Environmental Impact Assessment (EIA) at DE170

Document no: D3591700-EIA-06
Revision no: 6

Environmental Impact Assessment (EIA) at DE170 Construction of Tengah Vehicular Interchange at Kranji Expressway (KJE)
6 April 2023

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Project name:	Environmental Impact Assessment (EIA) at DE170 Construction of Tengah Vehicular Interchange at Kranji Expressway (KJE)		
Client reference:	DE170	Project no:	D3591700
Document no:	D3591700-EIA-06	Project manager:	Catherine Baldedara
Revision no:	6	Prepared by:	C De Zilva, CK Chua, J Tan, YY Ting
Date:	6 April 2023	File name:	CJC EIA DE170_Public Report

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
0	2023.01.26	For Review prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
1	2023.02.16	For URA/MND approval prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
2	2023.02.19	For URA/MND approval prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
3	2023.02.25	For URA/MND approval prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
4	2023.03.20	For URA/MND approval prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
5	2023.03.28	For MINDEF review prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara
6	2023.04.06	For MND approval prior to Public Disclosure	C De Zilva, CK Chua, J Tan, YY Ting	J Julia, X Wang	A Wong, K Gavile,	C Baldedara

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Acronyms and abbreviations

APHA	American Public Health Association
ASR	Air Sensitive Receiver
BIA	Biodiversity Impact Assessment
BOD	Biological Oxygen Demand
CCNR	Central Catchment Nature Reserve
COD	Chemical Oxygen Demand
COP	Code of Practice
CR	Critically Endangered
CS	Conservation Significance
dB	decibels
dBA	A-weighted decibels
DBH	diameter at breast height
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
EBS	Environmental Baseline Study
EIA	Environmental Impact Assessment
EN	Endangered
EPA	Environmental Protection Agency
EPM	Environmental Protection and Management
EPMA	Environmental Protection and Management Act
EW	Extinct in the Wild
EX	Extinct
GIS	Geographic Information System
GPS	Global Positioning System

HDB	Housing and Development Board
HK EPD	Hongkong Environmental Protection Department
IBC	Intermediate Bulk Container
JRL	Jurong Region Line
JRL	Jurong Region MRT Line
KJE	Kranji Expressway
L_{Aeq}	A-weighted equivalent continuous sound level in decibels
LOA	Letter of Award
LTA	Land Transport Authority
mg/m^3	microgram per cubic meter
MRT	Mass Rapid Transit
Ms	milliseconds
NE	Presumed Nationally Extinct
NG	Nature Group
NMDS	non-metric multidimensional scaling
NSR	noise sensitive receiver
NTU	Nanyang Technological University
pH	potential of hydrogen
PIE	Pan-Island Expressway
PM	particulate matter
PME	powered mechanical equipment
QGIS	Quantum Geographic Information System
RL	reduced level
SAAQT	Singapore Ambient Air Quality Target
SAC	Species accumulation curve
SING	Singapore Botanic Gardens' Herbarium

SLA	Singapore Land Authority
SS	Singapore Standard
TA	Technical Agencies
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
URA	Urban Redevelopment Authority
VUL	Vulnerable
WQ	Water Quality
WSP	Water Standpipe

1. Introduction

1.1 Overview

This Environmental Impact Assessment (EIA) Report has been prepared for the proposed DE170 Construction of Tengah Vehicular Interchange at Kranji Expressway (KJE) (hereinafter referred as "the Project") at Tengah, located in the western region of Singapore. The Lead Developing Agency for the Contract is Land Transport Authority (LTA) while the appointed Contractor is Chye Joo Construction Pte Ltd (CJC). This EIA is established to follow the scope requirements in the Contract Specifications.

The EIA report provides an evaluation of the existing pre-construction baseline environmental status along approximate development area and an assessment of the various impacts to the environment as a result of the proposed construction and operation activities carried out along the development area. Measures to mitigate and manage the potential impacts to the environment and sensitive receptors have been recommended as part of this EIA.

