










Land Transport Authority

Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line

FINAL CONSTRUCTION & OPERATION ENVIRONMENTAL IMPACT ASSESSMENT REPORT – *VOLUME I*

2 September 2019

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ERM

Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line

Final Construction & Operation EIA – *Volume I*

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Client	Project No
Land Transport Authority Singapore	0256660

Project Summary

The Land Transport Authority commissioned ERM to undertake environmental impact assessment studies relating to the construction and operation of the Cross Island Line (CRL) at or in close proximity to the Central Catchment Nature Reserve (CCNR), in Singapore. The phased studies are:

- *Phase 1a*: Environmental Baseline
- *Phase 1b*: EIA of the Soil Investigation (SI) Works
- *Phase 2*: EIA of the construction and operation of the CRL for the two route options.

This document presents ***Volume I*** of the Construction & Operation (C&O) EIA (*Phase 2*) for the Project.

Date

2 September 2019

Approved by

Alastair Scott

Senior Partner, on behalf of ERM (S) Pte Ltd

Revision	Description	By	Checked	Approved	Date
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ACRONYMS AND ABBREVIATIONS

AES	Advanced Engineering Study
ALARP	As Low As Reasonably Practicable
AOI	Area of Influence
BCA	Building Construction Authority
bgl	Below ground level
BH	Borehole
BKSR	Bukit Kalang Service Reservoir
C&O	Construction and operation
Ca_3SiO_5	Tricalcium sillicate
$Ca(OH)_2$	Calcium hydroxide
CBD	Convention on Biological Diversity
CCNR	Central Catchment Nature Reserve
CCTV	Closed circuit television
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CO	Carbon monoxide
CR	Critically endangered (IUCN Red List category)
CRL	Cross Island Line
CSM	Conceptual site model
DA	Developed Area
dBA	A-weighted decibel
DBH	Diameter at breast height
DD	Data Deficient (IUCN Red List category)
DTSS	Deep Tunnel Sewerage System
EAP	Environmental Advisory Panel
EC	Electrical conductivity
ECM	Earth Control Measures
ECO	Environmental Control Officer
EHS	Environmental Health & Safety
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EMS	Environmental Management System
EN	Endangered (IUCN Red List category)
ERM	Environmental Resources Management
ERSS	Earth Retaining Stabilising Structures
ET	Main Contractor's Environmental Team
EU	European Union
EW	Extinct in the Wild (IUCN Red List category)
EX	Extinct (IUCN Red List category)
GC	Golf Course
GHG	Greenhouse gas
HDC	Horizontal Directional Coring

HDV	Heavy duty vehicle
IA	Impact assessment
IAQM	Institute of Air Quality Management
IDF	Intensity-Duration-Frequency
IF	Isolated Forest
IFC	International Finance Corporation
ISA	International Society of Arboriculture
IUCN	International Union for Conservation of Nature
JGP	Jet grouting
km	Kilometer
km/h	Kilometer per hour
LC	Least concern (IUCN Red List category)
LRV	Light Reflective Value
LS	Launch shaft
LTA	Land Transport Authority
m	Meter
MRT	Mass Rapid Transit
MSDS	Material Safety Data Sheet
NBSAP	National Biodiversity Strategy and Action Plan
NCMP	National Conservation Master Plan
NE	Not Evaluated (IUCN Red List category)
NEA	National Environment Agency
NFPA	National Fire Protection Association
NHB	National Heritage Board
NOx	Nitrogen oxides
NParks	National Parks Board
NSS	Nature Society (Singapore)
PCO	Pest Control Operator
PF	Primary Forest
PIE	Pan Island Expressway
PM	Particulate matter
PPV	Peak particle velocity
PUB	Public Utilities Board
QECP	Qualified Erosion Control Professional
RA	Regeneration Forest A
RDB	Singapore Red Data Book (2nd ed, 2008)
RF	Recreation Facility
SAC-SINGLAS	Singapore Accreditation Council, Singapore Laboratory Accreditation Scheme
SBP	Secant bored pile
SCDF	Singapore Civil Defence Force
SHE	Safety, Health and Environment
SI	Soil investigation
SICC	Singapore Island Country Club

SME	Subject Matter Expert
SMS	Short Message Service
TBM	Tunnel boring machine
TDS	Total dissolved solids
TIW	Toxic industrial waste
TSP	Total suspended particulates
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
URA	Urban Redevelopment Authority
UVI	Ultraviolet Index
VOC	Volatile organic compound
VS	Ventilation shaft
VU	Vulnerable (IUCN Red List category)
WF	Wetland Forest
WHO	World Health Organisation
WM	Wetland Marsh

GLOSSARY OF TERMS

Terminology	Definition
Administrative Framework	The compendium of requirements with which the Project is required to, and/or has chosen to, comply.
Area of Influence	The primary Project site(s) and related facilities that the Land Transport Authority develops (eg, railway tunnels, vent shafts, stations, escape shafts) and the additional areas in which aspects of the environment could conceivably experience significant impacts, such as: • associated facilities that are not developed and funded as part of the Project but are essential for the Project and without which the Project cannot proceed, and the associated additional areas in which aspects of the environment could conceivably experience significant impacts; • areas potentially affected by cumulative impacts resulting from other developments known at the time of the IA, further planned phases of the Project or any other existing circumstances; and • areas potentially affected by impacts from predictable (but unplanned) developments as a result of the Project (ie, induced activities), occurring at a later stage or at a different location.
Baseline	The physical, biological, cultural and human conditions that will prevail in the absence of the Project, including interactions amongst them. The Baseline includes information on all receptors and resources that were identified during scoping (or at a later stage in the IA Process) as having the potential to be significantly affected by the Project.
Committed Development	A development which is underway and is considered as part of the Project **baseline**. Note, if there are other developments in the Study Area which are in preparation or envisaged, but are committed at the time of writing, they are not considered to be part of the **baseline**.
Cumulative Impact	An **impact** that arises as a result of an **impact** from the **Project** interacting with an **impact** from another activity to create an additional **impact**.

Terminology	Definition
Effect	The specific consequence (to a **resource/ receptor**) arising from an alteration of existing conditions caused by the **Project**.
Embedded Controls	Physical or procedural controls that are planned as part of the **Project** design (ie, not added solely based on a mitigation need identified by the **impact** significance assignment process). These are described from the very start of the **IA Process** as part of the **Project** (ie, in the Project Description and Administrative Framework chapters).
IA Process	A systematic process that predicts the **impacts** of the **Project** and evaluates the resulting **effects** it is likely to have on elements of the physical, biological, cultural and human environment. It identifies measures that the **Project** will take to avoid, reduce, abate, remedy or compensate for adverse **impacts/effects**, and to enhance positive **impacts/effects**.
Impact	Any alteration of existing conditions, adverse or beneficial, caused directly or indirectly by the **Project**.
L_{A90}	The percentile sound pressure level exceeded for 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis.
$L_{Aeq,T}$	Equivalent continuous sound pressure level with 'A' frequency weighting. Signifies the value of the sound pressure level of a continuous steady noise that, over a measurement interval of time (t), has the same mean square sound pressure as the sound under consideration whose level varies with time.
Mitigation Hierarchy	The types (in order of preference) of mitigation that can be applied to address an impact. The **Mitigation Hierarchy** is as follows: • **Avoid at Source; Reduce at Source:** avoiding or reducing at source through the design of the Project (eg, avoiding by siting or re-routing activity away from sensitive areas or reducing by restricting the working area or changing the time of the activity). • **Abate on Site:** add something to the design to abate the impact (eg, pollution control equipment, traffic controls, perimeter screening and landscaping). • **Abate at Receptor:** if an impact cannot be abated on-site then control measures can be implemented off-site (eg, noise barriers to reduce noise impact at a nearby residence or fencing to prevent animals straying onto the site). • **Repair or Remedy**: some impacts involve unavoidable damage to a resource (eg agricultural land and forestry due to creating access, work camps or materials storage areas) and these impacts can be addressed through repair, restoration or reinstatement measures. • **Compensate in Kind; Compensate Through Other Means:** where other mitigation approaches are not possible or fully effective, then compensation for loss, damage and disturbance might be appropriate (eg, planting to replace damaged vegetation, financial compensation for damaged crops or providing community facilities for loss of fisheries access, recreation and amenity space).

Terminology	Definition
Mitigation Measure	A feature, procedure or other action that the **Project** commits to implement to avoid or reduce the magnitude of an adverse **impact**, or to enhance the magnitude of a positive **impact**.
Precautionary Principle	The Precautionary Principle is an environmental approach that recommends for anticipatory action to be taken, when an activity possesses potential to cause harm and there is scientific uncertainty on the subject, including instances where there is a lack of available scientific information.
Project	The features and activities that are a necessary part of the Project Proponent's development, including all associated facilities without which the Project cannot proceed.
Project Activities	Activities that are planned as part of the Project, including all phases.
Project Alternative	A particular approach for the **Project** (eg, concept level alternatives, such as site location, technology, etc or detailed alternatives, such as geotechnical investigation method) that could potentially be employed.
Project Footprint	The area that may reasonably be expected to be physically touched by **Project** activities, across all phases. The **Project Footprint** includes land used on a temporary basis such as construction laydown areas or maintenance areas or temporary accommodation areas.
Project Site	The (future) primary operational area for the **Project** activities, eg vent buildings and stations.
Receptor	Humans and other animals which can be impacted by **Project** activities.
Resource	An element of the physical, biological, cultural or human environment which is not a human or other animal (these are referred to as **receptors**) which can be impacted by the **Project** activities. Typical **resources** include, but are not necessarily limited to: • In the physical environment: geological resources; sediments; land; water quality; water supply; air quality; noise level; vibration levels; light. • In the biological environment: terrestrial, freshwater and marine habitats; flora; biodiversity at the community, species and genetic levels; protected areas; ecosystem services. • In the human or cultural environment: subsistence resources; community health, welfare, amenity and safety; employment and incomes; business and economic activity; land use; traffic; sites and features of archaeological, historic, traditional, cultural or aesthetic interest.
Study Area	The area that needs to be studied in order to adequately understand and describe the **Baseline** likely to be affected by the **Project**. At a minimum, the **Study Area** will encompass the **Project Footprint** and the **Area of Influence**, and in some cases it may extend farther to further establish the context for the **Baseline**.
Unplanned Event	A reasonably foreseeable event that is not planned to occur as part of the **Project**, but which may conceivably occur as a result of **Project** activities (eg, accidents), even with a low probability.

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

This document presents the Environmental Impact Assessment (EIA) for the proposed Cross Island Line alignment (the 'Project'). The assessment covers the construction and operation (C&O) phases of the Project, and studies two alternative alignment options.

This EIA report for the C&O phases comprises the following volumes:

- ***Volume I:*** outlines the general introduction, project description for all alignment options assessed in the study, legislative context, methodology, screening and scoping findings of the C&O activities, and the stakeholder engagement process;
- ***Volume II:*** an addendum to the baseline study undertaken for the soil investigation (SI) phase of the Project(1) covering updates on baseline site setting, geological and hydrogeological conditions within the Project study area;
- ***Volume III:*** presents the Impact Assessment (IA) and Environmental Management and Monitoring Plan (EMMP) for the proposed C&O phases of Alignment Option 1; and
- ***Volume IV:*** presents the IA and EMMP for the proposed C&O phases of Alignment Option 2.

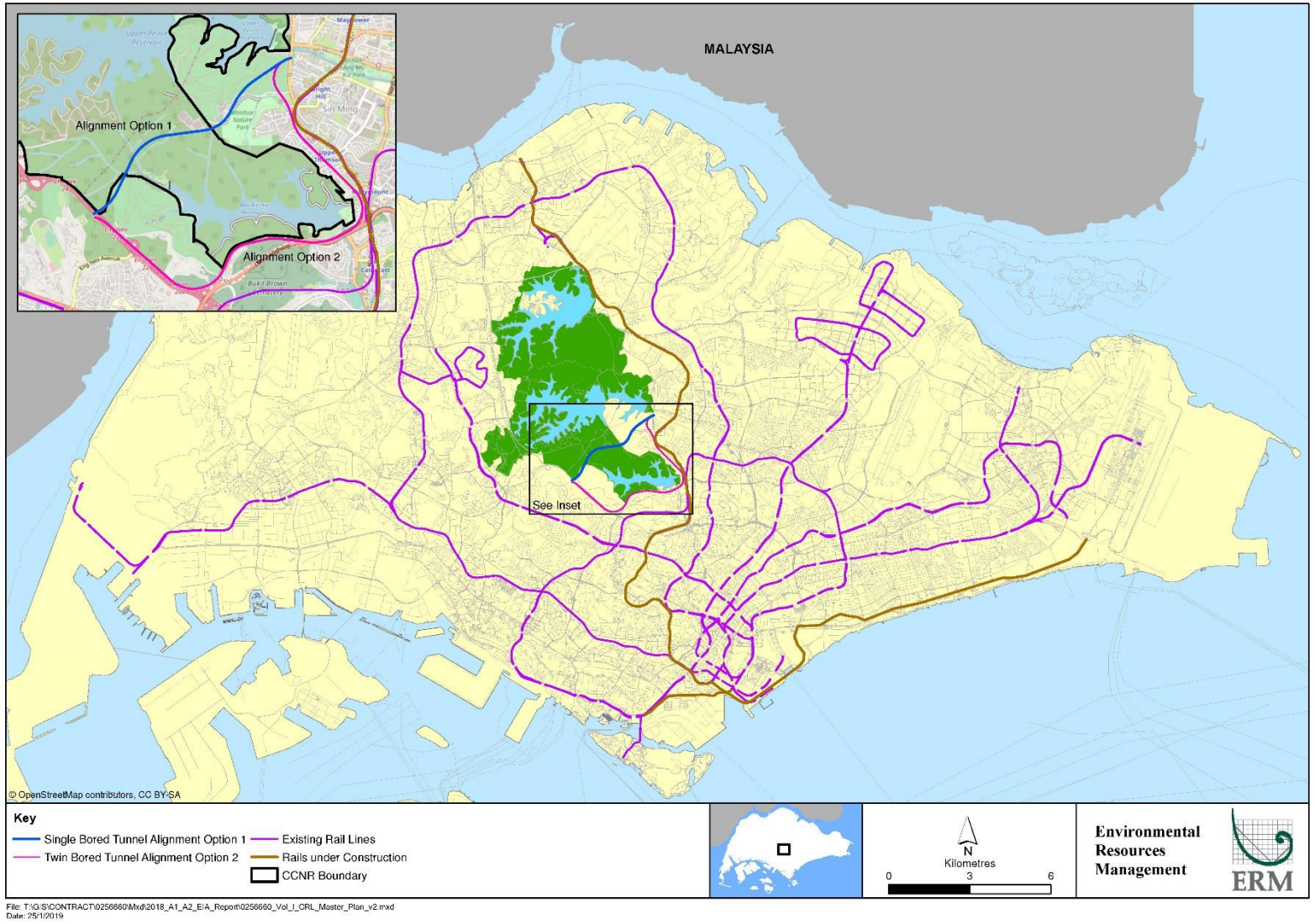
This EIA has been prepared for the Land Transport Authority (LTA) by Environmental Resources Management (S) Pte Ltd (ERM).

1.2 OVERVIEW OF PROJECT

The LTA intends to construct a new 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.

The LTA is considering two alignment options, as shown in *Figure 1.1*. The first would pass beneath the Central Catchment Nature Reserve (CCNR) (Alignment Option 1) whereas the second would pass around the CCNR boundary (Alignment Option 2). The LTA has commissioned an EIA of these alternative alignments to determine the potential environmental impacts associated with the C&O phases of each option, and determine the mitigation measures that would need to be implemented to reduce the environmental impacts identified.

Figure 1.1 Cross Island Line and Project Location



1.3 OBJECTIVES

The specific objectives of this IA were to:

- To identify and describe the elements of the environment likely to be affected by the C&O activities;
- To describe the baseline environmental conditions of the indicative corridors of each alignment option;
- To identify, quantify and assess potential impacts and determine the significance of impacts on sensitive receivers and potential affected uses;
- To identify, predict and evaluate the residual environmental impacts (after practicable mitigation) and the cumulative effects expected to arise during C&O activities in relation to the sensitive receivers and potential affected uses; and
- To propose mitigation measures to minimise any significant impacts during C&O activities;
- To detail the specific mitigation measures and implementation roles and responsibilities for the C&O phases in an EMMP.

This IA has considered the impacts associated with two alignment options. The EIA for each alignment option are presented respectively in *Volume III* and *Volume IV* of this report (see *Section 1.6* for the structure of the report). Each EIA has been undertaken in context of the established criteria, taking into consideration the location and setting of each alignment option. A comparative assessment of the two alignment options was not an objective of the IA.

1.4 SOURCES OF INFORMATION

Reference was also made to the following sources of information:

- Primary data obtained from site reconnaissance, environmental surveys and soil investigation works (see *Volume II* of the EIA);
- Concept design drawings and details from the engineering feasibility study;
- Noise measurements from existing construction sites within proximity of the Project;
- Historical vibration measurements from rock excavation (Footnote 1) activities at similar developments.
- Structural drawings from the Building Construction Authority (BCA);
- Historical borehole logs;

- Satellite imagery and online street directories;
- Online databases;
- Government websites; and
- ERM databases consolidated from similar projects.

1.5 LIMITATIONS OF THE REPORT

1.5.1 Concept Engineering Design at Feasibility Study Stage of the Project

This IA was undertaken at the engineering feasibility stage of the Project, and therefore assesses the concept design and features of the various alignment options. Where detailed engineering design information was not available to inform the study, reasonably conservative assumptions where possible were made based on ERM's internal subject matter experts' expertise and in consultation with the LTA and the Project engineers based on similar projects. With the exception of identification and assessment of ground improvement works, this EIA has considered the reasonable worst case scenario in the undertaking of the impact assessment, and the development of mitigation measures and monitoring plans for the construction and operation stages of the Project. Key measures related to Project engineering design, which were identified through the EIA process, will be passed on to the engineering team for incorporation into the detailed design at the Advanced Engineering Study (AES) stage of the Project.

1.5.2 Further Baseline Surveys at Advanced Engineering Study Stage of the Project

The existing environmental conditions, i.e. baseline, of the Project area were defined using primary data obtained from environmental surveys undertaken in 2015 during the SI phase of the Project. These surveys were designed to cover the general study area along the alignment option routes. In the course of this EIA, the locations considered for the Project construction worksites and operation buildings at that time were shifted out of the environmental survey areas undertaken in 2015 out of an interest to minimize the impacts on flora and fauna. Primary baseline data was not collected for the Project construction worksites and operational buildings. Nonetheless, secondary data review was undertaken to use as baseline for the assessment. It is noted that further baseline studies are not anticipated to change the findings of this EIA as a conservative approach has been adopted in this EIA. Nevertheless, in line with best practice, further detailed environmental surveys specific to these worksites will be commissioned by the LTA to establish pre-construction baseline at these locations during the AES stage of the Project.

1.5.3 Ongoing Studies to be Reported in an EIA Addendum

At the time of writing, the following studies were ongoing:

- A survey of Raffles' Banded Langurs to establish their usage of the habitat around one of the proposed worksites; and

- A survey of habitat conditions around selected Facility Buildings to supplement the assessment of potential edge effects associated with Project operation, and inform the final location and design of the Facility Building at the AES stage of the Project.

These studies were commissioned during the C&O EIA process, to close current data gaps and inform an assessment of specific impacts highlighted through consultation with members of the nature community and NParks. The studies will be undertaken over a minimum period of three months. In view of the overall CRL project schedule, it was not possible to complete the studies prior to the disclosure of this EIA report. It is noted however that the LTA has pre-emptively committed to measures to mitigate these impacts at the Project construction and operation, within this EIA. The findings of these studies will be provided as an Addendum to this EIA report.

1.5.4 Use of Precautionary Approach

Where appropriate, the Precautionary Principle[2] has been adopted in this EIA report. The Precautionary Principle is an approach that recommends for anticipatory action to be taken, when an activity possesses potential to cause harm and there is scientific uncertainty on the subject, including instances where there is a lack of available scientific information. The principle was adopted to overcome the lack of local or international standards / guidelines or scientific studies to allow for a quantitative assessment of impacts such as visual impacts to humans, or impacts to wildlife due to construction activities such as land clearance or tunneling. This resulted in the adoption of a reasonably conservative approach in undertaking the assessment, and in the recommendation of comprehensive mitigation measures as best practice.

1.6 REPORT STRUCTURE

The structure of this EIA report is outlined in *Table 1.1*.

Table 1.1 C&O EIA Report Structure

Volume	Chapter	Title
Volume I Introduction	1.0	Introduction
	2.0	Project Description
	3.0	Administrative Framework
	4.0	Impact Assessment Methodology
	5.0	Screening and Scoping
	6.0	Stakeholder Engagement
Volume II Baseline Environment	1.0	Introduction
	2.0	Site Setting
	3.0	Ecology & Biodiversity
	4.0	Geology
	5.0	Water Environment (Hydrogeology)
Volume III EIA of Alignment Option 1	1.0	Introduction
	2.0	Water Environment
	3.0	Noise & Vibration
	4.0	Air Quality
	5.0	Ecology & Biodiversity
	6.0	Visual, Cultural Heritage, Tourism & Recreation
	7.0	EMMP
Volume IV EIA of Alignment Option 2	1.0	Introduction
	2.0	Water Environment
	3.0	Noise & Vibration
	4.0	Air Quality
	5.0	Ecology & Biodiversity
	6.0	Visual, Cultural Heritage, Tourism & Recreation
	7.0	EMMP

2 PROJECT DESCRIPTION

This chapter of the IA report presents the location of the alignment options being considered for the CRL in the vicinity of the CCNR; the alternative designs considered; the C&O activities associated with each of the alignment options; and an indicative schedule.

This chapter is structured as follows:

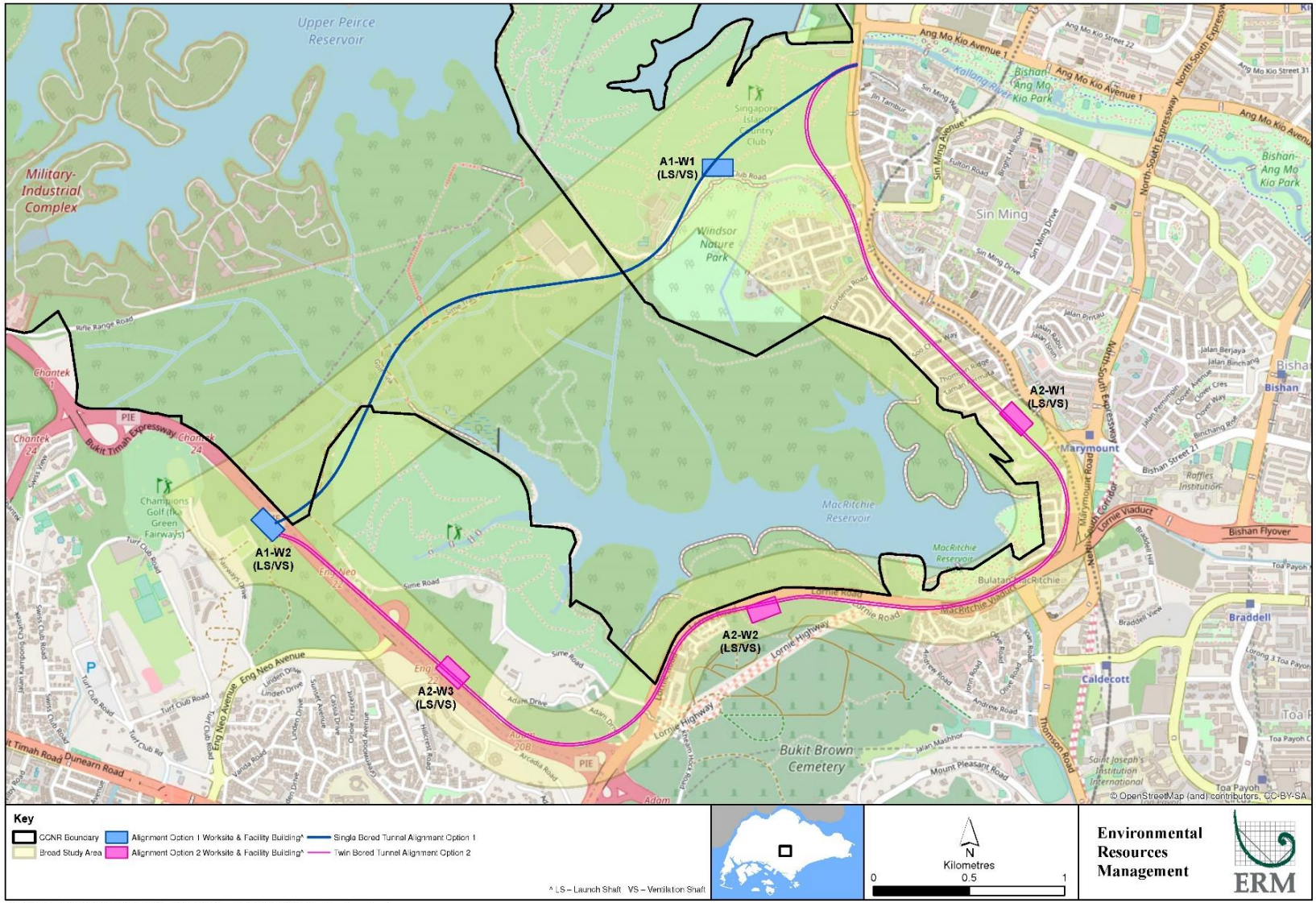
- *Section 2.1* describes the location of Alignment Option 1 and Alignment Option 2;
- *Section 2.2* presents an overview of the Project Study Area;
- *Section 2.3* defines the key underground and aboveground features to be constructed for the Project;
- *Section 2.4* presents the alternative options considered for the Project;
- *Section 2.5* describes the activities and resources required, and the response measures identified for unplanned events that might occur during the Project's construction phase;
- *Section 2.6* describes the activities and resources required, and the response measures identified for unplanned events that might occur during the Project's operation phase;
- *Section 2.7* presents the indicative Project schedule; and
- *Section 2.8* presents a summary of the key embedded controls that will be in place to ensure Project compliance to environmental, health and safety requirements.

2.1 PROJECT LOCATION

Two underground alignment options are being considered for the CRL, as illustrated in *Figure 2.1* and summarised as follows:

- ***Alignment Option 1***: This alignment, which is approximately 4 km in length, crosses under an area from the Singapore Island Country Club (SICC) Island golf course to the Pan Island Expressway (PIE), traversing under approximately 2 km of the CCNR area to the south of Lower Peirce Reservoir, and north of MacRitchie Reservoir. The tunnel will mostly be bored through bedrock strata at depths ranging between 23 m to 90 m below ground level (bgl) along the whole alignment (average 70 m bgl under the CCNR); and
- ***Alignment Option 2***: This alignment is approximately 9 km in length and would pass around the CCNR. The alignment will travel southeast from the SICC Island golf course under residential developments bounded by the MacRitchie area and Upper Thomson Road, then run west beneath Lornie Road before turning north at Adam Road and running northwest abutting the PIE. The tunnel will be bored at depths ranging between 23 m to 68 m bgl (average 45 m bgl), mostly in bedrock but also in mixed face conditions to avoid other underground infrastructure.

Figure 2.1 Project Alignment & Worksite Locations



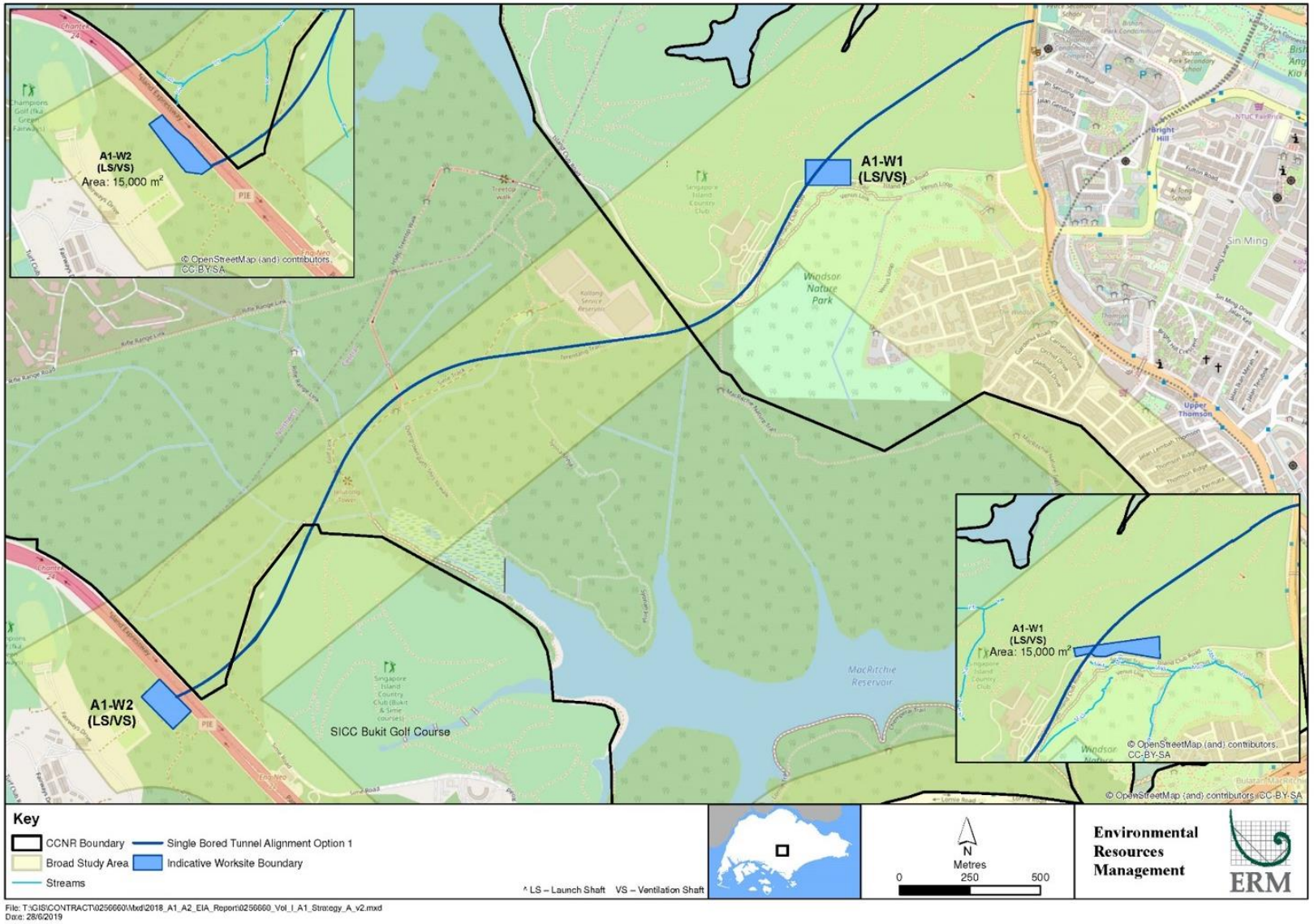
2.1.1 Alignment Option 1 Tunneling Strategy

For operational safety, ventilation shafts along a tunnel alignment are required as these serve as egress points during emergencies requiring evacuation from the tunnel. As Alignment Option 1 is approximately 4 km long, the base case for designing the tunnel for Alignment Option 1 therefore required at least one ventilation shaft within the Study Area. Given the ecological sensitivity of the CCNR and its status as a designated nature reserve, it was considered very important that the Project was designed to avoid any structures being erected within the CCNR, whether these structures be temporary in nature as with construction worksites, or permanent to support Project operation. The ventilation shaft options took into consideration factors such as environmental considerations and existing land uses in the area; construction and operational footprint requirements; interfacing with railway alignments east and west of CCNR; access constraints etc. The tunneling strategy developed for Alignment Option 1 is shown in *Figure 2.2*.

The tunnel depth for Alignment Option 1 was chosen to ensure that the tunnel will be bored entirely within rock while passing below the CCNR. The tunnel depth of 23 to 90 m bgl (average 70 m bgl) was determined following analysis of the borehole logs and results from the SI works and geophysical surveys (see *Vol II, Chapter 4* for a summary of the geological findings). The tunnel may encounter mixed face conditions of soil and rock when approaching Bright Hill (outside of CCNR). The tunnel depths have however been optimized, taking into consideration engineering constraints such as tunnel slope limits and the depths of underground stations east and west of the Project.

Alignment Option 1 Tunneling Strategy involves the location of a worksite south of SICC's Island golf course i.e. A1-W1 (LS/VS), where a TBM will be launched for the tunnel alignment underlying the CCNR. The TBM will be retrieved at a second worksite, A1-W2 (LS/VS) along the PIE west of the CCNR to construct the next tunnel package. Following completion of tunneling works, ventilation shafts and facility buildings will be constructed at the worksites. It is estimated that all works will be completed within 5.5 years.

Figure 2.2: Alignment Option 1, Tunneling Strategy



2.1.2 *Alignment Option 2 Tunneling Strategy*

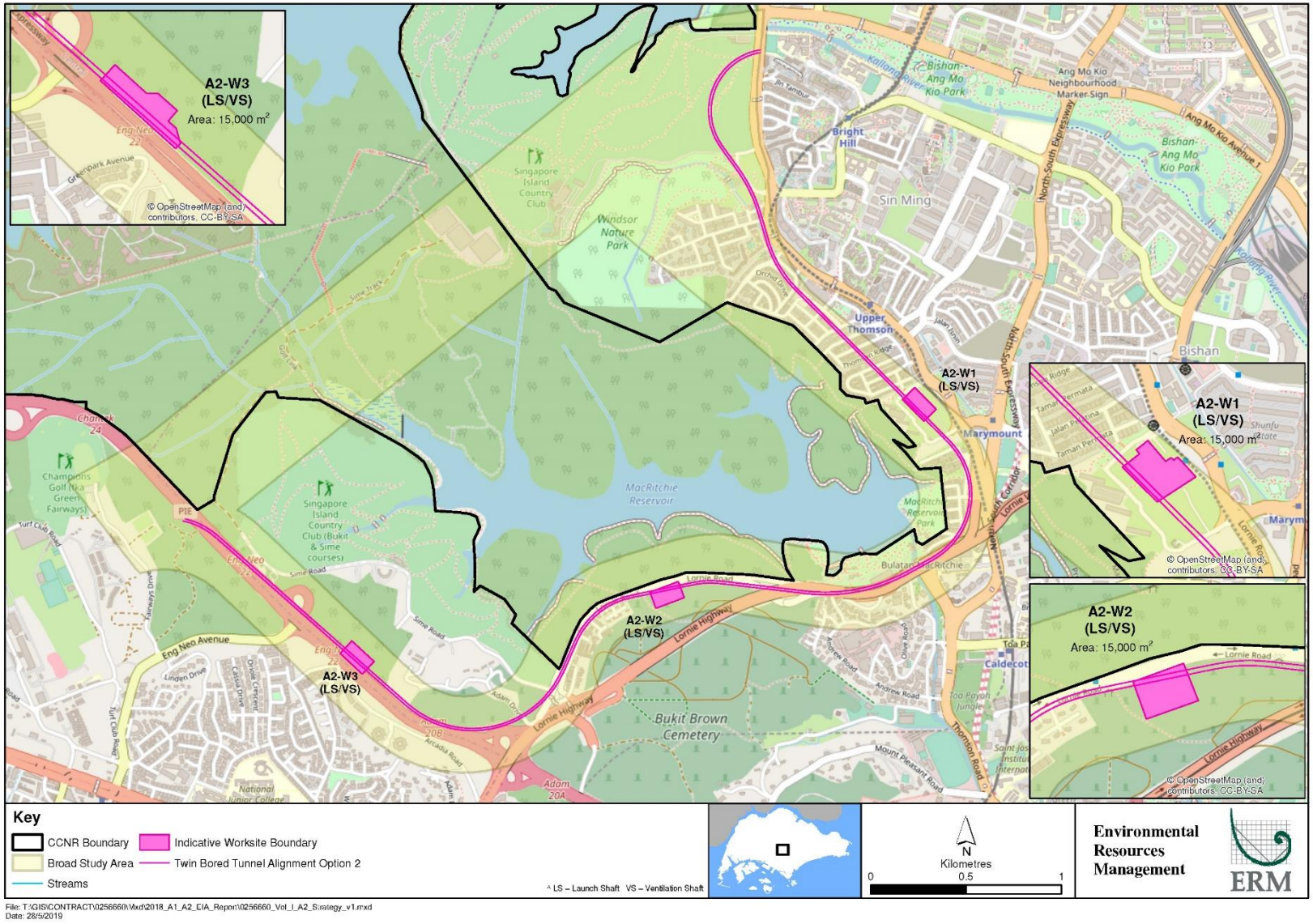
Alignment Option 2 is approximately 9 km long and will curve around the CCNR. Due to the length of the tunnel alignment, a minimum of three ventilation shafts would be required to meet the requirements for operational safety. The tunneling strategy developed for Alignment Option 2 is shown on *Figure 2.3*.

