Contract CR2005
Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Windsor & Eng Neo Avenue Forest) Final Report

Study Stage: Final

Volume 1 of 5

Submitted by:
AECOM Singapore Pte Ltd

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Abbreviations

Acronym	Definition
ABC	Active, Beautiful, Clean
AECOM	AECOM Singapore Pte. Ltd.
ALS	ALS Technichem (S) Pte. Ltd.
APCP	Air Pollution Control Plan
ASR	Air sensitive receptor
AVA	Agri-Food and Veterinary Authority of Singapore
BCA	Building Construction Authority
BIOME	NParks BIOME Biodiversity and Environment Database System
BOD_5	Biochemical Oxygen Demand
BS	British Standard
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

Acronym	Definition
VES	Visual Encounter Survey
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
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.
Biodiversity Study Area or Study Area (Biodiversity)	Forested area identified in the vicinity of the Project to be studied for its biodiversity value as defined by LTA for the purpose of this EIS (i.e. Windsor, Eng Neo Avenue Forest, Site I and II [forested area adjacent to Fairways Quarters]).
dB(A)	A-weighted sound pressure levels (dB) – weighted to human hearing frequencies
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
Emission Sources (Air Section)	Sources of air emissions for different activities such as earthworks, construction, trackout and demolition
Entire alignment	Station cut and cover area, construction worksite area, underground tunnels, tunnel portals, viaduct, and ventilation shafts (vent shafts)
Exotic Species	Plant or animal species introduced into an area where they do not occur naturally, non-native species.
Ex-situ	Testing is carried out offsite, or away from the natural location.

Term	Explanation
Ground Absorption Factor *Ref: SoundPLAN*	This factor is given to describe the noise propagation with respect to ground effect. For example, G = 0 describes a 100% hard ground such as asphalt, water or industrial sites; G=1 describes 100% soft ground such as fields, forests or grass
Airborne Noise	Sound that is transmitted by the air e.g. speech. The term airborne noise and noise are used interchangeably in this report and mean the same
Heavy Duty Vehicle	Heavy duty vehicles defined as vehicles with a gross weight greater than 3.5 tonnes
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-82, W-83, W-84, W-85]
Hydrology	The study concerned with the properties of the earth's water, and especially its movement in relation to land.
In-situ	Testing is carried out in the original place
ISO 9613-2:1996	Is the standard describing "Acoustics – Attenuation of sound during propagation outdoors – Part 2 : General method of calculation"
LAeq (1 hour)	Equivalent noise levels, averaged over a 1 - hour time period
LAeq (12 hours)	Equivalent noise levels, averaged over a 12 - hour time period
LAeq (5 mins)	Equivalent noise levels, averaged over a 5 - mins time period
Mitigated Scenario/ Mitigated Case	This scenario/ case represents the latest optimised worksites at the time of writing this report. It includes the incorporation of feedbacks from various environmental disciplines on the design and the usual design evolvement over time, as appropriate.
Non-metric Multidimensional Scaling (NMDS) Ordination	A way of visualising the level of similarity of individual cases of a data set. In this report, NMDS is used to compare the forest quality of the Study Area to the forest quality of the Central Catchment Nature Reserve.
Non-volant Mammals	Non-flying mammals, i.e. all mammals in Singapore, excluding bats
Northern Forest Fragment	Forest patch located north of Island Club Road near Singapore Island Country Club (Island location)
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.
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. A1-W1 worksite of 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 Fairways Quarters
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.

Term	Explanation
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 to 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.
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 Fairways 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.
Windsor	An area comprising of Windsor Nature Park and the Northern Forest Fragment near A1-W1 along Island Club Road
Windsor Nature Park	A designated nature park by NParks located south / southeast of Island Club Road (*Windsor Nature Parks, NParks*)

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 (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* (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, PUB) 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.

The objective of this **EIS report** is to conduct environmental impact study on the construction and operation of the railway line in the vicinity of the following forested areas identified: Windsor (part of Windsor Nature Park and the connected northern forest fragment, refer to Figure 3-1), Eng Neo Avenue Forest (between PIE and Fairways Drive), as well as Sites I and II (area adjacent to Fairways Quarters). The scope of CRL2 works considered includes construction worksites from Turf City to Bright Hill (see Table 2-1). The planning for the entire CRL2 alignment is still ongoing and separate EIS reports for the other CRL2 worksites in the vicinity of ecologically sensitive areas will be published. The original CRL2 location and construction worksites (i.e. A1-W2 launch shaft or FB5, A1-W1 facility building or FB4, Worksite at Peirce Secondary School, CR13 retrieval shaft at Bright Hill Station) are demonstrated in Figure 3-1 and Figure 3-2 as the base plan. The indicative operational footprint of A1-W2 and A1-W1 are demonstrated from Figure 3-5 to Figure 3-6.

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 as inputs to the design, which shall be discussed and then re-evaluated when the design incorporates/ develops/ changes at later stage of this Project.

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.

Generally, the construction activities of this Project include pre-construction activities and main construction activities. Pre-construction activities may require site clearance, traffic and utility diversion works, temporary worksite establishment, and monitoring instruments installation, while main construction activities could have ground improvement works, shaft construction with rock breaking and excavation works at both A1-W1 and A1-W2 worksites, underpinning works the Worksite at Peirce Secondary School, tunnelling with Tunnel Boring Machine (TBM) launching at A1-W2 launch shaft worksite towards CR13 retrieval shaft worksite (towards northeast direction), and construction of permanent structures like facility building at A1-W2.

It shall be noted that only CR13 TBM retrieval work is covered under this Project (CRL2), while other activities associated with CR13 retrieval shaft and Bright Hill Station such as shaft construction and excavation works, etc. are under a separate contract of CRL1.

It is noted that there are no stations located within the section of the alignment under this EIS, however, all Project components including station-associated construction and operational activities will still be discussed in general for the comprehensiveness of the study in this report.

Design Optimisation for Construction Worksites

Throughout the Project, various design optimisations were conducted and discussed with AECOM to take into considerations of reducing environmental impacts. One of those that is worth mentioning was the optimisation of A1-W1 worksite where construction footprint was reduced from approximately 15,000 m^2 to 7,000 m^2 with the purpose to mitigate the environmental impacts and allow ecological connectivity from Northern Forest Fragment to Windsor Nature Park. Besides, the original A1-W2 worksite, which was planned in the ecologically-sensitive Eng Neo Avenue Forest during Inception stage, has now been relocated outside of the Eng Neo Avenue Forest to existing less vegetated areas near Turf Club Road and Fairways Drive, including an existing sports field at Turf Club Road and another existing area of managed vegetation within Bukit Timah Saddle Club (see Figure 3-3). Apart from the base scenarios, all these design optimisation measures were assessed as mitigated scenarios in this report.

Summary of Impact Assessment

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

Other key developments identified in the vicinity of the Project have also been studied. As mentioned in Section 3.4.1 and Figure 3-42, there are three (3) major developments identified nearby where their construction activities might occur concurrently with this Project, including: CRL2-CR14 (CR14) at Turf Club Road; PUB BKSR water pipeline works in Windsor; as well as the CR13 excavation and shaft construction works. Quantitative cumulative airborne noise impact assessment was undertaken for these concurrent developments where data was available, and qualitative cumulative impact assessments were otherwise undertaken for all aspects to capture overall impacts to the environment in these areas.

The findings of the environmental impact assessment in this report are summarised as follows:

Biodiversity

The documentation of biodiversity baseline, assessment of impacts and the recommendations of mitigating measures aims to reduce the impacts of the proposed development and set out mitigating measures that will achieve the best conservation outcome for the development. Cumulative impacts from concurrent developments in the vicinity were also qualitatively assessed to ensure that the impacts from these developments are considered. Field surveys were conducted over an eight-month period (November 2019 – March 2020; June 2020 – August 2020) to cover all known vegetation and habitat types, and to generate the floral and faunal baseline findings that are reflective of the two main Study Areas (i.e. Windsor and Eng Neo Avenue Forest).

A total of five different vegetation types with more than 500 floral and faunal species were recorded in two Study Areas. Out of the Study Areas, Eng Neo Avenue Forest contained more floral and faunal species than expected. Many of the floral species found in Eng Neo Avenue Forest can only be found in the CCNR (Wong et al., 1994) and are considered to be less commonly encountered in Singapore. Many of these species are associated with older forests e.g. Nee Soon Swamp Forest (considered a sensitive habitat in Singapore). Faunal surveys at Eng Neo Avenue Forest also recorded species previously thought to be confined to CCNR. The range and rarity of the flora and fauna species found within Eng Neo Avenue Forest suggests that the forest fragment continues to retain part of its complex biodiversity even after the PIE fragments it from the core CCNR more than 20 years ago. Similarly, Windsor also had records of species such as the nationally Vulnerable gold-ringed cat snake (*Boiga dendrophila*) and globally threatened Sunda slow loris (*Nycticebus coucang*) that are mostly restricted to CCNR. This is expected due to the contiguity of the Study Area within the CCNR, where Windsor Nature Park directly abuts CCNR.

The generated baseline results were used to determine areas of high conservation value. Impact assessment was also conducted to evaluate the impact of construction and operational works. Both Eng Neo Avenue Forest and Windsor will be impacted, as the proposed works will involve some vegetation loss and impairment of ecological connection. However, waterbodies including freshwater streams should not be affected by the proposed worksites.

Through the efforts of the designers, engineers, client and Nature Groups, footprints of construction were adjusted away from areas of high conservation value within each Study Area and this has resulted in significant reduction in impact at Windsor and Eng Neo Avenue Forest.

Efforts to adjust footprints and reduce working space have also resulted in a significant reduction in need to clear forested areas at Eng Neo Avenue Forest, downgrading its impact to **Negligible**, while impact in Windsor is still **Moderate to Major** due to its close proximity to the worksite.

There were no concurrent developments assessed for Eng Neo Avenue Forest. One concurrent development was assessed for Windsor, resulting in significant cumulative impacts during the construction phase. While during operational phase, cumulative impacts were assessed to be insignificance.

It is also worthy to note that the Nature Groups were engaged throughout the process and were satisfied with the outcomes. As both Study Areas abut the sensitive forested sites and have the potential to disrupt fauna movement, a robust EMMP has been detailed to specifically attempt to reduce the expected impacts at these Study Areas.

Following the decision to shift the worksite at Eng Neo Avenue Forest into an adjacent forested area (Sites I and II), field surveys were conducted over four months from September 2021 – December 2021) to cover all known vegetation and habitat types, and to generate the floral and faunal baseline findings at this new Study Area.

Sites I and II are characterised by five vegetation types with 270 floral and 165 faunal species recorded. More than half of the floristic assemblage is native, with many of the species found in the native-dominated secondary forest in the Sites I and II also found in the CCNR and less commonly encountered in other secondary forests in Singapore.

Due to the shift of the worksite at Eng Neo Avenue Forest into Sites I and II, **Major** impact significance at the construction phase is anticipated for land clearance.

One concurrent development was assessed for Sites I and II, resulting in significant cumulative impacts during construction and operational stages. Hence, mitigation measures should be provided by the corresponding developers to lower down the cumulative impacts to acceptable levels.

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, secondary baseline data from concurrent study carried out by AECOM in the vicinity, site survey as well as PUB's water catchment map, water catchment areas within the vicinity of the Biodiversity Study Area mainly contribute to the identified nine (9) major watercourses. Water from the identified drains/streams will eventually flow into Marina Reservoir, which stores water to be treated for drinking water purposes. Four (4) watercourses are located in Eng Neo Avenue Forest, which includes a man-made ephemeral earth drain, an ephemeral concrete drain, an Anaerobic Pond and a natural stream. In the Sites I and II, there are two (2) drains and one (1) stream: a perennial naturalised stream and two (2) ephemeral concrete drain. In Windsor, there are one (1) ephemeral concrete drain and one (1) natural stream. The natural stream in Windsor Nature Park (i.e. D/S13) and stream D/S14 in Eng Neo Avenue Forest are located within the areas of high ecological conservation values, supporting surrounding ecological systems. Hence, it is very important to understand how the potential environmental impacts arising from the Project activities can impact those drains/streams.

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 thirteen (13) water quality stations at the watercourses from Eng Neo Avenue Forest, Sites I and II, and Windsor. 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), Nitrates (NO_3-N), Ammoniacal Nitrogen (NH_4-N), Total Organic Carbon (TOC), *Enterococcus* and Lead (Pb). Analysis of the water quality results have shown that the water quality of the watercourses is relatively consistent with its ecological significance.

The ephemeral man-made earth drain and concrete drain in Eng Neo Avenue Forest were found to have relatively good water quality. The Anaerobic Pond in Eng Neo Avenue Forest was found to have relatively poor water quality, which corresponds with the absence of aquatic life with high ecological value present within the watercourse. However, the Pond still has some ecological value as it can support the surrounding bird species. The water quality of natural stream in the Eng Neo Avenue Forest was found to have suitable conditions for aquatic life, which is consistent with its identified high ecological value (Section 7.4.1.1). At Sites I and II, the water quality in the ephemeral concrete drain was found to have high TSS, as the runoff likely contained solids that were flushed from surrounding soil, vegetation and urban areas. Elevated BOD_5 level found in an ephemeral concrete drain to the north of Sites I and II (i.e. D/S9) might be due to receiving stormwater runoff from the surrounding horse barn in Bukit Timah Saddle Club which could consist of high organic substances during wet weather. The perennial

naturalised stream was found to have relatively good water quality during dry weather. However, the naturalised stream is to be slightly impacted by storm events, as the water quality deteriorates during wet weather conditions. Despite the variation in water quality, this watercourse was found to support aquatic life and has a high ecological value (Section 7.4.2.1). For Windsor Nature Park, the perennial natural stream was found to have good water quality in term of physical and chemical parameters and the stream considered to be of high ecological value also based on biodiversity findings (Section 7.4.3.1).

Based on the assessment of the hydrology and surface water quality related impacts on the various sensitive receptors, the assessment findings have been summarised in Table 8-13 and Table 8-14. The proposed construction footprint were assessed to cause significant Moderate impacts on drains D/S10 and D/S11 and Major impact on stream D/S14 while the operational footprint was assessed to cause Moderate impact on the watercourses (i.e. D/S10, D/S11 and D/S14) in term of hydrology and/or water quality components, even with implemented minimum controls. Hence, mitigation measures were proposed such as shifting of A1-W2 construction and operational footprint outside of Eng Neo Avenue Forest which reduced the impact significance on watercourses in Eng Neo Avenue Forest. However, the mitigated scenario construction footprint of A1-W2 would cause significant hydrology and surface water quality impact on the watercourse (i.e. drain D/S16) in Site I. Therefore, the impact significance was assessed to be Negligible to Major in summary during both construction and operational phases.

For the rest of the watercourses, they were assessed to have only Negligible to Minor impacts during both construction and operational phases. Thus, apart from the minimum controls identified and those incorporated in the construction and operational plans for the Minor impacts, no additional management or mitigation measures are required. It is noted that the LTA had further minimised the A1-W1 worksite area (from the base scenario to mitigated scenario) to significantly reduce adverse impact on the surrounding biodiversity. This smaller worksite has also helped to further reduce the impacts to the hydrology and water quality of the surrounding watercourses.

Therefore, given that the minimum controls and mitigation measures for the LTA construction and operational activities will be implemented, as well as the additional mitigation measures such as the flow diversion of affected area of stream D/S16 before construction of temporary access road during construction phase, the significance of residual impacts from the potential hydrology and water quality impacts on the sensitive water receptors was assessed to be **Negligible to Moderate** as in Table 8-16. Although the impact on the D/S16 within Site I has been slightly increased to Moderate, compared with the previous major impact on natural stream within Eng Neo Avenue Forest due to base scenario of worksite, the overall impact on watercourses within this region has been reduced as the natural stream in Eng Neo Avenue Forest has relatively higher ecological value than the naturalised concrete drain in Site I.

Assessing the cumulative impacts from concurrent developments identified in the vicinity of the Project, it was concluded that only the concurrent project of CR14 at Turf Road is likely to increase the impact extent on hydrology and water quality of watercourses at Site I during construction phase. PUB water pipeline works in Windsor and CR13 excavation and shaft construction works are unlikely to increase the impact extent on hydrology and water quality of identified watercourses at Eng Neo Avenue, Sites I and II, and Winsor given best management practices and minimum controls provided by its developer are in place during both construction and operational phases.

Soil and Groundwater

The potential impacts on soil and groundwater from historical and current land uses as well as activities associated with the construction and operational phases of the Project were discussed by using the information from HLUS reports completed by LTA in a separate study [R-4, R-5], construction waste information and other best available data. Furthermore, AECOM also reviewed previously carried out soil and/ or groundwater investigation studies within the Study Area, inclusive of both Soil Investigation (SI) reports [R-74] [R-75] [R-76] [R-77] [R-78] [R-79] [R-80] [R-81] [R-82] and soil and groundwater environmental baseline studies [R-70].

The soil and groundwater within the Project site were identified as Priority 3 sensitive receptors, as they are 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. Streams which are partially supported by groundwater with biodiversity conservation significance were identified as Priority 2 sensitive receptors but can only be assessed with the EBS results where groundwater flow can be deduced from.

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 chemicals/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 facility building 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.

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

Hence, the significance from potential sources of soil and groundwater impacts during construction and operational phases such as decreased groundwater baseflow feeding into the streams, 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 the CRL2 Project.

Cumulative impacts from concurrent developments identified in the vicinity of the CRL2 Project during both construction and operational phases concluded that the concurrent development PUB water pipeline works in Windsor might increase the impact during construction phase only. Hence, appropriate mitigation measures should be proposed to minimise these adverse impacts by the PUB's project developer to avoid accidental spillage of chemicals for impacting on the quality of soil and groundwater, and to ensure surface streams are diverted with an equivalent capacity of stream if impacted and to minimise groundwater drawdown in line with best practice measures. The impact from the rest of the concurrent developments (i.e. CR14 at Turf Road and CR13 excavation with retrieval shaft construction works) might not add to soil and groundwater impact significantly in their construction or operational phases given best management practices and minimum controls provided by its developer are in place as both developments might only have insignificant changes on the land use of Eng Neo Avenue Forest, Site I, Site II, and Windsor.

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 two (2) representative monitoring locations between 26 March to 26 June 2020 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 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. The mitigation measures are also applicable for the utility diversion work at Sin Ming Walk and A1-W1 worksite. In addition, the worksite option with smaller footprint (i.e. Mitigated Scenario of A1-W1) is preferred. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

For air quality impact assessment during operational phase, it is assumed that all new vehicles to meet their Euro emission standard. Furthermore, there is currently a large traffic volume along the PIE. The buffer from some green

areas which will not be disturbed as part of the Project, will also help in terms of providing cleaner air from the impact from the vehicles. At a much higher level, trains are meant to replace substantial vehicles from roads, 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 overall Impact Significance is not expected to significantly increase from the Project.

Airborne Noise

Noise impact assessment was carried for the construction phase of the proposed worksites for CR2005. The construction noise Study Area was defined as combination of Eng Neo Avenue Forest, Site I, Site II, and 150 m from A-W2 worksites, and 150m from A1-W1 construction worksite or Windsor whichever is greater. The noise impact assessment for the operational phase of the proposed worksites for CR2005 included providing 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 the 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 six (6) locations. Uncorrected baseline noise was used as a more stringent criteria for assessment of ecological receptors in this Study. Besides, 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 construction phase.

For the assessment on construction phase, the noise levels generated from the equipment used during construction detailed in Section 11.3.1 was predicted using SoundPLAN ver 8.2. Topography plays an important role in noise propagation and was included in 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). The identified noise sensitive receptors will be assessed in accordance to the impact evaluation matrix as shown in Section 6.4.2. Noise contours were provided to the extent where 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 two (2) different construction scenarios, including Scenario 1: Cut and cover works and associated activities; and Scenario 2: Tunnel Boring Machine (TBM) works. 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.

For the impact assessment on the modelling scenario 1 to scenario 2 of construction, base scenario results show impact significance of Moderate to Major with a highest noise level 65 dB(A) at Windsor, Major with a highest noise level 77dB(A) at Eng Neo Avenue Forest, Moderate to Major with a highest noise level 55dB(A) at Site I, and Minor to Moderate at Site II.

Following the assessment of all design optimisation options, it still requires for noise barrier with a height of 12m as the mitigation measures at A1-W1 site (as shown in Figure 11-5). At A1-W2 site, it still requires for 12m height noise barrier around the worksite and LTA standard 15m full enclosed noise barrier for TBM. The ground level and low height noise sensitive receptors benefit from the noise barrier, however, receptors at top of the trees may not benefit from noise barriers. Based on a couple of height sensitivity analysis, it was determined that an optimum height of 12 m noise barrier gives the maximum benefit to the arboreal receptors around the site and any further increase in noise barrier height does not yield any benefit to the receptors at optimised A1-W1 and A1-W2 worksites. Based on the residual airborne noise impact assessment above, the proposed 12m noise barrier at A1-W1 worksite will be beneficial by reduction impact significance from Moderate-Major (base scenario) to **Minor-Moderate** (post mitigated scenario) for main construction activities at Windsor. It is to be noted that sound power level of utility diversion works along Island Club Road at A1-W1 worksite is much lower than worst-case (shown in

Table 11-10), which was not modelled for this assessment. If there are any complaints regarding the noise impact arising from the Project worksites, the PRO shall engage with ECO to resolve this issue.

For A1-W2, impact significance reduced to **Minor** from base scenario-Major impact significance for both scenarios at Eng Neo Avenue Forest. Site I still experiences **Major** impact from both base worksite and post-mitigated worksite due to its close proximity to surrounding forested area, which cannot be mitigated any further. But at Site II impact significance became **Major** due to the A1-W2 worksite which is closer to the boundary of surrounding forested areas during Cut and cover works and associated activities. However, the total areas of "Major" impact significance are expected to be reduced significantly from base to mitigated worksite and can be seen obviously in the noise figures (refer to Figure 11-6 to Figure 11-20) at optimised A1-W1 and A1-W2 worksites.

The road work construction of the A1-W2 worksite was also modelled separately under this assessment. Since its construction footprint is very close to the ecological receptors at Site I and Site II, predicted noise level is expected to be up to 22 dB(A) exceedance than criteria with **Major** impact significance. However, non-safety critical works during road construction should only be restricted in the day, and road construction be carried out for short lengths at a time, and for a short period of time. Erecting high barriers for road construction can be more intrusive to the habitat due to short duration of actual road construction, therefore during this phase, portable noise barriers are highly recommended close to the noisy equipment/ activities and no night works after 7pm for all non-safety critical activities since the site is next to the sensitive receptors. If there are any complaints regarding the noise impact arising from the Project worksites, PRO shall engage with ECO to resolve this issue.

For rock breaking and excavation works proposed at the A1-W1 and A1-W2 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 (location, depth, method) and known information (distance to nearest receptors), this assessment provides an estimate on the maximum amount of charge (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 A1-W1 worksite (Base Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Windsor will potentially experience medium impact intensity with medium impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain and the resulting impact significance is Major. From the A1-W2 worksite, the Priority 1 ecologically sensitive receptors at Eng Neo Avenue Forest, Site I and Site II will potentially experience medium impact intensity and the resulting impact significance is Major. After applying the mitigation measures within Section 11.8 are implemented, A1-W1 Worksites (Mitigated Scenario), the resulting impact significance from rock breaking and excavation ranges from **Minor** to **Moderate**. and A1-W2 Worksites (Mitigated Scenario), the resulting impact significance ranges from **Negligible** to **Major**.

In addition to mitigation measures, EMMP for conducting further noise monitoring at adequate numbers in other proposed locations in conjunction with ground-borne vibration impact assessment have been proposed for vibration sensitive phases. Information on the additional monitoring locations will be further addressed in Section 12.

For the cumulative impact assessment for the concurrent developments, the information about the inventory and PMEs was not available except for CR14 near A1-W2 worksite and PUB Water Pipeline project at BKSR around Shaft 4 located at A1-W1 worksite. For the assessment of cumulative impact, the information about the inventory and PMEs were included as part of the noise impact calculation as worst case and assessed jointly in the noise section. At Windsor, overall, the predicted noise level generated from BKSR site (120 dB(A)) is same as the maximum generated level at A1-W1 worksite. Therefore, the noise contribution from both sites are the same, although the areas of both sites are different. The footprints of this BKSR project does not add on significantly to the noise level at A1-W1 worksite.

For the cumulative impact assessment on the concurrent developments near A1-W2, it was included in the noise model and evaluated to be contributing to the noise level from A1-W2 especially at Site II. Therefore, the noise contribution is Major. Due to confidentiality of that project, the detail information about the noise figures, inventory and PMEs were not included in the section above.

No cumulative impacts were considered as significant during operational phase at A1-W2, A1-W1, CR13 retrieval shaft worksites. Currently there are no developments planned near CR13 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

A vibration impact assessment was carried out to assess the vibration impacts arising from the construction and operational phases of the Project on ecologically sensitive receptors in the Study Area. Ground-borne vibration

from construction activities (at A1-W1, A1-W2 worksites and alignment) and operational activities may be felt by or cause a disturbance, especially on the ecological receptors proximity to the Project. The local geological profile along the alignment is mainly dominated by Bukit Timah Granite (Rengam Facies).

Five construction activities assessed were rock breaking and excavation, rotary bore piling, bulldozing, vibratory compacting and tunnel boring. 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.

Flora is not considered to be sensitive to vibration impact. Hence the impact assessment was for the behaviour of fauna only. The main focus of the assessment was Priority 1 sensitive ecological receptors. The indicator species for the assessment were Sunda pangolin (*Manis javanica*) and lesser mousedeer (*Tragulus kanchil*). Ground-borne noise is generated by the vibration of walls, ceilings and floors inside buildings. Therefore ground-borne noise only occurs indoors; and is excluded from the assessment of fauna which lives in the open.

Currently, there are no applicable Singapore or international standards or guidelines that assess the impacts of ground-borne vibration from the construction and operation of the railway on faunal/ ecological receptors. There are limitations concerning established reliable criteria for assessing vibration impact on fauna. Based on the literature review, the impacts on the behaviour of ecological species and burrow collapse depend on the vibration level and the frequency of vibration.

The baseline vibration study aims to understand the existing vibration levels at the sensitive receptors. 99th percentile of baseline vibration data was used to develop a criterion for Eng Neo Avenue Forest; used as an input to a regression equation to calculate the impact intensity criteria for Windsor. The baseline study comprises monitoring carried out (primary data collection) and data measured previously for other Projects (secondary). The Peak Particle Velocity (PPV) vibration metric has been used throughout. A matrix for impact intensity was formulated with two components, vibration thresholds and impacted area (based on the home range of the Sunda pangolin).

The study assesses the vibration impacts on the structural integrity of the burrows belonging to the fossorial species and the behaviour of the ecologically sensitive receptors in the biodiversity area. The vibration threshold for partial burrow collapse in a desert environment is PPV, 10.00 mm/s [W-87]. The predicted construction vibration levels were screened to identify levels equal to or greater than PPV, 5.00 mm/s (equivalent to 50 % of the recorded partial burrow collapse). Rock breaking and excavation; high amplitude vibratory compacting could generate vibrations greater than PPV, 5.00 mm/s at the biodiversity study areas. The burrows may be susceptible to vibration damage and collapse, thus entombing the fossorial species. To avoid an overly onerous assessment that may be impractical for the Singapore context, the Project considered taking the 80% value of the vibration threshold as the assessment criteria – PPV, 8.00 mm/s for burrows. Supposed the Contractor implements vibration control measures, damage/partial collapse of the burrows may be avoided.

In terms of behavourial impacts, the predicted vibration levels from the five construction activities were assessed. Based on the results, the construction vibration levels (with minimum control measures) would likely cause Minor - Major impact significance at Eng Neo Avenue Forest; Negligible - Moderate impact significance at Site I and II and; Minor - Major impact significance at Windsor. Hence, mitigation measures were recommended to reduce the impacts.

The mitigation measures were:

- Removal of TBM launch/ retrieval at A1-W1, which reduced trucks and heavy equipment on-site;
- Optimising A1-W1 and A1-W2 worksites;
- Apply best available techniques (BAT) to control construction vibration levels to PPV, 8.00 mm/s at the biodiversity areas;
- Implement temporary water barriers at Island Club Road to prevent fauna from fleeing across the road, resulting in roadkills;
- Restrict the entry of visitors into the trails of Windsor;
- Keep the impact zone as small as possible;
- Avoid construction activities at night; and
- Use low vibration construction methods, e.g. use secant bored piling instead of rotary bore piling.

Based on the results, the construction vibration levels (with mitigation measures) would likely cause **Minor - Moderate** impact significance at Eng Neo Avenue Forest; **Negligible** - **Moderate** impact significance at Site I and II and; **Minor** - **Moderate** impact significance at Windsor.

Although Contractors may limit their construction levels to PPV, 8.00 mm/s at the biodiversity areas, the size of the impacted area would remain the same, which is equal to or greater than 6 ha. Hence there would be **Moderate** residual impacts. The study recommended that the contractors implement the best available technology (BAT) for low vibration construction methods and the EMMP. The EMMP required Contractors to carry out continuous vibration monitoring and fauna behaviour monitoring (using camera traps and observing specialists) during the construction and commissioning stages. The ecologist monitors 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. In addition, monitoring of burrow collapse will be required during the rock breaking and excavation period, where daily measurements for over 15 days will be taken. The soil content and vibration levels will be monitored in parallel to identify the threshold of 30% soil volume relative to control soil volume. The control site for the burrow collapse monitoring shall be set up 1 month prior to commencement of construction works.

To determine and quantify impact amplitude for the operational phase, LTA provided predicted vibration levels from the operation of the trains. The study assessed the given vibration levels (with standard track form and deep tunnel depth as minimum control measures) for potential damages/collapse of the burrows and behavioural impacts on fauna. As the operational train vibration levels were low, the resulting impact significances in the biodiversity study areas were **Minor**. Mitigation measures were not required to reduce the impacts further; thus, residual impacts remain **Minor**.

In terms of cumulative vibration impact significance, there are other concurrent developments during the construction and operational phases of this Project. There could be some overlapping schedules in construction works with BKSR and CR14 works. The ground-borne vibration caused by the construction works at BKSR would probably be low as the construction activities mainly involve the construction of potable water pipelines and pipelaying works.

At A1-W2, there could be some overlap with CR14 works. Potential construction activities are tunnel boring, rock breaking and excavation. Due to a lack of information on the future work site, the vibration impacts can only be qualitatively assessed at the moment. There is a potential for Moderate to Major impact significance on the impacted ecological sensitive receptors.

No significant high vibration activities or works are known to be ongoing during the operational phase; therefore, the cumulative impacts are unlikely.

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[5]	Residual Impact Significance with Mitigation Measures (if required)
Eng Neo Avenue Forest	Biodiversity	Minor to Major	Negligible
	Hydrology and Surface Water Quality	Moderate to Major	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Minor
	Ground-borne Vibration	Minor to Major	Minor to Moderate[4]
Site I and Site II	Biodiversity	Negligible to Major	Minor to Major[1]
	Hydrology and Surface Water Quality	Negligible	Negligible to Moderate[2]
	Soil and Groundwater	Minor	Minor

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls[5]	Residual Impact Significance with Mitigation Measures (if required)
	Air Quality	Negligible	Minor
	Airborne Noise	Negligible to Major	Negligible to Major[3]
	Ground-borne Vibration	Negligible to Moderate	Negligible to Moderate[4]
Windsor	Biodiversity	Major	Moderate to Major[1]
	Hydrology and Surface Water Quality	Minor	Minor
	Soil and Groundwater	Minor	Minor
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Moderate to Major	Minor to Moderate[3]
	Ground-borne Vibration	Minor to Major	Minor to Moderate[4]

Note:

1. Biodiversity: Major impact still exists due to the irreversible loss of vegetation and habitats during site clearance in construction phase (Sites I and II: mortality and impediment to seedling recruitment for two flora species - Alstonia angustiloba and Thyrsostachys siamensis; Windsor: mortality for six flora species - *Bambusa multiplex, Cyrtophyllum fragrans, Ficus benjamina, Glochidion zeylanicum var. zeylanicum, Guioa pubescens, Palaquium obovatum*).
2. Water Quality: Moderate at Site I, as the proposed road will cross existing major drain in Site I, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the immediate presence of drain segment adjacent to the construction site.
3. Noise: due to the surrounding ambient noise levels which are naturally very low, the fact that sensitive receptors are in close proximity, and that noise barriers are unlikely to impede noise that will reach habitat on elevated/undulant terrain, meaning receptors in these locations will still be impacted. Collectively, these therefore mean, that impact significance cannot be reduced further.
4. Vibration: Moderate residual impact on all the Biodiversity Study Areas, although with mitigation measures, is due to construction activities such as pipe jacking, rock breaking and excavation and tunnel boring produce high PPV levels at the studied forested areas. Thus, EMMP measures should be implemented.
5. 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.