1.2 Project Understanding

The Project is the design and construction of a new road interchange across KJE with connecting vehicular road and bridge called Forest Drive, leading into Tengah New Town (**Figure 1-1**). This flyover sits above the forest corridor running through Tengah Town that is envisioned to form part of the larger network of greenery that connects the Western Water Catchment Area (WWCA) and the Central Catchment Nature Reserve (CCNR), allowing connectivity to remain underneath. The Project also involves the widening and modification of Lam Sam Flyover and vehicular bridge widening along KJE. At the western section, a culvert will be built to provide fauna connectivity from the forest corridor into WWCA.

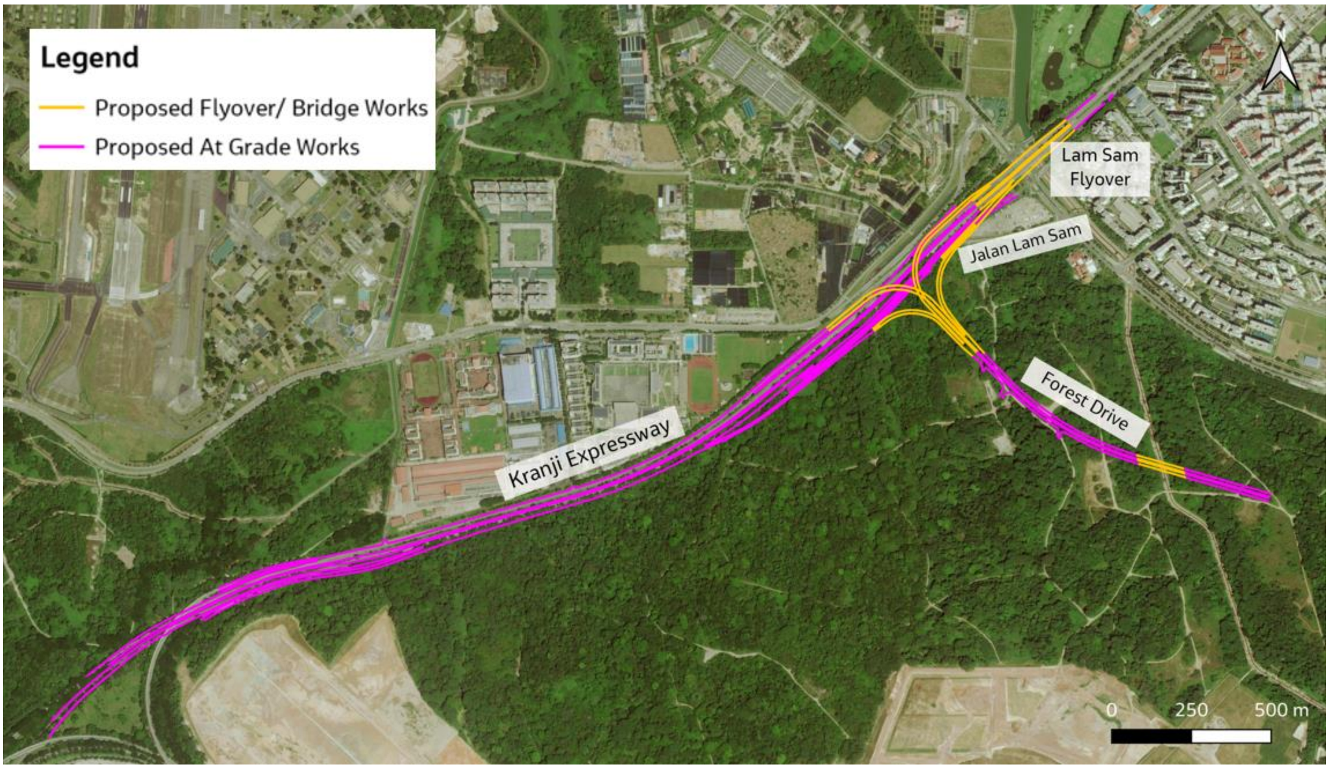


Figure 1-1: Proposed At Grade Works and Bridge Works for the Project
Source: ESRI

