Contract CR2005
Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Turf City and Holland Plain)

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.
AES	Advance Engineering Study
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
CCNR	Central Catchment Nature Reserve
CCS	Central Control System
COD	Chemical Oxygen Demand
COPPC	SS 593: Code of Practice for Pollution Control, 2013
CRL	Cross Island Line
CRL1	Cross Island Line Phase 1
CRL2	Cross Island Line Phase 2
D-walls	Diaphragm walls
DGPS	Differential Global Positioning System
DO	Dissolved Oxygen
DSTA	Defence Science and Technology Agency
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
LOR	Limit of Reporting
LTA	Land Transport Authority
LTH	Light Temperature Humidity
m bgl	Meter below ground level
MCCY	Ministry of Culture, Community and Youth
MIC	Maximum Instantaneous Charge
MLS	Marchwood Laboratory Services Pte Ltd
MND	Ministry of National Development

Acronym	Definition
MOM	Ministry of Manpower
MRT	Mass Rapid Transit
MND	Ministry of National Development
MPA	Maritime and Port Authority
NAAQS	National Ambient Air Quality Standards
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
PID	Photoionization Detector
PIE	Pan Island Expressway
PRO	Public Relation Officer
PME	Powered mechanical equipment
ppm	Parts per million
PPV	peak particle velocity
PSI	Pollution Standard Index
PUB	Public Utilities Board
QA/QC	Quality Assurance and Quality Control
QECP	Qualified Erosion Control Professional
QP	Qualified Professional
RPD	Relative Percentage Difference
SAC	Species Accumulation Curve
SCDF	Singapore Civil Defence Force
SDS	Safety Data Sheet
SECS	Singapore Environmental Consultancy and Solutions Pte Ltd
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
SVOC	Semi Volatile Organic Compounds
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
TOC	Total Organic Carbon
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
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

Acronym	Definition
VOC	Volatile Organic Compounds
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
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
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).
Base Scenario/ Base Case	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.
Baseflow	Fair weather flow, the portion of the streamflow that is sustained between precipitation events, fed to streams by delayed pathways.
dB(A)	A-weighted sound pressure levels (dB) – weighted to human hearing frequencies
Clementi Forest	A forested area near Holland Plain and Old Holland Road. It is located adjacent to Site IV (forested area adjacent to Rail Corridor) and directly west of Site V (forested area at Holland Plain. Clementi Forest is situated east of Clementi Road.
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 facility buildings 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
Eng Neo Avenue Forest	A forested area near Turf City and Pan Island Expressway (PIE). It is located at the east of Site I and II (forested area adjacent to Fairway Quarters).
Biodiversity Study Area or Study Area (Biodiversity)	Forested areas identified in the vicinity of the project for its biodiversity value as outlined by LTA for this EIS, i.e. Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor), Site V (forested area at Holland Plain).

Term	Explanation
	The Biodiversity Study Area in this report context excludes the other adjacent forested areas (i.e. Eng Neo Avenue Forest and Clementi Forest), however the relevant findings will be discussed when necessary with reference to the separate EIS conducted for these forested area due to their close proximity to Site I to II and Site IV to V respectively.
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.
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
Home Range	Home range is related to the spatial scale of animal movement, where it also refers to an area where an animal usually confines its daily activities, to survive and reproduce. [W-80, W-81, W-82, W-83]
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
Maju Forest	A forested area opposite of the southern part of Clementi Forest and located at the west of Clementi Road near Maju Drive. It is connected to Clementi Forest via Old Jurong Railway Corridor.
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 facility building, 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.
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/ facility building 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.

Term	Explanation
Rail Corridor (or “Old Jurong Railway Corridor”)	In this report context, it refers to an important ecological corridor that connects Clementi Forest and Maju Forest, located near Holland Plain. The 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.
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 e.g., CR14 worksite for this Project.
Root Mean Square (RMS)	The square root of the mean of the of a certain set of values squared
Site I and II	Forested area adjacent to Fairway Quarters
Site III	Forested area within racecourse oval
Site IV	Forested area adjacent to Rail Corridor
Site V	Forested area at Holland Plain
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
Study Area (Air)	Construction: 50m (Ecological Impact) from construction worksite areas 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: 100 m around the construction worksites and extended when impacts went beyond the entire Biodiversity Study Area; Operation: 100 m from the centre of rail alignment, and extended when impacts went beyond to entire Biodiversity Study Area
Study Area (Hydrology and Surface Water Quality)	Construction and Operation: Any major watercourses with direct impact from the Project within Biodiversity Study Area
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.

Term	Explanation
Tree Mapping	Tree mapping is purely the mapping of trees using a Differential Global Positioning System (DGPS), without assessment by the arborists. This was carried out at the forested area adjacent to Fairway Quarters in this report.
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 to 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 – 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 (hereinafter referred to as 'the Project') on the Biodiversity Study Areas abutting the Phase 2 alignment.

The current work scope of this Contract only focuses on the direct alignment of CRL Phase 2 (CRL2) between Bright Hill and Clementi, excluding the alignment portions 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* (hereinafter referred to as "CCNR EIA") gazetted by LTA on 2 September 2019 as published online on LTA's website [R-1]. Prior to commission of the EIS, an Environmental Consultation Process was undertaken by LTA with the relevant technical Agencies (i.e., MPA, SFA, NEA, NParks), as well as URA/MND. Thereafter the scope of EIS was documented in the form of Inception Report Rev B [R-2] submitted to LTA on 13 March 2020.

The objective of **this report** is to conduct an environmental impact study about the potential environmental impacts arising from the construction and operation of the stretch of CRL2 rail alignment and its associated worksites (i.e., CR14, CR15) from Turf City to Holland Plain on the forested areas nearby. The forested areas located in the vicinity of these worksites comprise Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor) and Site V (forested area at Holland Plain). The project location and base scenario of the construction worksites (i.e. CR14, CR15) are demonstrated in Figure 3-1 and Figure 3-2, while the indicative operational footprint of CR14 and CR15 stations are demonstrated from Figure 3-4 to Figure 3-5.

Eng Neo Avenue Forest is a forested area located in close proximity to Site I and II, while Clementi Forest is a forested area located adjacent to Site IV and V. It should be noted that the focus of this report is of Sites I to V, all of which are located nearby CR14 and CR15 worksites. The relevant baseline and study findings of EIS (Windsor and Eng Neo Avenue Forest) and EIS (Clementi Forest and Maju Forest) are discussed in respective reports; these are referenced in this report to allow for a holistic discussion, where necessary.

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 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 impact). It also 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, airborne noise, as well as ground-borne vibration). 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.

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 relating to the design; these will be discussed and then re-evaluated when the design incorporates, develops and/or changes at a later Design stage.

Project Components and Schedule

According to current planning 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 Year 2022 to end Year 2032. This timeline may subject to changes while the Project progresses from time to time according to the actual situation.

The major components of the Project are:

- Pre-construction activities: may include road and utilities diversion works, road widening works, site and tree clearance, temporary worksite establishment, monitoring instruments installation.
- Ground improvement work: expected at the worksite with launch/retrieval shaft to ensure water tightness between the interface of the soil and the face of launch/retrieval shafts.

- Construction of shafts – includes rock breaking and excavation: a launch shaft is proposed for the worksite near Eng Neo Avenue Forest (studied in a separate report).
- Tunnelling: Tunnel Boring Machine (TBM) will be launched from the CR14 worksite towards CR15 and pulled back to CR14. There will be no retrieval shaft at CR15. The schematic launch/ retrieval plan is shown in Figure 3-26.
- Permanent works: periodic maintenance works will be required once the MRT rail, stations and facility buildings are operational.

Design Optimisation for Construction Worksites

Throughout the Project, various design optimisations were conducted and discussed with AECOM to take into account considerations of reducing environmental impacts. It is worth mentioning that the CR14 worksite footprint has been reduced from 158,000 m^2 to 105,500 m^2, whereas the CR15 worksite footprint has been reduced from 106,000 m^2 to 82,000 m^2. This has minimised the area or source of environmental impacts indirectly. Apart from the base scenarios, all these design optimisation measures (see Figure 3-3) were assessed as mitigated scenarios in this report.

Summary of Impact Assessment

The construction and operational activities as described in Section 3.1.1 and Section 3.1.2, respectively, will impact the environment. These impacts were, therefore, assessed within the Study Area and considered the agreed scope of works. Cumulative impacts with other major concurrent development in the vicinity of the Project (see Section 3.4.1 and Figure 3-39) have also been taken into consideration in this study. The overall findings of the environmental impact assessment in this report are summarised as follows:

Biodiversity

Field surveys were conducted over a nine-month period (September 2021 – May 2022) to cover all known vegetation and habitat types and generate the floral and faunal baseline that is reflective of each of the Study Areas (i.e., Sites I to V).

Adjacent to Eng Neo Avenue Forest and CCNR, Sites I to III recorded a total of seven different habitat types, including four native-dominated secondary forest patches with have high ecological value. Alongside the native patches, the mixed forest habitat in Site I and II which comprises abandoned urban plantings with native epiphytes, and native saplings and treelets, has high ecological value as well. Three naturalised waterbodies were also found running through Sites I and III. A total of 270 and 128 plant species were recorded in Sites I and II, and Site III, respectively. Of these, respectively, 54 and 17 species are of conservation significance, which are widespread and occur in high numbers. The floristic assemblage is largely native. Many species found in the native-dominated secondary forest can also be found in the CCNR and are less commonly encountered in other secondary forests in Singapore. Some species associated with older forests and considered rare even in Nee Soon Swamp Forest, were also recorded in the Study Area. Fauna surveys at Sites I to III captured a total of 197 species, 15 of which are of conservation significance. Most notably, the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) was observed utilising the entire area of Sites I and II. Other species of conservation significance include the globally Critically Endangered straw-headed bulbul (*Pycnonotus zeylanicus*) and nationally Vulnerable common birdwing (*Troides helena cerberus*).

Contiguous with Clementi Forest and in proximity with CCNR, Sites IV and V recorded a total of seven habitat types, including two high-valued native-dominated secondary patches. Other key habitat findings include the freshwater marsh and, scrubland and herbaceous vegetation, which are also of high ecological value. The marsh is a unique habitat that is increasingly rare in Singapore, formed naturally over the course of at least 40 years, which acts as an important carbon sink. In particular, it supports a high richness of marsh-specific odonates, including species of conservation significance like the restless demon (*Indothemis limbata*). The extensive scrubland is a refugia for pitcher plants outside of nature reserves, as it contains clusters of all *Nepenthes* species found in Singapore, including the nationally Vulnerable pitcher plant species – *Nepenthes ampullaria* and *Nepenthes rafflesiana*, and hybrid species (*Nepenthes × trichocarpa*). A total of 229 plant species were observed, 17 of which are of conservation significance and pre-dominantly occur in the native patches and scrubland. For fauna, a total of 160 species were recorded, including 11 species of conservation significance such as the Sunda pangolin, ruddy kingfisher (*Halcyon coromanda*) and red-wattled lapwing (*Vanellus indicus*).

At Sites I to II, the proposed works will involve some vegetation loss, including native-dominated secondary forest patches, and impairment of ecological connection to the adjacent forest patches during construction. The works will also affect one freshwater stream. At Sites IV and V, substantial vegetation loss will occur with the proposed works, including the native patches and freshwater marsh. The other waterbody in the site will also be completed lost.

The generated baseline results were used to determined areas of high conservation value where development should be avoided. Impact assessment was also conducted to evaluate the impact of construction and operational works. Through the efforts of both the designers, engineers and clients, footprints of construction were adjusted away from areas of high conservation value within each Study Area as much as possible and where viable. This has resulted in a significant reduction in impact at Sites I to III, downgrading impact significance for habitat loss from mostly Major to mostly **Moderate**. However, due to land constraints and future land use plans, there was minimal changes to the footprint of construction at Sites IV and V, and impact significance for habitat loss remains mostly **Major**.

Recommendations of mitigating measures and EMMP have also been proposed to reduce the impacts of the proposed development to achieve the best conservation outcome. As the worksites lie adjacent to the sensitive forested Sites and have the potential to disrupt fauna movement, a robust plan has been detailed to specifically attempt to reduce the expected impacts at the Study Areas. Other specific measures include the transplanting of affected pitcher plants and construction of a new freshwater marsh at Sites IV and V, which require a collaborative effort by the various technical agencies.

Subsequently, cumulative impacts from concurrent developments in the vicinity were qualitatively assessed to ensure that the impacts from these developments are considered. All impact significance assessed for cumulative impacts were **Negligible/Minor**.

Hydrology and Surface Water Quality

The hydrological baseline survey was aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on available topographic data, from concurrent study carried out by AECOM in the vicinity, site surveys as well as PUB water catchment map, water catchment areas within the vicinity of the Biodiversity Study Area at Turf City (i.e. Site I, II and III) mainly contribute to the three (3) watercourses, and water catchment areas within the vicinity of Biodiversity Study Areas at Holland Plain (i.e. Site IV and V) and its vicinity contribute to three (3) watercourses and numerous waterbodies. Water from the identified drains/streams in Turf City will eventually flow into Marina Reservoir, while water from the identified drains/streams/waterbodies in Holland Plain will eventually flow into Pandan Reservoir. Both reservoirs store water to be treated for drinking water purposes.

To study water quality within the identified drains/streams, two (2) dry and/or one (1) wet weather samples were taken from each of the eight (8) water quality stations at the watercourses from Turf City and Holland Plain. Most water samples were tested for both physical and chemical parameters relevant for sustenance of aquatic life including Temperature, pH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Turbidity, Total Suspended Solids (TSS), Biochemical Oxygen Demands (BOD_5), Chemical Oxygen Demand (COD), Total Phosphorous (TP), Orthophosphates (PO_4-P), Total Nitrogen (TN), and Nitrates (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. Results were compared with both NEA discharge guidelines in Singapore and identified international criteria for aquatic life. The international criteria include guidelines/ criteria from United Nations Economic Commission for Europe, World Health Organization, United States Environmental Protection Agency, Australian & New Zealand, Canada, Philippines and Malaysia. The ephemeral concrete drain (D/S15) in Site I was found to have high TSS, as the runoff likely contained solids flushed from surrounding soil, vegetation and urban areas. The perennial naturalised stream (D/S16) had relatively good water quality during dry weather, but its water quality deteriorates during wet weather conditions. Despite the variation in water quality, the stream was found to support aquatic life and has a high ecological value (Section 7.4.1). The perennial man-made earth drain (D/S8) in Site III had water quality suitable to support aquatic life, but was considered to be of low ecological value due to human disturbance (Section 7.4.1). Ephemeral earth drain (D/S3) in Site IV was found to have relatively low pH, which was attributed to the flushing of humic acid from its earth banks. Two (2) ephemeral concrete drains (D/S4, D/S5) in Site IV and V were found to have relatively good water quality. The freshwater marsh had relatively poor water quality, as compared to the aquatic life criteria, which indicates that the marsh has unfavourable conditions for aquatic life during dry weather. However, the marsh was found to support an ecosystem of conservation significant biodiversity, which include marsh-specific odonates and birds (Section 7.4.2).

At Turf City (i.e. Site I, II and III), the mitigated scenario construction worksite and planned road works would cause Moderate hydrological impacts on earth drain D/S8 and Major hydrological and water quality impacts on naturalised stream D/S16. As such, mitigation measures were proposed, such as flow diversion or culvert construction (subject to Contractor’s design at a later stage) to connect the upstream and downstream of earth drain D/S8 and the discharge of treated runoff into drain D/S8 to maintain its existing flow (i.e., runoff is treated to meet NEA Trade Effluent Discharge Limits). For stream D/S16, the installation of box culvert to ensure continuous perennial flow the stream and flow diversion (i.e., follows PUB Code of Practice on Surface Water Drainage) prior to culvert integration are recommended. Therefore, this reduced the hydrology and water quality impact significance to **Minor** and **Moderate**, respectively.

During operational phase, the mitigated station entrance, vent shafts and future roads under for CR14 station was found to have Moderate hydrological impacts on earth drain D/S8 and Major hydrological impacts on naturalised stream D/S16. Given that the abovementioned mitigation measures are in place during operational phase, the impacts to the watercourses during operational phase is reduced to **Minor**.

For the rest of the watercourses, they were assessed to cause only Negligible to Minor impacts during both construction and operational phases. Thus, apart from the minimum controls identified for the Minor impacts, no additional management or mitigation measures are required.

Assessing the cumulative impacts from concurrent developments identified in the vicinity of the Project in Turf City, it was concluded that the concurrent project of the launch shaft worksite would not significantly increase the impact extent on hydrology and water quality of watercourses at Sites I during construction phase. In Holland Plain, with the assumption that there would be adequate drainage capacity designed for the worksites and that the best management practices and minimum controls will be provided by its developer, the concurrent road network construction works would have minor impacts on the hydrology and water quality on the nearby concrete drain D/S4. The three (3) concurrent projects of construction of CR16 station, Old Jurong Line Nature Trial and Clementi Nature Trail in Clementi Forest are situated far away from Site IV and Site V, and therefore are unlikely to contribute cumulative impacts.

Soil and Groundwater

The potential impacts on soil and groundwater of historical and current/ potential land uses as well as activities associated with the construction and operational phases of the Project was discussed with reference to LTA’s HLUS reports [R-4, R-5], previously carried out soil and/ or groundwater studies [R-71, R-74, R-75, R-76, R-77, R-78, R-79, R-80, R-81] 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 expected for direct sensitive uses (e.g. agricultural/ irrigation/ drinking water purposes) and not directly extracted for industrial uses, therefore not posing unacceptable risks. Waterbodies that support habitats and/ or species of high conservation significance and 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 and 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 the alignment and station 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. Those 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 assumed to be implemented. 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 improper management and disposal of excavated soil and 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 CRL2 Project. With regards to groundwater baseflow reduction, only impact on freshwater marshes was assessed to be Moderate, while the impact on other identified waterbodies was assessed to be Minor. Upon implementation of proposed mitigation measure (i.e. creation of new freshwater marsh habitat in the vicinity) it is expected that the impact will remain Moderate, due to its proximity to construction footprint.

Cumulative impacts from concurrent developments identified in the vicinity of the Project during both construction and operational phases were assessed. It was concluded that the concurrent development of A1-W2 (i.e. launch shaft and temporary access road during construction phase and facility building during operational phase) might increase the impact during construction phase only. Therefore, appropriate mitigation measures should be proposed to minimise adverse impacts by the project developer to avoid accidental spillage of chemicals impacting the quality of soil and groundwater 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. Due to the distance of CR16 worksite from Site IV and V, it is not expected that its construction and operational activities would have any additional impacts on soil and groundwater. Land use change due to road network to support Holland Plain developments could potentially decrease the seepage of water into the soil. However, given the relatively small area compared to the overall catchment area it is not expected that this development will increase soil and groundwater impact. Jurong Line Nature Trail and Clementi Forest Stream Nature trail are expected to include mostly minor construction activities and are unlikely to increase soil and groundwater impacts..

Air Quality

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 operational phase, fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the Project is expected. Dust generated can have adverse effects upon vegetation by restricting photosynthesis, respiration and transpiration. Furthermore, gaseous pollutants can lead to phytotoxic by penetrating into the plants. The overall effect can be a decline in plant productivity.

In order to assess the current baseline air quality in the Study Area, baseline air quality data was collected at three (3) representative monitoring locations between 25 February – 3 March 2020 and 6 – 13 July 2022, and secondary data sourced from concurrent study carried out by AECOM in the vicinity for another two (2) locations. All pollutant concentrations (PM_{10} and $PM_{2.5}$) were found to be within the Singapore Ambient Air Quality Long Term Targets.

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 ecologically sensitive receptors in the vicinity of the worksites. Upon evaluation of impacts during construction phase, the results of the assessment show that unmitigated impacts were assessed as Moderate to Major across all construction worksites analysed (see Section 10.7.1 for assessment details). This is mainly 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, therefore, recommends 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, Section 13.9.1 and Section 13.13.

When these 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. In addition, the worksite option with smaller footprint (i.e., Mitigated Scenario) is preferred. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

For air quality impact assessment during the operational phase, it is assumed that all new vehicles meet their respective Euro emission standard. The proposed buffers of some green areas will not be disturbed as part of the Project, and as such it will also help to provide cleaner air, helping to mitigate the air pollution impact emanating from vehicles. At a much higher level, trains are meant to replace substantial vehicles from roads, therefore in that scheme, the Project may have a positive effect on road traffic. However, immediate localised road traffic to and from the facility buildings may see minor 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 development 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. Nevertheless, with all these concurrent construction activities, the cumulative Impact Significance is not expected to significantly increase from the Project.

Airborne Noise

A noise impact assessment was carried for the construction phase of the proposed worksites for CR2005. The construction noise study area was defined as a combination of Site I, Site II, Site III, and 150 m from CR14 worksites, and a combination of Site IV, Site V, and 150m from CR15 construction worksite whichever is greater. The noise impact assessment for the operational phase of the proposed worksites for CR2005 included defining noise boundary criteria for ACMV noise at the facility buildings and qualitatively assessing traffic noise to the noise sensitive receptors. 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 shall form a mandatory requirement when the worksite is designed during detailed design stage. Baseline noise monitoring was carried out at nine (9) locations. Uncorrected baseline noise was used as a more stringent criteria for the assessment on ecological receptors in this Study. Nonetheless, the baseline airborne noise monitoring was supplemented with secondary baseline data obtained from the concurrent study carried out by AECOM in the vicinity, to obtain the baseline noise levels within the Study Area.

The baseline study recorded average $L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$ and $L_{Aeq(5\ min)}$ baseline noise levels and compared against the construction criteria provided by NEA guidelines. The baseline noise levels were used to develop project-specific criteria.

For the assessment on construction phase, the noise levels generated from the equipment used during construction detailed in Section 11.3.1 were predicted using SoundPLAN ver 8.2. Topography plays an important role in noise propagation and as such were considered as part of this assessment. A quantitative assessment at the noise sensitive receptors (within the Study area) was carried out and compared with the stipulated *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.* Uncorrected baseline noise was used as a more stringent criteria for assessment of ecological receptors in this Study. 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 to the extent that topography is available. Based on the impact evaluation, mitigation to reduce airborne noise impacts were 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 scenarios in CR14 worksite and two (2) different construction scenarios in CR15 worksite. The three (3) different construction scenarios in CR14 worksite are: Scenario 1: Cut and cover works and associated activities; Scenario 2: Tunnel Boring Machine (TBM) works; and Scenario 3: Construction of station entrances. The two (2) different construction scenarios in CR15 worksite are: Scenario 1: Cut and cover works and associated activities; and Scenario 2: Construction of station entrances. It must be noted at this stage that worst-case assumptions on equipment usage, period of usage, and more conservative approach for barrier heights were proposed to predict the worst impacts to these locations 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 sensitivity of habitats and the species they support to airborne noise. Urban habitats and features, such as hardstanding areas, identified nearby the Biodiversity Study Area and Proposed Development, which are not considered suitable to support fauna, were assessed as '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.

Site I, Site II and Site III

The modelling undertaken as part of the impact assessments for CR14 construction worksite base scenario 1 to base scenario 3, indicated that an impact significance of **Major** is likely to occur, with a maximum exceedance of 20 dB(A) in Site I, 23 dB(A) in Site II and 18 dB(A) at Site III respectively. 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 CR14 worksite 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 was recommended that noise barriers with a height of 5m and 8m, respectively, are implemented as mitigation measures at the CR14 worksite (as shown in Figure 11-12).

Based on the residual airborne noise impact assessment above, the proposed 5m and 8m noise barriers at the CR14 worksite will be beneficial by reducing the area of major impact significance significantly from 3.9 hectares (Base Scenario) to 1 hectare (Post Mitigated scenario) at Site I, from 2.6 hectares (Base Scenario) to 1.8 hectares (Post Mitigated scenario) at Site II and from 0.2 hectares (Base Scenario) to less than 0.1 hectares (Post Mitigated scenario) at Site III respectively. However, the residual impact significance is still **Major**, as there are minor areas left with these impacts, largely immediately outside 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 CR14 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 CR14 worksite (Mitigated Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Site I and Site III will potentially experience low impact intensity with very low impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain, the resulting impact significance is **Minor**. The Priority 1 ecologically sensitive receptors at Site II 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, the resulting impact significance is Major. Since the impact significance is **Major** in Site II, the additional mitigation measures stated in Section 12.9.1.2 from vibration section and EMMP requirement in Section 13.11 should be applied to reduce the residual impact and the resulting impact significance is Minor-Moderate after applying the mitigation measure; note that Minor-Moderate is based upon rock breaking and air over pressure only. The impact significance changes to **Minor-Major** when the residual impact is considered.

Site IV and Site V

The modelling undertaken as part of the impact assessments for CR15 construction worksite base scenario 1 to base scenario 2, indicated that an impact significance of **Major** is likely to occur, with a maximum exceedance of 20 dB(A) in Site V and impact significance of **Minor** to **Major** with a maximum exceedance of 5 dB(A) in Site IV respectively. 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 CR15 worksite 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 8m, be installed, as a mitigation measure at the CR15 worksite (as shown in Figure 11-12).

Based on the residual airborne noise impact assessment above, the proposed 8m noise barriers at the CR15 worksite will be beneficial by reducing the impact significance and area of major impact significance from Major (Base Scenario) to **Minor** (Post Mitigated scenario) at Site IV, and the area of major impact significance significantly from 4.6 hectares (Base Scenario) to 0.4 hectares (Post Mitigated scenario) at Site V.

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.

Cumulative impacts from other relevant major concurrent development in the vicinity of the Project were assessed qualitatively based on the worst-case construction activities where the timelines of CR14 worksite and CR15 worksite coincide with other major concurrent development such as A1-W2 worksite, CR16 worksite. Based on the residual airborne construction noise prediction, there is a potential for Major impact significance area will be increased significantly especially at Site I from 1 hectare (CR14 alone) to 2.5 hectares (CR14 and A1-W2), and at Site II from 1.8 hectares (CR14 alone) to 3.2 hectares (CR14 and A1-W2) on the impacted ecological sensitive receptors after implementing mitigation measures. Therefore, the noise contribution from this concurrent activity to CR14 of this project is considered major (refer to Table 11-24 and Figure 11-27). Based on the residual airborne construction noise prediction, there is a potential for Major impact significance area will be increased significantly especially at Site V from 0.4 hectares (CR15 alone) to 4.2 hectares (CR15 and CR16) on the impacted ecological sensitive receptors after implementing mitigation measures. Therefore, the noise contribution from this concurrent activity to CR15 of this project is considered major (refer to Table 11-25 and Figure 11-28).

No cumulative impacts were considered significant during operational phase at A1-W2 site, CR14 worksite, CR15 worksite, CR16 worksite. Currently there are no other developments planned near CR14 worksite and CR15 worksite, however, if similar developments are planned around it in distant future, the cumulative impact may need to be assessed at that stage as well.

Ground-borne Vibration

The study assesses the impact of construction ground-borne vibration on the impacted areas within the biodiversity areas such as Sites I to V.

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. Therefore, the step threshold endured by humans was used to inform the study criterion used for this study.

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 were classified into Priority 1, 2 and 3 ecologically sensitive receptors based on their ecological values and sensitivity towards vibration. The indicator species are mouse deer and pangolin. The predicted vibration levels from the construction and operational phases of the Project are then evaluated against the impact assessment matrix for impact intensity, impact consequence, likelihood and impact significance on the ecological behaviours of the ecologically sensitive receptors.