The tunnel depths of 23 to 68 m bgl (average 45 m bgl) for Alignment Option 2 were chosen to avoid underground major infrastructures like the Circle MRT Line, Thomson-East Coast MRT Line, Deep Tunnel Sewerage System (DTSS) tunnel and Singapore Powergrid's high voltage power cable tunnel. These are located in close proximity to the southeast section of the alignment, underlying Upper Thomson Road and Marymount Road.

At these depths, the tunneling works may be undertaken within mixed face conditions at localized areas that will require ground improvement works. The exact locations of these areas will be determined at the AES stage when more site investigation works will be carried out.

The strategy will involve the location of launch shaft worksites along Upper Thomson Road, Lornie Road and the PIE. The TBM will be launched from the A2-W1 (LS/VS), A2-W2 (LS/VS) and A2-W3 (LS/VS) worksites to construct the twin tunnels for Alignment Option 2. Following completion of tunneling works, ventilation shafts and facility buildings will be constructed at the worksites. It is estimated that all works will be completed within 5.5 years.

Figure 2.3: Alignment Option 2 Tunneling Strategy



2.2 STUDY AREA

The Study Area comprises the footprint of aboveground worksites and structures, the area immediately overlying the tunnel alignments, as well as the area which may be impacted by construction and operation activities, i.e. the Project Area of Influence (AOI). The Study Area differs across various environmental aspects, for example, the area over which noise propagates is different than the extent of impact due to surface water discharges. These Study Areas are detailed in the respective chapters in *Volume III* and *Volume IV* of the EIA.

2.3 KEY FEATURES

The key features associated with a typical railway project consist of both underground and aboveground elements, such as launch shafts, access roads, tunnels, cross passages, ventilation shafts, facility buildings and stations etc. The key features associated with the CRL development of Alignment Options 1 and 2 are defined in *Table 2.1*. *Table 2.1* also indicates whether the feature will be *temporary*, i.e. just required for the construction phase; or *permanent*, i.e. required for the operational phase.

Table 2.1: Key Underground & Aboveground Features

Feature	Description	Nature
Access roads	Temporary access road paved with hardcore or milled waste, for use by construction vehicles accessing and exiting the worksites during the construction phase; and permanent access road paved with asphalt for use by maintenance vehicles to be constructed for facility buildings and stations for use during the operation phase	Temporary (during construction phase only) and permanent
Launch shaft (Note 1)	Subsurface shaft for launch of Tunnel Boring Machines (TBMs) at the start of a tunnel drive.	Temporary
Tunnel	**Alignment Option 1:** Underground single bored tunnel of 12.5 m external diameter housing two tracks **Alignment Option 2:** Underground twin tunnels of 6.85 m external diameter housing one track each	Permanent
Cross passageway	**Alignment Option 2:** Underground passageway which serves as a connection between twin tunnels to enable the safe evacuation of passengers during an emergency within one of the tunnels	Permanent
Ventilation shaft (Note 2)	Subsurface shaft connecting the tunnel to the surface, for the venting of air during normal train operations and smoke during a fire emergency within the tunnels. Following completion of tunneling works, all launch shafts will be used to create ventilation shafts.	Permanent

Feature	Description	Nature
Facility building	Aboveground double storey structure to house the electric substation, ventilation shaft and other electrical and mechanical installations, as well as escape staircases to provide ingress and egress to responders and facilitate the evacuation of commuters during an emergency	Permanent

Note 1: Worksites where launch shafts will be constructed during Project Construction are indicated with the suffix 'LS' in *Figure 2.1*.

Note 2: Worksites where ventilation shafts will be constructed for Project Operation are indicated with the suffix 'VS' in *Figure 2.1*.

The footprint of construction worksites will be dependent on the type of underground or aboveground feature(s) required for each alignment option. The type of underground/subsurface feature will in turn, determine the type of activities undertaken and the associated equipment and facilities required. Activities and typical construction area footprints required for the features outlined are presented in *Table 2.2*.

Table 2.2: Construction Worksite Characteristics

Features	Access Road	Launch Shaft	Ventilation Shaft /Facility Building
			
Activities	• Site clearance and/or demolition of existing road structures • Grading works • Laying of road aggregates (hardcore, milled waste, asphalt) • Road planning • Concreting and reinstatement of road verges	• Excavation and rock excavation for shaft construction • Launch of slurry type TBM • Tunnel excavation and construction • Slurry treatment and storage • Tunnel segment lining storage • Backfilling and concreting to double up as ventilation shaft (applies for most launch shafts)	• Excavation and rock excavation for ventilation shaft construction • Backfilling • Construction of facility building • Construction of permanent access road
Typical Worksite Features	• Materials will be stored within nearby worksites • Road construction equipment will be temporarily mobilised within the footprint of the road during construction	• Launch shaft • Slurry treatment plant • Tunnel segment storage area • Equipment storage and workshop area • Raw material storage • Waste management facilities and storage • Hazardous materials storage • Office area • Vehicle parking lot	• Ventilation shaft (adapted from launch shaft after completion of tunneling works) • Equipment storage area • Raw material storage • Waste management facilities and storage • Hazardous materials storage

Features	Access Road	Launch Shaft	Ventilation Shaft / Facility Building
			
Approximate Footprint of Worksite	• Temporary access road 8 to 10 m wide • Permanent access road 7.4 to 10 m wide	• Footprint of the launch shaft is approximately 40 m by 25 m • Total footprint of launch shaft worksite is ~9,000 m^2	• Footprint of the ventilation shaft approximately 40 m by 25 m • Footprint of facility building is 70 m by 40 m (~2,800 m^2) • Facility building is 10 m high on average • Footprint of facility building worksite is ~6,000 m^2

2.4 PROJECT ALTERNATIVES

During development of the concept engineering design presented herein, construction feasibility, health, safety, technical risk, spatial constraints, schedule and accessibility, as well as environmental and stakeholder concerns, were taken into consideration. A number of alternatives were considered for both alignment options.

These alternatives were examined and ultimately rejected in line with the mitigation hierarchy (see *Volume I, Chapter 4, Section 4.6.3*), which prioritises avoidance, followed by abatement, repair and compensation for resulting impacts.

2.4.1 Alignment Option 1 Alternatives

2.4.1.1 Alignment Routing

The starting point for the Alignment Option 1 route selection was a straight line undercrossing the CCNR.

The route was subsequently refined as far as technically practicable to align it with the existing public trails routes through the CCNR (see *Figure 2.1*). The western portion of the alignment was also moved further south out of the CCNR boundary to dissect the Bukit golf course, thereby shortening the alignment route length under the CCNR from 2 km to 1.8 km. This was undertaken to minimize the footprint of soil investigation works within the forested portions of the CCNR. This EIA assesses the impacts associated with the refined route for Alignment Option 1.

2.4.1.2 Tunnel Configuration

The initial concept design for Alignment Option 1 involved consideration of twin bored tunnels. Each tunnel would have an external diameter of approximately 6.85 m and would house a single train track. Due to construction safety considerations, only one TBM would operate at any one time along each tunnel contract. The twin tunnels would therefore be constructed by launching a TBM from the launch shaft for the first tunnel, retrieving the TBM and re-launching it to bore the second parallel tunnel segment.

For safety reasons however, cross passageways would need to be constructed between the tunnels at fixed intervals to facilitate the evacuation of commuters from an affected tunnel to the second tunnel in the event of a fire emergency (see *Section 2.5.2.4* for details). Due to the optimized tunnel depth for Alignment Option 1, rock excavation methods for the construction of cross passageways such as blasting might need to be undertaken. Taking into consideration the potential impacts to ecological receptors within the nature reserve resulting from the rock excavation, a single bored tunnel configuration with a 12.5 m external diameter was considered instead for Alignment Option 1. A single bored tunnel would also have the advantage of only requiring one launch of a 12.5 m diameter TBM, instead of the two TBM launches required for a twin bored tunnel configuration.

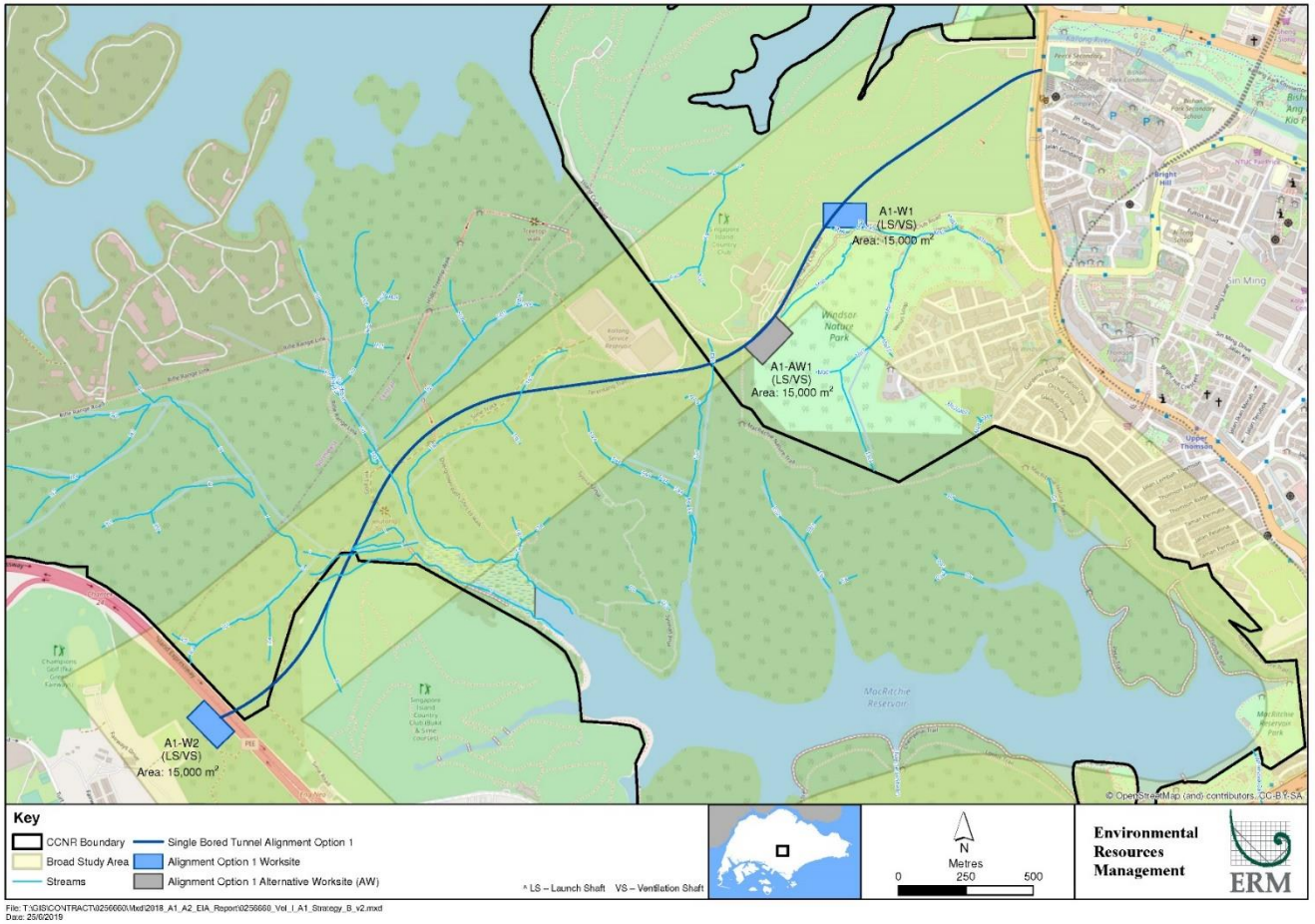
This EIA therefore assesses the impacts associated with the construction and operation of a single bored tunnel for Alignment Option 1.

2.4.1.3 Tunneling Strategy

An alternative tunneling strategy for Alignment Option 1 was initially developed. As shown in *Figure 2.4*, the alternative tunnelling strategy involved the location of one launch shaft worksite and future facility building within Windsor Nature Park, i.e. A1-AW1 (LS/VS). Two TBMs would be launched from A1-AW1 (LS/VS) to construct the tunnels east and west of the worksite. It is estimated that all works will be completed within 5.5 years.

It was observed that the A1-AW1 (LS/VS) worksite would involve vegetation clearance and construction works being undertaken within the Windsor Nature Park. In addition, the A1-AW1 (LS/VS) worksite would be located in close proximity to stream catchment areas in both the Windsor Nature Park and the CCNR. This alternative strategy was therefore not taken forward and was therefore not assessed in this EIA.

Figure 2.4: Alignment Option 1, Alternative Tunneling Strategy



2.4.1.4 Facility Building Location

An alternative option to A1-W2 (LS/VS) initially considered was a ventilation shaft within the northernmost portion of SICC Bukit golf course (see *Figure 2.5)*. This alternative location, A1-AW2 (VS), would have been 700 m closer to A1-W1 (LS/VS). Following completion of tunneling works, A1-AW2 (VS) would then be constructed as a ventilation shaft and facility building. In view of the proximity to the CCNR boundary; the proximity to the streams and wetland forest habitat within the CCNR; and the large area of land and vegetation clearance that would be required for the worksite, this option was not taken forward for further consideration.

Instead, the two facility building configuration associated with the final tunneling strategies for Alignment Option 1 was identified for further assessment within this EIA (see *Figure 2.2*).

2.4.2 Alignment Option 2 Alternatives

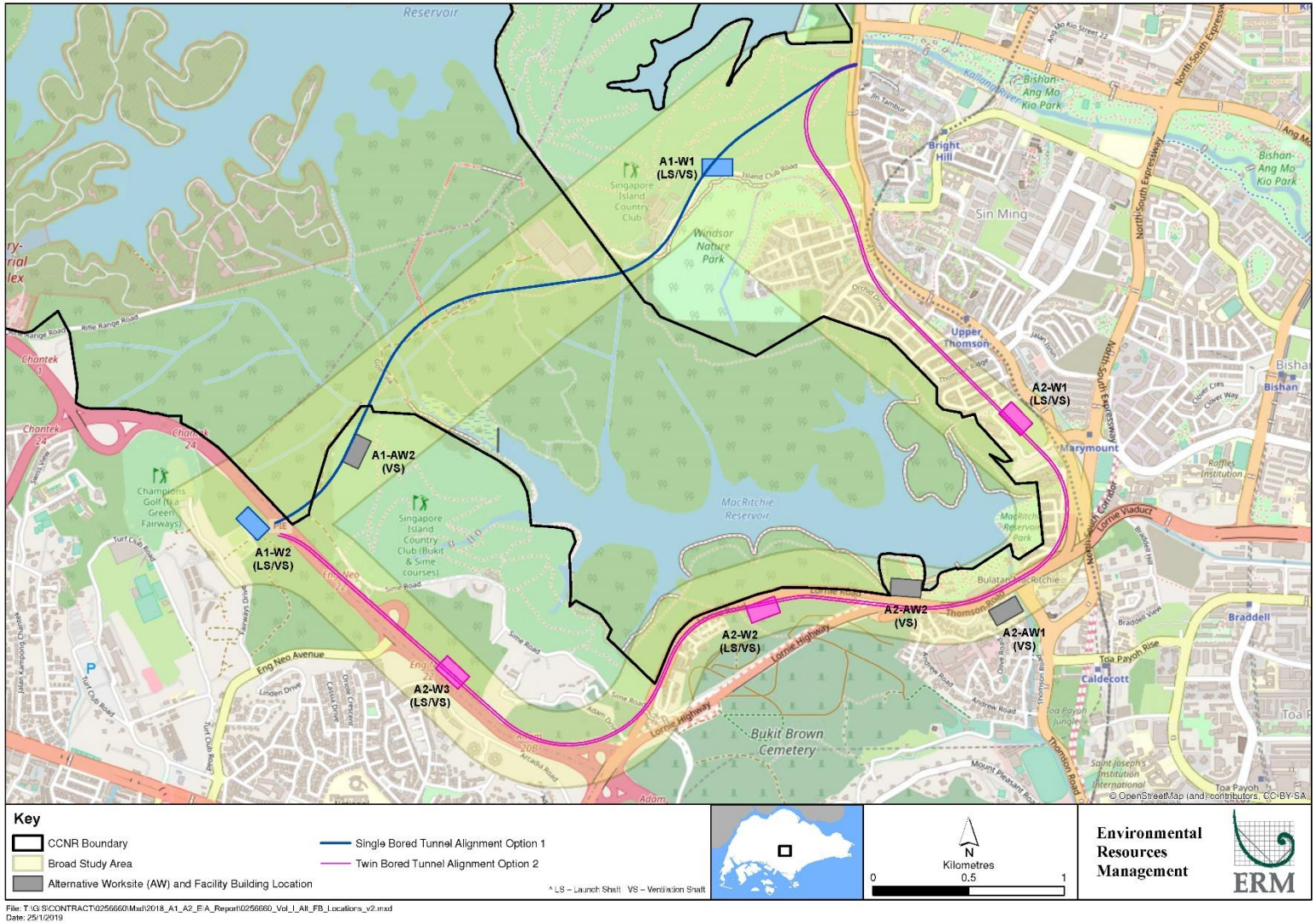
2.4.2.1 Facility Building Location

In compliance with operational safety requirements, facility buildings were initially considered at the following locations presented in *Figure 2.5*:

- **A2-AW1:** At the road reserve by the cross junction of Lornie Road and Thomson Road; and
- **A2-AW2:** Within MacRitchie Reservoir Park, along Lornie Road and Reservoir Road.

Rock excavation may be required for the excavation of the ventilation shafts down to tunnel depth. In view of the proximity of vibration sensitive receptors such as the Mount Alvernia hospital along Thomson Road and Lornie Road, A2-AW1 was relocated further west along Lornie Road. Due to the complexities of designing suitable road diversions near the Lornie Road entry and exit ramps to Lornie viaduct, A2-AW1 was relocated to A2-AW2. However, given the close proximity of A2-AW2 to the CCNR boundary, as well as the location of primary forest habitat within the footprint of A2-AW2, this facility building location was further relocated to the final A2-W2 (LS/VS) location (see indicative worksite boundary for A2-W2 (LS/VS) in *Figure 2.3*).

Figure 2.5: Alternative Facility Building Locations



2.4.2.2 Tunnel Depth

In view of the density of buildings along the Alignment Option 2 route, the option of tunneling at greater depths was considered. This was done to explore if the distance between the TBM and building foundations could be maximized and if the tunnel could be bored fully within the bedrock strata.

It was noted that to fully avoid underground infrastructure and be fully within the bedrock strata, the tunnel depth would need to be well below existing, ongoing and future multiple underground infrastructure underlying Upper Thomson Road and Marymount Road. It was observed however that tunneling at such depths along Alignment Option 2 would require very steep slope gradients for the tunnel portions linking to the underground stations east and west of the Project.

The EIA therefore assessed the tunneling of Alignment Option 2 at depths of 23 to 68 m bgl, which places the tunnel below building foundations and above other major underground infrastructure.

2.4.2.3 Tunnel Configuration

In view of the need to construct cross passageways at regular intervals along the tunnel alignment for twin bored tunnels, a single bored tunnel design was considered for Alignment Option 2. It was noted however that due to the tunneling depths (see *Section 2.4.2.2*) for Alignment Option 2, there might be interface with underground structures such as building pile foundations. A twin bored tunnel with diameter 6.85 m each, was therefore selected as there is greater flexibility to route these both horizontally and vertically, in order to avoid interfacing with underground structures.

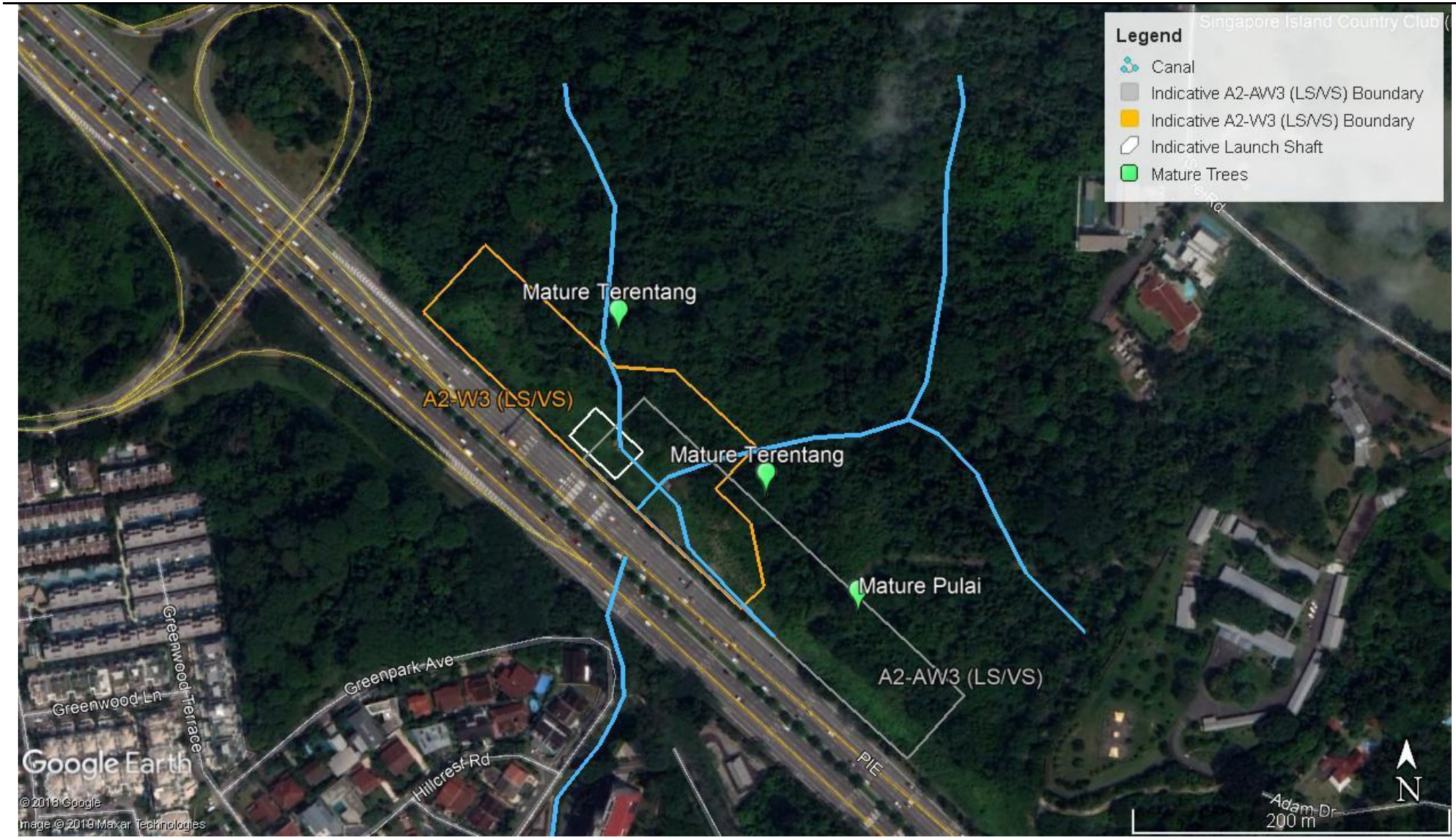
The EIA therefore assessed a twin bored tunnel configuration for Alignment Option 2.

2.4.2.4 Worksite Location & Boundary (A2-W3)

The initial worksite for A2-W3 comprised a 50 m by 300 m plot of land located adjacent to the PIE. The narrow configuration was designed to maximize the proportion of the worksite that would be within close proximity to the PIE, as the strip of land east of PIE was observed to largely comprise of less mature trees and grassland. It was further noted that the existing habitat in close proximity to the PIE i.e. within 50 m, would be exposed to high noise levels from vehicular traffic. The initial worksite location and indicative boundary, A2-AW3 (LS/VS) is presented in *Figure 2.6*.

Anecdotal evidence provided by Anthony O'Dempsey reported the presence of a mature tree within the footprint of the A2-AW3 (LS/VS) worksite, as well as the sighting of arboreal species of conservation significance such as the Sunda Slow Loris (*Nycticebus coucang*) in the area. Arboreal species of conservation interest such as Colugos (*Galeopterus* variegates) also reportedly frequent the area. Due to the importance of mature native tree species in supporting these arboreal species, the A2-W3 worksite was shifted north and configured to avoid mature trees. The EIA assessed the A2-W3 (LS/VS) worksite presented in *Figure 2.6*.

Figure 2.6: Alternative Worksite Boundary, A2-W3



2.5 CONSTRUCTION PHASE

2.5.1 Pre-Construction Activities

Pre-construction activities typically involve site investigation works to determine the geotechnical characteristics and rock depths along each alignment option for engineering of the alignment depths. Environmental impacts associated with the site investigation works for both alignment options have been identified and assessed in a separate study undertaken in 2016(1), and are therefore excluded from this EIA.

Other pre-construction activities will be required for both alignments to prepare nearby road users and surrounding areas for the impending construction works. Key activities for all worksites will comprise road and utilities diversion works, land clearance, establishment of temporary laydown areas and worksites, the creation of access roads and the installation of instrumentation for the monitoring of tunneling works. These are further discussed below.

2.5.1.1 Road & Utilities Diversion Works

Applicable for both Alignment Options

Utilities such as underground sewers, electrical and telecommunication lines, as well as existing surface drainage within the Project footprint may need to be diverted prior to construction works, to prevent disruption of services to members of the public. Roadworks will also be required for the construction of temporary access roads(Footnote 1) between 8 m to 10 m wide. Drainage associated with temporary and permanent access roads will also be constructed in accordance with the PUB's *Code of Practice on Surface Water Drainage*. The indicative works required at this phase are presented in *Table 2.3*.

Table 2.3: Indicative Utilities and Drainage Diversion, and Road Works

Worksite	Works Required
Alignment Option 1	
A1-W1 (LS/VS)	Utilities diversion and construction of a temporary and permanent access road linking the facility building to Island Club Road
A1-W2 (LS/VS)	Utilities diversion, and construction of a temporary and permanent access road linking the PIE to the facility building
Alignment Option 2	
A2-W1 (LS/VS)	Utilities and drainage diversion, and construction of a temporary and permanent road linking the facility building to Lakeview Road
A2-W2 (LS/VS)	Utilities diversion, and construction of a temporary and permanent access road linking the facility building to Lornie Road
A2-W3 (LS/VS)	Utilities diversion, construction of a temporary and permanent access road from the PIE to the facility building

(Footnote 1) Temporary access road during the construction phase entails taking access from slip road into the worksite. No new road networks are anticipated for the project.

Any diversion works will be carried out in conjunction with the relevant utility providers and authorities and in compliance with their requirements. Depending on the alignment option selected, such diversion works will involve tree felling and clearance of land, demolition of existing surface structures, concrete and road breaking, excavation, access road construction and concrete resurfacing works. Based on the current Project design, all temporary and permanent diversion works will be undertaken within the worksite boundaries.

2.5.1.2 Land Clearance

Applicable for both Alignment Options

Land clearance will be undertaken for the pre-construction activities outlined, as well as for the preparation of worksites and temporary laydown areas as presented in *Figure 2.2* and *Figure 2.4*. This will involve vegetation clearance, demolition of any existing surface structures, concrete breaking and earthworks to level the ground. Removal of trees with girths exceeding 1 m will only be undertaken with approval from NParks. Yard waste, construction debris and spoil will be temporarily stored on site prior to collection by specialist third parties for offsite disposal.

In addition, due to the location of the A2-W2 (LS/VS) worksite within the Bukit Brown cemetery, exhumation of graves may need to be undertaken. This work will be undertaken in close consultation with the National Heritage Board and the National Environment Agency, if required.

The indicative area of land that would need to be cleared and levelled at each worksite is 15,000 m^2. No land clearance will be required within the CCNR boundary.

2.5.1.3 Establishment of Temporary Worksites

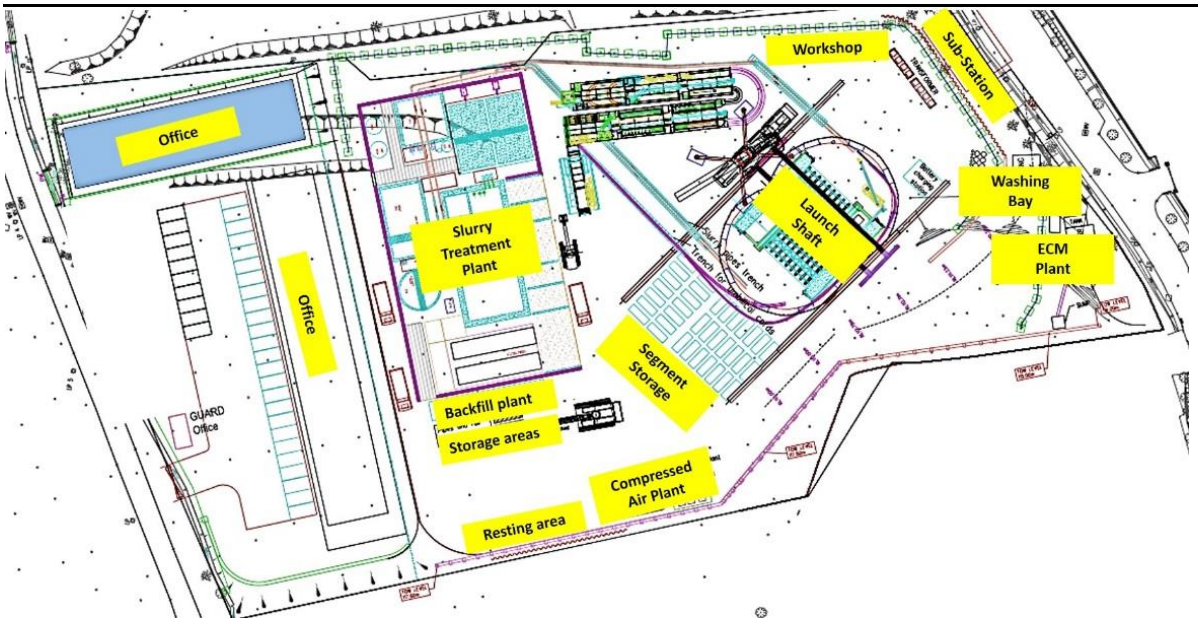
Applicable for both Alignment Options

Following land clearance, temporary structures as described in *Table 2.1* will be set up at each worksite. As indicated in *Table 2.2*, aboveground facilities at the launch shaft worksites will need to be more extensive than those solely used for ventilation shafts, due to the additional land area required for tunneling operations from within the launch shaft. For example, a slurry treatment plant for the treatment of excavated material from the tunnel and a segment storage area for storage of the segment linings that form the final tunnel structure, will be required to support rock excavation from within the launch shaft and tunnel. Pre-construction activities will typically comprise the erection of hoarding along the worksite boundaries; construction of temporary office buildings and vehicle parking lots; establishment of equipment and chemical storage areas; establishment of workshop areas; and set up of equipment such as the slurry treatment plant to support tunneling activities at the launch shaft. A typical layout for the launch shaft cum ventilation shaft worksite is presented in *Figure 2.7*, although it is noted that the layout and temporary access roads presented are indicative, and will be dependent on the location and shape of each worksite.

For worksites located upstream of sensitive waterbodies, bund walls for containment of storm water, drainage and a temporary storm water holding sump will be constructed prior to or in parallel with site clearance works (see *Section 2.5.1.2*). This will be put in place to prevent sediment loading of

downstream waterbodies due to the occurrence of rainfall during site clearance works, prior to concreting of the full worksite and establishment of the Earth Control Measures (ECM) plan for the worksite (see *Section 2.5.3.7* for further elaboration on storm water management).

Figure 2.7: Typical Worksite Layout at Tunnel Boring Machine Launch Shaft



Source: LTA, 12 April 2018

2.5.1.4 Installation of Monitoring Instrumentation

Applicable for both Alignment Options

Piezometers

A piezometer is a device used to measure the pressure of groundwater within a column. Piezometers are typically installed at 25 m intervals along a tunnel alignment to enable the monitoring of groundwater pressure while tunneling works is underway. An A-frame bored piling rig is typically used to drill a hole of maximum diameter 100 mm down to the relevant tunnel depth. A durable tubular casing and the piezometer will then be installed within the drilled hole, and the casing will be capped at the surface.

During the construction phase of the Project, a worker will access the piezometer with a handheld data logger to undertake groundwater pressure readings. The frequency of such measurements is typically not more than once a day, and is only necessary during the period when the TBM approaches and passes under the piezometer. Surface monitoring of groundwater pressure serves as a secondary means of pre-empting the onset of excessive groundwater ingress at the tunnel cutterhead. Groundwater ingress is primarily monitored by the TBM operator using sensors within the TBM (see *Section 2.5.2.2*). In the event that abnormal readings are registered at the TBM sensors, the frequency of measurements at the piezometers will be increased to once in every 4 hours.

Due to the lack of buildings on the ground surface along Alignment Option 1, the necessity for, and final locations of, piezometers will be studied at the AES stage of the Project. Should piezometers be

required for the monitoring of groundwater during tunneling of the proposed Alignment Option 1, these will be drilled and installed at the same locations and using the same equipment and embedded controls utilized in the drilling of the SI boreholes completed within the CCNR in 2017. No additional vegetation clearance within the CCNR will therefore be undertaken for the installation of piezometers. The relevant equipment and key embedded controls used for SI works within the CCNR are detailed in the SI EIA [(Footnote 2)], and summarised in *Table 2.4*. As a precautionary approach, this EIA has assessed the impacts associated with the installation of piezometers and the daily access of workers to piezometer locations within the CCNR. There was a total of 16 locations within the CCNR, 10 of which were located on the exiting Sime and Terentang trails within the CCNR; 2 of which were located slightly of trail but within existing clearings in the CCNR; and 4 of which were located on the Kalang Service Reservoir Road off Island Club Road. These locations are presented in *Figure 2.8*.

Table 2.4: Summary of Drilling Equipment & Key Embedded Controls for Piezometer Installation within the CCNR

Equipment	Crawler Mounted A-Frame Drilling Rig
Worksite footprint	2 m x 11 m Maximum worksite required for: rig, drilling rods; hydraulic fluid; water bowser; waste water bowser; pumps; mud tub; operators; loading/unloading area for refilling water bowsers and removal of wastewater.
Duration of drilling	Approximately 2 – 3 weeks
Manpower required	4-5 for mobilization/demobilization & set up 3-4 for operation
Other requirements	• Ancillary vehicle required during mobilization/demobilization for transport of pumps, generator and drill rods and casing, drip tray for motor, customized fluid containment tank, fluid containment tank and boxes containing piezometer instrumentation. • Ancillary vehicle also required for daily transport of fresh water and wastewater removal from each drilling worksite location. • Water is added to the borehole to provide lubrication, cooling of the drill bit and to aid in the removal of cuttings. The volume of water required will vary with the geology encountered and drilling method. For the purpose of the EIA, it is assumed an average of 1,000 l/d of freshwater will be required for drilling each borehole. • Sanitary facilities for all workers will consist of portable lavatories positioned outside the CCNR. Sanitary facilities at the Ranger Station within the CCNR may also be utilized.

[(Footnote 2)] ERM (2016) **Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line: Site Investigation Environmental Impact Assessment Report – Volume III, Alignment Option 1**. Chapter 2. Retrieved from https://www.lta.gov.sg/content/dam/ltaweb/corp/PublicTransport/files/Final%20SI%20EIA%20Volume%20III.pdf

Key Embedded Controls	• Not more than 3 rigs mobilized within the CCNR at any one point in time. Drilling to be undertaken sequentially at locations from either an east to west, or west to east direction, to ensure connectivity is maintained for wildlife across the CCNR trails. • Only S25A or equivalent equipment to be used as ancillary vehicle for twice daily round trips for transportation of water/wastewater. • Erosion control blanket will be positioned at the worksite. • Temporary closure of access route and trails in proximity to drilling worksites along Terentang Trail, to prevent trampling of vegetation by bypassing recreational users due to narrow tra il. Temporary diversion plans will be put in place to allow recreational users to bypass worksites along Sime Trail. • Refueling is carried out with piston pumps and no fuel is stored within the CCNR. Valves will be included on the refueling pipework to limit leaks/spills during refueling process. Spill kits and secondary containment trays will also be available and used during refueling operations. • Use of other areas within the CCNR for sanitation purposes will be strictly prohibited. • Prior to commencement of the drilling works, a waste management plan will be put in place and training provided to all workers on waste management procedures, which will include bagging and daily removal of all solid waste from each worksite and daily inspection of waste management facilities.