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

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls[1]	Residual Impact Significance with Mitigation Measures (if required)
Eng Neo Avenue Forest	Biodiversity	Negligible to Moderate	Negligible
	Hydrology and Surface Water Quality	Moderate	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible
	Ground-borne Vibration	Minor	Minor
Site I and Site II	Biodiversity	Negligible to Minor	Minor
	Hydrology and Surface Water Quality	Negligible	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls[1]	Residual Impact Significance with Mitigation Measures (if required)
	Ground-borne Vibration	Minor	Minor
Windsor	Biodiversity	Moderate	Minor
	Hydrology and Surface Water Quality	Minor	Minor
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible
	Ground-borne Vibration	Minor	Minor

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 completely eliminated.

This EIS Final Report only presents the impact assessment on the environmental parameters from the preliminary design stage of the Project, where the assessed worksite areas exclude detailed design elements such as locations of piezometers, utilities/ traffic diversion areas, 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 Contract – Provision of Services to Conduct Environmental Impact Study (EIS). An EIS is required to be undertaken to assess the potential environmental impacts arising from, and associated with, the construction and operation of Cross Island Line (CRL) Phase 2 (the Project) on the biodiversity 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* (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 has already covered the CCNR stretch, the scope of work for this CR2005 Contract only includes the changes and development made for the alignment portions outside the CCNR.

The objective of this **EIS report** is to conduct environmental impact study on the construction and operation of the railway line in the vicinity of the following forested areas identified: Windsor (part of Windsor Nature Park and the connected northern forest fragment, refer to Figure 3-1), Eng Neo Avenue Forest (between PIE and Fairways Drive), as well as Sites I and II (area adjacent to Fairways Quarters). The scope of CRL2 works considered includes construction worksites from Turf City to Bright Hill (see Table 2-1). The planning for the entire CRL2 alignment is still ongoing and separate EIS reports for the other CRL2 worksites in the vicinity of ecologically sensitive areas will be published. The original construction worksites associated with this report are presented in Figure 3-1 and Figure 3-2, while the indicative operational footprint are demonstrated from Figure 3-5 to Figure 3-6. 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.

Table 2-1 EIS (Windsor and Eng Neo Avenue Forest) 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, Figure 3-2)	Mitigated/ Optimised Scenario (see Figure 3-3)	Base Scenario (see Figure 3-5, Figure 3-6)	Mitigated Scenario (see Figure 3-5, Figure 3-6)
A1-W2 worksite	Eng Neo Avenue Forest or Sites I and II	Launch shaft worksite at Eng Neo Avenue Forest	Launch shaft worksite at Sites I and II	Above-ground facility building with vent shaft	No facility building above-ground. Only underground tunnel ventilation only.
A1-W1 worksite	North to Windsor Nature Park	Ventilation shaft (or Vent shaft) worksite		Above-ground facility building with vent shaft	
CR13 retrieval shaft worksite	Near Bright Hill MRT Station	Retrieval shaft (*for TBM retrieval works only)		Operating as part of the Bright Hill station building (CR13)	
Worksite at Peirce	At Peirce Secondary	Worksite for underpinning works only		-	

Construction Worksites in This Report	Location	Type/ Function (Construction Phase)		Type/ Function (Operational Phase)	
		Base Scenario (see Figure 3-1, Figure 3-2)	Mitigated/ Optimised Scenario (see Figure 3-3)	Base Scenario (see Figure 3-5, Figure 3-6)	Mitigated Scenario (see Figure 3-5, Figure 3-6)
Secondary School	School near Sin Ming Walk				
** Note: The construction and operation of CR13 station is under a separate contract of CRL1.*					

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 Final Report only presents the impact assessment on the environmental parameters from the preliminary engineering design. Pursuant to this study there are some recommendations as input to the design, which 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.

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, PUB) 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 available from LTA 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 3** – Description of the Project provides a general description of the Project components, construction activities, operational activities, schedule, Project resources, waste and emissions expected from the Project;
- **Section 4** – Description of the Environment provides a general description of the site setting, land use, historical features, topography, geology, water catchment and climate of the Project;
- **Section 5** – Environment Legislation, Policies, Plans, Standards and Criteria provides the legislative requirements relevant to the Project;
- **Section 6** – Description of Assessment Methodologies provides the overview of the methodology used for the assessment;
- **Section 7** – Biodiversity presents the methodology, baseline environment, sensitive receptors, and potential sources of impacts, minimum controls and evaluation of impacts to biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 8** – Hydrology and Surface Water Quality presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts to hydrology and surface water quality within the Study Area, along with recommendations for mitigation measures;
- **Section 9** – Soil and Groundwater presents the methodology, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts from construction and operational activities (e.g. general and toxic solid/ liquid waste generated, spoil handling, storage of bulk hazardous materials on site, etc.) to soil and hydrogeological conditions of the Study Area, and also to ascertain the presence of possible pollutants in the underlying soil and groundwater that may impact the local vegetation and downstream watercourses, along with recommendations for mitigation measures;
- **Section 10** – Air Quality presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of impacts from the Project to air quality on the biodiversity within the Study Area, along with recommendations for mitigation measures;

- **Section 11** – Airborne Noise presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of noise impacts on the biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 12** – Ground-borne Vibration presents the methodology, baseline environment, sensitive receptors, potential sources of impacts, minimum controls and evaluation of ground-borne vibration impacts on the biodiversity within the Study Area, along with recommendations for mitigation measures;
- **Section 13** – Environmental Monitoring and Management Program (EMMP) details the organisational framework, stakeholder roles and responsibilities, monitoring program requirements and detailed EMMP; and
- **Section 14** – Conclusions provides a conclusive summary of the EIS's outcomes.

2.3 Study Limitations, Assumptions and Constraints

The information contained in this document originally produced by AECOM Singapore Pte. Ltd. ("AECOM") was produced solely for the use of the Client and was prepared to assist in the Environmental Impact Study for the Contract CR2005. The focus in this report will be a portion of the direct CRL2 alignment and its associated worksites from Turf City to Bright Hill (i.e. A1-W2 worksite, A1-W1 worksite, Worksite at Peirce Secondary School and CR13 Retrieval Shaft Worksite) which are located at/nearby the Biodiversity Study Area (i.e. Windsor, Eng Neo Avenue Forest, Sites I and II), but excluding the area within CCNR which has been covered separately under the CCNR EIA [R-1] published by LTA.

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

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3. Description of the Project

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

3.1 Project Location and Components

The Project scope includes consideration of both the construction and operational phases of a portion of the direct CRL2 alignment and its associated worksites from Turf City to Bright Hill (i.e. A1-W2 worksite, A1-W1 worksite, Worksite at Peirce Secondary School and CR13 Retrieval Shaft Worksite) which are located at/nearby the Biodiversity Study Areas (i.e. Windsor, Eng Neo Avenue Forest, Sites I and II), but excluding the area within CCNR which has been covered separately under the CCNR EIA [R-1] published by LTA.

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 A1-W2 (also named as FB5 in this report) worksite for launch shaft near Eng Neo Avenue Forest, A1-W1 (also named as FB4 in this report) worksite for facility building to the north of the Windsor Nature Park, worksite for underpinning works at Peirce Secondary School, CR13 TBM retrieval shaft worksite near Bright Hill MRT Station.

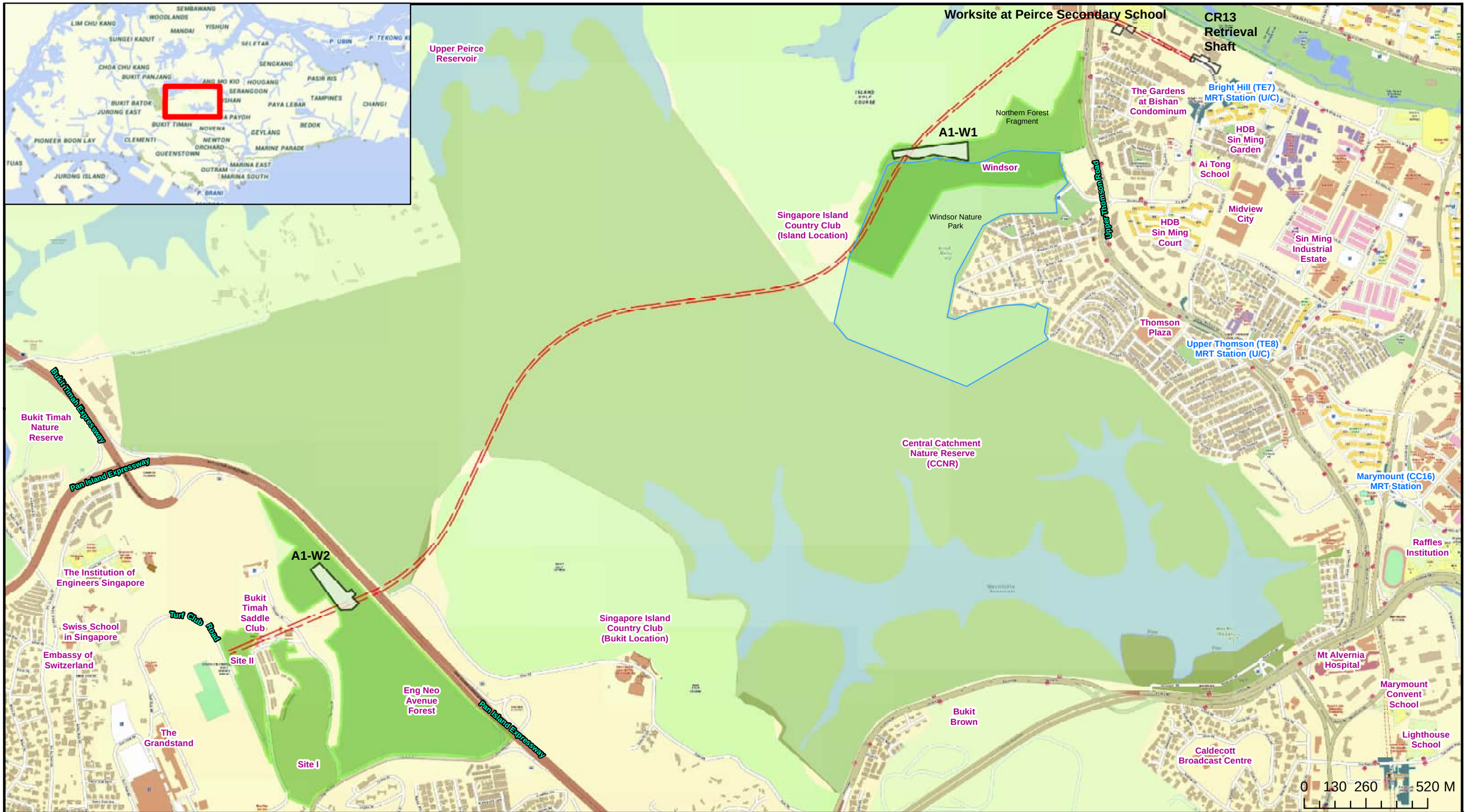
Windsor (inclusive of northern part of Windsor Nature Park and the Northern Forest Fragment near A1-W1 worksite) and Eng Neo Avenue Forest (near A1-W2 worksite), as well as Sites I and II are identified as the Biodiversity Study Areas likely to be impacted by some of these worksites. The Windsor's Northern Forest Fragment is separated from the Windsor Nature Park by the Island Club Road. The location and footprints of the original construction worksites as well as Biodiversity Study Areas are shown in Figure 3-1 and Figure 3-2. Thereafter, Section 3.1.1.1 has also provided insights of the design optimisation of worksites with purpose to reduce the overall environmental impacts during construction phase, in which the mitigated construction worksites with comparison to the original construction worksites are presented in Figure 3-3.

As mentioned in Section 2, this CRL2 alignment passes through CCNR area, whereby the tunnel alignment will mostly be bored through bedrock strata at depths ranging between 23m to 90m below ground level (bgl) along the whole alignment (average 70 m bgl under the CCNR). As per current planning, the CRL2 alignment (excluding CCNR) in overall would not exceed -60m below Singapore Height Datum (SHD). According to current planning, launch shaft in A1-W2 worksite will launch TBM towards the CR13 retrieval shaft where the TBM will be retrieved.

Overall, both underground and above-ground construction works are expected at A1-W2 and A1-W1 worksites, whereas only underpinning works are expected for the worksite at Peirce Secondary School. Only TBM retrieval work of CR13 retrieval shaft worksite is covered under this Contract, whereas the excavation works, shaft construction works and other works associated with CR13 retrieval shaft and its station worksite are covered under a separate contract of Cross Island Line Phase 1 (CRL1).

In terms of planned road works for construction worksites in this report, a temporary access road will be constructed to connect A1-W2 temporary worksite to Eng Neo Avenue via the existing Fairways Drive and Turf Club Road (see Figure 3-3). Upon completion of the construction works, the A1-W2 temporary access road will be handed over to a Contractor of a separate contract for permanent road construction at the same area. Whilst for access to the A1-W1 temporary worksite at Windsor, the existing Island Club Road is assumed to be utilised for similar purposes (see Figure 10-24). As of current planning, street lamps may be built along the access roads if found to be insufficient to allow clear vision at night and when night works are required during night-time at the work areas of the access roads.

Apart from the above, an existing guardhouse (approximately with 3m width, 3m length, 3m height) opposite A1-W1 worksite across Island Club Road will be demolished and a new guardhouse will be built about 25m horizontally towards the Singapore Island Country Club (SICC) direction at the roadside. Additional vegetation clearance within Windsor will not be required as the construction of the guardhouse will be constrained within the paved area along the roadside. The indicative location of the existing and/or new guardhouse is shown in Figure 3-4.



Legend

- Proposed CRL Alignment
- Base Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Windsor Nature Park

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :
PROJECT LOCATION AND CONSTRUCTION WORKSITES (1/2)

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	Drawn ML	Date MAR 2022	CAD File Name : NA		A3

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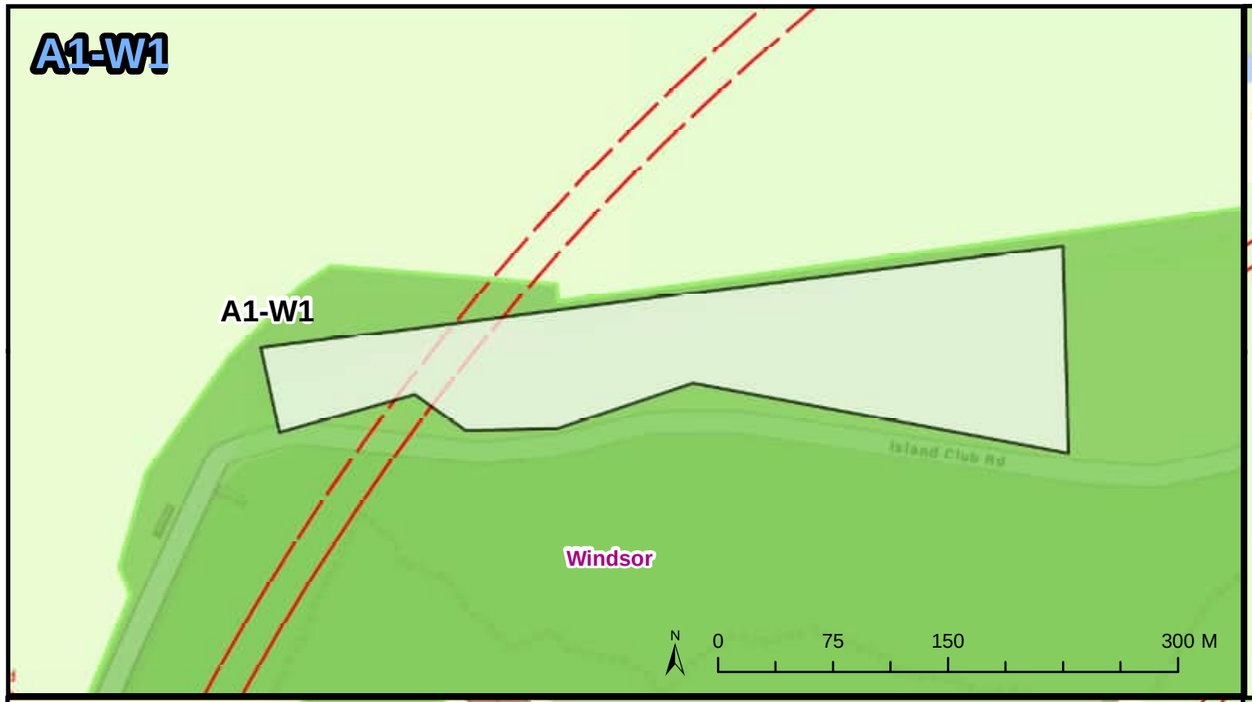

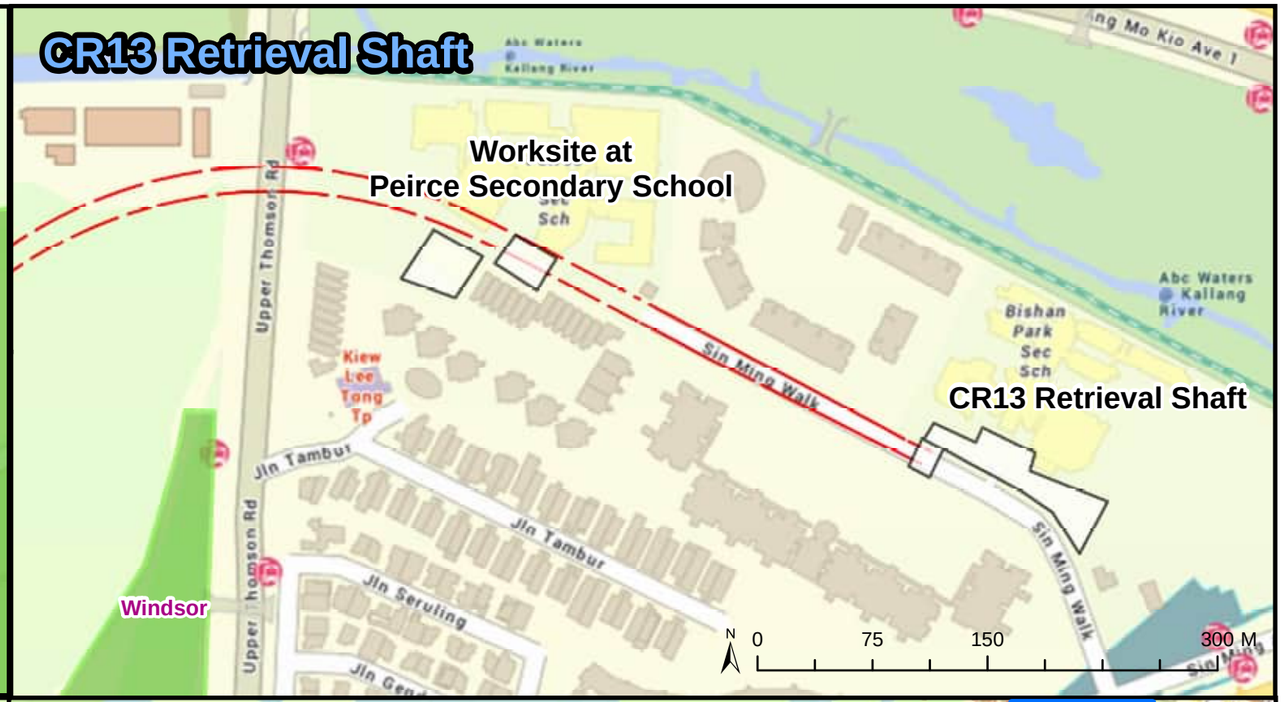

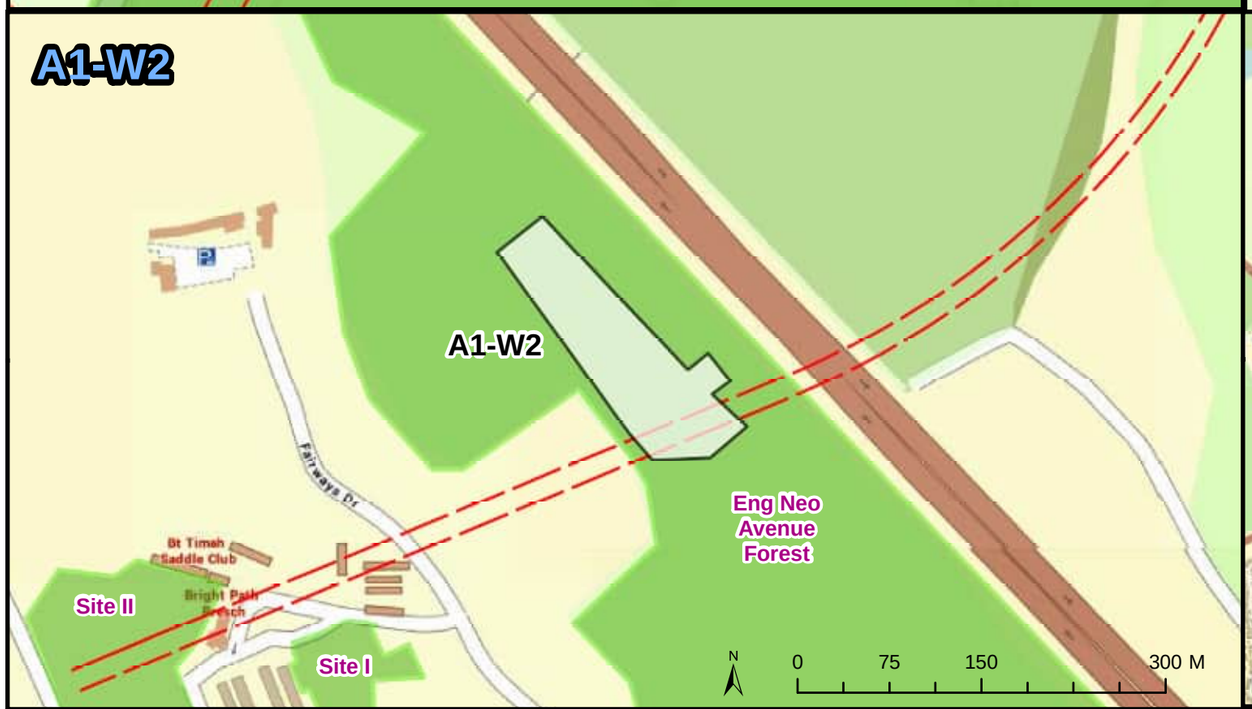

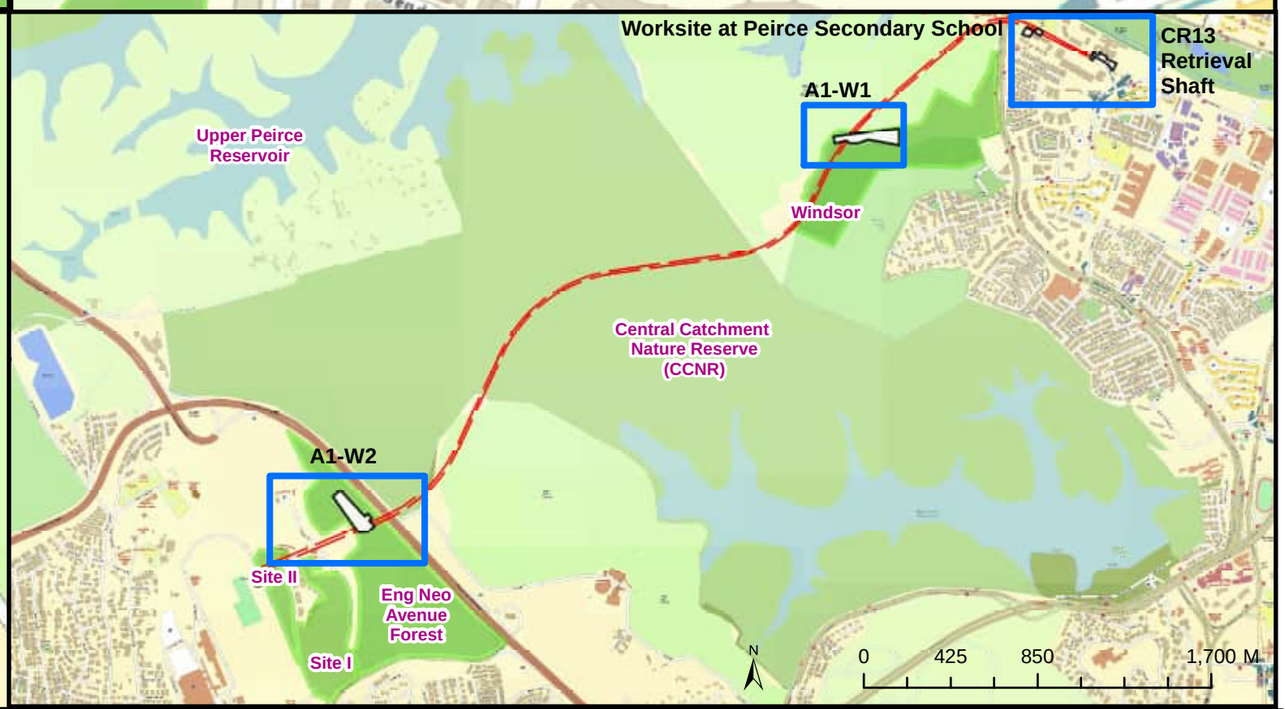

Legend

- Proposed CRL Alignment
- Base Scenario Construction Worksite Footprint
- Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Qualified Person Endorsement :
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(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**PROJECT LOCATION AND
CONSTRUCTION WORKSITES
(2/2)**

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ML	JAG	JAG	3 - 2	-	1 of 1
	Drawn ML	Date MAR 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

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, client and the agencies, 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.

Optimisation of A1-W2 Launch Shaft Worksite

The original A1-W2 worksite (base scenario) was located within the defined area of Eng Neo Avenue Forest during Inception stage, which is an area identified with ecologically-sensitive habitats based on the biodiversity surveys undertaken for this Project. Various options were discussed with LTA and other relevant Agencies to mitigate the potential biodiversity impacts towards Eng Neo Avenue Forest. Thereafter, decision was made to relocate the original A1-W2 worksite outside of Eng Neo Avenue Forest to existing less vegetated areas near Turf Club Road and Fairways Drive, including an existing grassland at Turf Club Road and another existing area of managed vegetation within Bukit Timah Saddle Club (see Figure 3-3). This design optimisation process has been targeting towards avoiding direct encroachment into Eng Neo Avenue Forest, Sites I and II.

Optimisation of A1-W1 Facility Building Worksite

As shown in Figure 3-1, the A1-W1 worksite (base scenario) was initially planned to be located in the forest fragments north to the Windsor Nature Park (outside of the Park) with a construction footprint of 15,000 m^2 connecting to a larger forest patch to the east. This forest patch is also precepted to be a potential canopy connection between the northern and southern part of CCNR, with reforestation efforts. To note that the CCNR EIA and its discussions had already led to substantial depth of the alignment in this area in an attempt to mitigate operational impact of train pass by on the biodiversity.

As for sensitivity of this area, a separate study was conducted for Raffles banded langur (RBL) which showed that a large area worksite in the base scenario location would potentially discourage RBL from using this corridor to return to their place of origin, therefore, several options were considered by LTA in this aspect in an attempt to relocate as well as optimise the site area based on works minimisation. It was also noted simultaneously that there may be other viable paths of return of RBL to the Upper Peirce Forest (where they are known to have originated from) that completely avoid Island Club Road. In other words, this identified canopy connection may not be the only travel path for RBL. However, an attempt must be made to preserve some canopy connections and reduce the footprint to the maximum possible level. Therefore, proposing as part of the mitigation measures to minimise such biodiversity impact, the construction footprint of A1-W1 worksite was reduced from 15,000 m^2 to 7,000 m^2. This optimisation can also disconnect A1-W1 worksite (mitigated scenario) from the said forest patch and relocate further away from the potential corridor for RBL. The reduction in the size of worksite has generally reduced the area of impacts, such as reduction in area of dust, noise and vibration emissions.

Besides, at the time of CCNR EIA (before the commencement of this report), A1-W1 was a worksite with a planned shaft for TBM launching/ retrieval. Various engineering options were considered to evaluate the use of this site. However, owing to its proximity to CCNR, solutions were devised such that both launch and retrieval options were cancelled for this site and it was selected as TBM pass by alone. If this was to continue as a potential launch/ retrieval site location, it would not only have a longer construction period, but also potentially much more significant biodiversity, water, air, noise, vibration impacts in conjunction with others. As recommended during the EIS process, the plan for tunnel launch and retrieval at A1-W1 worksite has been cancelled and the TBM will only pass by below ground, which has significantly reduced the impact on biodiversity, water, noise and ground borne noise and vibration in this worksite area. This plan also means that a substantial daily movement of truck loads carrying excavated spoil as well as TBM segments from TBM launch/ retrieval would also be avoided on a daily basis during construction.

With the decision of including it only for TBM pass-by, due to safety reasons, a tunnel vent shaft (which is currently the proposed A1-W1 facility building worksite of this report) is still the least requirement to be constructed in this location, which shall be constructed only after TBM has already passed by from this area in an attempt to connect the surface to the tunnel below for movement and exchange of air.

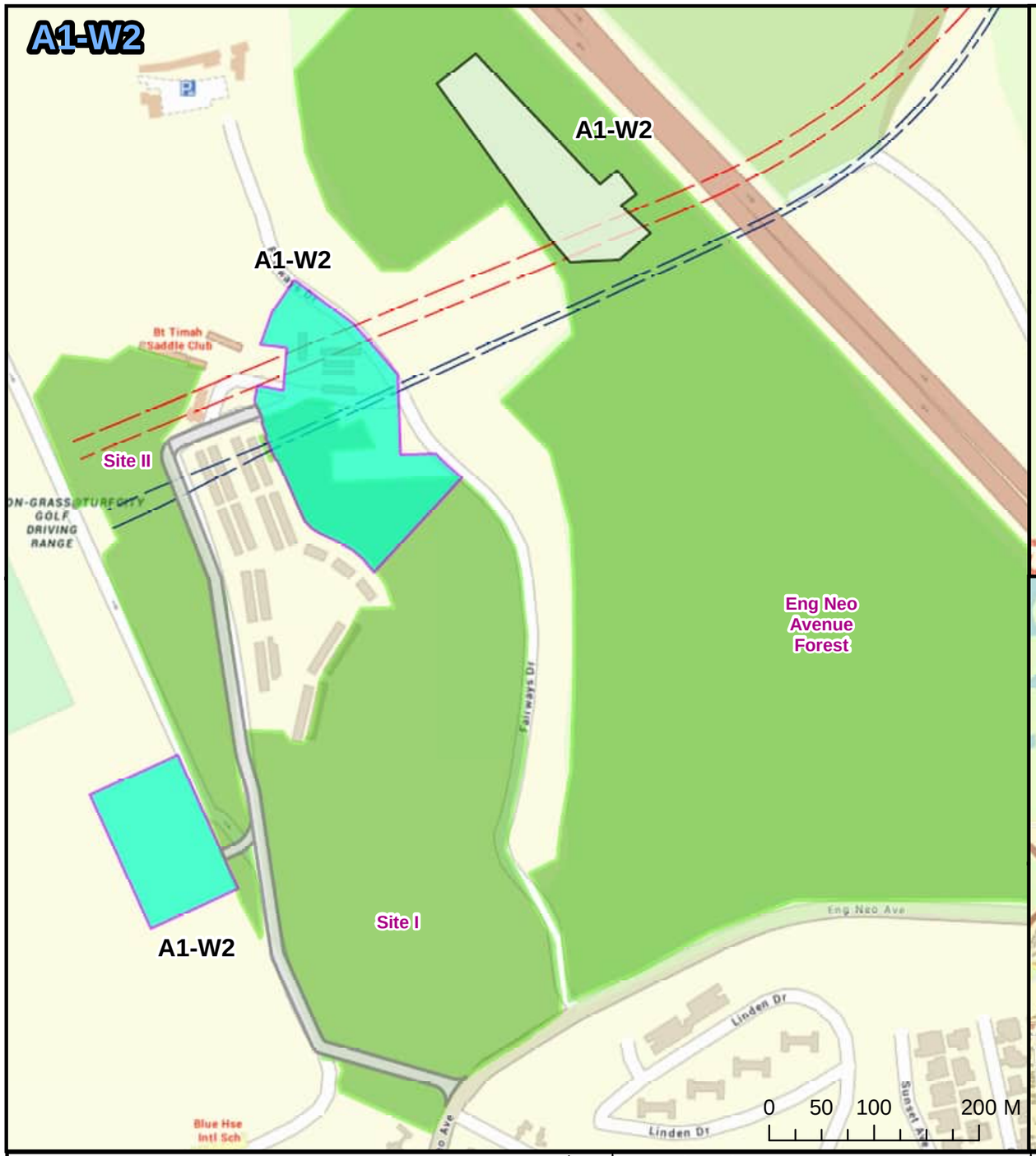
Furthermore, in parallel to A1-W1 of this Project, PUB also planned to locate a worksite (PUB BKSR Shaft 4) at the same location for its Bukit Kallang Service Reservoir (BKSR) water pipeline overlay. Interface meetings with PUB

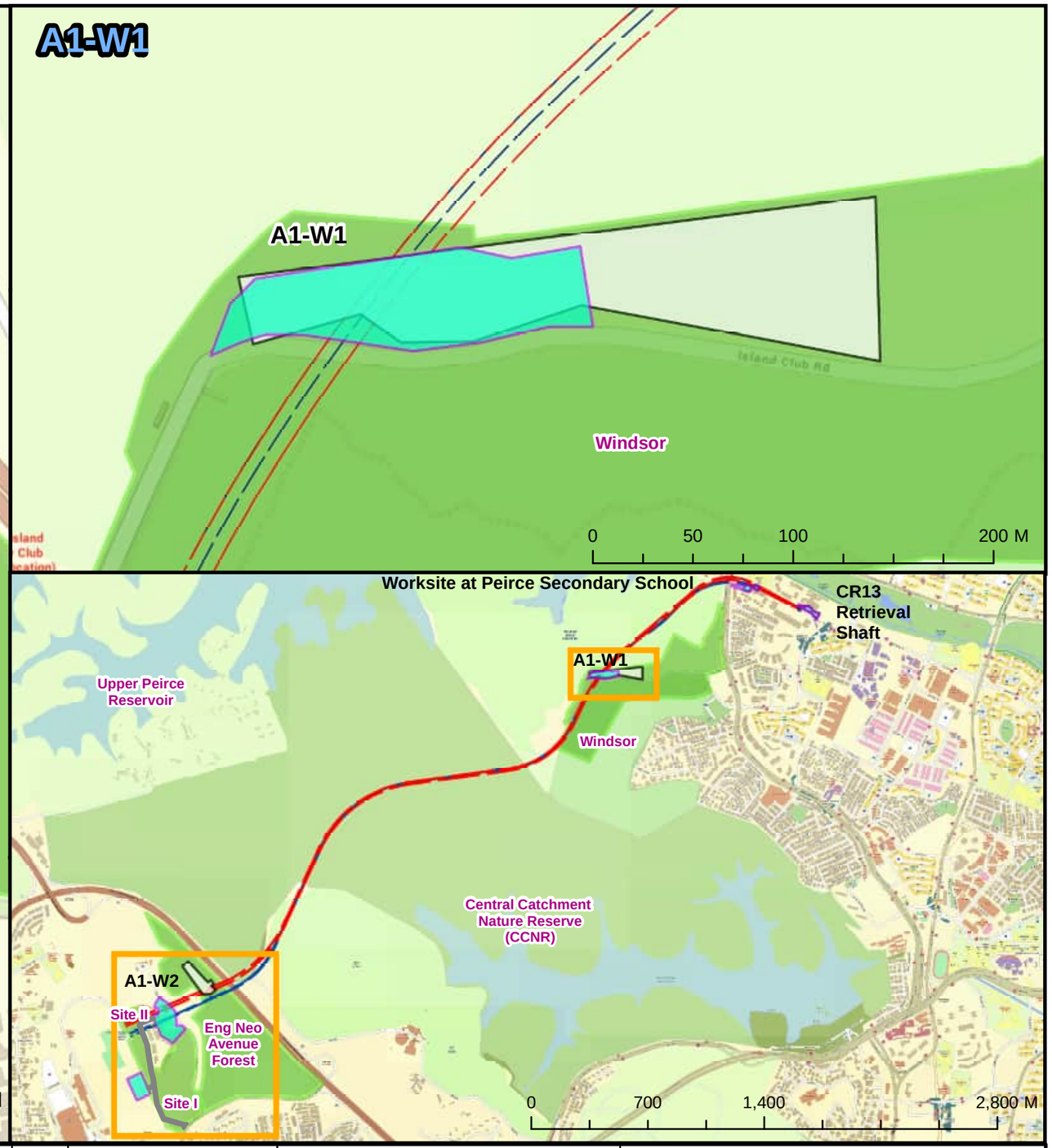
were held to collocate both the sites as well as timeline for commencement of A1-W1 in a way that there are minimum cumulative impacts from the two projects' construction in this area.

