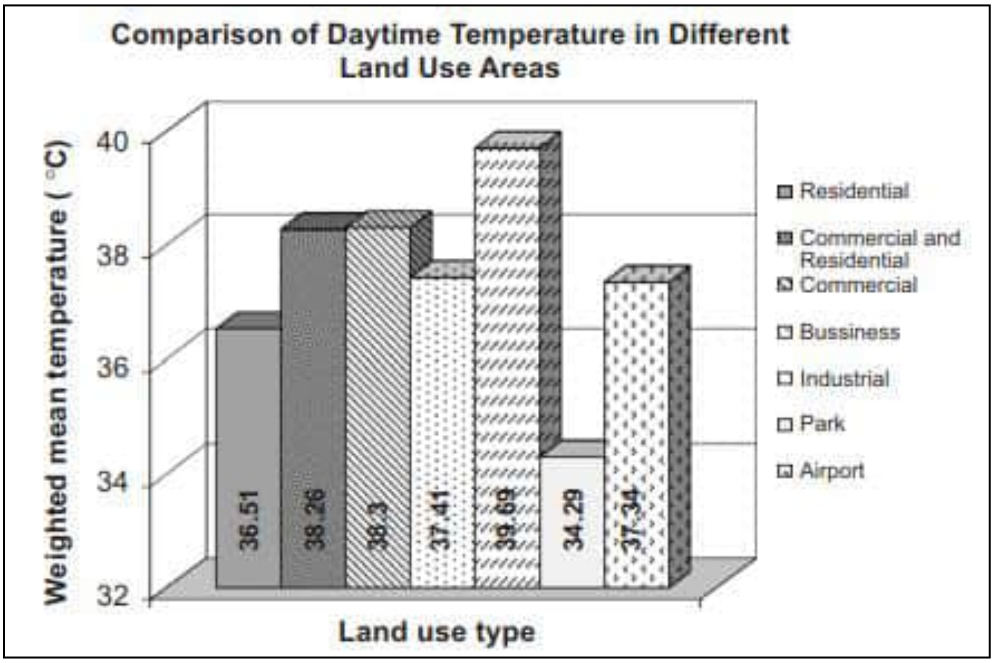


Figure 4-14 Comparison of Daytime and Night Time Temperature in Different Land Use Areas [P-43]

4.9.3 Relative Humidity

Relative humidity shows a fairly uniform pattern throughout the year and does not vary much from month to month (refer to Figure 4-15). Its daily variation is more marked, varying from more than 90% before sunrise to around 60% in the mid-afternoon on days when there is no rain. While the mean annual relative humidity is 83.9%, the relative humidity frequently reaches 100% during prolonged periods of rain.

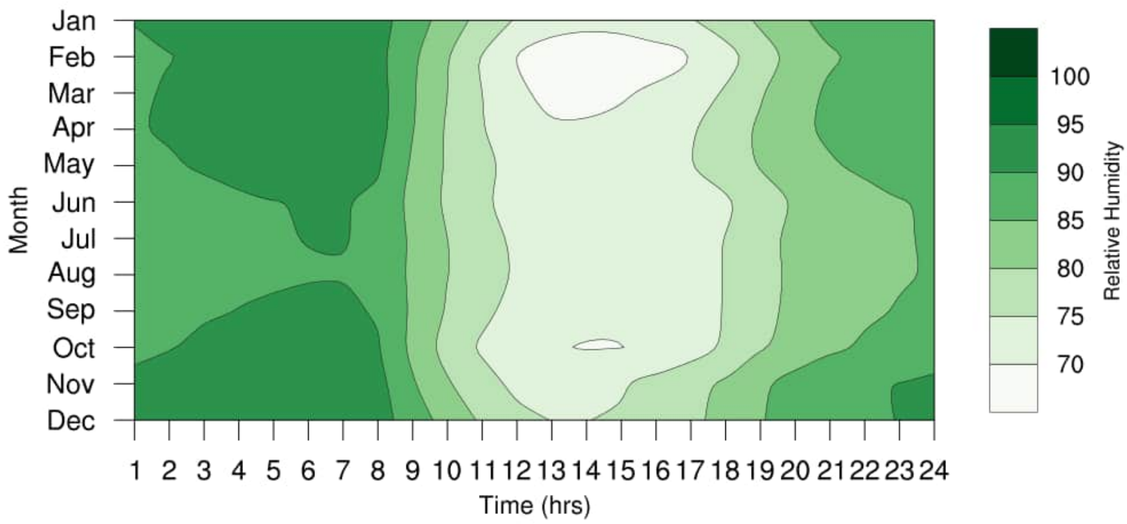


Figure 4-15 Hourly Variation of Relative Humidity for Each Month (1981-2010) [W-27]

4.9.4 Surface Wind

Winds in Singapore are generally light, with the mean surface wind speed normally less than 2.5 m/s. An exception to this is during the presence of a Northeast Monsoon surge, where mean speeds of 10m/s or more have been observed. Strong winds also occur during thunderstorms. Surface wind gusts are produced from thunderstorm downdrafts and from the passage of Sumatra Squall Lines. As shown in Figure 4-16, the most prominent winds in Singapore are from northeast and the south, occurring during the Northeast and Southwest Monsoon, respectively. The mean monthly wind speed ranges from 1.5 to 3 m/s [W-27].

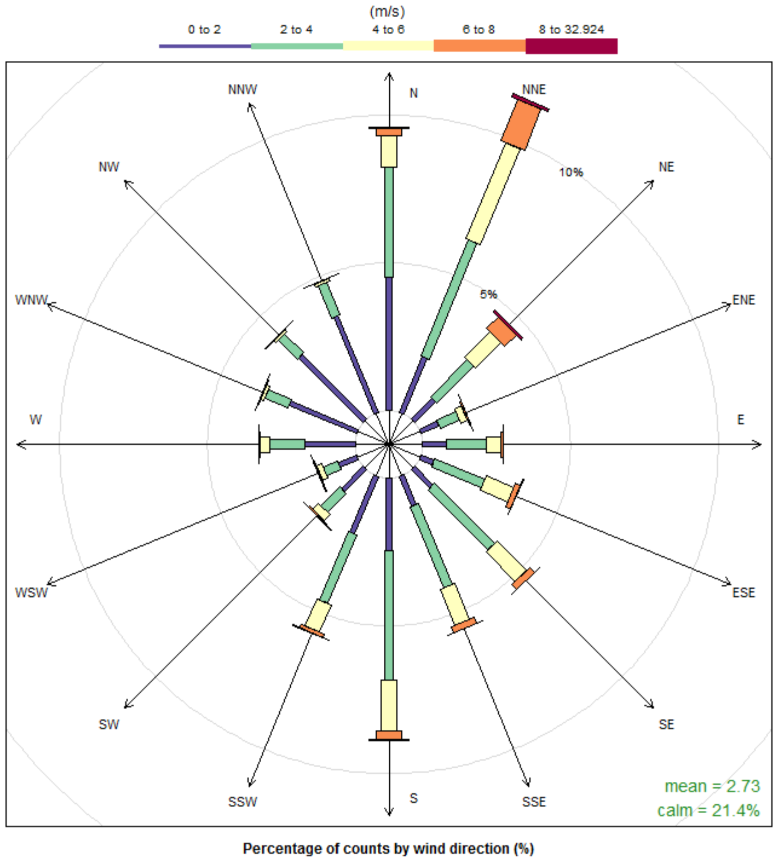


Figure 4-16 Annual Wind Rose of Singapore [W-27]

5. Environmental Legislations, Policy Frameworks, Guidelines, Plans, Standards and Criteria

A review of applicable environmental legislations, guidelines, policy frameworks, plans, standards and criteria to the construction and operational phases of the whole Project were carried out and listed in the tables below. Where relevant and appropriate, reference has been made to international guidelines and best practices. All the following sections analysing the environmental impacts refer to achieve compliance with the legislative references made in the tables below.