1.3 Environmental Impact Assessment (EIA) Requirement for the Project

1.3.1 EIA Requirement in Singapore

In Singapore, agencies within the Government collectively evaluate the possible environment impacts of development proposals through environmental consultation submission procedure as prescribed under the Planning Act and Revised EIA Framework.

In this regard, LTA has initiated the environmental consultation submission to Ministry of National Development (MND)/ URA and relevant Technical Agencies, i.e., National Parks Board (NParks), Singapore Food Authority (SFA) Aquaculture Technology Department, and National Environment Agency (NEA) for Contract DE170.

The Environmental Protection and Management Act (EPMA) provides the legislative framework for the control of environmental pollution, and covers air pollution, water pollution, land pollution, noise pollution and hazardous substances control. The EPMA is administered and enforced by NEA. While Singapore does not have a specific law or regulation on EIA studies, some sections of the EPMA are relevant to the preparation of EIA report for this Project, namely Section 35 on the prevention of pollution from construction sites and Section 36 on pollution control studies.

In addition to the EPMA, the following Acts and their subsidiary regulations (**Table 1-1**) are also relevant to environmental protection in Singapore with implications to EIA studies:

Table 1-1: Acts and Subsidiary Regulations

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Parks, Tree, and Flora Protection	• Parks and Trees Act • Parks and Trees Regulations • Parks and Trees (Preservation of trees) order • Parks and Trees (Heritage Road Green Buffer)	NParks
Animal/ Wildlife/ Fauna Protection[1]	• Wildlife Act	NParks
Development and Redevelopment	• Planning Act	MND/URA
Reservoirs and Catchment Area Protection	• Public Utilities Act • Public Utilities (Water Supply) regulations • Public Utilities Act (Reservoirs and Catchment Areas) Regulations, 2006	PUB
Sewerage and Drainage Planning and Development	• Sewerage and Drainage Act • Sewerage and Drainage (Surface Water Drainage) Regulations • Sewerage and Drainage (Trade Effluent) Regulations	PUB
Noise at Construction Sites	• Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008	NEA
Air Pollution	• Environmental Protection and Management (Vehicular Emissions) Regulations 2008 • Environmental Protection and Management (Air Impurities) Regulations 2008 • Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2008 • Singapore Air Quality Targets	NEA
Water Pollution	• Environmental Protection and Management (Trade Effluent) Regulations 2008	NEA
Public Health and Environment	• Environmental Public Health Act • Environmental Public Health (Registration of Environmental Control Officer) regulations	NEA

[1] Formerly administered and enforced by Agri-Food & Veterinary Authority of Singapore (AVA)

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
	• Environmental Public Health (Employment of Environmental Control Officer) Order • Environmental Public Health (Qualifications of Environmental Control Officer)	
Waste	• Environmental Protection and Management (Hazardous Substances) Regulations • Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, 2000	NEA
Vector Management	• Control of Vectors and Pesticides Act, 2002 • Environmental Public Health (Food hygiene) regulations	NEA

The laws also give relevant agencies the power to issue directions on environmental management and pollution control as required. This has led to the development of Code of Practices (COPs) and guidelines issued by the relevant agencies. These COPs and guidelines detail more specific requirements on regulatory compliance, various control techniques as well as best practices with regards to environmental management and related issues. The relevant COPs and guidelines are summarised on **Table 1-2**.