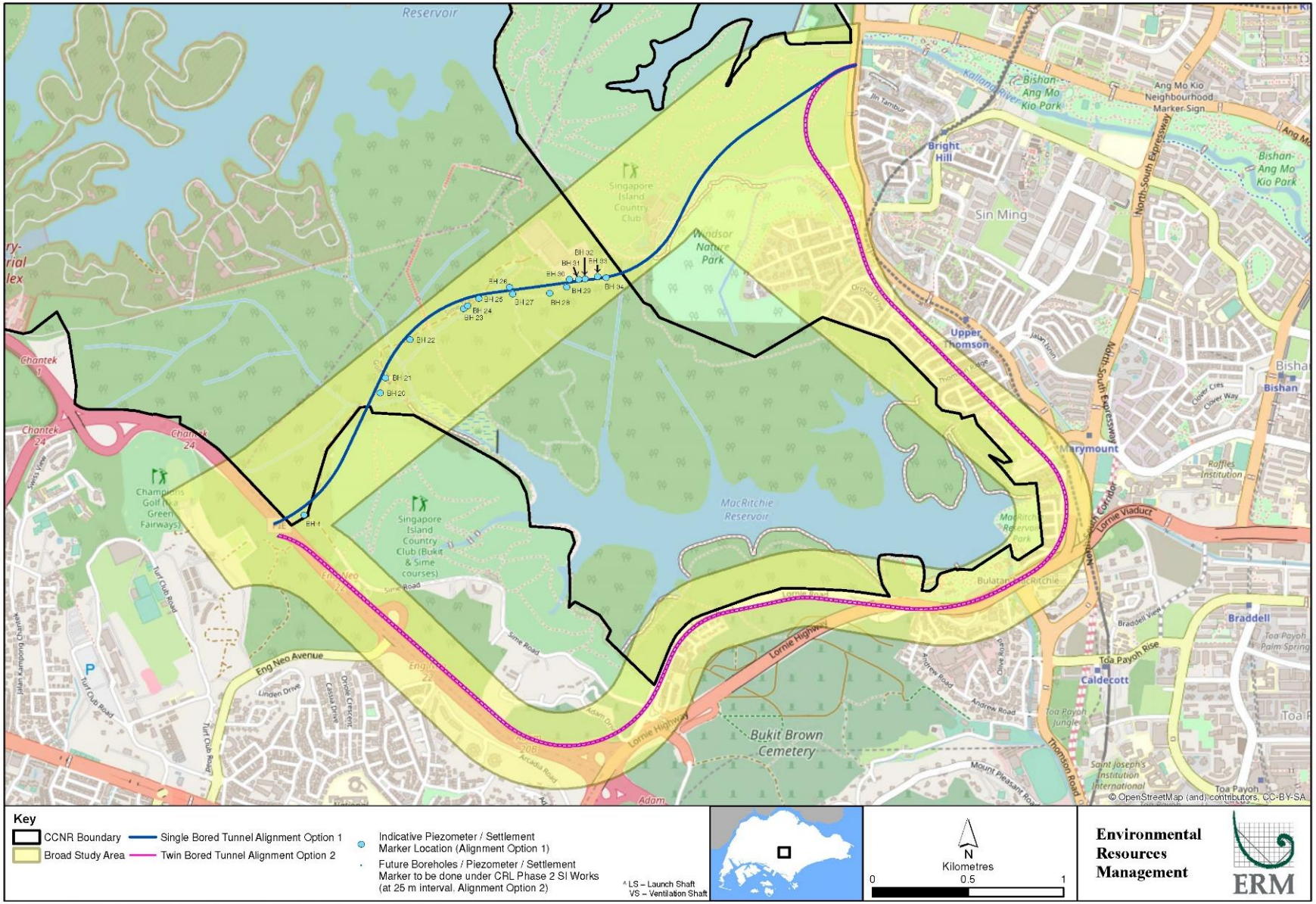
Due to the presence of infrastructure such as buildings and roads along Alignment Option 2, future piezometer installations will be undertaken in conjunction with future SI borehole works associated with the proposed alignment. This will be undertaken in the event that the proposed Alignment Option 2 is selected. Notwithstanding the presence of surface infrastructure such as buildings, roads and viaducts, the boreholes will be installed at 25 m intervals using A-frame rigs as typical for the standard SI campaign. As a precautionary approach, this EIA has assessed the impacts associated with the installation of piezometers and daily access of workers to the indicative borehole locations at 25 m intervals along Alignment Option 2, as shown in *Figure 2.8*.

Settlement Marker

A settlement marker is a steel rod of approximately 20 mm diameter, which is installed in the ground. The localized vertical settlement of the ground surface at the marker is measured using an inclinometer or equivalent digital level equipment that is mounted on a tripod. The frequency of such measurements is typically not more than once a day, and is only necessary during the period when the TBM approaches and passes under the marker. As with the piezometer, surface monitoring of ground settlement is a secondary means of pre-empting the onset of excessive ground settlement at the TBM cutterhead. The volume loss at the TBM cutterhead is primarily monitored via sensors at the TBM (see *Section 2.5.2.2*). In the event that abnormal readings are registered at the TBM sensors, the frequency of measurements at the settlement markers will be increased to once in every 4 hours.

For Alignment Option 1, the settlement marker will comprise a nail-shaped rod less than 20 cm in length, which will be installed by hammering it directly into the ground. The location of this marker will be marked using a visual aid such as a piece of reflective tape. For locations along Alignment Option 2 where the ground is non-concreted, the settlement marker will be similar to those used for Alignment Option 1. Where the ground is concreted, the settlement marker will comprise a steel rod at least 1 m long to penetrate the concrete layer and reach the soil. A concrete coring drill and handheld drill will be used to install each settlement marker. The indicative locations of settlement markers along both alignment options are proposed at the same location as the piezometers (see *Figure 2.8*).

Figure 2.8 Indicative Location of Piezometers & Settlement Markers



File: T:\GIS\CONTRACT\0256660\Mxd\2018_A1_A2_EIA_Report\0256660_Vol_I_Location_of_piezometers_AO1_v1.mxd
Date: 2/7/2019

2.5.2 Construction Activities

Construction of the CRL tunnels will involve the construction of the launch shafts; tunnel works; ground improvement works; the construction of tunnel cross passages for Alignment Option 2; the construction of ventilation shafts and facility buildings; and general landscaping and finishing works.

Pre-tunnelling works will be undertaken at aboveground worksites, and comprise the activities such as launch shaft construction and ground improvement works. Construction activities at aboveground worksites will largely be undertaken during the daytime i.e. 7 am to 7 pm, although essential activities such as traffic diversion works may need to be undertaken in the night. The duration of pre-tunnelling works for both alignment options is estimated at 1.5 years.

Tunnelling works will be undertaken underground, with supporting activities at aboveground launch shaft worksites. Tunnelling operations will be ongoing throughout the day and night, for an estimated duration of 3 years for both alignment options. Planning will be undertaken to minimize vehicular movement and activities at the aboveground worksites after 7 pm, wherever possible.

Post-tunnelling works will comprise the construction of ventilation shafts and facility buildings, and general reinstatement and landscaping of the aboveground worksites. These works will largely be undertaken during the daytime i.e. 7 am to 7 pm. The duration of post-tunnelling works for both alignment options is estimated to be 1 year.

2.5.2.1 Launch Shaft Construction

Applicable for both Alignment Options

Launch shafts, which typically measure 40 m by 25 m, will be constructed to allow the TBM to be launched within. Construction of the launch shaft first begins with the installation of perimeter walls known as Earth Retaining Stabilising Structures (ERSS), before strutted excavation is carried out to form the opening of the launch shaft. These ERSS help to support the adjacent soil and prevent water ingress, thereby limiting ground movement to ensure the integrity of nearby buildings, structures and utilities. The ERSS will be designed to comply with the Building and Construction Authority's requirements and relevant standards and codes of practice, as stipulated in the LTA's *Civil Design Criteria for Road and Rail Transit Systems, Feb 2010 Edition*. The ERSS will also be waterproofed in accordance with standards for underground structures, as detailed in LTA's *Materials & Workmanship Specification for Civil & Structural Works, Jun 2010 Edition*, to ensure minimal groundwater ingress to the shaft.

At the time of writing, details on the ERSS for each worksite were not available to inform the EIA; however, of the ERSS commonly used for permanent underground structural support, secant bored piles (SBPs) were assessed to be a reasonable worst case option for the Project. Following ERSS installation, soil will be excavated and struts installed between the retaining walls to stabilise the shaft. Once the shaft is excavated to rock level (Bukit Timah Granite), rock excavation methods will

be undertaken to deepen the shaft to tunnel depth. Where blasting is used as a rock excavation method, it is assumed that the frequency of blasting will be one blasting cycle per week. Relief holes will be drilled near the SBP walls, to prevent damage to the retaining walls during the rock excavation. In the event that blasting is used, blast protection measures will be undertaken prior to detonation of the explosive charges, and will comprise the laying of blast protection mats over the shaft floor and the covering of the shaft opening with a temporary metal deck. Blasting will be overseen by a licensed operator, and measures will be undertaken in accordance with the *Arms and Explosives (Explosives) Rules, 2007* to ensure public health and safety during blasting works.

2.5.2.2 Tunnel Works

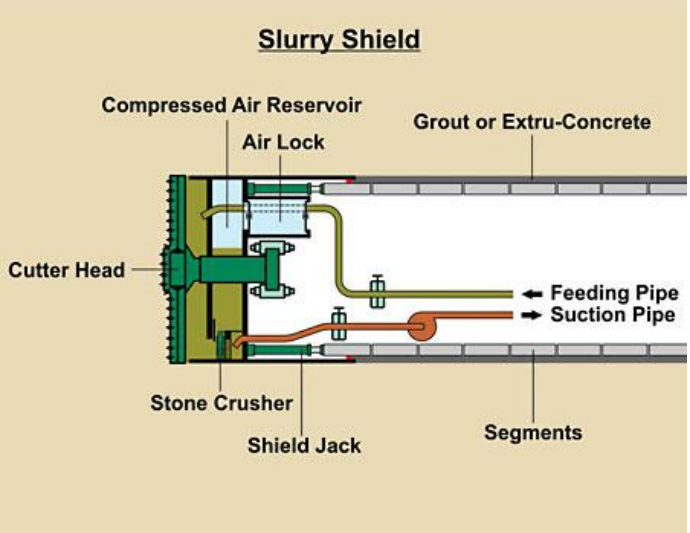
Applicable for a 12.5 m diameter single bored tunnel for Alignment Option 1; and 6.85 m diameter twin bored tunnels for Alignment Option 2.

Following the completion of the launch shaft, the TBM will be lowered into the shaft to commence the tunneling works. A slurry type closed shield TBM will be used to excavate the tunnels at the required tunnel depth[(Footnote 3)]. The TBM will have a circular cross section of approximately 12.5 m for the single bored tunnel design for Alignment Option 1, or 6.85 m for the twin bored tunnel design for Alignment Option 2. Bespoke TBMs will be newly commissioned for the Project in accordance with LTA's standard.

A slurry TBM is a closed shield TBM that uses compressed air to control the bentonite slurry to create a filter cake for supporting of the tunnel face. As the TBM advances, the cutterhead cuts the soil, and the excavated materials are transported through the pipelines along the tunnels via the fluid conveying system, into the slurry treatment plant on the surface. The stone crusher, which is located behind the cutterhead, helps to break down any large, incoming rock fragments into smaller pieces to facilitate the transportation through the pipelines. Excavated rock or muck will be conveyed to the slurry treatment plant for recovery, and will be temporarily stored on site before collection by licensed collectors for disposal or recycling off site. The TBM propels itself forward through the use of the shield jacks, and operate continuously throughout the day and night at an estimated rate of 3 to 7 m per day. Once the TBM has advanced sufficiently, tunnel segment linings, which are fabricated off site and transported to the launch shaft, will be installed to form the permanent tunnel structure. A schematic of a typical slurry type TBM is presented in *Figure 2.9.*

[(Footnote 3)] The tunnel for Alignment Option 1 will be bored at depths ranging between 23 m to 90 m bgl; and the tunnels for Alignment Option 2 will be bored at depths between 23 m to 68 m bgl. Based on geological information from existing boreholes undertaken in the study area, the rock depth ranges between 15 to 75 m bgl along the Alignment Option 1 routing; and between 14 to 57 m bgl along the Alignment Option 2 routing.

Figure 2.9: Schematic of a Slurry Type Closed Shield TBM



Source: Facesupport, 2016

The slurry type TBM provides continual support to the tunnel face during excavation through the close monitoring of the slurry properties. In particular, when going through an area of changing geology, it is possible to design slurry with high viscosity and density when driving through heavily fractured rock, so as to minimise the loss of slurry within the rock fissures. The use of a dense slurry mixture enables the formation of a filter cake so that the pressure at the face of the cutterhead is maintained to be higher than the hydrostatic pressure from surrounding groundwater, throughout the tunnel drive. Regular testing will be carried out to ensure the high quality of slurry used so as to minimise slurry loss within the rock fissures.

The TBM is also designed with a closed face i.e. the pressurized chamber behind the cutterhead is sealed off from the working chamber and the excavated tunnel. The working chamber itself is structurally supported by the newly constructed tunnel, the shield jacks and the TBM. The use of a slurry type TBM therefore ensures a lower likelihood of excessive ground settlement at the surface.

To minimize the risk of ground subsidence due to mixed face conditions, advance probing will be undertaken at the TBM head, in particular when the TBM is approaching potential fracture zones or areas where there is insufficient geological information. Should probing indicate that the TBM will be transiting from good quality rock to more fractured rock, parameters such as the viscosity of the slurry mixture can be adjusted to maintain positive pressure at the TBM cutterhead. Where necessary, ground improvement works will also be undertaken (see *Section 2.5.2.3*) to stabilise the ground ahead of the cutterhead. These measures will be undertaken to minimise the risk of groundwater drawdown or loss of tunnel pressure to the surface, to as low as reasonably practicable (see *Section 2.5.4.1* and *Section 2.5.4.3*).

In addition, groundwater ingress and ground settlement will be monitored through the undertaking of measurements at piezometers and settlement markers respectively (see *Section 2.5.1.4* for locations). During the period when the TBM approaches or passes under this monitoring instrumentation, a worker will undertake measurements using handheld tools at a frequency of not more than once a day. In the event that tunneling KPIs are not met, measurements will be undertaken at a higher frequency of once every 4 hours.

As the TBM advances, a mixture of slurry and crushed rock (otherwise referred to as muck) will be fed back from the TBM cutterhead and circulated via the TBM's fluid conveying system to be treated at the slurry treatment plant located at the aboveground launch shaft worksite. Excavated rock or muck will be conveyed to the slurry treatment plant for recovery, and will be temporarily stored on site before collection by licensed collectors for disposal or recycling off site.

Tunnel segment linings, which will be fabricated off site and transported for temporary storage at the launch shaft worksites, will be installed as the TBM advances along the tunnel alignment. Tunnel segment linings will be waterproofed in accordance to standards detailed in LTA's *Materials & Workmanship Specification for Civil & Structural Works, Jun 2010 Edition*, to ensure no groundwater ingress during tunneling works (see *Section 2.5.4.3*).

For safety considerations, all works associated with tunneling will need to be undertaken continually throughout the day and night. Night works will be required at the aboveground worksites to support the operation and maintenance of the TBM within the tunnel e.g. treatment of slurry excavated from the tunnel. Works will be planned to minimize non-critical activities such as the delivery of materials, so as to minimize vehicular traffic and noise emissions from the worksites at night.

Once the TBM has advanced and tunnel linings have been installed for parallel sections of the twin railway tunnels proposed for Alignment Option 2, cross passageways between the railway tunnels will be constructed (see *Section 2.5.2.4*). Following construction of the tunnels and the cross passageways, tunnel finishing works such as the laying of railway formwork and installation and testing of operational and emergency systems within the tunnel, will be undertaken. This will involve the movement of vehicles and manpower between aboveground worksites and within the tunnel.

2.5.2.3 Ground Improvement Works

Applicable for worksites and tunnel alignment for both Alignment Options

The purpose of ground improvement works is to reduce permeability and improve the stability of the soil column, which the TBM will be boring through. It involves the drilling of tubes into the ground, through which grouting materials such as bentonite, cement etc, are injected into the soil. The grout then sets and hardens.

In the case of the Project, ground improvement works will be undertaken at the following locations:

- Within the first 12 m stretch from the launch shaft, at the start of the TBM drive;
- Within the last 12 m stretch towards the receiving shaft, at the end of the TBM drive; and
- Where there is a mix of rock and soil encountered at the face of the TBM cutterhead.

Ground improvement works at the start and end of the launch shafts will be undertaken within the footprint of aboveground worksites. As the tunnel proposed for Alignment Option 1 will mostly be constructed fully within the bedrock layer, no other aboveground works associated with ground improvement will be required. The tunnel may encounter mixed face conditions while approaching

Bright Hill (outside of CCNR). Due to the localized extent of the potential mixed face zone, effective ground improvement works can be undertaken from within the tunnel, if necessary.

It is anticipated that portions of the twin tunnels proposed for Alignment Option 2 may be constructed above the bedrock. Ground improvement works from the surface may therefore be required in particular when the alignment passes under infrastructure such as buildings, canals, roads, or viaducts. The smaller diameter of 6.85 m for Alignment Option 2 twin bored tunnels presents a space constraint for ground improvement works to be undertaken effectively from the tunnel face.

There is a potential for mixed face conditions to be encountered at localized areas along Alignment Option 2. The exact locations of these areas will be determined at the AES stage when more site investigation works will be carried out.

Construction equipment required for ground improvement works include jet grouting rig (JGP), high pressure pump, air compressor, power generator and a vertical silo containing 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. Ground improvement is carried out via the following steps:

- Concrete breaking of the asphalt / concrete covering the surface, where necessary;
- A 1.3 m diameter casing is driven by vibratory driving method, up to 3 m into the ground, to act as a guide for the JGP drill probe;
- The JGP rig 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 1.5 m by 1.5 m metal box installed around the bore site, and subsequently pumped out into a tote tank for collection and offsite disposal; and
- A grouting mix is pumped into the drill probe and injected into the soil column to form a concrete column within the soil strata.

The necessity for and final locations of ground improvement works will be studied at the AES stage of the Project.

2.5.2.4 Cross Passageway Construction

Applicable for the Alignment Option 2 tunnel only

For Alignment Option 2, where the tunnels are to be constructed using the 6.85 m diameter TBM, construction of a cross passage connection between the two tunnels is required to serve as a means of evacuation of train passengers during emergency.

Based on LTA[3] and SCDF[4] respective guidelines, cross passageways will be constructed at 250 m intervals along the tunnel alignment. This will however take into consideration the presence of subsurface structures; cross passageways will be spaced to avoid such features.

Depending on the degree of weathering of the rock where the cross passage is located, either the drill-and-blast (D&B) method, or the mining method can be adopted. The D&B method will be used in areas of fresh rock e.g. G(I), while the mining method can be adopted in weathered rocks between highly weathered, G(VI), and completely weathered, G(V), rock.

The D&B method will consist of the following:

- Drilling of boreholes into the cross passage tunnel face;
- Laying of explosive charges within the boreholes;
- Detonation of charges;
- Venting of fumes from the tunnel;
- Removal of debris from the tunnel; and
- Reinforcement of the tunnel through rock bolting and/or application of shotcrete.

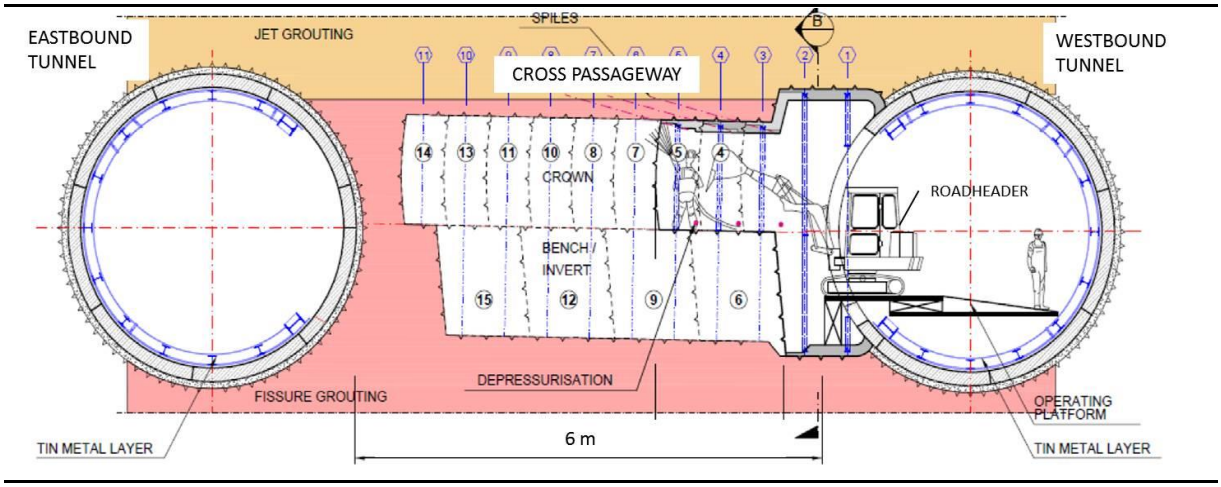
The above activities would be repeated in cycles until the full cross passageway is excavated. In order to reduce the risk of creating fractures within the surrounding rock, and to minimise the breaking of rock beyond the planned cross passageway diameter, perimeter blasting technique will be undertaken as this allows an increased degree of control over the blasting works.

The mining method will consist of the following:

- Breaking through the tunnel segment lining;
- Deployment of a roadheader to cut through the rock and excavate the cross passageway in vertically apportioned segments (crown and bench segments);
- Clearing of rock debris;
- Installation of temporary support such as face bolts, shotcrete or spiles as the roadheader advances; and
- Installation of permanent support structures and access features.

A schematic of a cross passageway constructed using the mining method is presented in *Figure 2.10.*

Figure 2.10: Cross-section of Mined Cross Passageway



Source: Arup, 1 July 2016

The mining method is generally preferred to the drill-and-blast method as it is likely to generate lower vibration levels at the ground surface. However, this method is not suitable for construction in strong Bukit Timah Granite. The twin bored tunnels for Alignment Option 2 may pass through between Fresh rock, G(I) to Completely weathered rock, G(V). Both the mining and the drill-and-blast method for cross passageway construction have therefore been taken into consideration in *Volume IV* of the IA.

2.5.2.5 Facility Building Construction

Applicable for all worksites associated with both Alignment Options

Following completion of tunneling works, works will be undertaken to convert all of the TBM launch shafts into ventilation shafts connecting each tunnel to the surface.

A facility building will be constructed at ground level over the ventilation shaft. Each facility building is estimated to occupy a footprint of size 70 m by 40 m, and will encompass an aboveground double storey structure that will house an electric substation, tunnel ventilation system and other electrical and mechanical installations, e.g. fire detection and alarm system. Construction activities will include foundation works, installation and testing of utilities and equipment, construction of the aboveground building structure, and construction of permanent access roads. Depending on the site specific layout, the permanent access road will be between 8 m to 10 m wide, and constructed in accordance with LTA's *Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition*. Fencing will be constructed around the facility building compound to prevent unauthorised access to the building premises, in accordance with the LTA's *Civil Design Criteria for Road and Rail Transit Systems, February 2010 Edition* and *Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition*.

2.5.2.6 General Landscaping & Finishing Works

Applicable for all worksites associated with both Alignment Options

Road works, provision of lighting and landscaping will be undertaken in accordance with requirements in LTA's *Civil Design Criteria for Road and Rail Transit Systems, February 2010 Edition* and NParks' *Guidelines on Greenery Provision and Tree Conservation for Developments*, as part of finishing works at the aboveground worksites.

For worksites where the existing topography has been altered during land grading works to prepare the site for the construction phase, it is assumed that no reinstatement of topography will be undertaken following completion of construction works.

2.5.3 Construction Phase Resources

Typical resources that will be required include construction equipment and raw materials; temporary power and water supply; existing off site waste management infrastructure; and the construction workforce along with associated welfare facilities.

2.5.3.1 Ancillary Facilities

Ancillary facilities that are temporarily established within each worksite to support the construction phase of the Project typically include: office area, portable sanitary facilities, temporary shelters for workers during rest breaks and meals, and laydown areas for storage of raw materials, equipment and wastes.

2.5.3.2 Manpower

Due to spatial constraints, it is assumed that workers will be housed at temporary quarters outside the Project area and transported by vehicles to the worksites on a daily basis. The number of workers present on site would be dependent on the stage of the Project construction. Workers will be trained to adhere to Project-specific safety and environment-related rules and regulations, and undergo daily tool box briefings to ensure effective communication of construction plans, in accordance with the LTA's *General Specifications (Appendix A) Safety, Health and Environment (Rail Project), September 2016 Edition*.

2.5.3.3 Equipment

It is anticipated that a significant quantity of construction vehicles and equipment will be required for the construction phase. The details for these resource requirements will need to be developed by the construction Contractors. For the purposes of this assessment, an indicative list of equipment commonly associated with each construction activity was drawn up as presented in *Annex 1.0.* For this study, it is assumed that equipment selection, operation and maintenance will be in accordance with LTA's *General Specifications (Appendix A) Safety, Health and Environment (Rail Project), September 2016 Edition*. For example, equipment will be inspected on a monthly basis to ensure

that these are operating according to specifications and in compliance with noise and air emission limits.

Other equipment will be required to support management of waste and effluents generated on site. These include storage bins, sedimentation basin or storm water storage tank, and storm water treatment system etc.

2.5.3.4 Fuel, Chemicals & Raw Materials

Materials required for construction works, and which will be stored at the temporary laydown areas, will include diesel fuel for the refueling of construction equipment and other chemicals required for construction. Fabricated parts such as railway formwork and ventilation system equipment will also be temporarily stored at the worksites prior to installation. In accordance with local regulations and standards, the following substances will be stored as follows:

- Chemicals and hazardous substances[5] - within areas sheltered from exposure to rain, and with appropriate secondary containment, in accordance with the National Environment Agency's (NEA's) *Code of Practice on Pollution Control*[6] as well as requirements stipulated in the individual Material Safety Data Sheets (MSDS) for each material.

- Explosives - in an authorised magazine outside of the Project worksites, in accordance with the requirements of the *Arms and Explosives (Explosives) Rules* or as per the instructions of a licensing officer from the Singapore Police Force.

- Fuel and any other flammable materials – stored in accordance with requirements stipulated in the MSDS, and in such quantities as is allowed by the SCDF.

- Compressed gases - stored and handled with appropriate safeguards in accordance with standards published by the National Fire Protection Association (NFPA)[7].

- Raw materials, e.g. cement and aggregates - in temporary stockpiles within areas of the worksite that are concreted or laid with steel plates, and covered with sheets when not in use. Cement used for surface ground improvement works along Alignment Option 2 will be stored in a vertical cement silo.

2.5.3.5 Power Supply

Electricity for lighting and operation of equipment will be supplied through the use of portable generators or through connection to the electrical substation where feasible. It is assumed that up to six generators will be used at each worksite. Usage of electricity from nearby mains will be undertaken with the appropriate approvals from the relevant authorities, and in compliance with requirements to ensure that there is no disruption to the local electrical supply.

2.5.3.6 Water Supply

Water will be required for construction activities such as concreting, recharging of groundwater, dust suppression, wheel washing etc, as well as for potable use and temporary sanitary facilities. Water will either be drawn from the mains or transported and stored at worksites in totes.

2.5.3.7 Waste Management

The Project will adhere to a Waste Management Plan developed by the Contractor, which will be in compliance with local regulations and LTA's guidelines[8]. This will require measures such as provision of adequate waste collection bins, skips and storage areas with appropriate containment measures; as well as segregated collection of hazardous, general and recyclable waste.

Wastes generated from the construction phase of the Project are anticipated to include but not be limited to the following:

- Groundwater or accumulated surface runoff from launch and ventilation shafts;
- Liquid effluents from washing activities on site;
- Excavated earth;
- Domestic refuse, including food packaging;
- Sewage from temporary sanitary facilities;
- Yard waste from tree felling activities during land clearance at worksites within forested areas;
- Packaging such as empty bags, drums and containers that used to contain chemicals; and
- Slurry, crushed material and tunnel discharge from shaft and cross passageway excavation, rock excavation and TBM operation.

It is estimated that the volume of spoil and crushed rock generated from the construction of the shafts and tunnels will amount to approximately 980,000 m^3 for Alignment Option 1; and more than 1,200,000 m^3 for Alignment Option 2.

Contractors will be required to develop an ECM plan to control erosion and prevent sediment loading of any surface water bodies downstream of the site, or storm water drains that will receive controlled discharges from the Project worksites. As part of the ECM, all storm water runoff generated on site will be treated prior to discharge to nearby storm water drains, in accordance with the prescribed limits under Regulation 4 of the *Sewerage and Drainage (Surface Water Drainage) Regulation*. Typical ECM measures as presented in the PUB's *Code of Practice for Surface Water Drainage 2013* comprise perimeter surface drainage around the worksite, sedimentation basin, silt traps, and storm water treatment system to ensure compliance with the limits of 50 ppm for total suspended solids (TSS) for construction sites or 30 ppm for TSS for discharge to controlled surface water drainage, whichever is the more stringent. The ECM plan will be implemented for the worksite prior to the commencement of any heavy earthworks.

Licensed collectors of general and toxic industrial wastes will be contracted to periodically collect wastes and sanitary effluents for proper disposal at off site facilities.

Where possible, wastes such as excavated earth, rocks and construction debris will be segregated and collected for recycling as backfill, grouting works or road construction at other offsite developments.

2.5.4 Unplanned Events

During the engineering feasibility stage, construction methodology and equipment were studied to identify any unplanned events which may occur during the Project construction phase. These were identified as:

- Excessive ground settlement near shafts, or during tunneling works;
- Slope failure within the CCNR during tunneling works;
- Excessive water ingress to tunnel leading to groundwater drawdown;
- Spillage or overflow of effluent into surface waterbodies;
- Fire at the worksite during construction works;
- Fire within the tunnel during construction works; and
- Total breakdown of TBM during tunneling;

The likelihood of occurrence for the unplanned events that were further assessed in this EIA, were quantified following a review of historical Projects. The quantification of likelihood is detailed in *Volume III, Annex 1.0* for Alignment Option 1; and in *Volume IV, Annex 1.0* for Alignment Option 2.

Key embedded controls, i.e. measures that will be put in place as part of the Project design, will be implemented during the construction and operation phase to prevent or minimize the risk of the occurrence of the abovementioned unplanned events. These key embedded controls are summarised in the subsequent subsections. Key embedded controls for the management of impacts in general are presented in *Section 2.8*, and detailed in *Volume I, Annex 2.0*.

Response measures will be implemented in the event that these unplanned scenarios occur. These response measures are described in the following subsections. The consequences of these response measures were considered within the worst case scenario where the unplanned event occurs.

2.5.4.1 Excessive Ground Settlement

From a review of past studies and tunneling developments, excessive ground settlement during construction could possibly occur due to loss of pressure at the TBM face. Based on literature review, excessive ground settlement tends to occur when tunneling encounters an unpredicted mixed face. As a key embedded control, the tunnel depth for Alignment Option 1 was therefore designed to ensure that the TBM will be operated fully within rock conditions for the alignment beneath CCNR (Rock grades are typically defined as G(I), G(II) and G(III). Due to the limited extent of G(IV) granite found the SI works, the rock head level was defined by the LTA as the encounter of G(IV) and better

weathering grades of Bukit Timah Granite Formation). There may be a potential for the TBM to encounter mixed face conditions due to relatively shallower tunnel depth while approaching Bright Hill (outside of CCNR). The exact location of mixed face conditions will be determined at the AES stage of the Project.

As described in *Section 2.4.2.2*, the tunnel for Alignment Option 2 will be constructed at depths of 23 to 68 m bgl in order to avoid damage to underground infrastructure underlying Upper Thomson Road and Marymount Road. Portions of the alignment route may therefore encounter mixed face conditions (exact locations to be determined at the AES stage of the Project).

To minimise the risk of excessive ground settlement during the transition of TBM between rock and soil strata, a combination of engineering embedded controls will be undertaken during the tunneling of both alignment options:

- As described in *Section 2.5.2.2*, the use of a slurry type closed shield TBM will exert positive pressure to the tunnel face to minimise the ingress of groundwater to the tunnel and surface movements, as well as to ensure the stabilisation of the tunnel face.
- The excavation method shall be chosen so as to minimise the settlement and disturbance of the groundmass to ensure the structural integrity of existing surface and underground structures in the vicinity of excavation works.
- Excavation shall be appropriate to the size of the underground opening and to prevailing ground conditions. Excavation will be subject to acceptance by the Engineer at all times.
- Adequate training and supervision will be provided to the TBM staff and operators.
- Regular maintenance inspections will be carried out at the front of the TBM using access through a chamber known as the manlock, under compressed air to stabilise the face. During the inspections, workers will access to the front of the TBM to change the cutter tools, when necessary, and to inspect any presence of boulders to remove any blockages.
- As an additional measure to reduce the likelihood of excessive ground settlement during the transition of TBM between rock and soil strata, advance probing will also be undertaken during operation of the TBM so that further operational measures may be undertaken to minimise the likelihood of occurrence of the above scenarios. These operational measures include close adherence to proposed slurry properties for tunneling in mixed face conditions and close monitoring of mining key performance indicators during TBM operations.
- For tunneling along Alignment Option 2, ground improvement will be carried out from the ground surface, in advance of the TBM arriving at locations where mixed face will be encountered.
- Ground loss from the face and tail void or overcut, etc should be minimised by providing adequate support to the face and continuous tail void grouting.
- The tunnel shall be continuously and fully supported with a permanent lining designed to support the full overburden including water load with minimal deformation during the work. In soil or mixed face conditions, the lining should satisfy the load combinations and distortion loads requirements. Segmental pre-cast concrete lining shall consist of a number of pre-cast segments bolted together to form rings.

As a worst case scenario for the EIA, it has been assumed that underground blasting works will be undertaken for the construction of cross passageways constructed within the rock head, for Alignment Option 2. Other less impactful methods such as mining or chemical splitting may be undertaken instead. As described in *Section 2.5.2.2*, perimeter blasting of cross passageways for Alignment Option 2 will be undertaken to minimise damage to surrounding rock due to blasting. This controlled blasting technique will involve a limit on the amount of explosives used to charge each borehole, and involve the drilling of boreholes in such a way as to minimise fracturing or breaking of rock beyond the designed perimeter of the cross passageway.

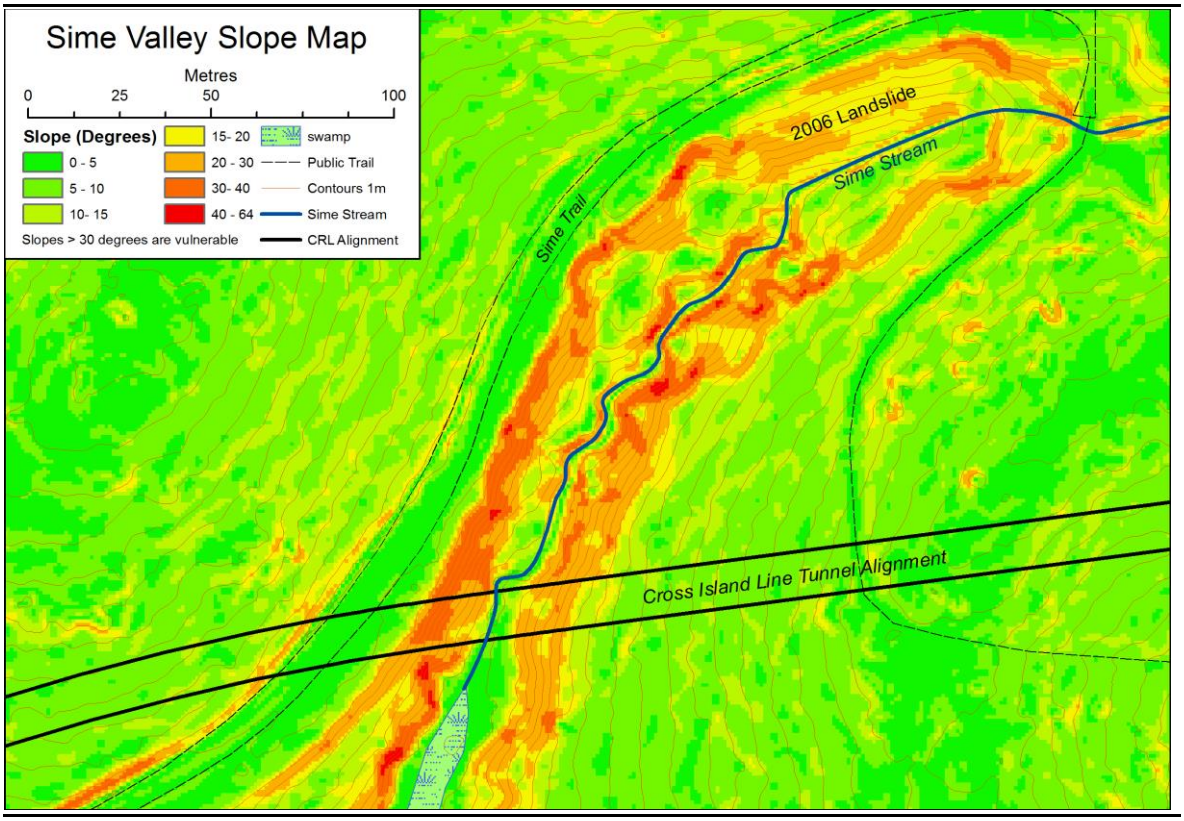
Response Plan to Unplanned Event

During the onset of ground settlement, remedial grouting will be undertaken from within the tunnel to fill up any voids formed at the tunnel face, in order to prevent further settlement at the ground surface. For Alignment Option 1, it is assumed as a worst case scenario that access pathways may be required to ferry workers and equipment to undertake restoration works in the event that excessive ground settlement occurs at an off-trail location within the CCNR. For Alignment Option 2 where largely urbanised areas are easily accessible, visual inspections will be undertaken of the ground surface to identify areas where ground stabilization and/or structure reparation works need to be undertaken. Where restoration or reparation works need to be undertaken, arrangements will be made through engagement with the relevant stakeholders such as authorities managing the land and/or affected public infrastructure such as drains, utilities, roads; and private owners of affected properties or land.