5.1 Construction Phase

Table 5-1 lists out the applicable legislations, guidelines and policy frameworks for construction phase.

Table 5-1 Applicable Legislations, Guidelines and Policy Frameworks for Construction Phase

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
Biodiversity	National Biodiversity Strategy and Action Plan (NBSAP), 2019 [R-61]	This document provides a framework to guide biodiversity conservation efforts in Singapore. It intends to establish both policy frameworks and specific measures to ensure better planning and co-ordination in the sustainable use, management and conservation of biodiversity. A holistic approach has been adopted where the input of various public sector agencies and nature groups have been taken into consideration in the preparation of the document.
	Wildlife Act, Chapter 351, 2000 [R-62]	• An Act for the protection, preservation and management of wildlife for the purposes of maintaining a healthy ecosystem and safeguarding public safety and health, and for related matters
	Parks and Trees Act, 2006 [R-63]	• An Act to provide for the planting, maintenance and conservation of trees and plants within national parks, nature reserves, tree conservation areas, heritage road green buffers and other specified areas, and for matters connected therewith. • No tree with a girth exceeding one meter (when measured 1-m from the ground) should be cut or damaged without the prior approval of the relevant authorities; and • No tree or plant will be cut or damaged if located within the heritage road green buffer.
	Parks and Trees Act (Parks and Trees Regulations), 2006 [R-64]	Prohibitions and regulations on trees and animals within national park, nature reserve or public park.
	Parks and Trees (Heritage Road Green Buffers) Order, 2006 [R-65]	Lists the areas designated as heritage road green buffers.
	Parks and Trees (Preservation of Trees) Order, 1998 [R-66]	Lists the designated tree conservation areas

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
		No cutting or damaging of tree having girth of more than one metre.
	The Singapore Red Data Book (SRDB) [P-26]	Lists the endangered plants and animals in Singapore Published by Singapore's Nature Society Provides the scientific name, common name, status, description, habitat, distribution, threats, scientific interest and potential value, as well as conservation measures for each plant and animal listed.
	The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species [R-59]	Provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated.
	National Parks Board Biodiversity Impact Assessment (BIA) Guidelines, 2020 [R-72]	This document provides a guideline on how to conduct biodiversity impact assessment as an individual study or as the biodiversity component of an EIA/ EIS.
Hydrology and Surface Water Quality	Singapore Environmental Protection and Management Act, 2020 [R-13]	Regulates the discharge of trade effluent, oil chemical, sewage or other pollution matters into drains.
	SS 593: 2013 – Code of Practice for Pollution Control (COPPC) [R-7]	• Provides guidelines for the appropriate discharge of any effluent into public sewer or watercourse. • Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Singapore Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-25]	• Regulates the discharge of trade effluent to public watercourse. • Any discharge into a watercourse has to comply with the regulatory standards established in these regulations.
	Singapore Sewerage and Drainage Act, 2001 [R-22]	An Act to provide for and regulate the construction, maintenance, improvement, operation and use of sewerage and land drainage systems, and to regulate the discharge of sewage and trade effluent. Regulates the protection, maintenance and provision of stormwater drainage system.
	Singapore Sewerage and Drainage (Trade Effluent) Regulations, 2007 [R-24]	Regulates trade effluent discharge into public sewerage system.
	Singapore Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-23]	Regulates measures to be implemented to protect the stormwater drainage system.
	PUB Code of Practice on Surface Water Drainage, 2013 [R-21]	Provides guidelines for measures to be implemented to protect the stormwater drainage system and manage surface water drainage (e.g. development and

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
		implementation of an Earth Control Measures (ECM) plan).
	LTA Safety, Health and Environment (General Specifications Appendix A) [R-8]	Cover the requirements for eliminating and mitigating incidents, injuries and environmental harm in LTA construction sites.
	PUB Circular on Preventing Muddy Water from the Construction Site, October 2015 [W-25]	All new construction sites with site area of 0.2ha and above, sites with problematic ECM, and sites within sensitive areas are required to implement CCTV including a Silty Imagery Detection System (SIDS) at the public drain to monitor the surface runoff discharges from the sites.
	New York and Geneva UNECE Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life (1994) (1994) [R-18]	Provides standards for water quality assessment relating to aquatic life for surface watercourses
	Water Quality Requirements WHO (n.d.) [R-20]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	USEPA Water Quality Standards Handbook (2017) (2017) [R-19]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2000) [R-26]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007) [R-27]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Philippines Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ) [R-16]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Malaysia (DOE) National Water Quality Standards [R-28]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	ASEAN Strategic Plan of Action on Water Resources Management 2005 [R-73]	Provides standards for water quality assessment for surface watercourses.
Chemical Substances (Surface water and soil and groundwater quality sections)	Environmental Protection and Management (Hazardous Substances) Regulations, 2008 [R-30]	Regulates the transport, use and storage of hazardous substances.
Fire Safety (Surface water	Fire Safety Act, 2013 [R-31]	Makes provisions for fire safety and for matters connected therewith.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
and soil and groundwater quality sections)	Fire Safety (Petroleum and Flammable Materials) Regulations, 2008 [R-32]	Regulates the transport, use and storage of flammable material to prevent occurrence of accidents.
	Code of Practice for the Storage of Flammable Liquids (SS 532:2007) [R-33]	Provides guidelines for the transport, use and storage of flammable material to prevent occurrence of accidents.
Soil and Groundwater Quality	Environmental Protection and Management Act, 2020 [R-13]	Regulates the discharge of trade effluent, oil chemical, sewage or other pollution onto land.
	SS 593:2013 Code of Practice for Pollution Control (COPPC) [R-7]	• Provides guidelines for the control of land pollution and remediation of contaminated sites. • Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-25]	Regulates the discharge of trade effluent into any watercourse or onto land.
	Sewerage and Drainage Act, 2001 [R-22]	Regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-23]	Regulates measures to be implemented to protect the storm water drainage system and avoid flooding. Regulates the provision and maintenance of ECM in accordance with the Code of Practice on Surface Water Drainage.
	JTC Guideline on Environmental Baseline Study, 2015 [R-29]	Provide the responsible parties necessary guidance for conducting EBS for assessing contamination of a site
	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination, 2020 [R-40]	The soil remediation Dutch Intervention Values (DIV) indicate when the functional properties of the soil for humans, plant and animal life, is seriously impaired or threatened. They are representative of the level of contamination above which there is a serious case of soil contamination.
	Section 7 of SS 593:2013 Code of Practice for Pollution Control (COPPC) [R-7]	Provides the necessary guidance for conducting Environmental Baseline Study (EBS) for assessing contamination of a site and the respective standards to be followed.
Waste (Surface water and soil and groundwater quality sections)	Environmental Public Health, 2002 Act [R-34]	Regulates the storage, handling and disposal of wastes.
	Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 [R-35]	Regulates the storage, collection and disposal of toxic industrial waste.
	Environmental Public Health (General Waste Collection) Regulations, 2000 [R-36]	Regulates general waste (incinerable and non-incinerable waste) disposal.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	Hazardous Waste (Control of Export, Import & Transit) Regulations 1998 [R-37]	Provides the application and granting of import, export, transit, Basel or special permits for hazardous wastes.
	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal [R-38]	Singapore signed the Basel Convention in 1995. Its requirements were transposed into Singaporean law through the Hazardous Waste Act. The Convention obligates parties to provide for the environmentally sound management of hazardous and other wastes, e.g. restrictions on the import, export and trans-boundary movement of hazardous wastes. Appropriate measures must be taken to ensure that the generation of such wastes, as well as the consequences of waste pollution on human health and the environmental is minimal. Adequate disposal facilities must be available.
	SS603: 2014 Code of Practice for hazardous waste management [R-39]	This code provides guidance on best practice measures for managing hazardous waste on site
	Code of Practice for Licenced General Waste Collector [R-41]	This code provides list of wastes allowed to be collected by various licenced collector types.
	NEA circulars on import and export of waste [W-24]	Several circulars have been rolled out prohibiting certain import / export of waste One of the circulars prohibits import/ export of metal/plastic scrap containing toxic or heavy metals (PCD/BASEL/05-0021)
Air Quality	Environmental Protection and Management Act, 2020 [R-13]	Provides standards and regulations on air impurities
	Environmental Protection and Management (Air Impurities) Regulations 2015 [R-43]	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets) [W-19]	Stipulates the recommended limit values for ambient concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and O_3 to be applied from the year 2020. Target values are based on World Health Organisation (WHO) Limit Values (mixture of Interim and Final values).
	Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012 [R-44]	Stipulates that all off-road diesel engines (including construction equipment with diesel engines) imported for use in Singapore from July 2012 must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards.
	UK Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction [R-45]	The document provides guidance for developers, their consultants and environmental health practitioners on how to undertake a construction impact assessment (including demolition and earthworks).