Table 1-2: Relevant Code of Practice and Guidelines

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Biodiversity	• Singapore Red Data Book • Biodiversity Impact Assessment (BIA) Guidelines	NParks
General Environment	• SS 593:2013 Code of Practice on Pollution Control • COP for Environmental Control Officers	NEA
Surface Water	• COP on Surface Water Drainage • Guidebook on Erosion and Sediment Control at Construction Sites • PUB Circular on Preventing Muddy Water from the Construction Site	PUB
Noise	• SS 602:2014 Code of Practice for Noise Control on Construction and Demolition Sites	NEA

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Vibration	• BS 5228-2 2009: COP for Noise and Vibration Control on Construction • DIN 4150, BS 6472, BS 7385, ISO 2631 IEST-RP-CC12.1, US FTA Guidance Manual, U.S Dept of Transportation "High-Speed Ground Transportation Noise and Vibration Impact Assessment	International
Waste	• COP for Licensed General Waste Collectors • SS 603:2014 Code of Practice for Hazardous Waste Management	NEA

1.3.2 EIA Objectives

The objectives of the EIA are as follows:

- To identify and describe the elements of the community and environment likely to be affected by the Works and/or likely to cause adverse impacts to the Project, including both the natural and man-made environment and the associated environmental constraints to and by the Project.
- To define the study area and describe its baseline conditions.
- To identify, quantify and assess potential impacts and determine the significance of impacts on sensitive receivers and potential affected uses.
- To propose and justify effective mitigation measures (if any) to minimize adverse impacts (e.g., pollution, environmental disturbance and nuisance) during construction.
- To identify, predict and evaluate the residual environmental impacts (i.e., after practicable mitigation) and the cumulative effects expected to arise during construction in relation to the sensitive receivers and potential affected uses.
- To identify, assess and specify methods, measures and standards, to be included during construction which are necessary to mitigate the residual environmental impacts and cumulative effects and reduce them to minimal levels.
- To investigate the extent of the secondary environmental impacts that may arise from the proposed mitigation measures and to identify constraint associated with the mitigation measures (if any) recommended in the EIA, as well as the provision of any necessary modification.
- To design and specify contract-specific EMMP to ensure the effectiveness of the recommended environmental protection and pollution control measures.
- To develop and ensure that suitable contingency plans are incorporated into the EMMP in case of failure of the mitigation measures adopted.
- To develop a contract-specific Environmental Impact Register to ensure proper and effective cascading and tracking of environmental impacts.

1.4 EIA Limitation

The EIA Scope of Works will be limited to the Scope of Works as defined above following the DE170 Contract Specifications and the approved EIA Inception Report. It should be noted that the EIA is not for the overall Tengah Town development but limited to only within the EIA Study Area defined in the following section.

2. EIA Approach and Methodology

The EIA scope of work is in accordance with the Contract Specifications where the purpose of the EIA is to assess the nature and extent of environmental impacts arising from the Project and related activities that take place concurrently.

In alignment with the purpose, the EIA has studied possible impacts of the Project's construction works at the Tengah Forest, its wildlife, and the environment, and to recommend mitigation measures for implementation. We have evaluated the existing pre-construction baseline environmental status and carried out an objective assessment of the various impacts on the environment as a result of the construction and operation phase activities in compliance with the relevant existing legislation and guidelines. Mitigation measures are recommended in the EIA report to minimise adverse environmental impacts during the construction and operation activities. An EMMP will be prepared for the implementation during the construction phase.

2.1 EIA Study Area Definition

The EIA Study Area Boundary as defined the Contract Specifications is 100 meters (m) beyond the Contract boundary as presented in **Figure 2-1**. The area hatched in yellow has been cleared and hoarded up by the J102 contract. Due to the ongoing construction works and access restriction, the hoarded area is omitted from the EIA Study Area.