The construction works assessed for vibration impact were bulldozing, low and high amplitude vibratory compactors, rock breaking and excavation and tunnel boring for the CRL alignment. The worksites are CR14 for a station and CR15 for a station with a retrieval shaft. Based on the assessment results, mitigation measures were recommended and included major design modifications/ process modifications such as optimisation of CR14 and CR15 worksites.

For the base scenario, the bulldozer is predicted to cause minor – moderate vibration impact significance at Sites I to III and minor vibration impact significance at Sites IV to V. Low and high amplitude vibratory compactor causes negligible – minor impact significance in the base scenario for Sites I to V. Tunnel boring vibration levels in the base scenario predicted using the Esvelt method cause minor impact significance at Site III and IV, while Sites I, II and V were not affected by tunnel boring in the base scenario.

Based on the study outcome of the base scenario, the overall impact significance on ecological behaviour is **Minor** and **Moderate**. Thus, mitigation measures are recommended.

High vibratory compactors generate vibration levels exceeding PPV, 5.0 mm/s, the Contractor should use best available techniques (BAT) and control construction vibration levels to PPV, 8.0 mm/s at vibration sensitive biodiversity area/forested areas. Schedule high vibration activities during the daytime; no night works should be conducted after 7 pm for all non-safety critical activities since the site is next to the human and fauna sensitive receptors. Use tri-axle trucks to reduce truck trips on the road thus generating less vibration.

For the mitigated scenario, the bulldozer causes minor – moderate vibration impact significance at Sites I to III and **minor** vibration impact significance at Sites IV to V. Avoiding construction work at night could reduce the vibration impacts impact significance from moderate to minor at Sites I to III. Low and high amplitude vibratory compactor for mitigated scenario is predicted to cause negligible – minor impact significance in the mitigated scenario for Sites I, II IV and V, and negligible impact significance at Site III. Tunnel boring vibration levels do not affect Site I, II and V in the mitigated scenario.

For the mitigated scenario, the rock breaking and excavation is predicted to cause **negligible – minor** at Site I. and **minor – major** vibration impact significance at Sites II and III. Hence, temporary barriers (i.e. water barriers of 1 m height) should be implemented. Hoardings must be ensured at all worksites to mitigate roadkills due to the impacted fauna trying to dash onto the road during construction activity. No night works should be conducted after 7 pm. This could reduce vibration impact significance from **major** to **moderate.**

Based on the study outcome of the mitigated scenario, the residual impacts are predicted to be **negligible – moderate** for Site I and **negligible – major** for Sites II and III in Turf City, and **negligible – minor** for Sites IV and V in Holland Plain. Thus future mitigation measures and EMMP are recommended.

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 overall residual impact significance on ecological behaviour with mitigation measures is **minor** in Turf City and Holland Plain.

Cumulative impacts were assessed based on the worst-case construction activities where the timelines of A1-W2, CR16, Turf City, and Holland Plain coincide. Typical construction works at Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail are unlikely to cause higher vibration levels than this Project.

Since there are overlaps in timelines, the concurrent activities were assessed for CR14 with A1-W2 and CR15 with CR16. For the former, three pairs of activities coincide. high vibratory compactors at CR14 coincide with rock breaking and excavation at A1-W2, causing minor – moderate impact significances at Sites I to III and Eng Neo Avenue Forest. Bulldozer at CR14 coincides with rock breaking and excavation at A1-W2, causing minor – moderate impact significances at Sites I to III and Eng Neo Avenue Forest. Lastly, rock breaking and excavation at CR14 and A1-W2 coincide, causing minor – major impact significances at Sites I, II and Eng Neo Avenue Forest, while Site III has a minor – moderate impact significance.

At CR15 and CR16, three pairs of activities coincide as well. Bulldozing at CR15 coincides with pipe jacking at CR16, causing **minor** impact significances at Sites IV and V, while Clementi Forest has a minor – major impact significance. Tunnel boring at CR15 coincides with rock breaking and excavation at CR16, causing minor impact significances at Sites IV and V, while Clementi Forest has a minor – major impact significance. Lastly, high amplitude vibratory compactors occur at the same time for both worksites, causing minor impact significances at Sites IV and V and negligible – minor impact significance at Clementi Forest.

During the operational phase of CR2005, the ground-borne vibration levels caused by the movement of the trains would have been mitigated by the track works. The levels will be insignificant in the cumulative impact of other concurrent developments.

This Project suggested implementing temporary barriers (i.e., water barriers of 1 m height) for activities that causes major impact significances such as rock breaking and excavation. In addition, the ecologist will monitor the environment for any faunal behaviours (e.g., charging) that could result in roadkill, burrow damage/collapse resulting in mortality and their presence and absence in and around the worksite. Suppose the mortality of fauna is under threat, the work is immediately halted, and mitigation measures are adapted to avoid such events in the future.

Conclusions and Recommendations

In conclusion, the summary of unmitigated impact significance and potential residual impact significance of the assessed environmental aspects for both construction and operational phases are presented in the following tables. The recommended Environmental Monitoring and Management Program (EMMP) measures are summarised in Section 13.

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

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Site I	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Major	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Moderate (see Note 2)
Site II	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Major	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major (see Note 3)
Site III	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Minor to Moderate	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Moderate to Major (see Note 1 and 5)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major (see Note 3)
Site IV	Biodiversity	Minor to Major	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Minor	Negligible to Minor
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor
	Ground-borne Vibration	Negligible – Minor (see Note 4)	Negligible – Minor (see Note 4)
Site V	Biodiversity	Minor to Major	Minor to Major
	Hydrology and Surface Water Quality	Minor	Minor
	Soil and Groundwater	Minor to Moderate	Minor to Moderate (see note 7)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Minor- Major (see Note 1)
	Ground-borne Vibration	Negligible – Minor (see Note 4)	Negligible – Minor (see Note 4)

Note:

1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevation difference which cannot be blocked by the proposed noise barrier/ multiple barriers, further mitigation of noise levels are challenged. The area of "Major" impact significance during the residual impact significance with mitigation measures are expected to be reduced significantly than base scenario.
2. Construction activities such as bulldozing produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
3. Construction activities such as rock breaking and excavation is only required in the mitigated scenario, which produces high PPV levels and impact significance at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
4. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.
5. The area of moderate impact significance is less than 0.1 hectares and this is due to close proximity of Site III with station entrance worksite during Post-Mitigated Scenario than Base Scenario.
6. Water Quality impacts at Site I and Site III was assessed to be Moderate impact significance, as the proposed road under study will cross existing major stream in Site I and the proposed CR14 worksite likewise for earth drain in Site III, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the watercourses are in the immediate vicinity of the construction site.

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
7. Construction of entrance of CR15 will occupied the freshwater marsh, and its impact on groundwater drawdown in the vicinity cannot be avoided.			

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

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Site I	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology and Surface Water Quality	Negligible to Major	Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)
Site II	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology and Surface Water Quality	Negligible to Major	Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)
Site III	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology and Surface Water Quality	Minor to Moderate	Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)
Site IV	Biodiversity	Mostly Moderate/Minor	Mostly Minor
	Hydrology and Surface Water Quality	Negligible to Minor	Negligible to Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)
Site V	Biodiversity	Mostly Moderate/Minor	Mostly Minor
	Hydrology and Surface Water Quality	Minor	Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Note: 1. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are eliminated.			

This EIS 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, site elements (e.g., workers dormitory, detention tank and site office. Shall there be any changes to the design of the Project elements in this report during detailed design stage or actual construction phase, the Contractor shall 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 – 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 (hereinafter 'the Project') on the Biodiversity Study Areas abutting the Phase 2 alignment.

The LTA intends to construct eighth and Singapore's 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* (hereinafter referred to as "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 the 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 already covered the CCNR stretch, the scope of work for this CR2005 Contract only includes the changes and development made in Windsor area and the alignment portions outside the CCNR.

The objective of **this report** is to conduct an environmental impact study about the potential environmental impacts arising from the construction and operation of the stretch of CRL2 rail alignment from Turf City to Holland Plain and its associated worksites (i.e., CR14, CR15) as well as the forested areas nearby. The forested areas nearby these worksites are Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor) and Site V (forested area at Holland Plain). The planning for the entire CRL2 alignment is still ongoing and a separate report will be provided to evaluate the remaining construction worksites i.e., EIS Windsor and Eng Neo Forest, and EIS Clementi Forest and Maju Forest. The original construction worksites of CR14 and CR15 are presented in Figure 3-1 and Figure 3-2, while the indicative operational footprint of CR14 and CR15 stations are demonstrated from Figure 3-4 to Figure 3-5. It is worth noting here that the design optimisation for construction worksites to reduce environmental impacts had been undertaken during the EIS process as described in Section 3.1.1.1, in which the mitigated construction worksites with comparison to the original construction worksites are presented in Figure 3-3.

Eng Neo Avenue Forest is a forested area located in close proximity to Site I and II, while Clementi Forest is a forested area located adjacent to Site IV and V. This report does not focus on Eng Neo Avenue Forest and instead focuses on Sites I to V given that they are situated in closer proximity to CR14 and CR15 worksites. The baseline findings and findings from environmental studies from nearby areas, such as Eng Neo Avenue Forest, are drawn from the EIS undertaken for Windsor and Eng Neo Avenue Forest, and Clementi Forest and Maju Forest; these are referenced in this report, where appropriate to allow for a more holistic discussion.

Table 2-1 EIS (Turf City and Holland Plain) Construction Worksites along CRL2 Alignment

Construction Worksites in This Report	Location	Type/ Function (Construction Phase)		Type/ Function (Operational Phase)	
		Base Scenario (see Figure 3-1 and Figure 3-2)	Mitigated/ Optimised Scenario (see Figure 3-3)	Base Scenario (see Figure 3-4 and Figure 3-5)	Mitigated Scenario (see Figure 3-4 and Figure 3-5)
CR14 worksite	Turf City	Retrieval shaft and station worksite in Site I to III and encroaching Eng	Retrieval shaft and station worksite in Site II to III and outside	Underground station with above-ground facilities (e.g., vent shaft, station exits/ entrances)	

Construction Worksites in This Report	Location	Type/ Function (Construction Phase)		Type/ Function (Operational Phase)	
		Base Scenario (see Figure 3-1 and Figure 3-2)	Mitigated/ Optimised Scenario (see Figure 3-3)	Base Scenario (see Figure 3-4 and Figure 3-5)	Mitigated Scenario (see Figure 3-4 and Figure 3-5)
		Neo Avenue Forest	of Eng Neo Avenue Forest		
CR15 worksite	Holland Plain	Station worksite at Holland Plain			

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. 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 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 shall be discussed and then re-evaluated when the design incorporates/ develops/ changes at the later stage of Design stage as well as this Project.

In addition, LTA understands that AECOM has been involved in an ongoing environmental baseline study (EBS) whose study locations overlap with this Project. AECOM has sourced and referred to existing information and findings from **another concurrent study carried out by AECOM in the vicinity** (or hereinafter referred to as the “concurrent study” or “concurrent environmental baseline study”) where applicable, to provide a more holistic view about the environmental baseline conditions at the surrounding areas of 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), as well as MND/URA. Thereafter the scope of EIS was documented in the form of Inception Report Rev B [R-2] submitted to LTA on 13 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 the preliminary design scope of CR2001 Advance Engineering study Contract available at the time of writing. Understanding of the Project construction methods and operational activities has 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 shall be undertaken by LTA to address these changes.

2.2 Report Structure

The structure of the report is as follows:

- **Section 0** – 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** – Environmental legislations, policy frameworks, guidelines, plans, standards and criteria 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 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 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 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 from Turf City to Holland Plain (i.e., CR14 worksite, CR15 worksite) which are located at/nearby the Biodiversity Study Area (i.e., Site I to III and Site IV to V, respectively).

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

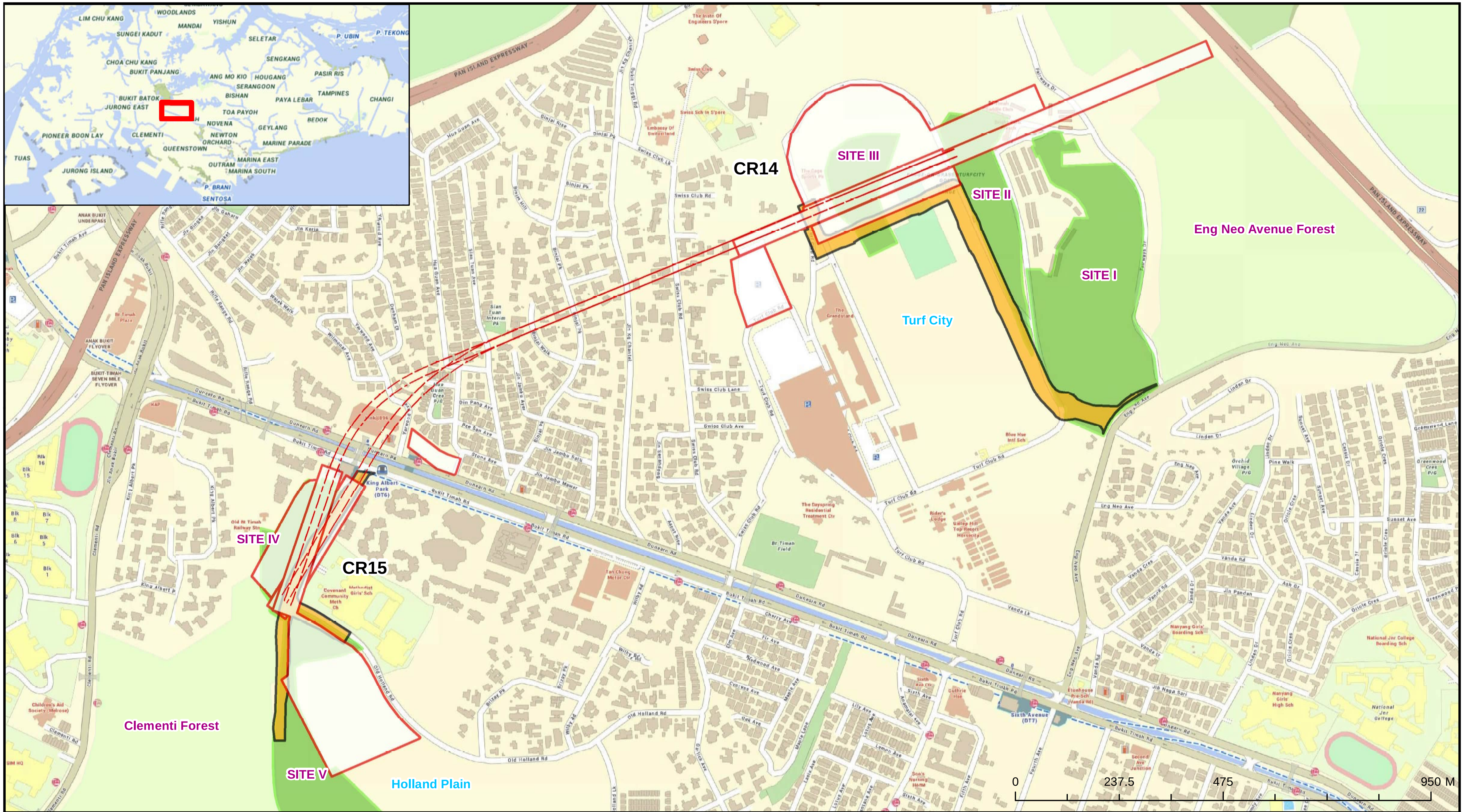
The Project scope includes consideration of both the construction and operational phases of the proposed CRL2 alignment, that will be take place in the associated worksites of Turf City (CR14) and Holland Plain (CR15). In order to objectively assess the Project at this stage, the locations of construction 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 peak of its construction phase, the Project footprint will include CR14 worksite at Turf City and CR15 worksite at Holland Plain. The location and footprints of all these construction worksites are as shown in Figure 3-1 and Figure 3-2. Furthermore, several forested areas are located in the vicinity of these worksites. These forests collectively comprise the Biodiversity Study Area as they were identified as having the potential to be impacted by the worksites. The forests are situated in the following sites: Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor) and Site V (forested area at Holland Plain). The project location and base scenario of the construction worksites (i.e. CR14, CR15) are demonstrated in Figure 3-1 and Figure 3-2, while the indicative operational footprint of CR14 and CR15 stations are demonstrated from Figure 3-4 and Figure 3-5.

Following the mitigated scenario, it is understood that during construction, the existing road north of CR14 will remain accessible and not be closed during construction, as with all other construction site arrangements. This road will not be used for construction access, which will instead be controlled via Eng Neo Avenue (Figure 3-3).

Overall, both underground and above-ground construction works are expected at CR14 and CR15 worksites. According to current planning, Tunnel Boring Machine (TBM) at a launch shaft worksite near Eng Neo Avenue Forest (studied in a separate report) will be launching southwest along the CRL2 alignment, passing through CR14 worksite, and towards the CR15 worksite where the TBM will be retrieved. The stretch of the CRL2 tunnel alignment outside of CCNR in overall would not exceed -60m below Singapore Height Datum (SHD).



Legend

- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Study Area

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-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

PROJECT LOCATION AND CONSTRUCTION WORKSITES (1/2)

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ML	JAG/NHT	JAG	3 - 1	-	1 of 1
	Drawn: ML	Date: JULY 2022	CAD File Name : NA		A3

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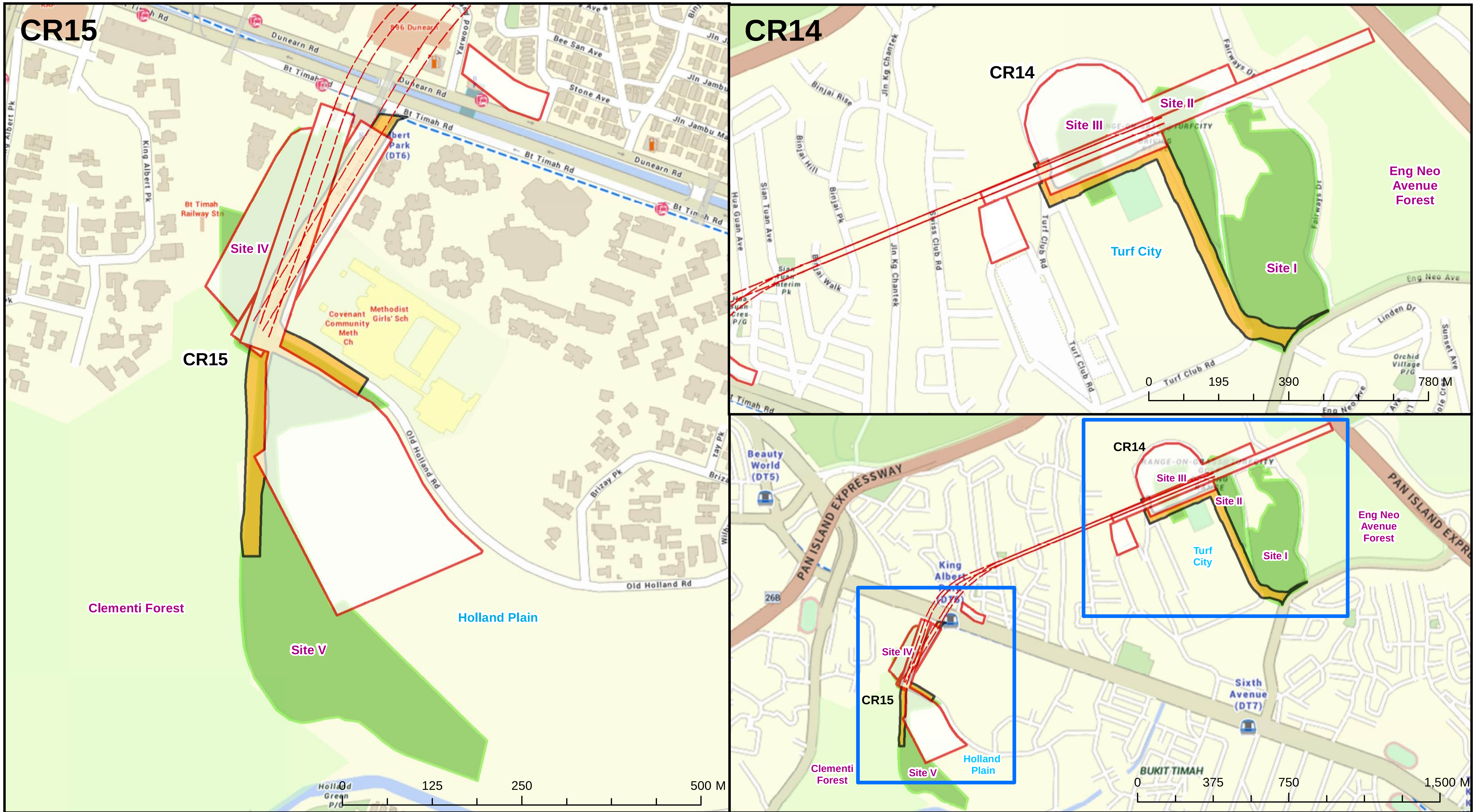

Legend

- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
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Figure Title :

PROJECT LOCATION AND CONSTRUCTION WORKSITES (2/2)

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3.1.1.1 Design Optimisation and Changes of Construction Worksites in Mitigated Scenario

In parallel to the EIS work, feedback was provided to the design engineers and vice versa during the concept and preliminary design phases of the design development. During these meetings with the design group and the agency, various design optimisations and considerations to reduce environmental impacts were discussed with the AECOM and the feedback was incorporated as design progressed. Apart from the base scenarios, all the design optimisation mentioned 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 3-3.

<u>Optimisation of CR14 Worksite</u>

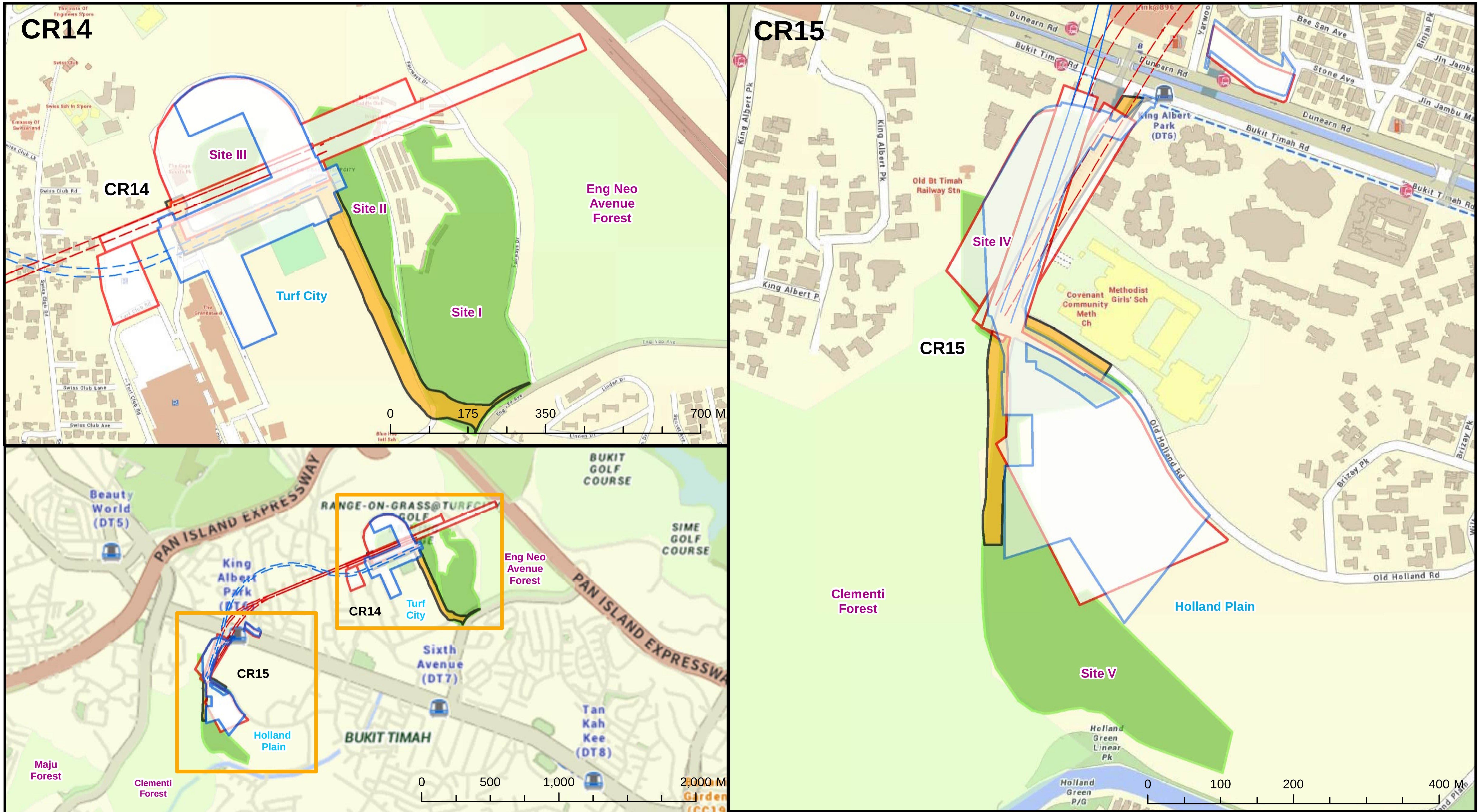
The original CR14 worksite (base scenario) has a large construction footprint of approximately 158,000 m^2, that connects with the original A1-W2 worksite (base scenario). In parallel with the separate EIS, to minimise the area of environmental impacts towards the nearby sensitive receptors, it was further optimised with construction footprint reducing from 158,000 m^2 to 105,500 m^2.

<u>Optimisation of CR15 Worksite</u>

The original CR15 worksite (base scenario) has a large construction footprint of approximately 106,000 m^2. In parallel with the separate EIS, to minimise the area of environmental impacts towards the nearby human and ecologically sensitive receptors, the construction footprint of CR15 worksite was further reduced from 106,000 m^2 to 82,000 m^2.

<u>Other Design Changes</u>

In addition, resulting from the changes due to design optimisation of construction worksites, there will be a slight difference between the base scenario CRL2 alignment and the mitigated scenario CRL2 alignment as shown in Figure 3-3.