2.5.4.2 Slope Failure

Slope failures in granitic Bukit Timah formations in Singapore predominantly occur due to the effects of heavy and/or prolonged periods of rainfall on slopes with angles greater than or equal to 27° [12]. A landslide had previously occurred in 2006 at the slope located north of the proposed alignment (see *Figure 2.9*). The generation of vibration through the ground due to tunneling may be an additional factor resulting in the occurrence of a slope failure during tunneling works under an area with slopes. One such area identified for the Project was the valley of Sime Stream within the CCNR, which will overlie the proposed tunnel alignment for Alignment Option 1, as shown in *Figure 2.11*.

Figure 2.11: Sime Valley Slope Map



Source: O'Dempsey A, 12 March 2019

Vibration may be generated through the ground during the operation of the TBM for the construction of the tunnel alignment. There will be no other potentially significant source of vibration as the single bored tunnel design for Alignment Option 1 will remove the need for rock excavation for the construction of cross passageways.

The contributing factors resulting in the occurrence of the slope failure in 2006 were assessed to be:

- Accumulation of heavy surface runoff at the brow of the slope after prolonged heavy downpour; and
- Possible weakening of the slope due to natural undercut erosion from the passage of streams at the base of the slope.

As part of repair works for the failed slope in 2006, a system of surface water drains were installed at the brow and base of the restored slope. The drain has been observed to be effective in channeling surface runoff from the brow of the slope. Existing surface water drains have been observed at the slope overlying the proposed Alignment Option 1, indicating that the slope is stable.

Response Plan to Unplanned Event

In the unlikely event of a slope failure, reparation works will be undertaken as soon as feasible under close consultation with stakeholders such as NParks. Reparation works may involve the replacement of displaced soil mass with re-compacted soil, interspersed with layers of granular material wrapped in geotextile bundles, and the review and re-installation of a surface drainage system. The geotextile bundles will serve to dissipate the pore pressure within the soil matrix, which

is a result of ground saturation during heavy rainfall and which is a key factor in the occurrence of slope failure. Surface drainage will also be reinstated to allow for the proper channeling of surface runoff.

2.5.4.3 Excessive Water Ingress to Tunnel

Water ingress to tunnels could occur when tunneling through grounds of high permeability such as transiting from rock to soil, where there could be a potential pathway for water to flow and enter the TBM cutterhead. Where there is hydraulic connectivity between surface waterbodies and the groundwater table, excessive water ingress into the tunnel may lead to drawdown on surface streams.

The engineering embedded controls as described in *Section 2.5.4.1* will be undertaken to minimise the risk of water ingress when encountering fracture zones:

- Design of Alignment Option 1 tunnel alignment beneath the CCNR to be tunneled at depths so as to ensure the TBM will be operated fully within rock conditions.
- Use of a slurry type close shield TBM, which exerts positive pressure to the tunnel face to minimise water ingress and ensure stabilization of the tunnel face.
- Advance probing will be undertaken during operation of the TBM to inform the operators on ground conditions ahead of the TBM cutterhead, so that further operational measures may be undertaken to prevent water ingress when tunneling in mixed face conditions.
- For tunneling along Alignment Option 2, ground improvement will be carried out from the ground surface, in advance of the TBM arriving at locations where mixed face will be encountered.
- Controlled blasting technique will be used in the construction of cross passageways within the rock head for Alignment Option 2.

It is noted that during the site investigation works undertaken by LTA contractors in 2017, there were reportedly no observation of artesian water pressure conditions during the drilling of vertical and horizontal boreholes. LTA reported that examinations of the HDC rock core samples undertaken along Alignment Option 1 did not yield any observation of interconnected fractures, which is indicative that no significant fault zones were encountered. Packer test results also indicate the presence of an aquitard between the surface and lower geological strata, implying that there will be little to no hydraulic connectivity between surface waterbodies and the proposed tunnel.

Response Plan to Unplanned Event

In the event that excessive water ingress is detected, tunneling activities will be stopped. The fracture zone encountered will be located and grouted to seal the pathway. Tunneling works will then continue to be undertaken with close monitoring of the water seepage. Grouting will be undertaken at regular intervals throughout the tunneling works within the fracture zone encountered.

2.5.4.4 Spillage or Overflow of Effluent into Surface Waterbodies

There is a potential for spillage or overflow of effluents into surface waterbodies due to the proximity and location of worksites upstream of these waterbodies. This could be due to any one of the following unplanned events occurring during the construction phase:

- Exceptionally heavy rainfall overwhelming the ECM system;
- Failure of ECM outlet discharge pump resulting in overflow of sedimentation basin;
- Rupture due to accident or leakage due to wear and tear, of ECM discharge pipeline for A1-W1 (LS/VS) located along Island Club Road;
- Accidental spillage or leakage of aggregate materials, concrete, chemicals, fuel etc from construction transport vehicles along worksite access roads; and
- Uncontrolled discharge of firewater due to firefighting outside the worksite boundary, or overflow of worksite ECM system during firefighting undertaking within the worksite.

Embedded controls will include:

- The sizing of an ECM system with adequate capacity to cater for exceptional rainfall events such as a once in 10 year storm, in accordance with PUB requirements;
- The storage of spare pumps and pipelines segments at worksites for redundancy, so repairs to the ECM system can be undertaken quickly;
- The use of double containment piping for the ECM pipeline located within the drainage reserve of Island Club Road;
- Regular inspections of ECM system and discharge pipeline to ensure necessary repairs are promptly undertaken throughout the construction phase;
- The enforcement of speed limits of not more than 40 km/h along worksite access roads; and
- The design of the ECM with adequate capacity to cater for a one in 10 year storm, which will double up as a holding pit for firewater till collection by a third party Contractor for off site disposal.

Response Plan to Unplanned Event

In the event of spillage or overflow of effluents into downstream surface waterbodies, as much of the contaminating material will be removed manually (in the case of viscous or solid material) and/or through the flushing of the waterbody using harvested rainwater kept in storage at the nearest worksite. Following this, regular visual inspections and monitoring of the relevant chemical parameters will be undertaken for the affected stream until stream conditions return to normal.

2.5.4.5 Fire during Construction Works

A fire emergency may occur at the aboveground worksite, within the launch or ventilation shafts and/or the tunnel during construction works. This may occur due to:

- Electrical shortage due to wear and tear or overloading of electrical equipment;
- Accidental ignition of flammable materials such as diesel fuel or combustible waste stored at the worksite; and
- Build-up of flammable gases and vapours within the launch/ventilation shafts and/or tunnel.

The following embedded controls will be implemented as part of the Project design (see *Section 2.8*):

- Regular checking and certification of use of all temporary electrical installations, equipment and tools by a full-time licensed electrical worker.
- Restriction of the volume of petroleum and flammable materials stored at the construction worksite.
- The hoarding/noise barrier for the worksite will be composed of non-combustible material to deter the spread of fire beyond the worksite.
- Petroleum or flammable materials will be stored in compliance with requirements under the relevant storage license, including proper segregation from incompatible chemicals, provision of clear signage indicating flammability and prohibition of ignition sources, management of and controlled access to the storage areas by trained personnel etc.
- Workers will be trained to use firefighting equipment to be provided at the aboveground and underground worksites.
- Provision of adequate ventilation of shafts and tunnel to prevent the build-up of flammable gases and vapours, and that worksites are in compliance with *Workplace Safety and Health (Construction) Regulations 2007* as summarised in *Annex 2.0*. Worksites will also be set up with adequate firefighting facilities to enable a timely response to a fire emergency.

Response Plan to Unplanned Event

In the event of a small fire, first responders who are adequately trained will attempt to extinguish the fire with firefighting equipment available at the worksite. The Singapore Civil Defense Force (SCDF) will be mobilized to the worksite if the fire worsens. Where possible, firewater will be collected via the perimeter drainage system and sedimentation basin, which are part of the worksite's ECM system. The firewater will be pumped out by a third party contractor for offsite disposal.

2.5.4.6 Total Breakdown of TBM

The total breakdown leading to immobilization of a TBM may occur due to failure of machine components beyond repair.

Embedded controls include:

- Commissioning of new bespoke TBM(s) for the Project.
- Regular shutdown of the TBM during tunneling for maintenance.
- Storage of spare cutting tools and systems part on site to allow for the prompt replace of worn parts.

Response Plan to Unplanned Event

In consideration of the existing land uses aboveground (eg the CCNR, residential estates, etc), any method of TBM retrieval that will involve surface excavation shall not be considered for this Project. Measures to recover or restart the TBM will be undertaken within the worksite and/or the excavated tunnel. In the worst case scenario when measures to restart the TBM are not successful, the TBM will be dismantled within the tunnel and conveyed back to the nearest launch shaft.

2.6 OPERATION PHASE

Activities undertaken during the operation phase will comprise the operation of the trains within the tunnels. Best available technology will be used for the design of the tunnel and railway tracks with the view to minimise the effects of vibration to as low as reasonably practicable. Rolling stocks similar to the existing configuration will be used. The tunnels are designed for operation for 120 years. However, with regular maintenance and remediation during operation phase, the useful life of tunnels will go beyond 120 years, and there will be no need to replace the tunnels. Periodic maintenance works will be undertaken within the tunnels and for the equipment within the facility buildings.

2.6.1 Ancillary Facilities

Ancillary facilities associated with the operation of the Project and located within the study corridor will comprise of the facility buildings housing electrical substations and tunnel ventilation systems. These facility buildings will be located outside of the CCNR and will be designed using best available technology with the view to reduce effects from air and noise emissions to as low as reasonably practicable.

2.6.2 Operation Phase Resources

Resources required during the operation phase will include electricity and manpower for the operation of the train service, as well as for periodic maintenance activities at the facility buildings and within the tunnel.

2.6.3 Unplanned Events

Unplanned events that may occur during the operation phase include groundwater seepage into the tunnel, and fire within the tunnel or facility building.

2.6.3.1 Excessive Groundwater Seepage into Tunnel

Excessive groundwater seepage may occur during the operational lifespan of the tunnel, due to wear and tear of design controls such as the waterproof lining of the tunnel or spalling of the concrete tunnel walls. As an embedded control, the tunnel will be inspected regularly to detect anomalies such as cracks or localised groundwater seepage.

Response Plan to Unplanned Event

Anomalies will be reported and repair works such as grouting, will be undertaken promptly to prevent the onset of damage leading to excessive groundwater seepage.

2.6.3.2 Fire during Operation Phase

A fire may occur within the tunnel or at the facility building during the operational phase of the Project due to:

- Electrical shortage of wiring within the tunnel;
- Faulty or old electrical equipment within the facility building;
- Use of faulty electrical equipment or ignition from maintenance works undertaken within the tunnel; and
- Accidents involving train(s) operating within the tunnel.

Embedded controls will include:

- The facility building will be designed with a detention tank for containment of firewater;
- Regular inspections will be undertaken of electrical equipment within the tunnel and facility building;
- Partitions for electrical storage rooms within the facility building will be designed to contain a fire for a minimum period of 4 hours;
- Where the facility building is located near forested areas, a buffer distance of at least 30 m will be maintained between the facility building and the forest edge to minimize the risk of fire spreading to the surrounding vegetation;
- Practical measures will be undertaken during maintenance works to minimize the risk of ignition of flammable materials handled or stored at temporary worksites within the tunnel;
- In addition, the operation of the Project will be undertaken in accordance with the LTA's Code of Practices for rail operators, which will include the following[10]:
    - *Competency Management System* to ensure that maintenance crew and operating staff are adequately trained and competent;

- *Rail Incident Management Plan* detailing response protocols during a train disruption, which will be reviewed for compliance against LTA's Rail Incident Management Framework;
- Prescriptive requirements on the frequency and extent of repair and maintenance, in accordance with industry best practices; and
- Annual simulation exercise (table top exercise for the first two years, and ground deployment in the third year and thereafter) to assess and enhance the readiness of operation systems in responding to incidents.

Response Plan to Unplanned Event

The tunnel and facility building will be designed with fire safety equipment such as smoke detectors, a sprinkler system, fire containment partitions and ventilation fans, in accordance with the SCDF's and LTA's specifications[9]. In the event of a fire within the tunnel or facility building, these systems will be activated automatically. The SCDF will also be mobilized automatically to respond to the emergency and ensure that the fire is contained as soon as possible. During such scenarios, the facility building will double up as access to the tunnels via the protected stairway for emergency responders. For Alignment Option 1, evacuation and/or tunnel access during fire events will be through the cross passage doors within the single bored tunnel. Cross passageways between the twin tunnels for Alignment Option 2 will also facilitate evacuation of passengers from the affected train tunnel. Provisions within the railway tunnel for such scenarios will also include dry mains, emergency tunnel ventilation system, emergency lighting and power supply, and motorised trolleys to support the deployment of heavy fire fighting equipment. Firewater will be channeled via perimeter drains to a holding sump within the site, until collection by a third party contractor for offsite disposal.

2.7 PROJECT SCHEDULE

As per LTA's Master Plan 2013, the CRL is targeted to be completed and operational around 2030[11]. It is estimated that works will be completed within a general timeline of 5.5 years for both alignment options.

2.8 EMBEDDED CONTROLS

The project description presented herein already includes a number of "embedded controls" (Footnote 4) that will help protect against potential impact to the environment. These embedded controls are predominantly based on the regulatory requirements and LTA's own specifications and guidelines. Measures required by law or by LTA's requirements for contractors are detailed in *Annex 2.0* and *Annex 3.0*, while a summary of the embedded controls is presented in *Table 2.5*.

(Footnote 4) Embedded controls are defined as measures that will be put in place as part of the Project design.

Table 2.5: Summary of Embedded Controls

Reference	Embedded Controls
Arms and Explosives Act and subsidiary regulations	**General** • Blasting works will be undertaken under direct supervision by the worksite operator, and by competent and experienced personnel. • Areas identified as danger zones will be clearly demarcated and barred to prevent inadvertent access by unauthorised persons.
Control of Vectors and Pesticides Act	**General / Ecology & Biodiversity** • The Contractor will develop a Vector Control Plan, and form an in-house pest control team to carry out vector surveillance and control activities, as well as implement necessary measures outlined in the Plan to prevent the site from becoming favourable for the breeding and habouring of vectors. • An external NEA-licensed Pest Control Operator (PCO) will be engaged to carry out vector control and surveillance at least once a week for each worksite. • The worksite will be designed and operated to minimise the formation of breeding grounds for vectors.
Environmental Protection and Management Act and subsidiary regulations	**Water Environment** • Only trade effluent that are treated and compliant with the discharge standards for controlled watercourse, and which do not contain prohibited materials such as pesticides, refuse, petroleum etc, will be discharged from the Project worksites. • Hazardous materials will be stored and handled in accordance with regulations to minimise the risk of accidental release into the environment. **Ambient Noise** • For worksites within 150 m of residential buildings, no construction works will be carried out during prohibited periods i.e. 10 pm on Saturday or eve of a Public Holiday, to 7 am on the following Monday or day after the Public Holiday. • Motor vehicles used on site will be in compliance with noise emissions stipulated in the *Environmental Protection and Management (Vehicular Emissions) Regulations, 2008*. **Ambient Air Quality** • Vehicles and off-road diesel engines used on site will be in compliance with emissions standards stipulated in the relevant regulations.

Reference	Embedded Controls
Environmental Public Health Act and subsidiary regulations	**Water Environment / Waste Management** • Adequate temporary sanitary facilities will be provided for workers to ensure no public areas will be used for sanitary purposes. • Toxic waste and contaminated soil generated from construction works will be collected for off-site disposal by a licensed toxic waste collector. • Workers will be adequately trained to handle toxic wastes stored on site, and to implement emergency action plans to deal with spills and leaks of toxic waste. • Emergency response kits will be provided at all worksites. **Ambient Noise / Ambient Air Quality** • The operator shall put in place control measures to minimise dust and noise nuisance arising from construction works.
Fire Safety Act and subsidiary regulations	**Water Environment / Waste Management** • Petroleum or flammable materials will be stored in compliance with requirements under the relevant storage license. • All practical steps will be taken to prevent the occurrence of an accident through fire, explosion, leakage or ignition of any petroleum or flammable material or vapours. • Firefighting equipment and other emergency response equipment will be provided at all worksites. • Workers will be trained in the use of available firefighting and emergency response equipment.
Parks and Trees Act and subsidiary regulations	**Ecology & Biodiversity** • Activities that will damage tree, plants, fauna etc in the CCNR are strictly prohibited. • Workers will be trained to avoid undertaking prohibited activities that will disturb animals within the CCNR. • Trees with girths exceeding 1 m which are growing within any Tree Conservation Area or any vacant land, will not be cut down without approval from NParks.
Public Utilities (Reservoirs and Catchment Areas and Waterway) Regulations	**Water Environment / Ecology & Biodiversity** • No vehicles will be brought into the CCNR without the prior consent in writing from the PUB or an authorised officer. • Any vehicles brought into the CCNR will only operate within areas authorised by the PUB, and will maintain a speed not exceeding 25 km/h. • Activities that will impact surface water quality of the reservoir or stream, or cause damage to the habitat and flora and fauna, will be prohibited.

Reference	Embedded Controls
Sewerage and Drainage Act and subsidiary regulations	**Water Environment** • An Earth Control Measures (ECM) plan endorsed by a Qualified Erosion Control Professional (QECP) will be developed for the Project worksites and will include effective measures and facilities such as a site management system, perimeter cut-off drain, silt traps, storage ponds, treatment plants etc, to ensure clean discharge that complies with the statutory requirement. The ECM plan will be submitted by the QECP to the PUB for approval before commencement of works. The facilities laid out in the approved ECM plan shall be implemented prior to commencement of any works and all potentially affected watercourses shall be continually monitored for siltation until completion of works. • Only trade effluent treated and compliant with discharge standards for controlled watercourses will be discharged from the Project worksites to the public sewer. • Trade effluent discharged to the public sewer from the worksites will be monitored and recorded. • The worksite layout will be planned to ensure that runoff will be effectively drained away without causing flooding within and in the vicinity of the worksite. • Earth stockpiles will be positioned outside of the drainage reserve, and all land adjacent to drains will be turfed during general landscaping and finishing works to minimise sediment loading of stormwater drains during rainfall events. • Used water will be recycled whenever practicable.
Wild Animals and Birds Act and subsidiary regulations/orders	**Ecology & Biodiversity** • Workers will be trained to avoid prohibited activities within the CCNR and Windsor Nature Park, such as the injuring, killing, taking by any means or keeping of any wild animals and birds.
Workplace Safety and Health Act and subsidiary regulations	**General** • Reasonably practicable precautions shall be undertaken to prevent the possibility of a fire outbreak during construction at all aboveground and underground worksites. • At least one joint exercise for fire and rescue purposes will be conducted between the SCDF and the Contractor's team once in every six months in the course of the tunneling works, to ensure emergency response preparedness of the workers.

Reference	Embedded Controls
LTA's General Specification (Appendix A) Safety, Health and Environment (for Rail Project), September 2016 Edition; LTA Handbook on Development Building Works in Railway Protection Zone, January 2005 Edition; LTA Civil Design Criteria for Road and Rail, February 2010 Edition; LTA Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition; LTA guidebooks for Contractors; and LTA design specifications.	**Water Environment** • A paved truck wash bay will be maintained at each vehicular egress point for the washing of vehicles. • Measures will be undertaken to minimise the spillage of materials from transportation vehicles onto the roadways outside the worksites. • Water efficient equipment, water saving practices and recycling will be undertaken at the worksite to minimise the usage of water. • All activities involving the use of chemicals e.g. repair, servicing, engine overhaul works, etc will be carried out on a concreted area bunded with scupper drains to channel wastewater into the sewerage system. • An emergency response plan will be developed to cater to accidental spillages into watercourses. • An Environmental Control Officer will be appointed to ensure that the implementation, maintenance and monthly inspection of the ECM are in accordance with the QECP's design throughout the construction phase. • Discharges from the site to the nearest public drain will be monitored continuously with a closed circuit television (CCTV) system of at least 1 megapixel resolution. **Ambient Noise** • The contractor will develop a Noise Management Plan that will include protocols around sourcing of quieter equipment, monitoring, and stakeholder engagement. • Machinery and equipment will be shut down or throttled down to a minimum when not in use.

Reference	Embedded Controls
LTA's General Specification (Appendix A) Safety, Health and Environment (for Rail Project), October 2018 Edition; LTA Handbook on Development Building Works in Railway Protection Zone, January 2005 Edition; LTA Civil Design Criteria for Road and Rail, February 2010 Edition; LTA Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition; LTA guidebooks for Contractors; and LTA design specifications.	• All machinery and equipment will be labelled with a weather proof sticker clearly indicating its noise emission level at source under normal operating conditions. • All machinery and equipment used on site will be sound-reduced, as far as is practicable, e.g. a localised noise enclosure shall be erected to cover the rotary head of piling rigs. Equipment which cause excessive noise shall be removed from the site. • All machine and equipment operators and workers will be trained and briefed on quieter work techniques, in particular during loading/ unloading activities, dismantling scaffolding or moving materials. • High noise and vibration generating activities such as rock excavation using blasting method shall be restricted to be undertaken only in continuous blocks not exceeding 3 hours each, with a minimum respite period of one hour between each block. • The worksite layout shall be planned to ensure site access points and loading and unloading of materials/ deliveries occur as far from sensitive receivers as possible. • No piling works to be done between 10 pm and 7 am unless both machinery and method are of a quiet nature. • Noisy activities such as bored piling works will be barricaded with localised portable acoustic panels whenever possible. • Preparation for traffic diversion work will be carried out during the day and only the actual diversion will be carried out at night. Where activities have to be carried out at night (as approved by the Engineer), portable acoustic barriers must be set up in advance of such works. Residents must also be informed in advance of traffic diversion works. • Unless exempted by the NEA, real time "live" monitoring devices shall be installed at each worksite to monitor noise levels throughout the construction period. • Noise levels shall be monitored using portable Type 1 standard noise meters for the duration of noisy activities, night works and works carried out over the weekends. **Ambient Air Quality** • All excavated materials and spoil will be removed from the site by the end of each working day. • See above measures for minimization of trackout and spillage of material on roadways (Water Environment). **Ecology & Biodiversity** • The contractor will develop a Biodiversity Monitoring and Management Plan to reduce impacts on ecology and biodiversity.

Reference	Embedded Controls
LTA's General Specification (Appendix A) Safety, Health and Environment (for Rail Project), September 2016 Edition; LTA Handbook on Development Building Works in Railway Protection Zone, January 2005 Edition; LTA Civil Design Criteria for Road and Rail, February 2010 Edition; LTA Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition; LTA guidebooks for Contractors; and LTA design specifications.	• Use environmentally-friendly methods for vector control such as Bti and search & destroy operation etc. instead of anti-malaria (AM) oil, or chemical larvicides. • Use sound reduced machines prior to entering the site. • Barricade noisy activities with portable sound barriers or panels. • Lighting at aboveground worksites will be directed downwards where the work is carried out to minimise glare effects on surrounding habitats. • Site utilization plans shall consider preservation and protection of native trees as far as possible. Tree or shrubs that can be preserved and protected shall be identified with methods to prevent harm to the tree, branches and roots (refer to NParks Conservation of Trees and Plants Guideline). • Preventive measures to ensure no trade effluent, chemical, diesel or silt discharges into nearby water bodies. • An arborist will be engaged prior to the commencement of any site clearance or tree felling and transplanting activities. The arborist shall submit a proposal on the tree type(s) that require his supervision during felling and/or transplanting. For trees that have been identified by the arborist as requiring special attention, specific method statements and risk assessments with detailed diagrams on the tree removal method has to be endorsed by the arborist before the tree removal operation commences. • All bins containing the site waste shall be cleared regularly to prevent build-up in these bins. They shall be removed from site and replaced/emptied once they have been filled. • The contractor shall conduct housekeeping at least once a day to ensure that all litter is cleared from site. • The site shall not allow feeding, rearing or breeding of animals such as dogs and all food waste shall be protected from animal scavenging for food. **Waste Management** • All construction debris shall be collected by licensed collectors for disposal at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA. • All excavated materials and spoil will be removed from the site by the end of each working day. • Up to a maximum volume of 5 liters of petrol will be stored on site in a suitably constructed store licensed by the Fire Safety & Shelter Department of the SCDF.

Reference	Embedded Controls
LTA's General Specification (Appendix A) Safety, Health and Environment (for Rail Project), September 2016 Edition; LTA Handbook on Development Building Works in Railway Protection Zone, January 2005 Edition; LTA Civil Design Criteria for Road and Rail, February 2010 Edition; LTA Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition; LTA guidebooks for Contractors; and LTA design specifications.	**Tunneling** • The tunnel should be continuously and fully supported with a permanent lining designed to support the full overburden including water load with minimal deformation during the work. In soft ground, the lining should satisfy the load combinations and distortion loads requirements. Segmental pre-cast concrete lining shall consist of a number of pre-cast segments bolted together to form rings. • Ground loss from the face and tail void or over-break, etc. should be minimised by providing adequate support to the face and continuous tail void grouting. • Measures to prevent ingress of water with fines/ soil must be implemented. Specified degree of water tightness must be achieved within 100m of the tunnel face during construction and thereafter, to minimise surface settlements due to consolidation in soft ground through waterproofing. • Ground improvement measures such as grouting should be adopted to prevent excessive ground settlement or raveling or soil, etc. A suitable grout mix shall be proposed for each set of ground conditions to be encountered along the tunnel drive. Ground improvement, if necessary, will be carried out from within tunnels. The grout shall be sufficiently fluid as to ensure that it flows freely under pressure into all parts of the space to be filled. All grout mixes and injection methods shall be submitted to the Engineer for acceptance. • Use of blasting technique to remove hard strata or obstruction is not acceptable unless the inherent risks are reduced to acceptable levels. • Cross Passageways between bored running tunnels shall be located in accordance with requirements for the Standard for Fire Safety in Rapid Transit Systems issued by the Singapore Civil Defence Force & Land Transport Authority. • Advance probe drilling will be conducted ahead of excavation face, with details of drilling parameters and other relevant observations recorded for later interpretation. **Hydrogeology (Excavation)** • The excavation method shall be chosen as to minimise the settlement and disturbance of the groundmass to ensure the structural integrity of existing surface and underground structures in the vicinity of excavation works. • Excavation shall at all times be subject to acceptance by the Engineer. • Adequate protection shall be provided against the ingress of ground water into the excavation. **Hydrogeology (Tunneling)** • Groundwater leakage rates shall not exceed a general value of 2 ml/m^2/h. For any 10 m length of tunnel the leakage rate shall not exceed 5 ml/m^2/h. The Contractor shall ensure that no loss of ground occurs through any part of the completed structure. The specified degree of water tightness shall be achieved within 100 m of the tunnel face during construction and maintained thereafter. • Co-extruded single composite gasket consisting of an elastomeric carrier and hydrophilic facing material will be used to ensure waterproofing throughout the segmental tunnel linings.

3 ADMINISTRATIVE FRAMEWORK

This Chapter describes the administrative and regulatory context for the Construction and Operation Phase of the CRL EIA. Key legal acts, standards and guidelines applicable to the environmental aspects of the Project have been reviewed and are presented below.

3.1 NATIONAL PLANS

The following plans have been developed in line with the objectives of both the LTA and other government agencies for the management of land use in Singapore:

- **Land Transport Master Plan**[11]**:** key plan to increase connectivity of public transport and network resilience of MRT infrastructure.
- **Sustainable Singapore Blueprint 2015**[13]**:** sets out targets to be achieved by 2030 for factors attributing to a sustainable, high quality living environment, e.g. green and blue spaces, mobility and air quality.
- **National Biodiversity Strategy and Action Plan**[14]**:** sets out goals to conserve and enhance Singapore's biodiversity.
- **Parks and Waterbodies Control Plan**[15]**:** sets out land use plans for green areas and waterbodies for the next five years.
- **Nature Conservation Master Plan 2015**[16]**:** sets out biodiversity conservation plans for the following five years in order to achieve the Singapore's vision of a City in a Garden.

3.2 LEGISLATURE, REGULATIONS & GUIDELINES

A number of legal acts, regulations and guidelines are applicable to the Project as they specify key measures and emission limits that the Project is required to adopt and comply with respectively. This is with the aim of managing the environmental impacts of construction projects and reducing the risk of occurrence of unplanned events. Management measures specified in these acts, regulations and guidelines are considered part of the Project design and are defined as embedded controls (see *Table 2.6* and *Annex 2.0*).

Annex 3.0, *Table A3.1* presents the relevant legal acts and regulations and guideline documents, a summary of their key objectives and requirements. The statutory limits for noise emissions, emissions to air and discharge of trade effluent into waterways during construction works are detailed in *Annex 3.0, Tables A3.2* to *A3.8*. A brief description of the relevant acts and regulations can be found in the following subsections.

3.2.1 Applicable to the Generation of Wastewater, Trade Effluent and Silt

The Project will involve the generation of wastewater and must therefore comply with the permissible discharge limits for trade effluent. These are specified in the *Sewerage and Drainage (Trade Effluent) Regulations 2007*, and the *Environmental Protection and Management Act (Trade*

Effluent) Regulations 2008 for discharge into public sewers and watercourses respectively. *Annex 3.0, Table A3.2* presents these discharge limits.

The water quality of the MacRitchie Reservoir is monitored by the Public Utilities Board (PUB) to ensure that water used for treatment and potable supply purposes is within acceptable standards. MacRitchie Reservoir and its tributaries are also known to support a diversity of flora and fauna, including endangered aquatic organisms, which are sensitive to changes in water quality. The *Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations 2006* state that activities that may lead to the pollution of MacRitchie Reservoir or its associated streams in any manner are strictly prohibited.

3.2.1.1 Earth Control Measures

Construction sites are required by the Public Utilities Board (PUB) and LTA to develop an Earth Control Measures Plan that is designed and endorsed by a Qualified Erosion Control Professional (QECP). This will minimise the risk of silt from construction sites entering and polluting waterways. In the case of the project, construction areas for Alignment Option 1 will be in close proximity to the MacRitchie Reservoir and its tributaries. These have been identified to be areas of high ecological sensitivity(1). Construction worksites for Alignment Option 2 are in close proximity to major canals, which feed into various reservoirs in Singapore. The Project will therefore implement the embedded controls specified in the *Guidebook on Erosion and Sediment Control at Construction Sites (4th Edition)* and LTA's *General Specifications, Appendix A, Safety Health and Environment (for Rail Project) October 2018 Edition*, as detailed in *Annex 2.0, Table A2.1*.

3.2.2 Applicable to the Generation of Noise & Vibration

Noise emission standards and procedures applicable to the Project can be found in the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* and *Environmental Protection and Management (Vehicular Emissions) Regulations, 2008*.

3.2.2.1 Construction Noise

The maximum permissible noise levels for construction sites are detailed in the Second Schedule of the *Environmental Protection and Management (Control of Noise At Construction Sites) Regulations, 2008* and presented in *Annex 3.0*, *Table A3.3*. The Project should note that authorities may call for the measurement and submission of noise levels from Project sites and therefore undertake preparations for noise monitoring over the Project duration.

The Regulations stipulate that the maximum permissible noise levels detailed in the Second Schedule may be adjusted if other sources of noise affecting the measurement of noise emissions from a construction site are present. This will involve the gathering of baseline noise level data to assess the necessity for an adjustment of applicable noise limits. The Third Schedule of the Regulations presents the noise correction factors which may be applied to maximum permissible noise levels; these are outlined in *Annex 3.0*, *Table A3.4*.

The Project will also implement measures for the control of ambient noise levels generated from the construction worksites, in accordance with the LTA's *General Specification, Appendix A, Safety, Health*

and Environment (for Rail Project), October 2018 Edition and LTA's guidebook on *Best Environmental Practices: Noise Control at LTA Sites, 2008*. These are summarised in *Annex 2.0, Table A2.2*.

3.2.2.2 Vehicular Noise

Noise emissions from vehicles are regulated under the *Environmental Protection and Management (Vehicular Emissions) Regulations, 2008*. Standards for noise emissions can be found in the Fourth, Sixth and Seventh Schedule of the Regulations. These are detailed in *Annex 3.0*, *Table A3.5.*

3.2.2.3 Vibration

There are no regulatory limits for vibration generated from construction activities. However, under LTA's specifications for activities related to rock excavation, where these are located in the vicinity of slopes, underground infrastructure and buildings, blasting works will have to be designed in consideration of vibration requirements as determined by the relevant authorities and/or building owners. Furthermore, under the *Environmental Public Health Act 2002*, measures have to be undertaken to address nuisance effects due to human exposure to vibration generated from a place or activity.

3.2.3 Applicable to Emissions to Air

3.2.3.1 Vehicular Emissions to Air

Construction of the CRL will require the transport of materials to and from Project sites by motor vehicles. The Project must therefore adhere to the exhaust emission standards stipulated in the First, Second and Third Schedules of the *Environmental Protection and Management (Vehicular Emissions) Regulations, 2008*.

Singapore's exhaust emission standards are adopted from European Union Standards and Japanese Standards; these standards define acceptable limits for exhaust emissions of new vehicles sold in EU member states and Japan, and are progressively being adopted by other countries to regulate nitrogen oxides (NOx) and fine particulate emissions. New petrol vehicles purchased after September 2017 will be required to comply with the Euro VI emission standards. These new standards specify more stringent limits for hydrocarbons, NOx, and fine particulates in exhaust emissions. The Japanese emission standards, JPN 2009, are considered equivalent to Euro VI emission standards. The current exhaust emissions standards applicable to motor vehicles in Singapore are detailed in *Annex 3.0*, *Table A3.6*.

In addition to the standards above, the *Environmental Protection and Management (Vehicular Emissions) Regulations, 2008,* prescribes additional regulations that are applicable to the exhaust emissions of in-use motor vehicles. These are summarised in *Annex 3.0*, *Table A3.7*.

With effect from 1 July 2012, all off-road diesel engines imported into Singapore must comply with the engine emission limits listed under the EU Stage II, US Tier II and Japan Tier I standards. These standards specify exhaust emission limits for carbon monoxide, nitrous oxides, particulate matter, hydrocarbons and stipulate the smoke opacity limit of exhaust fumes. These are applicable to construction equipment such as power generators and off-road vehicles which may be used during the Project.

The standard (i.e. EU Stage II, US Tier II, or Japan Tier I) that an off-road diesel engine must comply with is selected based on the net engine power of the diesel engine. This is outlined in *Table A3.8*. Detailed emission limits are listed in the *Schedule of the Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012*.

3.2.3.2 Dust Emissions

The construction and operation phase of the CRL project may generate dust largely in the form of PM_{10}[17] from vehicle movement, land clearance, tunneling and excavation, and to a smaller extent, venting. The EIA has adopted the guide published by the UK Institute of Air Quality Management (IAQM), titled the *Guidance on the Assessment of Dust from Demolition and Construction*. This guide details the impacts of dust produced from earthworks on human and ecological receptors.

The Project will also adopt erosion control measures listed in the LTA's *General Specifications, Appendix A, Safety Health and Environment (for Rail Project) October 2018 Edition* that are applicable to dust suppression. These are similarly summarised in *Annex 2.0*, *Table A2.3*.

3.2.4 Ecology & Biodiversity

The activities associated with the C&O phase of the CRL will be carried out in the vicinity of ecologically sensitive areas, namely NParks managed areas such as the MacRitchie forest and Windsor Nature Park. MacRitchie forest is located within the Central Catchment Nature Reserve (CCNR), an area gazetted as a nature reserve and protected water catchment under the *Parks and Trees Act* and the *Public Utilities (Reservoir and Catchment Areas)* Regulation. In addition, construction worksites will be located within land surrounding the CCNR south of Lornie Road and west of the Pan Island Expressway (PIE), which are gazetted as part of the Central Tree Conservation Area[18] managed by NParks.

The Project shall therefore be required to comply with the stipulations listed under the *Parks and Trees Act, 2005,* and the *Public Utilities (Reservoir and Catchment Areas) Regulations, 2006*. In addition, the Project shall consider, with guidance from the *EPMA* and *Sewerage and Drainage Act*, 2001, the potential impacts of air and noise emissions, trade effluent and waste generation from its activities in an ecological context.

The *Wild Animals and Birds Act* 2000 and *Parks and Trees Act 2005* will be applicable to all Project construction and operation activities. The Project is obligated to ensure that its activities do not result in harm to organisms or lead to adverse impacts on the mature heritage trees at these sites. Measures that will be undertaken in accordance with the abovementioned regulations and LTA's *General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition* are summarised in *Annex 2.0*, *Table A2.4*.