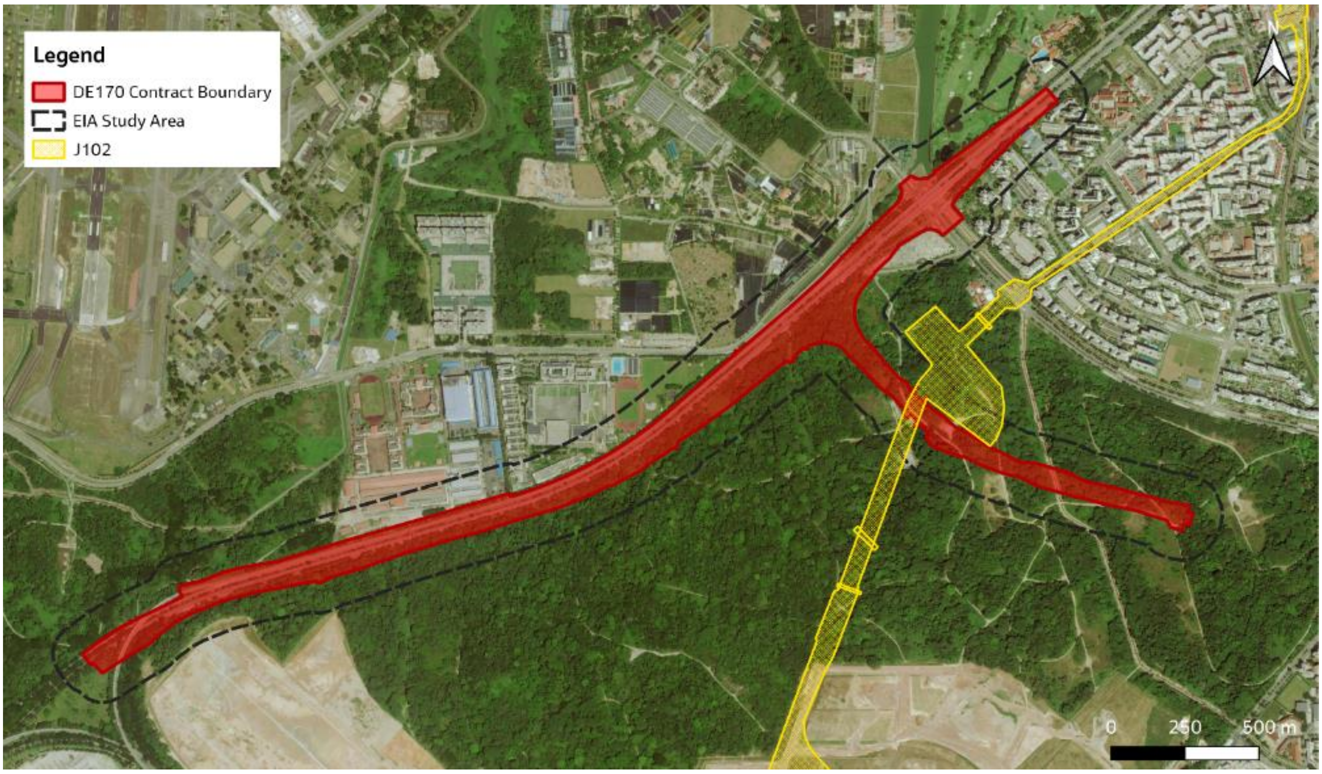


Figure 2-1: EIA Study Area
Source: ESRI

2.2 EIA Baseline Components

The baseline study for this EIA is to establish the existing pre-construction environmental conditions at the EIA Study Area prior to the construction activities and provide a benchmark against which the potential impacts of the Project can be assessed to determine their significance.

The environmental aspects for the baseline anticipated associated with the construction and operation phases comprise of the following:

Physical Environment

- Ambient air quality
- Airborne noise levels
- Ground-borne Noise and vibration
- Surface water quality
- Soil and groundwater

Biological Environment

- Habitat
- Trees, Flora and vegetation
- Ecosystems and the species of flora and fauna, focusing specifically on species and taxonomic groups that are rare and threatened, have significant ecological or keystone functions, or otherwise of public interest

Human Environment

- Waste

2.3 Assessment of Potential Environmental Impacts

The assessment of key environmental impacts takes account of the methodologies of the proposed activities. The proposed impact assessment approach and methodology for the EIA is shown in **Figure 2-2**.