While substantial success was obtained in locating and optimising the site for A1-W1, it was also found that the entire area is underlain by Bukit Timah granite, given which any excavation to deeper layers of the tunnel, would require rock breaking and excavation works in order to penetrate through this rocky layer. Alternatives to rock breaking and excavation works were discussed during the design development and an alternative was not found. Therefore, this aspect is weighed in subsequent sections of the report.

Other Design Changes

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. Besides, changes were made for the Worksite at Peirce Secondary School and CR13 retrieval shaft worksite based on latest design and Project needs in mitigated scenario, which were assessed for each individual environmental parameter.





Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
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LTA Endorsement :
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Consultant : AECOM

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Project Title :

**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :

DESIGN OPTIMISATION FOR CONSTRUCTION WORKSITES AS MITIGATED SCENARIOS

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

3.1.2 Operational Phase

During operational phase, the A1-W2 launch shaft worksite which was originally planned to be converted to a facility building in the base scenario, is now planned to only support underground rail-passing in the mitigated scenario where there will be no above-ground structure, whilst A1-W1 worksite will be converted to a permanent facility building (i.e. FB4) as planned. Similar to the optimised A1-W2, the CR13 retrieval shaft worksite will have only permanent underground structure without housing any facility, hence only rail-passing is expected there. As mentioned in Section 3.1.1, this report only considers TBM retrieval works at the CR13 retrieval shaft, the operational footprint of CR13 station box (i.e. Bright Hill Station) under CRL1's contract is not assessed.

Following the optimised design of construction worksites, there will also be slight difference in terms of the operational footprint of facility building based on the boundary of construction worksites and CRL2 alignment in both the base and mitigated scenarios. The indicative operational footprint of A1-W2 and A1-W1 are demonstrated from Figure 3-5 to Figure 3-6.

Apart from the above, as mentioned in Section 3.1.1, the existing guardhouse (see Figure 3-4 below) located alongside Island Club Road opposite A1-W1 worksite will be shifted horizontally towards the SICC direction to facilitate access to the permanent FB4 during operational phase. Additional vegetation clearance at the boundary of Windsor will be expected to be minimal as the proposed new guardhouse will be located within the paved area along the roadside.

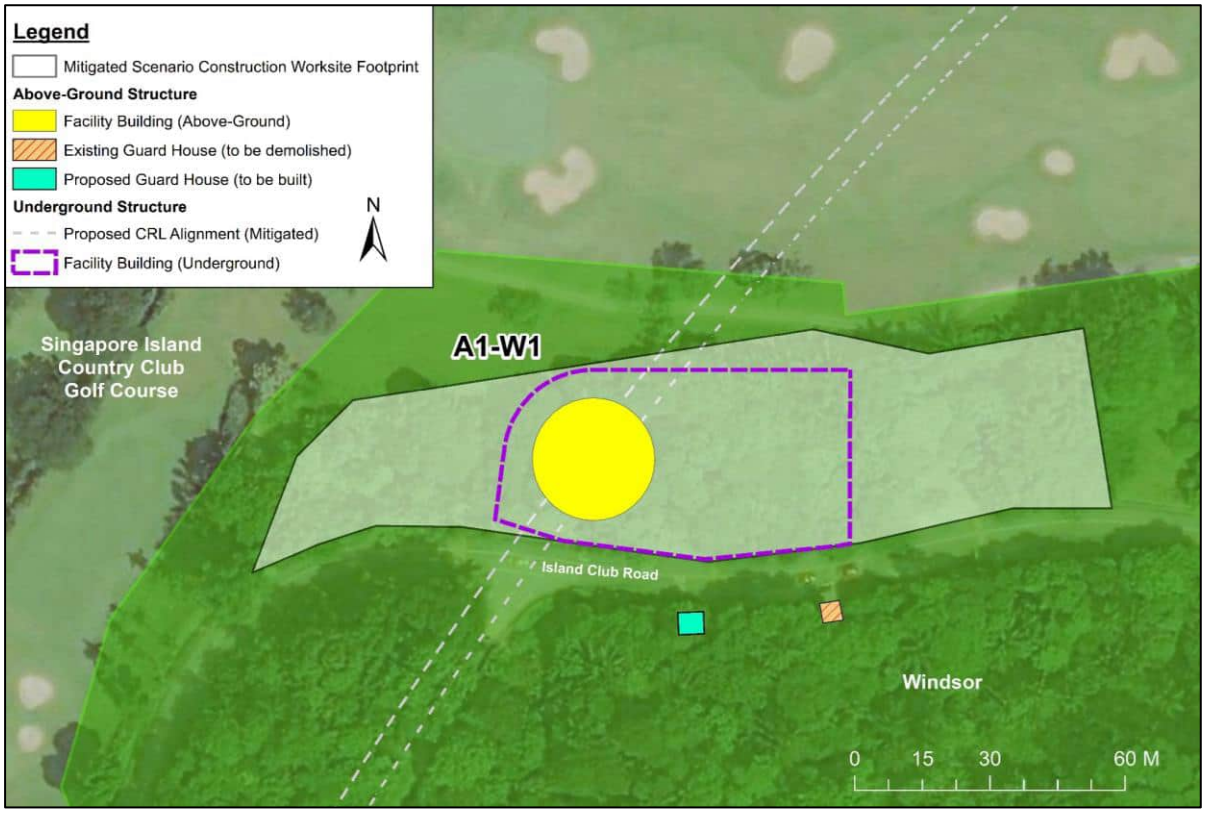
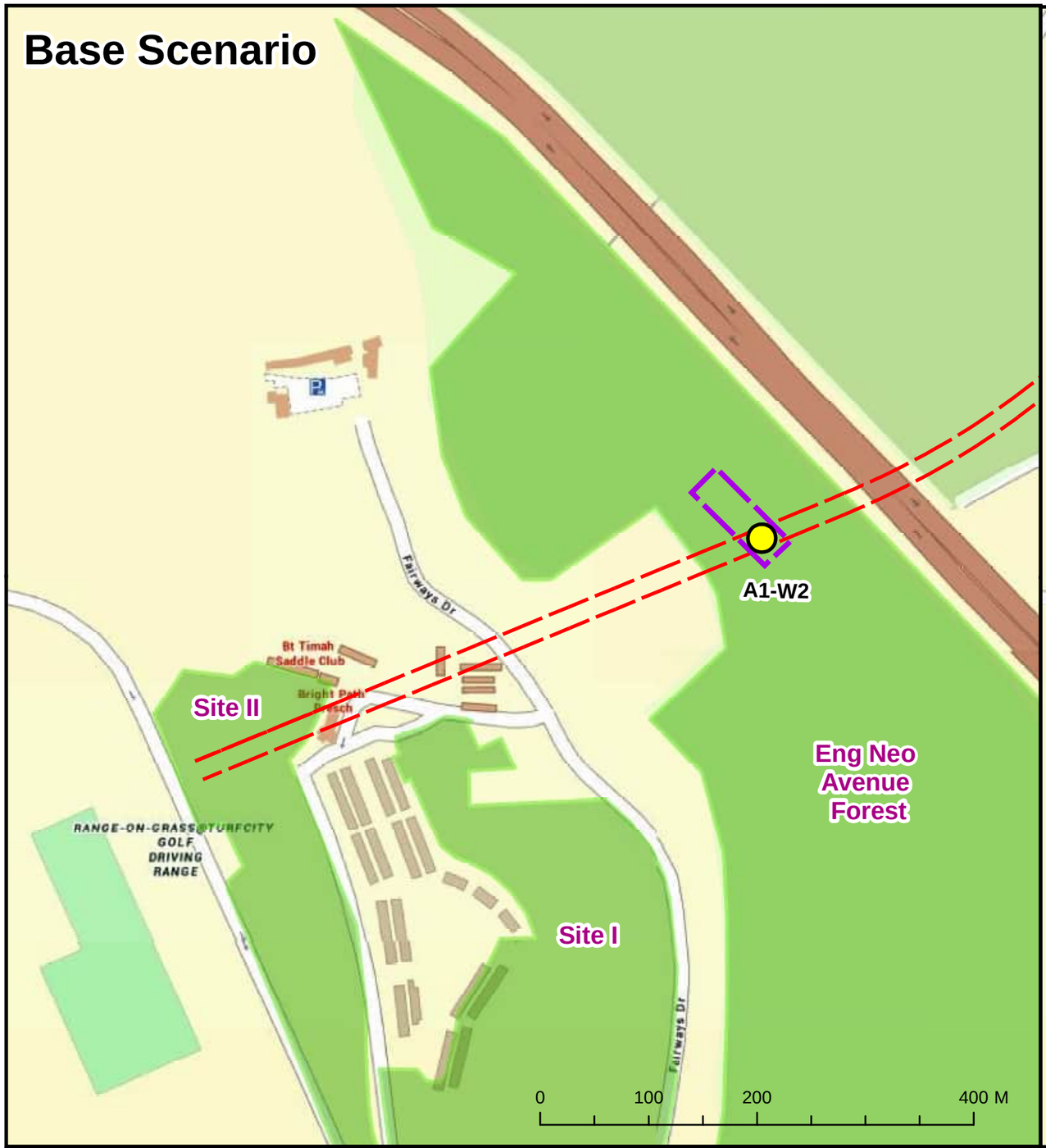


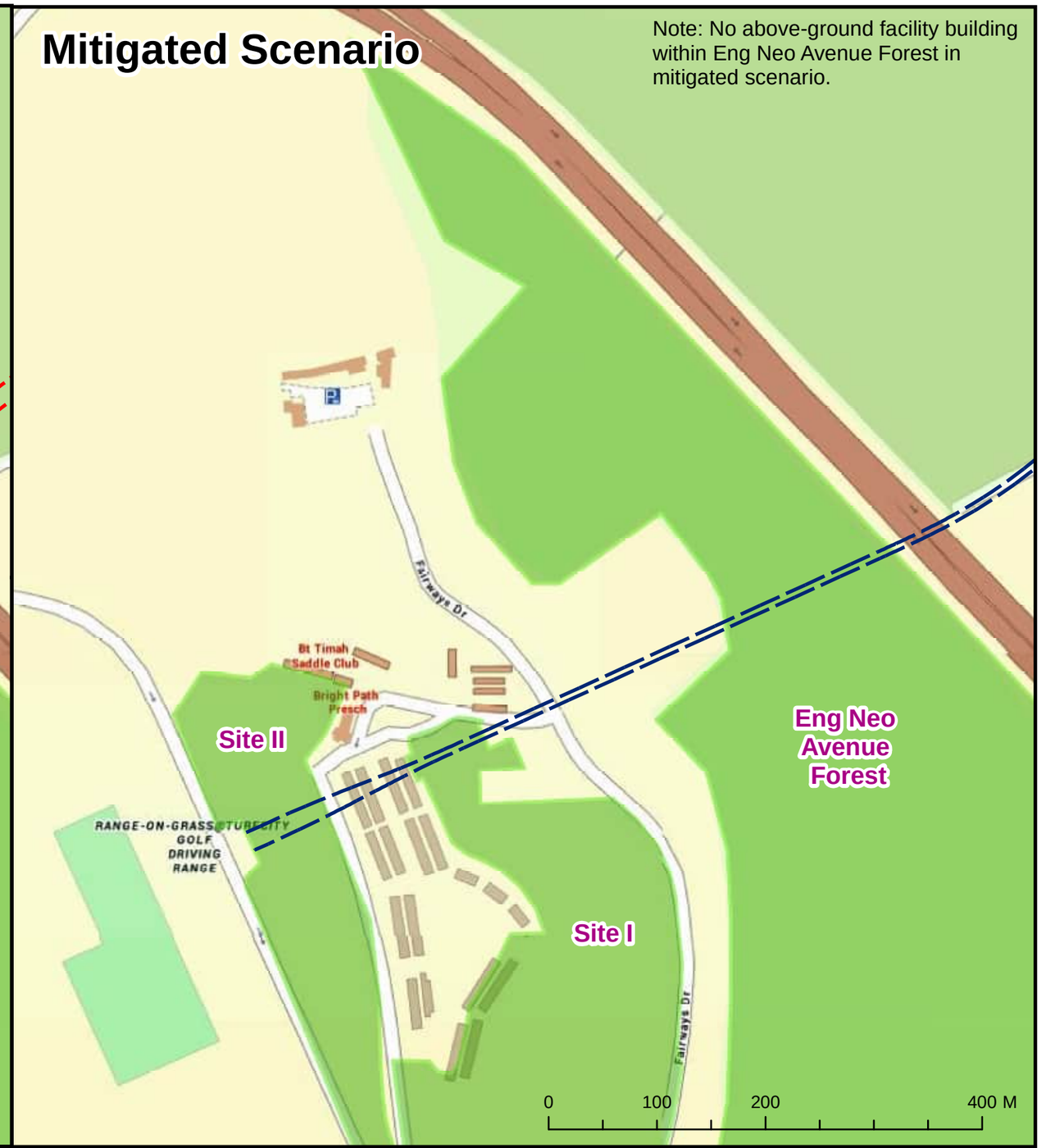
Figure 3-4 Indicative Location of Existing Guardhouse and New Guardhouse near Optimised A1-W1

Base Scenario



Mitigated Scenario

Note: No above-ground facility building within Eng Neo Avenue Forest in mitigated scenario.



Legend

- Biodiversity Study Area

Above-Ground Structure

- Facility Building (Above-Ground)

Underground Structure

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Facility Building (Underground)

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Qualified Person Endorsement :
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LTA Endorsement :
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Consultant : AECOM

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Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**INDICATIVE
OPERATIONAL FOOTPRINT
AT A1-W2**

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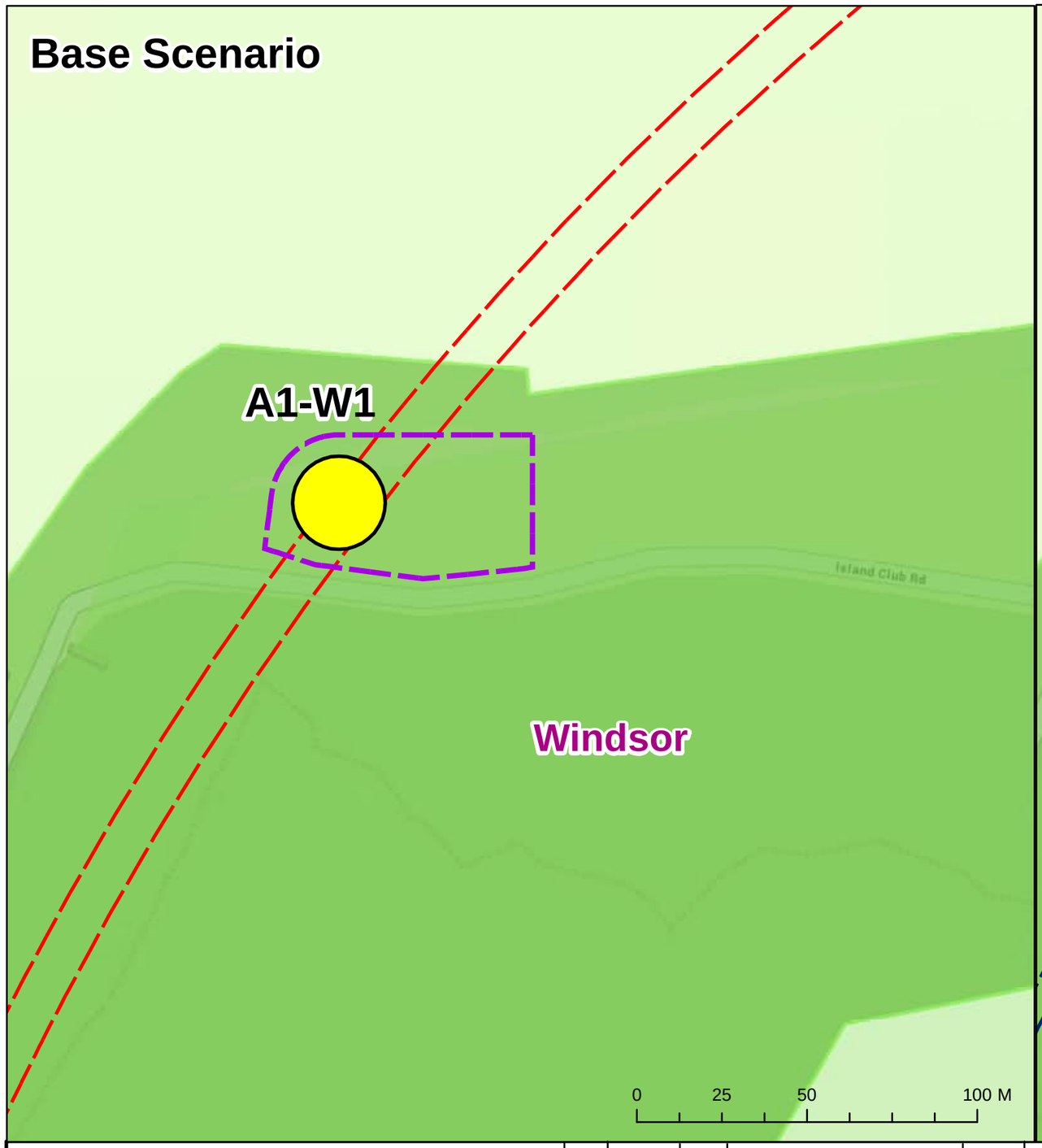
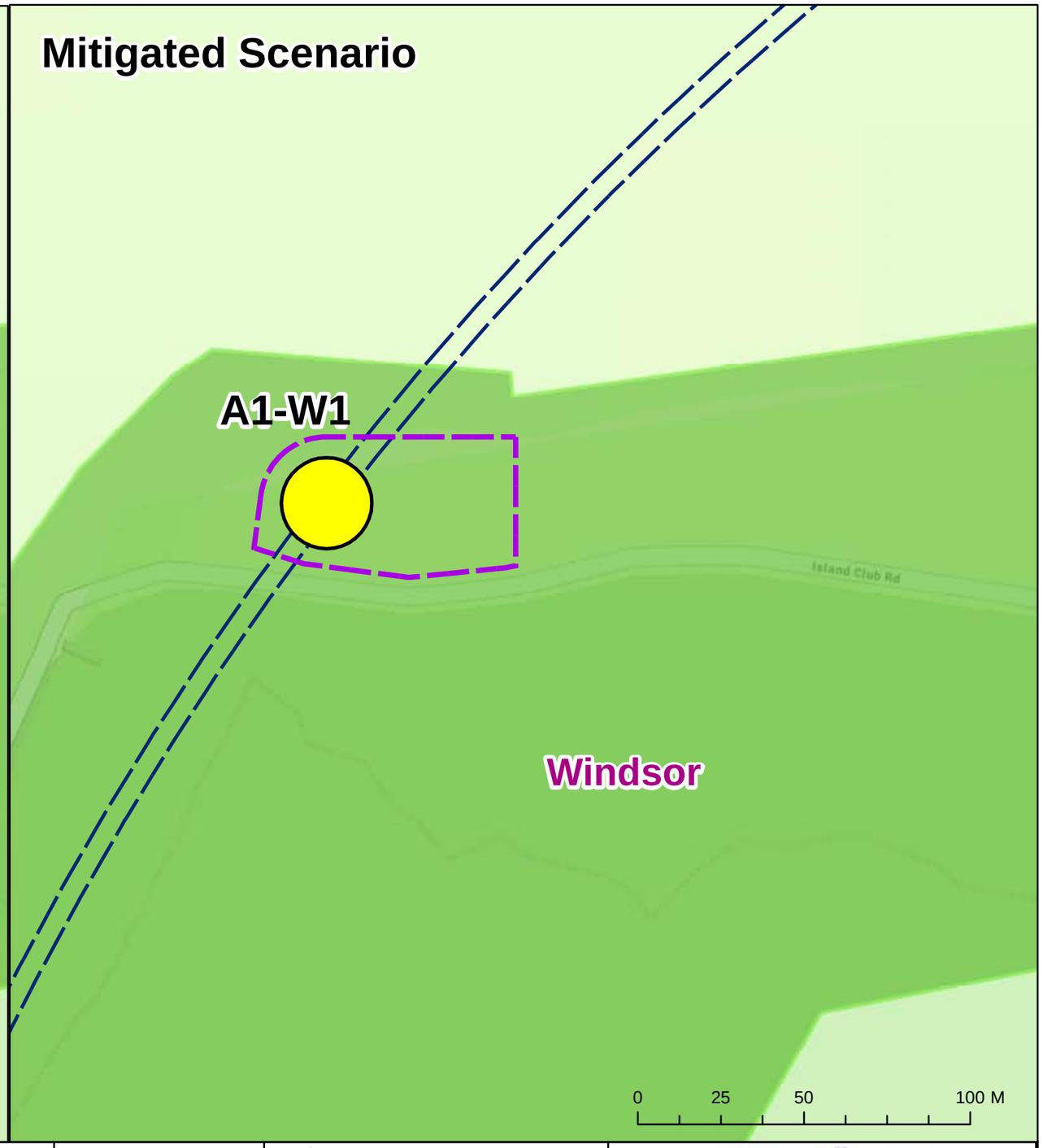
Note: Source of basemap - OneMap

Base Scenario



Mitigated Scenario



Legend

- Biodiversity Study Area

Above-Ground Structure

- Facility Building (Above-Ground)
- Proposed Guardhouse (indicative)

Underground Structure

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Facility Building (Underground)

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
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LTA Endorsement :
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Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**INDICATIVE
OPERATIONAL FOOTPRINT
AT A1-W1**

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG	JAG	3 - 6	-	1 of 1
	Drawn ML	Date MAR 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

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. In terms of construction hours, after various discussions with LTA and other relevant Agencies, it was agreed that in overall there will be no above-ground night works (not safety-critical) at A1-W1 and A1-W2 worksites after 7pm due to the ecological sensitivity of Windsor and Eng Neo Avenue Forest, except for D-wall trenching works and the underground TBM works which will be continuous for 24 hours due to safety considerations. The restriction of working hours was included as one of the proposed biodiversity and noise mitigation measures in this report. Construction 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 as well as for the access roads. For this, the construction Contractor's Qualified Erosion Control Professional (QECP) will prepare Erosion Control Plan (ECP) and obtain approval from the Public Utilities Board (PUB). The Contractor also maps the trees on site and the trees planned for removal or retention and obtains National Parks Board (NParks) approval. The construction site debris, felled trees and spoil will be temporarily stored on site and then collected by licenced third parties for offsite disposal.

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

- For any areas rich in trees of conservation interest where tree-felling of girth more than 1m is required [W-3], the Contractor should employ a certified arborist to map the trees carefully while applying for tree felling approval. This is to gauge the health, species, size and conservation significance of the tree;
- If there are trees that are required to be transplanted, this is done prior to commencing site clearance;
- If the area is rich in wildlife, the Contractor consults wildlife specialist and prepares a wildlife shepherding plan, obtains NParks approval and executes it prior to/ along the site clearance process. In this case, the direction of clearance is set by the Wildlife Shepherding plan. The site clearance is led by wildlife specialist(s), who helps shepherd, save, relocate wildlife as necessary; and
- Site hoarding process and extent should also be governed by the above factors and the approved plans by NParks (see example in Figure 3-8 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 3-7 Examples of Site Clearance, Tree Felling and Internal Access Roads [O-6]

Figure 3-8 Examples of Site Hoarding Erection [O-6]

In this process, the site is eventually levelled for construction to begin (See Figure 3-9 below). This may involve cutting and stabilising of slopes (See Figure 3-10 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 3-11 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 3-9 Examples of Site Levelling Works [O-6]

Figure 3-10 Examples of Slope Cutting Works [O-6]

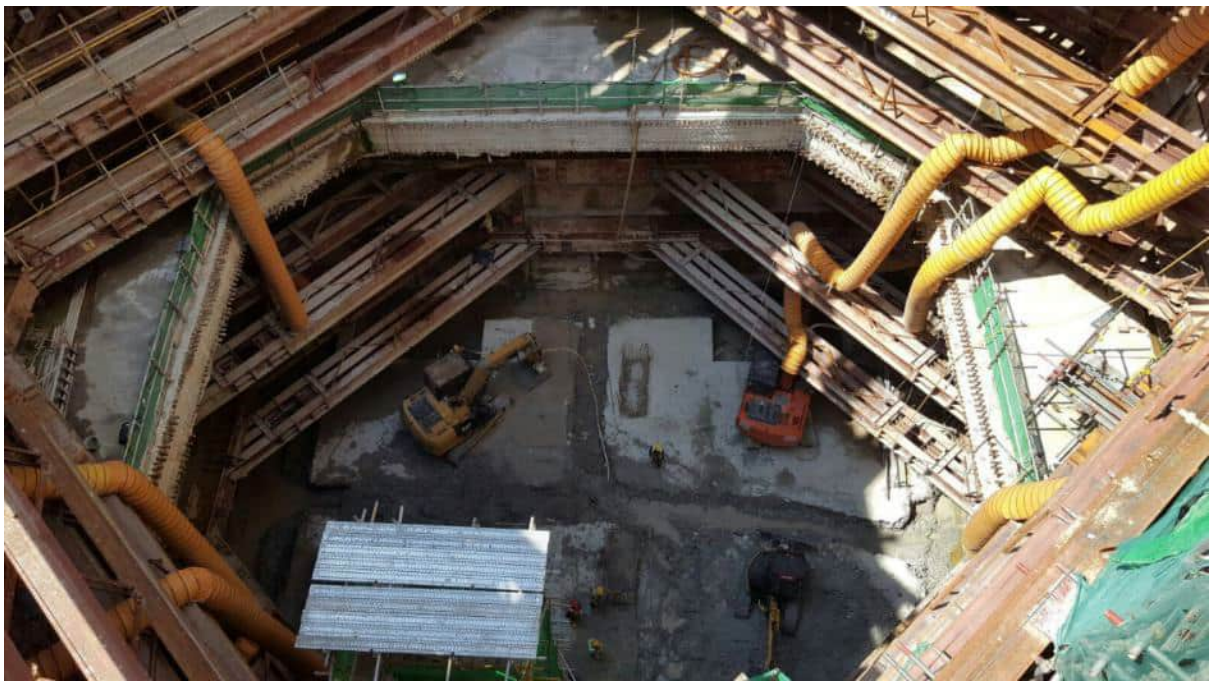


Figure 3-11 Examples of ERSS Schemes Planned at Fort Canning Site to Stabilise Slopes/ Prevent Caving in Soil [O-7]

3.2.1.1.1 *Alternative of Using Secant Bored Piles (SBP) for Temporary Earth Retaining Structure*

At the time of writing this report, there is a proposal from LTA to replace Diaphragm wall (D-wall) with secant-bored wall for A1-W1 worksite's temporary earth retaining structure or ERSS scheme, which utilises secant bored piles (SBP). In general, SBP is an interlocking piling method designed to form the temporary retaining wall system for the construction zone to minimise disturbance and vibrations to adjacent structures. The SBP wall is formed by constructing intersecting reinforced concrete piles, which consists of overlapping hard and soft piles to form structural or cut-off walls and achieve required water tightness. The reinforcement of SBP will be undertaken either using steel rebar or steel beams, which then being constructed by either drilling under mud or augering [P-102]. Primary piles are installed first with secondary (male) piles constructed in between primary (female) piles once the latter gain sufficient strength. Pile overlap is typically in the order of 3 inches (8 cm). The main advantages of SBP are the increased construction alignment flexibility which may assist in optimising the construction hours required, increased wall stiffness compared to sheet piles, allowing installation in difficult ground (cobbles/ boulders) and less noisy construction [W-81].

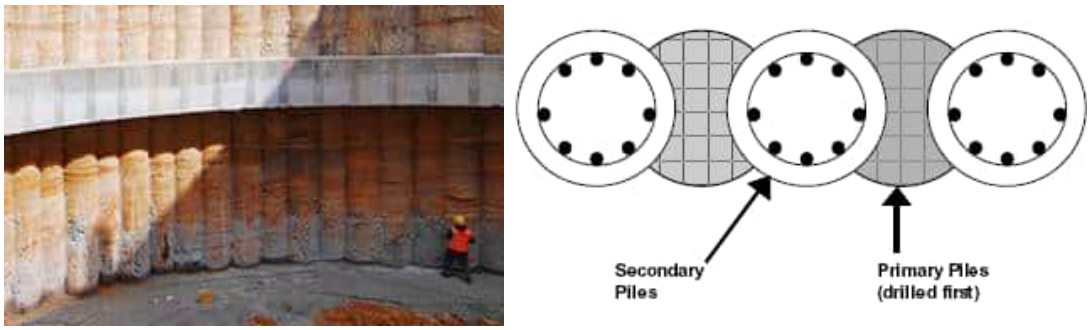


Figure 3-12 Examples of Secant Bored Piles [W-81]

Discussion is currently ongoing by LTA to explore possibilities of avoiding night works at A1-W1 worksite by introducing SBP due to the considerations of reducing environmental impact on nocturnal species in Windsor nearby. Further details can be provided at later stage of the Project.