3.2.5 Waste Management

Waste is expected to be generated from Project Activities in the form of general waste, hazardous waste and Toxic Industrial Waste. Considering the types of waste that will potentially be generated, the Project's waste management practices are required to adhere to the *Environmental Public Health Act 2002* and *Environmental Protection and Management (Hazardous Substances) Regulations 2008* as summarised in the following subsections and detailed in *Annex 2.0*, *Table A2.5*.

3.2.5.1 General Waste

General Waste is defined under the *Environmental Public Health Act 2002* as refuse waste; waste from sewerage systems; waste from sanitary conveniences that are not part of a sewerage system; and toxic industrial waste that has been treated, rendered harmless and determined to be safe for disposal. Under the *Environmental Public Health Act 2002* and *Environmental Public Health Act (General Waste Collection) Regulations 2000*, waste generators are responsible for arranging for the safe disposal of general waste and are prohibited from dumping waste in a public space.

3.2.5.2 Hazardous Substances

Certain construction activities and equipment may involve the use of or generate hazardous substances listed under the Schedule of the *Environmental Protection and Management (Hazardous Substances) Regulations 2008*. These Regulations prescribe mandatory actions that contractors should undertake surrounding the transport, import, storage and supply of hazardous substances. Emergency action plans should also be established to deal with accidental spills and leaks.

3.2.5.3 Toxic Industrial Waste

Toxic Industrial Waste (TIW) is defined under the *Environmental Public Health Act 2002* as waste that constitutes a danger to human health or the environment, contains or has the potential to produce pathogens of transmissible disease due to its nature, composition or quantity. The types of waste which qualify as TIW are listed under The Schedule of the *Environmental Public Health (Toxic Industrial Waste) Regulations 2002*. Generators of TIW must engage a licensed TIW collector and furnish sufficient information such that the collector is able to manage the waste appropriately.

3.2.6 Health and Safety

Provisions in the *Workplace Safety and Health Act* are targeted at ensuring proper safety and health management practices in the workplace to minimise the risk of unplanned events that may lead to direct or indirect impacts to the environment. There are several subsidiary regulations under the act that are applicable to the construction phase of the CRL project as detailed in *Annex 2.0*, *Table A2.6*.

3.2.7 Cultural and Historical Heritage Resources

Specific to cultural and historical heritage resources that have conservation value, the *Planning Act* stipulates that the Minister for National Development may designate in the master plan "any area… of special architectural, historic, traditional or aesthetic interest" as a conservation area. Conservation permission would have to be obtained before work is carried out in such conservation areas. Based on the URA Masterplan 2014, there are no designated conservation areas within the Project area.

The *Preservation of Monuments Act* confers on the Minister the power to make a preservation order to place any monument under the protection of the National Heritage Board following consultation with the National Heritage Board and the National Monuments Advisory Committee. As defined in the *Preservation of Monuments Act*, a monument which is subject to a preservation order is awarded a national monument status, and the owner and the occupier of any national monument has the duty to ensure that the national monument is maintained in accordance with any guidelines that may be

issued. A literature review of the Project Area revealed that there are four sites/structures located in the proximity of proposed worksites within the Project area that have been designated as historical sites by the National Heritage Board but these four historical sites do not have national monument status and are not subjected to any legislative protection. These historical site markers are summarised in *Table 3.1*.

Table 3.1: Historical Site Markers within the Project Study Area

No.	Name	Nearest Worksite (Note 1)
1	Sime Road Machine-Gun Pillbox	A2-W4
2	Sime Road Camp	A2-W4
3	MacRitchie Reservoir	Alignment Option 2 Tunnel
4	Lim Bo Seng's Burial Site, MacRitchie Reservoir Park	Alignment Option 2 Tunnel

Note 1: It is noted that these historical site markers are not located within the footprint of any Project worksite or overlying any of the Project tunnel alignment options.

Source: National Heritage Board

3.3 INTERNATIONAL CONVENTIONS

3.3.1 Convention on Biological Diversity (CBD)

The CBD is an international treaty pertaining to the conservation of biological diversity and the environment. It sets broad goals, policies and obligations for its signatories and requires them to develop a national biodiversity strategy and action plan for integration into national development plans. Singapore, having signed the Convention in 1992, formulated its NBSAP in 2009, signaling its commitment towards the Convention's objectives of promoting conservation and sustainable use of biological resources. Singapore is required to regularly report its progress on the implementation of the NBSAP at the Conference of the Parties (COP). In addition, the Singapore Index on Cities' Biodiversity was endorsed at the 10th COP to the Convention on Biological Diversity in Nagoya. Targeted at allowing cities to assess their biodiversity conservation efforts in an urban context, the Index was deemed as Singapore's first major contribution to the Convention. This reflects Singapore's continued interest and participation in the international conservation movement.

3.3.2 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is an international agreement aimed at ensuring that the trade of wild animals and plants does not threaten their survival. Singapore has been a party of CITES since 1987 and NParks has been designated as the management authority responsible for administering the CITES licensing system. Species that are protected by CITES from overexploitation are listed in the CITES Appendices. The Appendices comprise approximately 5,600 species of animals and 30,000 species of plants[19].

Singapore is home to several plant and animal species that are listed in the CITES Appendices, most of which can be found in the nature reserves.

3.3.3 *United Nations Framework Convention on Climate Change (UNFCCC)*

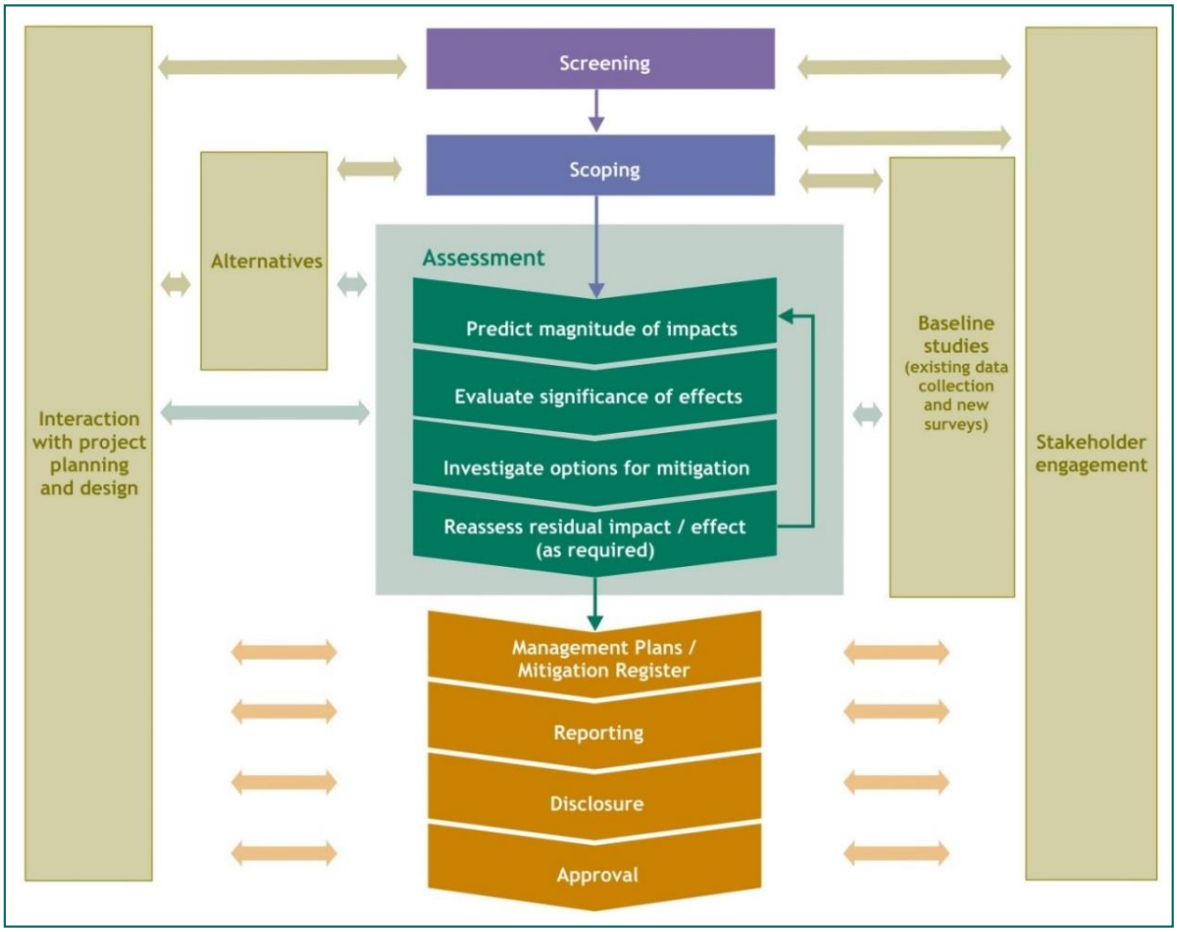
The UNFCCC is an international treaty targeted at stabilising Greenhouse Gas (GHG) concentrations by providing a framework for negotiating the challenges of climate change. Singapore became party to convention in 1997 and in 2008, developed a National Climate Change Strategy with the goal of reducing GHG emissions[20].

4 IMPACT ASSESSMENT METHODOLOGY

4.1 INTRODUCTION

The IA methodology follows the overall IA approach illustrated in *Figure 4.1*. The IA has been undertaken following a systematic process that predicts and evaluates the potential impacts from the Project on aspects of the physical and biological environment, and identifies measures that the Project will take to avoid, minimise/reduce, mitigate, offset or compensate for adverse impacts; and to enhance positive effects where practicable. The stages of the IA process are described below.

Figure 4.1: Impact Assessment Process



*Note: "*Management plans/mitigation register" encompasses a range of environmental management plans and environmental monitoring plans depending on the assessment outcome and legislative requirements.
Source: *ERM*

4.2 SCREENING

At the initial stage of the IA, preliminary information was provided to aid in the determination of what legal and other requirements apply to the Project. This step was conducted utilising a high level description of the Project and its associated facilities.

4.3 SCOPING

Scoping was undertaken to identify the potential Area of Influence for the Project (and thus the appropriate Study Area), to identify potential interactions between the Project and environmental resources/receptors in the Area of Influence and the impacts that could result from these interactions, and to prioritise these impacts in terms of their likely significance.

This stage is intended to ensure that the IA focuses on those issues that are most important for design, decision-making and stakeholder interest.

Table 4.1 presents the environmental resources/receptors considered in the scoping stage, together with the changes that might indicate a Project-related impact.

Table 4.1: Environmental Resources/Receptors and Impacts Considered in Scoping

Resources/Receptors	Impacts
Physical Environment	
Ambient Air Quality / Dust Deposition	Emissions of NOx, SOx, PM, CO, VOC, greenhouse gases (CO_2, CH_4, and N_2O), ozone, TSP etc
Ambient Noise	Change in ambient noise levels
Groundborne Noise & Vibration	Change in vibration levels and subsequent generation of groundborne noise
Surface Water and hydrology	Changes to physical, chemical or biological quality of surface water bodies; Introduction of exotic species, changes in habitat quality, abundance, diversity; effluent discharge
Geology	Changes to geology, geomorphology, topography, including changes to physical and chemical properties and soil ecology
Hydrogeology	Contamination of shallow or deep groundwater resources, change in groundwater resources
Sediments	River/waterbed morphology, physical and chemical properties, benthic organisms.
Biological	
Terrestrial Habitats	Changes in habitat quality and conditions, and subsequent effects on the ecosystem
Terrestrial Flora & Fauna	Changes to vegetation community, health, species abundance and diversity and impact on endangered species and changes to wildlife assemblages
Aquatic Habitats	Changes on the aquatic ecosystem within streams and wetlands
Aquatic Flora & Fauna	Changes to aquatic vegetation community, health, species abundance and diversity and impact on endangered aquatic species
Protected Areas	Compatibility of activities within designated national park/protection areas

4.4 BASELINE CONDITIONS

Baseline environmental conditions were documented in *Volume II* of this EIA report for relevant resources/receptors that were identified during scoping as having the potential to be significantly affected by the Project.

4.5 STAKEHOLDER ENGAGEMENT

An effective IA Process requires engagement with relevant stakeholders throughout the key stages. This assists in understanding stakeholder views on the Project, in identifying issues that should be taken into account in the evaluation of impacts and in development of appropriate mitigation and enhancement measures.

4.6 IMPACT ASSESSMENT

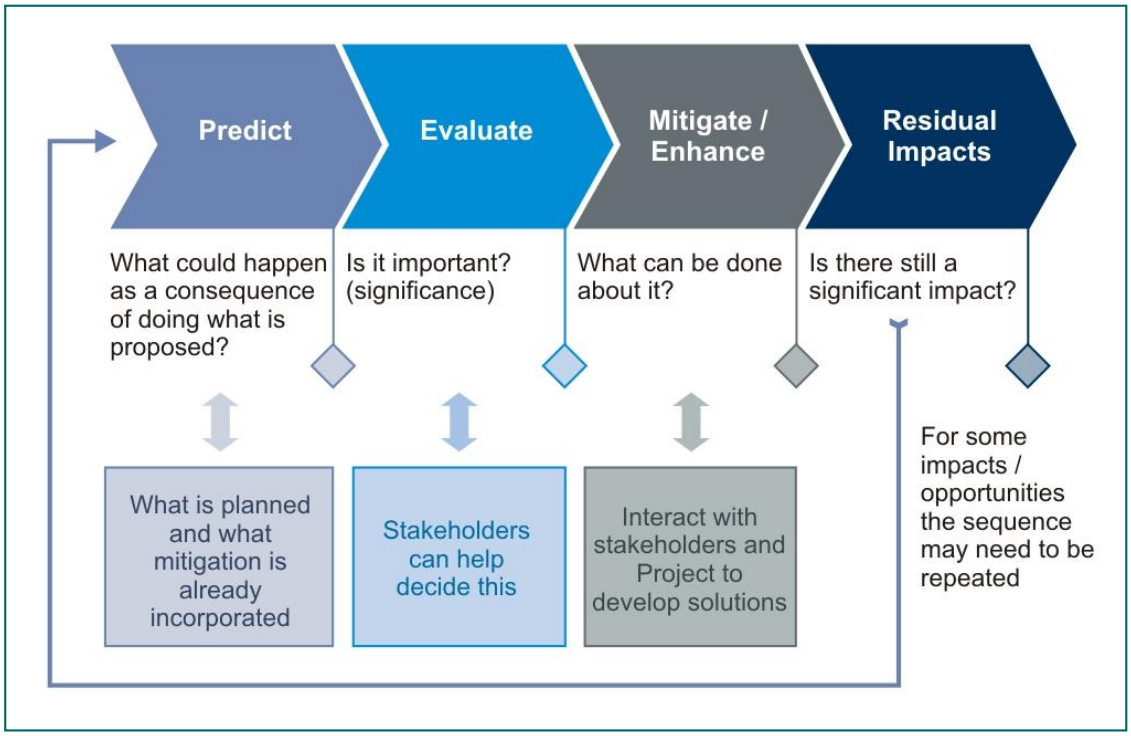
Impact identification and assessment starts with scoping and continues through the remainder of the IA Process. The principal IA steps are summarised in *Figure 4.2* and comprise:

- Impact prediction: to determine what could potentially happen to resources/receptors as a consequence of the Project and its associated activities.
- Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value and/or importance of the affected resource/receptor.
- Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts.
- Residual impact evaluation: to evaluate the significance of impacts assuming effective implementation of mitigation and enhancement measures.

4.6.1 Prediction of Impacts

Prediction of impacts is essentially an objective exercise to determine what is likely to happen to the environment as a consequence of the Project and its associated activities. From the potentially significant interactions identified in Scoping, the impacts to the various resources/receptors are elaborated and evaluated. The diverse range of potential impacts considered in the IA process typically results in a wide range of prediction methods being used, including quantitative, semi-quantitative and qualitative techniques.

Figure 4.2: Impact Assessment Process



Source: ERM

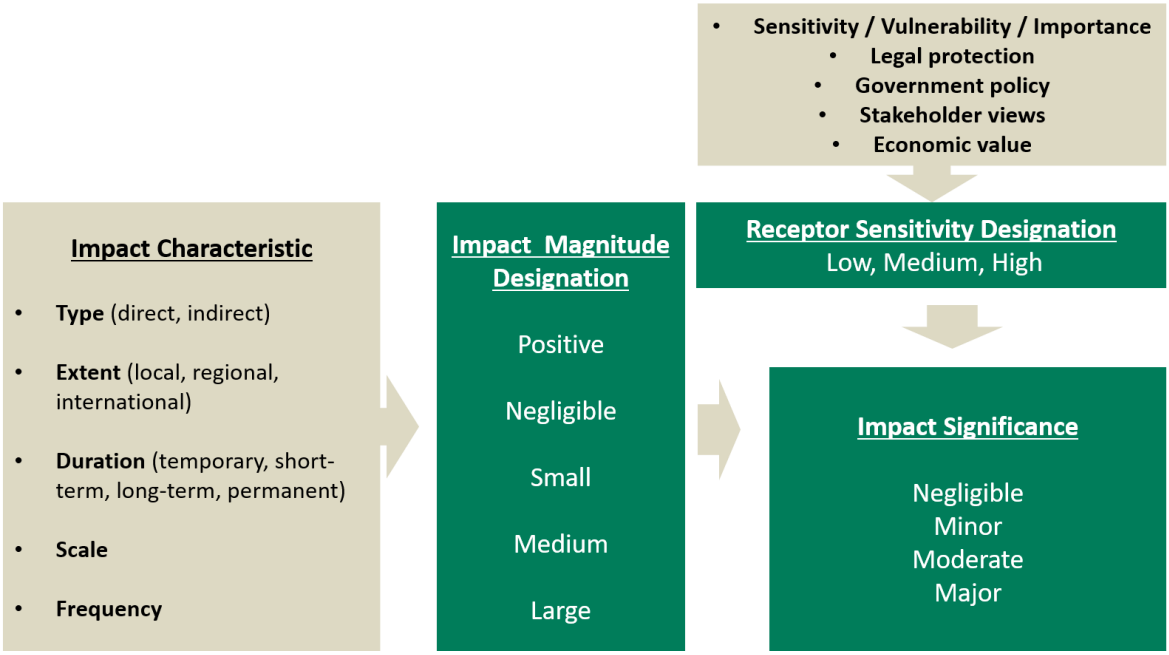
4.6.2 Evaluation of Impacts

The significance of an impact is evaluated by considering the magnitude of the impact, and the sensitivity of a receptor.

4.6.2.1 Impact Magnitude

Each impact is described in terms of its various relevant characteristics (e.g. type, scale, duration, frequency, extent). An impact magnitude designation is assigned based on an evaluation of the impact characteristics, as shown in *Figure 4.3*. Magnitude essentially describes the intensity of the change that is predicted to occur in the resource/receptor as a result of the impact. The magnitude designations themselves are universally consistent, but the descriptions for these designations vary on a resource/receptor-by-resource/receptor basis.

Figure 4.3: Evaluation of Impact Significance (Planned Event)



In the case of a positive effect (i.e. a benefit), no magnitude designation (aside from 'positive') is assigned. It is considered sufficient for the purpose of the IA to indicate that the Project is expected to result in a positive effect, without characterising the exact degree of positive change likely to occur.

Impact prediction and evaluation take into account any embedded controls (i.e. physical or procedural controls that are already planned as part of the Project design, regardless of the results of the IA Process). Example of embedded controls include a standard acoustic enclosure that is designed to be installed around a piece of major equipment or a piece of legislature that stipulates requirements a Project must fulfill, e.g. discharge requirements.

4.6.2.2 Receptor Sensitivity

In addition to characterising the magnitude of impact, the other principal impact evaluation step is definition of the sensitivity/vulnerability/importance of the impacted resource/receptor. There are a range of factors to be taken into account when defining the sensitivity/vulnerability/importance of the resource/receptor, which may be physical, biological, cultural or human. These factors are summarised in *Figure 4.3*. As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent, but the definitions for these designations vary on a resource/receptor basis.

4.6.2.3 Impact Significance

Once magnitude of impact and sensitivity/vulnerability/importance of resource/receptor have been characterised, the significance can be assigned for each impact. Impact significance is designated using the matrix shown in *Figure 4.4*.

Figure 4.4: Impact Significance Matrix (Planned Event)

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High
Impact Magnitude	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Critical/ Major

Box A provides a context for what the various impact significance ratings signify.

Box A: Context of Impact Significances

An impact of **negligible significance** is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.

An impact of **minor significance** is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

An impact of **moderate significance** has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit i.e. major. Where there are no clearly defined thresholds for resource/receptors, an impact is considered to be of moderate significance where a small impact magnitude occurs to high valued/sensitive resource/receptors, or where a large impact occurs to a resource/receptor that is of low sensitivity/vulnerability/importance.

Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.

An impact of **major significance** is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An impact of **critical significance** has a similar definition, but is only applicable to the biodiversity assessment and when large magnitude impacts interact with critical habitats [(Footnote 1)].

An aim of IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

[(Footnote 1)] Critical Habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes.

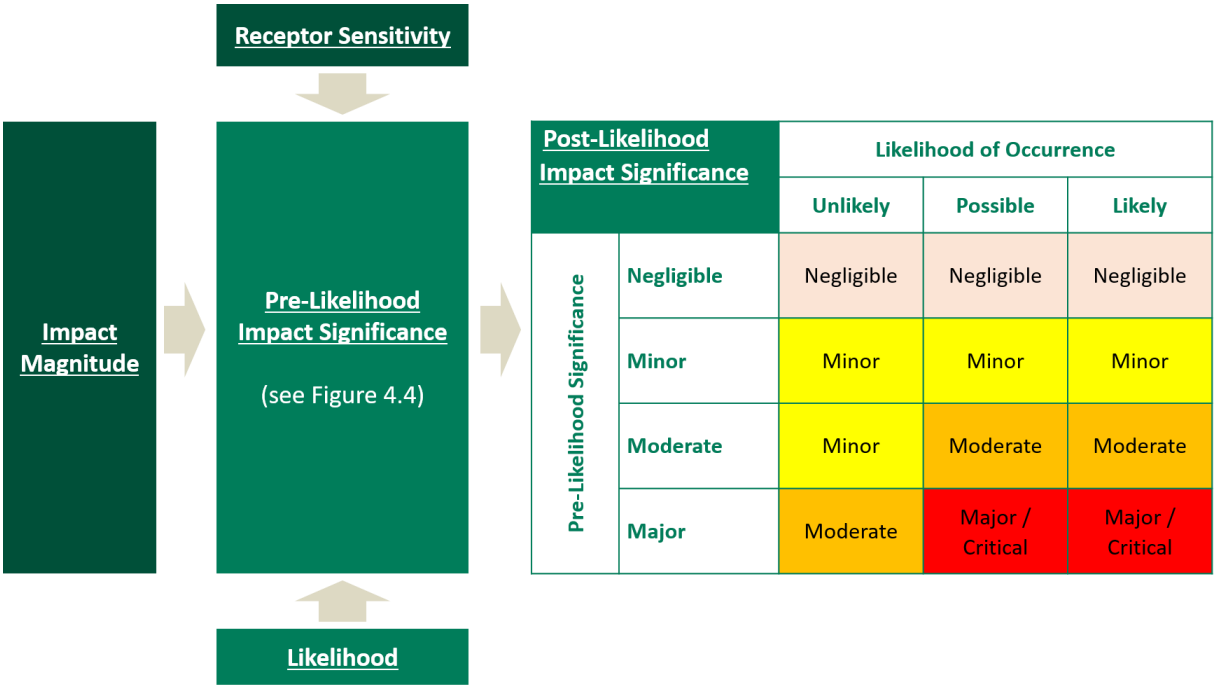
Likelihood (Unplanned Event)

The process of designating impact magnitude and receptor sensitivity as shown in *Figure 4.3* applies to planned events. In the case of unplanned events, i.e. unintended occurrences in the Project such as a fire emergency, an additional factor that is considered is likelihood. The likelihood of an unplanned event occurring is designated using a qualitative scale, as described in *Table 4.2*. The impact significance of an unplanned event is then designated using the matrix shown in *Figure 4.5*.

Table 4.2: Definitions for Likelihood Designations

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely	The event will occur during normal operating conditions (i.e. it is essentially inevitable).

Figure 4.5: Impact Significance Matrix (Unplanned Event)



4.6.3 Identification of Mitigation and Enhancement Measures

Once the significance of an impact has been characterised, the next step is to evaluate what mitigation and enhancement measures are warranted. For the purposes of this IA, ERM has adopted the following Mitigation Hierarchy:

- Avoid at Source, Reduce at Source: avoiding or reducing at source through the design of the Project (e.g. avoiding by siting or re-routing activity away from sensitive areas or reducing by restricting the working area or changing the time of the activity).
- Abate on Site: add something to the design to abate the impact (e.g. pollution control equipment or erosion control).
- Abate at Receptor: if an impact cannot be abated on-site then control measures can be implemented off-site (e.g. noise barriers to reduce noise impact at a nearby residence or fencing to protect ecological sensitive receivers).
- Repair or Remedy: some impacts involve unavoidable damage to a resource (e.g. forestry due to creating access, work camps or materials storage areas) and these impacts can be addressed through repair, restoration or reinstatement measures.
- Compensate in Kind, Compensate through Other Means: where other mitigation approaches are not possible or fully effective, then compensation for loss, damage and disturbance might be appropriate (e.g. planting to replace damaged vegetation or providing community facilities for loss of recreation and amenity space).

The priority in mitigation is to first apply mitigation measures to the source of the impact (i.e. to avoid or reduce the magnitude of the impact from the associated Project activity), and then to address the resultant effect to the resource/ receptor via abatement or compensatory measures or offsets (i.e. to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

4.6.4 Residual Impact Assessment

Once mitigation and enhancement measures are declared, the next step in the IA Process is to assign residual impact significance. This is essentially a repeat of the impact assessment steps discussed above, considering the implementation of the proposed mitigation and enhancement measures.

4.6.5 Cumulative Impacts

A cumulative impact can be defined as, an impact that arises as a result of an impact from the Project interacting with an impact from another activity to create an additional impact. For example, a residential property positioned between a CCNR construction worksite and other developments would result in the residential receptors experiencing the combined effect of the two noise sources. It is noted that how cumulative impacts are assessed are strongly influenced by the status of the other activities (e.g. already in existence, approved or proposed) and how much data is available about them.

The impact assessment process itself is broadly similar to that presented herein, i.e. scoping to define the committed developments, level of information available, potential interactions; baseline data gathering which is usually captured in the study area of the project; impact assessment to determine the magnitude and significance of impacts considering the vulnerability of the resources and receptors and their limits of acceptable change; and development of any management and monitoring measures to mitigation significant impacts.

4.7 MANAGEMENT, MONITORING AND AUDIT

The final stage in the IA Process is definition of the basic management and monitoring measures that are needed to identify whether: a) impacts or their associated Project components remain in conformance with applicable standards; and b) mitigation measures are effectively addressing impacts and compensatory measures and offsets are reducing effects to the extent predicted.

5 SCREENING AND SCOPING

5.1 INTRODUCTION

This chapter presents the approach and the findings from the screening and scoping stage of the EIA process. Details of the key issues which were identified through the screening and scoping, and which are further assessed in *Volume III* and *Volume IV* of this EIA report, are also outlined.

5.2 SCREENING

Screening was undertaken by the LTA through early engagement with external stakeholders. A CRL Working Group comprising various scientists and green group representatives was also formed during the screening process, to consolidate available research and survey findings pertaining to the biodiversity within the CCNR. In addition, the Nature Society (Singapore) (NSS) was engaged with regard to their concerns about the impacts to the ecology within the CCNR, as summarized in their position paper [21] on the Project. Environmental aspects that may potentially be impacted by Project activities within the CCNR as highlighted in the CRL Working Group Report [22] and NSS' position paper and considered at the screening phase were as follows:

- Ambient air quality (including effects due to dust deposition);
- Ambient noise;
- Groundborne noise and vibration;
- Hydrology (including surface water quality);
- Hydrogeology;
- Geology (including soil quality);
- Topography;
- Terrestrial habitats;
- Terrestrial flora and fauna;
- Aquatic habitats;
- Aquatic flora and fauna;
- Cultural heritage and historical resources;
- Landscape and visual; and
- Tourism and recreation.

5.3 SCOPING

The Project Scoping was completed by undertaking a workshop early in the EIA process with key personnel from the LTA's Project team (including engineers) to identify the Project activities and potential environmental interactions. The Project footprint, embedded controls that will be in place during the Project (see *Volume I, Annex 2.0*), and factors such as the spatial extent and duration of construction activities for Alignment Options 1 and 2 were reviewed and assessed iteratively during

the scoping process. Activities associated with the construction and operation phases and environmental receptors within the Study Area were classified into one of the following:

- **No interaction:** where the Project is unlikely to interact with the resource/receptor (e.g. wholly terrestrial projects may have no interaction with the marine environment);
- **Interaction likely, but not likely to be significant:** where there is likely to be an interaction, but the resultant impact is unlikely to change baseline conditions in an appreciable/detectable way; and
- **Significant interaction:** where there is likely to be an interaction, and the resultant impact has a reasonable potential to cause a significant effect on the resource/receptor.

Where positive interactions were anticipated, these were also captured. The findings of Scoping the construction and operational activities for both alignment options are detailed within the potential interactions matrix provided in *Annex 4.0* and summarised in *Table 5.1*. Ambient air quality, ambient noise, groundborne noise and vibration, surface water quality, hydrology, geology, soil quality, hydrogeology, terrestrial and aquatic habitats (including flora and fauna), landscape and visual, and tourism and recreation were considered to have potentially significant interactions with construction activities, though to a different extent for each alignment option given the site settings. Interactions due to unplanned events have also been considered. The potentially significant interactions for both alignments, which are carried forward for further consideration in the IA, are summarised in *Table 5.1*.

Geology, including soil quality, is not a resource that is mined for use in Singapore and was therefore not identified as a sensitive receptor. Direct effects on geology was however identified to lead to secondary adverse effects to sensitive receptors such as surface waterbodies and ecological receptors. Effects on geological resources within the Study Area were therefore discussed under the impact assessment for hydrology and hydrogeology, and ecology and biodiversity topics in this EIA.

Similarly, changes to the local topography around the worksites may lead to secondary adverse effects to ecological receptors during construction. The feasibility of reinstating the topography of worksites following construction will be studies at the AES stage of the Project. The EIA has however studied the impacts to ecological receptors in the worst case scenario where the topography around worksites are permanently altered.

Table 5.1: Summary of Scoping Findings and Aspects to be carried forward for Assessment

Resource/Receptor	Scoping Findings for Alignment Option 1	Scoping Findings for Alignment Option 2
Ambient air quality	**Construction** • Dust may be generated during site clearance, earthworks (land grading, excavation, backfilling), exposed ground and temporary stockpiles located at the worksites. **Operation** • No significant interaction anticipated.	**Construction** • Dust may be generated during site clearance, earthworks (land grading, excavation, backfilling), exposed ground and temporary stockpiles located at the worksites. **Operation** • No significant interaction anticipated.
Ambient noise	**Construction** • Noise generated during construction activities at the aboveground worksites may lead to adverse impacts to human and ecological receptors located in close proximity to the worksites. **Operation / Unplanned Event(s)** • No significant interaction anticipated.	**Construction** • Noise generated during construction activities at the aboveground worksites may lead to adverse impacts to human and ecological receptors located in close proximity to the worksites. **Operation / Unplanned Event(s)** • No significant interaction anticipated.
Groundborne noise and vibration	**Construction** • Vibration may be significant to receptors during rock blasting and piling activities during the excavation of shafts and operation of TBM during tunneling works. **Operation / Unplanned Event(s)** • No significant interaction anticipated. Design technology for railway track mounting within tunnels are available to ensure that vibration generated at the ground surface during train operation will be below the existing vibration levels.	**Construction** • Vibration may be significant to receptors during rock blasting and piling activities during the excavation of shafts, operation of TBM and blasting of tunnel cross passages. **Operation / Unplanned Event(s)** • No significant interaction anticipated. Design technology for railway track mounting within tunnels are available to ensure that vibration generated at the ground surface during train operation will be below the existing vibration levels.

Resource/Receptor	Scoping Findings for Alignment Option 1	Scoping Findings for Alignment Option 2
Hydrology (including Surface Water Quality) & Hydrogeology	**Construction** • Construction activities such as land clearance, installation of piezometers, construction of temporary access roads, and temporary storage of waste and cementitious materials at worksites e.g.A1-W1 (LS/VS), located upstream of and/or in close proximity to surface water features could lead to adverse impacts to surface water quality due to increased sedimentation or potential contamination due to runoff from worksites. • Alteration of hydrogeology due to an increase in impermeable ground cover at the A1-W1 (LS/VS) worksite and the construction of underground structures. • Impact to groundwater quality due to the injection of slurry during tunneling works. **Operation** • No significant interaction anticipated. **Unplanned Event(s)** • Impact to surface water features may be significant during unplanned construction activities such as discharge of firewater[Footnote 1] in the event of a fire during construction and/or operation. • Impact to water quality due to accidental leakage or spillage from temporary storage of hazardous chemicals at the aboveground or tunnel worksites, or accidental uncontrolled discharge of untreated runoff or hazardous materials. • Unplanned events such as excessive ground settlement, failure of steep slope near Sime Stream overlying tunnel alignment, or water ingress during tunneling works, may impact surface hydrology.	**Construction** • Construction activities such as land clearance, installation of piezometers, and temporary storage of waste and hazardous materials at worksites e.g. A2-W2 (LS/VS), located upstream of and/or in close proximity to surface water features could lead to adverse impacts to surface water quality due to increased sedimentation or potential contamination due to runoff from worksites. • Utilities and drainage diversion may lead to changes in hydrology or drainage regimes, resulting in increased flash flooding occurrences. **Operation** • No significant interactions anticipated. **Unplanned Event(s)** • Impact to surface water features may be significant during unplanned construction activities such as discharge of firewater[Footnote 1] in the event of a fire during construction and/or operation. • Unplanned events such as excessive ground settlement and or water ingress during tunneling works, may impact surface hydrology.

[Footnote 1] Firewater is defined in this study as water that has been used for firefighting and which requires disposal.

Resource/Receptor	Scoping Findings for Alignment Option 1	Scoping Findings for Alignment Option 2
Topography	**Construction** • Ground levelling during site clearance for worksites outside the CCNR will alter the topography of the land in the locality of the worksites. **Operation** • It is assumed as a worst case scenario that levelled ground at the worksites outside the CCNR will not be reinstated following completion of construction. **Unplanned Event(s)** • Existing topography may be slightly altered due to unplanned events during tunneling, e.g. excessive soil and ground settlement and failure of steep slope near Sime Stream overlying tunnel alignment.	**Construction** • Ground levelling during site clearance for worksites will alter the topography of the land in the locality of the worksites A2-W2 and A2-W3. **Operation** • It is assumed as a worst case scenario that levelled ground at worksites A2-W2 and A2-W3 will not be reinstated following completion of construction. **Unplanned Event(s)** • Existing topography may be slightly altered due to unplanned events during tunneling, e.g. excessive soil and ground settlement.

Terrestrial and Aquatic Habitats, Flora and Fauna	**Construction** • Tree felling and ground levelling during site clearance and preparation for Project construction at worksites outside the CCNR, will alter the terrestrial/aquatic habitats (including population numbers) at and in proximity to the construction worksites. • Noise emissions from the presence of human and machinery during near-surface works such as site clearance, excavation of shafts if rock blasting method is used, etc. at worksites outside the CCNR; and installation of piezometers/settlement markers within the CCNR, may result in behavioral or distribution changes to the wildlife in the area. • Increased illumination due to night-time operations at the TBM launch/retrieval shaft worksites may result in behavioral or distribution changes to the wildlife in the area. • Potential roadkill due to increased heavy vehicular traffic along temporary access roads at A1-W1 (LS/VS) and A1-W2 (LS/VS) and along roads adjacent to worksites. • Impact to aquatic habitats from increased sedimentation or contaminated runoff from worksite A1-W1 (LS/VS) due to site clearance, temporary stockpiling and storage of waste and hazardous chemicals. **Operation** • Potential roadkill due to periodic vehicular traffic along permanent access roads to facility buildings at A1-W1 (LS/VS) and A1-W2 (LS/VS). **Unplanned Event(s)** • Alteration of terrestrial/aquatic habitats due to unplanned events during construction such as excessive soil and ground settlement, and failure of steep slope near Sime Stream overlying tunnel alignment.	**Construction** • Tree felling and ground levelling during site clearance and preparation for Project construction at worksites outside the CCNR, will alter the terrestrial/aquatic habitats (including population numbers) at and in proximity to the construction worksites A2-W2 (LS/VS), A2-W3 (LS/VS), and surface ground improvement worksites along portions of the tunnel alignment. • Noise emissions from the presence of human and machinery during near-surface works such as site clearance, installation of piezometers, surface ground improvement works, excavation of shafts if rock blasting method is used, etc. at worksites outside the CCNR may result in behavioral or distribution changes to the wildlife in proximity to the construction worksites A2-W2 (LS/VS), A2-W3 (LS/VS). • Increased illumination due to night-time operations at the TBM launch shaft worksites A2-W2 (LS/VS) and A2-W3 (LS/VS) may result in behavioral or distribution changes to the wildlife in the area. • Potential roadkill due to increased heavy vehicular traffic along temporary access roads to worksite A2-W2 (LS/VS), A2-W3 (LS/VS) and along roads adjacent to worksites. • Impact to aquatic habitats from increased sedimentation or contaminated runoff from worksite A2-W2 (LS/VS) due to site clearance, temporary stockpiling and storage of waste and hazardous chemicals. **Operation** • Potential roadkill due to periodic vehicular traffic along permanent access roads to facility buildings at A2-W2 (LS/VS) and A2-W3 (LS/VS). **Unplanned Event(s)** • Alteration of terrestrial/aquatic habitats due to unplanned events during construction such as excessive soil and ground settlement. • Air emissions from unplanned events i.e. fire during construction works.