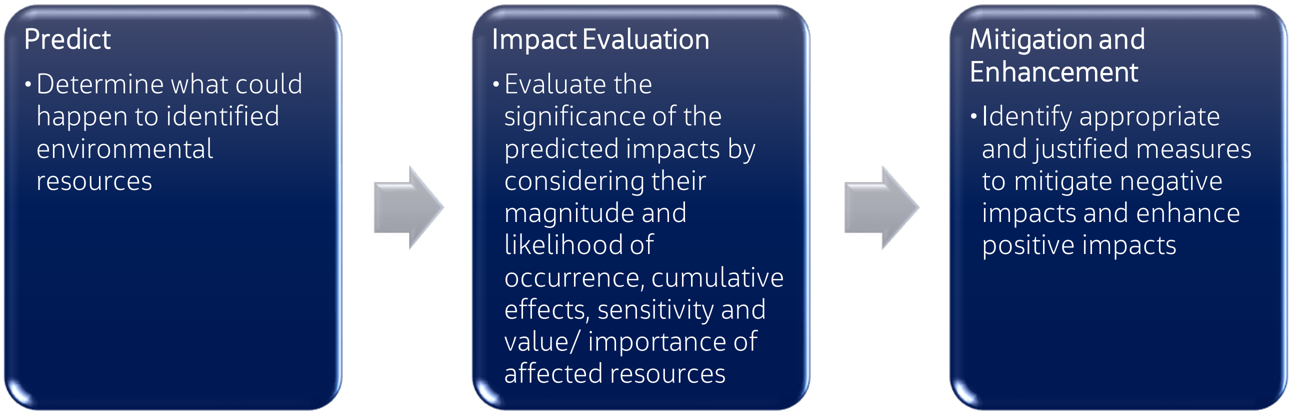


Figure 2-2: Impact Assessment Approach for the EIA

We have used modified Rapid Impact Assessment Matrix (RIAM) as the impact assessment methodology to assess the overall impacts to the key environmental aspects from the development of this Project in the pre-construction, construction, and post-construction phases. RIAM is a semi-quantitative impact assessment method modified/ adopted from Pastakia (1998) and Ijas et al. (2009). This modified RIAM approach applies scoring matrix (quantitative indicators) for impact evaluation in the form of Environmental Scores (ES) which range from extreme positive impact to critically negative impact for each specific project activity with consideration of the sensitivity level of the existing baseline environmental condition.

2.3.1 Assessment Criterion

The criteria used for the assessment fall into two groups, Group A and Group B, with their respective factors of assessing indicated in **Figure 2-3**.