3.2.1.2 Traffic and Utility 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

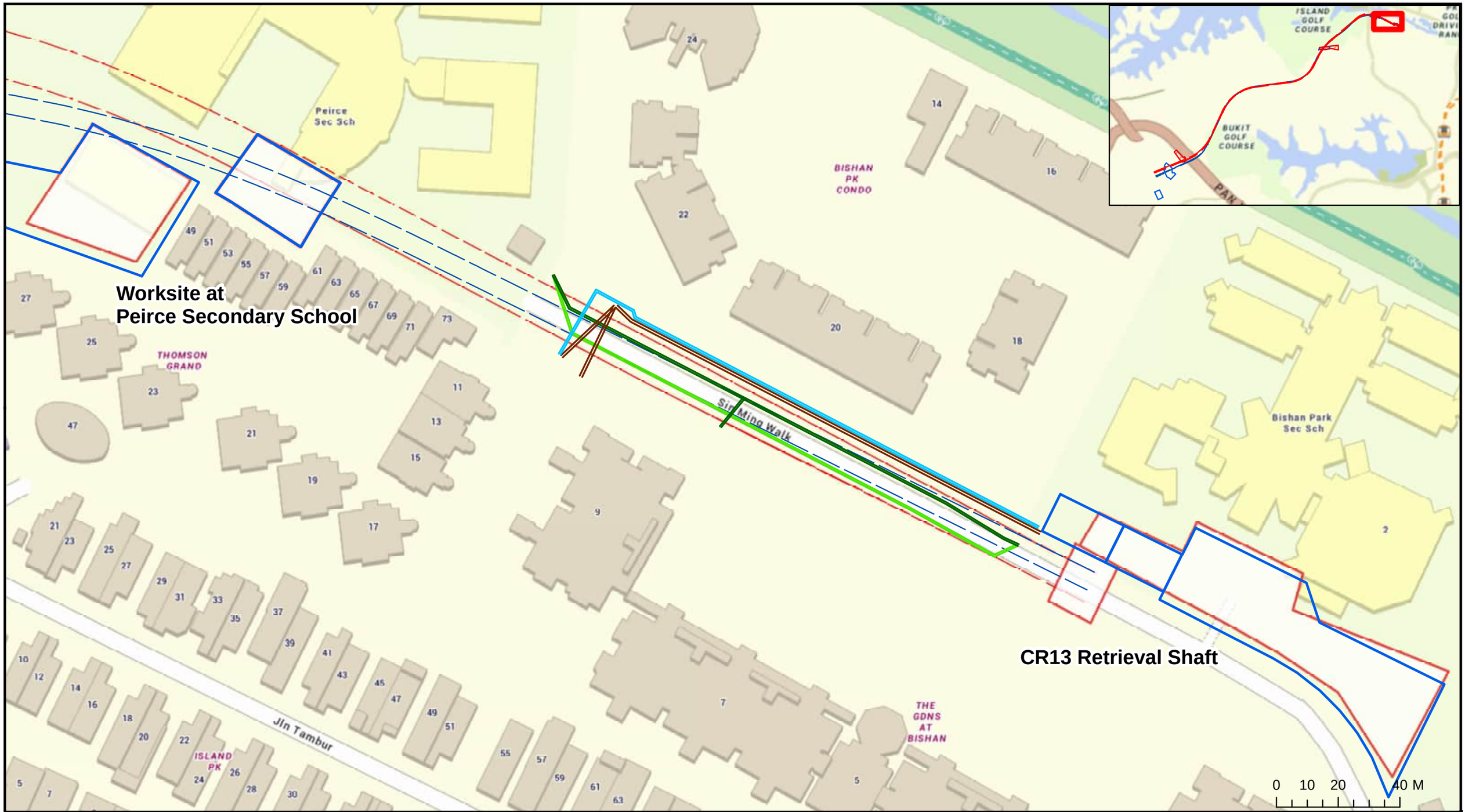
will include land clearing and tree feeling, road widening activities, construction of temporary roads to divert traffic and setting up of barriers around impending cut-and-cover works or around laydown areas. In addition, as the natural landscape will be replaced by impervious surfaces, it will reduce 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. For instance, box culvert may be constructed at the affected area where existing drain is cut by the construction of the temporary access road to the A1-W1 worksite.

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 human beings. If required, some of the utilities will be reinstated after underground station or tunnelling is completed and these utilities need to be restored at the same place. Depending on the utility to be diverted, this may involve tree felling, excavation, access road construction and concrete resurfacing works, etc.

For this Project, it is noted that there will be temporary water, power and gas diversion works along Sin Ming Walk (between CR13 retrieval shaft worksite and Worksite at Peirce Secondary School) in conjunction with traffic diversion to facilitate the ground improvement works, where the area will then be reinstated within the road reserve line upon completion. The utility diversion work at this area will be intermittent and night works will be avoided to minimise the potential noise impacts to the surrounding neighbourhood. Apart from that, there will also be a permanent diversion of water pipe along Island Club Road at A1-W1 worksite for a relatively short period of time. It will mainly be construction via pipelaying of a shallow pipe of approximately 1m deep. The works will be constrained within the existing Island Club Road where encroachment into the Windsor Nature Park will be avoided.

The above-mentioned utility diversion works are illustrated in Figure 3-14 and Figure 3-15. The potential environmental impacts associated with utility diversion are qualitatively discussed in each respective chapter. If there are complaints received due to the utility diversion works (outside of current worksites in this report), for example regarding noise and air nuisance, the Contractor shall inform the Public Relation Officer (see roles and responsibility in Section 13.4.5) and conduct relevant on-site environmental monitoring to rectify the issues where possible.

Figure 3-13 Examples of Traffic Diversion and 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
- Water Diversion
- Power Diversion
- Gas Diversion (Stage 1)
- Gas Diversion (Stage 2)

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	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
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**UTILITY DIVERSION AT
SIN MING WALK**

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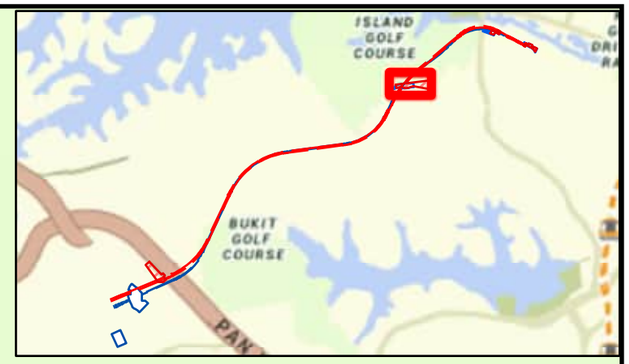
Note: Source of basemap - OneMap



A1-W1

Island Club Rd

Windsor

0 12.5 25 50 M

Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Water Diversion
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	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
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**UTILITY DIVERSION AT
A1-W1**

Designed	Checked	Approved
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	Drawn: ML	Date: MAR 2022

Figure No. : 3 - 15 | Rev. : - | Sheet : 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), recharge wells, internal temporary roads for movement of vehicles and vehicle parking lot (see Figure 3-16 below). All these site elements will only be provided in detailed design stage and are not available for assessment at the time of writing this report.

According to the latest planning based on the optimised scenario, the total construction footprint of A1-W2 mitigated worksite and A1-W1 mitigated worksite are estimated to be around 7,000 m^2 and 41,000 m^2 respectively. The total construction footprint of CR13 retrieval shaft mitigated worksite is estimated to be around 3,000 m^2. The total construction footprint of Worksite at Peirce Secondary School is approximately 3,500 m^2.

A typical layout of construction site with some basic features is shown in the building worksite picture below. It shows site office, internal access roads, equipment laydown area, concrete batching plant, etc. Roads around the site boundary will be also constructed before the commencement of site work, where necessary. For this Project, a temporary access road has been planned to connect A1-W2 temporary worksite to Eng Neo Avenue via the existing Fairways Drive and Turf Club Road (see Figure 3-3). Largely for most part this is widening of the existing road, as heavy vehicles transporting tunnel segment would need wider roads to transport these segments. Upon completion of the construction of these road works, the A1-W2 temporary access road will be handed over to a Contractor of a separate contract for permanent road construction at the same area. Whilst for access to the A1-W1 temporary worksite at Windsor, the existing Island Club Road is assumed to be utilised for similar purposes (see Figure 10-24). Street lamps may be built along the access roads if found to be insufficient to allow clear vision at night and when night works are required during night-time at the work areas of the access roads.

Figure 3-16 Typical Worksite Layout at Bright Hill MRT [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.

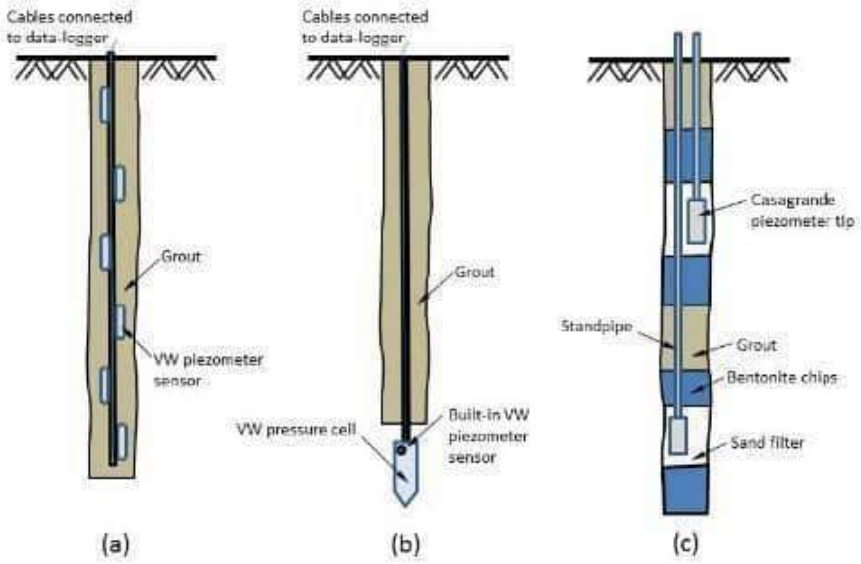


Figure 3-17 Schematic of Piezometer [P-62]

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

Figure 3-18 Examples 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 Biodiversity Study Area located 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, underpinning works, rock breaking and excavation works, shaft construction, temporary road access, tunnelling or TBM launch/retrieval works, concrete batching works (if any), as well as the construction of superstructures such as MRT stations, facility buildings, as well as general landscaping/ finishing works.

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 A1-W2 and tunnel retrieval at CR13 retrieval shaft. Besides, it is expected that a ground improvement zone of about 185m long will be required along Sin Ming Walk, which is located in between CR13 retrieval shaft and Worksite at Peirce Secondary School.

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

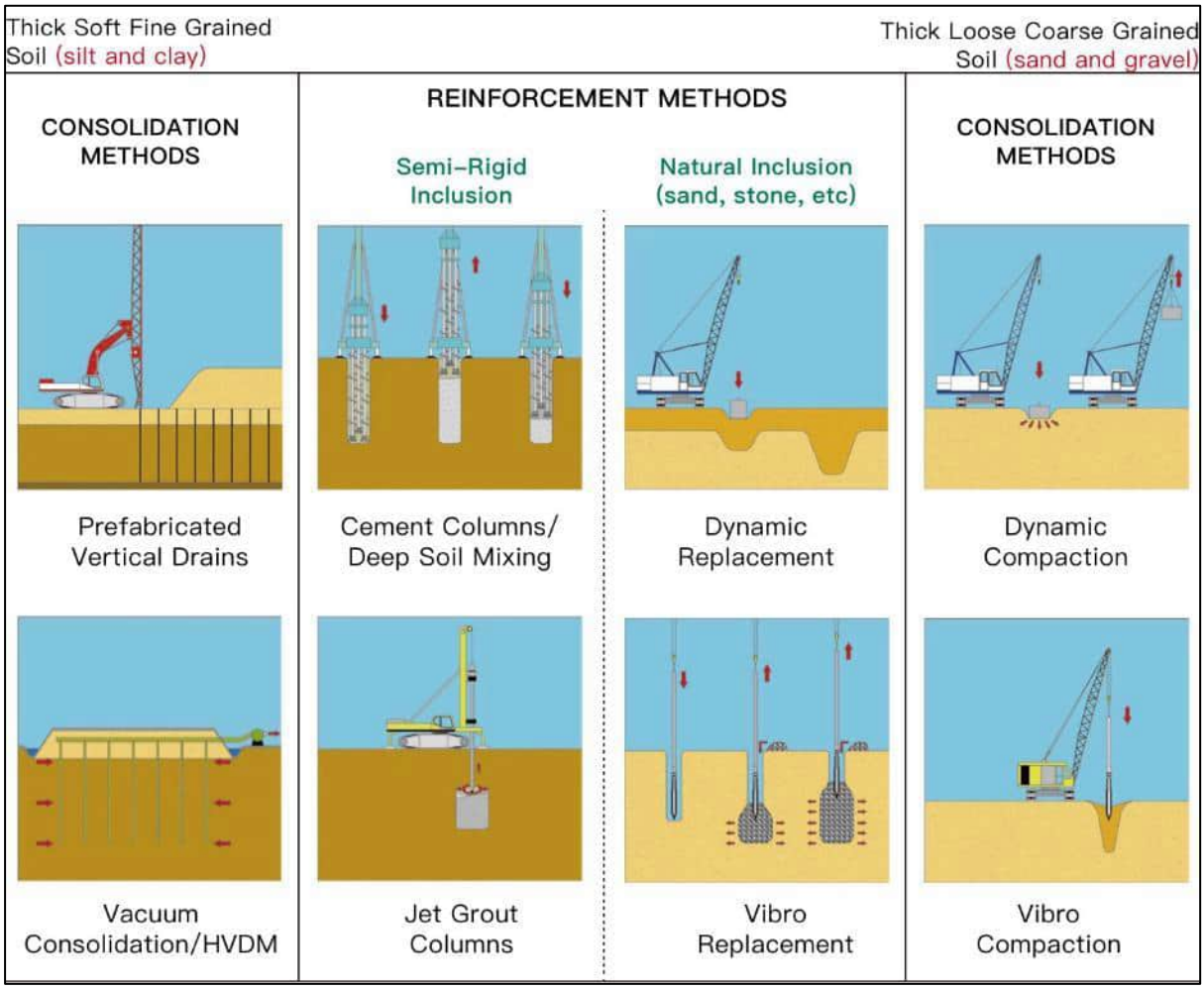


Figure 3-19 Common Ground Improvement Techniques Prior to Excavation [W-15]

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 carried out by LTA in a separate study), 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].

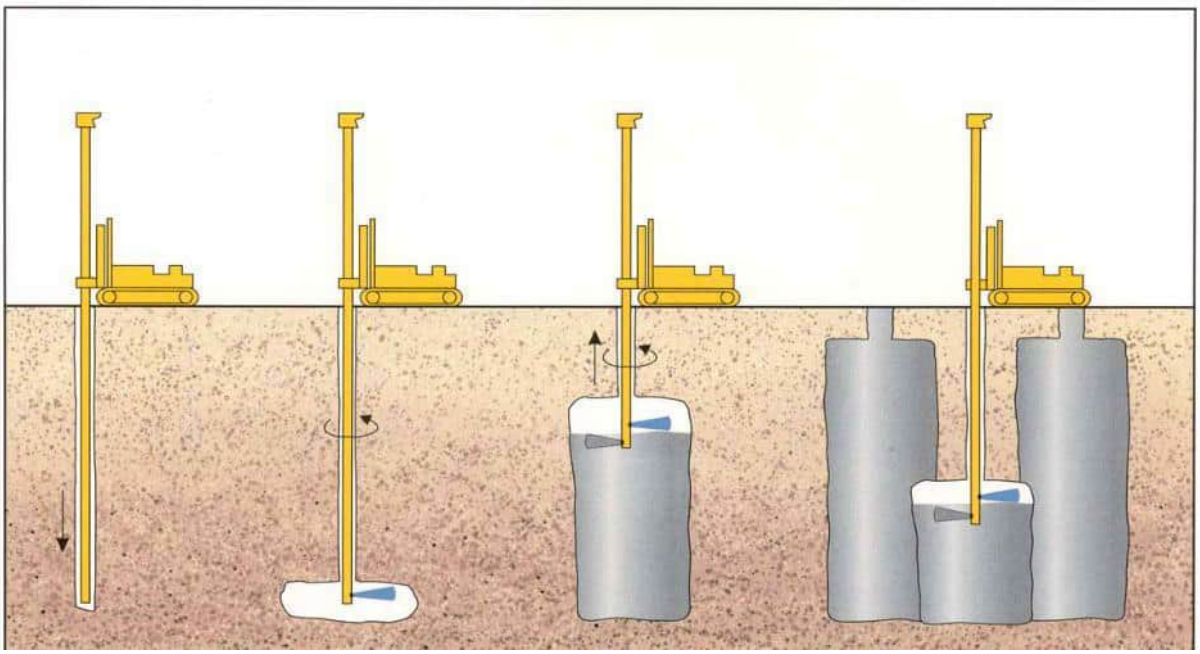
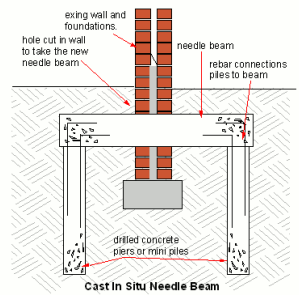


Figure 3-20 Schematic of Jet Grouting Rig Operational Process [W-16]

3.2.2.2 Underpinning Building Foundations

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

In this alignment, the Peirce Secondary School has been identified as one of the buildings which will require underpinning works before the tunnel construction. It is to be noted that when underpinning works are performed, the school shall be vacated for safety purposes until the works are completed, then tunnel boring will be carried out from underneath the building.



According to the current planning, underpinning by piling method would likely to be implemented. The objective is to spread the load or transfer it to deeper soil or bedrock with higher bearing capacity [W-69]. Generally, piles are driven on adjacent sides of the wall that supports the weak foundation. A needle or pin penetrates through the wall that is in turn connected to the piles as shown in the figure. These needles behave like piles caps. Settlement in soil due to water clogging or clayey nature can be treated by this method. [W-51]

Source of figure: Underpinning, from Wikipedia (https://en.wikipedia.org/wiki/Underpinning)

Under this method, there are two common type of piling systems expected to be applicable for this Project, i.e. Driven piling system and Bored piling system.

3.2.2.2.1 *Driven Piling for Underpinning*

Driven piling is basically forcing or driving a pile into the ground where soil is displaced rather than being removed [W-53]. It is suitable for underpinning from outside buildings and where sufficient space and headroom are available. It is considered as a quick and economical method, which has been widely used in conservation and restoration projects, low rise housing development, addition and alteration to both residential and building development projects, underpinning and strengthening to existing foundation projects in Singapore [W-52]. Driven piles tend to be stable in soft, squeezing soils, and if the soil is loose they can make it denser [W-53]. However, this method would face limitation under circumstances where it causes vibration, soil displacements and further settlement, especially for old structures (Promboon et al., 1988). Installation of driven piles can be carried out in total performance or driven cast-in-situ, usually with steel tubes. According to White (1962), driven piles can be sectional steel pipes (300 – 450mm diameter) in short lengths, and these should be filled with concrete. [P-71]

Alternatively, micropile or mini pile, which is a small diameter pile ranges from 150mm to 300mm), is a trending option for driven piling system due to its small, light, inexpensive characteristics but with similar capability for heavy-loading [W-53], which is commonly known as “Driven Micropiling” system. According to the Conservation Technical Handbook published by URA [W-70], micropiling is recommended for the underpinning works at historic buildings to minimise impact on existing historic floor slab and floor finishes.

3.2.2.2.2 *Bored Piling for Underpinning*

Bored piling is a non-displacement pile system formed by drilling small diameter hole ranging from 150mm to 250mm in diameter. The hole is then grouted by cement grout after placement of steel reinforcement bars. The combined cement grout which complies the BS/SS Standard (typically 30 or 35 N/mm^2) and high tensile steel reinforcement bars (typically 460N/mm^2) will give the structural capacity of pile. Geotechnical capacity of the pile is derived from the frictional resistance between pile and surrounding soil. [W-52]

Unlike driven piling system, this bored piling system is suitable to be used in dense and hard ground areas where driven piling system may not be viable. In addition, it causes little or no soil displacement and can be installed with low headroom, which also involves minimal noise and vibration. [P-71]

Similar to driven piling system, the size of the drilled hole for bored piling can be the same as the size of micropile or mini pile with a narrow diameter ranging from 150mm to 300mm, which alternatively named as “Bored Micropiling” system, so as to minimise the disturbances to surrounding and existing structures.

3.2.2.3 Shaft Construction

Generally, construction of shafts is required to support the TBM launch/retrieval works to construct the proposed CRL2 alignment, as well as to prepare for the construction of facility building and/or station worksites.

In this report, the worksites involved are:

- Retrieval shaft at CR13 near Bright Hill MRT Station *(to be constructed under CRL1 contract)*;
- Launch shaft at A1-W2 near Eng Neo Avenue Forest; and
- Facility Building at A1-W1 at Windsor.

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.

Construction of shafts for launch/ retrieval or facility building construction typically involves similar construction methods but with different area sizes. It is worth noting here that while launch and retrieval shafts will be constructed before the tunnelling commences, the facility building construction at A1-W1 will be constructed after the tunnelling is completed. The A1-W1, like most facility buildings, will be built as a compact and inconspicuous building. Given its close proximity to Windsor Nature Park, its façade will include greening and other design considerations to camouflage it with the surroundings.

3.2.2.4 Rock Breaking and Excavation Works

In case of hard underlying rocks like Bukit Timah Granite, rock breaking and excavation works may be required. The A1-W1 and A1-W2 worksites are underlain by Bukit Timah Granite rock at an overall depth range of 25-50 m (further details on geological profile is provided in Section 4.7), hence could require rock breaking and excavation to certain degrees at this depth. It is estimated that a total of 35 weeks would be required for the rock breaking and excavation of the 50m deep shaft (25m in rock) at A1-W1. Frequency of rock breaking and excavation at A1-W1 is assumed to be 1 time per day, hence 6 times per week for a 6-days work week, which calculates to about 210 events over the span of 35 weeks.

Whilst at A1-W2 worksite, rock breaking and excavation could be required to break down 25m deep of Bukit Timah Granite rock with estimated 2 times per day, hence 12 times per week for a 6-days work week, that calculates to about 480 events over a span of 40 weeks. Details of noise and vibration impacts caused by rock breaking and excavation works are provided in Section 11 and Section 12 respectively.

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

3.2.2.5 Station Box Construction

At the time of writing this report, there is no station box construction worksite covered under this report, while the planning for remaining station worksites along the CRL2 alignment are ongoing. However, the construction method of station box will still be discussed for comprehensiveness purpose.

A typical station box will be associated with overrun tunnels and TBM launch/receive shafts or possibly with cripple sidings. Generally, cut and cover construction method will be used for station box construction, where the structure is built inside an excavation and covered over with backfill material when construction of the structure is complete. Excavation includes piling, earthworks, ERSS construction, ground improvement works, roof slab formation, etc.

The construction of station area can be either top down or bottom up approach, which will be decided by the ERSS plan by LTA. Brief introduction of the two approaches are provided below:

Top Down Construction

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.

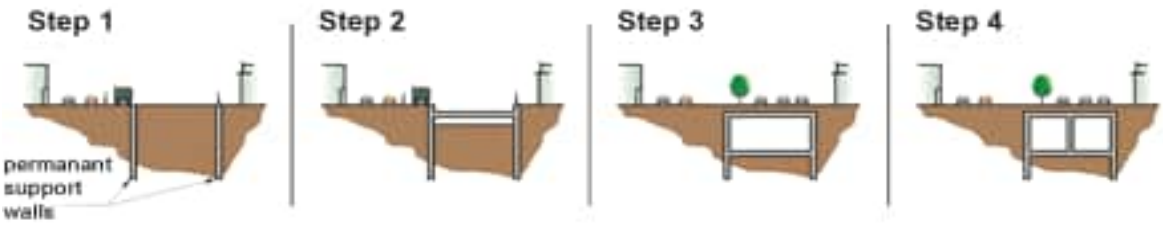


Figure 3-21 Top-down Cut and Cover Construction [P-65]

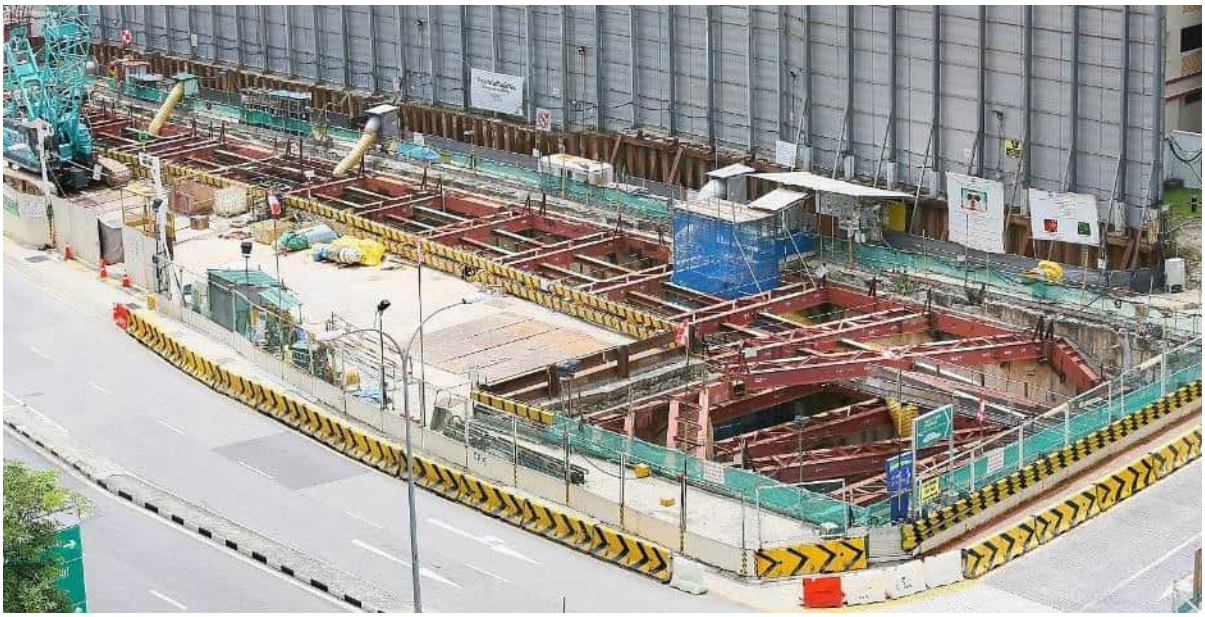


Figure 3-22 Examples of Top Down Construction at Lentor MRT Worksite [W-22]

Bottom Up Construction

In the bottom-up construction, tunnel construction takes place in a trench which is excavated from the ground surface at the shallow depth [P-107]. The trench is formed either using open cut (sides sloped back and unsupported), or with vertical faces using an excavation support system. The trench is then backfilled, and the excavated surface restored. In the bottom-up type of construction, the tunnel is completed before it is covered up and the surface reinstated. The steps for a bottom-up construction are depicted in the figure below.

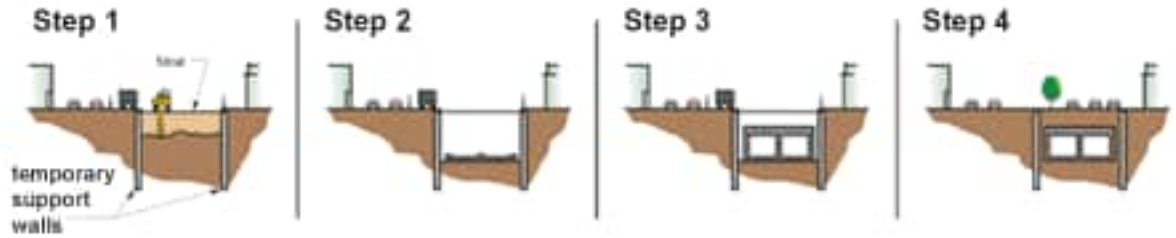


Figure 3-23 Bottom up Cut and Cover Construction [P-65]

Figure 3-24 Examples of Bottom Up Construction at Woodlands South Worksite [W-7]

3.2.2.6 Construction of Tunnel/Rail Alignment

The tunnel or rail alignment of this Project will be constructed typically via the tunnel boring machine (TBM). Apart from that, mining work is expected for the construction of transition tunnel near A1-W2 mitigated worksite where the New Austrian Tunnelling Method (NATM) will be used. These two methods will be described briefly as follows. The potential ground-borne vibration impacts (see Section 12) associated with the tunnel boring and mining works have been taken into consideration in this EIS.

3.2.2.6.1 *Tunnel Boring Works for General Tunnel/Rail Construction*

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 to relevant LTA standards, where they will be lined with High Density Polyethylene (HDPE) to provide additional protection from the corrosive underground environment [W-77]. 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-78].

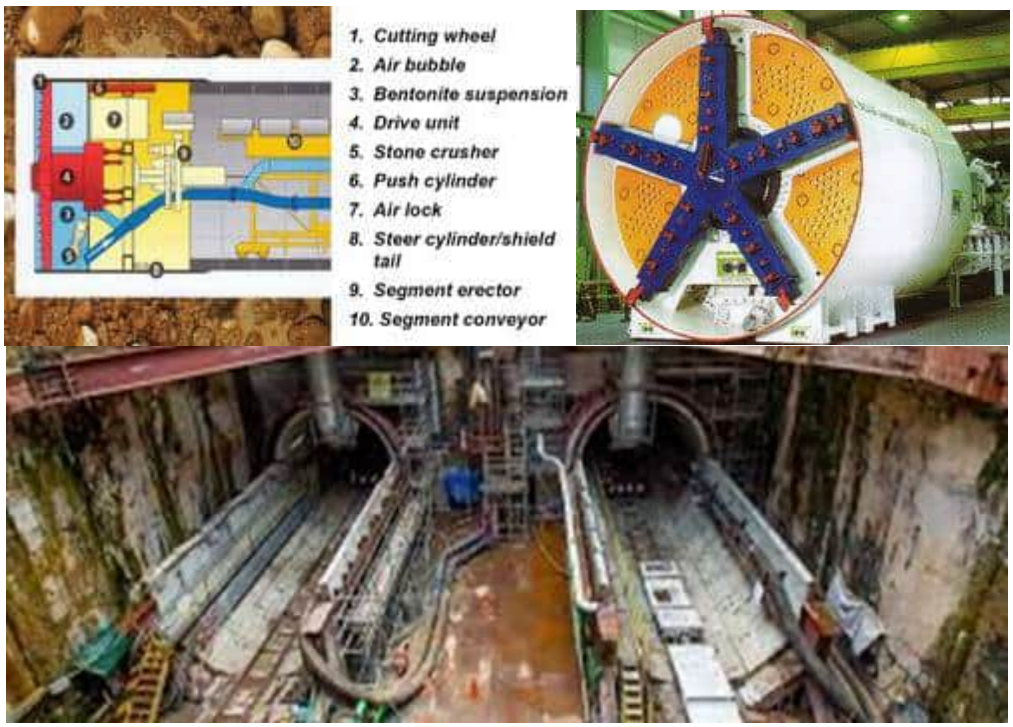


Figure 3-25 Examples of Slurry TBM [W-58] and Twin-Bored Tunnel at A Station Site in Singapore [W-21]

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.

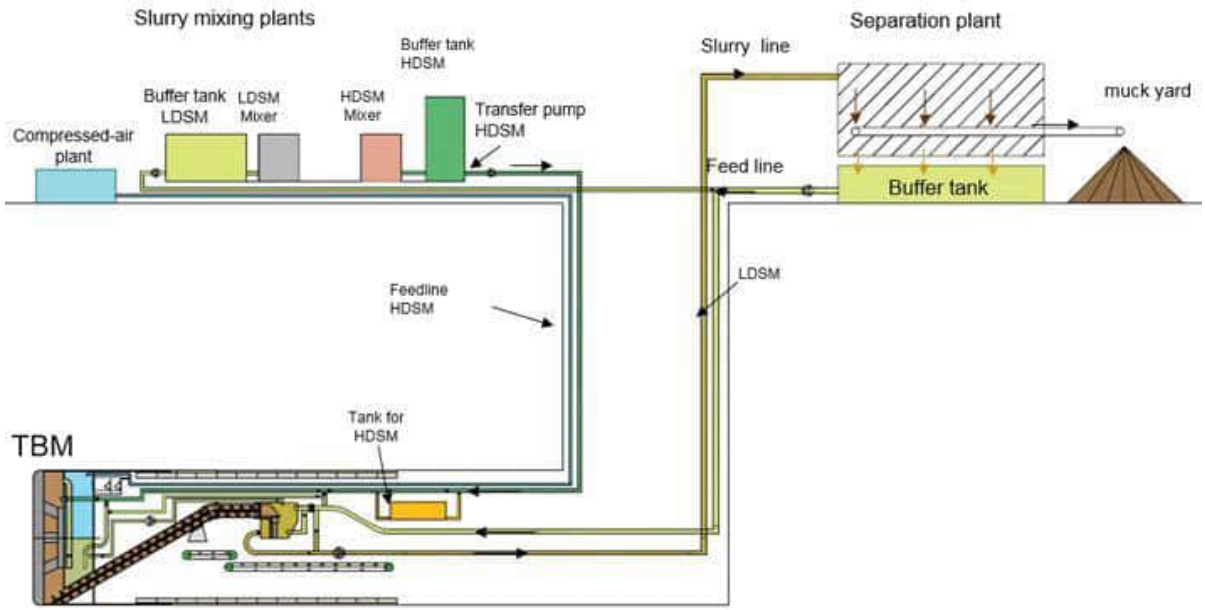


Figure 3-26 Schematic Showing a Variable Density TBM Operating below Ground and Treatment of Extracted Slurry at Above Ground Plant [W-12]

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

For this Project, it is planned that the TBM launching from A1-W2 to CR13 retrieval shaft will be a single-bored tunnel (SBT) with a diameter of 12.2m which will house 2 tracks. A schematic launch/ retrieval plan associated with the worksites in this report is shown in Figure 3-27 below.