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Study Area

N

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Figure Title :

DESIGN OPTIMISATION FOR CONSTRUCTION WORKSITES AS MITIGATED SCENARIOS

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ML	JAG/NHT	JAG	3 - 3	-	1 of 1
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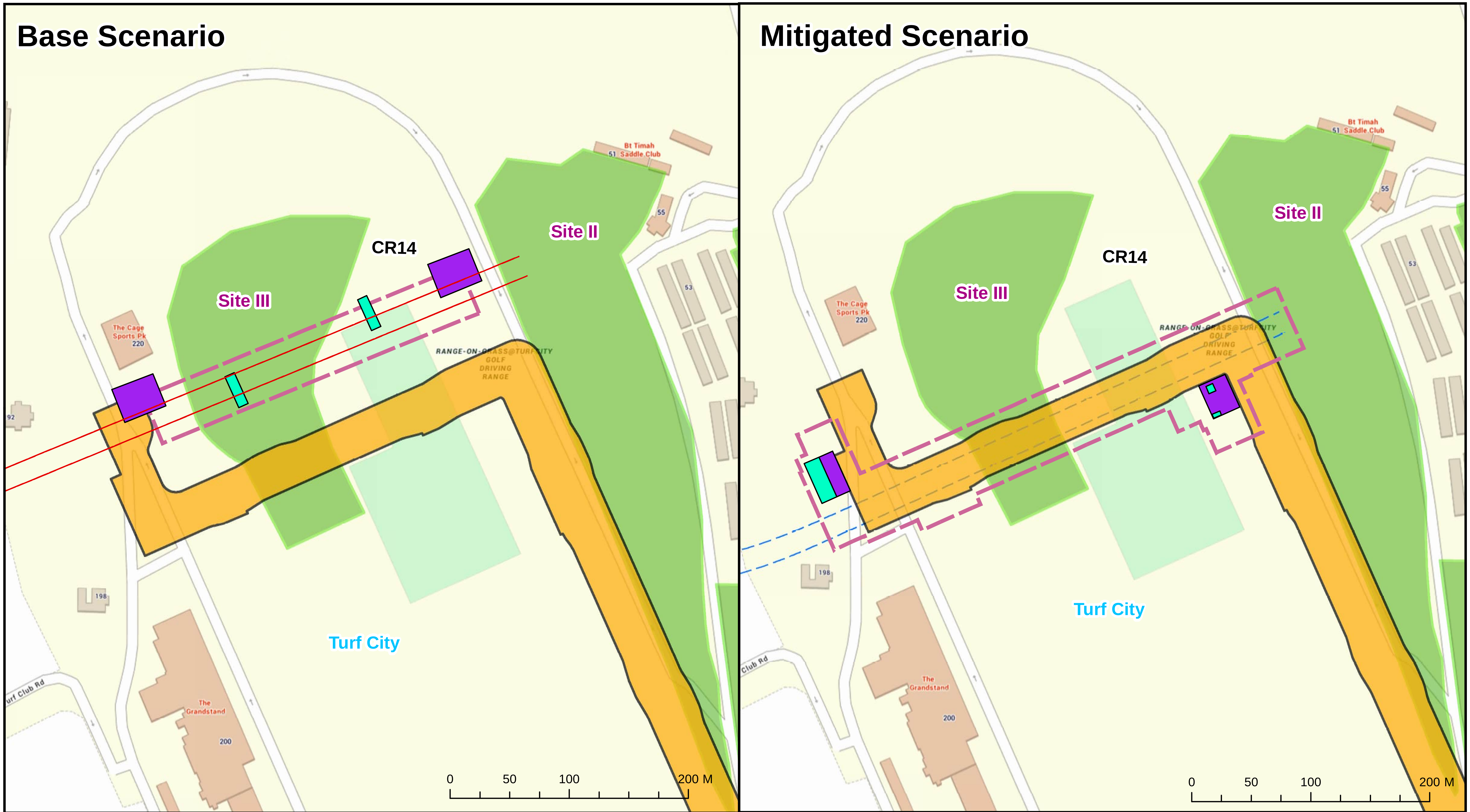
Note: Source of basemap - OneMap

3.1.2 Operational Phase

The CR14 and CR15 worksites will become MRT stations at the time of operation. The launch shaft associated with CR14 worksite, which will also act as the retrieval shaft, will be part of the station structure, acting like a ventilation shaft for underground ventilation. Besides, future roads under study are being considered as part of the construction phase and will potentially serve as the road access to the CR14 and CR15 stations during operational phase. Following the optimised design of construction worksites, there will also be slight difference in terms of the operational footprint of stations and facility buildings based on the boundary of construction worksites and CRL2 alignment in both base and mitigated scenarios. The indicative operational footprint of the CR14 and CR15 stations are demonstrated from Figure 3-4 and Figure 3-5.



Legend

Biodiversity Study Area

Above Ground Structure

Ventilation Shaft

Station Entrances/Exits

Underground Structure

Proposed CRL Alignment (Base)

Proposed CRL Alignment (Mitigated)

Planned Road Works

Station Box Outline

N

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :

INDICATIVE OPERATIONAL FOOTPRINT AT CR14

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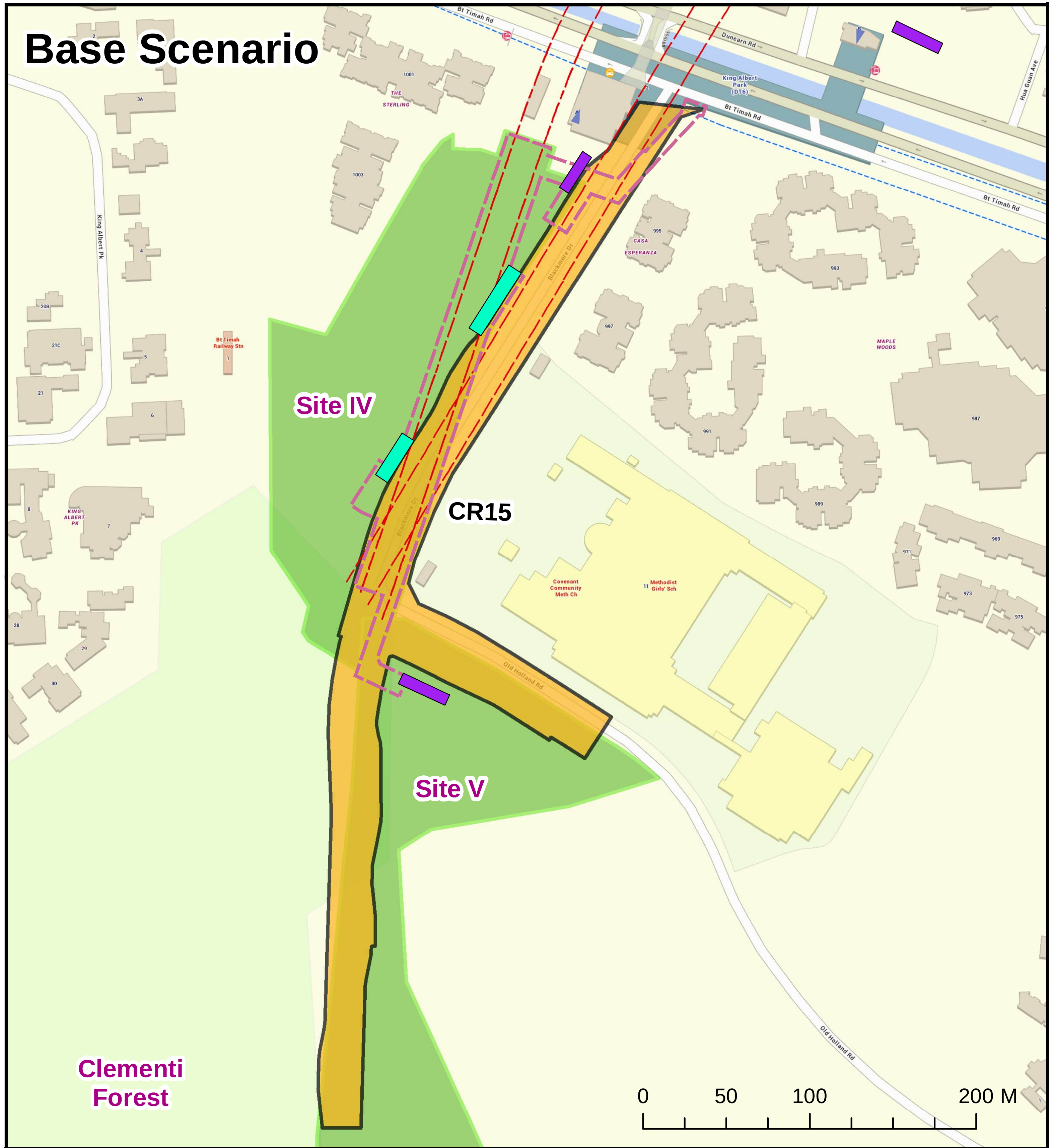

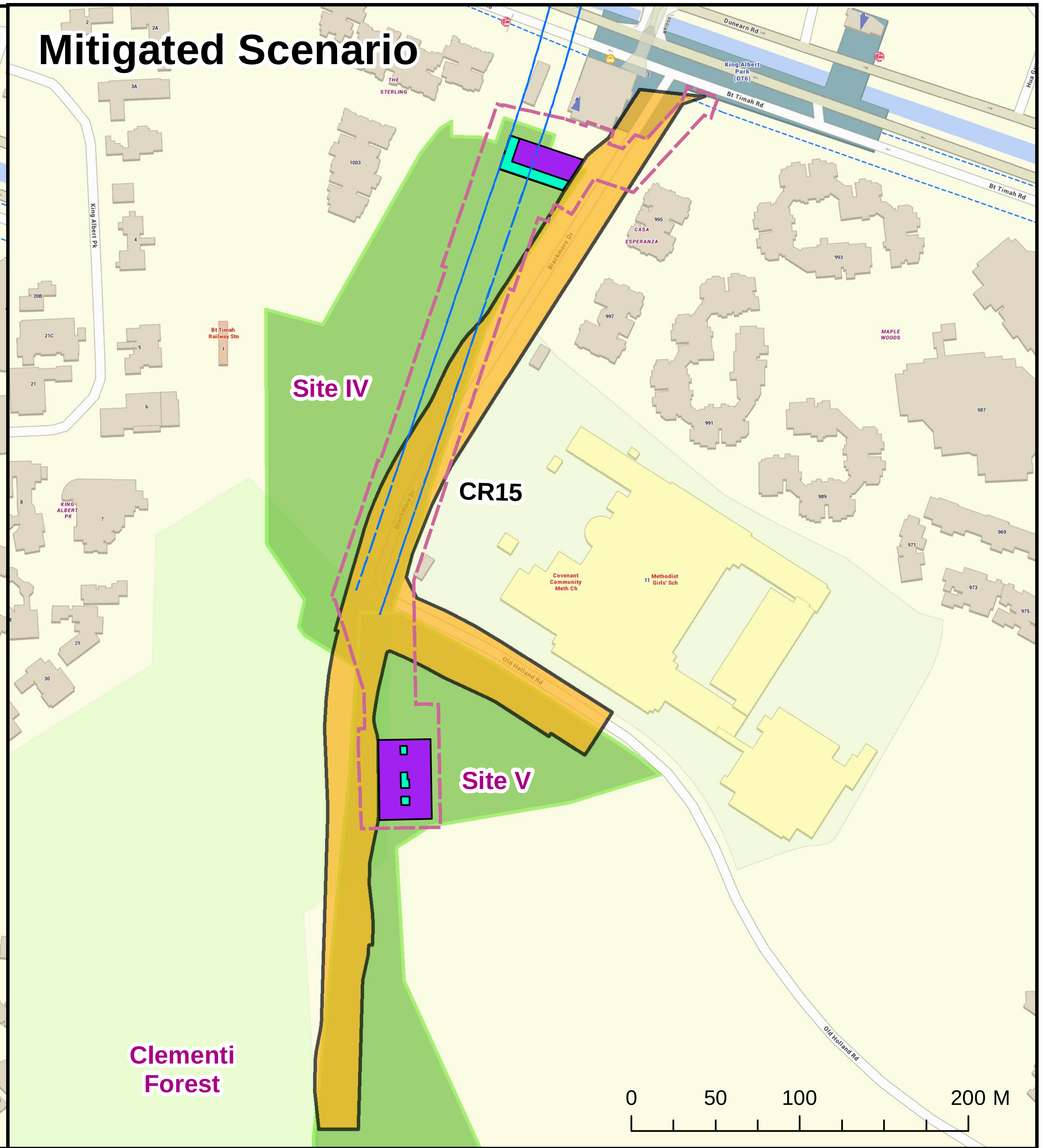

Legend

Biodiversity Study Area

Above Ground Structure

Ventilation Shaft

Station Entrances/Exits

Underground Structure

Proposed CRL Alignment (Base)

Proposed CRL Alignment (Mitigated)

Planned Road Works

Station Box Outline

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement : NA

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Project Title :

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :

INDICATIVE
OPERATIONAL FOOTPRINT
AT CR15

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ML	JAG	JAG	3 - 5	-	1 of 1
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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 canteens. The areas designated for the above ground components will also support the construction of the underground components of the Project. Construction phase includes the following activities:

3.2.1 Pre-Construction Activities

Pre-construction activities include site and vegetation clearance for site setting up, construction of site access, road and utilities diversion works and installation of instrumentation for the monitoring of tunnelling works. The pre-construction activities 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, access roads. For this, the construction contractor's Qualified Erosion Control Professional (QECP) will prepare Erosion Control Plan (ECP) and obtains 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, 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. 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 3-7 below).
- The Safety, Health and Environmental (SHE) Personnel engaged by the Contractor during the construction phase shall incorporate the above-mentioned requirements into the EMMP.

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

Figure 3-7 Example of Site Hoarding Erection [O-6]

In this process, the site is eventually levelled for construction to begin (See Figure 3-8 below). This may involve cutting and stabilising of slopes (See Figure 3-9 below). In this case geotechnical engineers will develop a temporary Earth Retaining Stabilisation Structures (ERSS) schemes to stabilise the exposed slopes in their engineering design (See Figure 3-10 below). ECO considers measures to prevent erosion of soil into the nearest drainage network. This may or may not accompany ground improvement works depending on the nature of the soil in the area.

Figure 3-8 Example of Site Levelling Works [O-6]

Figure 3-9 Example of Slope Cutting Works [O-6]

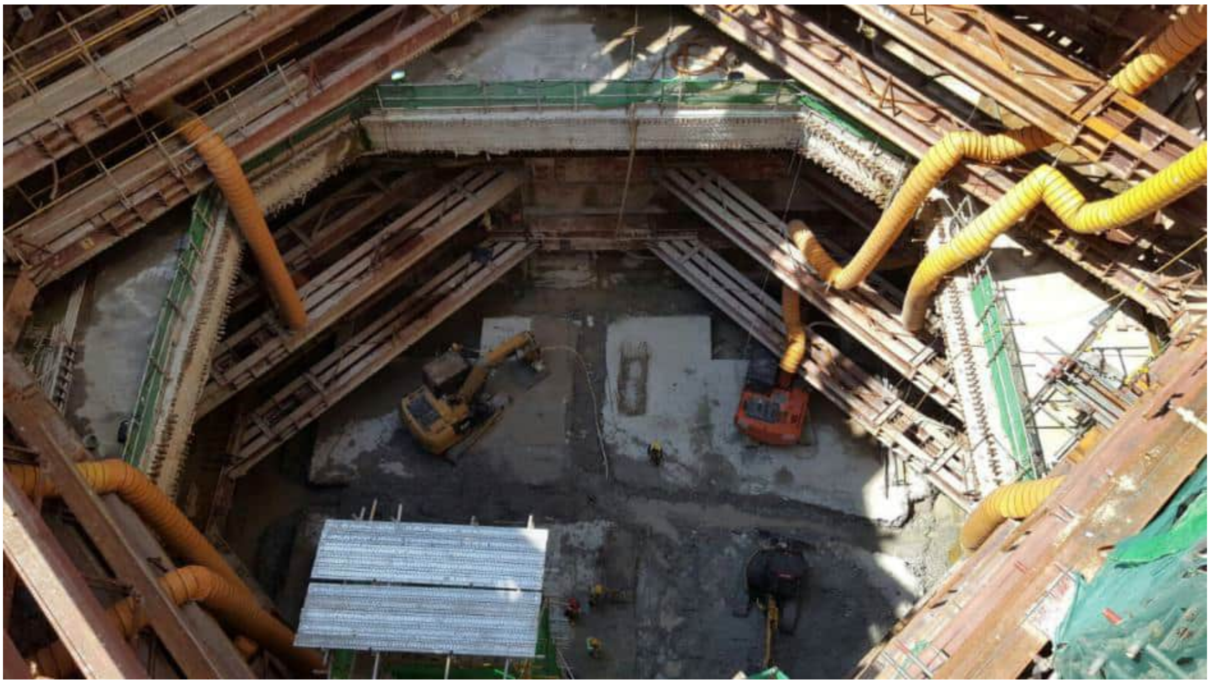


Figure 3-10 Example of ERSS Schemes Planned at Fort Canning Site to Stabilise Slopes/ Prevent Caving in Soil [O-7]

3.2.1.2 Traffic and Utilities Diversion Works

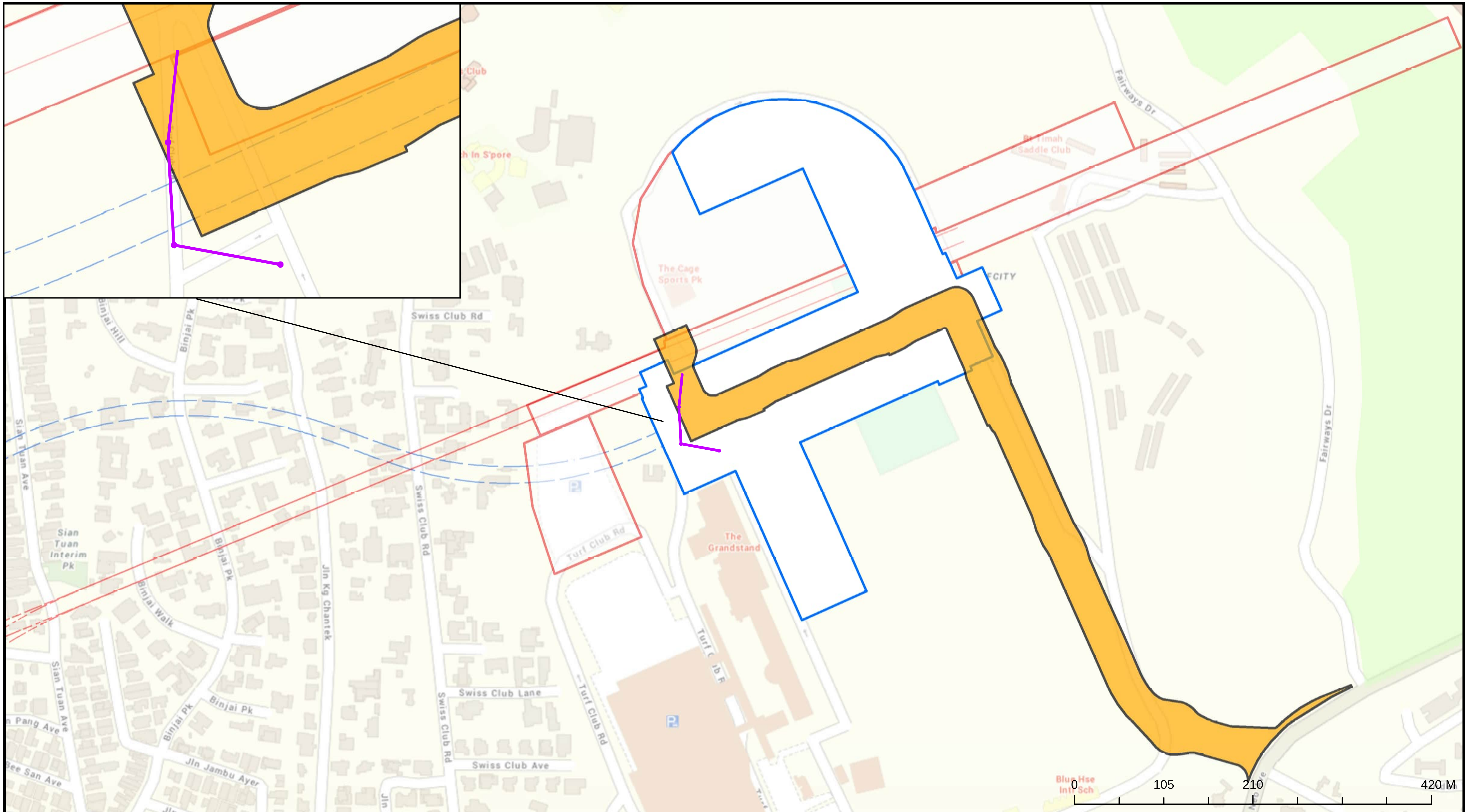
A key initial preparation activity will be traffic and utility diversion. Sections of selected roads, which will be affected by the construction, will be either temporarily diverted or access will be restricted to certain parts of the road. Works will include land clearing and tree feeling, road widening 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 shallow 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 receptors. 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.

For this Project, it is noted that a permanent diversion of existing sewer pipes of approximately 128m at Turf Club Road may be required for the construction of CR14 worksite as illustrated in Figure 3-12. Besides, there will also be underground temporary sewer diversion works from Blackmore Drive encroaching into the boundary of Casa Ezperanza (condominium) at the east of CR15 worksite, which may pose concern of potential airborne noise and air quality impacts on the residents. There will also be temporary water, power and gas diversion works along Blackmore Drive as well. Once the station is constructed, some of the temporary utility diversion lines will be reinstated as permanent utility lines, for example the permanent sewer lines near Casa Ezperanza as shown in Figure 3-13.

The above-mentioned utilities diversion works are illustrated in Figure 3-12 and Figure 3-13. The potential environmental impacts associated with utilities/ road diversion are qualitatively discussed in each respective chapter. If there are complaints received due to the utilities diversion works (outside of current worksites in this report), for example regarding noise and air nuisance, the Contractor shall 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 3-11 Example 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 Construction Worksite Footprint
- Planned Road Works
- Permanent Sewer Diversion

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-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

UTILITY DIVERSION AT CR14

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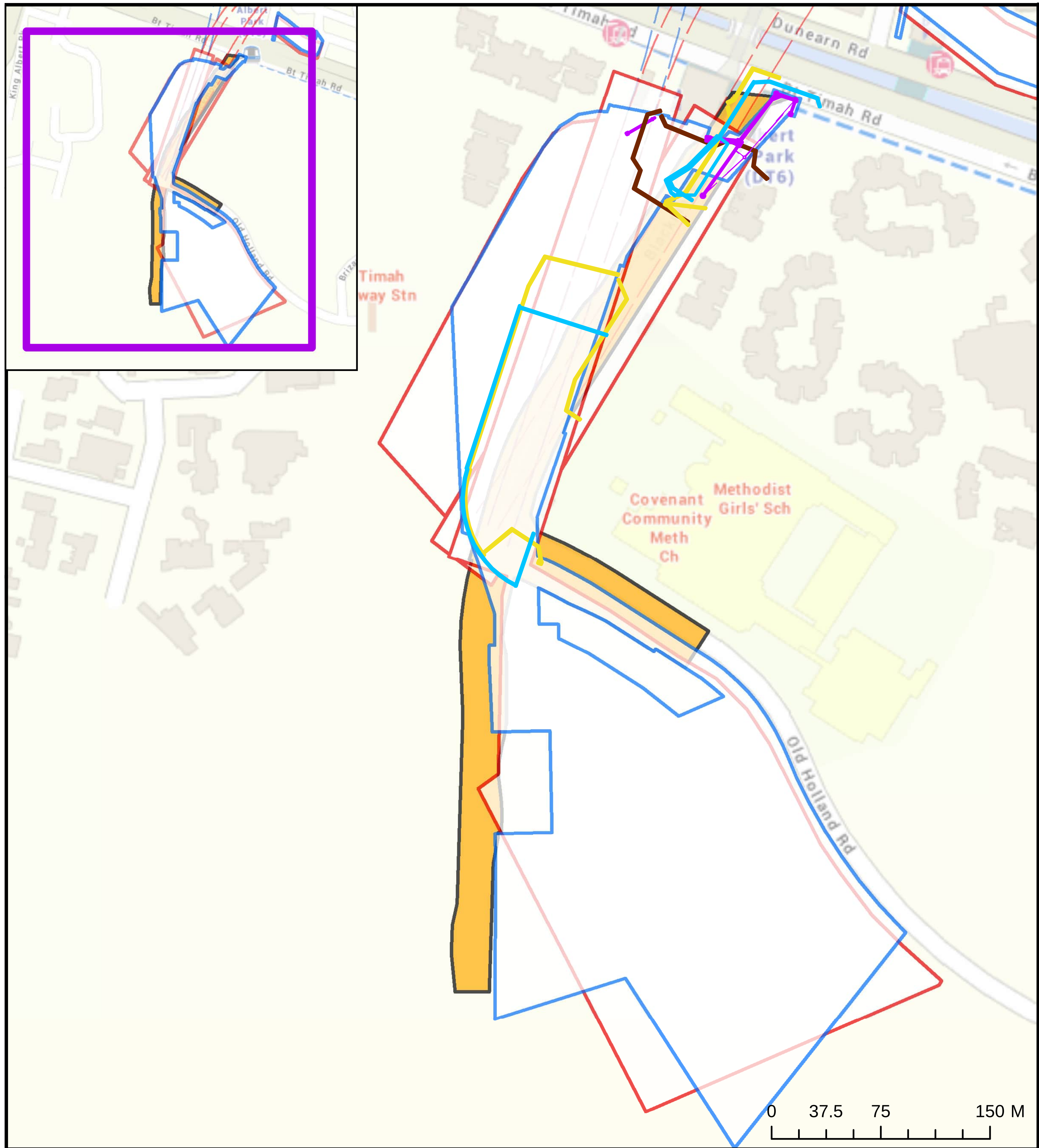
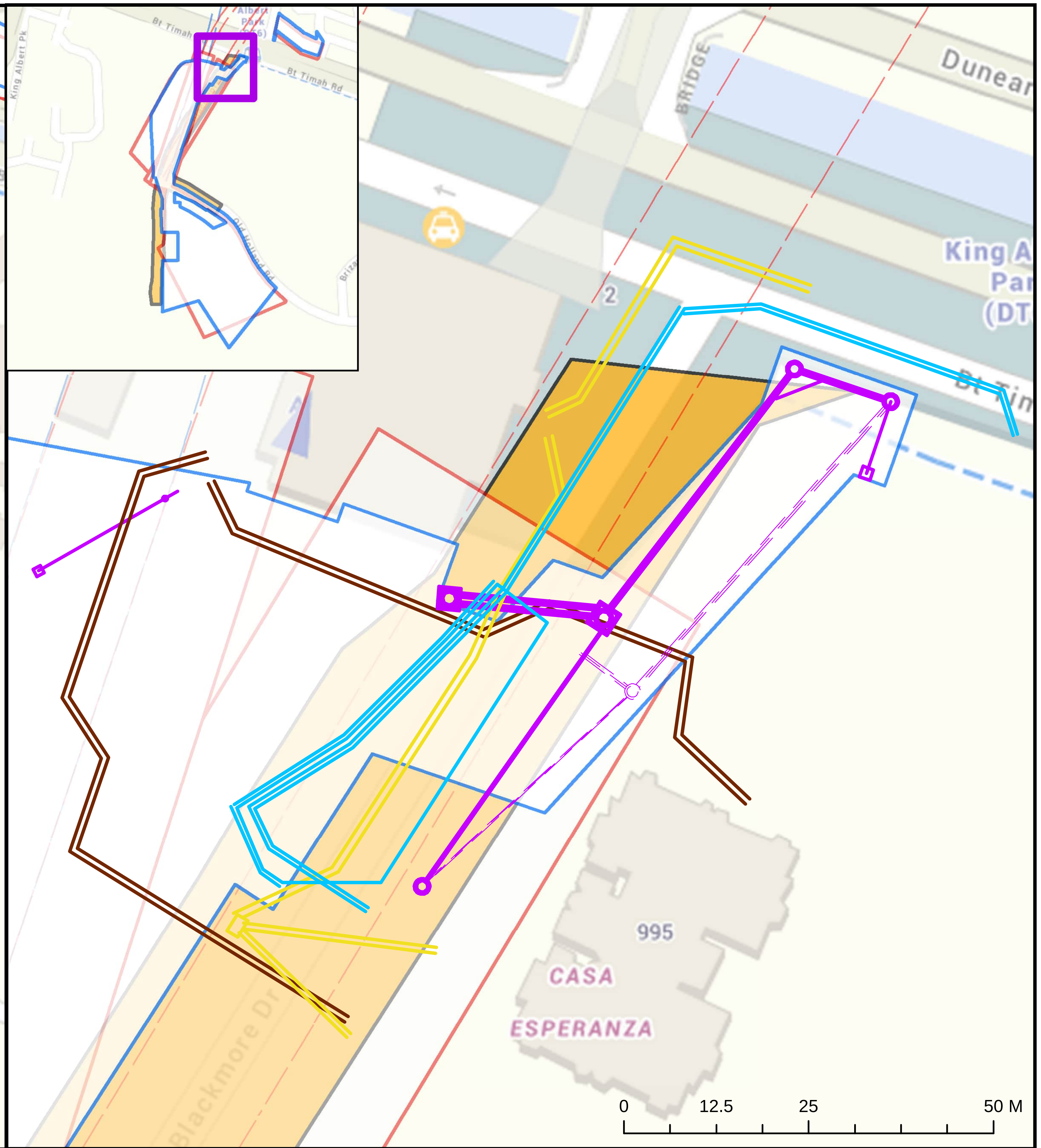
ML	JAG	JAG	3 - 12	-	1 of 1
	Drawn ML	Date JULY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap





Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Planned Road Works
- Water Diversion
- Telecom Diversion
- Power Diversion
- Permanent Sewer Diversion
- Temporary Sewer Diversion

N

Rev.	Date	By	Description	Chk'd	App'd
-	SEPT 2022	TTR	EIS (Turf City and Holland Plain) Rev A	JAG	JAG
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	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 (TURF CITY AND HOLLAND PLAIN)

Figure Title :

UTILITY DIVERSION AT CR15

Designed	Checked	Approved	Drawn	Date
ML	JAG	JAG	TTR	SEPT 2022

Figure No.	Rev.	Sheet
3 - 13	A	1 of 1

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Note: Source of basemap - OneMap

3.2.1.3 Establishment of Temporary Worksites

Following the site clearance, the temporary worksite structures are set up at each worksite (see Section 3.1.1 for worksites). 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), internal temporary roads for movement of vehicles and vehicle parking lot (see Figure 3-14 and Figure 3-15 below). All these site elements will only be provided in detailed design stage and are not available for review at the time of writing this report.