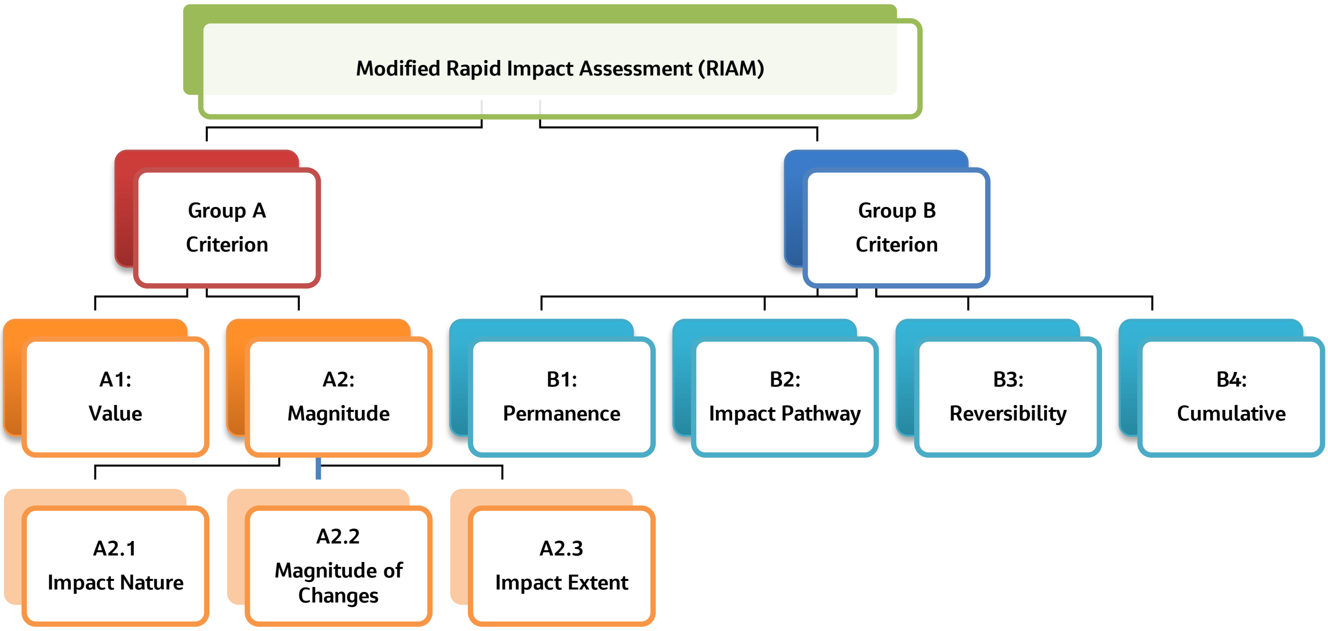


Figure 2-3: Assessment Criteria for Impact Significance following the RIAM Method

2.3.1.1 Group A Criterion

Group A Criterion is the measure of importance of the existing sensitive receiver characteristic with value level (A1) against the magnitude (scale) of the changes whether the impact nature is a beneficial or dis-beneficial impact (A2). Score for Group A will be calculated using multiplication, i.e. (A1) x (A2.1) x (A2.2) x (A2.3) = AT, where (A1) to (A2.3) are the individual criteria scores in Group A and (AT) is the result of multiplication of all Group A scores. The definition and score general criteria considered for Group A is given on **Table 2-1**.

Table 2-1: Definition and Score Criteria for Group A Criterion

Group A Criterion	Score/ General Criteria Considered	
A1 – Value Sensitive Receiver Characteristic	4:	Important to international interest (beyond Singapore) (Very High)
	3:	Important to national/ regional interest (within Singapore context) (High)
	2:	Important to area immediately outside local condition (i.e., EIA Study Area :100 m buffer – Tengah, Choa Chu Kang, Western Water Catchment) (Medium)
	1:	Important to local condition (within the DE170 Contract Boundary) (Low)
	0:	No importance, i.e., value does not carry important role in local interest (Not Important)
A2 – Magnitude Measure of the scale of benefit/dis-benefit	A2.1 – Impact Nature (Benefit or Dis-benefit)	
	+1:	Positive impact
	-1:	Negative impact

Group A Criterion	Score/ General Criteria Considered	
(impact nature) of an impact or a condition	0:	Negligible impact/ no change/ status quo
A2 – Magnitude Measure of the scale of benefit/dis-benefit (impact nature) of an impact or a condition	A2.2 – Magnitude of Changes*	
	3:	High impact/ changes
	2:	Medium impact/ changes
	1:	Low impact/ changes
	0:	No change/ status quo/ negligible
	A2.3 – Impact Extent (Geographical Extent of the Induced Change)	
	4:	Transboundary (Impact extends beyond Singapore boundary)
	3:	Impact extends up to National boundary
	2:	Impact extends immediately beyond DE170 Contract Boundary, i.e., Buffer area
	1:	Impact within local area, i.e., within the DE170 Contract Boundary
	0:	No change/ status quo

Note: *Magnitude of changes – there will be specific definition of magnitude for each environmental component/ aspect given in their respective evaluation section.