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
Airborne Noise	SS 593: 2013 – Code of Practice for Pollution Control (COPPC) [R-7]	Specifies recommended pollution control requirements and good practices for prevention of impacts to noise.
	SS602:2014 Code of Practice for Noise Control on Construction and Demolition Sites [R-56]	Specifies recommendations and good practices for prevention of noise impacts from construction and demolition activities.
	Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-50]	• Stipulates a set of maximum allowable noise limits for construction sites for different time periods of the day and for different types of premises affected by construction noise. • Stipulates the correction factor that needs to be applied to the applicable noise criteria based on background noise levels.
	Biodiversity 2020 (UK) [R-9]	"Theme 3: reduce environmental pressures - integrate consideration of biodiversity within the sectors which have the greatest potential for direct influence, and reduce direct pressures." The guide does not provide airborne noise criteria for biodiversity impact assessment but only serves as a reference that sets out biodiversity policies and strategies to conserve biodiversity for AECOM to consider and implement in the EIS study.
Ground-borne Vibration	BS 5228-2 2009+A1:2014: Code of practice for noise and vibration control on construction and open sites – vibration [R-55]	BS 5228-2 provides a 'best practice' guide for control of construction vibration and guidance on the human response to vibration in terms of peak particle velocity (PPV). It also provides case history vibration data and calculation methods for vibration from construction activities, including piling and tunnel boring.
	BS 6472-2:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings Part 2: Blast Induced Vibration [P-61]	This part of BS 6472 guides human exposure to vibration induced by rock breaking and excavation works in buildings. It is used to assess other forms of vibration caused by rock breaking and excavation works, including when charges are utilised in civil engineering and demolition activities.
	There are no relevant national or international standards-setting criteria for vibration impacts on biodiversity. The most commonly used vibration criteria on humans are from the British Standard (BS) and Federal Transport Administration (FTA) in Singapore which were used as references. In undertaking this EIS, AECOM generally relies on a quantitative assessment	

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	of the various disturbance sources that particular receptors are likely to encounter and focuses on the factors likely to cause the most disturbance.	

5.2 Operational Phase

Table 5-2 lists out the applicable legislations, guidelines and policy frameworks for the operational phase.

Table 5-2 Applicable Legislation for Operational Phase

Environmental Parameter	Applicable Legislation	Key Points
Biodiversity	Same as construction phase	
Surface Water Quality	Same as construction phase	
Chemical Substances (Surface water and soil and groundwater quality sections)	Same as construction phase	
Fire Safety (Surface water and soil and groundwater quality sections)	Same as construction phase	
Soil and Groundwater Quality	Same as construction phase	
Waste (Surface water and soil and groundwater quality sections)	Same as construction phase	
Air Quality	Environmental Protection and Management Act, 2020 [R-13]	Provides standards and regulations on air impurities
	Environmental Protection and Management (Air Impurities) Regulations 2015 [R-43]	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets) [W-19]	Stipulates the recommended limit values for ambient concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and O_3 to be applied from the year 2020. Target values are based on World Health Organisation (WHO) Limit Values (mixture of Interim and Final values).
	Environmental Protection and Management (Vehicular Emissions) Regulations 2008 [R-46]	The document provides guidance for enforcement against smoky vehicles and idling engines while the vehicle is stationary.
Airborne Noise	Technical Guideline for Land Transport Noise Impact Assessment from National Environment Agency (NEA) [R-52]	Airborne noise: Airborne noise limit (from MRT trains) of LpAeq1hr of 67 dB when measured at 1m from the façade of existing residential buildings/noise

Environmental Parameter	Applicable Legislation	Key Points
		sensitive premises are set by the National Environment Agency (NEA).
	Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings by National Environmental Agency (NEA); Code of Practice on Pollution Control by National Environment Agency [R-51]	Legislative requirements for boundary noise due to noise emissions from mechanical ventilation systems for non-industrial buildings.
	Biodiversity 2020 (UK) [R-9]	"Theme 3: reduce environmental pressures - integrate consideration of biodiversity within the sectors which have the greatest potential for direct influence and reduce direct pressures." The guide does not provide airborne noise criteria for biodiversity impact assessment but only serves as a reference that sets out biodiversity policies and strategies to conserve biodiversity for AECOM to consider and implement in the EIS study.
Ground-borne Vibration	Same as construction phase	

6. Assessment Methodology

6.1 Approach

The general approach to the EIS is as follows:

- Scoping of Project, completed through an Inception Report, including:
    - Project definition (Section 3);
    - Identification of Study Area (Section 4.1);
    - Identification sensitive receptors (Section 6.2.2); and
    - Identification of sample collection locations (Section 6.3.1).
- Environmental Impact Study and Evaluation, detailed in this Report, including:
    - Data collection and analysis (Section 6.3);
    - Prediction of impacts (Section 6.4.1)
    - Impact evaluation (Section 6.4.2); and
    - Environmental Impact Register (mitigation and management plan) (Section 6.5).