According to the current planning for base scenario, the total construction footprint of CR14 worksite is estimated to be around 158,000 m^2 for base scenario worksite and 105,500 m^2 for mitigated scenario worksite, whereas for CR15 worksite is around 106,000 m^2 for base scenario and 82,000 m^2 for mitigated scenario worksite. Temporary and permanent utilities diversion works that comes along with traffic diversion stage are excluded from these area estimations as they will be undertaken outside of the Project worksites as shown in Figure 3-12 and Figure 3-13.

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. During construction, the existing road north of CR14 will remain accessible and not be closed during construction, as with all other construction site arrangements. Whilst hoarding will be used, this is to facilitate safe wildlife movement only; note, no hoarding will be placed adjacent to the forest. In addition to this road, Turf Club Road and Fairways Drive will be utilised for access; Turf Club Road is planned to be widened and extended to connect with Eng Neo Avenue, to allow for controlled construction access into the Site (Figure 10-8; Figure 10-23).

Furthermore, the planned road works for CR15 will provide access into the CR15 Site (Figure 10-9; Figure 10-24). The construction of these permanent access roads (see Figure 3-1 and Figure 3-2) will also be used to provide public access to CR14 and CR15 stations during operational phase.

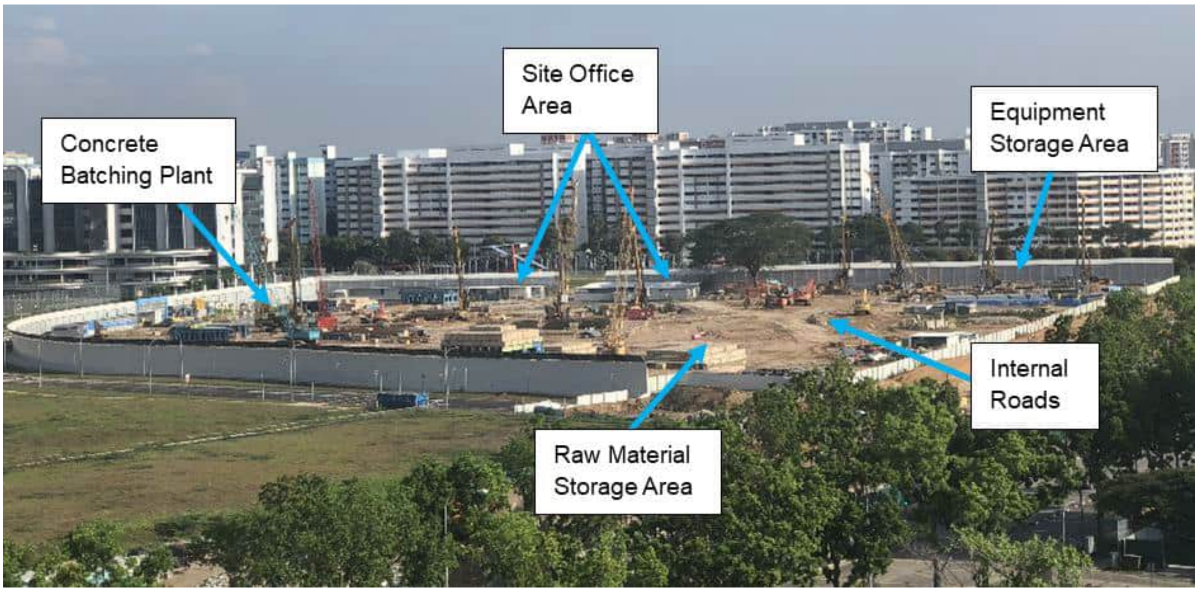


Figure 3-14 Example of a Typical Worksite Layout [O-6]

Figure 3-15 Bright Hill MRT – Example of a 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.

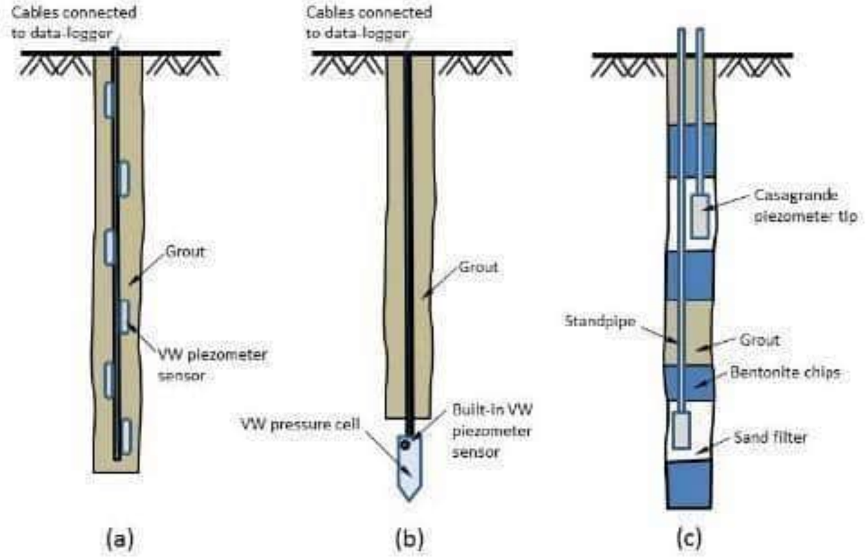


Figure 3-16 Schematic of Piezometer [P-71]

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 3-17 Example of Settlement Markers [W-6]

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 shall be constrained within the respective worksites to avoid additional site clearance beyond of the worksites. This is to minimise disruption to the forested areas nearby. If installation of monitoring instruments has to be conducted outside of the worksites, it shall 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 Construction Activities

Construction of this Project will involve ground improvement works, shaft construction, tunnelling or TBM launch/retrieval works, concrete batching works (if any), as well as the construction of superstructures such as MRT stations, facility buildings, as well as general landscaping/ finishing works. Furthermore, for CR15, a two-storey site-office is proposed to be constructed directly north of Dunearn Road for the duration of construction.

3.2.2.1 Ground Improvement Works

Ground improvement works will be carried out at the worksites with launch/retrieval shafts, which is intended to ensure water tightness between the interface of the soil and the face of launch/retrieval shafts. According to the preliminary design planning at the time of writing this report, ground improvement with a size of 15m (width) x 15m (length) may be required for the tunnel launching from CR14 and retrieval at the same worksite.

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

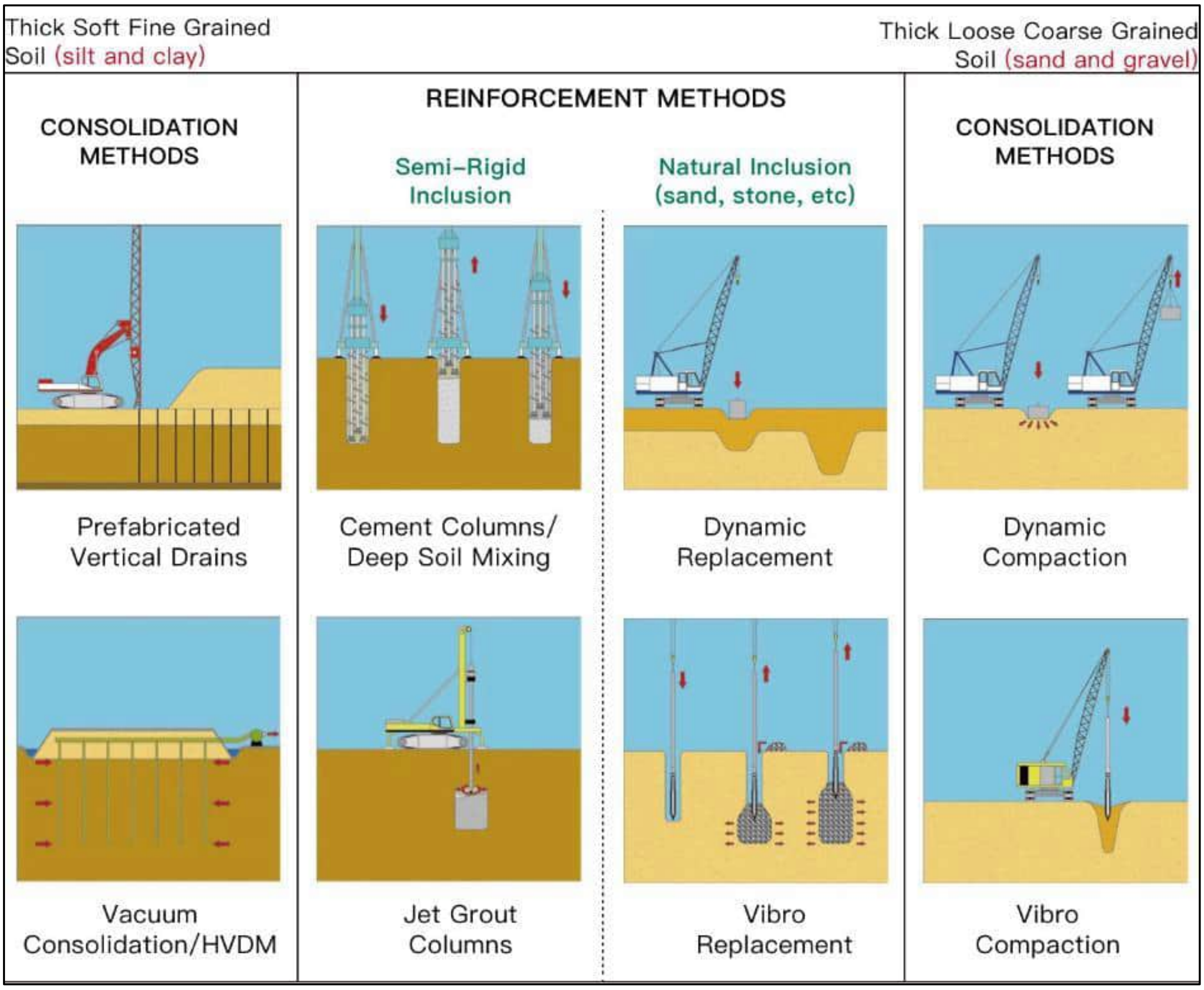


Figure 3-18 Common Ground Improvement Techniques Prior to Excavation [W-15]

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 during CR2001 Advance Engineering Study (AES) Consultant's contract period), 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].

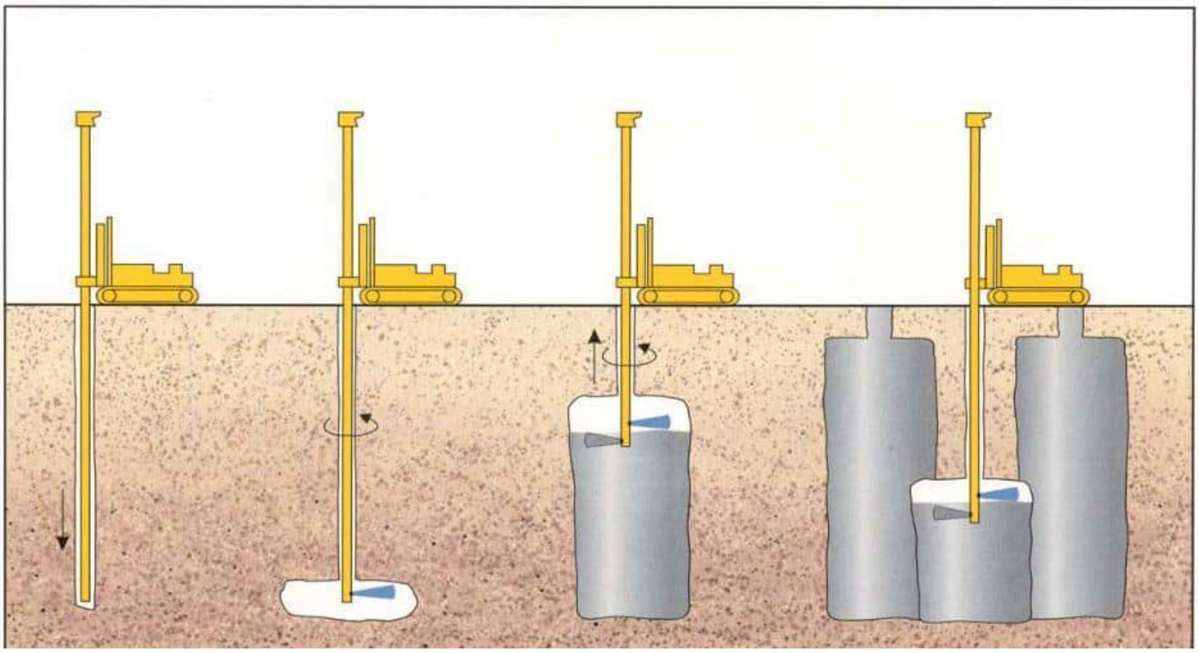


Figure 3-19 Schematic of Jet Grouting Rig Operational Process [W-16]

3.2.2.2 Shaft Construction

Generally, construction of shafts is required to support the TBM launch/retrieval works (see Section 3.2.2.6) to construct the proposed CRL2 alignment, as well as to prepare for the construction of station worksites and/or facility buildings (if any). As mentioned in Section 3.1.1 and further described in Section 3.2.2.6, TBM at CR14's launch shaft worksite will be launching southwest along the CRL2 alignment, passing onto CR15 Worksite, where the TBM will be docked and pulled back to CR14, where it will be retrieved. The schematic launch/ retrieval plan is shown in Figure 3-26. Generally, the launch and retrieval shafts 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-6]. 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-7] to ensure minimal groundwater ingress into the shaft.

3.2.2.3 Station Box Construction

The station boxes for CR14 and CR15, including overrun tunnels, cripple sidings at CR14 and TBM launch/retrieval shaft at CR14 will be constructed using the cut and cover construction method. Generally, 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.).

In this Project, the construction of station area can be either top down or bottom-up approach, which will be decided by the ERSS plan by the AES consultants or LTA's in-house design engineers. As per current planning, the construction of CR14 station is planned to utilise a bottom-up approach, whilst the construction of CR15 station is planned to utilise a top-down approach.

For completeness, a brief introduction of the two approaches are provided below:

Top Down with Island Method

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 shallow structures such as station boxes, interfaces with existing MRT lines, turn-backs and supporting structures, such as underground pedestrian walkways (subways) and escape routes.

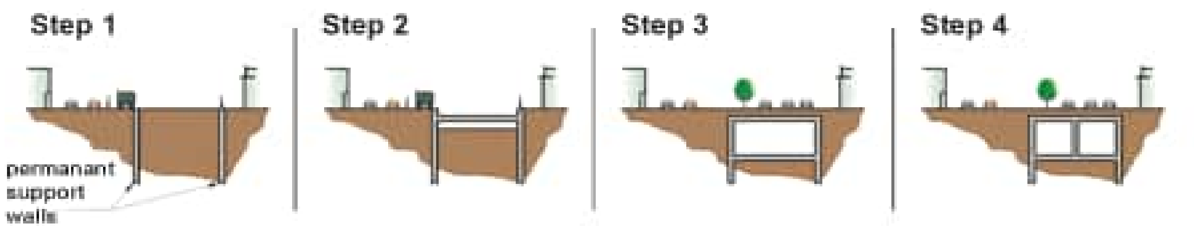


Figure 3-20 Top-down Cut and Cover Construction [P-74]

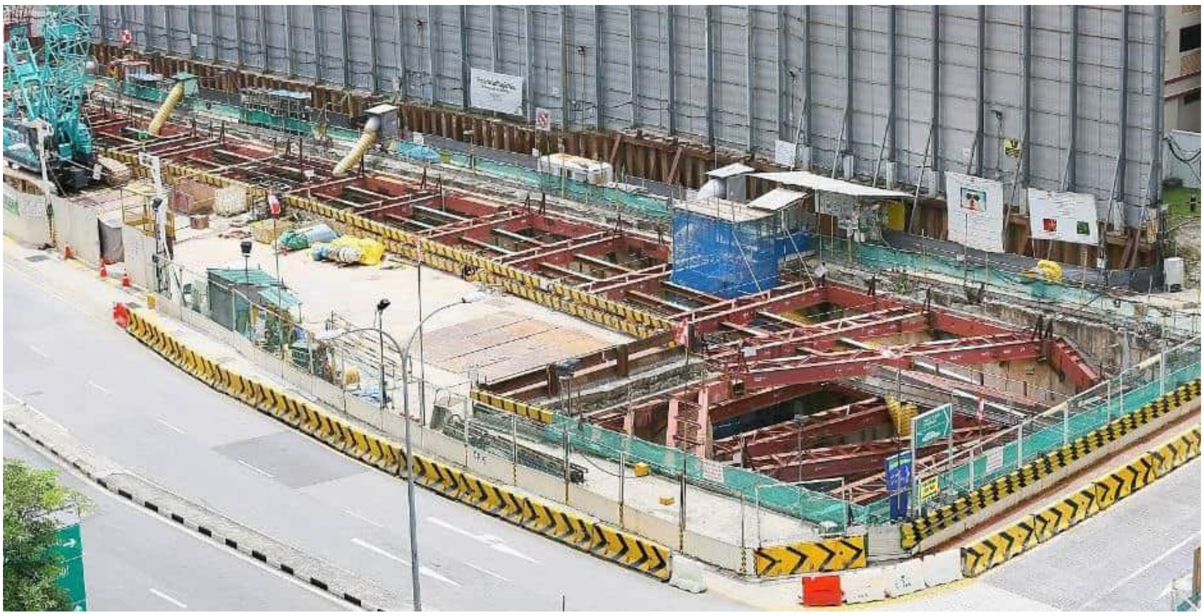


Figure 3-21 Example of Top Down Construction at Lentor MRT Worksite [W-22]

Bottom-Up Construction

In the bottom-up construction, a trench is first excavated on the surface and a tunnel is then constructed within. The trench is then backfilled, and the excavated surface restored. The trench is formed either using open cut (sides sloped back and unsupported), or with vertical faces using an excavation support system. 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.

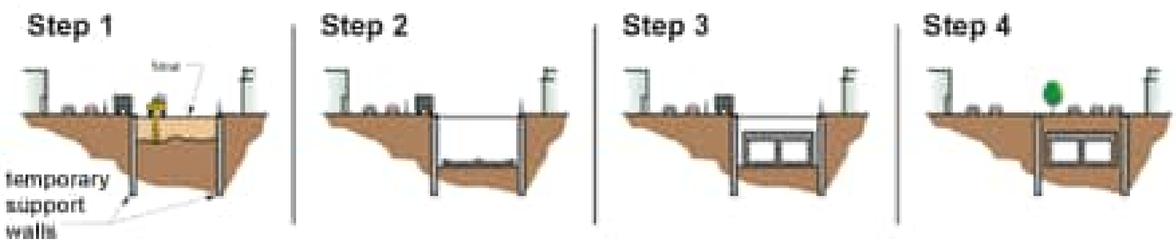


Figure 3-22 Bottom up Cut and Cover Construction [P-74]

Figure 3-23 Example of Bottom-Up Construction at Woodlands South Worksite [W-7]

3.2.2.4 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 [W-75]. 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-76].

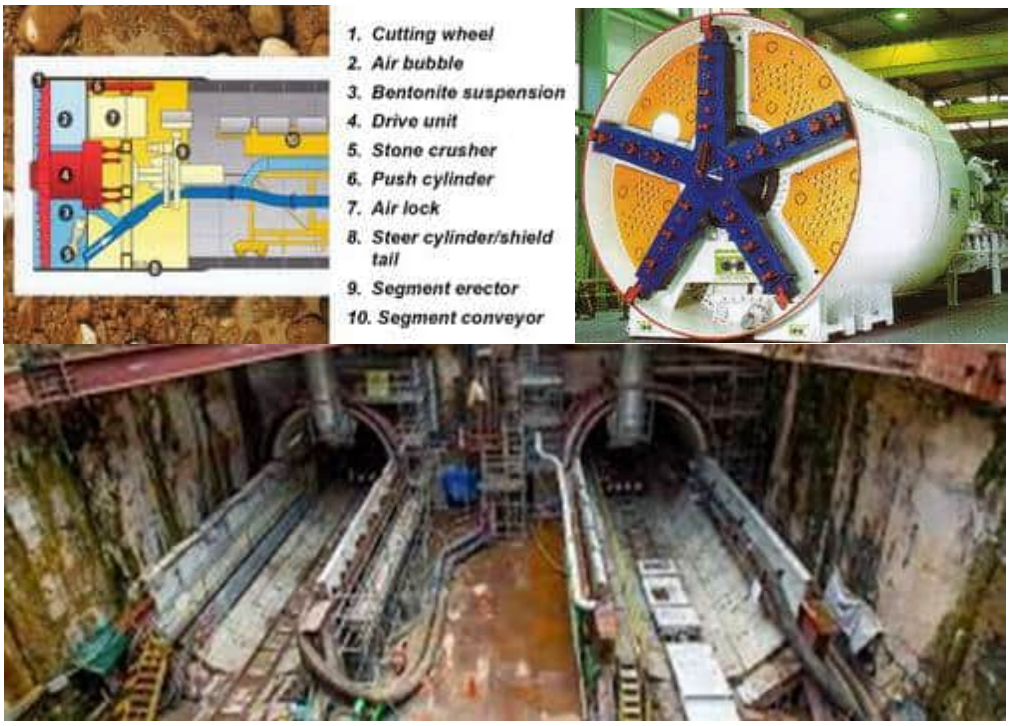


Figure 3-24 An Example of Slurry TBM [W-56] and Twin-Bored Tunnel at A Station Site in Singapore [W-21]

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.

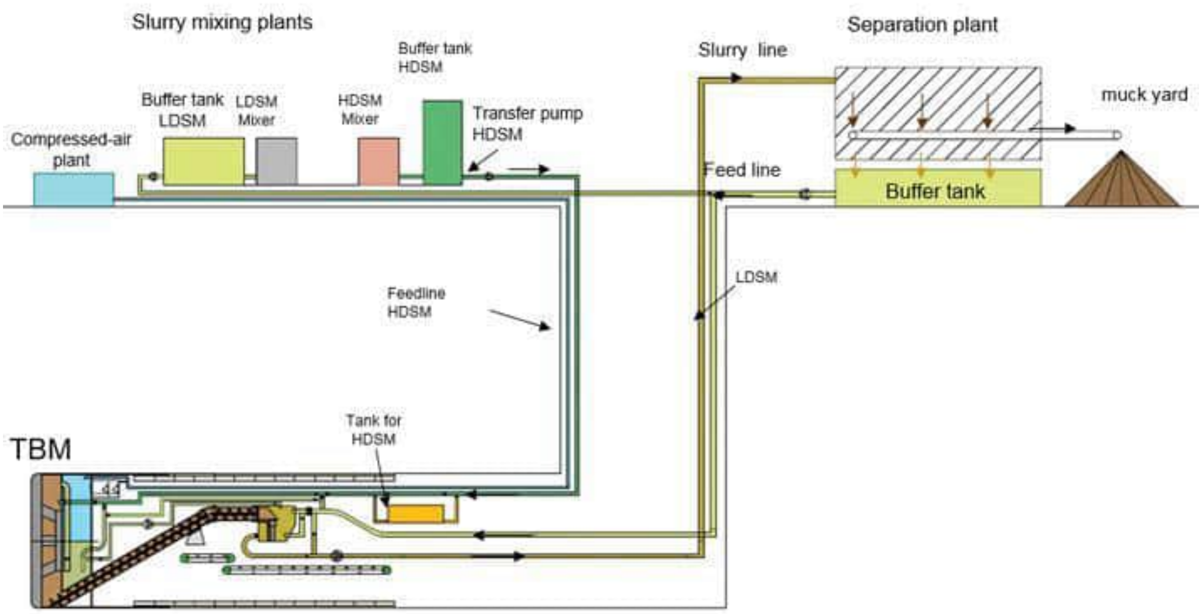


Figure 3-25 Schematic Showing a Variable Density TBM Operating below Ground and Treatment of Extracted Slurry at Above Ground Plant [W-12]

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

According to current planning of this Project, a standard 6.6m diameter twin-bored tunnels (TBT) will be launching from a planned launch shaft at the CR14 Worksite towards the southwest direction along the CRL2 alignment, passing onto the CR15 Worksite where it will be docked and pulled back to CR14 for retrieval. A schematic launch/retrieval plan associated with the worksites in this report is shown in Figure 3-26 below.