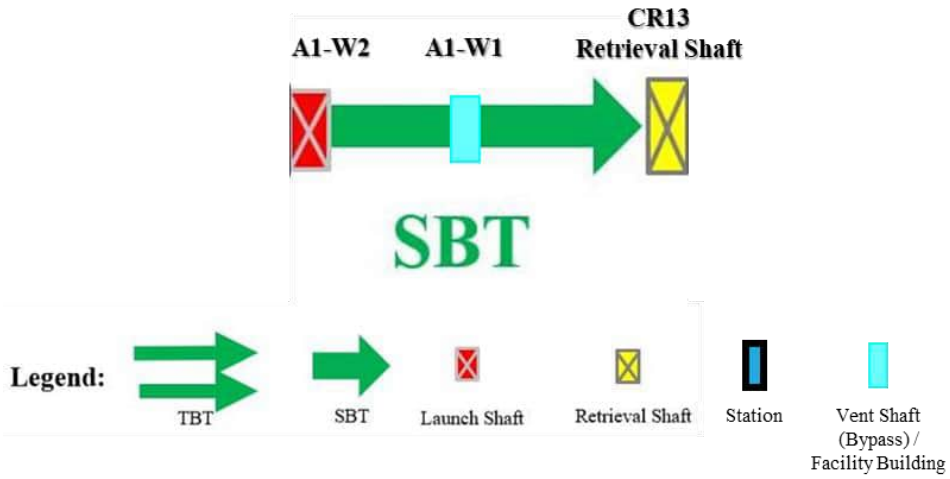


Figure 3-27 Schematic Plan of CR2005 TBM Launch and Retrieval

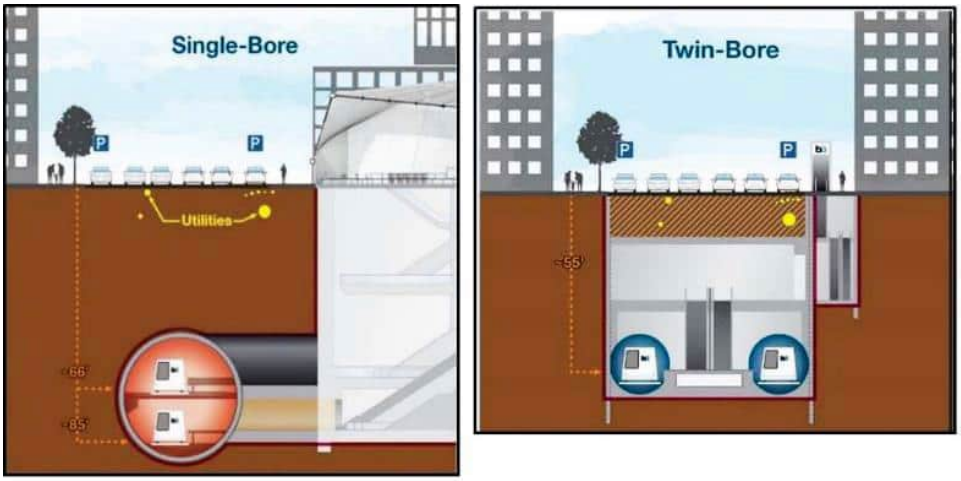


Figure 3-28 Single-Bored and Twin-Bored Tunnels [W-59]

Once the TBM has advanced and tunnel linings installed for the single-bored tunnels of the proposed CRL2 alignment from A1-W2 to CR13 retrieval shaft in this report, escape staircases (for alignment outside of CCNR) between railway tunnels are typically constructed once every 250 m for emergency preparedness in the tunnels in line with Singapore Civil Defence Force (SCDF) requirements. For the CRL2 alignment stretch within CCNR which was studied in the CCNR EIA [R-1], cross-passage doors, instead of escape staircases, will be built at every 250m within the tunnel for emergency evacuation purposes. This may again involve traffic and utility diversion before the escape staircases or cross passages can be mined or constructed.

Figure 3-29 Examples of Escape Staircase and Cross Passage Door [W-94]

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

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

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

3.2.2.6.2 *Tunnel Mining at Transition Tunnel using NATM Method*

Mining works will be required for the construction of transition tunnel near A1-W2 mitigated worksite, where NATM method is proposed to be adopted as of current planning.

NATM is a method of modern tunnel design and construction employing sophisticated monitoring to optimise various wall reinforcement techniques based on the type of rock encountered as tunnelling progresses [W-98]. It is a standard method for building tunnels that uses geological stress from natural ground around a tunnelling site to build the tunnel safely, especially in mountainous areas [W-99]. The origins of the New Austrian Tunnelling Method (NATM) are based on practical experiences with previous construction methods which assume that the tunnel support needed to carry the weight of deconsolidated rock masses. In those days, tunnel construction was influenced by experiences in the mining industry [P-109].

With reference to the construction of the Chuo Shinkansen in Japan [W-99], the NATM will first use necessary machines/ equipment (e.g. excavator underground) to excavate natural ground. The soil waste generated from this activity will be transferred off site using a dump truck or belt conveyor. After excavation, concrete is sprayed onto the excavated areas to reinforce natural ground. Rock bolts are then used to integrate the tunnel into natural ground. Depending on the conditions of the natural ground, arch-shaped steel material is used for reinforcement. This enables safe and efficient construction of a tunnel integrated into natural ground, using the geological stress of surrounding soil.

Excavation work can proceed at the front while finishing work follows along the rear. Firstly, waterproofing sheets are laid to mitigate the impact of groundwater. Next, lining concrete and trackbed concrete are applied in the same sequence. Tunnel construction will be completed by undertaking these processes.

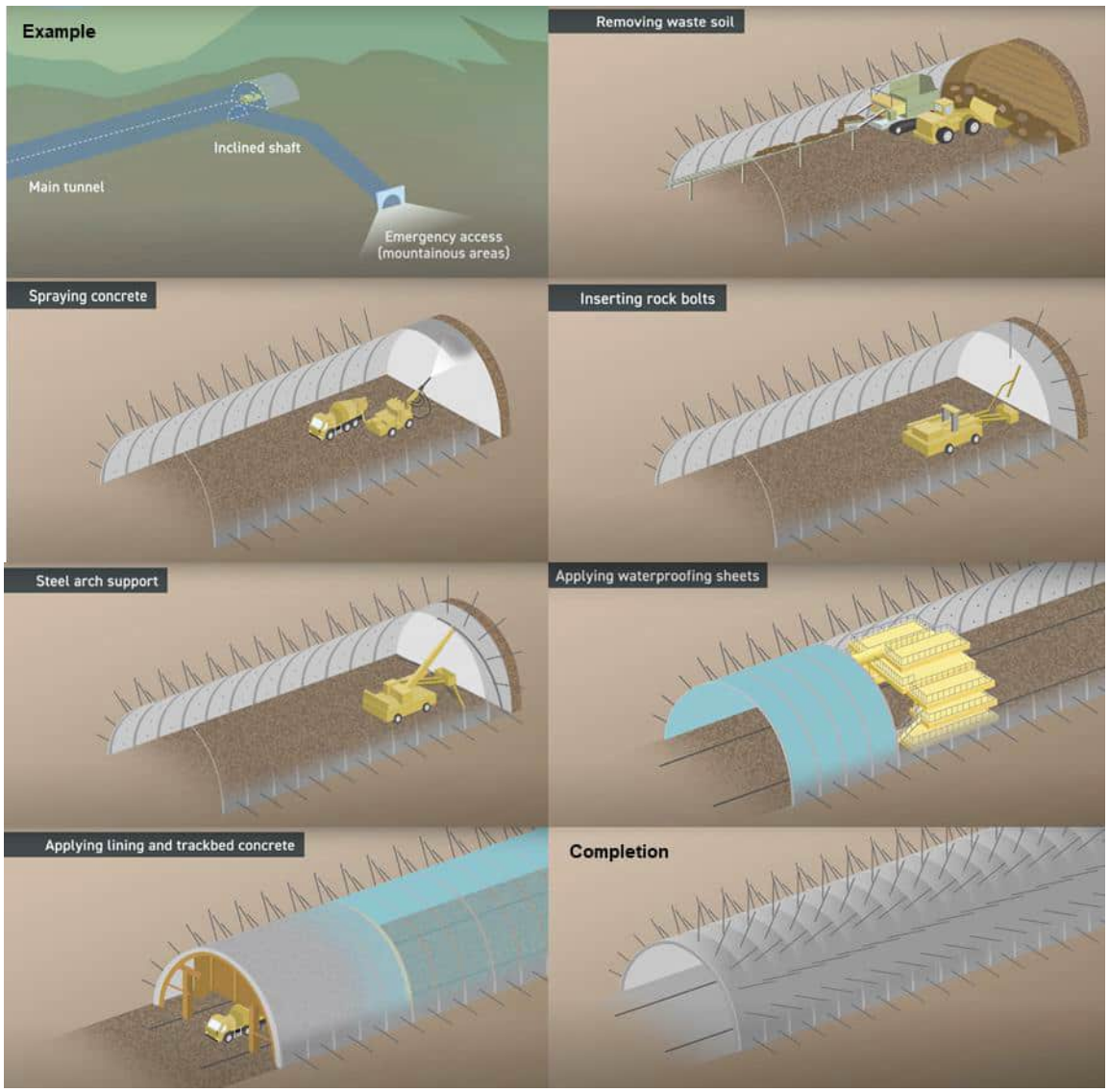


Figure 3-30 Examples of NATM Tunnel Construction [W-99]

3.2.2.7 Concrete Batching Plant

Construction of MRT station will be normally associated with the need of concrete batching plant to supply its daily concreting needs. At the time of writing this report, there is no location of concrete batching plant planned with the construction worksites covered under this report. However, the activities associated with concrete batching plant will still be discussed for comprehensiveness purpose.

A concrete batching plant is an equipment that combines various ingredients to form concrete. Some of the ingredients used in concrete plant include water, air, admixtures, sand, aggregate (rocks, gravel, etc.), fly ash, silica fume, slag, and cement. A concrete batching plant is equipped with various accessories, including mixers, cement batchers, aggregate batchers, conveyors, radial stackers, aggregate bins, cement bins, heaters, chillers, cement silos, batch plant controls, and dust collectors. There are mainly two types of concrete batching plant, i.e. Dry Mix Plant and Wet Mix Plant. A Dry Mix Plant first mixes the above-mentioned ingredients without water at a factory, which then being loaded into a mixer truck with water added and being mixed while being transported long distances to the worksite; whereas a Wet Mix Plant (can be mobile or stationary) mixes all necessary ingredients including water directly at the worksite or a central location near the worksite, where the ready-mixed concrete is simply transported using a ready mix truck or hauled using an open-bodied dump truck within worksite. [W-54, W-55]

A generalised diagram of a typical concrete batching process flow is included in Figure 3-31.

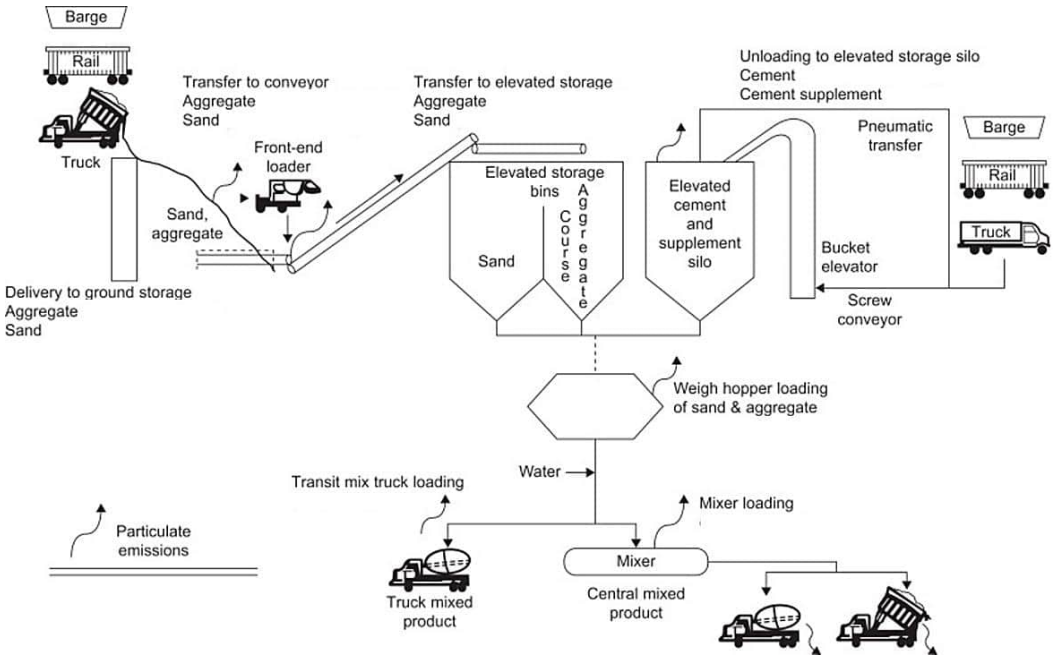


Figure 3-31 Generalised Concrete Batching Process Flow Diagram [P-67]

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

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 3-32.

Figure 3-32 Examples of Batching Plant at Marina South for Tunnel and Station Box Construction [W-8]

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

3.2.2.8 Construction of Permanent Facility Buildings

To prepare for operational purposes, construction works will be required for the A1-W1 worksite to convert it into a permanent facility building where its vent shaft will remain functional. The A1-W1 facility building (FB4) is expected to have a circular above-ground structure (20m diameter), rectangular underground Basement 1 and 2 (70m by 20m), as well as a circular underground structure below basement (25m diameter).

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 (where applicable). 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 3-33 An Example of Permanent Facility Building Construction at Springleaf Station [W-9]

The original A1-W2 worksite in base scenario was planned to be converted to facility building as well, which has been optimised and relocated outside of Eng Neo Avenue Forest and will not be converted to facility building during operational phase, therefore no construction of facility building at A1-W2 is required. Similarly, CR13 retrieval shaft which will only be an underground structure without housing any facility.

3.2.2.9 Construction of MRT Superstructures

Construction of the MRT superstructure or the concourse level is like any other building superstructure construction over the roof slab built after either the top down or bottom up station box construction (Refer to Section 3.2.2.5). At the time of writing this report, construction of MRT station and its associated superstructures are not applicable for the worksites in this report, however it will still be discussed for comprehensiveness purpose of the study.

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

Figure 3-34 Examples of Completion of Station Concourse [W-6]

3.2.2.10 General Landscaping and Finishing Works

Facility buildings are provided with façade cosmetics with theme decided for a rail line. Landscaping around these buildings for the CRL2 stations in the Biodiversity Study Area 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 3-35 Examples 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-45]. 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 footprints of A1-W2 and A1-W1 are demonstrated from Figure 3-5 to Figure 3-6.

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

It is noted that there are no stations located within the section of the alignment under this EIS. However, operational activities associated with station entrances/ exits will still be discussed for comprehensiveness purpose.

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

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

All station entrances are provided with canopies or roof to adequately protect them from the weather. Canopies and roof are constructed with adequate projection and fascia or parapets to cover the structural elements of the roof and provide enough upstand against rainwater spillage which will be collected and discharged to the surface drains. For rainwater runoff collected by drains at the sides of the station, it will be channelled to discharge into public storm drains [W-34]. A typical example of station entrance/ exit is illustrated in figure below.

Figure 3-36 TEL Mayflower Station Entrance G [W-35]

3.3.2 Station Buildings and Platforms

It is noted that there are no stations located within the section of the alignment under this EIS. However, operational activities associated with station buildings and platforms will still be discussed for comprehensiveness purpose.

During operational phase of the MRT line, the stations are assumed to be operational from 5.30am to 12.00am and therefore have an increase in activities in terms of human activities and light/ temperature changes in and around the stations during these hours. The typical example of an MRT station and platform is as shown in Figure 3-37.

Figure 3-37 Examples of Interior at TEL Bright Hill Station [W-35]

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-34]. The proposed ACMV system (e.g. air-conditioning equipment, exhaust, condenser etc.) in stations has several equipment housed in the outer façade of the building, either on the roof or the façade, thus the noise levels have to be controlled such that it meets the noise levels at the boundary of the building in accordance with *NEA Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-industrial Buildings*.

An MRT station will also be equipped with sanitary facilities, where waste or foul water from the station 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 an MRT station's island platform with cripple sidings is demonstrated in Figure 3-38.

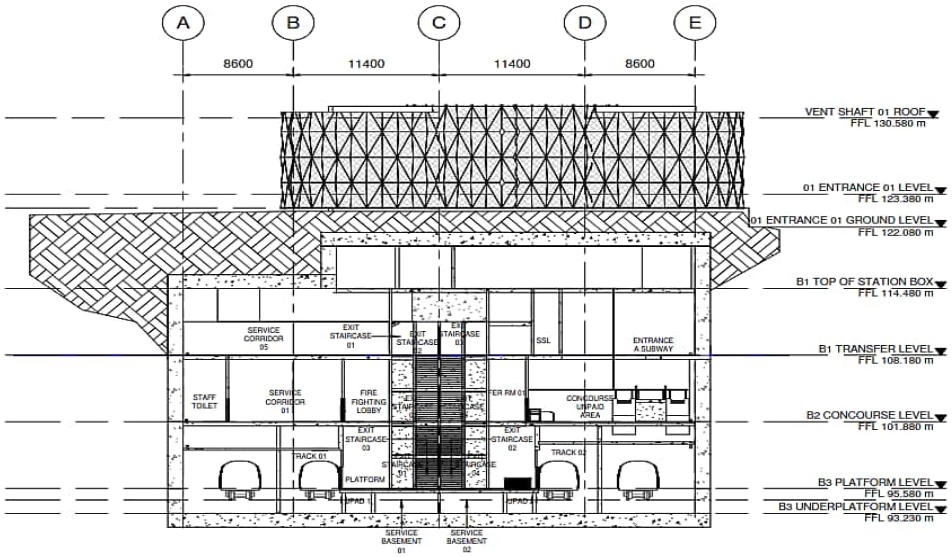


Figure 3-38 Concept Design of MRT Station [O-2]

3.3.3 Tunnel alignment

As per current planning, the CR2005 tunnel alignment (exclude CCNR) in overall would not exceed -60m below Singapore Height Datum (SHD). The tunnels will be designed with twin tracks for the trains to operate in both directions with a design lifetime of up to 120 years. These tracks sometimes run parallel to each other and at places

can be stacked one above the other depending on the engineering constraints (e.g. geological constraints or existing underground utilities/ existing services nearby). The track form for this Project is expected to be non-ballasted type where its potential ground-borne vibration impacts have been discussed in Section 12 of this report.

During the Commissioning phase, test trains will run and extensive track testing will be completed before the MRT line is opened to public for safety reasons. However, with regular maintenance and correction during operational phase, the useful life of tunnels can go beyond 120 years, and there should be no need to replace the tunnels. The periodic maintenance works for the rails within the tunnels will be carried out once a week, typically between 0100 hrs and 0400 hrs when the trains are not operating, or whenever the need arises. The list of maintenance equipment is provided in Section 3.5.2. Typically, a diesel-operating wagon/ vehicle may be used for mobility for maintenance work in the tunnels in the night.

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

In addition to the regular two-way track forms, an MRT station may be associated with a pair of cripple sidings in parallel to the tunnel alignment alongside the island-type platform. A cripple siding is an extra track needed to facilitate withdrawal or storage of impaired/ crippled train that is not fit for passenger service. The cripple siding will also be used to store trains that are on standby as evacuation trains during operational phase [W-38]. 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-40] as illustrated in Figure 3-39. The impact of cripple sidings is only due to the fact that this area is usually constructed by cut and cover method, along with a station box, hence the worksite footprint for this purpose tends to be larger than usual.

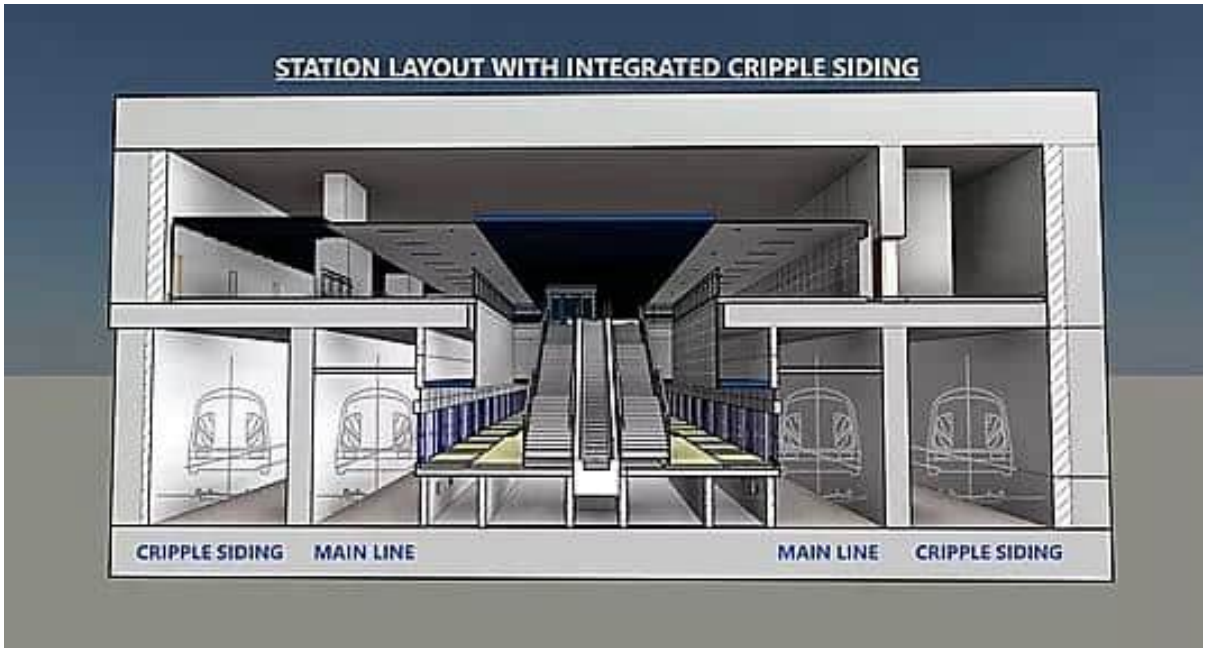


Figure 3-39 Examples of Station Layout (Island Platform) with Integrated Cripple Sidings [W-38]

3.3.4 Ventilation Shafts Associated with Stations and Facility Buildings

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

During the operational phase, therefore, there will be vent shafts associated with each station box [W-34] and/or facility building. After design optimisation, there will be an additional intermittent vent shaft/ facility building as the A1-W1 worksite will be converted to permanent facility building where its vent shaft will be remained functional. In order to ventilate the tunnels with fresh air and in the event of fire emergency, to prevent recirculation and re-entrance of smoke into the stations, these vent shafts are installed. The vent shafts are connected from the station box/ tunnels, to the vent, and lastly to the atmosphere. The ventilation supply (VS) shafts take in fresh air from the atmosphere, while the ventilation exhaust (VE) shafts exhaust air from the stations. Tunnel Ventilation (TV) shafts are for the ventilation of tunnels through the piston effect brought about by the train movements through tunnels. In case of fire emergency, the VE shafts and TV shafts will purge smoke and hot gases from the station and tunnel. In addition, TV shafts may also act as intake shafts supplying air into the tunnel during congested/ peak hour operations and tunnel maintenance activities. Replacement air for the station smoke purging system and trackway emergency ventilation system will be supplied from the station entrances. [W-34]

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-34]

In future, any potential construction activities in the vicinity of the vent shaft will generate dust pollution, smoke and exhaust fumes and other environmental pollution which will affect the performance of the environmental control equipment as well as the fire and smoke detection system of the stations and facility buildings. Care should be taken to ensure no restriction to free flow of air around the vent shafts, hence effective measures to minimise dust pollution, etc. shall be implemented during operational phase. [W-34]

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

Access roads will be constructed for this purpose to lead to the facility building entrances. Facility buildings may generate airborne noise due to the air-conditioning and mechanical ventilation (ACMV) at the rooftops of relevant buildings, such as air-conditioning units, exhaust air fans, intake air fans and cooling towers. These buildings will be built to comply to relevant NEA's mechanical buildings noise regulations at boundary. Besides, the tunnel may accumulate wastewater during heavy rainfall, which will be pumped out to proposed detention tank and disposed properly according to NEA's *Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse* [W-17].

Figure 3-40 Ventilation Shaft at Bedok North MRT Station within an open park setting [O-7]

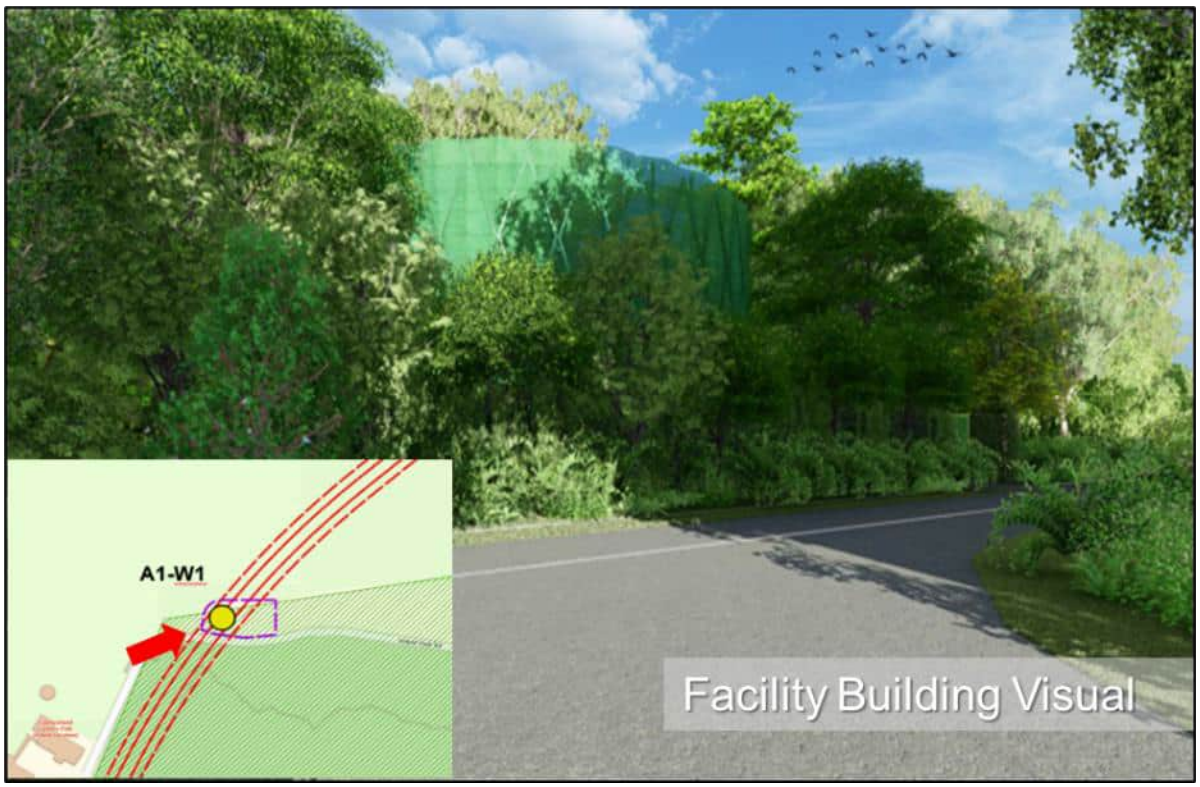


Figure 3-41 Visual Impression of A1-W1 Facility Building [O-9]

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 Developments

It is known that other construction activities are planned to occur in the vicinity of the Project as identified below. The locations of these concurrent developments relevant to this report are presented in Figure 3-42. The cumulative impacts of these concurrent developments were assessed qualitatively in each individual section of different environmental disciplines, except for airborne noise where quantitative approach was undertaken as sufficient information were provided for the cumulative airborne noise impact assessment.

a) CR14 at Turf Club Road near A1-W2 worksite:

LTA is currently planning for CR14 MRT station facilities and other supporting amenities that can be connected to the Project alignment demonstrated in this EIS. The planning of this CR14 is currently ongoing at the time of writing this report, hence no information can be presented in Figure 3-42. The construction of the CR14 and its associated road works is expected to be overlapping with the construction of A1-W2 for about 96 months, hence the cumulative impact during this overlapping period was taken into account in the impact evaluation of this report.

b) Shaft 4 of PUB Water Pipeline Project at BKSR located at A1-W1 worksite:

PUB BKSR involves the laying of a total length of 4600m of twin 1800mm diameter potable water pipelines from Bukit Kalang Service Reservoir via Island Club Road to Ang Mo Kio Avenue 1 and Upper Thomson Road. The pipelaying works will be conducted by either open-cut method (i.e. trenches are cut at the ground surface for pipe sections to be lowered into position and joined together before the progressive backfilling works at the completed sections) or pipe-jacking method (i.e. pipeline is jacked section by section from jacking shaft to receiving shaft using a specialised tunnel boring machine with hydraulic press).

According to the published PUB BKSR EIA [R-59], the PUB BKSR Shaft 4 is planned to be co-located with A1-W1 worksite. The site preparation at Shaft 4 is expected to be conducted in parallel with Shaft 3 and 5, which is around Q3 2022. Thereafter, the construction works (including shaft construction, pipelaying/ pipejacking, welding, lining works as well as permanent reinstatement works) at PUB BKSR Shaft 4 is expected from Q4 2022 to Q4 2024. These concurrent activities from PUB BKSR Shaft 4 during the construction of A1-W1 worksite is expected to have an overlap of about 15 months of works at both sites, and the cumulative impact of this period was taken into account in this report.

c) CR13 excavation and shaft construction works under a separate contract for CRL1:

It shall be noted that only CR13 TBM retrieval activity is covered under this Project (CRL2), while other activities associated with CR13 retrieval shaft and station such as shaft construction and excavation works, etc. are under a separate contract of CRL1. The CR13 excavation and shaft construction works are expected to overlap with the retrieval works at CR13 retrieval shaft worksite of this Project for about 21 months. Since this worksite is away from the Biodiversity Study Area, the cumulative impact from this site's co-location is considered insignificant to biodiversity, however it will still be discussed qualitatively in this report for the comprehensiveness of this study.

Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Concurrent Development

- CRL1 - CR13 Excavation and Shaft Construction
- PUB Water Pipeline Project at BKSR (Shafts)
- PUB Water Pipeline Project at BKSR (Pipeline)

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	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
(WINDSOR AND
ENG NEO AVENUE FOREST)

Designed	Checked	Approved
ML	JAG	JAG
	Drawn: ML	Date: MAR 2022

Figure Title :
INDICATIVE LOCATIONS OF OTHER CONCURRENT MAJOR DEVELOPMENTS

Figure No. :	Rev.	Sheet
3 - 42	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - OneMap

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 is provided in Table 3-1 below.

Table 3-1 Project Concrete Requirements

Worksite	Total Concrete Required for Above-Ground Structure	Total Concrete Required for Below-Ground Structure
A1-W2	< 25,000 m^3	5,000 – 30,000 m^3
A1-W1	< 25,000 m^3	5,000 – 30,000 m^3
CR13 Retrieval Shaft and Worksite at Peirce Secondary School	< 25,000 m^3	5,000 – 30,000 m^3

3.5.1.4 Equipment

Table 3-2 provides an indicative list of equipment and/or facility which may be required during construction phase of the Project, where construction of MRT station and superstructures is listed for the comprehensiveness of the study. Fuel and other chemical materials (e.g. cement additives, etc.) are the common inputs to operate the equipment for construction works, which 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-80].