6.2 Scoping of Project

Referring to the Inception Report Rev A [R-2] accepted by LTA on 5 May 2020, the environmental impacts resulting from the construction and operational activities of this Project towards the Biodiversity Study Area are assessed in this EIS Report as follows:

- Biodiversity;
- Hydrology and Surface Water Quality;
- Soil and Groundwater (including waste);
- Air Quality;
- Airborne Noise; and
- Ground-borne Vibration.

Note that ground-borne noise only occurs inside a building. Hence it would not apply to ecologically sensitive receptors which are located outdoor. Therefore, ground-borne noise during both construction and operational phases is not included in this EIS Report's scope of work. In addition, it should be noted that the operational impact of ground-borne vibration from train operation addressed in this EIS takes reference from a separated study from LTA.

6.2.1 Identification of Study Area

The Study Area for this EIS includes the tunnel alignment, stations and worksites which is used to determine any potential environmental impacts to the nearby sensitive receptors due to construction and operational activities in the vicinity of the Project. Study Area will vary depending on the technical discipline as summarised in Section 4.1 and will be described respectively for each impact in the following chapters.

6.2.2 Identification and Classification of Sensitive Receptors

Sensitive receptors are those receptors within or in the vicinity of the Study Area which may potentially be impacted by the Project’s construction and operational activities. Environmentally sensitive receptors are sub-categorised into three categories: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least) as shown in the following table. The identification of sensitive receptors for each environmental parameter will be developed based on the findings of the environmental reconnaissance surveys, baseline surveys and review of the proposed Project footprint.

Table 6-1 Receptor Sensitivity Classification

Environmental Parameter	Receptor Sensitivity		
	Priority 1	Priority 2	Priority 3
Biodiversity	Flora, fauna species and habitats of high ecological value. (i.e., presence of conservation significant flora, fauna species and habitats; trees of conservation significance and NParks-designated heritage trees)	Flora, fauna species and habitats of moderate ecological value. (i.e., mainly native species of flora, fauna and habitats)	Flora, fauna species and habitats of low ecological value. (i.e., mainly exotic or cryptogenic flora, fauna and habitats; managed vegetation which can provide crucial habitat for significant species)
Hydrology and Surface Water Quality	Surface watercourses protected and used for drinking supply[1], or supporting ecosystems of biodiversity conservation significance in consultant with Biodiversity specialist after surveys[2].	Surface watercourses used for industrial water supply or for recreational purposes, but not used for drinking water purposes and which do not support ecosystems of biodiversity conservation significance in consultant with Biodiversity specialist after surveys.	Surface watercourses not used for any purposes and not protected.
Soil and Groundwater	Groundwater is sensitive (i.e. used for agricultural / irrigation / drinking water purposes) or supports ecosystems of biodiversity conservation significance).	Groundwater may be extracted for industrial purpose but not used for agricultural / irrigation / drinking water purposes. Groundwater partially supporting ecosystems of biodiversity conservation significance.	Not sensitive groundwater (i.e. not extracted for any purposes or does not support any ecosystems of biodiversity conservation significance.
Air Quality	Flora, Fauna Species and Habitats of High Ecological Value within 20 m of construction worksite area.	Flora, Fauna Species and Habitats of High Ecological Value within 20 m to 50m of construction worksite area. Ecological sites having known sensitive communities within 20 m of construction worksite area.	Ecological sites having known sensitive communities within 20 m to 50 m of construction worksite area. Any other ecological sites within the Study Area of 50 m.

[1] Watercourse usage will be determined based on the PUB Water Catchment Map [W-26].
[2] The receptor sensitivity of surface waterbodies will be determined based on the biodiversity baseline survey results which will identify whether such surface waterbodies are supporting ecosystems of biodiversity conservation significance.

Environmental Parameter	Receptor Sensitivity		
	Priority 1	Priority 2	Priority 3
Airborne Noise[3]	Species that use sound for communication, foraging and breeding or are known to have their behaviours disrupted by sound or are of Conservation Significance.	Species that are less affected by airborne noise but are of Conservation Significance.	Species that are less affected by airborne noise and are not of Conservation Significance.
Ground-borne Vibration[4]	Fauna species and habitats of high sensitivity towards ground-borne vibration are of Conservation Significance. Species that inhabit the ground or aquatic environments and live in burrows and/or caves are more badly impacted by anthropogenic vibrations.	Fauna species and habitats less affected by ground-borne vibration are of Conservation Significance.	Fauna species and habitats are less affected by ground-borne vibration and are not of Conservation Significance.

6.3 Data Collection and Analysis

Collection of environmental baseline data within the Study Area was conducted both from primary sources and secondary sources.

6.3.1 Sample Collection Locations and Parameters

The sample collection and survey locations were selected for baseline data collection based on their proximity to the Project and receptor priority. These locations were confirmed during a site reconnaissance survey. Site visits were undertaken as tabulated in the following Table 6-2.

Table 6-2 Site Visits for Data Collection

Environmental Parameter	Site Visits
Biodiversity	<u>Site reconnaissance survey:</u> • Maju Forest: 20, 21 Nov 2019 • Clementi Forest: 07, 11, 15 Nov 2019 <u>Sampling dates:</u> • Maju Forest: 02 Dec 2019 - 22 Feb 2020 • Clementi Forest: 16 Dec 2019 - 24 March 2020 <u>Camera Trapping dates:</u> • Maju Forest: 03 Dec 2019 - 21 Jan 2020

[3] The fact is that different species are likely to react differently to disturbance and that will be influenced by various other factors such as how percussive the noise is (e.g. from rock breaking and piling), how far away the receptor is generally, behaviour of the fauna, and other factors such as whether the species is feeding or breeding/nesting and in particular from the complication of visual disturbance (particularly humans on foot nearby).

[4] The prioritisation of the fauna receptors is in the order of low, moderate or high sensitivity (Priority 3 to 1) has been broadly given at this stage in Inception report and will be refined in EIS based on the available data/publication and biodiversity specialist's perception of species' (of conservation interest) sensitivity to ground-borne noise and vibration levels. The exposure limit based on behaviour of the species will be taken into account in this case.