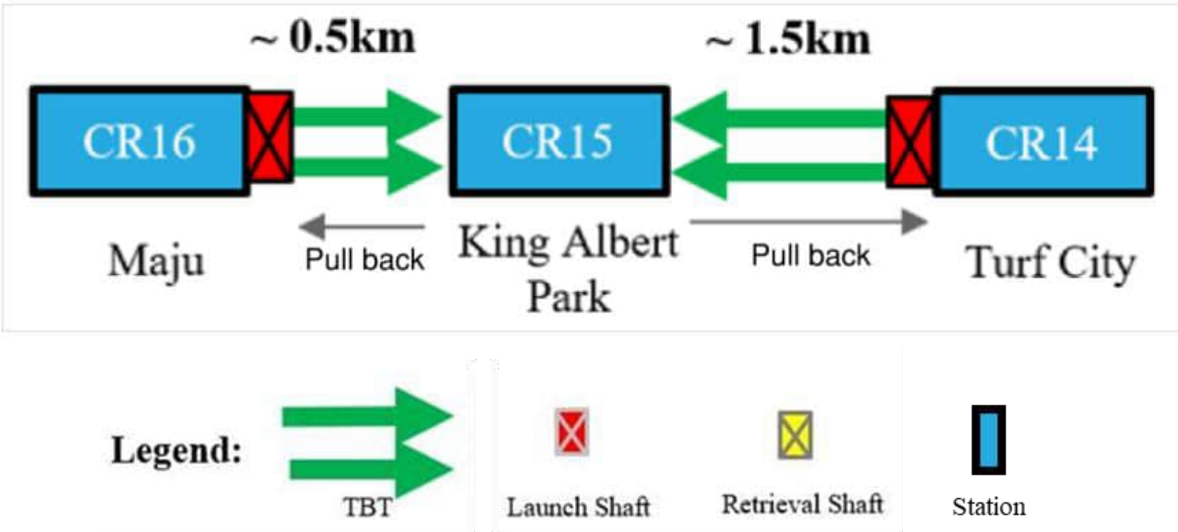


Figure 3-26 Schematic Plan of CR2005 TBM Launch and Retrieval between CR14 and CR15

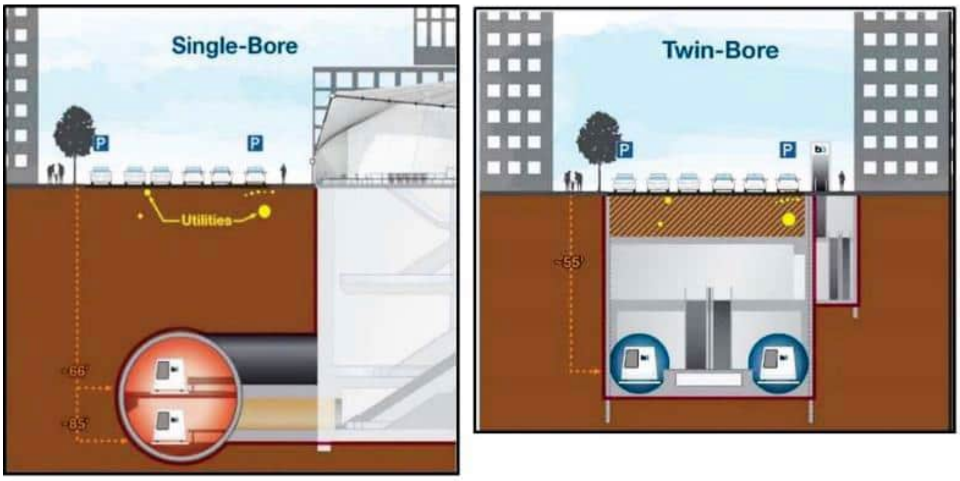


Figure 3-27 Single-Bored and Twin-Bored Tunnels [W-57]

Once the TBM has advanced and tunnel linings installed for the twin-bored tunnel covered in this report, escape provision between railway tunnels are provided in accordance with the Singapore Civil Defence Force (SCDF) requirements for emergency preparedness. As per the *Code of Practice for Fire Precautions in Rapid Transit Systems 2017*, escape staircases shall be provided throughout the underground or enclosed trainways and spaced so that the distance between escape staircases is at most 760m. Where this cannot be complied, escape shafts shall be provided at a maximum distance of 500m in between the stations. Alternatively, cross-passageways shall be provided at every 250m throughout the underground rail tunnel.

Escape staircase Pedestrian cross passage door

Figure 3-28 Example of Escape Staircase and Cross Passage Door [W-92]

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. Also, 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 it is complete. 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 maybe preceded 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).

3.2.2.5 Concrete Batching Plant

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 mixing while transporting 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-52, W-53] A generalised diagram of a typical concrete batching process flow is included in Figure 3-29.

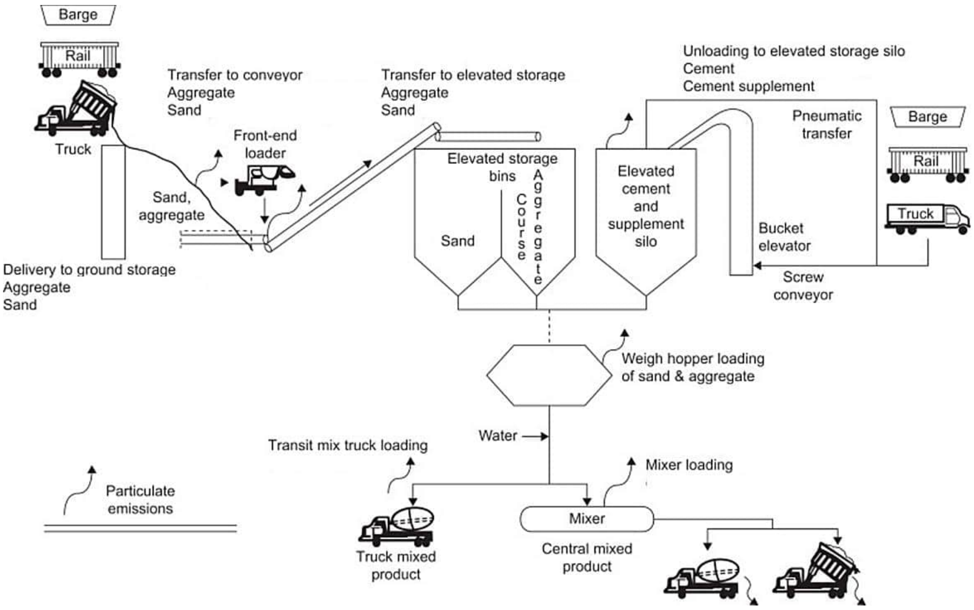


Figure 3-29 Generalised Concrete Batching Process Flow Diagram [P-76]

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 combine the proper amount of the ingredients. Water was 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 current planning, there will be one (1) concrete batching plant each at CR14 and CR15 worksite respectively. 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. An example of the concrete batching plant is as shown in Figure 3-30.

Figure 3-30 Example of a Batching Plant at Marina South for Tunnel and Station Box Construction [W-8]

Based on the information by AES Consultant of this Project, 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 7, Section 10 and Section 11 respectively.

3.2.2.6 Construction of Permanent Facility Buildings

Permanent standalone facility building is required to support the operation of the entire CRL2 alignment. In this report context, CR14 an CR15 station buildings will include necessary facilities for rail operation/ ventilation hence no standalone facility buildings will be required for the stretch of CRL2 alignment from Turf City to Holland Plain.

Nonetheless, construction of permanent facility buildings is discussed below for comprehensiveness of the study; noting that these facilities are integrated with the stations in this case.

Typically, each facility building includes 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 ventilation purpose for rail/ tunnel operation during operational phase.

Construction activities include constructing of foundation, installation and testing of utilities and equipment, construction of the above ground building structure and construction of permanent access roads. Referring to LTA's *Civil Design Criteria for Road and Rail Transit Systems, September 2019 Edition* [R-6] and LTA's *Materials & Workmanship Specification for Civil & Structural Works, September 2020 Edition* [R-7], the permanent access road will be between 8 to 10 m wide depending on the site-specific layout, while fencing will be constructed around the facility building compound to prevent unauthorised access to the building spaces.

Figure 3-31 Example of a Permanent Facility Building Construction at Springleaf Station [W-9]

3.2.2.7 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 3.2.2.3). The indicative operational footprint of the CR14 and CR15 station building with entrances/ exits are shown in Figure 3-4 and Figure 3-5 respectively.

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.

For this Project, permanent access roads will be constructed (see Figure 3-1 and Figure 3-2) to provide road access for public to CR14 and CR15 stations during operational phase.

Figure 3-32 Artistic Impression Created by LTA of the CR14 Station Superstructure

Figure 3-33 Artistic Impression Created by LTA of the CR15 Station Superstructure

3.2.2.8 General Landscaping and Finishing Works

Station and/or facility buildings are usually provided with façade cosmetics with theme decided for a rail line. Landscaping around these buildings for the CRL2 stations will follow *NParks Guidelines on Greenery Provision and Tree Conservation for Developments* [R-11], 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 3-34 Example of Reinstatement and Landscape Works at TEL1 Worksite [W-10]

3.3 Proposed Operational Activities

During operational phase, the entire CRL2 alignment is expected to make at least 600,000 trips per day [W-43]. 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, facility buildings) for the comprehensiveness of the study. The indicative operational footprint of CR14 and CR15 are demonstrated from Figure 3-4 and Figure 3-5.

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 expected to be undertaken during engineering hours (from 1am to 4am depending on rail operators) once per week for each station and/or facility buildings, 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, 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 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-32].

A typical example of station entrance/ exit is illustrated in Figure 3-35 below, while the indicative locations of CR14 and CR15 station entrances/exits are illustrated in Figure 3-4 and Figure 3-5 respectively.

Figure 3-35 TEL Mayflower – Example of a Station Entrance [W-33]

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 has 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 3-35.

Figure 3-36 Example of Station Interior - TEL Bright Hill Station [W-33]

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-32]. The ACMV equipment (e.g., air-conditioning equipment, exhaust, condenser etc.) The proposed ACMV system in stations has several equipment housed in the outer façade of the building, either on the roof or the façade, and 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 are 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. An example of concept design of the CR14 station's island platform with cripple sidings is demonstrated in Figure 3-36.

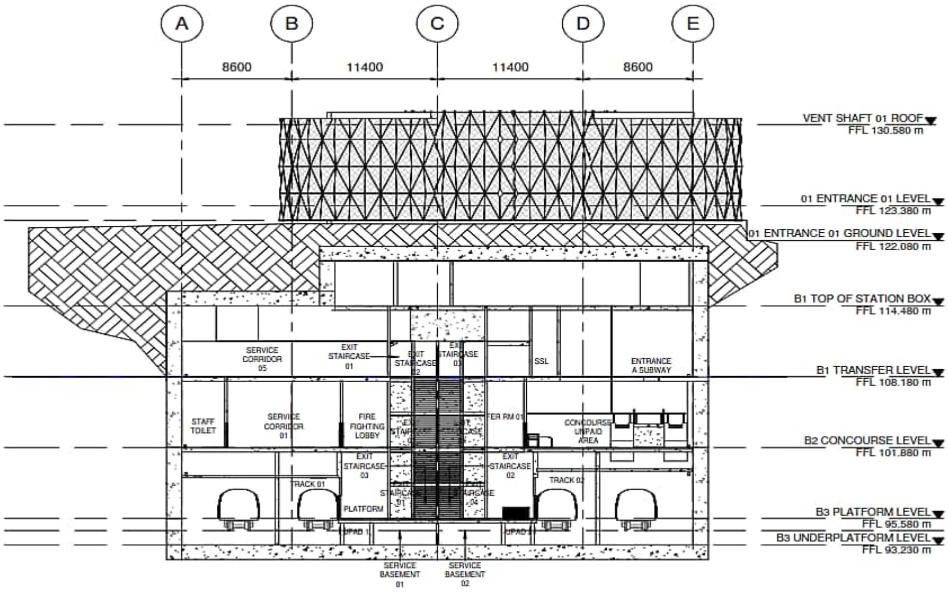


Figure 3-37 Concept Design of CR14 Station [O-2]

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 as 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 is normally a ballastless type in Singapore however, sometimes this can vary based on the recommendation made by the ground and vibration study or other engineering design outputs. At the time of writing of this report, no confirmed track type was available. Therefore, an assumption of basic ballastless type track form has been assumed.

During the commissioning phase, test trains are run, and extensive track testing 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. Typically, a diesel-operating wagon/ vehicle may be used for mobility for maintenance work in the tunnels in the night.

During 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 were studied by a specialist consultancy service under a separate CR2008 contract, where the 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, which is planned for the CR14 station in this report context. 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-36]. 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-38] as illustrated in Figure 3-37. 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 is usual.

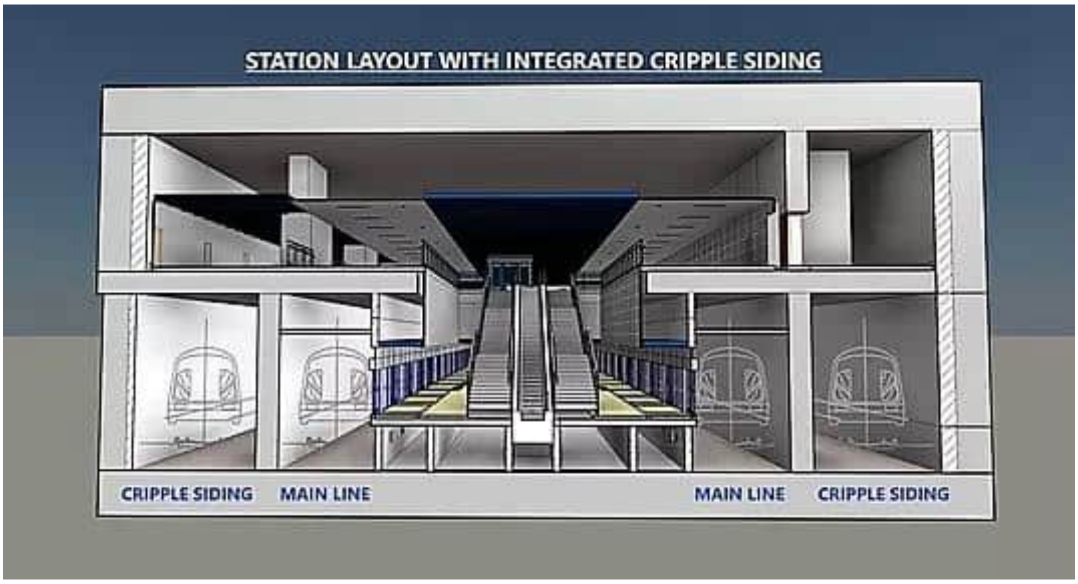


Figure 3-38 Example of Station Layout (Island Platform) with Integrated Cripple Sidings [W-36]

3.3.4 Ventilation Shafts Associated with Stations and/or 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 and have 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 operational phase, therefore, there will be vent shafts associated with each station box [W-32] and/or facility building. 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 respectively. 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-32]

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 shall provide a drainage system, including pumping system where necessary, to prevent accumulation of water in the shaft bottom [W-32].

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/or 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. shall be implemented during operational phase [W-32].

Station and/or facility buildings may generate airborne noise due to the air-conditioning and mechanical ventilation (ACMV) at the rooftops, 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-17].

Figure 3-39 Example of a 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 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 Development

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.

Locations of the concurrent developments relevant to this report are presented in Figure 3-40. The cumulative impacts of these concurrent developments were assessed qualitatively in the respective section of each environmental discipline, except for airborne noise, for which a quantitative approach was undertaken as sufficient quantitative data was provided for the cumulative airborne noise impact assessment.

a) **A1-W2 launch shaft worksite near Bukit Timah Saddle Club**

A launch shaft worksite (namely A1-W2) near Bukit Timah Saddle Club is currently being planned under the same CR2005 contract to support the launching of TBM for the construction of the CRL2 alignment. The proposed launch shaft worksite is associated with temporary access road construction for site access which will be reinstated at the last stage of its construction phase. Since there is no further information being developed at the time of writing this report, hence it is being assessed qualitatively as a concurrent project nearby CR14 worksite of this report. The overlapping construction duration with CR14 worksite is expected to be 96 months.

b) **Road network to support Holland Plain developments**

Construction works include road works at Old Holland Road, road extension works from Blackmore Drive and Holland Link to Laurel Wood Avenue, road realignment works for Holland Link and road widening works for Holland Road and Sixth Avenue Road. Potential worksite sharing with CR15 worksite may occur. Its construction is expected to be overlapping with the construction of CR15 worksite for an approximate duration of 30 months and the CR15 permanent road works for an approximate duration of 12 months. No other information available at the time of writing this report.

c) **CR16 worksite near Maju Forest**

Construction of CR16 is expected to take place between 2022 and 2032, the same timeframe outlined for CR15. The projects will therefore be constructed concurrently.

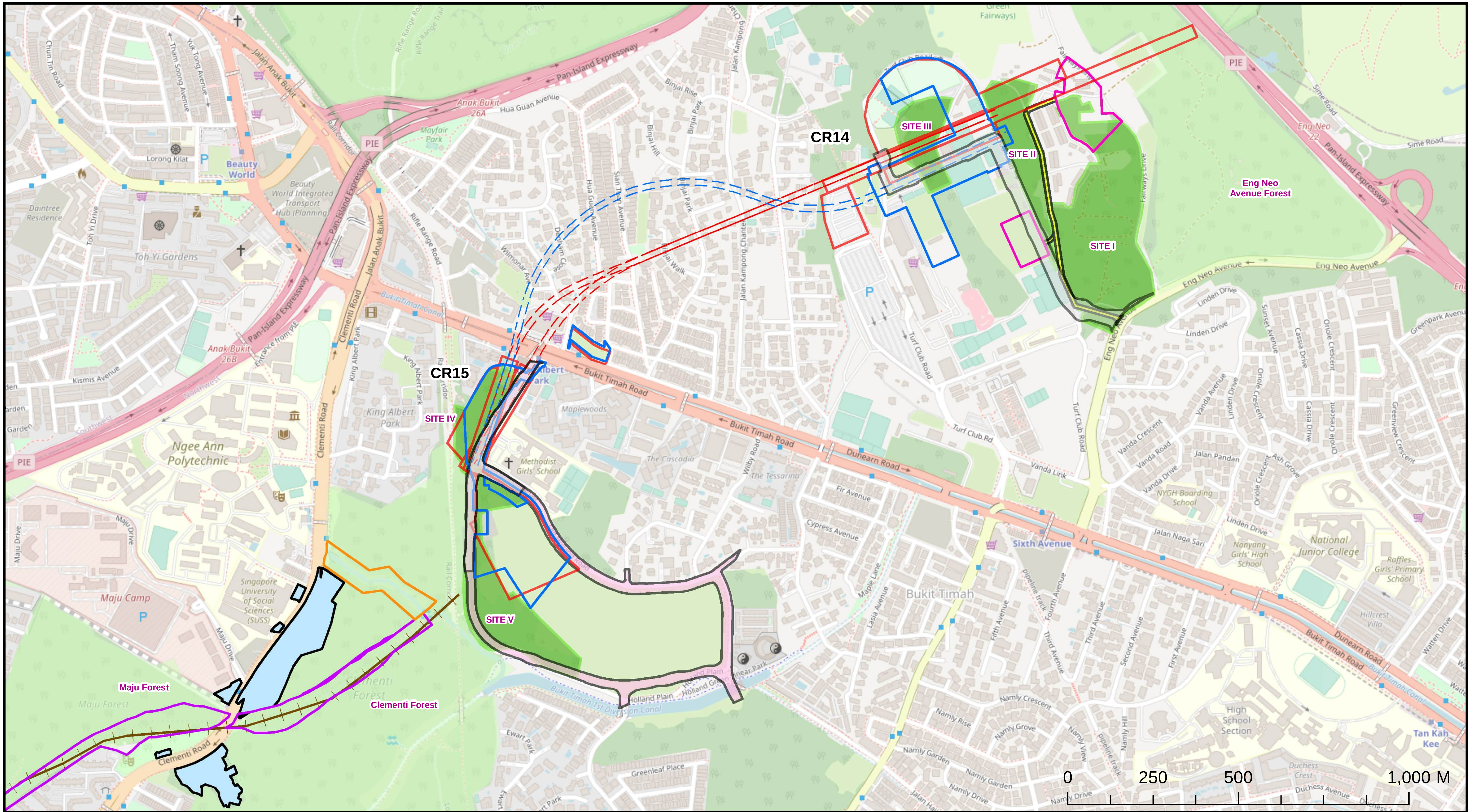
The cumulative impacts of the concurrent developments above were assessed qualitatively in each individual section of different environmental disciplines.

d) **Old Jurong Line 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 CR14 and CR15 construction within this period.

e) **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 CR14 and CR15 within this period.



Legend

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

Concurrent Development

- A1-W2 Launch Shaft
- A1-W2 Temporary Accesss Road
- Holland Plain Developments Roadworks
- Clementi Nature Trail
- Old Jurong Line Nature Trail
- CR16 Combined Mitigated Worksite

N

Rev.	Date	By	Description	Chk'd	App'd
A	SEPT 2022	TTR	EIS (Turf City and Holland Plain) Rev A	JAG/NHT	JAG
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	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 (TURF CITY AND HOLLAND PLAIN)

Figure Title :

INDICATIVE LOCATIONS OF OTHER CONCURRENT MAJOR DEVELOPMENTS

Designed	Checked	Approved
ML	JAG/NHT	JAG

Drawn	Date
TTR	SEPT 2022

Figure No. :	Rev.	Sheet
3 - 40	A	1 of 1

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Note: Source of basemap - Open Street Map

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 shall be supplied with power from the Singapore power grid. For the purposes of electrification, a 25kV alternating current system shall 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 shall 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 shall 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 are 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
CR14	< 25,000 m^3	> 30,000 m^3
CR15	< 25,000 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 are 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 shall 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 shall be labelled and stored in accordance with requirements stipulated in LTA's Construction Safety Handbook [W-78].

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.)	Lorry Cranes Hand Held Breaker Front End Loader Dump Truck
Temporary Earth Retaining Structure works (e.g. continuous bored piling, sheet piling, decking installation, etc.)	Lorry Cranes Excavator Hydraulic Foundation Drill Trailer (40 feet)

Activity	Indicative Equipment
Excavation to Work Platform Level	Lorry Cranes Front End Loader Dump Truck Generator Excavator Roller
Temporary work- Installing of D wall, Sheet Pile	D-wall rig with Grab Truck Mounted Crane Mobile Crane Ready Mix Concrete Truck Concrete Pump Colloidal Mixer (Bentonite) Compressor Generator Ripple Screen Measuring Tank & Agitator Bentonite Slurry Tanks
Installation of Wallers and Struts,	Welding Equipement Mobile Crane Crane Excavator Mini Excavator Trailer (40 feet)
Installation of Wallers and Struts, as well as Excavation and Reinforced Concrete Works	Rock Breaking and Excavation Equipment Concrete Pump Crane and/or Crane Crawler (50 tonne) Dump Truck Excavator Flat Truck Generator Loader Mini Excavator Tracked Excavator (30 tonne) Truck Mixer
Tunnelling/ TBM Launching and Retrieval	Air Chiller Air Compressor Air Receiver Cranes (200 tonne and 500 tonne) Excavator (30 tonne) Gantry Crane (40 tonne) Grout Mixing Plant Muck Away Truck TBM with Precast Segment Erector TBM Gantries Tunnel Segment Rings Delivery Shaft Hoist Slurry Separation Plant Ventilation Air Cooling Plant Ventilation Supply Fans Water Chiller Plant

Activity	Indicative Equipment
Construction of Permanent Structures for Stations and Facility Buildings (e.g. MRT Entrances/ Exits, etc.)	Compressor Concrete Pump Cranes, including Electronic Tower Cranes, Mobile Crane, Truck Mounted Crane and Crane mounted with Vibrator Pile Driver Dump Truck D-Wall Rig with Grab Excavator Excavator mounted with Vibrator Pile Driver Forklift Generator Mini Excavator Ready Mix Concrete Truck Temporary Water Pump Trailer (40 feet)
Reinstatement of work and existing Road	Asphalt Paver Dump Truck Excavator Front End Loader Generator Grader Roller
Construction of Material Storage Area	Lorry Cranes Tralier (40 feet) Dump Truck Excavator
Road Work	Lorry Cranes Hand Held Breaker Dump Truck Excavator Excavator mounted with Vibration Pile Hydraulic Foundation Drill

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 includes the associated operational activities at the station and facility buildings, as well as for periodic maintenance activities. The Project shall be supplied with power from the Singapore power grid during the operational phase. For the purposes of electrification, a 25kV alternating current system shall 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, 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 and station building operation and maintenance works during operational phase of the Project. [W-32]

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

Activity	Indicative Equipment/ Facility/ System
Rail operations and associated supporting systems/ services	**E&M System (all Railway Systems required for railway operations)** 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	**Common Equipment [W-31]** Track Tamping Vehicle Multi-Function Vehicle Rail Grinding Vehicle Viaduct Inspection Wagon Diesel Locomotive Tunnel Cleaning Wagon Heavy Crane Vehicle Rail-Road Vehicle
Building Services *(Applicable for station and facility buildings)*	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 and facility buildings)*	** 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) of facility buildings	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)	Offices Service counter

Activity	Indicative Equipment/ Facility/ System
when accessing station buildings, facility buildings and MRT	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 work. 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. An estimated total of 2,519,400 m^3 of spoil will be excavated during the Project works for the entire CRL2 alignment and the associated worksites. The total spoil volume includes cut and cover excavation works and TBM spoil volumes.

Table 3-4 Estimated Spoil Disposal for the Entire CRL2 Alignment and Associated Worksites

Project Activity	Disposal Required (m^3)
Station Buildings	1,432,100
Facility Buildings *(associated worksites are not covered in this report)*	397,200
Bored Tunnels	690,100
Total	**2,519,400**

A large proportion of this spoil shall be used as construction backfill, but exact spoil balance figures were not available at the time of writing this version of the report.

Recyclable wastes generated from the Project will comprise of excavated spoil material. As there will be no 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.

Liquid effluents generated from the construction activities will generally include extracted groundwater, sanitary discharges, effluent from bentonite slurry treatment, surface run-off 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 run-off 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 should be treated and discharged separately from stormwater run-off and shall be monitored and treated with compliance to the required discharge standards before discharging to the public sewer. Bentonite slurry treatment system/plant will be established within the project site with effluent released to public sewer only if they meet the required discharge standards. It should be noted that all trade effluent to be discharged into the drain/public sewerage system must be done with the written consent of the PUB and comply with PUB requirement. Further discussion on water and/or effluent discharge was provided in Section 7.

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 operation and maintenance of the alignment, stations and/or facility buildings. The operation of the trains on the alignment and at stations could potentially result in oil leakage to the rail tracks and possibly 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-71]. It can be assumed that each typical station would produce a total of 4.3 kg of general waste (staffs only) in a day.