Resource/Receptor	Scoping Findings for Alignment Option 1	Scoping Findings for Alignment Option 2
	• Air emissions from unplanned events i.e. fire during construction works.	
Cultural heritage & historical resources	No interactions with historical artefacts within the Study Corridor anticipated.	**Construction** • Site clearance for the A2-W2 (LS/VS) worksite may result in interface with historical graves at these locations. **Operation** • No significant interactions anticipated. **Unplanned Event(s)** • Unplanned events e.g. formation of sinkhole may interface with historical graves within the Bukit Brown Cemetery or Seh Ong Cemetery.
Landscape and visual	**Construction** • Site clearance, construction works leading to an increased presence of construction workers, equipment and storage/waste at construction worksites and piezometer locations may lead to adverse visual impacts to nearby residential and recreational users. **Operation** • No significant interactions anticipated due to small footprint of permanent aboveground structures. **Unplanned Event(s)** • No significant interactions anticipated due to engineering controls in place to minimise risk of occurrence and limit extent of impacts during occurrence of unplanned events that may result in visual impact, such as excessive soil and ground settlement and failure of steep slope near Sime Stream overlying tunnel alignment.	**Construction** • Site clearance at construction worksites, piezometer locations and surface ground improvement worksites may lead to visual intrusion to nearby recreational users, residents and/or visitors to the Bukit Brown cemetery. **Operation** • No significant interactions anticipated due to small footprint of permanent aboveground structures. **Unplanned Event(s)** • No significant interactions anticipated due to engineering controls in place to minimise risk of occurrence and limit extent of impacts during occurrence of unplanned events that may result in visual impact, such as excessive soil and ground settlement.

Resource/Receptor	Scoping Findings for Alignment Option 1	Scoping Findings for Alignment Option 2
Tourism and recreation	**Construction/Operation** • Site clearance, piezometer installation and diversion works, may lead to temporary closure of nearby recreational facilities. Similarly, rock blasting activities may lead to temporary disruption or closure of nearby recreational facilities. • Construction works may lead to temporal to short-term disturbance impacts to recreational users of the SICC Island golf course, Windsor Nature Park trails and the Bukit Timah Saddle Club riding arena. **Unplanned Event(s)** • There is a potential for disruption to recreational activities in the event of excessive soil and ground settlement and failure of steep slope near Sime Stream overlying tunnel alignment. • A fire emergency during construction works would lead to temporary access restrictions to recreational facilities and/or may lead to temporary disruption of recreational activities.	**Construction/Operation** • Construction works may lead to temporal to short-term disturbance impacts to recreational users of the walking trails within Bukit Brown Cemetery. **Unplanned Event(s)** • There is a potential for disruption to recreational activities in the event of excessive soil and ground settlement. • A fire emergency during construction works would lead to temporary access restrictions to recreational facilities and/or may lead to temporary disruption of recreational activities.

6 STAKEHOLDER ENGAGEMENT

6.1 INTRODUCTION

This Chapter presents the context behind stakeholder engagement planning for the Project, and summarises the consultation activities undertaken in line with the Project stakeholder engagement plan.

The chapter is structured as follows:

- *Section 6.1* presents an overview and main objectives of stakeholder engagement;
- *Section 6.2* describes the regulations and guidelines applicable to the Project stakeholder engagement process;
- *Section 6.3* details the geographical and Project-specific context behind the Project stakeholder engagement plan;
- *Section 6.4* summarises the consultation activities undertaken, key findings and follow up actions;
- *Section 6.5* presents planned future disclosure and consultation activities, and Project roles and responsibilities;
- *Section 6.6* describes the Project grievance process and Project contact details; and
- *Section 6.7* presents how implementation of the Project stakeholder engagement plan will be monitored and evaluated.

6.1.1 Overview

Stakeholder engagement is an integral part of the EIA process. It enables the sharing of information and knowledge and a collaborative approach to problem-solving. For this Project, a systematic process was undertaken to first develop an understanding of the issues, identify stakeholders, and allow stakeholders to participate in the process.

6.1.2 Purpose and Objectives

Stakeholders are defined as "*persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively*"[23]. The main objectives of stakeholder engagement are to:

- Ensure that adequate information is provided in a timely manner to those interested in or affected by the Project;
- Ensure that identified stakeholders are provided with sufficient opportunity to voice their opinions and concerns; and
- Ensure that stakeholder feedback is received and taken into account in Project decisions.

6.2 REGULATORY FRAMEWORK

The approach to stakeholder engagement has been informed by the following:

- International best practice; and
- LTA understanding of stakeholder expectations.

6.2.1 International Best Practice

ERM has followed its internal IA Standard which is generally consistent with international standards such as the World Bank and International Finance Corporation (IFC)[23]. For example, the Project stakeholder engagement plan was designed to support the EIA process in accordance with ERM's IA Standard, which requires the recording of all stakeholder consultation outcomes and the consideration of stakeholder concerns in the screening and scoping phases of the EIA, and engaging stakeholders in the subsequent management plans, reporting and disclosure processes. Other guiding principles which helped shape the Project stakeholder engagement plan include the following:

- For management of environmental risks associated with the Project, effective community engagement is required through disclosure of project-related information and consultation with local communities on matters that directly affect them, at appropriate milestones throughout the Project.
- Community consultation is required to define an appropriate system of independent verification for the sustainable management of natural resources to support the aim of biodiversity conservation.
- For management of impacts to cultural heritage, consultation with affected communities who use, or have used within living memory, any project-affected cultural heritage for longstanding cultural purposes will be required for incorporation of the affected communities' views on such cultural heritage into the Project's decision-making process. Consultation will also involve the relevant national or local regulatory agencies that are entrusted with the protection of cultural heritage.

6.2.2 LTA Understanding of Stakeholder Expectations

The Project stakeholder engagement plan was developed with the understanding that while the Project must obtain the requisite formal approvals by the relevant government agencies to proceed in accordance with the laws and regulations of the jurisdictions in which LTA works, it is also important to gain acceptance from other Project stakeholders. Processes were therefore developed to continually monitor, receive and incorporate stakeholder feedback into the Project decision making process.

6.3 CONTEXT OF STAKEHOLDERS IN SINGAPORE

To establish the context of stakeholders in Singapore, a desktop review was undertaken of media articles and publications pertaining to the proposed Project, including The Nature Society (Singapore) (NSS) Discussion and Position Paper[18], the Cross Island Working Group Report[19] and various blog posts. In addition, ERM facilitated an internal workshop with the LTA to identify Project stakeholders and their key concerns.

6.3.1 Identified Stakeholders

Project stakeholders identified were grouped in the following categories:

- Local Non-Government Organisations (NGOs) or green groups;
- Residents;
- Professionals;
- Public Institutions;
- Local industries and businesses;
- Public at large; and
- Media.

6.3.2 Identified Stakeholder Concerns

Key issues were identified from previous consultation undertaken by LTA as well as from materials published by relevant stakeholders. These are mapped to the respective stakeholder categories, as presented in *Table 6.1*.

Table 6.1: Stakeholder Categories and Issues Mapping

Stakeholder Category	Key Environmental Issues/ Interests

NGOs / Green Group representatives / Professionals	*General*
	• Legitimacy and credibility of IA studies, and whether public can see the results
	• Media updates from LTA
	
	Proposed Construction Works
	• Methodology and assessment criteria for EIA
	• Any impact on flora and fauna within the CCNR due to:
	  • Unplanned events occurring during tunneling;
	  • Effluent discharges to surface waterbodies;
	  • Noise and vibration from above- and underground activities; and
	  • Establishment and presence of aboveground construction worksites.
	• Damage to historical artefacts within the CCNR due to surface activities
	• Adequacy of the environmental protection measures recommended / implemented

Stakeholder Category	Key Environmental Issues/ Interests
Residents (including recreation users) / Public Institutions / Local Industries & Businesses	*Proposed Construction Works* • Loss of recreational value / flora • Nuisance impacts, e.g. visual, noise, vibration, air associated with proximity of worksite areas (launch shafts) • Impacts to recreation users in terms of restricted access during construction works
Media (including Social Media)	*General* • Project updates • Potential project benefits or impacts • Construction / environmental impacts especially within CCNR • Improvement of public transportation in Singapore • EIA findings

6.4 EIA ENGAGEMENT ACTIVITIES

LTA undertook early stakeholder engagement with local NGOs and green group representatives, collectively referred to as the CRL Working Group, as part of the screening phase for the Project. In order to maintain continuity, LTA established a Focus Group for the Project comprising interested parties from the CRL Working Group, as well as representatives from technical and other government agencies, and professionals with technical backgrounds in geotechnical site investigation works and urban planning. The aim of setting up a Focus Group was to consult with interested and informed stakeholders on a regular basis throughout the Project by sharing Project information and soliciting feedback on the Project design and implementation. Engagement of the Project Focus Group was established as one of the key consultation channels for the Project.

Other planned disclosure methods and/or communication channels used include:

- Media releases;
- Participation in residents' committee meetings by LTA Community Partnership Network Department; and
- Disclosure of EIA report for public feedback over a 4 week period.

6.4.1 Key Findings for the Impact Assessment

Engagements undertaken with the Project Focus Group comprised working sessions to present, gather feedback and inputs, and address concerns raised over the baseline survey and EIA for the soil investigation works. Key concerns highlighted during the abovementioned consultation activities, along with the concerns identified through a review of material published by stakeholders (see *Section 6.3*) are presented in *Table 6.2*, along with the corresponding report references which address the respective concerns.

Table 6.2: External Stakeholder Concerns & Report References

No.	Stakeholder	Concerns	Report Reference
1	Green group representatives (Focus Group)	• Sensitivity of the ecosystem within the CCNR due to its current size and extent of fragmentation. • Sensitivity of stream systems within the CCNR and their susceptibility to sedimentation due to erosion risks induced by clearance of vegetation. • Enforcement of control measures may be an issue as past construction near the CCNR has led to illegal dumping or discharge of effluents, which led to siltation of streams within CCNR. • Workers being inadequately trained and experienced in working in forested areas and implementing the embedded controls and mitigation measures developed through the EIA process. • Criteria used for determining magnitude of impact on biodiversity based on international best practice and not applicable and too broad for Singapore context. • Impacts due to the occurrence of unplanned events such as loss of tunnel pressure during tunneling, resulting in groundwater drawdown and excessive soil and ground settlement, as well as impacts due to presence of personnel and equipment during response to emergency.	*Chapter 2, 5* of *Volume III & Volume IV;* and *Table 7.1 EMMP*
2	Professionals (Focus Group)	• The objective of the Project, which is to achieve greater public transport ridership, would ultimately reduce the amount of land allocated to roads and alleviate the pressures of development on designated areas. • All viable alignment options should be explored – it is noted that each option would have different impacts which need to be weighed against each other.	• Engineering Feasibility Report

6.5 *Disclosure and Planned Consultation Activities*

The disclosure of this report provides the opportunity for the LTA to communicate the Project activities, implementation schedules, associated risks, impacts, benefits and mitigation measures. The LTA is planning further consultation with affected communities in recognition of the importance

of disclosing appropriate information throughout the various stages of the Project. As such, the LTA is committed to maintain its ongoing program of consultation and disclosure and will:

- Maintain regular communications with relevant stakeholders;
- Provide local residents and recreational users with timely information on Project progress and related implications;
- Maintain awareness of safety issues;
- Ensure that LTA's grievance mechanism (see *Section 6.6*) is communicated to stakeholders to provide them a platform to voice their concerns and any complaints throughout Project implementation;
- Ensure complaints are addressed in a timely manner and in accordance to the established process; and
- Continually monitor implementation to determine the effectiveness of mitigation measures.

All activities undertaken during disclosure and consultation will be appropriately documented and reported via LTA's website.

6.5.1 Past Consultation Activities

Consultation activities undertaken by the LTA leading up to the disclosure of this report are summarised in *Table 6.3.*

Table 6.3: Past Consultation Activities

No.	Description (Stakeholder Category)	Disclosure Method	Actions Undertaken Following Consultation
1	Presentation of scope and methodology of the C&O EIA (Focus Group)	Focus Group Discussion	• Clarifications provided and relevant stakeholder comments taken on board
2	Presentation of key findings from Pre-final C&O EIA (Focus Group)	Focus Group Discussion	• Response to concerns consolidated during the discussion via smaller breakout engagement sessions with the Focus Group
3	Discussion on key topics and concerns raised during the presentation of key findings from Pre-final C&O EIA (Focus Group)	Focus Group Discussions	• Clarifications provided and relevant stakeholder comments taken on board

6.6 LTA GRIEVANCE MECHANISM

For Project-specific feedback received through the LTA website, email, hotline or Short Message Service (SMS), LTA's internal guidelines require the relevant department to provide a response to the public within 14 working days, and within 20 working days for comments received via post, fax or forms. Where further study is required to address a comment / feedback, LTA commits to provide a formal response within 30 working days, as well as progressive updates in the interim.

7 REFERENCE LIST

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Annex 1.0

Construction Equipment

ANNEX 1.0 CONSTRUCTION EQUIPMENT

Table A1.1: Indicative Construction Equipment Inventory

Stage No.	Construction Activities	Type of Equipment	Quantity (typical on site at any one time)	% ON Time	Assumed Sound Power Level, dB(A)[Note 1]
Pre-Construction					
1	Road, utilities & drainage diversion works (Note 2)	Excavator with rock breaker	1	30%	118
		Excavator	1	30%	108
		Road planer	1	30%	110
		Concrete truck & pump	3	20%	103
		Compactor	1	20%	105
2	Land clearance & establishment of temporary worksites	Excavator	4	70%	106
		Generator	2	50%	102
		Dump Truck (on site)	3	20%	107
		Dump Truck (transit)	1	20%	115
		Bulldozer	1	10%	114
		Crane (50 ton)	2	10%	98
		Concrete truck & pump	3	10%	103
Construction					
3	Launch shaft construction – installation of secant bored piles	Boring rig / D-wall grabber	1	80%	111
		Crane (50 ton)	1	10%	98
		Generator	1	100%	94
		Pump	1	70%	96
		Bar Bender and Cutter	1	30%	112
4	Launch shaft construction (excl. rock blasting) (Note 2)	Excavator	2	80%	107
		Generator	1	100%	94

Stage No.	Construction Activities	Type of Equipment	Quantity (typical on site at any one time)	% ON Time	Assumed Sound Power Level, dB(A)[Note 1]
4	Launch shaft construction (excl. rock blasting) [Note 2]	Crane	2	30%	106
		Dump Truck (on site)	1	20%	107
		Dump Truck (transit)	5	20%	115
		Piling rig or D-wall grabber [Note 3]	1	30%	111
		Trailer trucks (for rebars)	1	30%	116
		Concrete truck & pump	3	30%	103
		Bar bending machine	1	20%	112
		Grouting Rig	2	30%	103
5	Tunnel works	TBM [Note 4]	2	100%	NA[Note 2]
		Generator	6	100%	94
		Sub Station (temp power supply)	1	100%	93
		Dump Truck (on site and inside muck pit)	3	20%	107
		Dump Truck (transit)	3	20%	115
		Gantry Crane	2	50%	92
		Compressed air plants (medical lock, air receivers)	1	100%	100
		Excavator (soil disposal at muck pit)	5	20%	116
		Trailers (for segment transportation into site)	1	100%	98
		Crane (50 ton)	2	100%	85
		Cooling tower & ventilation system	4	20%	116
		Muck loader	1	50%	NA[Note 2]
		Slurry treatment plant	1	100%	110
6	Ground improvement works (Jet Grouting method)	Jet grouting rig (power pack)	1 per 50 – 70 m^2 of land	100	108
		High pressure pump	1 per JGP	100	106
		Generator	2 per JGP	100	105
7	Cross passageway construction [Note 4]	Excavator	1	25%	99 [Note 5]

Stage No.	Construction Activities	Type of Equipment	Quantity (typical on site at any one time)	% ON Time	Assumed Sound Power Level, dB(A)[Note 1]
		Drilling jumbo	1	25%	120 [Note 5]
		Hydraulic rock cutter	1	25%	109 [Note 5]
		Wheeled loader	1	25%	108 [Note 5]
		Shotcrete machine	1	50%	108 [Note 5]
		Concrete mixing truck	3	50%	108
8	Facility building construction [Note 2]	Crane	2	30%	98
		Generator	2	100%	94
		Mobile Platforms	1	50%	95
		Concrete Mixing Truck	2	50%	108
9	General landscaping and finishing works [Note 2]	Lorry	3	20%	116
		Excavator	2	50%	108
		Road Roller	1	20%	108
		Vibratory compactor	1	20%	110
		Concrete Mixing Truck	1	30%	108
		Vibratory Poker	2	10%	106
		Generator	1	100%	94
		Dump trucks (onsite)	1	20%	107
		Dump truck (transit)	1	20%	115
		Road planer	2	30%	110
		Water cart	1	20%	104

Note 1: Reference made to noise databases in British Standards Institution's Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise. BS 5228-1:2014, and US Department of Transportation Federal Highway Administration Construction Noise Handbook.

Note 2: Most activities will be undertaken during the daytime period only i.e. 7 am – 7 pm. This is with the exception of activities where night works might be necessary due to safety considerations e.g. less traffic during road works, completion of trenching works; or engineering considerations e.g. completion of concrete pouring works.

Note 3: Due to noise considerations, equipment will not be operational in the event where the activity has to be undertaken in the evening or night i.e. after 7 pm.

Note 4: Cross passageway construction will only be undertaken for the twin tunnels proposed for Alignment Option 2.

Note 5: Noise contribution not significant as equipment will mainly be operating within underground shaft or tunnel.

Annex 2.0

Embedded Controls

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	Environmental Protection and Management Act, 2002 - Chap. 94A Environmental Protection and Management (Trade Effluent) Regulations, 2008 - Chap. 94A	• Treat all trade effluent before it is discharged into any watercourse or land, unless an exemption is specifically granted by the Director-General of the NEA. • Install sampling test points, inspection chambers, flow-meters, and recording and other apparatuses for trade effluent discharged into any watercourse or land. • Ensure trade effluent discharged to any land or watercourse complies with statutory limits and will not contain substances stipulated within the regulations. • Analyse trade effluent discharged into any watercourse or land in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation of the United State. • Prohibit discharge of any trade effluent, oil, chemical, sewerage or other polluting matters into any drain or land, without a license from the Director-General (NEA). • Prohibit discharge of trade effluent that contains: a) pesticides, fungicide, herbicide, insecticide, rodenticide or fumigant; b) refuse, garbage, sawdust, timber, human or animal waste or solid matter; c) petroleum or other inflammable solvent; and d) any reactive substance that may give rise to hazardous fumes or odour.	Construction
	Environmental Protection and Management (Hazardous Substances) Regulations, 2008 - Chap. 94A, Reg 4	Undertake measures to manage secondary impacts (i.e. vector) from primary impacts surface water quality (see *Table A2.6*).	Construction
2.0	Sewerage and Drainage Act, 2001 - Chap. 294 Sewerage and Drainage (Trade Effluent) Regulations, 2007 - Chap. 294	• Identify location of public sewerage drainage near any grading, boring, excavation or ground breaking works through desktop review of drainage plan and sewerage plan prior to the commencement of the works. Subsequent to this, carry out trial trenches to confirm the location of any such public sewerage system. •Restrict erection of structure or object, above or across any surface water drain. • Prohibit works that will affect any storm water drainage system, drain or drainage reserve, directly or indirectly, without obtaining in respect of those works, a clearance certificate or approval of the Public Utilities Board (PUB). • Monitor trade effluent discharged to the public sewer and submit a monitoring record that includes the following information to the PUB: (a) the amount of water consumed or used for the purposes of any trade, manufacture, business or building construction carried on by him and in the course of which the trade effluent is wholly or partly produced or of which the trade effluent is the waste or refuse; (b) the physical, organic and chemical nature of the trade effluent; (c) the raw materials and chemicals used in the trade, manufacture, business or building construction and the direction of the flow of any liquid or the trade effluent from or produced by any machinery, plant or equipment used in the trade, manufacture, business or building construction; and (d) such other matters relating to the trade effluent and the discharge thereof as may be required by the Board. • Prohibit discharge of trade effluent with characteristics that exceed the statutory limits to sewerage system. • Restrict works that involves extraction or intercepting of water from any place or sea. • Apply approval for works that involves extraction or intercepting of water from any place or sea.C8	Construction
3.0	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 - Chap. 294	• Recycle water used on site. • Develop and maintain an Erosion Control Measures (ECM) endorsed by a Qualified Erosion Control Professional (QECP) with the Code of Practice on Surface Water Drainage. • Prevent discharge containing total suspended solids (TSS) of more than 50 mg/l into any stormwater drainage • Undertake worksite planning to ensure that runoff within, upstream of and adjacent to the work site will be effectively drained away without causing flooding within or in the vicinity of the work site. • Position earth slopes outside of drainage reserve. • Turf all earth slopes adjacent to drains during reinstatement works. • Take all adequate measures to prevent any earth, sand, top-soil, cement, concrete, debris or any other material to fall or be washed into the storm water drainage system from any stockpile.	Construction
4.0	Code of Practice on Surface Water Drainage, 6th Edition, June 2013	• Submit an Earth Control Management Plan endorsed by a QECP to the PUB, prior to commencement of work. • Implement adequate preventive measures including the provision of proper and stable barricades or screens, where deemed necessary by a QECP.	Construction

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
5.0	Environmental Public Health Act, 2002 - Chap. 95 Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 - Chap. 95, Reg 11	• Provide adequate sanitary facilities for workers. • Contract a licensed toxic waste collector for collection and disposal of toxic waste, such as contaminated soil from construction works. • Train workers to handle toxic waste stored on site. • Prepare an emergency action plan that details how spillage and leakage from the transportation, storage, reprocessing or treatment of toxic waste will be handled. • Ensure that workers have received adequate instruction and training to handle any accident or emergency involving any toxic industrial waste stored or transported within the construction site. • Provide emergency response kits in the event of an emergency.	Construction
6.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition	**Chemical stored /handled onsite** • Obtain a storage license from SCDF for storage of petroleum and flammable materials within construction site. • The Contractor may store petrol up to a maximum volume of 5 litres on site provided that it is kept in a suitably constructed store which is licensed by the Fire Safety & Shelter Department of the SCDF. • Storage of diesel using drums or in bulk tanks and position the drums and tanks away from ignition sources or open drains. Label storage locations with a "No Smoking" sign. • Ensure that diesel drums and chemicals are stored under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all potential pollutive substances used on site, and shall be regularly maintained to prevent rain from washing out the pollutive substances. • All bulk diesel tanks shall be properly supported in an elevated position to facilitate gravity discharge. They shall stand within a bund constructed to contain a volume of 110% of the volume of the tank. There shall be no breaches in the bund wall, no material shall be stored within the bund and rain water collecting in the bund shall be regularly removed to prevent build-up. The inner face of the bund wall shall be coated with a chemical resistant material. A chemical resistant valve, which shall be closed at all times, except for releasing rainwater into a stormwater drain via an oil intercepting system, shall be installed at the outlet situated outside the bund, in accordance with the National Environment Agency (NEA) Code of Practice on Pollution Control. • Prohibit rolling of diesel drums along the ground. Transport diesel drums vertically chained on a trolley; or by a forklift fitted with a drum handling device and not standing unsupported on the forks or on a pallet; or by crane using a safe slinging technique. • Transfer diesel from the storage drum to another container, or to the tank of plant/machinery using a hand pump wherever practicable and at all times a drip pan must be provided. Where the diesel container is light enough to be lifted by one person it can be poured out by hand, using a funnel to guide the liquid. • Absorb spillages of diesel using sand or other absorbent materials and dispose the used absorbent materials as contaminated waste. • Prohibit diesel from entering the site drainage system unless this is connected to an interceptor prior to the site waste being discharged into the public sewer system. **Spillage on Road** • Provide and maintain a paved truck wash bay for washing vehicles leaving the worksite onto a roadway at each vehicular egress point before commencement of works on site. As part of the Earth Control Measures (ECM) Plan, obtain approval from Public Utilities Board (PUB) for the design of each truck wash bay. •Direct washwater from the wash bays into a water treatment plant for treatment. • Take preventative measures to limit the incidence of earth droppings from earth moving vehicles. • Assign personnel and establish a system of checks to ensure that all vehicles and trucks leaving the worksite do not have the potential to litter the roads due to its wheels or transportation materials. • Install a containment system or flap in all cement mixer trucks servicing LTA sites to prevent spillage of cement. • Ensure that specially designed and constructed watertight trucks are used to transport soft marine clay or similar transported wet materials. **Resource Conservation and Management** • Install water efficient products based on the Mandatory Water Efficiency Labelling Scheme (Mandatory WELS) as well as from the Voluntary Water Efficiency Labelling Scheme (Voluntary WELS) implemented by PUB. Use water efficient products used in site office such as basin taps & mixers, low capacity flushing cisterns, urinal flush valves and shower heads that are rated as "Excellent". • Use water efficient products used in site office such as basin taps & mixers, low capacity flushing cisterns, urinal flush valves and shower heads that are rated as "Excellent". • Ensure water-saving practices and recycling of water are undertaken. **Water and Land Pollution Control** • Ensure that all activities involving repair, servicing, engine overhaul works, etc are carried out on a concreted area which will be bunded or provided with scupper drains to channel all wastewater into the sewerage system. • Prepare a response plan to cater for accidental spillages into any watercourse and communicate this plan to all project personnel. • Conduct an emergency spillage exercise at least once per year. • Provide emergency spill kits on site in the event of any chemical spillages. Emergency response team shall also be competent in the use of these spill kits.	Construction

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		• Report all accidental spillages and trade effluent discharges to the Authority. • For construction sites involving earthworks with site area of 0.5 ha and above, the Contractor shall have an ECO with Earth Control Measures Officer (ECMO) qualification on site to ensure that the implementation, maintenance and inspection of ECM are in accordance to the QECP's design. The ECO shall also monitor the effectiveness of ECM throughout the various stages of construction. **Earth Control Measure** • Prevent silt from being washed into public drains by implementing Earth Control Measures (ECM) for the construction site. The discharge into public drains shall not contain Total Suspended Solids (TSS) in concentration greater than the prescribed limits under Regulation 4(1) of the *Sewerage and Drainage (Surface Water Drainage) Regulations.* • The Contractor shall note that the ECM are for the containment and treatment of silty discharge due to the impact of rainwater. ECM are not meant for the treatment of wastewater due to construction activities (such as slurry from tunnelling, pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under *Environmental Pollution Control Act (Chapter 94A)* . • Restrict the commencement of earth works without adequate ECM facilities, especially during the site clearance stage. • Submit schematic ECM plans of the construction site during tender stage taking into account the different phases of construction activities, including site clearance. Include the name of the Qualified Erosion Control Professional (QECP) who will be endorsing the ECM plan after the tender is awarded. • Prior to the commencement of construction works, engage a QECP to plan and design the ECM and implement the ECM accordingly. •Engage a QECP to conduct monthly site inspection to verify ECM implementation and its effectiveness during construction and submit an ECM inspection report based on the template specified in Guidebook on Erosion & Sediment Control at Construction Sites published by PUB, unless otherwise exempted by the Engineer. •Submit the ECM proposal duly endorsed by an appointed QECP. Develop the ECM proposal in accordance to the format in ATTACHMENT A-12 of *LTA General Specification Appendix A Safety, Health and Environment* . Submit the ECM proposal within 3 months of contract award. • For construction sites involving earthworks with site area of 0.5 ha and above, a CCTV system of at least 1 megapixel resolution shall be provided and operated at all times at the public drain near the discharge outlet(s) of the site to monitor discharge from the site. The system shall be capable of producing colour images to allow viewers to distinguish if the flow/discharge is clear or muddy. • Obtain a Certificate of Clearance from PUB and ensure that the ECM is implemented accordingly prior to the commencement of works. • During construction, the Contractor shall ensure the following measures are implemented on site, where applicable: Erosion Control Measures a) Sequence and schedule of the earthworks / demolition works in stages and progressively with the subsequent construction activities and building works; b) Minimise site disturbance by keeping site clearance works to a minimum by retaining as much of the existing vegetation as possible; c) Pave up the bare surfaces and all construction access by concrete or milled waste or other materials deemed suitable; d) Protect the bare slopes with close-turfing, concrete grouting, erosion control blanket or canvas; e) Protect the earth stockpiles with erosion control blanket or canvas; f) Restore ground cover over disturbed areas, which are or have become bare, as soon as possible; g) Carry out trench excavation work in sequence with the progress of permanent works to minimise impact on the environment; h) Identify the exposed bare surfaces and slopes for turfing or paving operation before the start of each phase of the project and restore ground cover over disturbed areas as soon as possible. i) Implement the appropriate covers, such as vegetation, hardcore, milled waste, concrete and erosion control blanket, to minimize the extent of any exposed earth surfaces. Sediment Control Measures a) Minimum C7 precast channel or concrete-lined cut-off drains within the construction sites. b) Silt fences shall be erected in front and along the cut-off drain. It shall be embedded firmly into the ground and constructed from an approved geotextile filter fabric to capture the sediment from storm water runoff. The sediment built-up behind the silt fence must be regularly removed. c) Intermediate silt traps of suitable size shall be installed at regular intervals along the perimeter lined cut-off drain. Within the intermediate silt traps, suitable geotextile filter fabric or equivalents shall be installed across the full depth and width and/or coagulation-assistance materials shall be placed. Silt traps relying primarily on hardcore, granite chips or sands for filtration are not acceptable	

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		d) The bio ball filtration system and/or other appropriate methods as approved by Engineer shall be used as part of the filtration system to control sediment. e) Sedimentation basin and/or storage pond/tank of adequate size and sufficient numbers shall be provided before treatment. It shall be minimum concrete lined and designed with storage capacity which complies with the design criteria specified in the Code of Practice on Surface Water Drainage. f) Suitable water treatment system/unit of adequate size and sufficient number shall be installed to treat only stormwater runoff before the discharge points into public drain. g) Water treatment system shall be equipped with a continuous, real-time, "live" monitoring of turbidity and TSS before any final discharge point and an on-line CCTV system at the public drain downstream of their final discharge outlet(s) to the public drain. This system should consist of a SMS "alert" feature when allowable limits are exceeded. The Contractor shall also submit the monitoring system proposal to the Engineer for acceptance. Access to the system shall be made available to the Engineer. h) The TSS monitoring meter shall be calibrated on a yearly basis. i) For construction sites involving earthworks with site area of 0.5ha and above, the Contractor shall provide and operate the CCTV system as follows: • Provide a CCTV system of at least 1 megapixel resolution at the public drain near the discharge outlet(s) of the site to monitor the discharge from the site. The CCTV should show clearly: - Site discharge outlet(s) at the public drain - Upstream public drain cross-section - Colour image that could distinguish if the flow/discharge is clear or muddy • Operate the CCTV at all times. The CCTV shall not have more than 4% downtime per month. Alert system such as via SMS, shall be provided to the Contractor if the system is not in operation. • Provide at least the past 15-day, 5-min interval snapshots of the CCTV within 2 days upon request by the Engineer or relevant authorities. • As part of the maintenance regime, the Contractor shall monitor the TSS value of discharged water using a portable TSS meter and compare the reading against the value provided by the real-time TSS meter of the treatment plant to determine if it is working properly. This shall be recorded and made available upon request. The portable TSS meter shall be made available for ad hoc monitoring/ upon request. • Removal of all excavated materials and spoils by the end of the day. • Ensure that the ECM plan is designed, installed and continuously reviewed by the QECP for every stage of the construction and earthworks. • Maintain the ECM for the whole duration of the contract to ensure that it is effective at all times. Proper records detailing the maintenance works, supported by dated photographs, shall be kept by the Contractor for verification. • In the event that there is any accidental discharge of silty water, activate emergency response measures to prevent the spread and to clean up the affected area. If the silty discharge is discovered by the relevant enforcement authority (i.e. PUB), the Contractor shall follow the PUB-LTA Working Response Protocol Framework (specified in Section 6 of ATTACHMENT A-12 of *LTA General Specification Appendix A Safety, Health and Environment*) to provide prompt investigation reporting to the Engineer and PUB. • Prohibit removal of the ECM until all works are completed and upon the advice of the QECP. Inform PUB and the Engineer prior to removal of ECM on completion of the project. **<u>Turbidity Curtain</u>** • For water bodies which are raw water sources for potable water and/or need for recreational purposes, high turbidity of the water in the water body will affect the treatment costs for potable water and/or the recreational use. • Install turbidity curtain for works in such water bodies, turbidity. The works including the design, fabrication, and installation of the primary and secondary turbidity curtains shall ensure that the turbidity of water in the water bodies around the works shall not exceed the preexisting levels or 50mg/l, whichever is greater. • Design, manufacture, install and maintain primary and, if necessary, secondary turbidity curtain(s) around the areas of marine construction, either across the water body to enclose the entire work area, or individual curtains within /around /along the water body to enclose work areas. • Use curtain(s) during excavation, installation of piles, foundations etc and backfilling works. Ensure that the curtain(s) is/are in good working condition for the duration of construction works. • Prohibit removal of turbidity curtain(s) until all the completion of all construction works and the water quality within the confines of the turbidity curtain meets the standards. • The purpose of the curtain(s) is to meet the water quality standards by minimizing the transport of turbidity and other constituents generated by construction activities in the water body. This includes excavation, wet recovery of micro tunnel equipment, bentonite slurry use, tremie concrete operations, backfill and all other construction activities conducted in or near the water body. The turbidity curtain system shall provide sufficient residence time to allow soil or bentonite slurry particles to fall out of suspension, reduce turbidity, and meet the water quality standards. • Submit the design of the curtain(s) for approval by LTA. The submission will include details required under LTA General Specification Appendix A Safety, Health and Environment	

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		Wastewater Management • The Contractor shall ensure that discharge of wastewater complies with all applicable statutory regulations, including the Sewerage and Drainage Regulations and Environmental Protection and Management Regulations. • The Contractor shall submit the process for wastewater management as part of the Waste Management Plan as specified in Attachment A- 10 of the *LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition.* • For wastewater (such as wastewater laden with chemicals from boring, diaphragm wall construction, EPB / slurry tunnelling, washing activities, etc.) generated due to the Contractor's work, the Contractor shall provide adequate separate containment, apart from surface runoff, and either treat in-situ to allowable discharge limits before discharging or dispose via licensed waste collector. The Contractor shall note that Earth Control Measures (ECM) are meant for the containment and treatment of silty rainwater runoff only, and not meant for the treatment of process water, such as oil, grease, cement and bentonite from tunnelling activities. • The Contractor shall minimise the volume of wastewater generated at source. Methods shall include reducing groundwater ingress into work areas, such as station, tunnel and shaft; reducing water usage for washing of tunnel and opting for manual scooping of spilled muck; minimising mixing of rainwater with wastewater; providing secondary containment for chemical drums inside TBM, etc. • For wastewater that is treated in situ on site, the Contractor shall seek the approval of the relevant authorities, including PUB and NEA, prior to discharging the treated wastewater into the sewer, watercourse or controlled watercourse. The Contractor shall engage a wastewater solution provider to design, install and maintain adequate treatment system to treat the wastewater to meet the respective allowable limits for the relevant parameters, such as pH, total suspended solid, total dissolved solid and chloride, before discharging the wastewater. • The Contractor shall also send samples of the treated wastewater at the final discharge point to an accredited laboratory for analysis to determine compliance with the applicable Environmental Protection and Management (Trade Effluent) Regulations or Sewerage and Drainage (Trade Effluent) Regulations, depending on the location of the discharge point, on a quarterly basis, or as and when requested by the Engineer. The Contractor shall maintain a proper record of all the sampling reports.	
7.0	Public Utilities (Reservoirs and Catchment Areas and Waterway) Regulations, 2006 - Chap. 261, S 401/2006	• Prior consent in writing from the PUB or an authorised officer shall be obtained for all vehicles brought into the Central Catchment Nature Reserve (CCNR); • No lorry exceeding a gross weight of 3 tonnes shall be allowed within the CCNR except with the permission of an authorised PUB officer; • Vehicles shall only be used through authorized entrances or exits or on roads within the CCNR approved by the PUB; • Vehicles shall maintain a speed not exceeding 25 kilometres per hour within the CCNR; and • The following activities which may cause damage are prohibited within the CCNR: (a) damage any plant, shrub or tree or any part of the same, or damage any flower bed, or do any act which causes damage to the flora; (b) kill, hunt, shoot or trap any animal or do any act which causes injury to the fauna; (c) bathe or wash himself or any other person, animal or thing in any reservoir or stream or pollute any reservoir or stream in any manner; (d) spit, urinate or defecate in any part of the grounds of the Catchment Area Park (including into any reservoir or stream therein) except in the appropriate toilet facilities provided for the purpose; and (e) destroy, damage, remove or displace any stone or granite block which is part of the structure of the reservoir (f) place, deposit or throw any refuse, rubbish, litter, food, bottle, glass, can or other article or thing in any place other than a refuse bin or receptacle provided for the purpose.	Construction and Operation
8.0	Guidebook for Best Environmental Practices: Water Resource Management at LTA Sites (2011)	• ECM is to be designed to cope with a minimum design rainfall intensity of a return period of 1 in 5 years storm; • Implement suitable erosion control measures to minimise the extent and duration of any exposed/bare/erodible surfaces by proper work sequencing, covering up all bare/erodible surfaces and progressive and timely revegetation and stabilisation - Minimise vegetation removal - Turfing - Stabilise site access - Install an Erosion Control Blanket (best complemented with turfing) or alternative covers - Slope gradient/slope terracing • Implement suitable sediment control measures that trap, contain and treat silty discharges from within a construction/earthworks site by installing: - Perimeter drain - Silt fence - Silt trap - Sedimentation basin/storage pond/tank - Treatment system - Turbidity curtains - Wheel wash • Provide all chemical/oil stores with facilities to contain any leak and spillage; • Collect all leaks and spillage for proper disposal as toxic industrial wastes; • Store concrete and cement as according to the Material Safety Data Sheet (MSDS); • Carry out washout of cement and concrete mixing plant or ready-mix lorries and equipment in concrete washout areas to protect against spills and leaks; and • In the event of an emergency spillage, stop work immediately to prevent further silty discharge/spillage, contain the spillage using bunds, sand, etc. immediately, and notify the Environmental Control Officer (ECO) immediately.	Construction