Environmental Parameter	Site Visits
	• Clementi Forest: 12 Dec 2019 - 13 Feb 2020
Hydrology and Surface Water Quality	Site reconnaissance survey: 4 November 2019 6 November 2019 11 November 2019 13 January 2020 16 March 2021 Sampling dates: 4 February 2020 (dry weather sampling) 5 February 2020 (dry weather sampling) 17 March 2020 (dry weather sampling) 22 June 2020 (wet weather sampling) 13 August 2020 (wet weather sampling) 28 March 2022 (dry weather sampling) 6 April 2022 (dry weather sampling) 11 April 2022 (wet weather sampling)
Soil and Groundwater	• Soil Investigation Studies (carried out by LTA):23 June 2015 – 29 July 2015 [R-69] • 5 September 2017 – 13 October 2017 [R-70]. Soil and Groundwater baseline studies (carried out by LTA): • 3 December 2020 – 8 March 2021 [R-75] • 26 January 2021 – 1 February 2021 [R-71].
Air Quality	Site reconnaissance survey: 5 – 6 November 2019 Sampling dates: SUSS: 11 – 18 March 2020
Airborne Noise	Site reconnaissance survey: 5 – 6 November 2019 Sampling dates: • Landed housing along Clementi Crescent: 14 January – 21 January 2020 • Within Clementi Forest: 14 January – 21 January 2020 • SUSS: 24 January – 03 February 2020 • Children's Aid Society (Melrose Home): 29 January – 05 February 2020
Ground-borne Vibration	Site reconnaissance survey: 5 – 6 November 2019 Sampling dates: • Within Clementi Forest: 14th June 2020 – 15th June 2020 • Within Maju Forest: 28 April 2022 – 07 May 2022

Further information on sample collection and survey locations and parameters is provided in Section 7 (Biodiversity), Section 8 (Hydrology and Surface Water Quality), Section 9 (Soil and Groundwater), Section 10 (Air Quality), Section 11 (Airborne Noise) and Section 12 (Ground-borne Vibration).

6.3.2 Secondary Data Collection

Additional secondary data was collected from sources including, but not limited to, the following:

- Review of available environmental surveys previously carried out within or in the vicinity of the Study Area (e.g. tree surveys, ecological surveys, etc);
- Publicly available data, existing literature, books (e.g. Singapore Red Data Book (SRDB) and online sources);
- Singapore ambient air quality available online;
- Historical, current and planned land uses, including commercial and recreational activities;
- Online databases (Climate, catchment area, biodiversity, historical land use, etc);
- Aerial photographs;
- Drainage maps of the catchment area;
- Weather Data (Rainfall, Wind, Evaporation);
- Landscape maps; and
- Commercial and recreational activities.

Further information on secondary data collection is provided in Section 7 (Biodiversity), Section 8 (Hydrology and Surface Water Quality), Section 9 (Soil and Groundwater), Section 10 (Air Quality), Section 11 (Airborne Noise) and Section 12 (Ground-borne Noise and Vibration).

6.4 Assessment Criteria

6.4.1 Prediction of Impacts

Key potential environmental impacts arising from the Project's construction and operational activities were assessed within the Project scope. The methodology for the prediction of impacts is as given in Table 6-3 and Table 6-4.

Table 6-3 Methodology for Prediction of Construction Impacts

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
Biodiversity	**Qualitative** assessment to evaluate the impacts of construction activities on key biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (if any)	Assessment criteria broadly take guidance from Hong Kong Environmental Impact Assessment Ordinance – Technical Memorandum Annex 8, with considerations from literature review and local biodiversity standards.	Section 7
Hydrology and Surface Water Quality	**Qualitative** and analytical methods were applied to assess hydrological and water quality impacts of the development construction phase. The hydrological impact study helped to understand the impact of construction activities as well as potential land-use changes to hydrological conditions of the site,	• Environmental Protection and Management (Trade Effluent) regulations [R-25] • Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-18], United States Environmental Protection	Section 8

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	such as the increase in peak flow discharge or changes in stream alignment of the site. Water quality impact study helped to evaluate potential impact of construction activities on the existing watercourses within/surrounding the site using analytical methods.	Agency [R-19], Philippines [R-16], Australian and New Zealand Environment and Conservation Council (ANZECC) [R-26], Canadian Council of Ministers of the Environment [R-27], and Department of Environment in Malaysia (DOE) [R-28].	
Soil and Groundwater	**Qualitative** assessment to evaluate the soil and groundwater impacts of construction activities.	The soil and groundwater will be assessed by referring to HLUS report [R-4] and previously carried out soil and/ or groundwater studies [R-69][R-70][R-71][R-75].	Section 9
Air Quality	**Qualitative** assessment following dust risk assessment methodology focusing on fugitive particulate emissions (dust) from the construction site.	Assessment broadly follows “Guidance on the Assessment of Dust from Demolition and Construction” which was published by the UK Institute of Air Quality Management (IAQM) in 2014.	Section 10
Airborne Noise	Modelling and **Qualitative** assessment was adopted to assess construction and operational noise to the noise ecologically sensitive receptors.	Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008	Section 11
Ground-borne Vibration* (excluding Ground-borne Noise as it is only applicable inside a building)	**Quantitative** assessment was adopted to assess construction and operational ground-borne vibration to the ground-borne ecologically sensitive receptors. • Empirical relationships defined in British Standard BS 5228-2:2009+A1:2014 were used to predict piling activities (construction works that produce the highest vibration levels throughout the construction period), together with a range of probabilities exceedance for categorised ground types. • Tunnel boring vibration levels were predicted on the ground above the works using BS 5228-2:2009+A1:2014 and the Esvelt equation; • Ground-borne vibration induced by rock breaking and excavation was predicted using the formulae	**Structural impact:** • The intensity of predicted impacts was compared to burrow collapse data from an international literature study (i.e. partial burrow collapse at 10 mm/s [W-89]) to address concerns of burrow collapse of fossorial mammals. • Note that this area is highly data deficient in the local Singapore context. Therefore, a conservative 50% of the available data from other countries were used to provide a significant value when mitigation is required. When construction/ operational activities cause more than PPV 5 mm/s than the predicted vibration levels, the plan for the construction activity must be made such that a	Section 12

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	in BS 6472-2-2008 and an empirical vibration prediction equation. The empirical vibration prediction equation (from LTA Contract T207) was also included to provide a local context; and • Alternative data were used if construction activities are not included in the BS 5228-2:2009+A1:2014 empirical relationships. The assessment comprises either case history data from BS 5228-2:2009+A1:2014 or AECOM's database.	vibration does not exceed the implemented threshold of PPV 8 mm/s at Windsor/ Eng Neo Avenue Forest and Forested Areas Adjacent to Fairways Quarters **Behavioural impacts:** • Based on several works of literature to gather information on vibration thresholds of fauna. Research shows that vibration thresholds for fauna are species-specific. There is a limited amount of information in this area for the indicator species for the study. • A project-specific criteria has been proposed based on the baseline levels and developed using the step changes of the Human Comfort Criteria which is further detailed in Section 12.2.2.	