Besides, 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 detention tanks 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

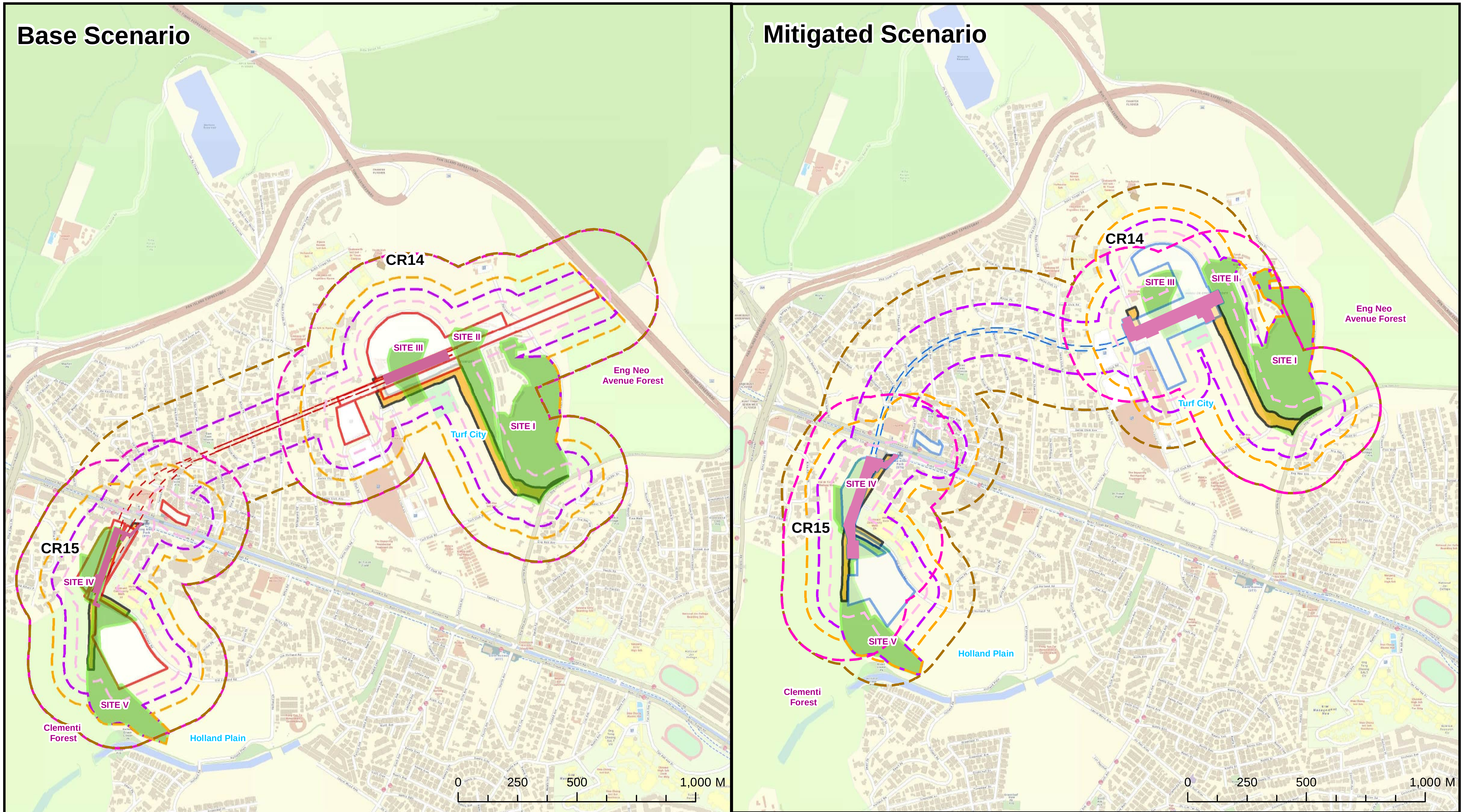
The study area is a representative area covering the construction/ operational footprint of the defined Project that is used for the assessment of environmental impacts, which excludes the area within CCNR. The purpose of identifying a study area is to determine any potential environmental impacts to 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

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. Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor), Site V (forested area at Holland Plain).		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 that is within or in the vicinity of 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-47] Operational phase: Based on other project experiences.
Airborne Noise	For Turf City: Site I, II and III or 150 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Holland Plain: Site IV and V or 150 m from the construction worksite, whichever Is greater. The area can be extended	For Turf City: Site I, II and III or 150 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Holland Plain: Site IV and V or 150 m from the construction worksite, whichever Is greater. The area can be extended	Construction phase: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-52] Operational phase: NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 [R-53], NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 [R-22]

Environmental Impacts	Study Area (Construction Phase)	Study Area (Operational Phase)	Justifications
	beyond, if significant impacts are greater.	beyond, if significant impacts are greater.	
Ground-borne Vibration	A combination of Site I, II, III, IV and V and 100 m from the construction worksites.	A combination of Site I, II, III, IV and V and 100 m from the alignment.	Based on extensive technical experiences on similar rail Projects.



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Planned Roadworks
- Station box
- Study area (Air-Operational)
- Study Area (Air-Construction)
- Study Area (Noise-Construction)
- Study Area (Soil-Construction)
- Study Area (Vibration-Construction)
- Water Courses / Study Area (Water)
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

SUMMARY OF STUDY AREAS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	4 - 1	-	1 of 1
	Drawn: ML	Date: JULY 2022	CAD File Name : NA		A3

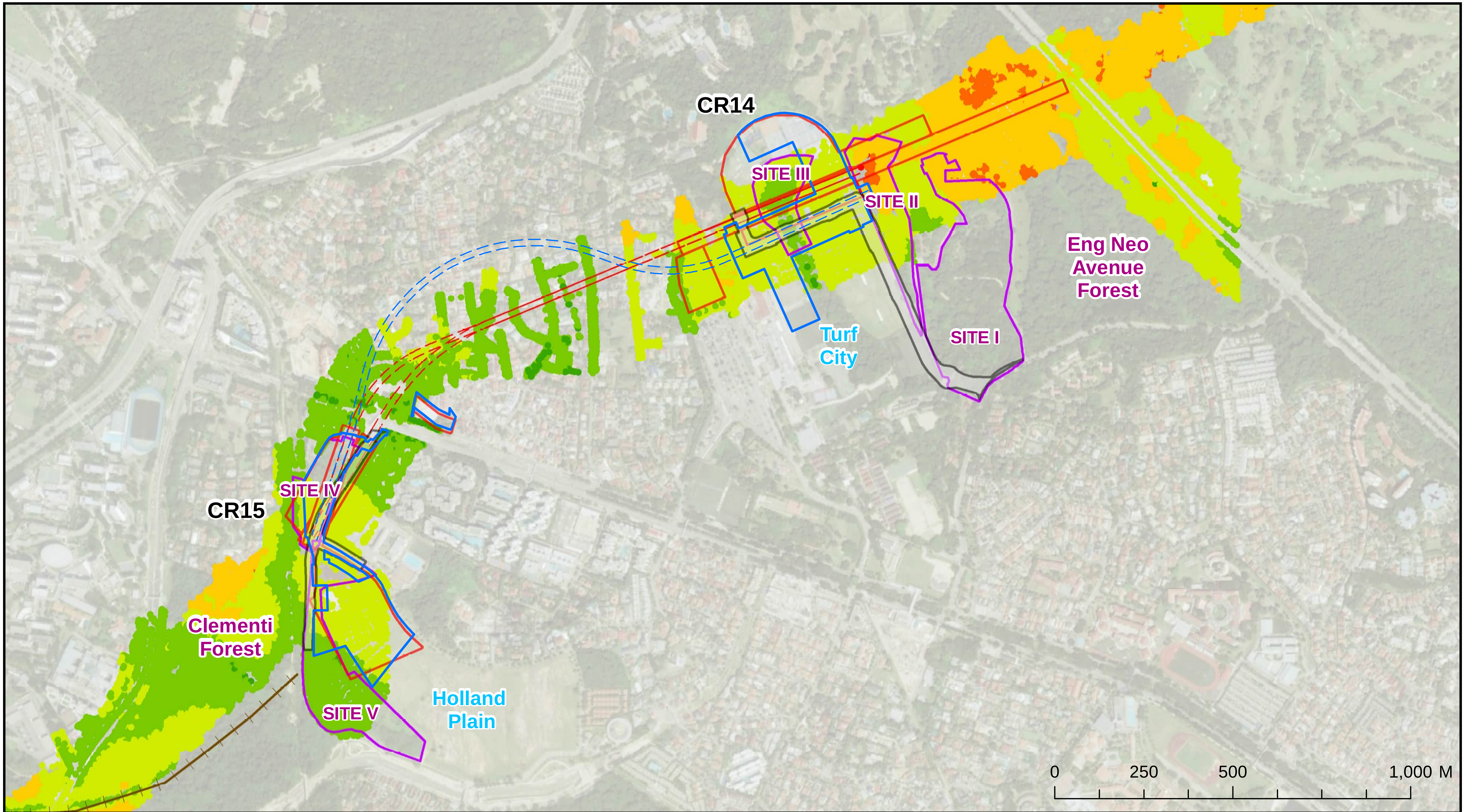
Note: Source of basemap - OneMap

4.2 Topography of the Study Area

The topographic survey data within the study area was provided by Client during the kick-off meeting dated on 30 October 2019 and via email on 30 July 2021. Based on the review of the topographic survey data and observations from the site visit, it is noted that the existing topography of the Study Area along the alignment ranges from 8 mSHD to 25 mSHD based on available topographic data (Figure 4-2). The topographic characteristics of each worksite are described as follows.

CR14 worksite (base scenario) was planned to be located within the existing Bukit Timah Turf City area, and the eastern half of the worksite will extend horizontally across the Bukit Timah Saddle Club and into Eng Neo Avenue Forest. The overall CR14 worksite (base scenario) has an existing topography that ranges from 11 mSHD to 57 mSHD. The western half of the CR14 worksite (base scenario) has decreasing elevation from its worksite boundary (i.e. the existing Turf Club Road) towards its centre, where an earth drain covered by dense vegetation is located. The downstream of the earth drain has elevations lower than 10 mSHD. The eastern half of the CR14 worksite (base scenario) spans horizontally across an undulating terrain that ranges between 24 mSHD to 57 mSHD. After optimisation, the CR14 worksite (mitigated scenario) is located at the urbanised areas in the vicinity of the western half, which has elevations of approximately 11 mSHD to 25 mSHD.

CR15 worksite (base scenario) will be located at an area with slightly higher elevation than its surrounding landmarks, which includes the Old Bukit Timah Railway Station in the east and existing Bukit Timah Road in the north. In the northern section of the CR15 worksite (base scenario), the elevation decreases northwards from 34 mSHD to 11 mSHD, while the southern section of the CR15 worksite (base scenario) is located within a relatively flat but elevated area, where the elevation ranges between 21 mSHD to 25 mSHD. With only minor changes in the worksite footprint, the CR15 worksite (mitigated scenario) is within areas with an elevation of 10 mSHD to 35 mSHD.



Legend

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

Elevation (mSHD)

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

N

Note:
Site I and II: Forested area adjacent to Fairway Quarters
Site III: Forested area within racecourse oval
Site IV: Forested area adjacent to Rail Corridor
Site V: Forested area at Holland Plain

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-	JULY 2022	ML	EIS (Turf City and Holland Plain)	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
(TURF CITY AND HOLLAND PLAIN)

Figure Title :

TOPOGRAPHIC MAP
OF THE STUDY AREA

Designed	Checked	Approved	Figure No.	Rev.	Sheet
ML	NHT/JAG	JAG	4 - 2	-	1 of 1

Drawn: ML
Date: JULY 2022
CAD File Name : NA
A3

Note: Source of basemap - Google Earth Map

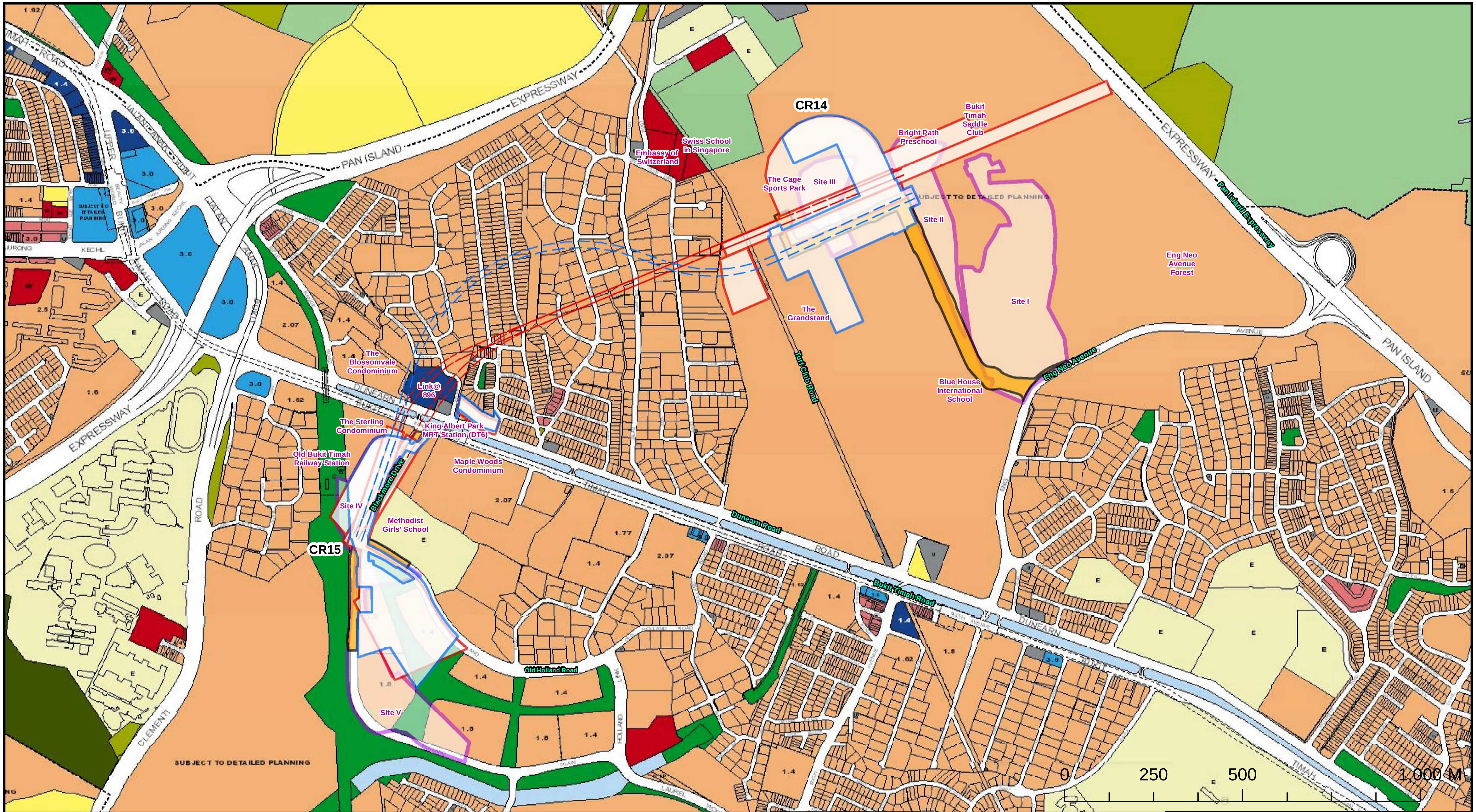
4.3 Current Land Zoning

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 zones 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.	Embassy of Switzerland
Conservation Area	These are areas with historical significance to be conserved.	Old Bukit Timah Railway Station, Bukit Timah Road Truss Bridge
Educational Institution	These are areas used or intended to be used mainly for educational purposes including tertiary education.	Methodist Girls' School, Covenant Community Methodist Church, Bright Path Preschool,
Open Space	These are areas used or intended to be used as open space.	Central Catchment Nature Reserve
Sports & Recreation	These are areas used or intended to be used mainly for sports and recreational purposes.	Swiss School in Singapore
Residential	These are areas used or intended to be used mainly for residential development.	**Non-Residences:** Eng Neo Avenue Forest, Old Jurong Railway Corridor (Underground), Bukit Timah Saddle Club, Blue House International School, Bright Path Preschool, The Cage Sports Park, The Grandstand **Residences:** Casa Esperanza Condominium, Maple Woods Condominium, The Sterling Condominium, The Blossomvale Condominium, Mayfair Gardens Condominium (U/C), Mayfair Modern Condominium (U/C), King Albert Lodge, etc.
Commercial	These are areas used or intended to be used mainly for commercial development.	Link@896
Residential with Commercial at 1st Storey	These are areas used or intended to be used mainly for residential development with commercial use at the 1st storey only.	Residences at Binjai Park (3, 4, 7, 7C, 9, 11, 15, 17, 19, 21, 23, 27, 29, 31 Binjai Park)
Utility	These are areas used or intended to be used mainly for public utilities and telecommunication infrastructure, including water works, sewage disposal works and other public installations such as electrical substations.	Forested area near The British Club
Road	These are areas used or intended to be used for existing and proposed roads.	Pan Island Expressway, Blackmore Drive, Dunearn Road, Bukit Timah Road, Turf Club Road, Old Holland Road, Holland Plain, Eng Neo Avenue, and other roads within study area
Mass Rapid Transit	These are areas used or intended to be used for mass rapid transit (MRT) purposes.	King Albert Park MRT Station (DT6)
Transport Facilities	These are areas used or intended to be used mainly for parking of vehicles and transport facilities including garages and at-grade structure of underground road tunnel and rapid transit system	Petrol stations/ kiosk (e.g. Shell, Sinopec) within study area

URA Master Plan 2019		Street Directory
Land Zones	**Description**	**Current Land Uses**
Watercourses	These are areas used or intended to be used for drainage purposes and water areas such as reservoirs, ponds, rivers and other water channels.	Water canal between Bukit Timah Road and Dunearn Road, Water canal near Holland Green Playground



Legend

- Proposed CRL Alignment (Base Scenario)
- Proposed CRL Alignment (Mitigated Scenario)
- Mitigated Scenario Construction Worksite Footprint
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Sudy Area

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

N

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-	JULY 2022	ML	EIS (Turf City and Holland Plain)	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 (TURF CITY AND HOLLAND PLAIN)

Figure Title :

LAND USE MAP

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ML	NHT/JAG	JAG	ML	JULY 2022

Figure No. : 4 - 3 | Rev. : - | Sheet : 1 of 1

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Note: Source of basemap - URA Master Plan 2019

4.4 Historical Land Uses

The historical land uses of a site can indicate potential contamination which have occurred at some 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 will be reviewed based on the details from Historical Land Use Survey Report (HLUS) [R-4, R-5] under CR2001 (a separate contract) 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 worthwhile to discuss the land use history of forested areas close to the construction worksites of this Project, such as Eng Neo Avenue Forest, which lies adjacent to Site I and in proximity to the Central Catchment Nature Reserve (CCNR) and could therefore act as a conduit for wildlife travelling between CCNR and the Project Site.

4.4.1 Turf City: Sites I, II and III near Eng Neo Avenue Forest

The earliest available map of the Project Site at Turf City dates back to 1914. At that time, MacRitchie Reservoir had already been established, and some development extended into Eng Neo Avenue Forest in the south, including several roads. A large extent of the area was used as a plantation for gambier in the 19th century (National Heritage Board, 2018 [P-42]), and lalang likely dominated the fields for a period when it was deserted and left to regrow (Figure 4-4A).

In the early 20th century, most parts of Singapore became plantations of rubber (Yee et al., 2016 [P-61]), including Khoo Chong Seng Estate near present-day Eng Neo Avenue and the Chasseriau Estate which stretched to Bukit Tinggi (National Heritage Board, 2018 [P-42]). Rubber processing factories that complemented the rubber plantations also operated in the area, particularly west of the Project Site (Figure 4-4B). These factories took advantage of the proximity to the railway in Bukit Timah that facilitated the transport of goods and materials. Around the same period, the northern part of Eng Neo Avenue Forest became a part of the Municipal Water Catchment (later gazetted as Central Catchment Nature Reserve), and Swiss Club area was left to regenerate first into a Belukar or degraded forest (Figure 4-4B).

The Singapore Turf Club was one of the main infrastructures built in the area and was constructed by 1933 (Tan, 2019 [W-94]), purchasing about 244 hectares of land from the previous Bukit Timah Rubber Estate. During its construction, some 30,000 rubber trees were cleared, and hilly areas flattened to create space and build facilities for hosting horse racing (National Heritage Board, 2018 [P-42]). The Southern Grandstand was used as a hospital during World War II. Later during the Japanese Occupation in the 1940s, the racecourse was used as a prisoner-of-war camp and open grounds were planted with banana, papaya, tapioca and vegetables in response to food shortages (National Heritage Board, 2018 [P-42]). In addition, the stables and workers' quarters were used as military car parks and after liberation, the site was used as a military transit centre. Based on an aerial photograph from 1950, the centre of the Project Site, including part of Eng Neo Avenue Forest, appears to remain barren (Figure 4-4C). In 1999, the Turf Club moved to Kranji and the racecourse was converted into a dining and recreational complex. Nonetheless, the former Turf Club still figures prominently in the history of horse racing in Singapore (National Heritage Board, 2018 [P-42]). Other notable developments in the area include the Singapore Island Country Club in 1925 that sits northeast of Eng Neo Avenue Forest (Conceicao, 2009 [W-95]). A topographical map dated in 1945 shows both the Turf Club and Country Club flanking Eng Neo Avenue Forest (Figure 4-4B).

By 1975, the second phase of the PIE was constructed from Thomson Road to Jalan Anak Bukit, cutting through the remaining patch of forest north of Eng Neo Avenue Forest (Figure 4-4D). The map also shows that majority of the Project Site was marked out as sundry tree cultivation (Figure 4-4D). After that period, the land was abandoned, and the forest likely developed with a canopy layer of mainly exotic species. Presently, all areas are covered by secondary forests of varying successional stages, occasionally interspersed with shrublands.

Small forest patches in Singapore, such as the Project Site, provide stepping stones for forest-dependent wildlife to move across the fragmented landscape. Landscape-level habitat connectivity is crucial in maintaining the long-term viability of populations and important ecological processes (Nor et al., 2017 [P-45]). The Project Site is located within 1 km of key biodiversity hotspots like BTNR and CCNR (Figure 4-7) and provides important habitats for wildlife across the landscape. Although the site is separated from the CCNR and Eng Neo Avenue Forest by the

PIE to its east, volant species may still be able to cross the expressway and move between these patches. The Project Site is therefore potentially ecologically sensitive in its own right, and important as a stepping stone for ecological connectivity in the region.

Table 4-3 Timeline summary of development at Turf City Project Site (Sites I, II and III)

Year(s)	Developments
1914	Post-gambier land and potentially fields of lalang, with some development in the south of Eng Neo Avenue Forest. Shortly later ensued by extensive rubber plantation (Figure 4-2A)
1925	Development of Singapore Island Country Club adjacent to Project Site in the east (Figure 4-2B)
1933	Development of Singapore Turf Club in middle of Project Site and clearance of surrounding land for supporting infrastructure, resulting in grassland habitat that persisted until at least 1950 (Figure 4-2C)
1940s	Introduction of fruit trees at Singapore Turf Club during Japanese Occupation
1975	Development of Pan-Island Expressway that cuts through Eng Neo Avenue Forest and separates the Project Site from CCNR, as well as sundry tree cultivation (Figure 4-2D)

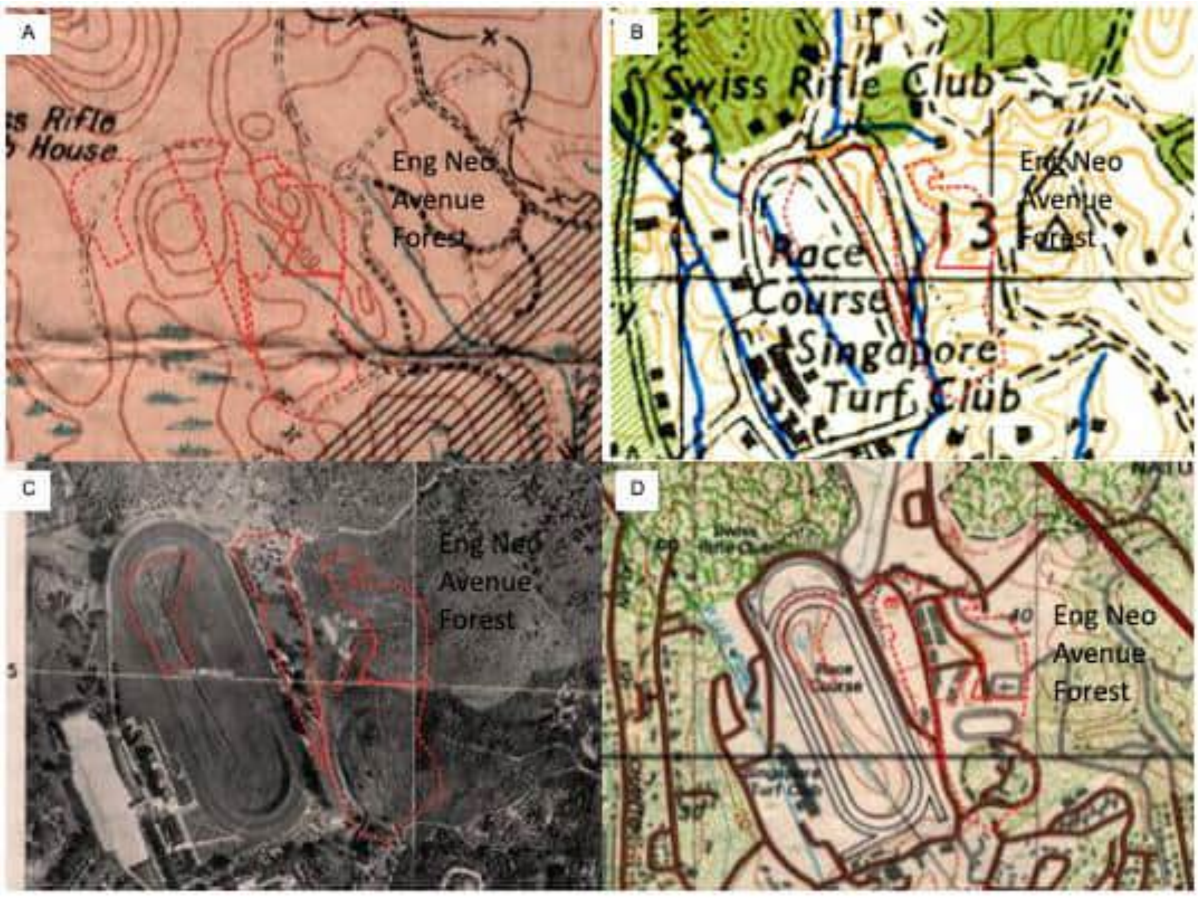


Figure 4-4 Maps showing chronological land use of the Project Site (bounded in red dashed line) in (A) 1914; (B) 1945; (C) 1950; (D) 1975. Source: National University of Singapore Libraries (2021).

4.4.2 Holland Plain: Sites IV and V near Clementi Forest

Between the 1920s and 1940s, present-day Clementi Forest and the Project Site at Holland Plain persisted as a rubber plantation that is presumed to have been abandoned during World War II (Neo et al., 2012). The Keretapi Tanah Melayu (KTM) railway, which commenced operations in the early 1930s and ran from Malaysia to Tanjong Pagar cut right through Clementi Forest and fragmented the Project Site (see Figure 4-5B). 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). Construction of the railway likely introduced large disturbance to both Clementi Forest and the Project Site. Development, in the form of low-density settlements, began to encroach onto both sites (Figure 4-5C).

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).

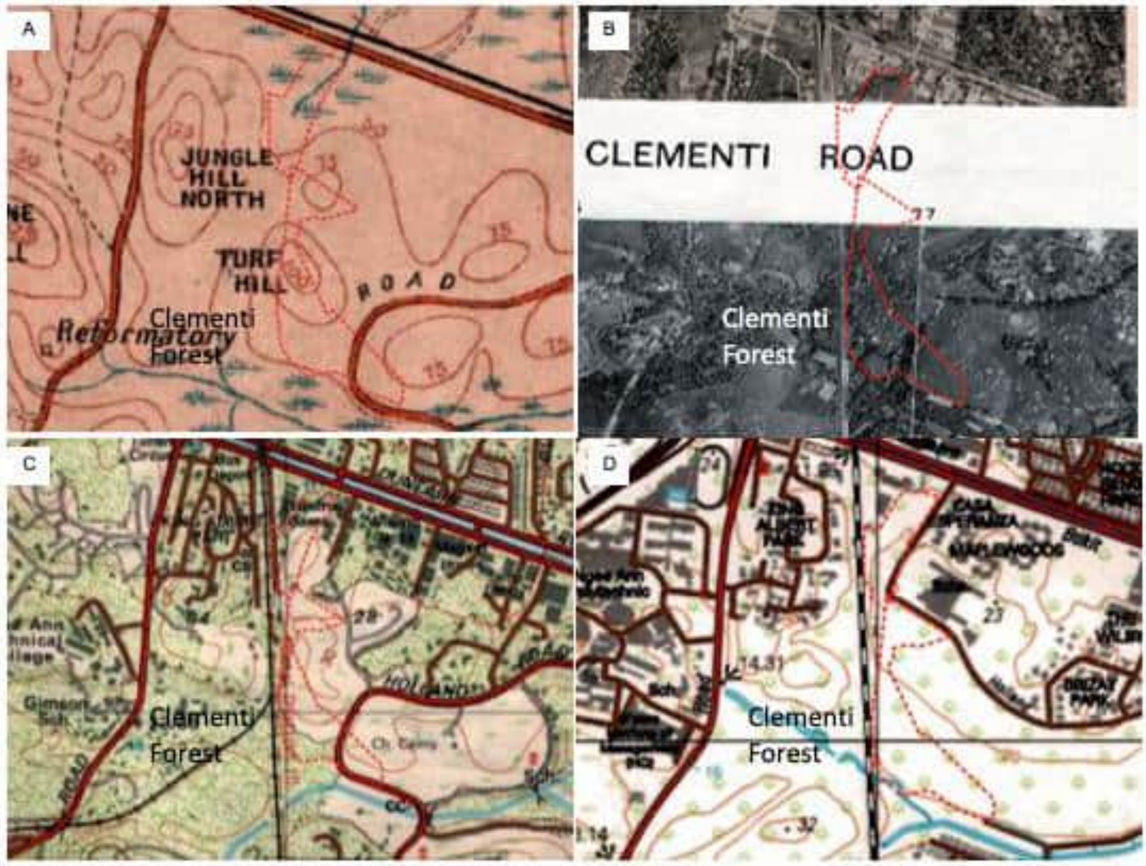


Figure 4-5 Topographical (A, C–D) and aerial (B) maps of Clementi Forest. (A) 1914; (B) 1950; (C) 1975, (D) 2005. Source: NUS Libraries (2019).