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
9.0	Guidebook on Erosion and Sediment Control at Construction Sites (PUB, 2014)	• A Clearance Certificate will be obtained from the PUB, before the commencement of works; • The ECM Plan shall include a monitoring and management system (including temporary stockpiled materials on site) and trainining of construction workers; • Cover all cleared or exposed areas when not in use or as specified by the QECP; • Ensure that cleared/exposed areas are reinstated following completion of construction works; and • Ensure that approval is obtained before removal of ECM.	Construction
10.0	Guidebook for Best Environmental Practices: Water Resource Management at LTA Sites (2011)	• Hydrocarbons and chemicals should be stored in an adequately sheltered area located away from the site drainage area, edges of watercourses and areas marked for vehicular movement; • Use drip trays or bunds of adequate capacity to contain at least 110% of the volume of the largest storage tank contained therein; • Washing of cement and concrete mixing equipment will be carried out in concreted areas with bunds designed for adequate containment of washout. Washout will be recycled on site where possible or collected by a licensed TIW collector (TIWC) for proper disposal offsite; • Onsite vehicles and equipment shall be inspected daily before commencement of works. Machinery exhibiting signs of oil or coolant leaks shall be serviced immediately at designated areas located away from watercourses or offsite; • The refuelling process shall be undertaken at a designated area with concrete flooring; • Delivery hoses and triggers shall be located within a bunded area at the worksite when not in use; • Refuelling facilities and equipment shall be checked on a regular basis to ensure that leaks or drips are fixed immediately to prevent loss and pollution; • Spill kits and emergency response equipment shall be provided at refuelling areas; and • All vehicle/equipment being refuelled shall be turned off and stationary, and shall not be left unattended during the refuelling operation.	Construction
11.0	LTA Engineering Group, Materials & Workmanship Specification for Civil & Structural Works (June 2010)	**Water Proofing for Structures** • The watertightness standards to be applied to all underground, water retaining or water excluding structures. • Ensure that all Category A structures are free from all visible leakage, seepage and damp patches. Category A structures are: 1. All Roof slabs 2. Suspended slab over tracks, concourses, and public areas, areas with sensitive electrical and mechanical plant, car parks and areas where leakage would, in the opinion of the engineer, affect the operation of the railway, roadway or other operations within the structure. 3. Walls and slabs to which finishes are applied. • Restrict leakage to minor damp patches with no visible film of water. (Note, Dampness is defined as moist to touch with no visible film of water) for all structures categorized as B. Structures fall within Category B include: 1. In situ base slabs with no finishes 2. In situ walls with no finishes 3. In situ abutments and retaining walls 4. Reinforced and unreinforced in situ tunnels or shafts 5. Diaphragm walls 6. Secant or contiguous piled walls **Stability of Pile Excavation Using Drilling Fluid** • Where the use of drilling fluid is accepted for maintaining the stability of a boring, the level of the fluid in the excavation shall be maintained so that the fluid pressure always exceeds the pressures exerted by the soils and external groundwater, and an adequate temporary casing shall be used in conjunction with the method to ensure stability of the strata near ground level until concrete has been placed. The fluid level shall be maintained at a level not less than 1.5 m above the level of the external groundwater. In the event of a rapid loss of bentonite suspension from the pile excavation, the excavation shall be backfilled without delay and the Engineer shall be informed immediately. The instructions of the Engineer shall be obtained before excavation at that location is resumed. • All reasonable steps shall be taken to prevent the spillage of bentonite suspension on the site in areas outside the immediate vicinity of boring. Discarded bentonite shall be removed from the site without delay. Disposal of bentonite shall comply with the regulations of the appropriate authority. • Pumping from a Pile excavation shall not be permitted unless a casing has been placed into a stable stratum which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping will not have detrimental effect on the surrounding soil or property. **Dewatering** • The Contractor shall install, operate and maintain all necessary pumping plant and drainage facilities and remove all accumulated silt and debris as required for proper execution of the works. • Groundwater control and drawdown shall be to the Engineer's acceptance and in line with the relevant method statement.	Construction and Operation

Table A2.1 Embedded Controls for Management of Impacts to Water Resources

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		• Where settlement due to consolidation is predicted to cause unacceptable damage to structures or utilities, the Contractor shall implement measures to prevent such damage. **Groundwater Leakage During Tunneling** • A high standard of waterproofing of bored tunnel linings shall be required. Groundwater leakage rates shall not exceed a general value of 2 ml/m2/h. For any 10 metre length of tunnel the leakage rate shall not exceed 5 $ml/m^2/h$. • The Contractor shall ensure that no loss of ground occurs through any part of the completed structure. • The specified degree of watertightness shall be achieved within 100 m of the tunnel face during construction and maintained thereafter. Where the tunnel is constructed in soft clays of the Kallang Formation the specified degree of watertightness shall be achieved within 30 m of the tunnel face in order to minimise surface settlement due to consolidation. • Notwithstanding the above limits on groundwater leakage the Contractor shall ensure that there is no visible water on the inside face of the tunnel segments beyond 200m from the tunnel face during the tunnel drive and that the final 200m of tunnel are similarly water free within 1 month of breaking through. **Disposal of Spoil & Slurry** • All contaminated spoilts and slurry discharge shall be properly contained and disposed separately to an acceptable dumpsite. • Maintain a record for quantity of slurry removed from site and spoil removed from site.	

Table A2.2 Embedded Controls for Management of Ambient Noise Impacts

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	Environmental Protection and Management (Control of Noise At Construction Sites) Regulations, 2008 - Chap. 94A, Reg 2	• Ensure that no work will be carried during the prohibited periods (Fourth Schedule) for construction work at any worksite located less than 150 m away from any hospital, home for the aged sick or residential building. If work is to be carried out during the prohibited periods within these contracts, the permission may be granted in writing by the Director-General of the NEA.	Construction
2.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition, Annex A-g, Clause 9	• Machinery and equipment will be shut down or throttled down to a minimum in the intervening periods between work. Vehicle drivers will ensure that engines will not be left idling if a longer-than-usual waiting time is anticipated. • All machinery and equipment used shall be labelled with a weather-proof sticker clearly indicating its noise emission level (at source) under normal operating conditions. Such emission levels should be measured at source (1 m to 3 m away). • All machinery and equipment used on site will be sound-reduced, as far as is practicable. Equipment which cause excessive noise shall be removed from the site. • All machine and equipment operators and workers will be trained and briefed on quieter work techniques, in particular during loading/ unloading activities, dismantling scaffolding or moving materials. • The contractor shall engage stakeholders and the community prior to commencement of the construction works and regularly throughout the construction period, to keep the community informed of activities via local newsletters, leaflets, newspaper advertisements and community notice boards. • A 24-hour contact telephone number shall be provided for the public to provide feedbacks. All feedbacks shall be recorded for subsequent follow up actions. • Quieter working or construction methods shall be used where available. Noise and vibration from piling activities, for example, may be reduced by the use of bored piling utilizing rotary boring/auger equipment. • Site inductions shall be undertaken to introduce all relevant project and subcontractor staff to noise mitigation measures, permissible hours of work, any limitations on high noise generating activities, location of nearest sensitive receptors, construction employee parking areas, designated loading/ unloading areas and procedures, site opening and closing times, environmental incident procedures. • High noise and vibration generating activities such as rock blasting shall be restricted only in continuous blocks not exceeding 3 hours each, with a minimum respite period of one hour between each block. • The worksite layout shall be planned to ensure site access points and loading and unloading of materials/ deliveries occur as far from sensitive receivers as possible; • No piling works to be done between 10pm and 7am unless both machinery and method are of a quiet nature. • Appropriate acoustic enclosures shall be provided for all launch shafts, including muck pits, and slurry treatment plants. Where this is not possible due to space constraints, alternative acoustic enclosure with the opened face oriented away from any residential/sensitive premises and covered with retractable acoustic rolling shutters shall be considered.	Construction

Table A2.2 Embedded Controls for Management of Ambient Noise Impacts

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		• Full length noise barriers shall be erected at immediate site boundaries facing any affected buildings as specified by NEA before work commences, unless otherwise justified to be non-implementable due to site constraint or safety reason by the Engineer. Such barriers shall be at least 10 m in height (not including cantilever) or break the line of sight from receiver to noise source. Such barriers shall have been tested to have a minimum of Sound Transmission Class (STC) 20 and must be erected with a cantilever extension inclined at 45 degrees at the top of the barriers. • Noisy activities such as bored piling works shall be barricaded with localized portable acoustic panels whenever possible. • Preparation for traffic diversion work will be carried out during the day and only the actual diversion will be carried out at night. Where activities have to be carried out at night (as approved by the Engineer), portable acoustic barriers must be set up in advance of such works. Residents must also be informed in advance of traffic diversion works. • Real time "live" monitoring devices shall be installed to monitor the noise levels for the entire construction period, unless exempted by the NEA. This system shall be equipped with a SMS "alert" feature when allowable limits are exceeded. • The Contractor shall monitor the noise levels for the whole duration of noisy activities, night works and works carried out over the weekends using portable Type 1 standard integrating noise meters.	
3.0	Best Environmental Practices: Noise Control at LTA Sites Guidebook, 2013	• Orient machinery/ equipment known to emit noise strongly in one direction, so that the noise is directed away from nearby sensitive receivers; • Reinforce behavioural practices. including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items/ slamming of doors; • Plan worksite traffic flow, parking and loading/ unloading areas to minimise reversing movements within the site; • Enforce a maximum speed limit for mobile equipment and vehicles within the site, so as to minimize noise and vibrational impacts from the movement of large equipment and heavy construction vehicles; • Include a resilient lining for the trucks which receive the waste material to reduce the high level of noise impact from dropping waste material into the truck; and • Plan the layout of the site by considering the use of materials and other large structural equipment such as noise barriers.	Construction
4.0	Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 - Chap. 94A, Reg 6	• Ensure that every motor vehicle (new or in use, whether or not registered in Singapore or elsewhere) conforms to the relevant standard of noise emission specified in *Annex 3.0* , *Table A3.5* .	Construction

Table A2.3 Embedded Controls for Management of Ambient Air Quality Impacts

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), April 2015	• Measures shall be taken to prevent materials (including earth) which are conveyed by trucks from dropping onto public roads or into public drains; • Regular housekeeping shall be carried out to ensure all nearby roads, pavements and public footpaths are kept clear of dust, silt and debris; • All site plant and machinery shall be thoroughly washed down before these leave the site; • All vehicular access points to the worksite shall be paved using suitable materials such as concrete, mill waste or hard core; • Vehicles shall comply with speed limit of 25 km/h for worksites within close proximity of the CCNR; • Water suppression shall be used for dust generating activities such as rock blasting; • All temporary stockpiles of spoil or backfill that have not been used for more than 3 days shall be covered with canvas sheeting or erosion control blankets; • Stockpiles shall be maintained on site for the shortest possible time. Stockpiles shall not have steep sides and kept moist using water or non-toxic chemical suppressants; • Drivers shall be trained to ensure that vehicles and equipment are not left idling when not in operation; and • All plant and machinery shall be maintained and operated in a manner such that they will not give rise to smoke emissions.	Construction
2.0	Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 - Chap. 94A, Reg 6	• Ensure that every vehicle used on site complies with the emission limits presented in *Annex 3.0* , *Table A3.5* to *Table A3.7;* • Every petrol driven motor vehicle that is in use must be equipped with a silencer, expansion chamber or other contrivance suitable and sufficient for reducing, as far as may be reasonable, the noise caused by the escape of exhaust gases from the engine where it is propelled by means of an internal combustion engine. • All parts of the exhaust system of any petrol driven motor vehicle shall be kept in good and sufficient condition and comply with the exhaust's requirements; and • Every diesel driven motor vehicle that is in use shall not emit smoke of opacity greater than 40 Hartridge Smoke Units (HSU) or its equivalent.	Construction
3.0	Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012 - Chap. 94A, S 299/2012 Singapore Air Quality Target	Ensure that all off-road vehicles meet US Tier II, EU Stage II or Japan Tier I emission standards depending on their power rating as specified in the regulations (see *Annex 3.0* , *Table A3.8*).	Construction
4.0	LTA's General Specification, (Appendix A) Safety, Health and Environment (for Rail Project), October 2018 Edition	• Provide and maintain a paved truck wash bay for washing vehicles leaving the worksite onto a roadway at each vehicular egress point before commencement of works on site. As part of the Earth Control Measures (ECM) Plan, obtain approval from Public Utilities Board (PUB) for the design of each truck wash bay. • Take preventative measures to limit the incidence of earth droppings from earth moving vehicles. • Assign personnel and establish a system of checks to ensure that all vehicles and trucks leaving the worksite do not have the potential to litter the roads due to its wheels or transportation materials. • Install a containment system or flap in all cement mixer trucks servicing LTA sites to prevent spillage of cement.	Construction

Table A2.4 Embedded Controls for Management of Impacts to Ecology & Biodiversity

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	Public Utilities (Reservoirs and Catchment Areas and Waterway) Regulations, 2006 - Chap. 261, S 401/2006	Undertake measures to manage impacts to surface water quality (see *Table A2.1*).	Construction and Operation
2.0	Parks and Trees Act, 2006 - Chap. 216 Parks and Trees Regulations, 2006 - Chap. 216, Reg 1	**Restricted activities in respect of trees, plants, etc., in the national parks and nature reserves** • The following activities are restricted in the CCNR: (a) cut, collect or displace any tree or plant or any part thereof; (b) affix, set up or erect any sign, shrine, altar, religious object, shelter, structure or building; (c) clear, break up, dig or cultivate any land; (d) use or occupy any building, vehicle, boat or other property of the Board; or (e) wilfully drop or deposit any dirt, sand, earth, gravel, clay, loam, manure, refuse, sawdust, shavings, stone, straw or any other matter or thing from outside the CCNR within CCNR. **Restricted activities in respect of animals, etc., in national parks and nature reserves** • The following activities are restricted in the CCNR: (a) capture, displace or feed any animal; (b) disturb or take the nest of any animal; (c) collect, remove or wilfully displace any other organism; or (d) use any animal, firearm, explosive, net, trap, hunting device or instrument or means whatever for the purpose of capturing any animal. (e) carry or have in the person's possession any explosive, net, trap or hunting device. (f) bring or release into, or abandon any animal in, or cause any animal to be brought or released into, or abandoned in a nature reserve; (g) release or abandon or cause any animal to be released or abandoned into any river, stream, canal or watercourse outside a nature reserve that the person knows, or ought reasonably to know, flows into or through the nature reserve; or (g) permit any animal belonging to or under the charge of the person to stray into a nature reserve. • Trees with girth exceeding 1 m which are growing within any tree conservation area or any vacant land, shall not be cut down without approval from the National Parks Board; • Temporary sanitary facilities and waste management areas will be provided to avoid the fouling of any lake, pool or other body of water due to presence of workers within the study area; and • Approval from the National Parks Board (NParks) shall be obtained before carrying out any activities that are restricted.	Construction and Operation
3.0	Wild Animals and Birds Act, 2000 - Chap. 351 Wild Animals and Birds (Bird Sanctuaries) Order, 1990 - Chap. 351, Order 1	• Workers will be trained to avoid undertaking prohibited activities such as: a) killing, taking or keeping of any wild animals and/or birds; b) placing or preparing or causing to be set, placed or prepared any spring gun, engine, pitfall, sharpened stake or other contrivance likely to endanger human life or inflict grievous hurt; and c) kinetting, snaring or taking by any means of contrivance of any bird.	Construction and Operation
4.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition	**Biodiversity Monitoring and Management Plan** • Use environmentally-friendly methods for vector control such as Bti and search & destroy operation etc. instead of anti-malaria (AM) oil, or chemical larvicides; • Use sound-reduced machines prior to entering the site; • Barricade noisy activities with portable sound barriers or panels; • When lighting has to be used, refrain from pointing the glare towards habitats. Lightings shall be directed downwards where work is carried out; • Site utilization plans shall consider preservation and protection of native trees as far as possible. Tree or shrubs that can be preserved and protected shall be identified with methods to prevent harm to the tree, branches and roots (refer to NParks Conservation of Trees and Plants Guideline); and • Preventive measures to ensure no trade effluent, chemical, diesel or silt discharges into nearby water bodies. **Site clearance including tree felling and transplanting works** • An arborist shall be engaged prior to the commencement of any site clearance or tree felling and transplanting activities. The appointed arborist shall be subject to the Engineer's approval. The arborist shall submit a proposal on the tree type(s) that require his supervision during felling and/or transplanting. For trees that have been identified by the arborist as requiring special attention, specific method statements and risk assessments with detailed diagrams on the tree removal method has to be endorsed by the arborist before the tree removal operation commences. **Waste Management** • All bins containing the site waste shall be cleared regularly to prevent build-up in these bins. They shall be removed from site and replaced/emptied once they have been filled; • The Contractor shall conduct housekeeping at least once a day to ensure that all litter is cleared from site; and • The site shall not allow feeding, rearing or breeding of animals such as dogs and all food waste shall be protected from animals scavenging for food.	Construction

Table A2.5 Embedded Controls for Waste Management

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	Environmental Public Health Act, 2002 - Chap. 95 Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 - Chap. 95, Reg 11	See Item 5.0 of *Table A2.1* .	Construction
2.0	Guidebook for Best Environmental Practices: Construction Waste Management at LTA Sites (2009)	• Excavated sand will be separated and collected for disposal at NEA's registered dumping site; • Non-contaminated excavated soil shall be sold to be reused for backfilling, reinstatement and landscaping works at off site locations; • Excess excavated materials shall be transported to LTA's staging ground; and • Labelled skip bins shall be provided for the proper storage and segregated collection of all construction waste.	Construction
3.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition	• All construction debris shall be disposed of at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA. Disposal of domestic refuse may be arranged with the Environmental Public Health Division (EHD). The Contractor shall pay all tipping fees at the gazetted dumping grounds. • The site shall not allow feeding, rearing or breeding of animals such as dogs and all food waste shall be protected from animals scavenging for food.	

Table A2.6 Embedded Controls for Management of Health & Safety

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	Workplace Safety and Health (General Provisions) Regulations 2007 Workplace Safety and Health (Construction) Regulations 2007	• Convene site coordination meetings to ensure safety, health and welfare of persons at work; • Ensure that no person carries out any manual work in the worksite unless the person has received adequate and relevant safety and health training; • All reasonably practical precautions to prevent possibility of fire will be undertaken, including but not limited to: - All electric wiring must be supported on proper insulators and not be looped over nails or brackets - No electric wiring or cable will be left or laid on the ground unless it is of the weather-proof type, provided with adequate protection to withstand wear and tear. Does not apply to flexible cables that are less than 3m in length and used to connect an electrical equipment to a plug. - All elevated power lines to have sufficient vertical clearance where they cross highways, access roads or areas travelled by trucks, cranes, shovels or other similar equipment, and be at least 5m above ground level - Any exposed metal part of an electrical appliance or current carrying equipment will be effectively earthed. - Regular housekeeping will be undertaken to ensure that combustibles do not accumulate so as to constitute a fire hazard in the worksite. - Adequate ventilation will be provided to ensure that air in the tunnel where a person has to work is free from flammable gases and vapours and contains between 19.5-23.5% oxygen by volume. - Oil, grease or fuel will be stored in tightly sealed containers in fire resistant areas at safe distances from explosives, magazines, electrical installations and away from the bottom of the launch / vent shafts. - Adequate and appropriate fire-fighting facilities will be provided in every tunnel in the worksite including a fire alarm system connected to the ground level. - At least one joint exercise for fire and rescue purposes will be conducted together with the Singapore Civil Defence Force in the course of the tunnelling works. • Explosives will be transported to and from the site under escort and supervision of armed guards from the Singapore Police Force. An armed guard will remain on during blasting works to ensure only authorized personnel have access to explosive material.	Construction
2.0	LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), September 2016 Control of Vectors and Pesticides Act, 2002 - Chap. 59	• A Vector Control Plan will be submitted to the LTA within 3 months of contract award, and will include all necessary measures to prevent the site from becoming favourable to the breeding and harbouring of vectors such as: - An in-house pest control team will be formed to carry out vector surveillance and control work; - An external NEA-licensed Pest Control Operator (PCO) will be engaged to supplement in-house vector surveillance and control. PCO must carry out vector control and surveillance at least once a week. - The in-house pest control team will carry out search and destroy activities of any potential breeding grounds, especially after every rainfall, using the "zoning method" as described in Section 7.9 of the LTA's General Specification, Appendix A, Safety, Health and Environment (for Rail Project), April 2015. - The adult mosquito population will be regularly monitored using well-maintained gravitraps. - All site offices/containers will have a sloping/pitched roof installed with the sides adequately shielded from rain. Containers for office or storage purposes on site will be sited on concrete paved ground with perimeter drains for effective surface water drainage. - Appropriate ground cover such as concrete paved, milled waste or steel plates shall be used to prevent puddling at the worksites. - Environmentally-friendly methods for vector control will be used e.g. Bacillus Thuringiensis Israelensis (BTI) and search & destroy operation etc. instead of anti-mosquito (AM) oil, chemical larvicides or fogging. - A Vector Control Time-out will be carried out when mosquito breeding is discovered on site by the NEA. A detailed search and destroy effort will be undertaken to eliminate any potential breeding grounds. • Undergrowth or vegetation within 6 m of any stream or water body will not be cleared without prior approval of Director-General of Public Health.	Construction

Table A2.6 Embedded Controls for Management of Health & Safety

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
3.0	Environmental Protection and Management (Hazardous Substances) Regulations, 2008 - Chap. 94A, Reg 4	• Application for a Hazardous Substances Permit will be undertaken should it be necessary to store hazardous substances in quantities exceeding that defined in the regulations; • Preventive measures will be taken to minimise accidental release of hazardous substances into the environment, such as the use of secondary containment and restricted access to storage areas; • An emergency action plan containing information as stated within the Regulations will be established to deal with accidents and emergencies that may arise from the transport or storage of hazardous substances; • Adequate instruction and training will be provided to all workers to enable them to understand: a) Nature of the dangers of all hazardous substances being stored. b) Emergency action plan to be implemented in the event of any accident or emergency involving any hazardous substances stored.	Construction
4.0	Fire Safety (Petroleum and Flammable Materials – Exemption) Order, 2008 - Chap. 109A, Order 4 Fire Safety (Petroleum and Flammable Materials) Regulations, 2008 - Chap. 109A, Reg 7	• In the event that storage of petroleum and/or flammable materials in quantities exceeding that specified in the First Schedule of the Fire Safety (Petroleum and Flammable Materials – Exemption) Order, 2008, is required, Contractors will obtain a Petroleum & Flammable Materials Storage License from the SCDF. • Contractors holding a Petroleum and Flammable Materials Storage License shall implement the following controls for the storage of petroleum and/or flammable materials on site: - Keep and maintain up-to-date records of all petroleum and flammable materials on site for a minimum period of 3 years or until the petroleum or flammable materials have ceased to be stored on site, whichever occurs later. - Take all practicable steps to prevent the occurrence of an accident through fire, explosion, leakage or ignition of any petroleum or flammable material or vapours. - Ensure that security measures are undertaken to prohibit access to the licensed storage premises by untrained personnel. - Provide adequate fire-fighting material and other emergency response equipment eg spill kits at the storage site. - Ensure that chemical handlers are trained to handle available equipment and are aware of the actions to be taken in the event of any fire, explosion, leakage or other similar emergencies. • Only licensed drivers will be commissioned to transport petroleum and flammable materials to and from the worksites. Drivers will prepare, keep up-to-date and be trained to implement an adequate Transport Emergency Response Plan to deal with any spillage, leakage, release, accident or emergency which may arise from the transport of petroleum or flammable materials; and • Every container, tank, road tanker, freight container, or other vehicle used to store or transport any petroleum or flammable material is affixed with and has displayed on it the appropriate emergency information panel or warning labels as prescribed in the code of labelling specified in the Singapore Standard on Hazard Communication for Hazardous Chemicals and Dangerous Substances" (SPRING Singapore).	Construction
5.0	Arms and Explosives (Explosives) Rules, 2007	**<u>Transportation of Explosives</u>** • Only explosives that are compatible will be transported in the same vehicle to and from the shaft worksite before and after blasting works. • Explosives will not be transported via public roads during the following peak traffic periods: a) weekdays from 7 am to 9.30 am, and from 5 pm to 730 pm; b) weekends from 7 am to 9 am, and from 12 noon to 2.30 pm. • Only personnel above the age of 18 years, who have undergone training from the Hazmat Unit of the Singapore Civil Defence Force and has been issued a Hazmat permit, will function as an operator or driver of the vehicle transporting explosives to and from the worksite. • The operator or driver of the vehicle transporting explosives to and from the worksite will ensure that the type and quantity of explosives will not exceed the quantities specified in the *Sixth Schedule* of the *Arms and Explosives (Explosives) Rules* , for the relevant vehicle used. • The operator or driver of the vehicle transporting explosives to and from the worksite will ensure that the vehicle used is suitable, and is marked in accordance with the *Eighth Schedule* of the Arms and Explosives (Explosives) Rules, for the relevant type and quantity of explosives being transported. • The operator and the driver of a vehicle used for the transport of explosives to and from the worksite will only use a route specified by a Licensing Officer from the Singapore Police Force. The operator or driver will not convey the explosives through a road tunnel or an underpass.	Construction

Table A2.6 Embedded Controls for Management of Health & Safety

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
		• The Contractor will ensure that explosives are kept in a locked explosives store when not in use, and are at all times under the constant supervision of a competent person. • The Contractor will be present at every blasting operation and will ensure that the shotfirer is suitably trained with appropriate practical experience, and/or under the close personal supervision of a trained and competent shotfirer.	
6.0	LTA's General Specification Appendix A, Safety, Health and Environment (for Rail Project), October 2018 Edition	**Usage & Storage of Hazardous Materials** • The Safety Data Sheets (SDS) of all hazardous substances and chemicals will be assessed prior to its entry to site for its suitability in terms of environmental, health and safety hazards, for consideration of safer alternatives, if available; • All hazardous substance and chemical containers will be labelled, its movement recorded and returned to the designated storage areas when not in use; • Up to a maximum volume of 5 litres of petrol will be stored on site in a suitably constructed store licensed by the Fire Safety & Shelter Department of the SCDF; • Diesel will be kept in drums or bulk tanks located at a designated place away from any sources of ignition or open drain that does not lead to an interceptor; • Workers will be trained to avoid smoking at storage locations. A suitable charged fire extinguisher will be kept on standby at each storage location; • Diesel drums and chemicals will be stored under shelter within concrete bund walls or in storage containers with good ventilation. Drip trays will be provided and maintained for all drums, plant and machinery and potentially pollutive substances used on site; • Any spillages of diesel will straight away be absorbed using sand or other absorbent materials, which will be disposed of as contaminated waste. On no occasion shall diesel be allowed to enter the site drainage system unless it is connected to an interceptor prior to discharge to the drainage system. • Oil booms, skimming devices, and pollution containment devices will be provided as and when necessary to prevent contamination of nearby water bodies; • Emergency spill kits will be provided on site; and • All accidental spillages and trade effluent discharges from the worksites will be investigated and report to the LTA. **Blasting Works** • A Blast Assessment Report will be developed by a qualified Explosives Consultant, which will include: - Site details / diagrams and photographs; - Specific hazards / site conditions; - Identified existing and planned sensitive receivers; - Environmental and structural effects; - Measures to avoid the generation of flyrock; - Ground vibration calculations at various receptor locations, including assumptions made and equation used; - Methods of reduction of vibration generated; - Vibration measurement and equipment used; - Blast method, including blast pattern and limits fo charge weight per day; - Names of competent and experienced blasters; - Definition of danger zones around the blasting site; - Details of underground communication system for blasting; - Protectionary measures to ensure blasting safety and security; - Protection measures to any openings from excessive air blast/air overpressure and noise during blasting; - Contingency plans in the event of a misfire or delayed blast; - Emergency response plan for any blast related event which has the immediate potential to or has previously caused injury or death.	Construction

Table A2.7 Embedded Controls for Management of Geology (Tunneling and Excavation)

Item No	Act / Standard / Regulation	Embedded Controls	Applicable Project Phase
1.0	LTA Civil Design Criteria for Road and Rail Transit Systems February 2010	• The tunnel should be continuously and fully supported with a permanent lining designed to support the full overburden including water load with minimal deformation during the work. In soft ground, the lining should satisfy the load combinations and distortion loads requirements. Segmental pre-cast concrete lining shall consist of a number of pre-cast segments bolted together to form rings. • In order to minimise surface settlements due to consolidation in soft ground, the specified degree of water tightness shall be achieved within 30m of the tunnel face. In all other ground conditions, the specified degree of watertightness shall be achieved by the Tunnel Basic Structure Completion Date. • Co-extruded single composite gasket consisting of an elastomeric carrier and hydrophilic facing material. • Adequate protection shall be provided against the ingress of ground water into the excavation. • Ground loss from the face and tail void or over-break, etc. should be minimised by providing adequate support to the face and continuous tail void grouting. • Use of blasting technique to remove hard strata or obstruction is not acceptable unless the inherent risks are reduced to acceptable levels. • Cross Passageways between bored running tunnels shall be located in accordance with requirements for the Standard for Fire Safety in Rapid Transit Systems issued by the Singapore Civil Defence Force & Land Transport Authority.	Construction
2.0	LTA Materials & Workmanship Specification for Civil & Structural Works, June 2010 Edition	• Measures to prevent ingress of water with fines/ soil must be implemented. Specified degree of water tightness must be achieved within 100m of the tunnel face during construction and thereafter, to minimize surface settlements due to consolidation in soft ground through waterproofing. • Ground improvement measures such as grouting, pipe arch roof techniques should be adopted to prevent ground collapse or raveling or soil, etc. A suitable grout mix shall be proposed for each set of ground conditions to be encountered along the tunnel drive. The grout shall be sufficiently fluid as to ensure that it flows freely under pressure into all parts of the space to be filled. All grout mixes and injection methods shall be submitted to the Engineer for acceptance. • The excavation method shall be chosen as to minimise the settlement and disturbance of the groundmass to ensure the structural integrity of existing surface and underground structures in the vicinity of excavation works. • Excavation shall be appropriate to the size of the underground opening and to prevailing ground conditions. Excavation shall all times be subject to acceptance by the Engineer. • Advance probe drilling will be conducted ahead of excavation face, with details of drilling parameters and other relevant observations recorded for later interpretation.	Construction

Annex 3.0

Administrative Framework

ANNEX 3.0 ADMINISTRATIVE FRAMEWORK

This Annex presents the following:

- Singapore legislature applicable to the Construction and Operation phase of the CRL, a summary of their key objectives and embedded controls specified within; and
- The statutory limits for noise emissions, emissions to air, and discharge of trade effluent into controlled and uncontrolled waterways.

A3.1 LEGISLATURE AND GUIDELINES APPLICABLE TO THE PROJECT

Table A3.1: Key Objectives of Legislature and Guidelines Applicable to the Project

Legislature/ Guideline	Key Objectives
Legislature	
Environmental Protection and Management Act (EPMA) Chapter 94A, 2002	The EPMA consolidates the laws and regulations relating to environmental pollution control and aims to ensure the protection and management of the environment and resource conservation. These laws and regulations mostly encompass abiotic environmental aspects such as air, noise, wastewater emissions and waste management.
Environmental Public Health Act (EPHA) Chapter 95, 2002	This act stipulates regulations for the maintenance of public places to ensure the protection of public health. Regulations applicable to construction sites include stipulations around the management of waste and toxic industrial waste, as well as discharges or emissions that may result in nuisance to the public.
Building Control Regulations Chapter 29, 2003	These regulations detail requirements for plan submissions for excavations and construction of underground buildings; and outline the minimum duties and qualifications for personnel designing earth retaining and stabilizing structures.
Arms and Explosives (Explosives) Rules Chapter 13, 2007	These regulations stipulate the licensing requirements and duties of personnel involved in overseeing, planning and undertaking blasting works. Guidelines on the type and quantities of explosives to be transported to and from the site, as well as other transportation requirements are also prescribed.
Public Utilities Act Chapter 261, 2002	This is the authorizing act for regulations surrounding permitted and prohibited activities in reservoirs and catchment areas. These include the prohibition of causing injury to any flora or fauna in a Catchment Area Park, and provides for the prevention of pollution of any stream of a reservoir.
Sewerage and Drainage Act Chapter 294, 2001	This act stipulates regulations for the maintenance, improvement, operation, and use of sewerage and land drainage systems. It also sets the standards which trade effluent must meet before discharge into watercourses.

Legislature / Guideline	Key Objectives
Parks and Trees Act Chapter 216, 2006	This act sets provisions 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. The act also authorizes regulations surrounding permitted and prohibited activities within the areas listed above. All species of flora and fauna found NParks' managed areas are also protected under the Act.
Wild Animals and Birds Act Chapter 351, 2000	An act authorizing the penalization of activities causing harm to, the killing, trapping, and illegal trade of wild birds and animals. Six birds in Singapore are not protected under this act. These are the house crow (*Corvus splendens*), feral pigeon (*Columba livia*), purple-backed starling (*Sturnus sturninus*), Philippine glossy starling (*Aplonis panayensis*), common myna (*Acridotheres tristis*) and the white-vented myna (*Acridotheres javanicus*).
Guideline	
LTA's General Specifications (Appendix A) Safety, Health and Environment (Rail Project) September 2016 Edition	This document details LTA requirements for contractors working on LTA construction projects, in terms of management of worker health and safety, as well as environmental impacts.
LTA's Materials & Workmanship Specification for Civil & Structural Works June 2010 Edition	This document details LTA requirements for contractors working on LTA construction projects, in terms of materials and workmanship for a range of construction activities eg demolition, site clearance, earthworks, piling etc. Standards are prescribed with reference to local and international standards and guidelines.
LTA's Civil Design Criteria for Road and Rail Transit Systems February 2010 Edition	This document details LTA requirements for engineers working on LTA road and rail transit system projects, in terms of civil design standards. The prescribed standards make reference to local and international standards.
LTA's Architectural Design Criteria June 2015 Edition	This document lays out requirements for the architectural design of land transport facilities, to ensure that objectives such as integration with the existing character of the area, optimal use of space, public safety and pedestrian flow etc, are met.
Standard for Fire Safety in Rapid Transit Systems 2012 Edition	This standard is jointly published by the Singapore Civil Defence Force (SCDF) and the LTA, and details the fire protection and safety requirements for underground and aboveground rapid transit systems, such as tunnels, stations and facility buildings.
Fire Code 2013	This document details fire safety requirements for developments. Prescriptive guidelines are provided for temporary buildings at construction sites, buildings under construction as well as for mega underground developments eg underground MRT station.
NParks' Handbook on Tree Conservation & Tree Planting Provision for Development Projects	This handbook provides design guidelines in line with statutory and technical requirements on greenery provision within premises and along the roadside, tree planting and tree conservation for developments in Singapore.
Singapore Standard SS 593 : 2013 Code of Practice for Pollution Control	This document details good practices for potentially polluting industries in order to maintain a high quality living environment in Singapore. It compiles emission standards for air, noise and wastewater, and lists substances considered as hazardous or toxic industrial waste. The document supplies guidelines for controls and mitigation measures for the listed environmental aspects.