Table 6-4 Methodology for Prediction of Operation Impacts

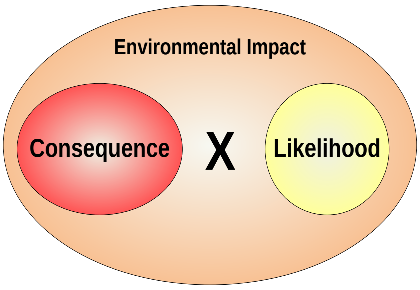
Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
Biodiversity	**Qualitative** assessment to evaluate the impacts of operational activities on key biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (if any)	Assessment criteria broadly take guidance from Hong Kong Environmental Impact Assessment Ordinance – Technical Memorandum Annex 8, with considerations from literature review and local biodiversity standards.	Section 7
Hydrology and Surface Water Quality	**Qualitative** and analytical methods were applied to assess hydrological and water quality impacts of the development operational phase. Hydrological impact study helped to understand the impact of operational activities as well as potential land use changes to hydrological conditions of the site, such as the increase in peak flow discharge or	• Environmental Protection and Management (Trade Effluent) regulations [R-25] • Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-18], United States Environmental Protection Agency [R-19], Philippines [R-16], Australian and New Zealand Environment and Conservation Council (ANZECC) [R-26], Canadian Council of Ministers of the Environment [R-27], and Department of	Section 8

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	changes in stream alignment of the site. Water quality impact study helped to evaluate potential impact of operational activities on the existing watercourses within/surrounding the site using analytical methods.	Environment in Malaysia (DOE) [R-28].	
Soil and Groundwater	**Qualitative** assessment to evaluate the soil and groundwater impacts of operational activities.	The soil and groundwater will be assessed by referring to HLUS report [R-4] and previously carried out soil and/ or groundwater studies [R-69][R-70][R-71][R-75].	Section 9
Air Quality	**Qualitative** assessment was conducted to assess air quality impacts of the development operational phase due to increased traffic in the vicinity of the stations.	Compare the change in predicted increase in traffic volume and access routes in the vicinity of the stations	Section 10
Airborne Noise	Modelling and **Qualitative** assessment was adopted to assess construction and operational noise to the noise ecologically sensitive receptors.	• NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 • NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016	Section 11
Ground-borne Vibration (excluding Ground-borne Noise as it is only applicable inside building)	**Quantitative** methods were applied to assess the ground-borne vibration impacts of the operational phase. An independent consultant provides the predicted vibration levels under a separate study by LTA.	**Structural impact:** • Same as construction. **Behavioural impacts:** Same as construction.	Section 12
Note: * Vibration frequency has not been considered in this assessment due to lack of adequate research on the impact of frequency of vibration and its impact on faunal behaviour. Please see Section 12.2.2 for details.			

6.4.2 Impact Evaluation

Impacts are evaluated based on their significance, which is a measure of the weight given to each impact in decision making and if it warrants impact management. It was assessed using the following two factors in the Impact Significance Assessment Matrix (refer to Table 6-6) as detailed below and in the following sections:

- **Impact Consequence:** The consequence of an impact is a function of a range of considerations, including impact spread, impact duration, impact intensity and nature, legal and guideline compliance (Section 6.4.2.1);
- **Likelihood of Occurrence**: The likelihood of the impact occurring during the project construction and operational periods, which takes into account the probability of the event happening as well as the duration of the event (Section 6.4.2.2).



6.4.2.1 Impact Consequence

In evaluating the consequence of environmental impacts, the following aspects were taken into consideration:

- **Receptor Sensitivity:** Categorises receptors according to their susceptibility to adverse impacts from the Project's construction and operational phases (refer to Table 6-1).
- **Impact Intensity:** defines the magnitude of the impact and the status of the impact in relation to regulations (e.g. discharge limits), standards (e.g. environmental quality criteria) and guidelines. The criteria presented in Table 6-5 will be used to categorise the impact intensity.

The EIS proposes minimum controls, or standard practices commonly implemented in Singapore for similar construction activities, that have been assumed to be implemented for the purposes of impact consequence assessment.

Table 6-5 Criteria Categorising the Impact Intensity for Construction and Operational Phases

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
Biodiversity (Construction and Operation) – Habitats	Potential impacts with no detectable changes to viability/function of habitats.	Potential impacts with: • Small temporal and spatial (localised) scale changes that affects part of the habitat, such that there is no loss of viability/function of habitat. • Changes that are reversible.	Potential impacts with: • Moderate duration and/or over a considerable spatial scale changes that affects part of the habit but does not threaten the long-term viability/function of the habitat. • Changes that are reversible with significant input and mitigation measures.	Potential impacts with: • Extensive duration and large spatial scale that affects the entire habitat, or a significant proportion of it, and the long-term viability/function of the habitat is threatened. • Changes that are non-reversible.
Biodiversity (Construction and Operation) – Flora and Fauna	No expected changes to species population.	• Short duration and small-scale localised spatial changes that could cause minimal changes to species population. • Changes are reversible.	• Moderate duration and medium-scale spatial changes that could cause moderate reduction in size of species population, but would not threaten species long-term viability.	• Extended duration and large-scale spatial changes that could cause substantial reduction in size of species population and threaten species long-term viability. • Changes are irreversible.

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
			• Changes are reversible with mitigation measures.	
Hydrology (Construction and Operation)	Very minor change to existing hydrology and flow.	Small scale localised changes to existing hydrology or flow.	Medium scale changes to existing hydrology or peak flow.	Major changes to existing hydrology or peak flow.
Surface Water Quality (Construction and Operation)	No contamination; or Likely to be well within regulatory limits.	Small scale localised contamination within regulatory limits.	Medium scale contamination or just exceed regulatory limits.	Large scale contamination exceed regulatory limits by hazardous levels for the habitat/ conservation species.
Soil, Groundwater (Construction and Operation)	None of the construction activities identified will cause contamination nor reduction of groundwater level on site.	• Small scale localised contamination which is not likely to extend beyond the construction worksite areas and possible to remediate. • Small scale localised groundwater level decrease which not likely going to extend beyond the Study Area.	• Medium scale contamination which is likely to extend beyond the construction worksite areas but possible to remediate within the construction period timeframe. • Medium scale groundwater level decrease that is possibly going to extend beyond Study Area.	• Large scale contamination which is likely to extend beyond the construction worksite areas and may require large scale remediation. • Large scale groundwater level decrease that is likely going to extend far beyond the Study Area.
Air Quality (Construction Phase)[5]	-	For Earthworks: • Total site area <2 ,500 sqm • Soil type with large grain size (e.g. sand) • <5 heavy earth moving vehicles active at any one time • Formation of bunds <4 m in height • Total material moved <20,000t • Earthworks during wetter months	For Earthworks: • Total site area 2,500 m^3 – 10,000 m^3 • Moderately dusty soil type (e.g. silt) • 5-10 heavy earth moving vehicles active at any one time • Formation of bunds 4 m - 8 m in height • Total material moved 20,000-100,000t	For Earthworks: • Total site area >10,000 sqm • Potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size) • >10 heavy earth moving vehicles active at any one time • Formation of bunds >8 m in height • Total material moved >100,000t
	-	For Construction: • Total building volume <25,000 m^3	For Construction: • Total building volume 25,000-100,000 m^3	For Construction: • Total building volume >100,000 m^3

[5] This impact intensity criterion is equivalent to the Emission Magnitude as defined in IAQM's Guidance [R-9].