4.5 Heritage Features

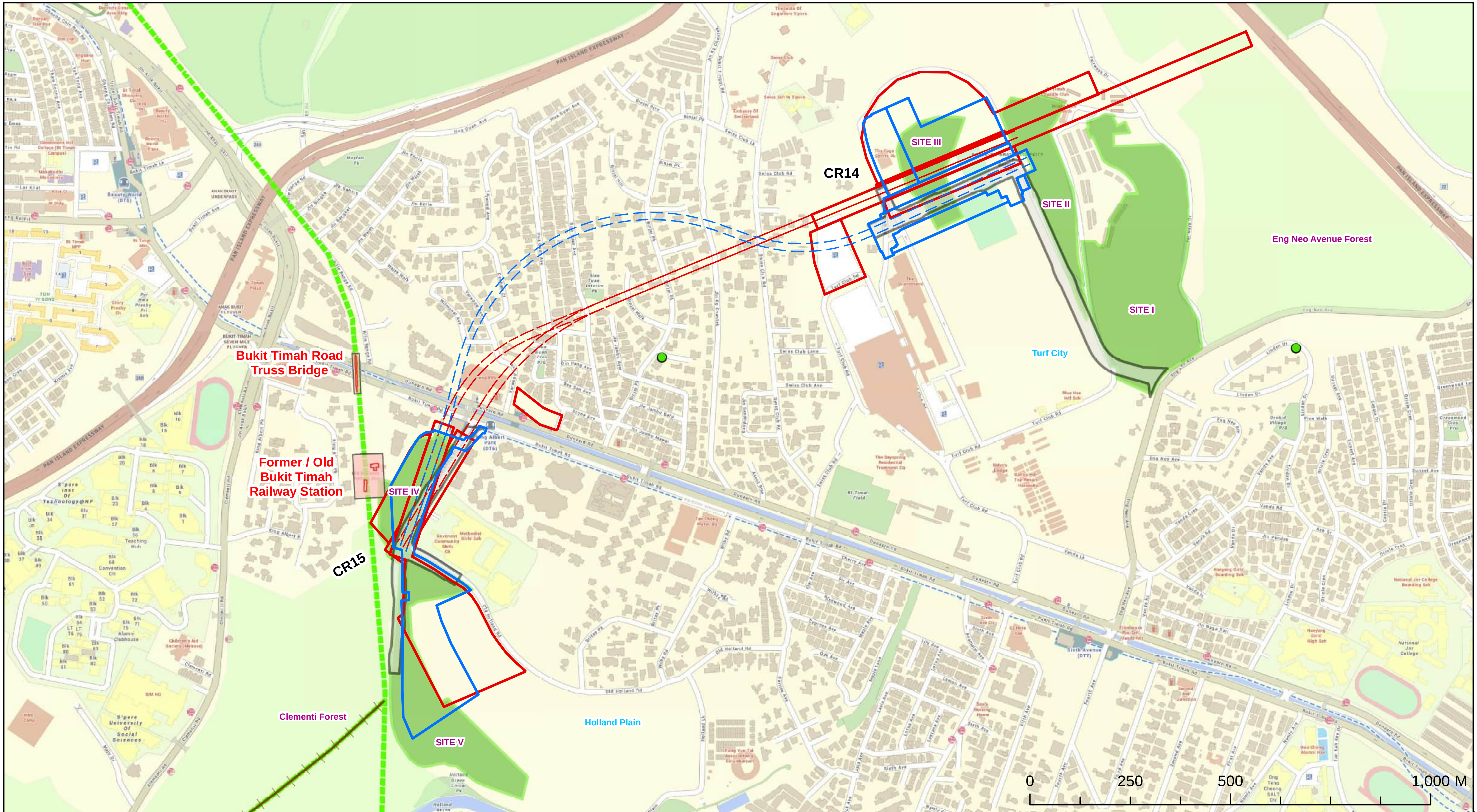
According to Singapore's Planning Act (Chapter 232) Section 9, *"any area of special architectural, historic, traditional or aesthetic interest"* can be designated as a conservation area, which may comprise of an area, a single building or a group of buildings. Any individual must not conduct any works 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-12] 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).

Based on the desktop review of heritage features via OneMap SG with sources contributed by NHB, there were no NHB-governed heritage features (i.e. museums, monuments, historical sites, heritage trees) found to be blocked or encroached by the Project footprint, as shown in Figure 4-6. The nearest NHB-governed heritage feature found is a heritage tree named *Mangifera caesia* (common name: Binjai) at Binjai Park Road, approximately 350m and 450m away from the CR15 base scenario and CR15 mitigated scenario worksites respectively.

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] as aligned with the identified Conservation Area in Section 4.3, there are two (2) Conserved Buildings/ Structures gazetted by URA situated around the Project footprint, as listed in Table 4-4 and indicated in Figure 4-6 Heritage Features around Project Footprint. Nonetheless, all heritage features including conserved buildings/ structures and heritage trees near the Project footprint will be preserved. Direct disturbance to heritage features is not anticipated for this Project.

Table 4-4 Heritage Features around Project Footprint

Heritage Features	Type	Description
Former/ Old Bukit Timah Railway Station (gazetted as Conserved Building by URA on 27 May 2011) [W-60, W-61, W-62]  *Source of Figure: URA Map (https://www.ura.gov.sg/maps/?service=conservation)*	Conserved Building/ Structure	This station is located approximately 10m to 30m away from the boundary of CR15 worksite. Its railway is connected as part of the Rail Corridor known by its rich heritage value and biodiversity resources. Originally, this station was constructed as one of the Singapore-Kranji Railway line (between Tank Road and Kranji) and started operation in 1903. Then it was re-built and started operation as one of the new Deviation line from Bukit Batok to Tanjong Pagar in 1932. It was designed as a simple brick building in the style of traditional small-town buildings which associated with 1-side platform and 3 tracks. This station was closed down on 1 July 2011, when Keretapi Tanah Melayu (KTM) the railway owner, a Malaysia-operated railway service company, ceased operations of this line in Singapore. Currently, other than heritage and biodiversity values, it was also featured as recreational and leisure venue accessible by public.
Bukit Timah Road Truss Bridge across Bukit Timah Road and Dunearn Road (gazetted as Conserved Structure by URA in 2015) [W-60, W-63]  *Source of Figure: URA Map* *(https://www.ura.gov.sg/maps/?service=conservation)*	Conserved Building/ Structure	This 45-m long railway bridge crosses Bukit Timah Road and Dunearn Road, locating approximately 160m away from the boundary of CR15 worksite. It was built as part of the re-aligned/ deviated former KTM railway line and opened in 1932, which lead further south towards the Former Bukit Timah Railway Station, therefore both are having similar historical background. This truss bridge was one of the three remaining steel truss bridges in Singapore. It was designed by United Engineers, one of the Singapore's pioneer engineering companies, demonstrating a high level of craftsmanship in the early 1900s. [W-64] Similar to Former Bukit Timah Railway Station, it is currently serving as recreational and leisure venue for the public as part of the Rail Corridor.
***Mangifera caesia* (Binjai)** Unique ID: HT 2003-86  *Source of Figure: NParks. Binjai. (https://www.nparks.gov.sg/gardens-parks-and-nature/heritage-trees/ht%202003-86)*	Heritage Tree	This heritage tree is located approximately 255m to 500m away from the CR15 worksite. It is native to Singapore and was found within grounds of House No. 32 at Binjai Park. It has a tree girth of 4.7m and tree height of 28m [W-93]. According to NParks, Binjai is a large tree of the mango family that grows up to 30m tall. Crown is dense and dome-shaped. Trunk is columnar, without buttresses, with greyish bark that exudes irritant sap. Leaves are large and leathery. Flowers are pinkish in colour. Flowering around April to June. Fruits are pale brown with rough skin, flesh is white and has a sour taste. The Binjai was commonly planted in villages for its brown potato-like fruits. [W-93] As per the preliminary design at the time of writing this report, the Project footprint is far away from this heritage tree, therefore not expect to be affecting it. Nonetheless, it should be noted in general that heritage trees shall be preserved as much as possible. In the event that heritage trees are to be removed, LTA shall consult NParks as per the *Guidelines on Greenery Provision and Tree Conservation for Development* [R-11].



Legend

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

Heritage Features [by NHB]

- Heritage Trees

Conservation Areas [by URA]

- Conserved Building/ Structure
- Conservation Areas [by URA]

Note:
Site I and II: Forested area adjacent to Fairway Quarters
Site III: Forested area within racecourse oval
Site IV: Forested area adjacent to Rail Corridor
Site V: Forested area at Holland Plain

Sources: *National Heritage Board (NHB) and Urban Redevelopment Authority (URA) as of 17th January 2022*

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

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ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :

HERITAGE FEATURES AROUND PROJECT FOOTPRINT

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ML	JAG	JAG	4 - 6	-	1 of 1

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Date: JULY 2022
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Note: Source of basemap - OneMap

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).

Sites I to III are adjacent to Eng Neo Avenue Forest and are located in close proximity to the BTNR and CCNR, providing important habitats for wildlife across the landscape (Figure 4-7). Although the sites are separated from the CCNR by the Pan-Island Expressway (PIE) to its east, volant species that may be able to cross the expressway and move between these patches.

Sites IV and V are contiguous with the adjacent Clementi Forest and are connected to the Bukit Timah Nature Reserve (BTNR) and Central Catchment Nature Reserve (CCNR) via Toh Tuck Woods and Bukit Batok Nature Park to its west (Figure 4-7) and the Old Jurong Railway Corridor. The Toh Tuck Woods is part of the Important Biodiversity and Bird Areas in Singapore (Singapore Bird Group, 2016). The 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. The Corridor links nodes of greenery between Woodlands in the north, as well as Jurong and Tanjong Pagar in the west and south of Singapore, respectively.

Located in proximity to the CCNR, a key biodiversity hotspot in Singapore, the Corridor allows opportunity for forest-dependent species to disperse from the reserves to nearby habitats thus contributing to their long-term viability (Ho et al., 2019).

Legend

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

Rev.	Date	By	Description	Chk'd	App'd
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LTA Endorsement : NA

Consultant : AECOM

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

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JW	JAG/NHT	JAG	4-7	-	1 of 1
	Drawn JW	Date JUL 2022	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 (CRL Phase 2) – CR2001*.

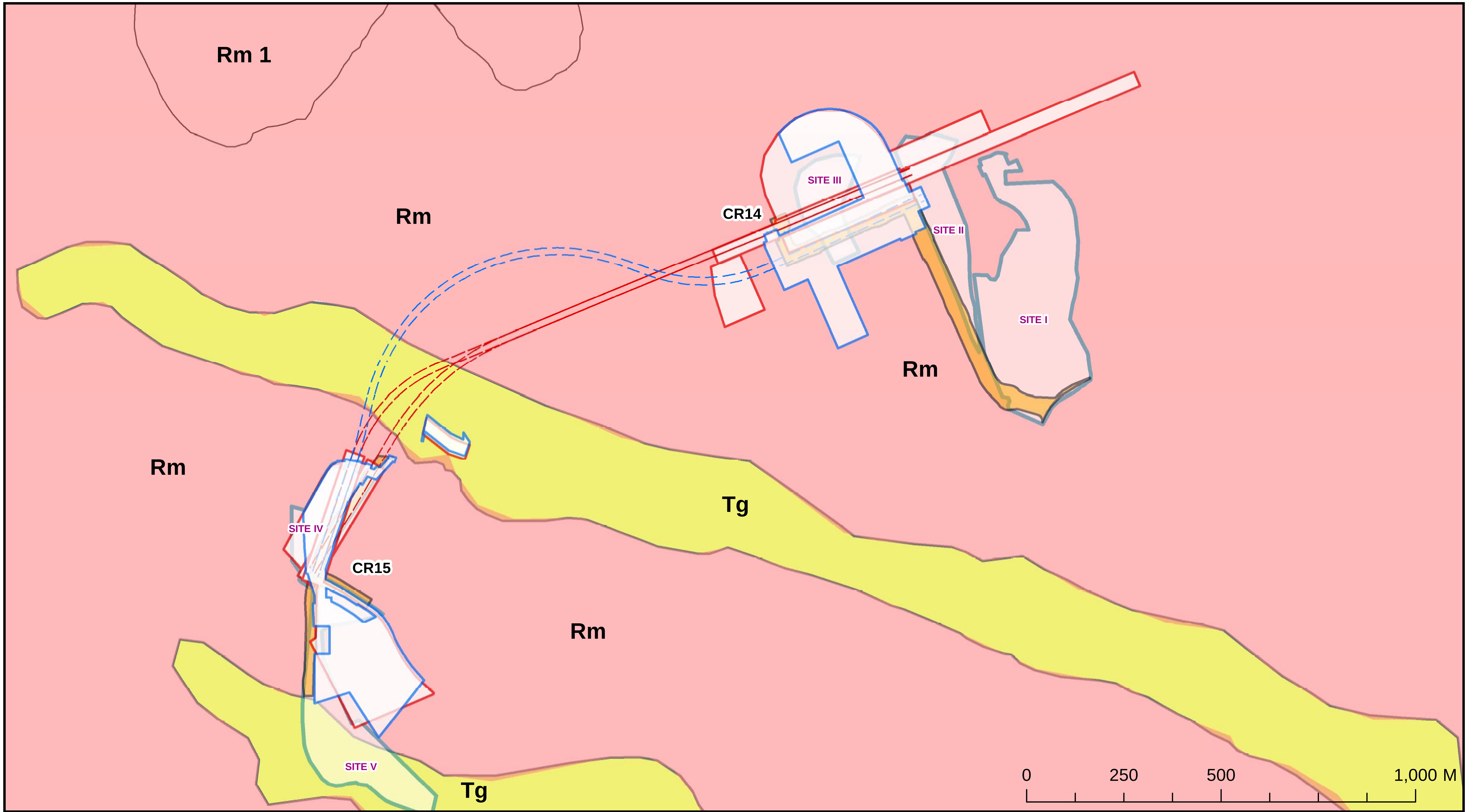
The geology of Singapore largely consists of three (3) formations: (i) igneous rocks of granitic composition (i.e., Bukit Timah Granite) in the central and northwest of Singapore, (ii) deposits of Tertiary to early mid-Pleistocene age (i.e., Old Alluvium) which masks older rock units located beneath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

Based on the CR2001 HLUS study and geology maps from DSTA, the local geological profile along the Project alignment is shown in Table 4-5 and Figure 4-8. It is mainly dominated by Bukit Timah Granite (Rengam Facies). Other than that, a small portion of Jurong Formation (Tengah Facies) is underlying the Project alignment at both sides of CR15 worksite.

Table 4-5 Geological Information in The Vicinity of Project

Formation	Composition	Occurrence within the Alignment and its vicinity
Bukit Timah Granite (Rengam Facies, Rengam Facies (red variant))	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. Underlying the segment of the alignment along Fairways Drive and Turf City. • The geological formation underlies the segment of the alignment: o Along Bukit Timah Road, Fairway Drive, Bukit Timah Saddle Club and Turf Club Road; and o Parallel to Pan Island Expressway and within Central Catchment Nature Reserve.
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, as well as the alignment at both sides of CR15 worksite. • The geological formation underlies the segment of the PES P1 alignment: o Residential area near King Albert Park MRT station along Dunearn Road o Empty land and forested area between Old Holland Road and Holland Green Linear Park, towards the direction of Clementi Road

Sources:
- *Historical Land Use Survey for the Advanced Engineering Study for Cross Island Line Phase 2 (CRL Phase 2) – CR2001.*
- *National Archives of Singapore*



Legend

- Proposed CRL Alignment (Base Scenario)
- Proposed CRL Alignment (Mitigated Scenario)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Study Area

Bukit Timah Granite
SOILS ON IGNEOUS ROCKS
- Rm — Rengam Facies
- Rm 1 — Rengam Facies (red variant)

Jurong Formation
SOILS ON ALLUVIUM
- Tg — Tengah Facies

N

Rev.	Date	By	Description	Chk'd	App'd
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Figure Title :
GEOLOGICAL MAP OF STUDY AREA

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Figure No. :	Rev.	Sheet
4-8	-	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - National Archives Singapore and OneMap

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 4-9, the proposed CR14 worksite will be located within the catchment area of Marina Reservoir, while the proposed CR15 worksite will be located within the catchment area of Pandan Reservoir. This indicates that the stormwater runoff within the Study Area is collected for drinking water purposes in these reservoirs. The detailed hydrology baseline information will be further discussed in Section 8.

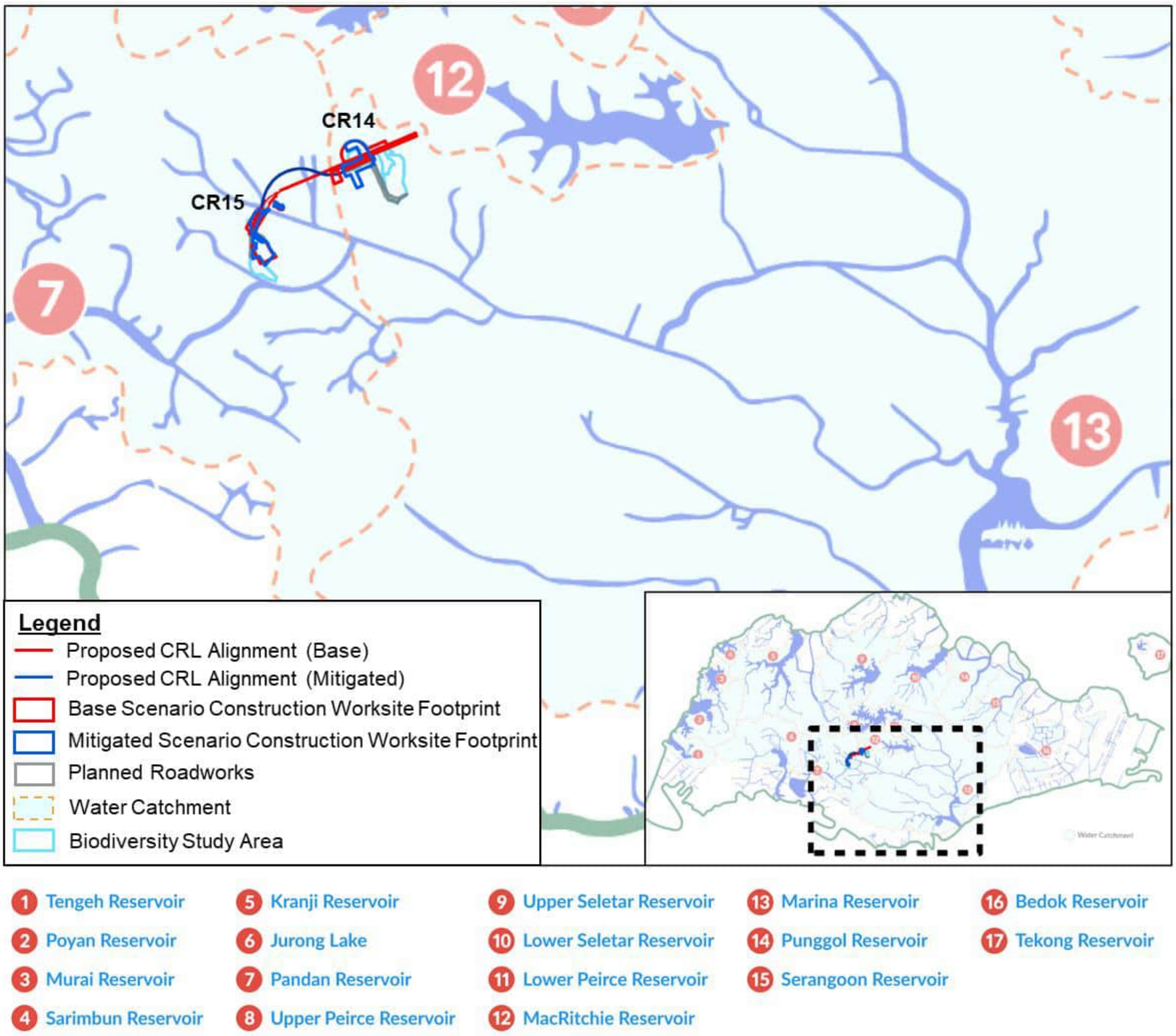


Figure 4-9 Singapore Water Catchment [W-19]

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-26]. The long-term mean annual rainfall total is 2534.4 mm when averaged across island-wide stations with long-term records [W-98]. 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 (refer to Figure 4-8) [W-99].

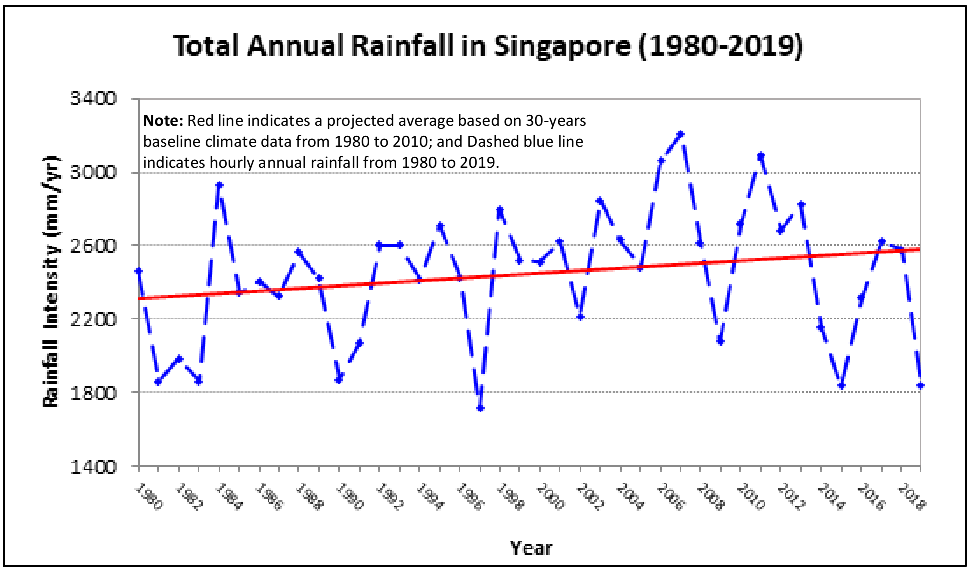


Figure 4-10 Annual rainfall total in Singapore from 1980 to 2019 (sourced from Meteorological Service Singapore [MSS] [W-99])

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 (Figure 4-9) [W-26]. 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-99].

Figure 4-11 Annual average rainfall spatial distribution (1981 - 2010) (sourced from MSS [W-26])

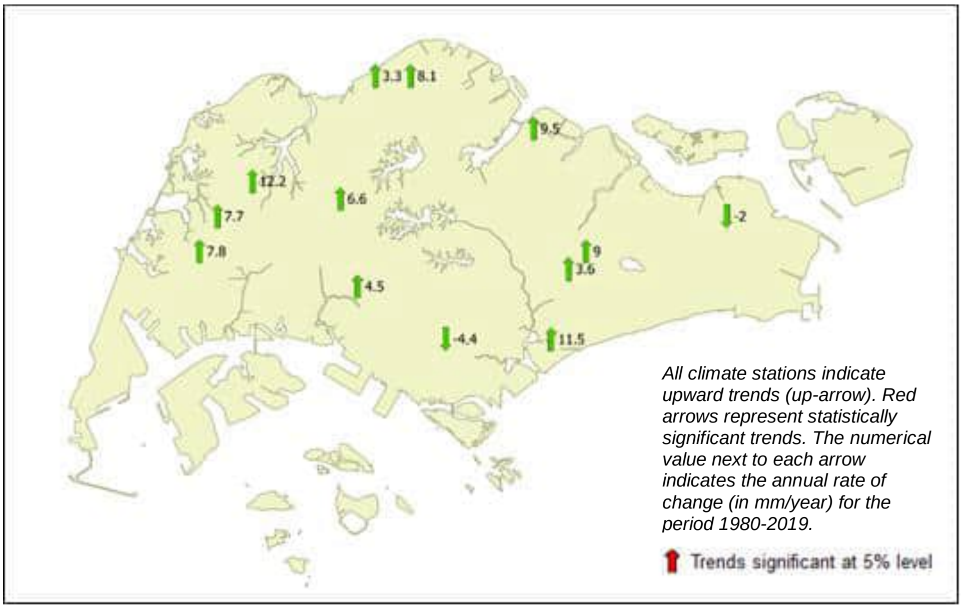


Figure 4-12 Past trends of annual rainfall total at indicative stations (1981-2019) [W-99]

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 rainy days (more than thirteen [13] days) and mean rainfall amount (more than 230 mm) from November to January every year (refer to Figure 4-11). The average rainfall in Singapore is approximately 230 mm and 180 mm during Northeast and Southwest Monsoon, respectively. Most months in 2021 had rainfall that was above average (refer to Figure 4-11).

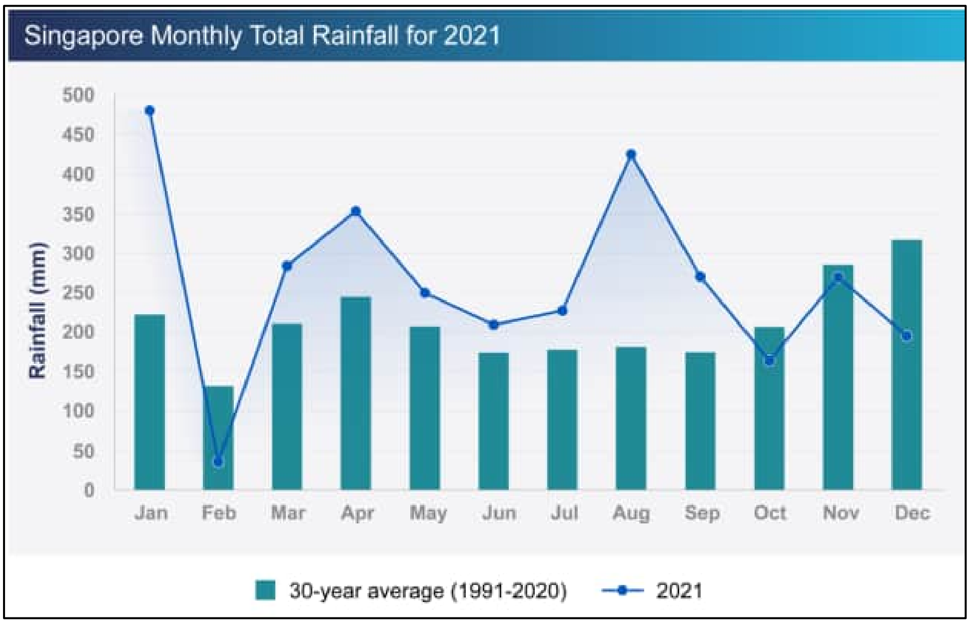


Figure 4-13 Monthly total rainfall in Singapore for 30-year average over island-wide stations with long-term records (bars, 1991 – 2020) compared to 2021 (solid line) (sourced from MSS [W-98])

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 (see Figure 4-12). 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.