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

Activity	Indicative Equipment
Site Clearance and Preparatory Works (e.g. hoarding setup, site levelling, tree removal, debris removal, etc.) including Traffic Diversion Works and Excavation to Work Platform Level	Breaker Concrete Pump Crane Drum Compactor Dump Truck Excavator

Activity	Indicative Equipment
	Front End Loader Generator Handheld Breaker Handheld Chainsaw Hydraulic Foundation Drill Lorry Cranes Roller Telehandler (5 tonne) Tracked Excavator Trailer (40 feet) Tractor Tree Saw Truck Mixer
Temporary Earth Retaining Structure works (e.g. continuous bored piling, sheet piling, decking installation, etc.)	Crane Crane mounted with Vibrator Pile Driver Excavator Excavator mounted with Vibrator Pile Driver Generator Hydraulic Foundation Drill Lorry Cranes Trailer (40 feet)
Earth Retaining Structure Systems (e.g. installation of D-Wall) and Concrete Batching Plant at station worksites, as well as other temporary works for all worksites (e.g. wall casting, earth removal, spoil and slurry disposal, concreting works etc.)	Bentonite Separation Plant Concrete Pump Crane Crawler (50 tonne) Dump Track D-Wall Rig with Grab Excavator Flat Truck Impact Piling Rig Lime Dosing Plant Loader Mobile Crane Ready Mix Concrete Truck Tracked Excavator (30 tonne) Truck Mixer Truck Mounted Crane **<u>Concrete Batching Plant</u>** Bentonite Slurry Tanks Clean Water Tanks Colloidal Mixer (Bentonite) Compressor Generator Measuring Tank & Agitator Ripple Screen (included in sewage treatment plant) Slurry Pump Concrete Aggregate Silos/ Elevated Storage Bins
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

Activity	Indicative Equipment
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
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 and Finishing Works	Asphalt Paver Dump Truck Excavator Front End Loader Generator Grader Roller

3.5.2 Operational Phase

3.5.2.1 Electricity Supply

During operational phase, electricity will be required to operate the train services, which also include the associated operational activities at the station and facility buildings, as well as 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, from where it reaches the public through water mains and taps. Water supply is essential throughout all phases of the Project, where water will be drawn from the mains for the operational activities (e.g. cleaning, washing, drinking).

3.5.2.3 Equipment

Table 3-3 provides an indicative list of equipment and/or facility associated with rail tunnel and facility building operation and maintenance works during operational phase of the Project, where station activities are also included for comprehensiveness of the study. [W-34]

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-33]** 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) when accessing station	Offices Service counter Retail space/ shops

Activity	Indicative Equipment/ Facility/ System
buildings, facility buildings and MRT	Normal and emergency lighting Storerooms with cleaning equipment and chemicals (e.g. oil/ diesel) Bicycles parking space outside station building
Note: ** The replacement of this equipment might involve heavy vehicle.	

3.6 Project Wastes

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

3.6.1 Construction Phase

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

Construction activities will generate large amounts of spoil material which will require disposal or reuse. A total of 2,519,400 m^3 of spoil may be excavated during the construction phase of the entire CRL2 alignment, which is estimated based on the spoil generated from the cut and cover excavation works and tunnel boring works from all the associated construction worksites, including the A1-W1 and A1-W2 worksites of this EIS. Within the estimated total spoil volume, it is assumed about 20,000 – 100,000 tonnes of spoil per worksite will be generated from the A1-W1 and A1-W2 worksites of this EIS. 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 runoff and trade effluent from tunnelling activities. Sanitary effluents will be released to the PUB's sewerage system while extracted groundwater (not contaminated with construction wastes) and surface water runoff will flow into the stormwater drains within the project area which will then be channelled to watercourses if they meet required discharge standards. The trade effluent from tunnelling activities will be treated and discharged separately from stormwater runoff. Bentonite slurry treatment system/plant will be established accordingly within the Project site. Contractor will need to seek approval from relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. Further discussion on water and/or effluent discharge was provided in Section 8.

3.6.2 Operational Phase

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

Non-hazardous waste can include paper, cardboard, plastics from wrapping/bottles, styrofoam and others generated from the site staff. It is to be noted that operation waste data was not readily available during the time of writing this report and non-hazardous waste was assumed to be generated from station staffs (5 persons) only. The domestic waste production of one person in Singapore is approximately 0.86 kg per day [W-73]. It can be assumed that each typical station would produce a total of 4.3 kg of general waste (staffs only) in a day. For A1-

W1 facility building which is assumed to be visited by the same number of staffs for the weekly maintenance work (refer to Section 3.3 for maintenance frequency), the expected waste production at facility building would be a total of 4.3 kg of general waste (staffs only) per week.

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.

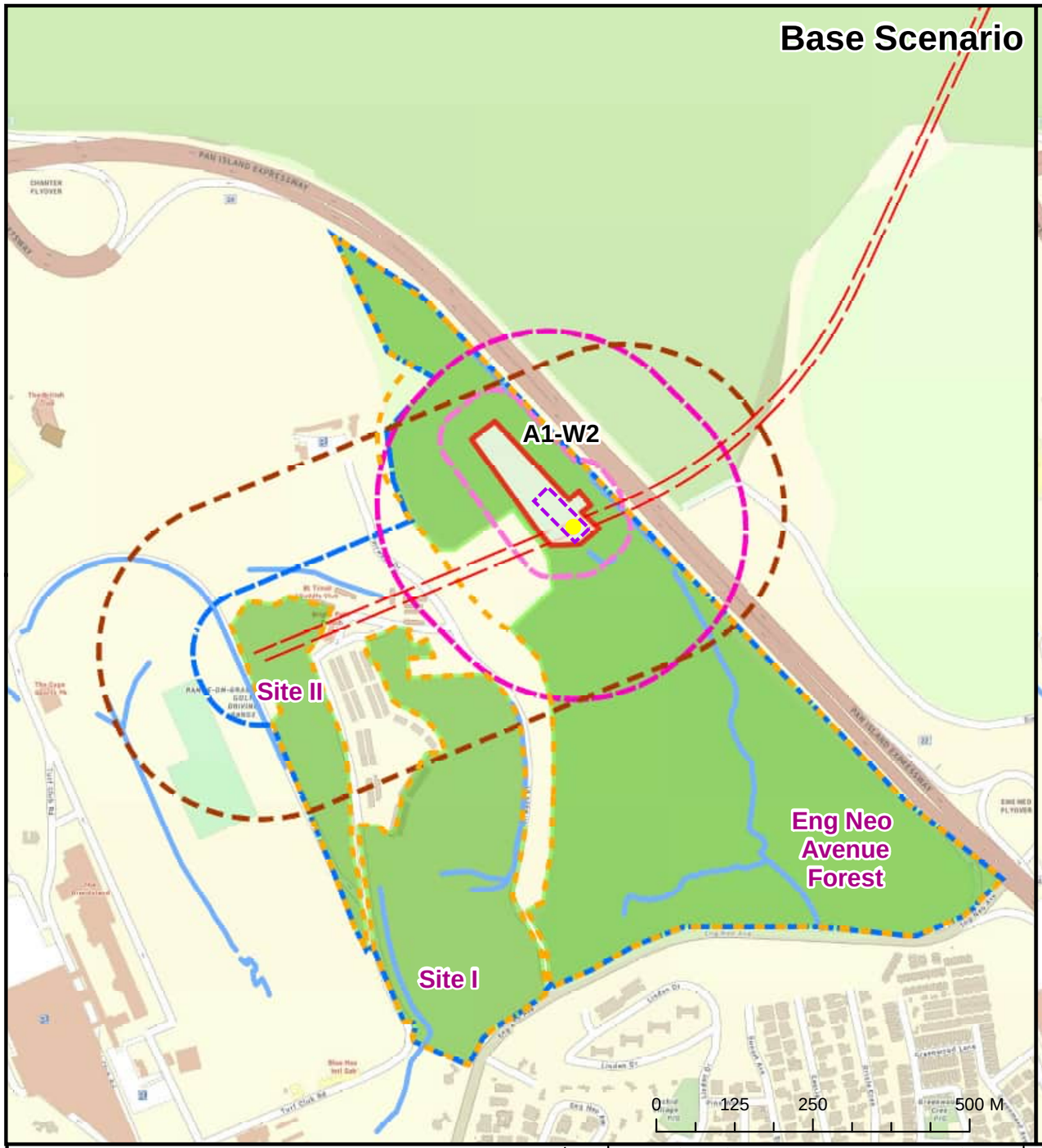
A varying size of Study Area is required for each environmental parameter based on the relevant legislation or international guidelines, which are justified and summarised in Table 4-1, and presented collectively in Figure 4-1. Further details of Study Areas will be discussed for each impact in the respective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

Table 4-1 Summary of Study Areas

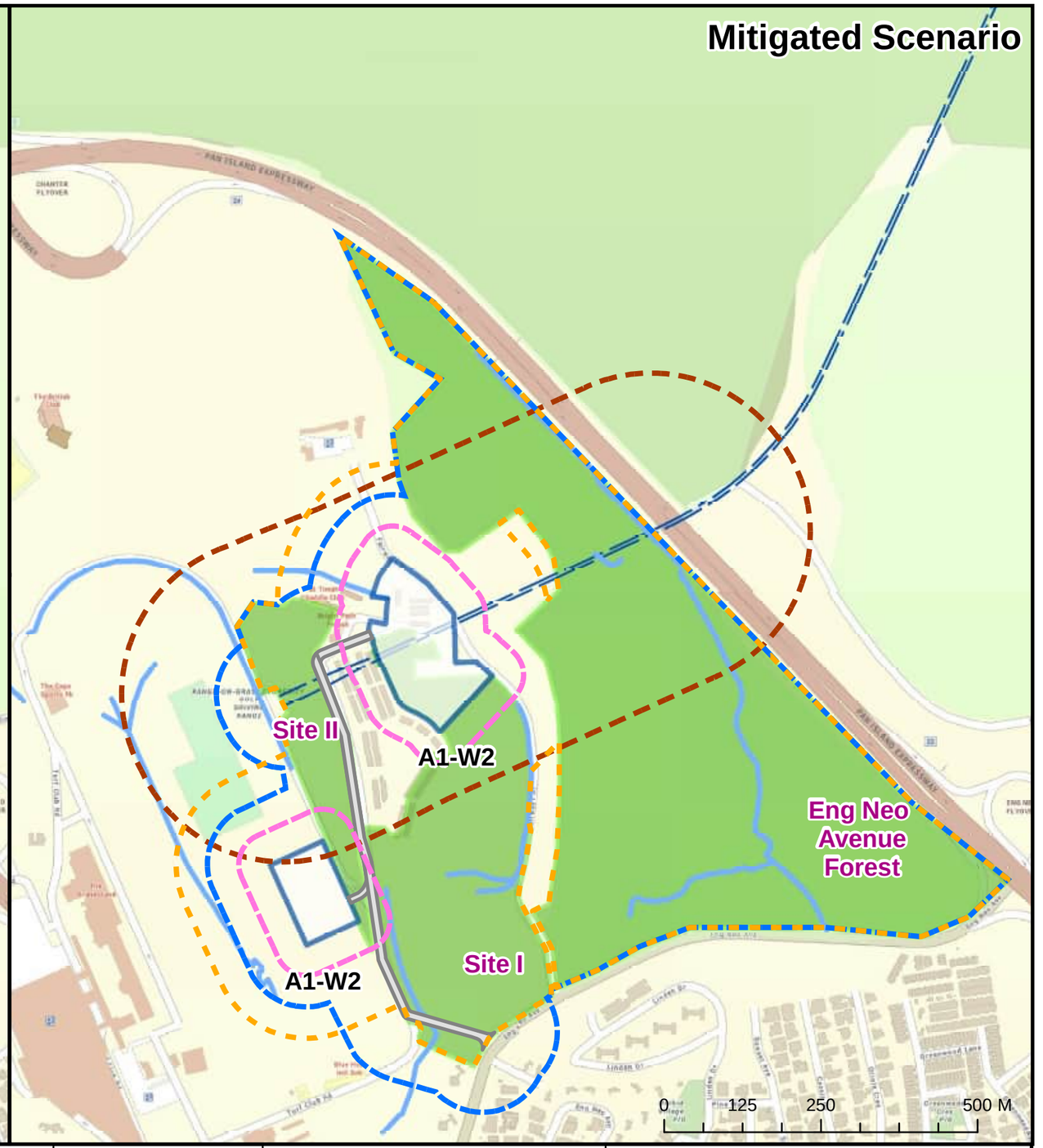
Environmental Impacts	Study Area (Construction Phase)	Study Area (Operational Phase)	Justifications
Biodiversity	Forested area identified in the vicinity of the Project to be studied for its biodiversity value as defined by LTA for the purpose of this EIS (i.e. Windsor, Eng Neo Avenue Forest, Sites I and II).		Construction and operational activities of the Project has potential to affect biodiversity and ecosystems.
Hydrology and Water Quality	Any major watercourses with direct impact from the Project within the Biodiversity Study Area.		Construction and operational activities of the Project has potential to impact hydrology and water quality of the watercourses affected by the Project.
Soil and Groundwater	250 m from the rail alignment/ station or other construction sites footprint		Based on typical Study Area in Historical Land Use Survey (HLUS) under separate studies done 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-46] Operational phase: Based on other Project experiences.
Airborne Noise	For Windsor: Windsor or 150 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Eng Neo Avenue Forest: A combination of Eng Neo Avenue Forest, Sites I and II, and 150 m from the construction worksites.	For Windsor: Windsor or 150 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Eng Neo Avenue Forest: A combination of Eng Neo Avenue Forest, Sites I and II, and 150 m from the construction worksites.	Construction phase: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-51] Operational phase: NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 [R-52], NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 [R-53]

Environmental Impacts	Study Area (Construction Phase)	Study Area (Operational Phase)	Justifications
Ground-borne Vibration	For Windsor: Windsor or 250 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Eng Neo Avenue Forest: A combination of Eng Neo Avenue Forest, Sites I and II, and 100 m from the construction worksites.	For Windsor: Windsor or 250 m from the construction worksite, whichever is greater. The area can be extended beyond, if significant impacts are greater. For Eng Neo Avenue Forest: A combination of Eng Neo Avenue Forest, Forested Area Sites I and II, and 100 m from the construction worksites.	Based on extensive technical experiences on similar rail projects.

Base Scenario



Mitigated Scenario



Legend

- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road

Above-Ground Structure

- Facility Building (Above-Ground)

Underground Structure

- Facility Building (Underground)
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)

Study Area

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

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

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Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**SUMMARY OF STUDY AREAS
AROUND ENG NEO AVENUE FOREST**

Designed	Checked	Approved
ML	JAG	JAG
	Drawn: ML	Date: MAR 2022

Figure No. : 4 - 1
Rev. : -
Sheet : 1 of 1
CAD File Name : NA
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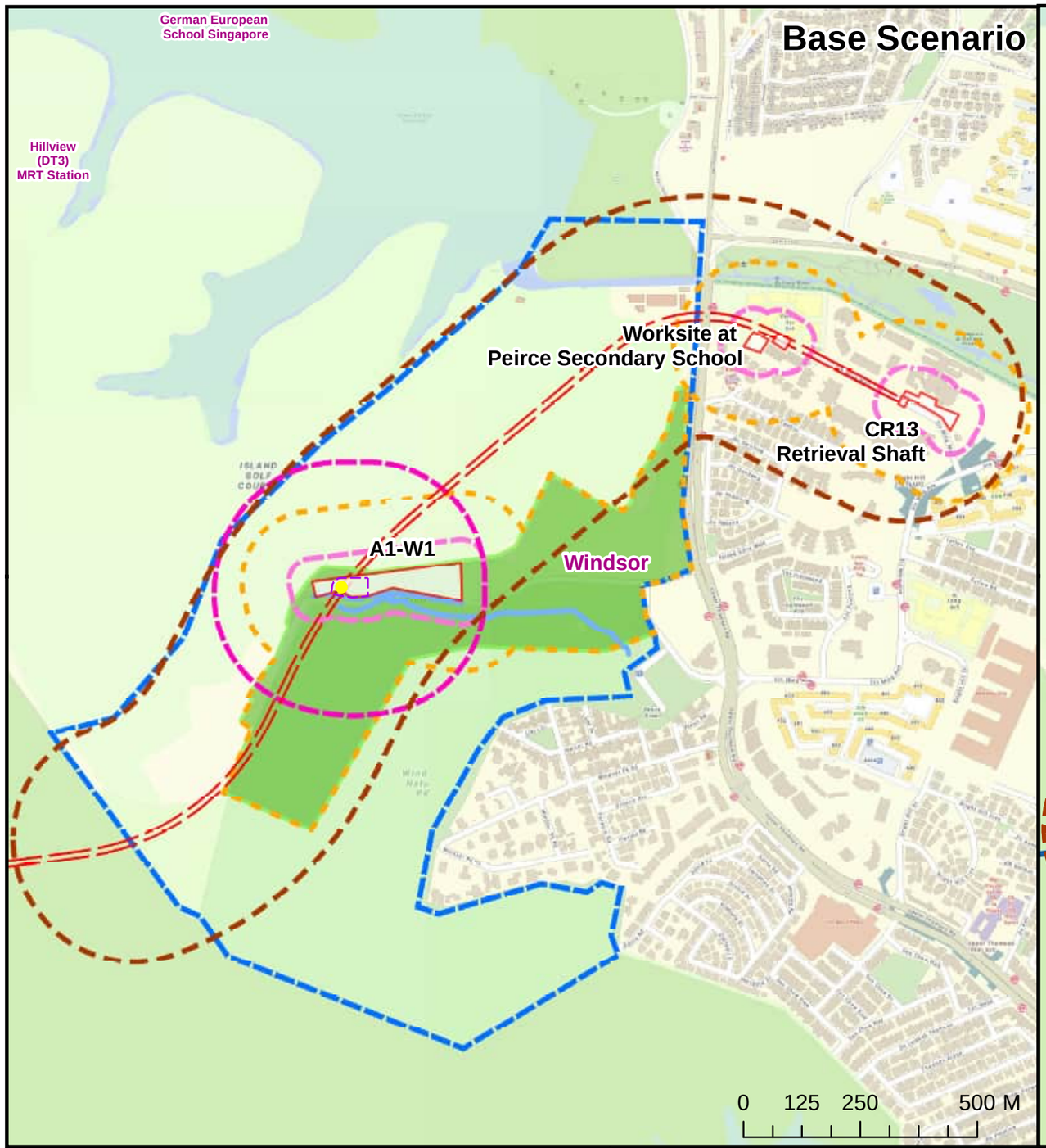
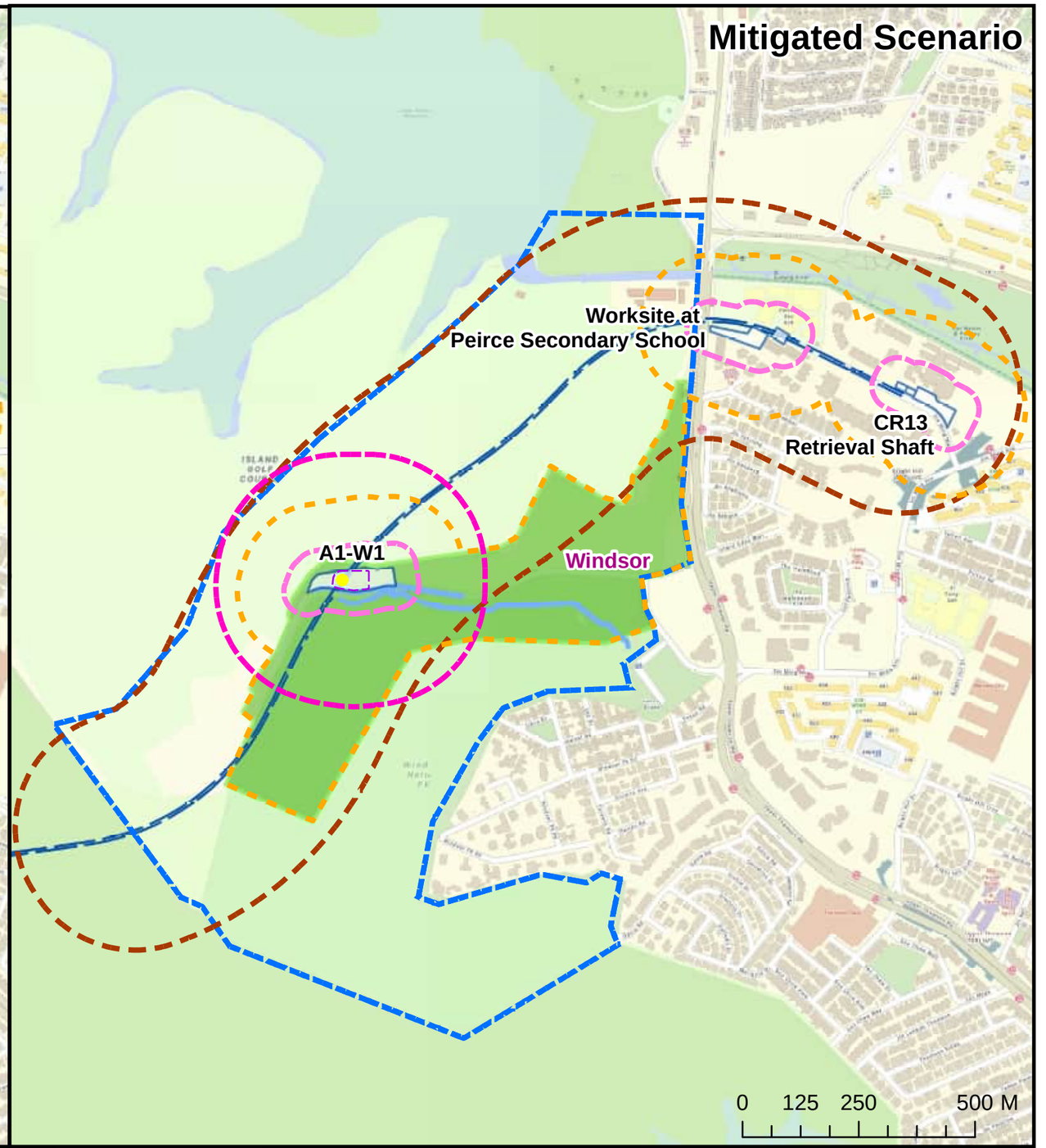
Note: Source of basemap - OneMap





Legend

- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint

Above-Ground Structure

- Facility Building (Above-Ground)

Underground Structure

- Facility Building (Underground)
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)

Study Area

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

N

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-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :
SUMMARY OF STUDY AREAS AROUND WINDSOR

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG	JAG	4 - 2	-	1 of 1
	Drawn ML	Date MAR 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 this topographic survey data and observations from the site visit, it is noted that the existing topography of the Study Area is generally flat along the alignment, ranging from 7 mSHD to 53 mSHD based on available topographic data (Figure 4-3). The topographic characteristics of each worksites are described as follows.

A1-W2 worksite (base scenario) will be located inside Eng Neo Avenue Forest. It has mild increasing slope from the A1-W2 towards the northern area of the Eng Neo Avenue Forest, while mild decreasing elevation towards Bukit Timah Saddle Club in the southwest of Eng Neo Avenue Forest. In the vicinity of A1-W2 worksite (base scenario), the existing topography ranges from 30 mSHD to 60 mSHD. Since A1-W2 worksite (mitigated scenario) will be located at the urbanised area of Site I and Site II as shown in Figure 4-3, there is minor elevation changes within the worksite, ranging from 20 mSHD to 40 mSHD.

Both base and mitigated scenario of A1-W1 worksites are located within Windsor. The elevation in the vicinity of A1-W1 generally decrease from west (around 53 mSHD) to east (around 16 mSHD) with a steep slope outside the west and south sides of the proposed worksites based on the available topographic data and site observation.

For both retrieval shaft and temporary underpinning worksite at Peirce Secondary School under base and mitigated scenarios, both are located within the well-developed urbanised city area with generally flat terrain. It has elevation ranging from 7 mSHD to 18 mSHD, generally rising from north to south.

Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Elevation (mSHD)

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

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	LAL	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Designed	Checked	Approved
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Figure Title :
**TOPOGRAPHIC MAP
OF THE STUDY AREA**

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

CAD File Name : NA | A3

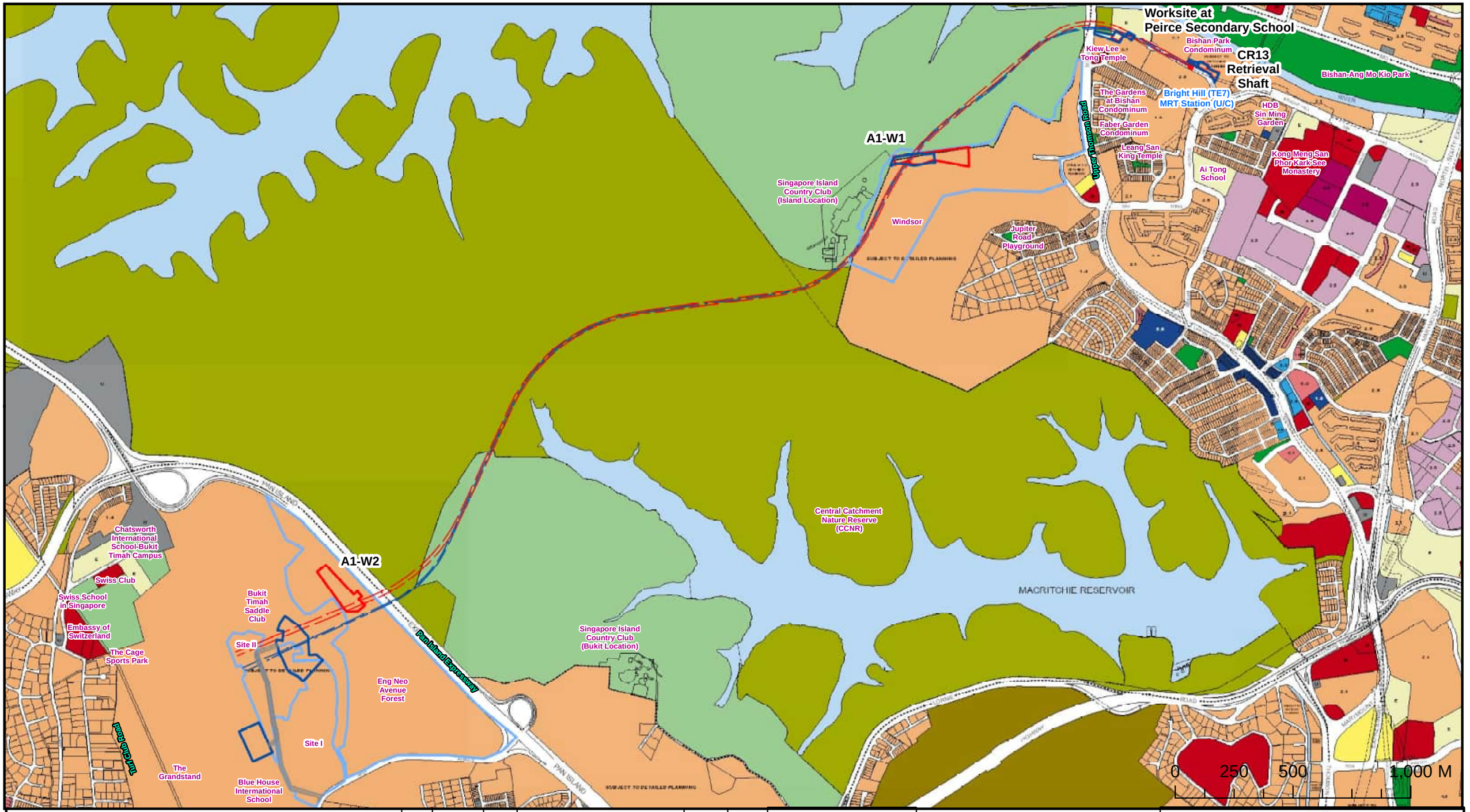
Note: Source of basemap - Google Earth Map

4.3 Current Land Zoning

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

Table 4-2 Land Zones and Uses within the Study Area

URA Master Plan 2019		Street Directory
Land Zoning	**Definition of Land Zoning**	**Current Buildings/ Spaces on URA Land Zoning**
Conservation Area	These are areas with historical significance to be conserved.	Kiew Lee Tong Temple
Educational Institution	These are areas used or intended to be used mainly for educational purposes including tertiary education.	Peirce Secondary School
Place of Worship	These are areas used or intended to be used mainly for religious buildings.	Kiew Lee Tong Temple
Open Space	These are areas used or intended to be used as open space.	Empty ground at Peirce Secondary School, Central Catchment Nature Reserve
Sports & Recreation	These are areas used or intended to be used mainly for sports and recreational purposes.	Singapore Island Country Club (Island Golf Course), Singapore Island Country Club (Bukit Golf Course)
Park	These are areas used or intended to be used mainly for parks or gardens for the enjoyment of the general public and includes pedestrian linkages.	Bishan Ang Mo Kio Park
Residential	These are areas used or intended to be used mainly for residential development.	Windsor Nature Park, Eng Neo Avenue Forest, Bukit Timah Saddle Club; HDB Sin Ming Garden, Bishan Park Condominium, The Gardens at Bishan Condominium, Faber Garden Condominium, forested area north of Island Club Road, Island Park Condominium, Thomson Grand Condominium, etc.
Road	These are areas used or intended to be used for existing and proposed roads.	Pan Island Expressway, Turf Club Road, Upper Thomson Road
Mass Rapid Transit	These are areas used or intended to be used for mass rapid transit (MRT) purposes.	Bright Hill MRT Station (TE7) U/C
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
Waterbody	These are areas used or intended to be used for drainage purposes and water areas such as reservoirs, ponds, rivers and other water channels.	Kallang River



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

	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

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

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Project Title :

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ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :

LAND USE MAP

Designed	Checked	Approved
ML	JAG	JAG
	Drawn: ML	Date: MAR 2022

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

CAD File Name : NA | A3

Note: Source of basemap - URA Master Plan 2019 (extracted in July 2020)

4.4 Historical Land Use

The historical land uses of a site can indicate potential contamination which has occurred at certain stage in its history. The nature of these historical activities can be in the form of materials storage, handling, utilization and improper disposal/ discharge from the past, which may potentially contaminate soil and groundwater resources in the vicinity of this Project which will be further discussed in Section 9. Therefore, similarly to the Study Area of soil and groundwater impact assessment, the historical land uses within 250m from both sides of the Project alignment were reviewed based on the details from Historical Land Use Survey Report (HLUS) [R-4, R-5] from LTA to give context to potential contamination considerations associated within the 250m Study Area. The HLUS study suggested that there is a potential for underground buried structures such as building foundations to be encountered during construction excavations. It is assumed that any buried foundations and piling associated with these structures will be cleared as part of the Project.

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

4.4.1 Eng Neo Avenue Forest and the Forested Area Adjacent to Fairways Quarters

One of the earliest topographical maps of the Study Area dates back to 1914. At that time, MacRitchie Reservoir had already been established and there were developments to its south. These developments extended into Eng Neo Avenue Forest and there were several roads built in the area (Figure 4-5A). The area was used as a plantation for gambier in the 19th century, just as the nearby Singapore Turf Club also was a plantation for rubber trees at that time (Lim, 2019). Around the same period, a part of Eng Neo Avenue Forest became a part of the Municipal Water Catchment, while the remaining areas were later converted to areas for rubber plantation and general agricultural practices.

By 1925, the Singapore Island Country Club (SICC) was established northeast of Eng Neo Avenue Forest (Conceicao, 2009) and the Singapore Turf Club was constructed by 1933 (Tan, 2019). A topographical map dated in 1945 shows both establishments bounding Eng Neo Avenue Forest (Figure 4-5B). 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). Based on the orthophoto map from 1950, Eng Neo Avenue Forest appears to be vegetated with signs of forest regeneration (Figure 4-5C). Around this period, the Municipal Water Catchment, which was partially occupied by the present-day Eng Neo Avenue Forest was gazetted as a nature reserve. By 1975, the second phase of the Pan-Island Expressway (PIE) was constructed from Thomson Road to Jalan Anak Bukit, cutting through the remaining patch of forest north of Eng Neo Avenue Forest (Figure 4-5D). The map also shows that forest at Eng Neo Avenue Forest had regenerated, and that Sites I and II were marked out as sundry tree cultivation (Figure 4-5D). In 1999, the Turf Club moved to Kranji and the racecourse was converted into a dining and recreational complex. Thereafter, the land was abandoned, and the forest likely developed with a canopy layer of mainly exotic species. Presently, the Sites I and II are covered by secondary forests of varying successional stages, occasionally interspersed with shrublands, while Eng Neo Avenue Forest is covered by secondary forest.