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
		• Construction material with low potential for dust release (e.g. metal cladding or timber)	• Potentially dusty construction material (e.g. concrete) • On-site concrete batching	• On-site concrete batching • sandblasting
	-	For Trackout: • <10 HDV[6] (>3.5t) outward movements in any one day • Surface material with low potential for dust release • Unpaved road length <50 m	For Trackout: • 10-50 HDV[6] (>3.5t) outward movements in any one day • Moderately dusty surface material (e.g. high clay content) • Unpaved road length 50-100 m	For Trackout: • >50 HDV[6] (>3.5t) outward movements in any one day • Potentially dusty surface material (e.g. high clay content) • Unpaved road length >100 m
	-	For Demolition: • Total building volume <20,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber) • Demolition activities <10m above ground • Demolition during wetter months	For Demolition: • Total building 20,000 – 50,000 m^3 • Potentially dusty construction material • Demolition activities 10-20 m above ground level	For Demolition: • Total building >50,000 m^3 • Potentially dusty construction material (e.g. concrete) • On-site crushing and screening • Demolition activities >20m above ground level
Air Quality (Operational Phase)	Insignificant increase in air quality levels in the vicinity of stations due to Project operation.	Small scale increase in air quality levels in the vicinity of stations due to Project operation.	Medium scale increase in air quality levels in the vicinity of stations due to Project operation.	Large scale increase in air quality levels in the vicinity of stations due to Project operation.
Airborne Noise (Construction and Operation) [4]	No detectable change to flora, fauna and habitats. Predicted noise level at receptors are within the corrected baseline criteria. For A1-W1, predicted noise levels at receptors are below the baseline noise (no correction applied here).	Potential impacts last a short duration, are reversible and/or of a small magnitude for species with low auditory sensitivity level. Predicted noise level exceeds the corrected baseline criteria of up to 3 dB(A).	Potential impacts last for a moderate duration, are reversible with significant input and compensatory measures, and/or of a moderate magnitude for species with auditory sensitivity level. Predicted noise level exceeds the corrected baseline	Potential impacts last for a long time, are non-reversible, and/or of a significant magnitude for species with high auditory sensitivity level. Predicted noise level exceeds the corrected baseline criteria of more than 6 dB(A).

[6] Heavy duty vehicles (HDV) defined as vehicles with a gross weight greater than 3.5 tonnes.

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
			criteria of up to 4 – 6 dB(A).	
Airborne Noise (Air Overpressure from rock breaking and excavation)*	The predicted noise levels are equal or lower than 120 dB.	The predicted noise levels are between 121 to 149 dB.	The predicted noise levels are between 150 to 179 dB.	The predicted noise levels are equal or higher than 180 dB.
Ground-borne Vibration (excluding Ground-borne Noise as it is only applicable inside building)	See Note 3 below			
Note 1. The intensity assessment is a multi-prong approach for structural (intensity-based) or behavioural impacts. Refer to Section 12.2.2 for details. 2. A threshold of 5 mm/s was used to screen out activities assessed for structural impact in this study. A criterion of 8 mm/s PPV has been adopted (equivalent to 80% of 10 mm/s PPV) to prevent damage to burrows. 3. For ground-borne vibration, structural and behavioural assessments are matrix-based, detailed in Section 12.2.2. 4. For airborne noise, only Weekday (Monday – Saturday) noise criteria were used as part of assessment in this Report.				

A consequence category is then derived based on receptor sensitivity and impact intensity, as shown in Table 6-6, which is generally applicable for the individual impact assessments except for air quality. It should be noted that air quality impact assessment has its own specific matrices defined based on applicable international guideline as detailed in Section 10.2

Table 6-6 Impact Consequence Matrix

Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	Imperceptible	Imperceptible	Very Low
Low	Very Low	Very Low	Low
Medium	Very Low	Low	Medium
High	Low	Medium	High

6.4.2.2 Likelihood of Occurrence

The likelihood is estimated based on experience and/or evidence that such an outcome has previously occurred. Impacts resulting from routine/planned events (normal operations) are classified under High Likelihood.

Where the general definition in a qualitative manner was applied for all environmental parameters, except for airborne noise and ground-borne vibration which was further defined quantitatively to provide an optimised view for the assessment impacts for the construction phase of the Project.

For operational phase impact assessment, airborne noise impact assessment would refer to local regulations. Ground-borne vibration impact assessment would use a quantitative manner for the assessment impacts from the operation of the underground train movements. This is done by multiplying the work period and the active vibration period for machinery together which can be seen in Table 12-8.

Table 6-7 Likelihood Criteria

Likelihood Criteria	Definition for All Environmental Parameters	Definition for Quantitative Evaluation (Construction & Operational)
Unlikely/ Remote	Would be unlikely or remotely expected to occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is < 5% during the construction or operation phase.
Less Likely/ Rare	Would less likely or rarely occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 5 – 15% during the construction or operation phase.
Possible/ Occasional	Would possibly or occasionally occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 16 – 25% during the construction or operation phase.
Likely/ Regular	Would likely to occur or would occur on a regular basis during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 26 – 50% during the construction or operation phase.
Certain/ Continuous	Would be certain to occur or would occur continuously during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is > 50% during the construction or operation phase.

Note:
* The second term (i.e. remote, rare, occasional, regular, continuous) is not applicable to noise/ground-borne vibration.

References:
1. Ecological Impact Assessment (EcIA). EIANZ Guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. May 2018. [R-14]
2. CIEEM (2018). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018. [R-15]

6.4.2.3 Significance of Impact

The significance of each impact was determined by assessing the impact consequence against the likelihood of the impact occurring using the Impact Significance Assessment Matrix. A simple risk-based matrix was used for the summation of consequence and likelihood, a sample of which is shown below.

Table 6-8 Impact Significance Matrix

Consequence / Likelihood	Imperceptible	Very Low	Low	Medium	High
Unlikely/Remote	Negligible	Negligible	Negligible	Negligible	Negligible
Less Likely/Rare	Negligible	Negligible	Minor	Minor	Minor
Possible/ Occasional	Negligible	Minor	Minor	Moderate	Moderate
Likely/Regular	Negligible	Minor	Moderate	Moderate	Major
Certain/Continuous	Negligible	Minor	Moderate	Major	Major

Impacts assessed as negligible or minor will require no additional management or mitigation measures (on the basis that the magnitude of the impact is sufficiently small, or that the receptor was of low sensitivity and/or that adequate controls were already included in the Project design). Negligible and minor impacts are therefore deemed to be "Insignificant". Impacts evaluated as moderate or major require the adoption of management or mitigation measures. Major impacts are therefore deemed to be "Significant" and moderate impact as "Relatively Significant".

Major impacts always require further management or mitigation measures to minimise or reduce the impact to an acceptable level.

An “acceptable level” is the reduction of a major impact to a moderate one after mitigation. In seeking to mitigate moderate impacts, the emphasis is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable. It will not always be practical to reduce moderate impacts to minor ones in consideration of the cost-ineffectiveness of such an approach (due to the diminishing return of a reduction of impact versus cost). Residual impact assessment will be conducted for those parameters where impact from the activity is identified to be significant and additional mitigation measures are recommended. Assessment of residual impact will follow similar risk approach as outlined above.

The table provides the brief understanding for the final impact significance level.