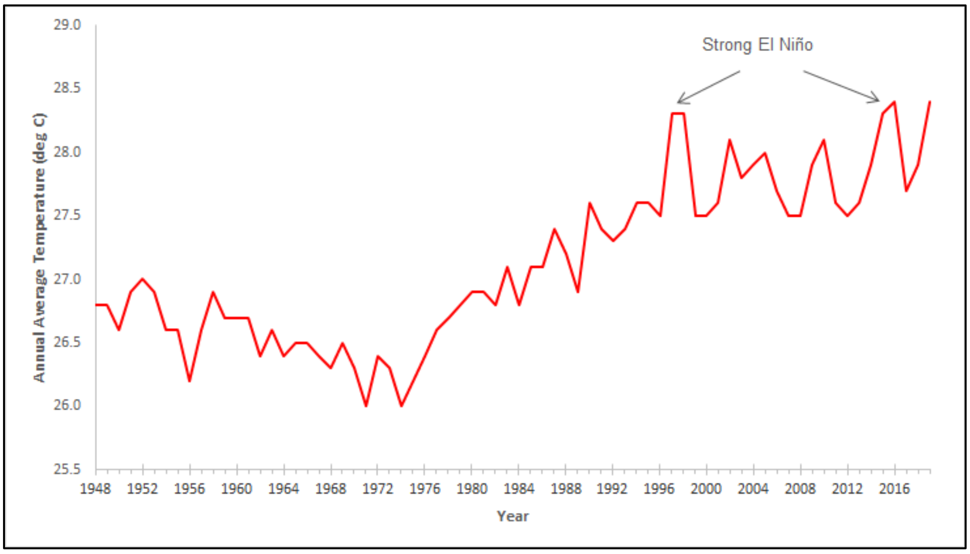


Figure 4-14 Annual mean temperature in Singapore from 1948 to 2019 (sourced from MSS [W-99])

Generally, the temperature variation throughout the year is relatively small as compared to the mid-latitude regions [W-100]. 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, though 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-98] as shown in figure below.

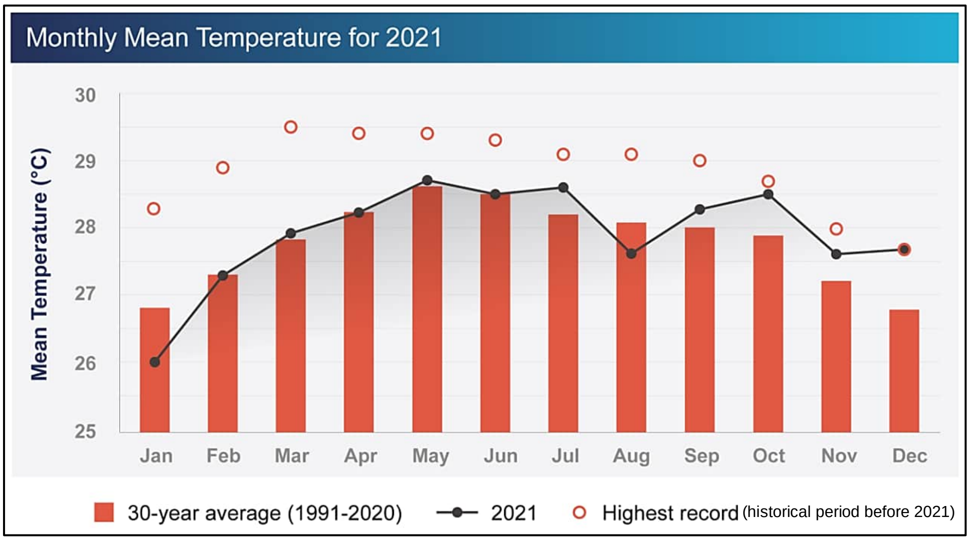


Figure 4-15 Singapore monthly mean temperature for 30-years average from Changi Climate Station with comparison to Year 2021 monthly mean temperature [W-98]

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-99]. This shows the presence of an Urban Heat 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 4-16, the daytime temperature in park areas is considerably lower compared to other type of land use areas [P-100].

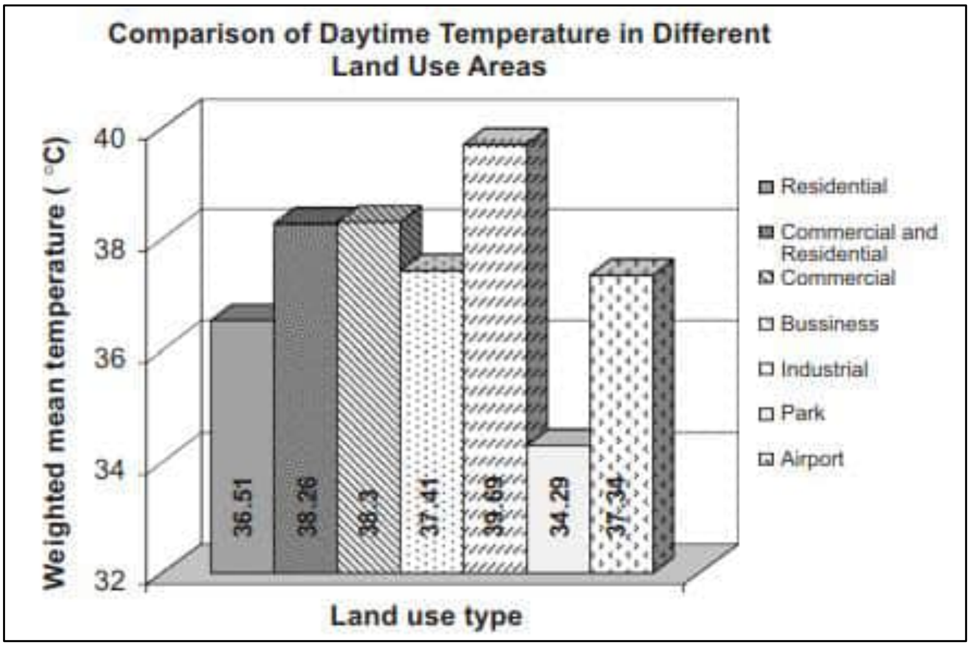


Figure 4-16 Comparison of daytime and night time temperature in different land use areas [P-100]

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 4-16). 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.

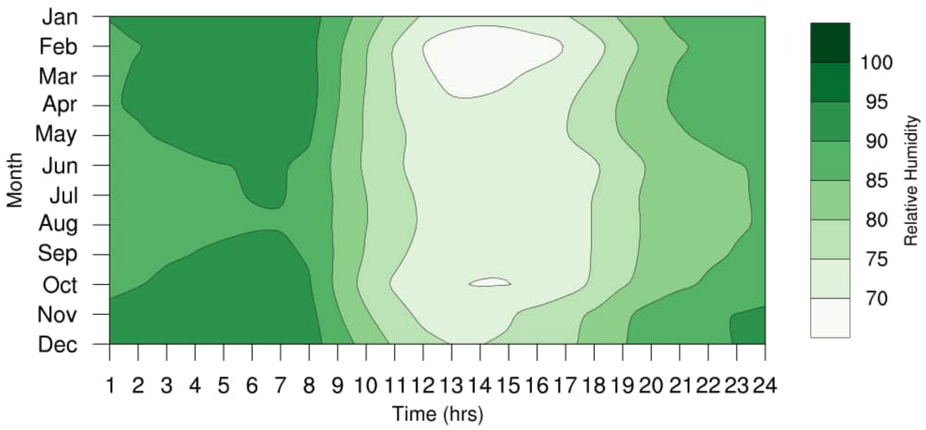


Figure 4-17 Hourly variation of relative humidity for each month from 1981 to 2010 (sourced from MSS W-26]

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 4-17, 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-26].

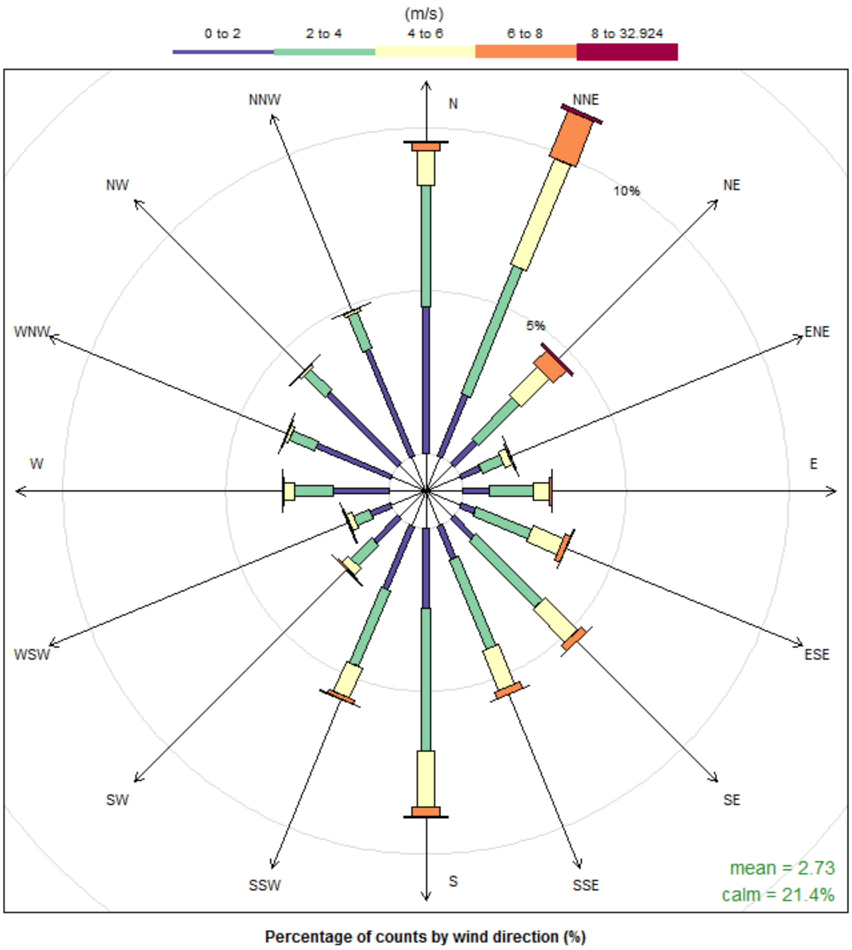


Figure 4-18 Annual Wind Rose of Singapore [W-26]

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

A review of applicable environmental legislations, policy frameworks, guidelines, plans, standards and criteria to the construction and operational phases of the whole project were reviewed 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-63]	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, 2020 [R-64]	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, 2020 [R-65]	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-66]	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-67]	Lists the areas designated as heritage road green buffers.
	Parks and Trees (Preservation of Trees) Order, 1998 [R-68]	Lists the designated tree conservation areas No cutting or damaging of tree having girth of more than one metre.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	The Singapore Red Data Book (SRDB) [P-21]	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-61]	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-70]	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	Environmental Protection and Management Act, 2020 [R-14]	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-8]	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.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-27]	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.
	Sewerage and Drainage Act, 2001 [R-24]	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.
	Sewerage and Drainage (Trade Effluent) Regulations, 2007 [R-26]	Regulates trade effluent discharge into public sewerage system.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-25]	Regulates measures to be implemented to protect the stormwater drainage system.
	PUB Code of Practice on Surface Water Drainage, 2013 [R-23]	Provides guidelines for measures to be implemented to protect the stormwater drainage system and manage surface water drainage (e.g. development

Environmental Parameter	**Applicable Legislations/ Guidelines/ Policy Frameworks**	**Key Points**
		and implementation of an Earth Control Measures (ECM) plan).
	LTA General Specification - Appendix A, Safety, Health and Environment, August 2019 Edition [R-9]	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-24]	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 run-off discharges from the sites.
	Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life, New York and Geneva UNECE (1994) [R-20]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Water Quality Requirements WHO (n.d.) [R-22]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Water Quality Standards Handbook USEPA (2017) [R-21]	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-28]	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-29]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ) [R-18]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	National Water Quality Standards for Malaysia (DOE) [R-30]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
Chemical Substances (Surface water and soil and groundwater quality sections)	Environmental Protection and Management (Hazardous Substances) Regulations, 2008 [R-32]	Regulates the transport, use and storage of hazardous substances.
Fire Safety (Surface water and soil and	Fire Safety Act, 2013 [R-33]	Makes provisions for fire safety and for matters connected therewith.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
groundwater quality sections)	Fire Safety (Petroleum and Flammable Materials) Regulations, 2008 [R-34]	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-35]	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-14]	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-8]	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-27]	Regulates the discharge of trade effluent into any watercourse or onto land.
	Sewerage and Drainage Act, 2001 [R-24]	Regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-26]	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-31]	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-42]	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-8]	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-36]	Regulates the storage, handling and disposal of wastes.
	Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 [R-37]	Regulates the storage, collection and disposal of toxic industrial waste.

Environmental Parameter	**Applicable Legislations/ Guidelines/ Policy Frameworks**	**Key Points**
	Environmental Public Health (General Waste Collection) Regulations, 2000 [R-38]	Regulates general waste (incinerable and non-incinerable waste) disposal.
	Hazardous Waste (Control of Export, Import & Transit) Regulations 1998 [R-39]	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-40]	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-41]	This code provides guidance on best practice measures for managing hazardous waste on site.
	Code of Practice for Licenced General Waste Collector [R-43]	This code provides list of wastes allowed to be collected by various licenced collector types.
	NEA circulars on import and export of waste [W-23]	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-14]	Provides standards and regulations on air impurities.
	Environmental Protection and Management (Air Impurities) Regulations 2015 [R-45]	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets) [W-18]	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-46]	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.

Environmental Parameter	**Applicable Legislations/ Guidelines/ Policy Frameworks**	**Key Points**
	UK Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction [R-47]	The document provides guidance for developers, their consultants and environmental health practitioners on how to undertake a construction impact assessment (including demolition and earthworks).
Airborne Noise	SS 593: Code of Practice for Pollution Control (COPPC), 2013 [R-8]	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-58]	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-52]	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-10]	"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-57]	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 [R-59]	This part of BS 6472 gives guidance on human exposure to vibration induced by the blast (rock breaking and excavation works) in buildings. It is used for assessing other forms of vibration that are caused by rock breaking and excavation works, including when MICs are utilised in civil engineering works and in demolition activity.
	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 reference. In undertaking this EIS, AECOM generally relies on a qualitative assessment of the various disturbance sources that particular receptors are likely to encounter and focus on the factors that are 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 Legislations, Guidelines and Policy Frameworks for Operational Phase

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	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-14]	Provides standards and regulations on air impurities
	Environmental Protection and Management (Air Impurities) Regulations 2015 [R-45]	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets) [W-18]	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-48]	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-54]	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 sensitive premises are set by the National Environment Agency (NEA).

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	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-53]	Legislative requirements for boundary noise due to noise emissions from mechanical ventilation systems for non-industrial buildings.
	Biodiversity 2020 (UK) [R-10]	"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 6.2.1);
  - 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
  - Impact mitigation, monitoring and management plan (Section 6.5).

6.2 Scoping of Project

Referring to the Inception Report Rev B [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 be applicable to ecologically sensitive receptors which are located outdoor. Therefore ground-borne noise during both construction and operational phases are not included in the scope of work of this EIS report. In addition, it should be noted that the operational impact of ground-borne vibration from train operation addressed in this EIS takes reference from the results of a separate study for the impacts from train operation by 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] Waterbody usage will be determined based on the PUB Water Catchment Map [W-25].
[2] The receptor sensitivity of surface watercourses will be determined based on the biodiversity baseline survey results which will identify whether such surface watercourses 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] (Excluding Ground-borne Noise as it is only applicable inside building)	Fauna species and habitats of high sensitivity towards ground-borne vibration and are of Conservation Significance. Species that inhabit the ground or aquatic environments and live-in burrows and/or caves will be more badly impacted by anthropogenic vibrations.	Fauna species and habitats that are less affected by ground-borne vibration and are of Conservation Significance.	Fauna species and habitats that 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 Projects 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> Sites I, II and III: 12 Jul, 28 Jul, 12 Oct 2021 Sites IV and V: 21 Jul, 22 Jul 2021 <u>Sampling dates:</u> Sites I, II and III: 14 Sep 2021 – 23 May 2022 Sites IV and V: 4 Oct 2021 – 25 Feb 2022 <u>Camera Trapping dates:</u> Sites I, II and III: 24 Sep 2021 – 11 Jan 2022 Sites IV and V: 1 Oct 2021 – 11 Jan 2022

[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 blasting 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
Hydrology and Surface Water Quality	Site reconnaissance survey: 4 November 2019 6 November 2019 11 November 2019 Sampling dates: 4 February 2020 (dry weather sampling) 5 February 2020 (dry weather sampling) 17 March 2020 (dry weather sampling) 13 August 2020 (wet weather sampling) 3 September 2020 (wet weather sampling) 16 November 2021 (dry weather sampling) 26 November 2021 (dry weather sampling) 30 December 2021 (wet weather sampling) 11 April 2022 (wet weather sampling) 6 May 2022 (dry weather sampling) 16 June 2022 (dry weather sampling)
Soil and Groundwater	Soil Investigation Studies (carried out by LTA): June 2015 – July 2015 [R-74] March 2016 – October 2016 [R-77] Aug 2016 – October 2016 [R-78] September 2017 – October 2017 [R-75] July 2019 – August 2019 [R-79] Soil and Groundwater baseline studies (carried out by LTA): January 2021 – February 2021 [R-76] December 2020 – March 2021 [R-71]
Air Quality	Site reconnaissance survey: 5 – 6 November 2019 25 March 2020 17 June 2020 28 June 2022 Sampling dates: Methodist Girls' School: 25 February – 3 March 2020 In the vicinity of Site V: 6 – 13 July 2022
Airborne Noise	Site reconnaissance survey: 5 – 6 November 2019 11 February 2020 Sampling dates: Methodist Girls School: 24 February – 02 March 2020 The Sterling Condominium: 24 February – 02 March 2020 Landed housing along Hua Guan Avenue: 29 January – 05 February 2020 Swiss School in Singapore: 24 February – 02 March 2020 Within Eng Neo Avenue Forest: 29 January – 05 February 2020 Within Site I: 13 September – 19 September 2021 Within Site II: 13 September – 19 September 2021 Within Site IV: 23 June – 30 June 2022

Environmental Parameter	Site Visits
	Within Site V: 24 September – 30 September 2021
Ground-borne Vibration	Sampling dates: Site I: 01 July 2022 - 08 July 2022 Site III: 01 July 2022 - 08 July 2022 South of Site V: 23 June 2022 - 30 Jun 2022 North of Site V: 23 June 2022 - 30 Jun 2022

Further information on sample collection and survey locations and parameters is provided in Section 7 (Biodiversity), Section 7 (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 carried out within or in the vicinity of the study area (e.g. tree surveys, ecological surveys, etc) for this Project, and/or from other project(s) permitted by the Client and the respective project owner for reference purposes (i.e. environmental baseline study of a concurrent study carried out by AECOM in the vicinity);
- Secondary air monitoring data from **other concurrent study carried out by AECOM in the vicinity**
- 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 7 (Hydrology and Surface Water Quality), Section 9 (Soil and Groundwater), Section 10 (Air Quality), Section 11 (Airborne Noise) and Section 12 (Ground-borne Vibration).

6.4 Assessment Criteria

6.4.1 Prediction of Impacts

Key potential environmental impacts arising from the Projects' 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	Assessment criteria broadly take guidance from Hong Kong	Section 7

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (if any).	Environmental Impact Assessment Ordinance - Technical Memorandum Annex 8, with considerations from literature review and local biodiversity standards.	
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, 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.	Environmental Protection and Management (Trade Effluent) regulations [R-27]; and, Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-20], World Health Organization [R-22], United States Environmental Protection Agency [R-21], Philippines [R-18], Australian and New Zealand Environment and Conservation Council (ANZECC) [R-28], Canadian Council of Ministers of the Environment [R-29], and Department of Environment in Malaysia (DOE) [R-30].	Section 7
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 reports [R-4, R-5] and previously carried out soil and/ or groundwater.	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 will be 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	**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	Section 12

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	using BS 5228-2:2009+A1:2014 and Esvelt equation; Ground-borne vibration induced by rock breaking and excavation predicted using the formulae in BS 6472-2-2008 and an empirical vibration prediction equation. Empirical vibration prediction equation (from LTA Contract T207) was also included to provide a local context; and, If construction activities are not included in the BS 5228-2:2009+A1:2014 empirical relationships, alternative data were used. This comprises either case history data from BS 5228-2:2009+A1:2014 or AECOM's database.	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 vibration does not exceed the implemented threshold of PPV 8 mm/s at Turf City and Holland Plain. **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.	
Note: * Frequency of vibration source has not been considered in the detailed assessment. Please see section 12.2.2 for details.			

Table 6-4 Methodology for Prediction of Operation Impacts

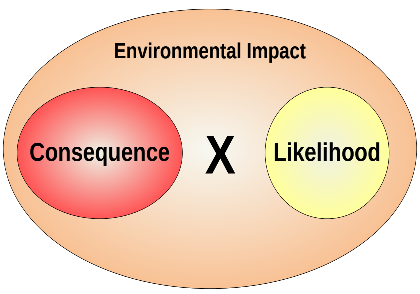
Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
Biodiversity	**Qualitative** assessment to evaluate the impacts of operational activities on key biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (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	Environmental Protection and Management (Trade Effluent) regulations [R-27]; Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-20], World Health Organization [R-22], United States Environmental Protection Agency [R-21], Philippines [R-18], Australian and	Section 7

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	discharge or 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.	New Zealand Environment and Conservation Council (ANZECC) [R-28], Canadian Council of Ministers of the Environment [R-29], and Department of Environment in Malaysia (DOE) [R-30].	
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 reports [R-4, R-5] and previously carried out soil and/ or groundwater studies.	Section 9
Air Quality	**Qualitative** assessment will be 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 will be 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: * Frequency of vibration source has not been considered in the detailed assessment. 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 Projects' 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 • Changes are reversible with mitigation measures	• 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**
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 exceeds regulatory limits by hazardous levels for the habitat/ conservation species.
Soil, Groundwater (Construction and Operation)	None of the construction activities identified will cause contamination on site.	Small scale localised contamination which is not likely to extend beyond the construction worksite areas and possible to remediate.	Medium scale contamination which is likely to extend beyond the construction worksite areas but possible to remediate within the construction period timeframe.	Large scale contamination which is likely to extend beyond the construction worksite areas and may require large scale remediation.
Air Quality (Construction Phase)[5]	-	For Earthworks: • Total site area <2 ,500 m^2 • 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 m^2 • 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 • Construction material with low potential for dust release (e.g. metal cladding or timber)	For Construction: • Total building volume 25,000-100,000 m^3 • Potentially dusty construction material (e.g. concrete) • On-site concrete batching	For Construction: • Total building volume >100,000 m^3 • On-site concrete batching • sandblasting
	-	For Trackout: • <10 HDV[6] (>3.5t) outward movements in any one day	For Trackout: • 10-50 HDV[6] (>3.5t) outward movements in any one day	For Trackout: • >50 HDV[6] (>3.5t) outward movements in any one day

[5] This impact intensity criterion is equivalent to the Emission Magnitude as defined in IAQM's Guidance [R-9].
[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
		• Surface material with low potential for dust release • Unpaved road length <50 m	• Moderately dusty surface material (e.g. high clay content) • Unpaved road length 50-100 m	• 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)	No detectable change to flora, fauna and habitats. Predicted noise level at receptors are within the corrected baseline criteria.	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 criteria of up to 4 - 6 dB(A).	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).
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 1, 2 and 3 below			

Environmental Parameters	Impact Intensity Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
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				

A consequence category is then derived based on receptor sensitivity and impact intensity, as shown in Table 6-6. The air quality impact assessment uses matrices specific to the Institute of Air Quality Management (IAQM) Guidance on the assessment of dust from demolition and construction [R-47] and these are provided 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.

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.

Likelihood Criteria	Definition for All Environmental Parameters	Definition for Quantitative Evaluation (Construction & Operational)
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:
- Ecological Impact Assessment (EcIA). EIANZ Guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. May 2018. [R-15]
- CIEEM (2018). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018. [R-16]

6.4.2.3 Significance of Impact

The significance of each impact will be determined by assessing the impact consequence against the likelihood of the impact occurring using the Impact Significance Assessment Matrix. A simple risk-based matrix will be 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 shall 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 shall 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 will be 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 minimization 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 adopted for the Biodiversity Impact Assessment of the EIS.

An EMMP will be 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 will be 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.

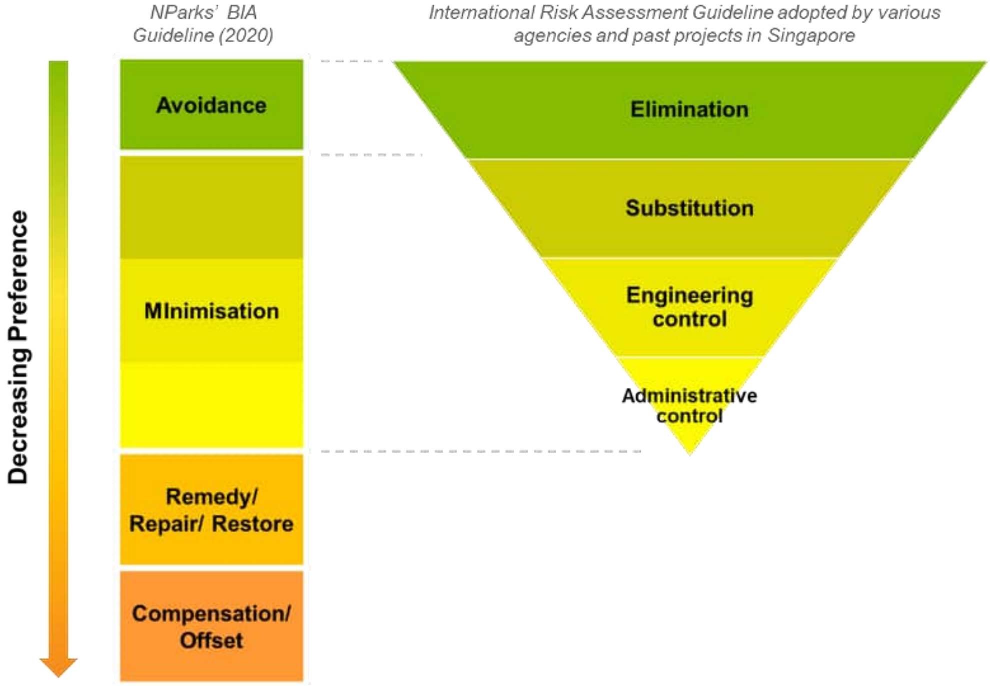


Figure 6-1 Mitigation Hierarchy