Legislature / Guideline	Key Objectives
Code of Practice on Surface Water Drainage 6th Edition, 2013	This document stipulates that discharge from any construction or earthwork sites into storm water drainage systems must adhere to discharge limits prescribed in the Sewerage and Drainage (Surface Water Drainage) Regulations. It also recommends that these sites practice recycling of water. Guidelines on good earth control practices can also be found in this document.
SS 602 : 2014 Code of Practice for Noise Control on Construction and Demolition Sites	This document details best practices undertaken during development and execution of construction and demolition works to ensure that noise emissions are appropriately and adequately controlled.
CP 5: 1998 Code of Practice for Electrical Installations	This document details good practices to ensure safety from electric shock and fire in the use of electricity and relates principally to the design, selection, erection, inspection and testing of electrical installations. This provides the standards against which electrical equipment should be certified against for the safe use of electricity.

A3.2 EMISSION STANDARDS

For surface runoff discharged from construction sites, the Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 stipulates a limit of 30 mg/l for Total Suspended Solids (TSS) due to the drainage system around the Project which discharges to Controlled Watercourse.

For trade effluent generated from construction sites, applicable limits are dependent on the discharge outlets. These are summarized in *Table A3.2*.

Table A3.2: Trade Effluent Discharge Limits to Public Sewers and Watercourses

Parameter	Limits for Discharge into Public Sewer (Units in mg/l or otherwise stated)	Limits for Discharge into a Watercourse (Note 1) (Units in mg/l or otherwise stated)	Limits for Discharge into Controlled Watercourse (Units in mg/l or otherwise stated)
Temperature of discharge	45 ºC	45 ºC	45 ºC
Color	-	7 Lovibond Units	7 Lovibond Units
pH	6 – 9	6 – 9	6 – 9
BOD_5	400	50	20
COD	600	100	60
Total Suspended Solids (TSS)	400	50	30
Total Dissolved Solids (TDS)	3,000	-	1,000
Chloride (as chloride ion)	1,000	-	250
Sulphate (as SO_4)	1,000	-	200
Sulphide (as sulphur)	1	0.2	0.2
Cyanide (as CN)	2	0.1	0.1
Detergents (linear alkylate sulphonate as MBAS)	30	15	5
Grease and Oil (Total)	-	10	1

Parameter	Limits for Discharge into Public Sewer (Units in mg/l or otherwise stated)	Limits for Discharge into a Watercourse (Note 1) (Units in mg/l or otherwise stated)	Limits for Discharge into Controlled Watercourse (Units in mg/l or otherwise stated)
Grease and Oil (Hydrocarbon)	60	10	-
Grease and Oil (Non-hydrocarbon)	100	-	-
Arsenic	5	0.1	0.01
Barium	10	2	1
Tin	10	-	5
Iron (as Fe)	50	10	1
Beryllium	5	-	0.5
Boron	5	5	0.5
Manganese	10	5	0.5
Phenolic compounds (expressed as phenol)	0.5	0.2	-
*Cadmium	1	0.1	0.003
*Chromium (trivalent and hexavalent)	5	1	0.05
*Copper	5	0.1	0.1
*Lead	5	0.1	0.1
*Mercury	0.5	0.05	0.001
*Nickel	10	1	0.1
*Selenium	10	0.5	0.01
*Silver	5	0.1	0.1
*Zinc	10	1	0.5
*Metals in total	10	1	0.5
Chlorine (Free)	-	1	1
Phosphate (as PO_4)	-	5	2
Calcium (as Ca)	-	-	150
Magnesium (as Mg)	-	-	150
Nitrate (NO_3)	-	-	20
Fluoride (F)	15	-	-
Caustic Alkalinity ($CaCO_3$)	2,000	2,000	2,000

Notes:

Note 1: Coastal waters are categorised as a watercourse, as defined by the *Environmental Protection and Management Act 2002*.

*The concentration of Toxic Metal shall not exceed the limits as shown, individually or in total. Where 2 or more of the metals listed are present in the trade effluent, the total concentration of the metals shall not exceed 10 mg/L.

Additional Notes:

Based on the *Environmental Protection and Management Act (Trade Effluent) Regulations 2008*, the trade effluent discharged must not include:

- Radioactive material;
- Any pesticide, fungicide, herbicide, insecticide, rodenticide or fumigant;
- Refuse, garbage, sawdust, timber, human or animal waste or solid matter;
- Petroleum spirit or other inflammable solvent; or
- A substance that either by itself or in combination or by reaction with other waste or refuse may give rise to any gas, fume, or odor or substance which is or is likely to be a hazard to human life, a public nuisance, injurious or otherwise objectionable.

In addition, based on the *Sewerage and Drainage (Trade Effluent) Regulations 2007,* the trade effluent discharged to sewers must not include:

- Any toxic industrial waste specified in the first column of the Schedule to the Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 (Chapter 95, Regulation 11);
- Calcium carbide;
- Any organic compound (VOCs/ SVOCs) specified in the First Schedule;
- Yeast, spent or unspent molasses, crude tar, tar oil, carbon disulphide, hydro-sulphide and poly-sulphide;
- Any waste or refuse liable to form a viscous or solid coating or deposit;
- Any excessively discoloring substance;
- Blood waste;
- Infectious waste; and
- Any substance of a nature or quantity which can cause a fire in, damage to or interfere with the public sewer or system.

The trade effluent shall be analyzed in accordance with the latest edition of *Standard Methods for the Examination of Water and Wastewater* (American Public Health Association, the American Water Works Association and the Water Environment Federation of the United States).

Sources: Environmental Protection and Management (Trade Effluent) Regulations 2008 and Sewerage and Drainage (Trade Effluent) Regulations 2007

Noise limits for construction sites are stipulated in the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008*, and summarized in *Table A3.3*. Where background ie pre-construction noise measurements are available, maximum permissible noise levels can be adjusted using correction factors presented in *Table A3.4*.

Table A3.3: Maximum Permissible Noise Levels for Construction Sites

Types of Affected Buildings	Maximum Permissible Noise Levels for Construction Sites in Decibels (A) (Note 1, Note 2)							
	Over 12 hours		Over 1 hour			Over 5 minutes		
	7am-7pm (Day)	7pm-7am (Night)	7am-7pm (Day)	7pm-10pm (Eve)	10pm-7am (Night)	7am-7pm (Day)	7pm-10pm (Eve)	10pm-7am (Night)
Hospitals, schools, institutions of higher learning, homes for the aged sick, etc.	60	50	-	-	-	75	55	55
Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	-	-	65	55	Mondays - Saturdays		
						90	70	55
						Sundays and Public Holidays		
						75	55	55
Buildings apart from those listed above	75	65	-	-	-	90	70	70

Note 1: For construction work commenced on or after 1 October 2007

Note 2: The Fourth Schedule states that all works are prohibited from 10 pm every Saturday to 7 am the following Monday, and from 10 pm on the eve of a public holiday to 7 am the following day.

Source: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008

Table A3.4: Noise Correction Factors

Difference in decibels (A)(Note 1)	Correction Factor in decibels (A)(Note 2)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	0

Note 1: Denotes the difference between the background noise level and the applicable maximum permissible noise levels listed in *Table A3.3*.

Note 2: The addition of the correction factor to the higher of the two noise levels, ie the background noise level or the relevant maximum permissible noise level will constitute the new maximum permissible noise level applicable to the Project.

Source: Third Schedule of the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008

Standards for noise and air emissions from vehicles are stipulated in the Environmental Protection and Management (Vehicular Emissions) Regulations 2008, and summarized in *Table A3.5* to *Table A3.7*. Air emission standards for off-road diesel engines, which are applicable for construction equipment, are stipulated in the Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012 and summarized in *Table A3.8*.

Table A3.5: Standards for Noise Emissions for New and In-Use Motor Vehicles

Class of Vehicle	Permissible Exhaust Noise Emission Levels in Decibels (A) (Note 1)		
	New Vehicles (Registered on/after 1 October 2010)	In-Use Vehicles (Registered on/after 1 July 1999)	In-Use Vehicles (Registered before 1 July 1999)
Motor cycle (with or without a side car), scooter or trivan	94	99	106
Motor car, taxi or station wagon (whether for passengers only or for goods and passengers)	96 or 100 (Note 2)	103	105
Goods vehicle or bus with gross vehicle weight not exceeding 3.5 tons	97	103	-
Goods vehicle or bus with gross vehicle weight exceeding 3.5 tons	99	107	-
Light goods vehicle (Note 3)	-	-	109
Goods vehicle or bus with engine capacity not exceeding 10,000 cm^3	-	-	113
Goods vehicle or bus with engine capacity exceeding 10,000 cm^3	-	-	115

Note 1: Measured 0.5 m from the open end of the exhaust pipe of the vehicle
Note 2: If engine is at rear end
Note 3: Refers to a goods vehicle with maximum laden weight not exceeding 3 metric tons registered in Singapore before, on or after 1 July 1999. This does not include to any construction equipment, vehicles used for specific purposes or a mobile canteen and recovery vehicles.

Source: Environmental Protection and Management (Vehicular Emissions) Regulations, 2008

Table A3.6: Exhaust Emission Standards for Motor Vehicles

Class of Vehicle	Date of Registration	Exhaust Emission Standards
Petrol driven motor vehicles	On or after 1 April 2014	i) EC Directive 98/69/EC-B (2005) (Note 1); or ii) Paragraphs 102 and 121 of Article 28 of the Japanese Ministry of Land, Infrastructure and Transport Announcement No. 1318 dated 26 September 2003
Diesel driven motor vehicles		
Passenger car	On or after 1 January 2014	i) Regulation (EC) No. 715/2007 (Note 2), Table 1, Annex I; or ii) JPN 2009 (Note 3)
Motor vehicle with gross vehicle weight not exceeding 3.5 tons		i) Regulation (EC) No. 715/2007, Table 1, Annex I; or ii) JPN 2009
Motor vehicle with gross vehicle weight exceeding 3.5 tons		i) EC Directive 2005/55/EC-B2 (2008) (Note 4); or ii) JPN 2009
Motor cycles and scooters		
All motor cycles and scooters	1 July 2013 - Before 1 October 2014	Directive 97/24/EC
Two-wheeled	On or after 1 October 2014	Row B of table referred to in paragraph 2.2.1.1.5 of Annex II of Chapter 5 of Directive 97/24/EC
Three-wheeled		Row A of the table referred to in paragraph 2.2.1.1.5 of Annex II of Chapter 5 of Directive 97/24/EC

Note 1: Refers to the Euro IV Emissions Standards.
Note 2: Refers to the Euro V Emissions Standards for the vehicle class stated above.
Note 3: JPN2009 refers to Article 41 of the Japanese Ministry of Land, Infrastructure and Transport Announcement No. 619 dated 15 July 2002.
Note 4: Refers to the Euro V Emissions Standards for the vehicle class stated above.

Source: Environmental Protection and Management (Vehicular Emissions) Regulations, 2008

Table A3.7: Exhaust Emission Limits for In-Use Motor Vehicles

Class of Vehicle	Date of Registration	Emission Limits for Carbon Monoxide[Note 1)]
Petrol driven motor vehicle (apart from motor cycle)	On or after 1 July 1992	3.5% by volume
	1 October 1986 - Before 1 July 1992	4.5% by volume
Motor cycle	On or after 1 October 1986	4.5% by volume
	Before 1 October 1986	6% by volume

Note 1: Taken as a percentage of total volume of exhaust emissions

Additional requirements:

- Every in-use diesel driven motor vehicle must not emit smoke of opacity greater than 40 Hartridge Smoke Units (HSU)
- Every in-use motor vehicle must not emit any visible smoke or vapor.
- Every in-use petrol driven motor vehicle must be equipped with a silencer, expansion chamber or contrivance to reduce the noise caused by the escape of exhaust gases from the engine
- All parts of the exhaust system of any petrol driven motor vehicle must be in good condition and comply with exhaust requirements.

Source: Environmental Protection and Management (Vehicular Emissions) Regulations, 2008

Table A3.8: Standards for Emissions from Off-Road Diesel Engines

Net Power (P) (kW)	Emission Standards
8 ≤ P < 19	Japan Tier I, EU Stage II, US Tier II
19 ≤ P < 560	Japan Tier I, EU Stage II
P > 560	US Tier II

Source: Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012

Annex 4.0

Scoping Matrix

Project	CRL CCNR EIA
Title	C&O EIA Scoping Review - Alignment Option 1
Reference	0256660
Date	2 August 2019

	No interaction
I	An interaction with the environment or receptor which is not expected to be significant
S	An interaction with the environment or receptor that could be significant
P	Denotes a positive interaction

	ACTIVITIES	ENVIRONMENT & RECEPTORS																	
		Physical								Biological									
	Project Activity	**Ambient Air Quality/ Dust Deposition**	**Ambient Noise**	**Groundborne noise & vibration**	**Surface water**	**Hydrology**	**Geology**	**Hydrogeology**	**Topography**	**Terrestrial Habitats**	**Terrestrial Flora & Fauna**	**Aquatic Habitats**	**Aquatic Flora & Fauna**	**Protected Areas**	**Cultural / Historical Resources**	**Landscape & Visual**	**Tourism/ Recreation**	**EMBEDDED CONTROLS**	**Comments**
A	**Pre-Construction**																		
1	Subsurface scanning for utilities									I									
2	Site clearance (incl. tree felling, land grading activities) for worksites, temporary access roads, road diversion works etc.	S	I		S	I	I	I	I	S	S	S	S			S	S	No activities that may cause damage to trees or vegetation within the CCNR is allowed. Approval will be sought from NParks prior to felling of any tree with girth > 1 m. Earth control measure (ECM) plan approved by a Qualified Erosion Control Professional (QECP) will be implemented at each worksite, and include consideration of temporary stockpiling activities and training of workers.	Direct impact to terrestrial habitats due to tree felling and earthworks within isolated forest in SICC Island golf course, and secondary impact to terrestrial habitats within Windsor Nature Park. Tree felling could lead to impacts to visual amenity of recreational users of the SICC Island clubhouse and Windsor Nature Park. Secondary impacts associated with land clearance and earth works are dust generation due to erosion of exposed soil; and increased sediment loading to nearby streams i.e.streams Ma3 and Ma4, which are tributary streams along the Venus Loop trail south of Island Club Road, are downstream of worksite within SICC Island golf course (see Figure 2.2, Vol I, Chapter 2).
3	Road, drainage and utilities diversion ie. cut and cover works	I	I		I			I								I	I	Road, drainage and utilities diversion will be undertaken in conjunction with respective agencies / utility providers, to ensure compliance with their requirements.	No major utilities were identified within the CCNR. Diversion of underground cables etc. will involve shallow excavation undertaken in the developed areas and will likely be short-term. Minor diversion works for Island Club Road to maintain access for recreational users of SICC amenities.
4	Setting up of temporary worksite office and laydown areas (incl. sanitary facilities)	I	I							S	S					I	I	Lighting at aboveground worksites shall be directed downwards to minimize glare effects on surrounding habitats.	

	ACTIVITIES	ENVIRONMENT & RECEPTORS																EMBEDDED CONTROLS	Comments
		Physical								Biological									
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Landscape & Visual	Tourism/ Recreation		
5	Installation of instrumentation e.g. piezometers, settlement markers at former soil investigation borehole locations (Phase I of Project)	I	S	I	S	I	I	I	I	S	S	S	S	S		S	S	- No vegetation clearance; - Avoid stream/wetland/heavily vegetated areas; - Use of erosion control blankets at the worksite; - Safety barriers around the worksite; - Potential closure of trail; - Storage of equipment etc on truck, to be transported out daily; - Use of environmentally friendly polymer to reduce volume of water used; - Customization of drill rig set up through the use of a metal container within the starter pit, to ensure full containment of slurry water; - Periodic visual checks to ensure no leakage along hose; - Selection of non-natural areas for installation of hoses; - Camouflaging of installations to minimize visual intrusion for wildlife; - Training of workers to undertake activities employing measures to minimize noise emissions eg metal on metal emissions due to dropping of metal casings; - Screens could be set up around the rig to control noise (typically 3 m high, not enclosed); and - Usage of least-intrusive backfilling methodology.	Piezometers / settlement markers are typically placed at 25 m intervals along a tunnel alignment. Selected locations at Phase I SI borehole locations i.e. 16 locations along approximately 2 km of tunnel alignment within the CCNR, was proposed taking into consideration environmental sensitivities of the CCNR. Duration of rig placement at each location estimated to be up to 20 days, inclusive of mobilisation and decommissioning. If proper housekeeping measures are implemented, impacts due to rig set up can be minimized. As the TBM approaches piezometer/settlement marker location, worker will access instruments via CCNR trails at most once a day to undertake measurements. In the event that abnormal readings are registered from the TBM, frequency of access to these surface instrumentation will be increased.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																		
		Physical								Biological										
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Landscape & Visual	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
B	Construction																			
1	Transportation of manpower, equipment and materials to/ from the worksites	I	I							I	S					S	I	Every petrol driven motor vehicle used shall comply with the air and noise emissions stipulated in the Environmental Protection and Management (Vehicular Emissions) Regulations, 2008. Measures shall be taken to prevent materials (including earth) which are conveyed by trucks from dropping onto public roads or into public drains. Regular housekeeping shall be carried out to ensure all nearby roads, pavements and public footpaths are kept clear of dust, silt and debris. All site plant and machinery shall be thoroughly washed down before these leave the site. All vehicular access points to the worksite shall be paved using suitable materials such as concrete, mill waste or hard core.	Increased risk of roadkill and restricted movement of fauna across temporary access routes.
2	Installation of retaining walls (i.e. secant bored piling and rock bolting) as part of construction of launch/retrieval shaft	I	S	S	I			I			S						I		Noise generated from secant bored piling may impact nearby ecological receptors.
3	Excavation of launch shaft (incl. rock blasting)	I	I	I			I	I	I	I	S						I	Ambient noise, overpressure and vibration associated with blasting may have impacts to nearby ecological receptors within Windsor Nature Park, as well as nearby human receptors. Use of blast protection measures such as the use of blast blankets and metal decking at the mount of the excavation pit.	Ambient noise, air overpressure and vibration associated with blasting may have impacts to ecological receptors. Recreational users may be impacted by temporary restriction of access to trails during blasting works at the A1-W1 (LS/VS) worksite. There will be no blasting works required at the A1-W2 (LS/VS) worksite.
4	Ground improvement works (grouting from within the tunnel)			I		I	I	I				I	I						The need for grouting will be determined through advance probing before the TBM approaches. Grouting will be undertaken from within the tunnel should the collection of bore samples from the advance probe verify the presence of local fractured zone ahead of the TBM cutterhead. Local fractured zones are projected outside the CCNR approaching Bright Hill.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																EMBEDDED CONTROLS	Comments
		Physical								Biological									
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Landscape & Visual	Tourism/ Recreation		
5	Operation of TBM for Single Bored Tunnel (SBT)		S	I			I	I		S	S		I	I			I	Soil investigation works has been undertaken to establish the rock head depth and depth of weathered granite. TBM will be operated below the rock head level at depths ranging between 15 m and 75 m.	Impacts from vibration due to passing TBM to recreational users of the SICC clubhouse and CCNR trails are not expected to be significant due to short-term duration and depth of tunnel. NOTE: Groundborne noise is only applicable where there are underground building structures that transfer vibration energy to noise. Groundborne noise impacts to ecological receptors is therefore not expected.
6	Finishing works within the tunnel			I															
7	Toxic industrial waste, site preparation waste (eg debris, vegetation, soil, aggregates) and general waste (domestic/non-hazardous) generation and disposal at the worksite (ie slurry, spoil)	S	I		S		S					S	S	S					Temporary stockpiling of soil on site during excavation and for backfilling works could lead to increased dust generation and sediment loading of nearby streams, i.e. streams Ma3 and Ma5 downstream of SICC Island golf course. Potential contamination of soil during temporary stockpiling of excavated spoil onsite.
8	Backfilling and construction of ventilation shafts	S	S				I	I			S					I	I		Disturbance to ecological receptors due to ambient noise generated from night-time activities such as concrete pouring for the construction of ventilation shafts. Earthworks may result in dust generation at the worksites.
9	Construction of Facility Building (incl. permanent access road, vehicle parking lot(s)	I	S		I					S	S	I	I			I	I		Permanent access roads to the facility buildings will inhibit movement of fauna between habtitats.
10	Finishing works (incl. landscaping, road works etc)		S						I	I						I			
C	**Operation**																		
1	Operation of ventilation shafts / Facility Buildings	I	I								I						I		Impacts due to the venting of air and emissions of ambient noise expected to be insignificant.
2	Vehicular access to Facility Building for maintenance	I	I								S						I		Increased risk of roadkill.
3	Vehicular access during replacement of ventilation shaft equipment eg fan (once every 20 years approx)	I	I								I						I		Impacts associated with vehicular access insignificant due to low frequency of occurrence.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																		
		Physical								Biological										
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Landscape & Visual	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
4	Operation of trains			I						I	I	I	I	I					Groundborne noise and vibration impact associated with operation of trains not expected to be significant due to depth of tunnel, availability of technology for low vibration generation and implementation of engineering mitigation solutions, if required. NOTE: Groundborne noise is only applicable where there are underground building structures that transfer vibration energy to noise. Groundborne noise impacts to ecological receptors is therefore not expected.
D	**Unplanned Events**																		
1	Excessive ground settlement due to loss of tunnel pressure during tunnelling works				S	S	S	S	I	S	S	S	S	S		S	S	Soil investigation works have been undertaken to establish the rock head depth to inform the tunnel depth, and thereby reduce the likelihood of encountering weathered/fractured granite. TBM will be operated below the rock head level at depths ranging between 23 - 90 m bgl.	Excessive soil and ground settlement during tunnelling could impact terrestrial and aquatic habitats overhead due to sedimentation, groundwater drawdown, tree fall etc. Recreational users of CCNR trails and golfers would also be impacted due to potential closure of affected areas. It is noted that the likelihood of sinkhole formation occurring is negligible when tunnelling within rock, drawing from LTA tunnelling works undertaken in the last 30 years. The alignment underlying the CCNR will be tunnelled fully within rock. However, a section of the alignment outside of the CCNR approaching Bright Hill will be tunnelled above rockhead.
2	Failure of slope near Sime Stream, triggered by vibrations generated during tunneling works undertaken in heavy rainfall conditions				S	S	S	S	S	S	S	S	S	S		S	S		
3	Water ingress to tunnel leading to potential water drawdown at surface water bodies				I	s		S				I	I	I				Entrances to TBM will be designed for flood prevention during heavy rain ie. Elevated entrances. Operation of close-face TBM, using slurry to maintain pressure at the cutter head. Advanced probing during TBM operation.	
4	Retrieval of TBM when it gets stuck		I	I						I	I							Retrieval options will be undertaken wholly underground via existing tunnels. The TBM will be dismantled in situ and removed to the nearest worksite via the existing tunnels.	In the event emergency retrieval of the TBM is required, ambient noise associated with retrieval operations are only expected at launch/retrieval shafts which are outside the CCNR. Impacts to nearby ecological receptors are therefore not expected to be significant.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																		
		Physical								Biological										
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Landscape & Visual	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
5	Fire during construction works	S			S					S	S						S	Contractor shall develop a comprehensive plan for fire precautions and evacuations during tunneling works, to address activities that may pose a fire risk. Fire fighting equipment and procedures shall be installed / implemented during tunnel boring and equipment installation phases.	Generation of smoke plumes from launch/retrieval shaft worksites could lead to impacts to nearby terrestrial habitats. Recreational users may be impacted by temporary restriction of access to trails during firefighting.
6	Fire during train operation	I								I	I			I				Inspection of track system and tunnels once every 4 - 7 days to identify and change out defective components that may lead to fire, e.g. electrical cables.	Impacts to air quality will be transient during venting of smoke from ventilation shafts.
7	Accidental spillage/leakage of hazardous chemicals, waste etc handled or stored at the worksites or uncontrolled discharge of untreated runoff or materials from worksites to nearby surface waterbodies due to failure of Earth Control Measures system, vehicular accident along access roads leading to dumping of concrete etc				S							S	S	S				Concreting of worksite and provision of secondary containment for chemicals/fuel/waste stored at worksites, such as bunds and drip trays. Design and sizing of Earth Control Measures system for worksite to take into consideration a minimum containment capacity associated with a once in 10 year storm. Enforcement of speed limit to 40 km/h at worksite access roads.	

Project	CRL CCNR EIA
Title	C&O EIA Scoping Review - Alignment Option 2
Reference	0256660
Date	2 August 2019

	No interaction
I	An interaction with the environment or receptor which is not expected to be significant
S	An interaction with the environment or receptor that could be significant
P	Denotes a positive interaction

	ACTIVITIES	ENVIRONMENT & RECEPTORS																	
		Physical								Biological									
	Project Activity	**Ambient Air Quality/ Dust Deposition**	**Ambient Noise**	**Groundborne noise & vibration**	**Surface water**	**Hydrology**	**Geology**	**Hydrogeology**	**Topography**	**Terrestrial Habitats**	**Terrestrial Flora & Fauna**	**Aquatic Habitats**	**Aquatic Flora & Fauna**	**Protected Areas**	**Cultural / Historical Resources**	**Aesthetics (Visual)**	**Tourism/ Recreation**	**EMBEDDED CONTROLS**	**Comments**
A	**Pre-Construction**																		
1	Site clearance (incl. tree felling, land grading activities) for worksites, temporary access roads, road diversion works etc.	S	S		S	I	I	I	I	S	S	S	S		S	S	S	Approval will be sought from NParks prior to felling of any tree with girth > 1 m. Earth control measure (ECM) plan approved by a Qualified Erosion Control Professional (QECP) will be implemented at each worksites, and include consideration of temporary stockpiling activities and training of workers.	Clearance of land for worksites / facility building and clearance of land to the east of PIE for road diversion of works, will lead to tree felling and possible exhumation of graves within Bukit Brown and Seh Ong cemeteries (cultural heritage/historical resources). Due to topography of indicative worksites, land grading required, leading to potentially significant dust generation during earthworks. Increased risk of sediment loading on stream(s) located downgradient of A2-W2 (LS/VS) worksite.
2	Road, drainage and utilities diversion i.e. cut and cover works	I	I		S			I	I	I	I				I	I		Road, drainage and utilities diversion will be undertaken in conjunction with respective agencies / utility providers, to ensure compliance with their requirements.	No major utilities identified. Air and noise emissions associated with road works and minor excavation works not likely to be significant due to short-duration of works, and considering high air/noise baseline levels.
3	Setting up of temporary worksite office and laydown areas (incl. sanitary facilities)	I	I		I		I				I					I		Lighting at aboveground worksites shall be directed downwards to minimize glare effects on surrounding habitats.	Short-term emission of noise and vehicular emissions during installation of pre-fabricated structures, not expected to have significant impacts.
4	Installation of instrumentation e.g. piezometers, settlement markers	I	S	I	S	I	I	I	I	S	S	S	S	S		S	S	- Avoid stream/wetland areas where possible; - Use of erosion control blankets at the worksite; - Safety barriers around the worksite; - Periodic visual checks to ensure no leakage along hose; - Selection of non-natural areas for installation of hoses; - Camouflaging of installations to minimize visual intrusion for wildlife; - Training of workers to undertake activities employing measures to minimize noise emissions eg metal on metal emissions due to dropping of metal casings; and - Screens could be set up around the rig to control noise (typically 3 m high, not enclosed) where worksite is located near to noise sensitive receptors.	Piezometers / settlement markers be placed at 25 m intervals along the tunnel alignment where such locations are accessible for workers. Duration of rig placement at each location estimated to be up to 20 days, inclusive of mobilisation and decommissioning. As the TBM approaches piezometer/settlement marker location, worker will access instruments at most once a day to undertake measurements. In the event that abnormal readings are registered from the TBM, frequency of access to these surface instrumentation will be increased.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																	
		Physical								Biological									
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Aesthetics (Visual)	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
B	Construction																		
1	Transportation of manpower, equipment and materials to/ from the worksite	I	I							I	S				I	I		Every petrol driven motor vehicle used shall comply with the air and noise emissions stipulated in the Environmental Protection and Management (Vehicular Emissions) Regulations, 2008. Measures shall be taken to prevent materials (including earth) which are conveyed by trucks from dropping onto public roads or into public drains. Regular housekeeping shall be carried out to ensure a ll nearby roads, pavements and public footpaths are kept clear of dust, silt and debris. All site plant and machinery shall be thoroughly washed down before these leave the site. All vehicular access points to the worksite shall be paved using suitable materials such as concrete, mill waste or hard core.	Air and noise emissions due to increased heavy vehicular traffic not likely to be significant as compared to baseline levels due to existing traffic.
2	Installation of retaining walls (i.e. secant bored piling and rock bolting) as part of construction of launch/retrieval shaft	I	S	S	I			I			S								Ambient noise and vibration associated with installation of ERSS (secant bored piling, rock bolting) may lead to nuisance impacts to nearby human and ecological receptors.
3	Installation of groundwater recharge wells	I	I		I			I			I					I			Groundwater recharge wells to be drilled at 5 m intervals around worksites located in proximity to other structures.
4	Excavation of launch shaft (incl. rock blasting)	I	I	I			I	I			S					I	I	Use of blast protection measures such as the use of blast blankets and metal decking at the mount of the excavation pit.	Ambient noise, overpressure and vibration associated with blasting may have impacts to nearby ecological receptors within Bukit Brown Tree Conservation Area and within isolated forest between Sime Road and PIE, as well as receptors in close proximity to the A2-W1 (LS/VS), A2-W2 (LS/VS) and A2-W3 (LS/VS) worksites.
5	Ground improvement works (grouting from the surface either vertically or inclined, assuming worst case method i.e. jet grouting)	I	S	I	S	I	I	I		S	S	S	S		I	S	I	- Noise barriers around the worksite - Acoustic enclosures for stationary equipment such as pumps and generators	Ground improvement will be undertaken from the surface using jet grouting rigs as a worst case method. Where there is surface access, rigs with vertical drills will be used; where there is limited surface access, rigs with inclined drills will be used. Where the tunnel will be excavated above the rockhead level or with rock cover less than 2 m thick, jet grouting rigs will be used to install 1.2 m diameter concrete piles at tunnel depth, in advance of the TBM. These concrete piles will be installed within a 12 m corridor centred on each tunnel. Vegetation clearance will be required within the corridor to create space for the jet grouting rig and ancillary equipment such as cement/water pumps, generator, and vertical cement silo for grout batching.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																		
		Physical								Biological										
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Aesthetics (Visual)	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
6	Operation of TBM for Twin Bored Tunnels (TBT)		S	S			I	I		I	S				I				Groundborne vibration generated from passing TBM might result in nuisance impacts to nearby residents, and may result in structural damage to Hai Lam Sua Tee Kong Toa Temple.
7	Construction of cross passages at 250 m intervals within the tunnels by mining and drilling-and-blasting methods			S			I	I										Perimeter blasting will be undertaken to minimise the likelihood of damage to surrounding geology (e.g. fractures).	Instantaneous vibration levels which are perceptible, may be felt at surface level.
8	Finishing works within the tunnels			I															
9	Excavation of standalone ventilation shafts	I	S	I			I	I								I		Use of blast protection measures such as the use of blast blankets and metal decking at the mount of the excavation pit.	Ambient noise, overpressure and vibration associated with blasting may have impacts to nearby residents.
10	Toxic industrial waste, site preparation waste (eg debris, vegetation, soil, aggregates) and general waste (domestic/non-hazardous) generation and disposal at the worksite (ie slurry, spoil)	S			I		S			I	I	S				I		Adequate sanitary facilities to be provided at worksites. Facilities to be provided for full containment and emergency spill response for toxic waste stored on site. Toxic waste to be periodically collected by licensed contractors for offsite disposal. Labelled skip bins to be provided for the proper storage and segregated collection of all construction waste. Stockpiles shall be maintained on site for the shortest possible time. All temporary stockpiles of spoil or backfill that have not been used for a fixed period stipulated by the QECP, shall be covered with canvas sheeting or erosion control blankets. Stockpiles shall not have steep sides and shall be kept moist using water or non-toxic chemical suppressants.	Temporary stockpiling of soil on site during excavation and for backfilling works could lead to increased dust generation. Increased risk of contaminated runoff into streams located downgradient from worksite A2-W2 (LS/VS).
11	Backfilling and construction of ventilation shafts at launch/retrieval shaft worksites	S	S				I	I			S					I			Disturbance to ecological receptors and nearby human receptors due to ambient noise generated from night-time activities such as concrete pouring for the construction of ventilation shafts. Earthworks may result in dust generation at the worksites.
12	Construction of Facility Building (incl. permanent access road, vehicle parking lot(s)	I	S		I					I	I	I	I		I	I	I		Permanent access roads to the Facility Buildings likely to have limited interface with the Bukit Brown Cemetery due to the location of Facility Building along Lornie Road.
13	Finishing works (incl. landscaping, road works etc)		S						I	I						I			

	ACTIVITIES	ENVIRONMENT & RECEPTORS																		
		Physical								Biological										
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Aesthetics (Visual)	Tourism/ Recreation	EMBEDDED CONTROLS	Comments
C	**Operation**																		
1	Operation of ventilation shafts / Facility Buildings	I	I								I					I			Impacts due to the venting of air and emissions of ambient noise expected to be insignificant.
2	Vehicular access to Facility Building for maintenance	I	I								S						I		Risk of roadkill not likely to be significantly increased as access to Facility Buildings will be ad-hoc, as compared to heavy vehicular traffic along existing roads.
3	Vehicular access during replacement of ventilation shaft equipment eg fan (once every 20 years approx)	I	I								I						I		Impacts associated with vehicular access insignificant due to low frequency of occurrence.
4	Operation of trains			I													I		Groundborne noise and vibration impact associated with operation of trains not expected to be significant due to depth of tunnel, availability of technology for low vibration generation and implementation of engineering mitigation solutions, if required. NOTE: Groundborne noise is only applicable where there are underground building structures that transfer vibration energy to noise. Groundborne noise impacts to ecological
D	**Unplanned Events**																		
1	Excessive soil and ground settlement due to loss of tunnel pressure to the surface				S		S	S	I	S	S	S	S		S	I	S	Soil investigation works will be undertaken to establish the rock head depth and depth of weathered granite, and thereby reduce the likelihood of encountering weathered/fractured granite.	Excessive soil and ground settlement during tunnelling could impact terrestrial habitats due to tree fall etc. Existing building structures could also be impacted.
2	Water ingress to tunnel leading to potential water drawdown at surface water bodies				I	S		S				S	S					Entrances to TBM will be designed for flood prevention during heavy rain ie. Elevated entrances. Operation of close-face TBM, using slurry to maintain pressure at the cutter head. Advanced probing during TBM operation.	There are no waterbodies overlying Alignment Option 2. However, significant groundwater drawdown could lead to formation of sinkholes (see interactions for formation of sinkholes).
3	Retrieval of TBM when it gets stuck		I	I							I							Retrieval options will be undertaken wholly underground via existing tunnels. The TBM will be dismantled in situ and removed to the nearest worksite via the existing tunnels.	In the event emergency retrieval of the TBM is required, ambient noise associated with retrieval operations are only expected at launch/retrieval shafts. Impacts to nearby ecological receptors are therefore not expected to be significant.
4	Fire during construction works	S					S	I		S	S							Contractor shall develop a comprehensive plan for fire precautions and evacuations during tunneling works, to address activities that may pose a fire risk. Fire fighting equipment and procedures shall be installed / implemented during tunnel boring and equipment installation phases.	Generation of smoke plumes from launch/retrieval shaft worksites could lead to impacts to nearby terrestrial habitats and human receptors.
5	Fire during train operation						I			I	I							Inspection of track system and tunnels once every 4 - 7 days to identify and change out defective components that may lead to fire, e.g. electrical cables.	Impacts to air quality will be transient during venting of smoke from ventilation shafts.

	ACTIVITIES	ENVIRONMENT & RECEPTORS																EMBEDDED CONTROLS	Comments
		Physical								Biological									
	Project Activity	Ambient Air Quality/ Dust Deposition	Ambient Noise	Groundborne noise & vibration	Surface water	Hydrology	Geology	Hydrogeology	Topography	Terrestrial Habitats	Terrestrial Flora & Fauna	Aquatic Habitats	Aquatic Flora & Fauna	Protected Areas	Cultural / Historical Resources	Aesthetics (Visual)	Tourism/ Recreation		
6	Accidental spillage/leakage of hazardous chemicals, waste etc handled or stored at the worksites or uncontrolled discharge of untreated runoff or materials from worksites to nearby surface waterbodies due to failure of Earth Control Measures system, vehicular accident along access roads leading to dumping of concrete etc				S							S	S					Concreting of worksite and provision of secondary containment for chemicals/fuel/waste stored at worksites, such as bunds and drip trays. Design and sizing of Earth Control Measures system for worksite to take into consideration a minimum containment capacity associated with a once in 10 year storm. Enforcement of speed limit to 40 km/h at worksite access roads.	

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