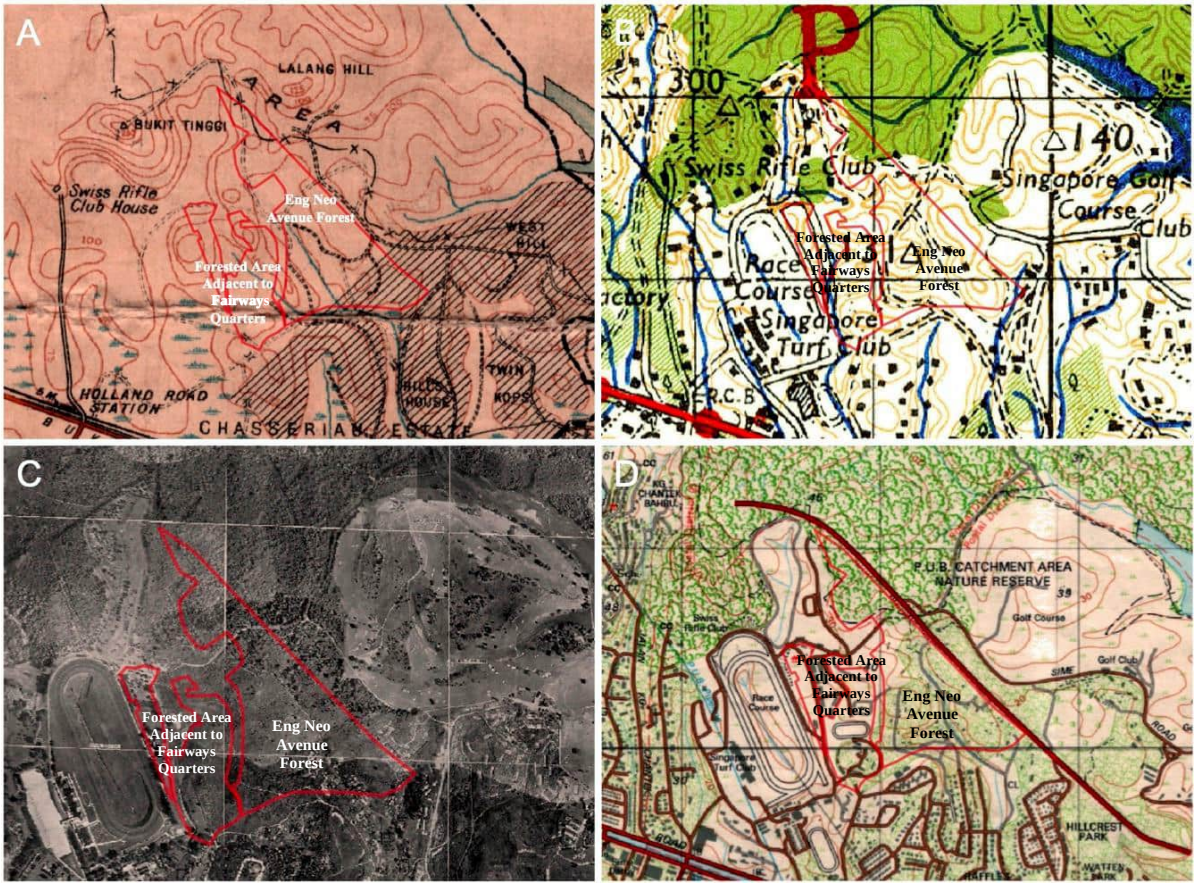


Figure 4-5 Topographical (A, B, D) and Orthophoto (C) Maps of Eng Neo Avenue Forest. (A) 1914; (B) 1945; (C) 1950, (D) 1975. Source: NUS Libraries (2019).

4.4.2 Windsor

Windsor consists of Windsor Nature Park and the Northern Forest Fragment near A1-W1 along Island Club Road. The Study Area is bounded by the SICC golf course in the north, Upper Thomson Road and Venus Drive to the east, and Windsor Nature Park to the south. The lower fragment is part of the existing Windsor Nature Park while the upper fragment is a vegetated site in between SICC and Windsor Nature Park, herein referred to as Northern Forest Fragment.

Preceding British colonization in 1819, the interior of Singapore was covered by primary lowland dipterocarp rainforest (Corlett, 1991). Vegetation connectivity of the Study Area to the larger Lower Peirce forest was likely disrupted by the construction of the SICC golf course in 1928. The golf course was subsequently converted to roads or tapioca farms during the Japanese Occupation between 1942 and 1945. The golf course was subsequently reconstructed between 1945 to 1947 after World War II.

In the 1920s, Windsor was converted to a rubber plantation and subsequently abandoned in the 1970s (NUS Libraries, 2019). Topographical maps from the 1940s show that the Windsor was characterised by three low hills and a valley. As the land became developed, it was flattened to the present elevation range of 20 m a.s.l to 40 m a.s.l. Recent floristic surveys in 2012 indicated forest regeneration and a high occurrence of native species and threatened species even though rubber is still commonly occurring on site (Neo et. al., 2014).

Following the subsequent abandonment of the rubber plantations, the area was considered to be part of a “green belt” outside of the boundary of the Central Catchment Nature Reserve, and part of the Windsor area was zoned “Residential “Subject to Detailed Plannin)” in the Master Plan 1998.

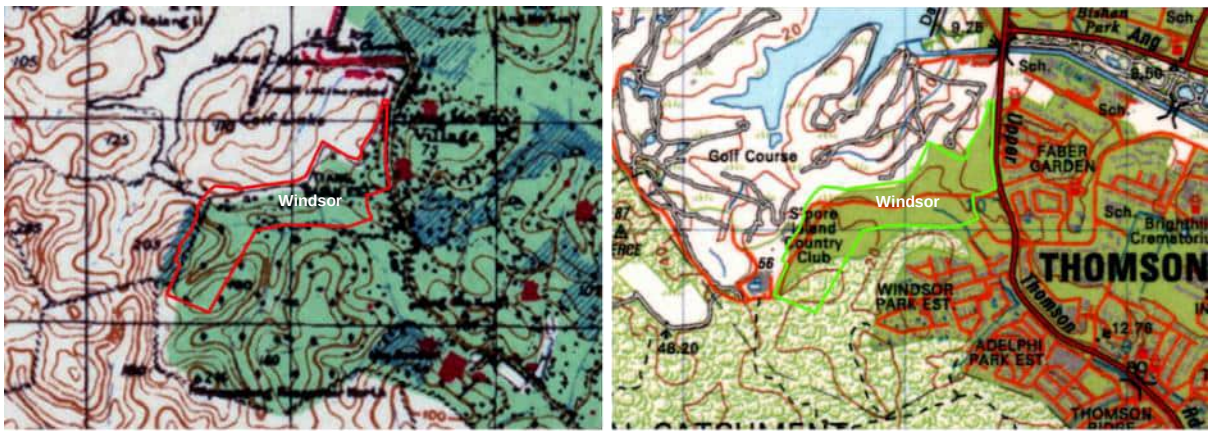


Figure 4-6 Old Topographical Maps of Windsor. (A) 1943; (B) 2010. Source: NUS Libraries (2020).

4.5 Heritage Features

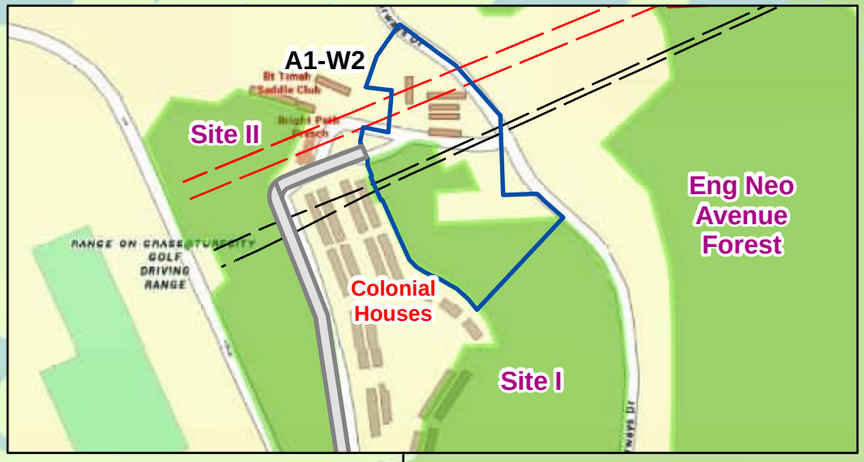
According to Singapore's Planning Act (Chapter 232) Section 9, *"any area of special architectural, historic, traditional or aesthetic interest"* can be designated as a conservation area, which may comprise of an area, a single building or a group of buildings. Any individual must not conduct any works 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). Besides, according to NParks, "*mature trees are the natural heritage of Singapore and serve as important green landmarks of our City in Nature*", hence a Heritage Tree Scheme was announced on 17 August 2001, which advocates the conservation of Singapore's mature trees [W-95].

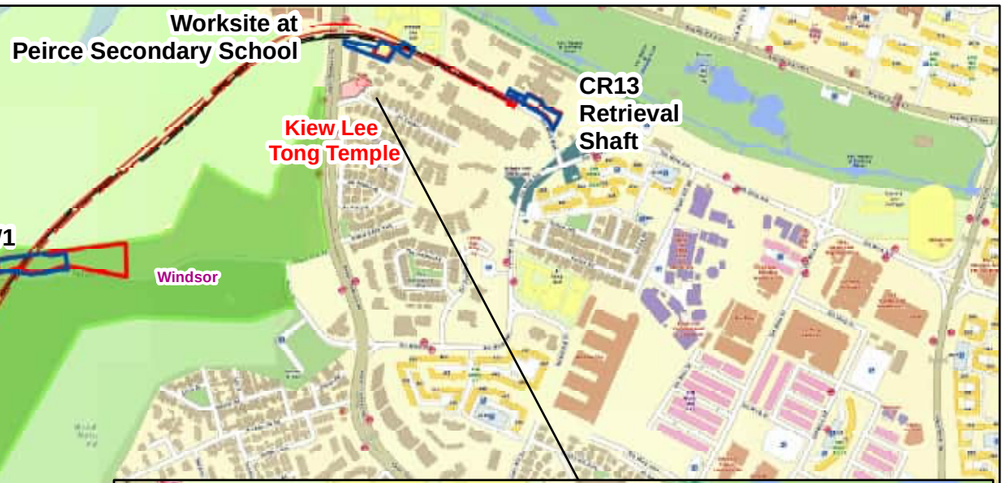
URA takes into account the conservation of built heritage or historic buildings as an essential part of Singapore's development and urban planning. Based on the desktop review of URA's Master Plan 2019 [M-3], there was one (1) Conserved Building/ Structure gazetted by URA observed in the vicinity of Worksite at Peirce Secondary School, as presented in Table 4-3 and Figure 4-7. While based on the desktop review of with NHB/NParks-governed heritage features via OneMap SG [M-2] with NHB/NParks-contributed sources (i.e. museums, monuments, historical sites, heritage trees), there were no heritage features found to be blocked or encroached by the construction and operational footprint of this Project, with the nearest heritage tree being relatively far way at more than 600m away from both base and mitigated A1-W2 worksite (see Figure 4-7). These heritage features including conserved buildings/ structures and heritage trees near the Project footprint will be preserved, where direct disturbance to these heritage features is not anticipated.

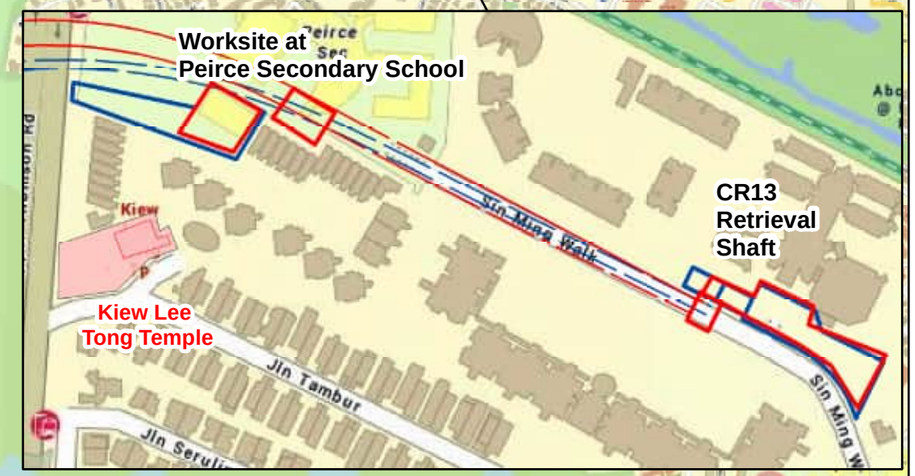
Meanwhile, URA is conducting a heritage study separately at the time of writing this EIS, with preliminary information indicating potential heritage value of the vacant colonial buildings located along Fairways Drive, which is in close proximity to the tunnelling works at the mitigated A1-W2 worksite (see Figure 4-7). The heritage study is going to be published and heritage impact management will be separately covered under that report, hence no information available as of now, nonetheless the Contractor shall note that any construction works which to be carried out near heritage building (if applicable) shall generally follow the requirements from BCA's DIN 4150 Guideline on Limit of Vibration [W-100]. As such, the potential ground-borne vibration impact from the tunnelling works on the colonial buildings has been discussed in Section 12 of this EIS.

Table 4-3 Conserved Building/ Structure or Other Heritage Feature near Project Footprint

Potential Heritage Feature	Description
Kiew Lee Tong Temple (gazetted as Conserved Building by URA on 6 June 2014) [W-67, W-68]  *Source of Figure: URA. Looking at Heritage Buildings. (https://www.ura.gov.sg/Conservation-Portal/Explore/History?bldgid=KLTTP)*	This Hokkien Taoist temple is an important landmark for the Henghwa community and the residence at Upper Thomson Road, locating approximately 90m away from the boundary of the Worksite at Peirce Secondary School. This temple was established in Year 1934 in Arab Street to commemorate the nine He brothers who ascended to heaven by riding on nine carps according to legend, hence alternatively named as the Abode of the Nine Carps. It was also well-known for the "Appeasement of Spirits Ritual" held once every ten years during the Hungry Ghost Festival which started after the Second World War. This temple was originally constructed in Year 1979 and undergone renovation around Year 1997 to 1998. Its wall structures are of exposed red-bricks which is an example of traditional Hokkien and Taiwanese architecture in the late 20th century of Singapore. Its roof is supported on a traditional post and beam system that was put together without nails. Another key architectural feature of this structure is the rich use of carved granite panels throughout the complex, also highlighted with a pair of carved granite dragon columns at the main entrance.
 *Source of Figure: Google Map* [M-1]	These colonial buildings are vacant and located along Fairways Drive beside A1-W2 mitigated worksite. URA is conducting a heritage studies separately at the time of writing this EIS to evaluate potential heritage value of these colonial buildings, hence no further information available at current stage. Note that these colonial buildings have not been gazetted by URA and NHB as either conserved building/structure or heritage feature (e.g. monument, historical site).







Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Heritage Features

- Historic Sites [by NHB]
- Heritage Trees [by NParks]

Conservation Areas [by URA]

- Conserved Building/ Structure
- Conservation Site

Sources: *National Heritage Board (NHB) and Urban Redevelopment Authority (URA) as of 4th January 2021*

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	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 (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :
HERITAGE FEATURES AROUND PROJECT FOOTPRINT

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG	JAG	4 - 7	-	1 of 1
	Drawn ML	Date MAR 2022	CAD File Name : NA		A3

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).

Eng Neo Avenue Forest, Sites I and II are located in close proximity to the BTNR and CCNR, and provide important habitats for wildlife across the landscape. Although both forest patches are separated from the CCNR by the Pan-Island Expressway (PIE) to their east, volant species that may be able to cross the expressway and move between these patches.

Windsor is located adjacent to the MacRitchie forest, which is contiguous with the CCNR, where rare or forest-dependent fauna are found. The Windsor's Northern Forest Fragment is separated from the Windsor Nature Park by the Island Club Road. While not contiguous with each other, dispersal and movement of floral and faunal species likely occur between these forest patches. There are two existing canopy connections along the Island Club Road that serve as crossings for arboreal fauna between these forest patches.

Located in proximity to the CCNR, a key biodiversity hotspot in Singapore, it 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
- Green Rail Corridor
- Old Jurong Railway Corridor
- Worksites and alignment

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	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
(WINDSOR AND
ENG NEO AVENUE FOREST)**

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

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JW	JAG	JAG	4 - 8	-	1 of 1
	Drawn JW	Date MAR 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

4.7 Local Geology

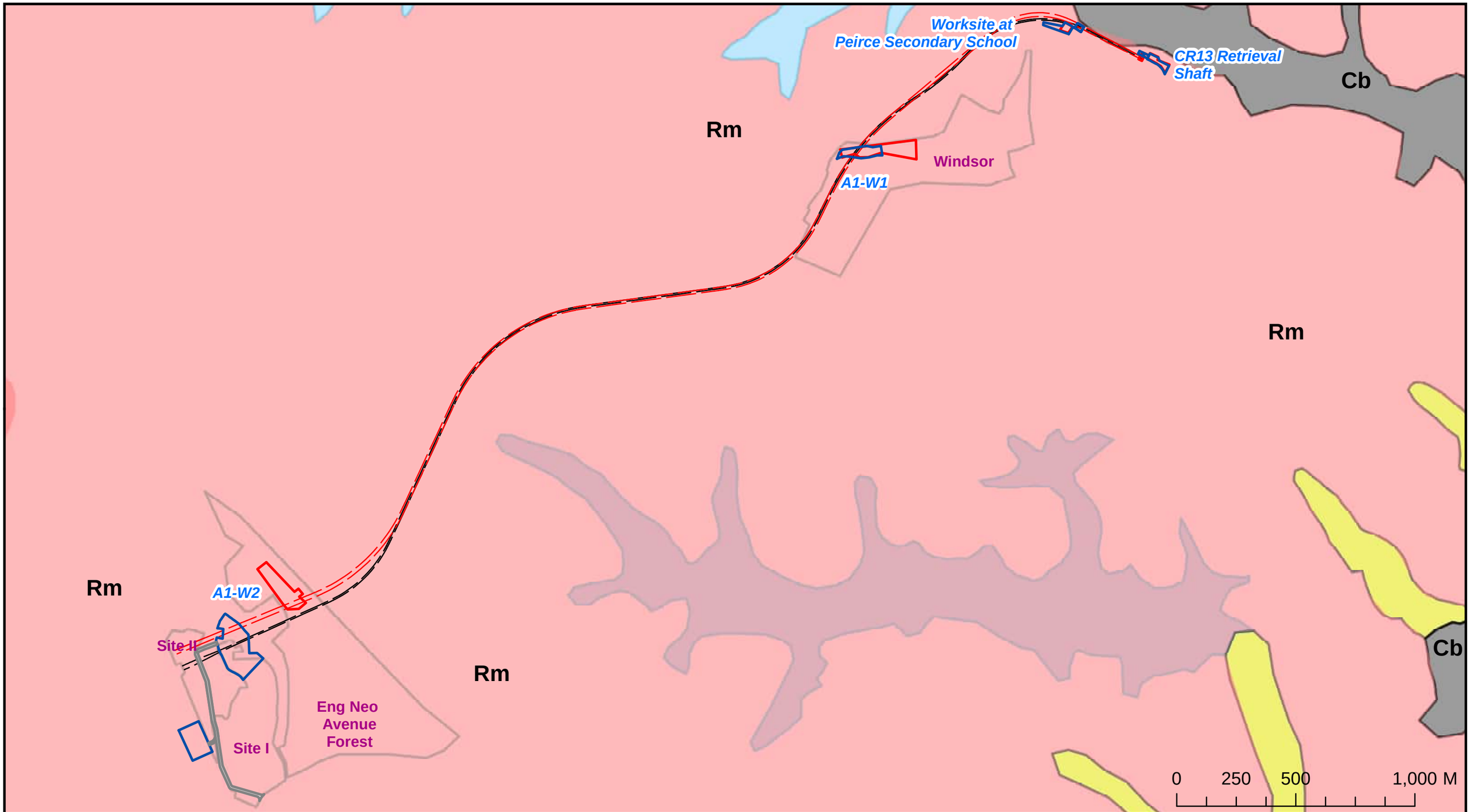
Information relating to the geology is provided in the geological publication published by the Defence Science and Technology Agency (DSTA) of Singapore entitled "Geology of Singapore" (2009) with the information below extracted from *Historical Land Use Survey for the Advanced Engineering Study for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

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

Based on LTA's HLUS study and geology maps from DSTA, the local geological profile along the Project alignment is shown in Table 4-4 and Figure 4-9. It is mainly dominated by Bukit Timah Granite (Rengam Facies). Other than that, there is a minimum portion of alignment between CR13 retrieval shaft and Worksite at Peirce Secondary School falls within the Kallang formation (Chew Boon Lay Facies).

Table 4-4 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	Present along majority of the alignment from Ang Mo Kio Avenue 1 through the Central Catchment Nature Reserve to Turf Club. The geological formation underlies the segment of the alignment: o Along Bukit Timah Road, Fairways Drive, Bukit Timah Saddle Club and Turf Club Road; and o Parallel to Pan Island Expressway and within Central Catchment Nature Reserve.
Kallang Formation (Alluvial Member with Organic Soils)	Refers to deposits that vary from pebble beds through sand, muddy sand, and clay to peat. Usually unconsolidated but there may also be lightly consolidated beds	According to HLUS reports [R-4, R-5], it underlies major roads such as Ang Mo Kio Avenue 1. According to the geological basemap from National Archives of Singapore, it exists as the smaller land area around Bishan-Ang Mo Kio Park and Kallang River near CR13 retrieval shaft. The geological formation underlies along alignment at CR13 retrieval shaft.
Sources: *Historical Land Use Survey for the Advanced Engineering Study for Cross Island Line Phase 2 (CRL Phase 2) – LTA.* *National Archives of Singapore*		



Legend

- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area

Bukit Timah Granite
SOILS ON IGNEOUS ROCKS
Rm Rengam Facies

Kallang Formation
ORGANIC SOILS
Cb Chew Boon Lay Facies

N

Note:
Site I and II: Forested area adjacent to Fairways Quarters

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	ML	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :
GEOLOGICAL MAP
OF STUDY AREA

Designed	Checked	Approved
ML	JAG	JAG
	Drawn: ML	Date: MAR 2022

Figure No. : 4 - 9 | Rev. : - | Sheet : 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 4-10, the runoff from the worksites at CR13 and Peirce Secondary School will flow to the catchment area of Marina Reservoir. For A1-W2 worksites, part of surface water of roadside drain along the PIE will flow to MacRitchie Reservoir (i.e. Central Catchment Nature Reserve) and most of surface water at the worksite will flow to Marina Reservoir based on detailed drainage plan shared by PUB. The stormwater from A1-W1 worksites will be drained to the Windsor Nature Park stream system and eventually ended up in the catchment area of Marina Reservoir. This indicates that the stormwater runoff within the Study Area is collected for drinking water purposes in Marina Reservoir. The detailed hydrology baseline information will be further discussed in Section 8.

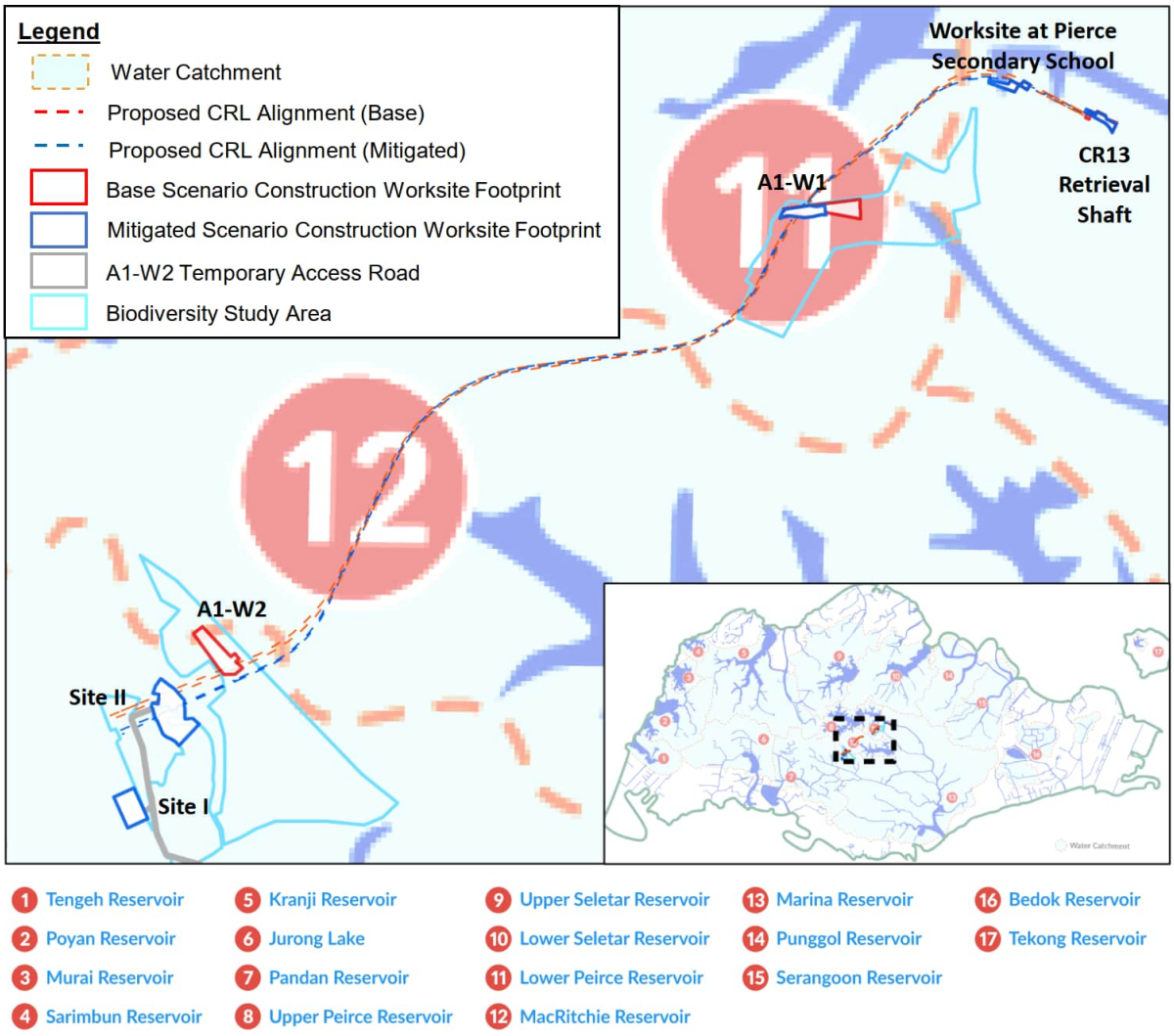


Figure 4-10 Singapore Water Catchment [W-19]

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-25]. The long-term mean annual rainfall total is 2534.4 mm when averaged across island-wide stations with long-term records [W-26]. Based on the findings from MSS, the annual rainfall total has increased at an average rate of 67 millimetres (mm) per decade, and hourly rainfall increased at the rate of 0.8 days per decade for heavy rain (>40 mm) and 0.2 days per decade for very heavy rain (>70 mm) from Year 1980 to 2019 (see Figure 4-11) [W-27].

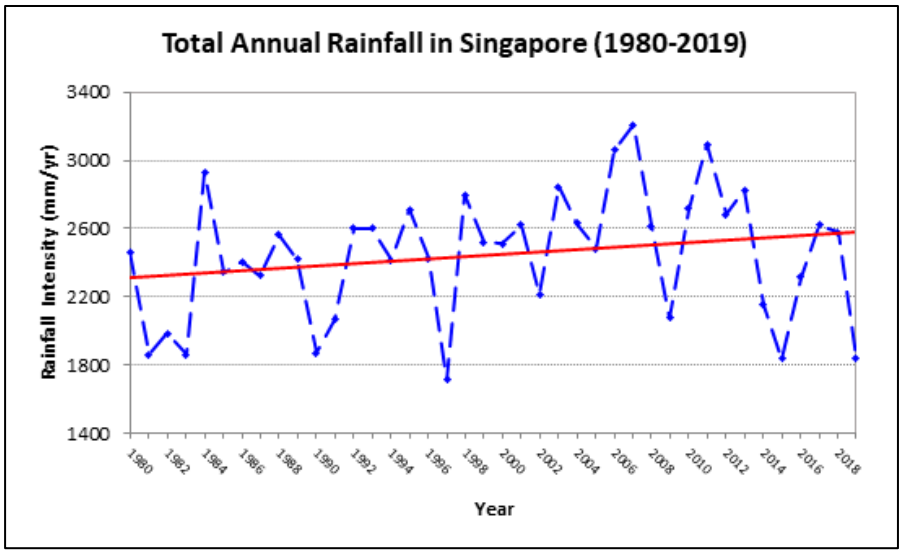


Figure 4-11 Annual Rainfall Total in Singapore from 1980 to 2019 [W-27]

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 4-12) [W-25]. 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 4-13) 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-27].

Figure 4-12 Annual Average Rainfall Spatial Distribution (1981-2010) [W-25]

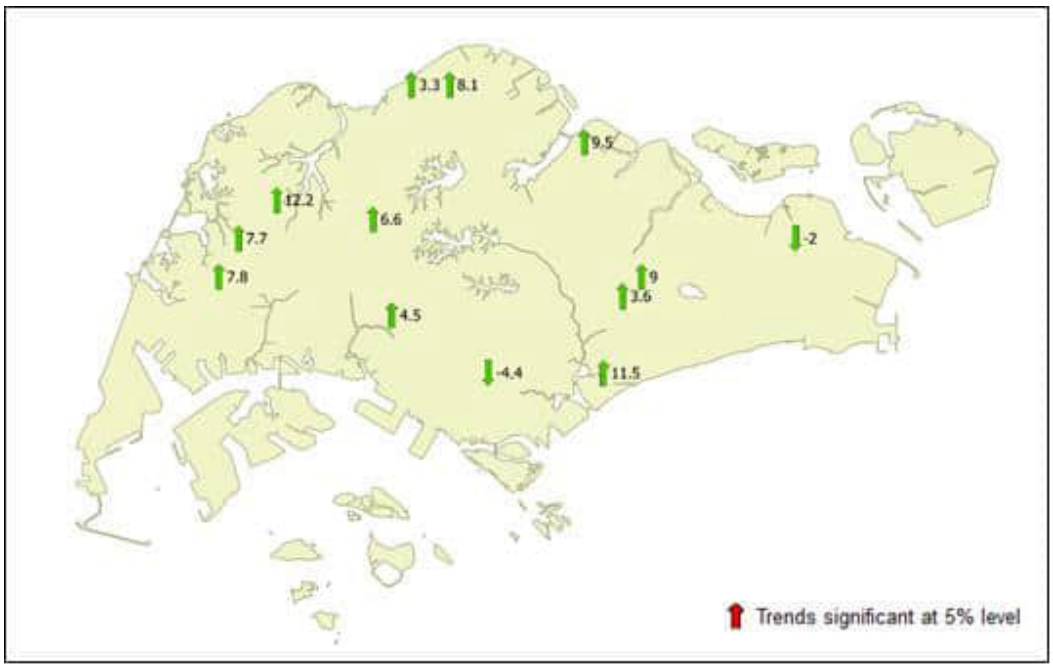


Figure 4-13 Past trends of annual rainfall total at indicative stations (1981-2019) [W-27]

Singapore has two monsoon seasons separated by inter-monsoonal periods, where the Northeast Monsoon occurs from December to early March and the Southwest Monsoon from June to September. It also has abundant rainfall all the year round with relatively higher mean rain days (more than 13 days) and mean rainfall amount (more than 230 mm) from November to January every year (refer to Figure 4-14). The average rainfall in Singapore is approximately 200mm and 150mm during Northeast and Southwest monsoon respectively. Most months in 2021 had rainfall that was above average (refer to Figure 4-14).

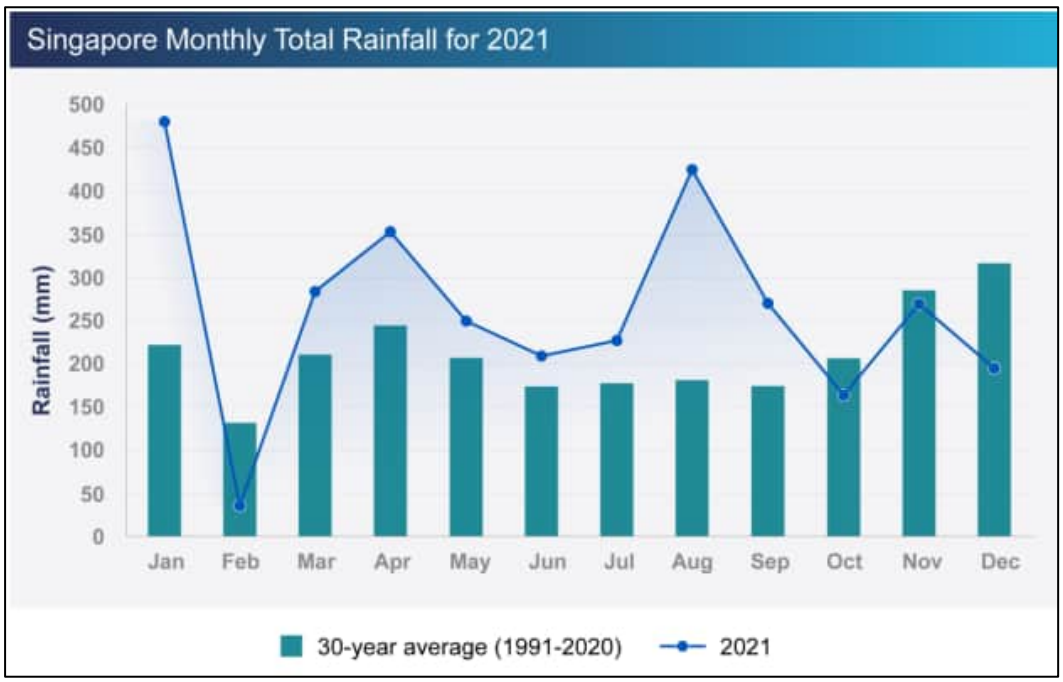


Figure 4-14 Monthly Rainfall in Singapore for 30-year average over island-wide stations with long-term records (bars, 1992 – 2020) compared to 2021 (solid line) [W-26]

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 4-15). 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.