Table 6-9 Definition of Final Impact Significance Level

Impact Significance Levels	Definitions
Negligible	Impacts are indistinguishable from the existing baseline environmental conditions, or non-noticeable by the receptor/ habitat as a change. A negligible impact is unlikely to pose concern to the government, communities and organisations.
Minor	Impacts of low magnitude, shorter term, reversible. Minor impacts are usually within accepted limits/standards provided with minimum controls or best practices, and is unlikely to pose concern to the government, communities and organisations.
Moderate	Impacts of medium magnitude, longer term, but reversible. Moderate impacts are manageable within accepted limits/standards after consideration of suitable mitigation measures or can be reduced to a level that is as low as reasonably practicable.
Major	Impacts of high magnitude, exceeds limits/standards, permanent and non-reversible. Major impacts should seek alternatives in design/ location etc. and/ or mitigation measures to avoid/compensate and/or reduce major impacts to as low as reasonably practicable.

6.5 Mitigation, Monitoring and Management

Where the implementation of minimum controls is insufficient to alleviate any significant environmental construction or operational impacts (moderate to major impacts), contract-specific final mitigation measures, in consultation with the LTA, will be proposed.

Where applicable and practical, engineering control measures will be accompanied by specifications (product brochures), estimated cost and source of supply. In addition, mitigation measures at receptors’ end will also be recommended on a case by case basis. For example, if the unmitigated construction noise levels are found exceeding the relevant criteria, practical direct mitigation measures such as the use of noise barriers, enclosures, quieter powered mechanical equipment (PME) and construction methods, etc. will be recommended. Effective dust control measures will be recommended to minimise dust emission from the site, where necessary.

Mitigation measures were proposed in accordance with the following principles and mitigation hierarchy reflected in Figure 6-1:

- **Elimination/ Avoidance** – Where changes to the Project design and construction methodology can be made to eliminate or avoid an identified impact (e.g. optimisation or reduction of construction footprint, shift or elimination of construction site in critical areas, exclusion of noisy construction phase to be conducted at evening/night period, etc.). If a full elimination is not possible, the next level of mitigation is to minimise the identified impact;
- **Minimisation (Substitution)** – Where changes to the Project design and construction methodology cannot affect impact elimination or avoidance, use of alternative construction methodology or any enhancement measures can be adopted to minimise for identified impacts. For example, tunnel boring

instead of open cut and cover, substitution of the noisier hammer piler with alternative silent piler to reduce impacts to residents, etc.;

- **Minimisation (Engineering controls)** – Where changes to the Project design and construction cannot affect impact avoidance and impact minimisation via substitution, engineering controls can be adopted to further reduce for identified impacts (and possibly an enhancement measure). For example, use of noise barriers to reduce noise, use of equipment enclosures wherever necessary, application of silt curtains to curb silt flow into drains, etc.;
- **Minimisation (Administrative controls)** – Where applicable, enhanced mitigation can be achieved by applying administrative controls on top of engineering controls. These controls do not remove environmental hazards, but limit or prevent receptor's exposure to hazards, such as repeated wetting of unpaved roads for dust suppression, proper scheduling of noisier construction activities, reducing work on weekends, etc.;
- **Remedy/ Repair/ Restore** – Where residual impacts need to be further reduced, measures should be taken to remedy/ restore/ repair the situation after the impact, e.g. replanting of trees and shrubs in appropriate locations on the impacted site to restore part of the habitat after construction; and
- **Compensation/ Offset** – Where possible, measures should be taken to compensate/ offset the impacts in a different part of the development, wherever technically and financially feasible, e.g. rare shrubs or trees that are important to birds and mammals to be planted elsewhere in consultation with NParks, etc.

The above mitigation approach is in line with the NParks Biodiversity Impact Assessment (BIA) 2020 Guidelines and the Hong Kong EIA Ordinance Annex 16 (2019) to be adopted for the Biodiversity Impact Assessment of the EIS.

An EMMP has been formulated specifying mitigation measures, monitoring scope, methodology and location, and triggers to report and escalate the irregularities in the baseline conditions at construction/commissioning stages. The basis of EMMP is provided in Section 13 and it is prepared in the form of EIR and provided in Appendix A which also summarises information about identified sensitive receptors, potential impacts evaluated, residual impacts (if any) and frequency of monitoring (if required), as well as close up actions.

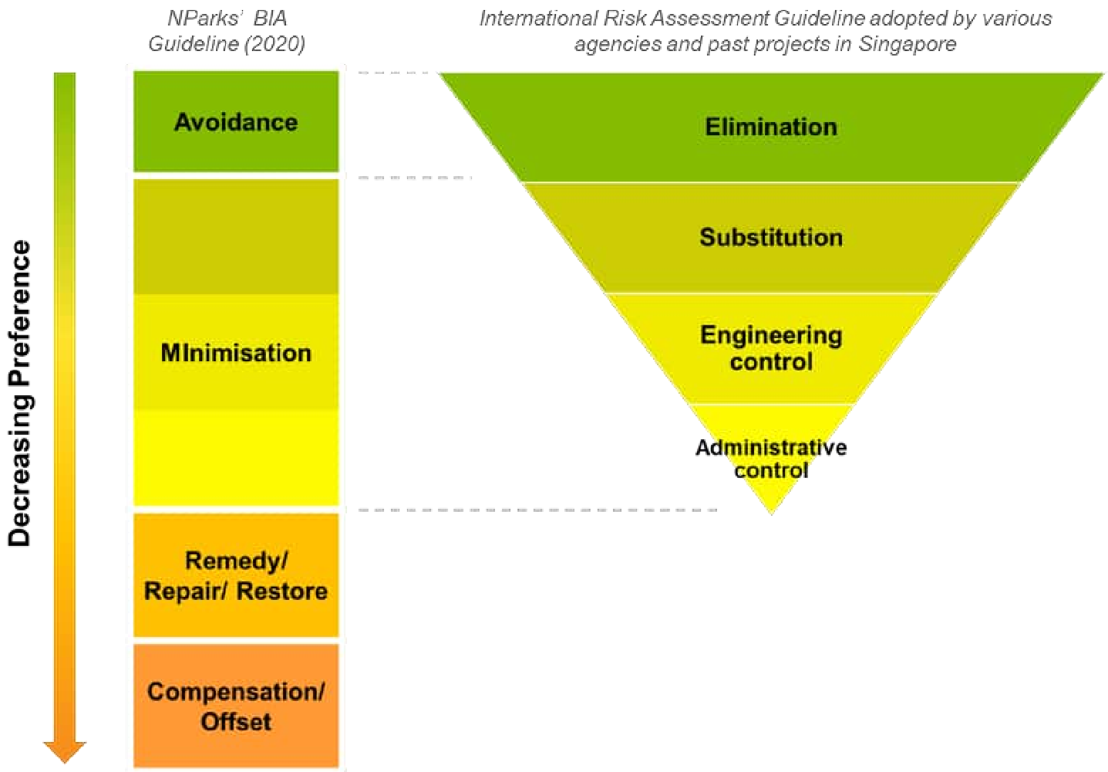


Figure 6-1 Mitigation Hierarchy

It is worth noting that the potential cumulative impacts from a few concurrent developments nearby the Project were discussed qualitatively during the impact evaluation process of this EIS, as provided the individual sections of each environmental discipline. When there was significant escalation of environmental impacts due to the concurrent development, relevant mitigation measures had been proposed holistically for this Project, and where appropriate, recommendations were provided to the Client and/or the corresponding developers to minimise or manage the potential cumulative impacts.