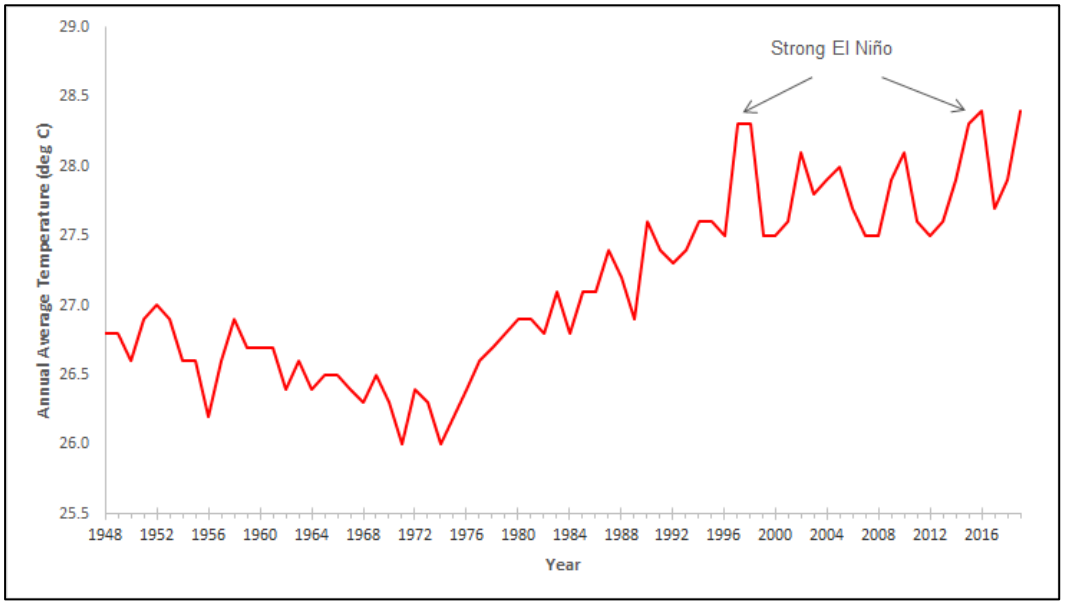


Figure 4-15 Annual Mean Temperature in Singapore from 1948 to 2019 [W-27]

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

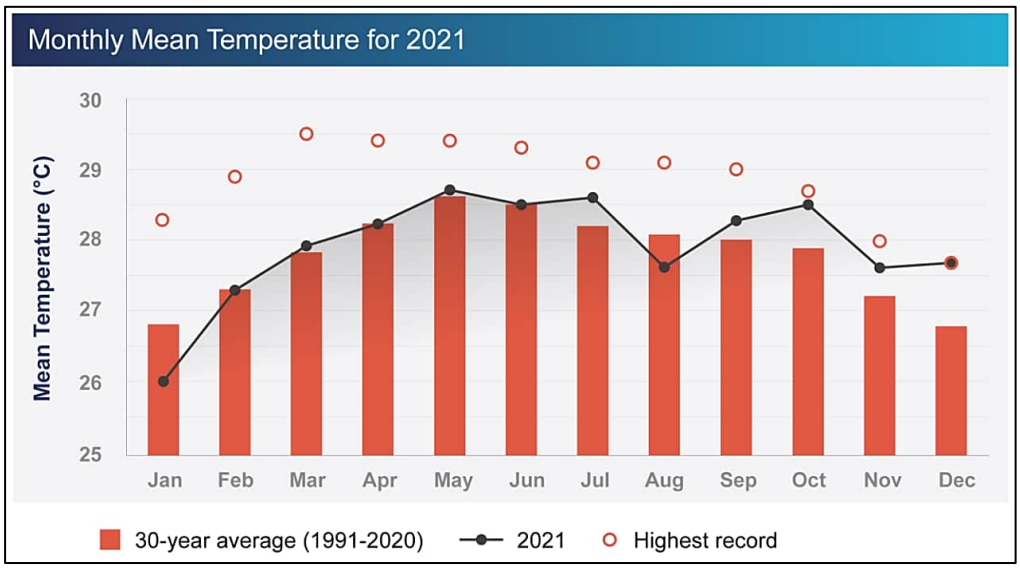


Figure 4-16 Singapore monthly mean temperature for 30-years average from Changi Climate Station with comparison to Year 2021 monthly mean temperature [W-26]

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-90]. This shows the presence of Urban Heating Island (UHI) effect in Singapore. Green areas in cities have been considered as potential measure in mitigating the UHI effect. This finding is also supported by a study conducted by Jusuf et al (2007), which shows different daytime temperature at different type

of land use areas in Singapore. As observed in Figure 4-17, the daytime temperature in park areas is considerably lower compared to other type of land use areas [P-91].

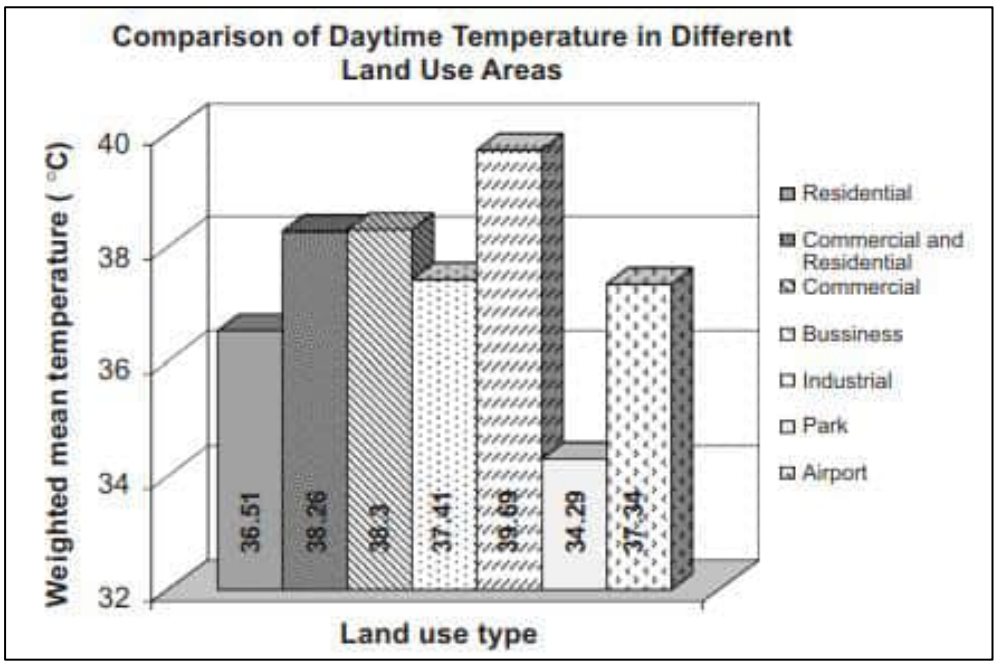


Figure 4-17 Comparison of Daytime and Night Time Temperature in Different Land Use Areas [P-91]

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 4-18). 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.

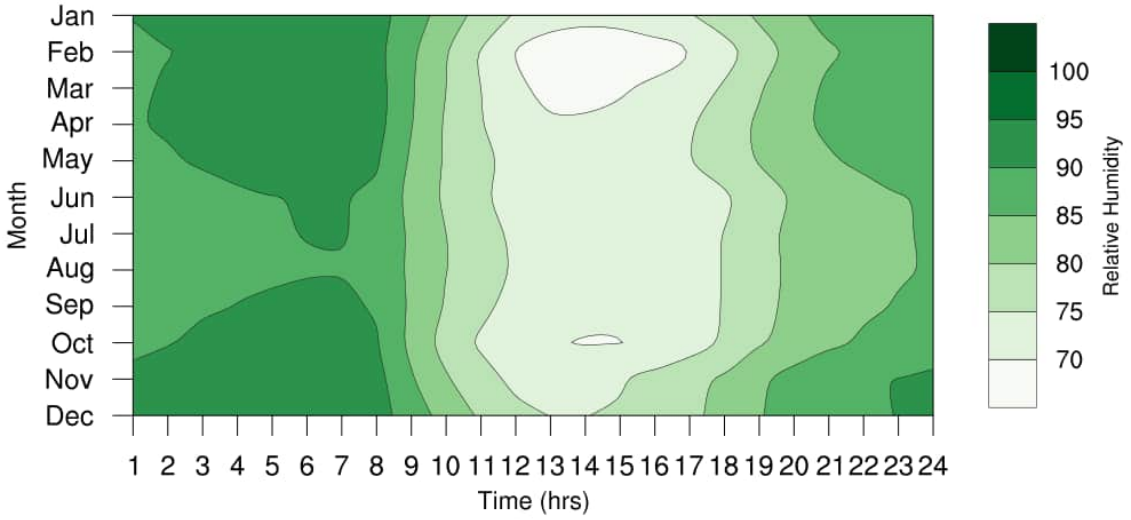


Figure 4-18 Hourly Variation of Relative Humidity for Each Month (1981-2010) [W-25]

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 4-19, 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-25].

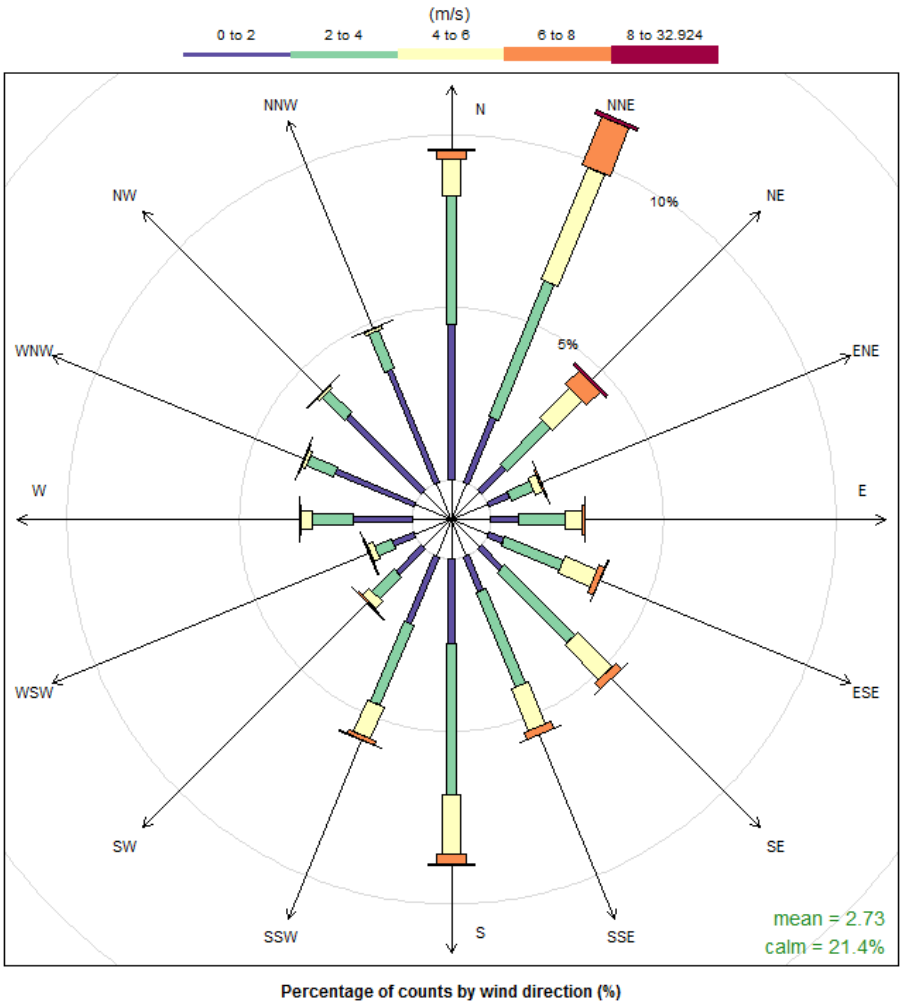


Figure 4-19 Annual Wind Rose of Singapore [W-25]

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

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

5.1 Construction Phase

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

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

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
Biodiversity	National Biodiversity Strategy and Action Plan (NBSAP), 2019 [R-62]	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-63]	An Act for the protection, preservation and management of wildlife for the purposes of maintaining a healthy ecosystem and safeguarding public safety and health, and for related matters
	Parks and Trees Act, 2006 [R-64]	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-65]	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-66]	Lists the areas designated as heritage road green buffers.
	Parks and Trees (Preservation of Trees) Order, 1998 [R-67]	Lists the designated tree conservation areas No cutting or damaging of tree having girth of more than one metre.
	The Singapore Red Data Book (SRDB) [P-20]	Lists the endangered plants and animals in Singapore

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
		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 Threated Species [R-60]	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-69]	This document provides a guideline on how to conduct biodiversity impact assessment as an individual study or as the biodiversity component of an EIA/ EIS.
Hydrology and Surface Water Quality	Singapore Environmental Protection and Management Act, 2020 [R-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.
	Singapore Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-26]	Regulates the discharge of trade effluent to public watercourse. Any discharge into a watercourse has to comply with the regulatory standards established in these regulations.
	Singapore Sewerage and Drainage Act, 2001 [R-23]	An Act to provide for and regulate the construction, maintenance, improvement, operation and use of sewerage and land drainage systems, and to regulate the discharge of sewage and trade effluent. Regulates the protection, maintenance and provision of stormwater drainage system.
	Singapore Sewerage and Drainage (Trade Effluent) Regulations, 2007 [R-25]	Regulates trade effluent discharge into public sewerage system.
	Singapore Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-24]	Regulates measures to be implemented to protect the stormwater drainage system.
	PUB Code of Practice on Surface Water Drainage, 2013 [R-22]	Provides guidelines for measures to be implemented to protect the stormwater drainage system and manage surface water drainage (e.g. development and implementation of an Earth Control Measures (ECM) plan).

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	LTA Safety, Health and Environment (General Specifications Appendix A) [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 runoff discharges from the sites.
	New York and Geneva UNECE Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life (1994) [R-19]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	USEPA Water Quality Standards Handbook (2017) [R-20]	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-27]	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-28]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Philippines Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ) [R-17]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	ASEAN Strategic Plan of Action on Water Resources Management 2005 [R-21]	Provides standards for water quality assessment for surface watercourses.
	Malaysia (DOE) National Water Quality Standards [R-29]	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-31]	Regulates the transport, use and storage of hazardous substances.
Fire Safety (Surface water and soil and groundwater quality sections)	Fire Safety Act, 2013 [R-32]	Makes provisions for fire safety and for matters connected therewith.
	Fire Safety (Petroleum and Flammable Materials) Regulations, 2008 [R-33]	Regulates the transport, use and storage of flammable material to prevent occurrence of accidents.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	Code of Practice for the Storage of Flammable Liquids (SS 532:2007) [R-34]	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-26]	Regulates the discharge of trade effluent into any watercourse or onto land.
	Sewerage and Drainage Act, 2001 [R-23]	Regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-25]	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-30]	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-41]	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-35]	Regulates the storage, handling and disposal of wastes.
	Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 [R-36]	Regulates the storage, collection and disposal of toxic industrial waste.
	Environmental Public Health (General Waste Collection) Regulations, 2000 [R-37]	Regulates general waste (incinerable and non-incinerable waste) disposal.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	Hazardous Waste (Control of Export, Import & Transit) Regulations 1998 [R-38]	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-39]	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-40]	This code provides guidance on best practice measures for managing hazardous waste on site
	Code of Practice for Licenced General Waste Collector [R-42]	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-44]	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-45]	Stipulates that all off-road diesel engines (including construction equipment with diesel engines) imported for use in Singapore from July 2012 must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards.
	UK Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction [R-46]	The document provides guidance for developers, their consultants and environmental health practitioners on how to undertake a construction impact assessment (including demolition and earthworks).

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
Airborne Noise	SS 593: 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-57]	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-51]	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-56]	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-58]	This part of BS 6472 guides human exposure to vibration induced by the rock breaking and excavation works in buildings. It is used to assess other forms of vibration caused by rock breaking and excavation works, including when charges are utilised in civil engineering and demolition activities.
	There are no relevant national or international standards-setting criteria for vibration impacts on biodiversity. The most commonly used vibration criteria on humans are from the British Standard (BS) and Federal Transport Administration (FTA) in Singapore which were used as references. In undertaking this EIS, AECOM generally relies on a quantitative assessment of the various disturbance sources that particular receptors are likely to encounter and focuses on the factors likely to cause the most disturbance.	

5.2 Operational Phase

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

Table 5-2 Applicable Legislations, Guidelines and Policy Frameworks for Operational Phase

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
Biodiversity	Same as construction phase	
Hydrology and 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-44]	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-47]	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-53]	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).
	Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings by National Environmental Agency	Legislative requirements for boundary noise due to noise emissions from mechanical ventilation systems for non-industrial buildings.

Environmental Parameter	Applicable Legislations/ Guidelines/ Policy Frameworks	Key Points
	(NEA); Code of Practice on Pollution Control by National Environment Agency [R-52]	
	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-19].
[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 are of Conservation Significance. Species that inhabit the ground or aquatic environments and live in burrows and/or caves are more badly impacted by anthropogenic vibrations.	Fauna species and habitats that are less affected by ground-borne vibration 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	Site reconnaissance survey: Eng Neo Avenue Forest: 05, 18, 19 Nov 2019 Windsor: March/June 2020 Sites I and II: July 2021 Sampling dates: Eng Neo Avenue Forest: 16 Dec 2019 - 25 March 2020 Windsor: 02 June 2020 – 24 August 2020 Sites I and II: 13 Sep 2021 – 5 Nov 2021 Camera Trapping dates: Eng Neo Avenue Forest: 13 Feb 2020 - 03 April 2020 Windsor: 02 June – 15 September 2020

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

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

Environmental Parameter	Site Visits
	Sites I and II: 5 Oct – 30 Dec 2021
Hydrology and Surface Water Quality	Site reconnaissance survey: 4 November 2019 6 November 2019 11 November 2019 13 January 2020 Sampling dates: 4 February 2020 (dry weather sampling) 5 February 2020 (dry weather sampling) 17 March 2020 (dry weather sampling) 26 August 2020 (wet weather sampling) 3 September 2020 (wet weather sampling) 13 October 2021 (dry weather sampling) 5 October 2021 (wet weather sampling) 16 November 2021 (dry weather sampling) 26 November 2021 (dry weather sampling) 30 December 2021 (wet weather sampling)
Soil and Groundwater	Site reconnaissance survey: Conducted by LTA term Contractors: 12 November 2020 Sampling dates: Conducted by LTA term Contractors: 14 December 2020 to 19 December 2020 (soil sampling) 27 December 2020 (groundwater sampling)
Air Quality	Site reconnaissance survey: 5 – 6 November 2019 25 March 2020 17 June 2020 Sampling dates: Eng Neo Avenue Forest: 26 March – 2 April 2020 Windsor: 19 – 26 June 2020
Airborne Noise	Site reconnaissance survey: 5 – 6 November 2019 11 February 2020 Sampling dates: Swiss School: 24 February – 02 March 2020 Within Eng Neo Avenue Forest: 29 January – 05 February 2020 Peirce Secondary School: 18 March – 25 March 2020 Windsor: 30 March – 06 April 2020
Ground-borne Vibration	Site reconnaissance survey: 5 – 6 November 2019 11 February 2020 Sampling dates: Eng Neo Avenue Forest: 25th June 2020 – 26th June 2020, 14 January 2022 to 21 January 2022* Windsor: 24th June 2020 – 25th June 2020
Note: * Baseline vibration monitoring was repeated for Eng Neo Avenue Forest in 2022. See Section 12.2.1.2.1 for details.	

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

6.3.2 Secondary Data Collection

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

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

Further information on secondary data collection is provided in Section 7 (Biodiversity), Section 8 (Hydrology and Surface Water Quality), Section 9 (Soil and Groundwater), Section 10 (Air Quality), Section 11 (Airborne Noise) and Section 12 (Ground-borne 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 biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (if any).	Assessment criteria broadly take guidance from Hong Kong Environmental Impact Assessment Ordinance – Technical Memorandum Annex 8, with considerations from literature review and local biodiversity standards.	Section 7
Hydrology and Surface Water Quality	**Qualitative** and analytical methods were applied to assess hydrological and water quality impacts of the development construction phase. The hydrological impact study helped to understand the impact of construction activities as well as potential land-use changes to hydrological conditions of the	Environmental Protection and Management (Trade Effluent) regulations [R-26]; Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-19], United States Environmental	Section 8

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	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.	Protection Agency [R-20], Philippines [R-17], Australian and New Zealand Environment and Conservation Council (ANZECC) [R-27], Canadian Council of Ministers of the Environment [R-28], and Department of Environment in Malaysia (DOE) [R-29].	
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].	Section 9
Air Quality	**Qualitative** assessment following dust risk assessment methodology focusing on fugitive particulate emissions (dust) from the construction site.	Assessment broadly follows "Guidance on the Assessment of Dust from Demolition and Construction" which was published by the UK Institute of Air Quality Management (IAQM) in 2014.	Section 10
Airborne Noise	Modelling and **Qualitative** assessment was adopted to assess construction and operational noise to the noise ecologically sensitive receptors.	Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008	Section 11
Ground-borne Vibration* (excluding Ground-borne Noise as it is only applicable inside a building)	**Quantitative** assessment was adopted to assess construction and operational ground-borne vibration to the ground-borne ecologically sensitive receptors. Empirical relationships defined in British Standard BS 5228-2:2009+A1:2014 were used to predict piling activities (construction works that produce the highest vibration levels throughout the construction period), together with a range of probabilities exceedance for categorised ground types. Tunnel boring vibration levels were predicted on the ground above the works using BS 5228-2:2009+A1:2014 and the Esvelt equation; Ground-borne vibration induced by rock breaking and excavation was predicted using the formulae in BS 6472-2-2008 and an empirical vibration prediction equation. The empirical vibration prediction equation (from LTA Contract T207) was also included to provide a local context; and Alternative data were used if construction activities are not included in the BS 5228-2:2009+A1:2014 empirical relationships. The assessment comprises either case history data from	**Structural impact:** The intensity of predicted impacts was compared to burrow collapse data from an international literature study (i.e. partial burrow collapse at 10 mm/s [W-89]) to address concerns of burrow collapse of fossorial mammals. Note that this area is highly data deficient in the local Singapore context. Therefore, a conservative 50% of the available data from other countries were used to provide a significant value when mitigation is required. When construction/ operational activities cause more than PPV 5 mm/s than the predicted vibration levels, the plan for the construction activity must be made such that a vibration does not exceed the implemented threshold of PPV 8 mm/s at Windsor/ Eng Neo Avenue Forest, Sites I and II **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.	Section 12

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
	BS 5228-2:2009+A1:2014 or AECOM's database.	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

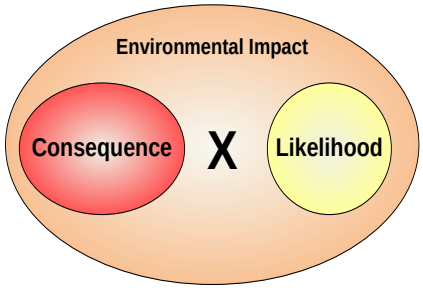
Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
Biodiversity	**Qualitative** assessment to evaluate the impacts of operational activities on key biodiversity sensitive receptors of floral communities, faunal species and habitats within the Study Area and its immediate surrounding (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 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.	Environmental Protection and Management (Trade Effluent) regulations [R-26]; Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe [R-19], United States Environmental Protection Agency [R-20], Philippines [R-17], Australian and New Zealand Environment and Conservation Council (ANZECC) [R-27], Canadian Council of Ministers of the Environment [R-28], and Department of Environment in Malaysia (DOE) [R-29].	Section 8
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].	Section 9
Air Quality	**Qualitative** assessment was conducted to assess air quality impacts of the development operational phase due to increased traffic in the vicinity of the stations.	Compare the change in predicted increase in traffic volume and access routes in the vicinity of the stations	Section 10
Airborne Noise	Modelling and **Qualitative** assessment was adopted to assess construction and operational noise to the noise ecologically sensitive receptors.	NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018	Section 11

Environmental Parameter	Predictive Methods	Assessment Criteria	EIS Section
		NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016	
*Ground-borne Vibration (excluding Ground-borne Noise as it is only applicable inside the building)	**Quantitative** methods were applied to assess the ground-borne vibration impacts of the operational phase. An independent consultant provides the predicted vibration levels under a separate study by LTA.	**Structural impact:** Same as construction. **Behavioural impacts:** Same as construction.	Section 12
Note: * Vibration frequency has not been considered in this assessment due to lack of adequate research on the impact of frequency of vibration and its impact on faunal behaviour. Please see Section 12.2.2 for details.			

6.4.2 Impact Evaluation

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

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



6.4.2.1 Impact Consequence

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

- **Receptor Sensitivity:** Categorises receptors according to their susceptibility to adverse impacts from the 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	Potential impacts with no detectable changes to	Potential impacts with	Potential impacts with	Potential impacts with Extensive duration and large spatial scale that

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
(Construction and Operation) – Habitats	viability/function of habitats.	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	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	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
Hydrology (Construction and Operation)	Very minor change to existing hydrology and flow.	Small scale localised changes to existing hydrology or flow.	Medium scale changes to existing hydrology or peak flow.	Major changes to existing hydrology or peak flow.
Surface Water Quality (Construction and Operation)	No contamination; or Likely to be well within regulatory limits.	Small scale localised contamination within regulatory limits.	Medium scale contamination or just exceed regulatory limits.	Large scale contamination exceed regulatory limits by hazardous levels for the habitat/ conservation species.
Soil, Groundwater (Construction and Operation)	None of the construction activities identified will cause contamination 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)	For Earthworks: Total site area 2,500 m^3 – 10,000 m^3 Moderately dusty soil type (e.g. silt)	For Earthworks: Total site area >10,000 m^2 Potentially dusty soil type (e.g. clay, which will be prone to

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

Environmental Parameters	Impact Intensity			
	Negligible Intensity	Low Intensity	Medium Intensity	High Intensity
		<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	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	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 Surface material with low potential for dust release Unpaved road length <50 m	For Trackout: 10-50 HDV[6] (>3.5t) outward movements in any one day Moderately dusty surface material (e.g. high clay content) Unpaved road length 50-100 m	For Trackout: >50 HDV[6] (>3.5t) outward movements in any one day Potentially dusty surface material (e.g. high clay content) Unpaved road length >100 m
	-	For Demolition: Total building volume <20,000 m^3 Construction material with low potential for dust release (e.g. metal cladding or timber) Demolition activities <10m above ground Demolition during wetter months	For Demolition: Total building 20,000 – 50,000 m^3 Potentially dusty construction material Demolition activities 10-20 m above ground level	For Demolition: Total building >50,000 m^3 Potentially dusty construction material (e.g. concrete) On-site crushing and screening Demolition activities >20m above ground level
Air Quality (Operational Phase)	Insignificant increase in air quality levels in the vicinity of stations due to project operation	Small scale increase in air quality levels in the vicinity of stations due to project operation	Medium scale increase in air quality levels in the vicinity of stations due to project operation	Large scale increase in air quality levels in the vicinity of stations due to project operation
Airborne Noise (Construction and Operation)	No detectable change to flora, fauna and habitats.	Potential impacts last a short duration, are reversible and/or of a small magnitude for	Potential impacts last for a moderate duration, are reversible with	Potential impacts last for a long time, are non-reversible, and/or of a significant

[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
	Predicted noise level at receptors are within the corrected baseline criteria. For A1-W1, predicted noise levels at receptors are below the baseline noise (no correction applied here).	species with low auditory sensitivity level. Predicted noise level exceeds the corrected baseline criteria of up to 3 dB(A).	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).	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 (Structural (Construction) and Behavioural (Construction and Operation)[1,2]	See Note 3 below			
Note 1) The intensity assessment is a multi-prong approach for structural (intensity-based) or behavioural impacts Refer to Section 12.2.2 for details. 2) A threshold of 5 mm/s was used for screening out those activities which will be 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 which can be seen detailed in Section 12.2.				

A consequence category is then derived based on receptor sensitivity and impact intensity, as shown in Table 6-6, which is generally applicable for the individual impact assessments except for air quality. It should be noted that air quality impact assessment have its own specific matrices defined based on applicable international guideline as detailed in Section 10.2.3.1.5.

Table 6-6 Impact Consequence Matrix

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

6.4.2.2 Likelihood of Occurrence

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

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

For operational phase impact assessment, airborne noise impact assessment would refer to local regulations. Ground-borne vibration impact assessment would use a quantitative manner for the assessment impacts from the operation of the underground train movements. This is done by multiplying the work period and the active vibration period for machinery together which can be seen in Section 12.2.

Table 6-7 Likelihood Criteria

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

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

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

Table 6-8 Impact Significance Matrix

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

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

An “acceptable level” is the reduction of a major impact to a moderate one after mitigation. In seeking to mitigate moderate impacts, the emphasis is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable. It will not always be practical to reduce moderate impacts to minor ones in consideration of the cost-ineffectiveness of such an approach (due to the diminishing return of a reduction of impact versus cost). Residual impact assessment 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 were proposed in accordance with the following principles and mitigation hierarchy reflected in Figure 6-1:

- **Elimination/ Avoidance** – Where changes to the project design and construction methodology can be made to eliminate or avoid an identified impact (e.g. optimisation or reduction of construction footprint, shift or elimination of construction site in critical areas, exclusion of noisy construction phase to be conducted at evening/night period, etc.). If a full elimination is not possible, the next level of mitigation is to minimise the identified impact;
- **Minimisation (Substitution)** – Where changes to the project design and construction methodology cannot affect impact elimination or avoidance, use of alternative construction methodology or any enhancement measures can be adopted to minimise for identified impacts. For example, tunnel boring instead of open cut and cover, substitution of the noisier hammer piler with alternative silent piler to reduce impacts to residents, etc.;
- **Minimisation (Engineering controls)** – Where changes to the project design and construction cannot affect impact avoidance and impact minimisation via substitution, engineering controls can be adopted to further reduce for identified impacts (and possibly an enhancement measure). For example, use of noise barriers to reduce noise, use of equipment enclosures wherever necessary, application of silt curtains to curb silt flow into drains, etc.;
- **Minimisation (Administrative controls)** – Where applicable, enhanced mitigation can be achieved by applying administrative controls on top of engineering controls. These controls do not remove environmental hazards, but limit or prevent receptor's exposure to hazards, such as repeated wetting of unpaved roads for dust suppression, proper scheduling of noisier construction activities, reducing work on weekends, etc.;
- **Remedy/ Repair/ Restore** – Where residual impacts need to be further reduced, measures should be taken to remedy/ restore/ repair the situation after the impact, e.g. replanting of trees and shrubs in appropriate locations on the impacted site to restore part of the habitat after construction; and
- **Compensation/ Offset** – Where possible, measures should be taken to compensate/ offset the impacts in a different part of the development, wherever technically and financially feasible, e.g. rare shrubs or trees that are important to birds and mammals to be planted elsewhere in consultation with NParks, etc.

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

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

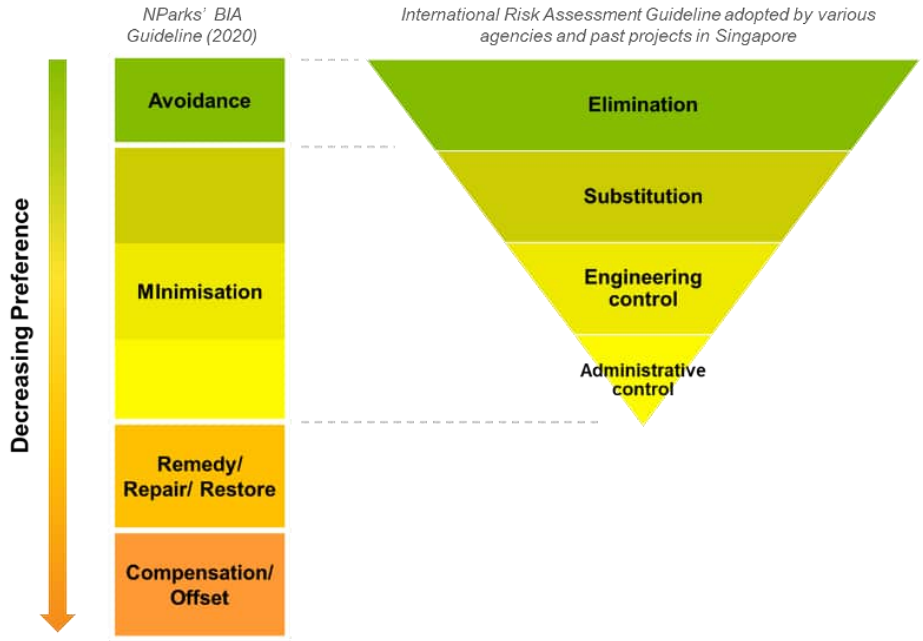


Figure 6-1 Mitigation Hierarchy

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