2.3.1.2 Group B Criterion

Group B Criterion is the measure of value to the situation, but individually should not be capable of changing the score obtained. The criteria factors definition with their individual scope in this group is shown on **Table 2-2.**

Score for the criteria in Group B will be calculated using summation, i.e. (B1) + (B2) + (B3) + (B4) = BT, where (B1) to (B4) are the individual criteria scores in Group B and (BT) is the result of summation of all Group B scores.

Table 2-2: Definition and Score Criteria for Group B Criterion

Group B Criterion	Scores/ Definition	
B1 – Permanence Whether a condition is temporary or permanent and should be seen only as a measure of the temporal status of the condition. The time period over which a resource/ receptor is affected	4:	Long term effects, i.e., > 10 years (over the lifetime of the Project)
	3:	Medium term, i.e., ≥ 3 years ≤ 10 years
	2:	Short term, i.e., less than 3 years
	1:	Temporary, i.e., less than one month
B2 – Impact Pathway Whether the receivers are directly or indirectly impacted	3:	Direct impact
	2:	Indirect impact
	1:	No change/ not applicable

Group B Criterion	Scores/ Definition	
B3 – Reversibility Whether a condition can be changed and is a measure of the control over the effect of the conditions	3:	Irreversible
	2:	Reversible
	1:	No change/ not applicable
B4 – Cumulative Whether the effect will have a single direct impact or whether there will be a cumulative effect over time or synergistic effect with other conditions	3:	Cumulative/ synergistic
	2:	Non-cumulative/ single
	1:	No change/ not applicable

2.3.2 Impact Severity/ Significance

The impact severity/ significance is evaluated against the impact criterions (Group A and Group B), and for each criterion a score is determined, which provides a measure of the impact severity expected for the potential impact identified.

The total environmental score (ES) will be calculated using the equation **(AT) x (BT) = ES**.

The severity of impact for each of the evaluated potential impact identified has been categorised using a qualitative scale of severity with range bands as indicated on **Table 2-3**.

Table 2-3: Range bands of Environmental Score (ES) and the corresponding level of Impact Significance

Environmental Score (ES)	Impact Severity/ Significance	Definition
481 to 624	Extreme Positive Effect	Impact which causes great improvement or benefit to the existing environment
313 to 480	Major Positive Effect	Impact which causes major improvement or benefit to the existing environment
121 to 312	Moderate Positive Impact	Impact which causes noticeable improvement or benefit to the existing environment
53 to 120	Minor Positive Impact	Impact which causes minor improvement or benefit to the existing environment
1 to 52	Slight Positive Impact	Impact which causes slight improvement or benefit to the existing environment
0	No Change/ Status Quo	No discernible deterioration or improvement to the existing environment
-1 to -52	Slight Negative Impact	Impact which causes slight deterioration or dis-benefit to the existing environment
-53 to -120	Minor Negative Impact	Impact which causes minor deterioration or dis-benefit to the existing environment

Environmental Score (ES)	Impact Severity/ Significance	Definition
-121 to -312	Moderate Negative Impact	Impact which causes a noticeable deterioration or dis-benefit to the existing environment
-313 to -480	Major Negative Impact	Impact which causes major deterioration or dis-benefit to the existing environment
-480 to -624	Critically Negative Impact	Impact which causes critical deterioration or dis-benefit to the existing environment

2.3.3 Identification and Recommendation Applicable Presentation/Mitigation/ Enhancement Measures

Once the impact severity/ significance has been evaluated from the impact evaluation exercise, whether semi-quantitative or quantitative, the next step is to determine the preventative measures and/or mitigation measures that are warranted. The mitigation hierarchy is shown in **Figure 2-4**.

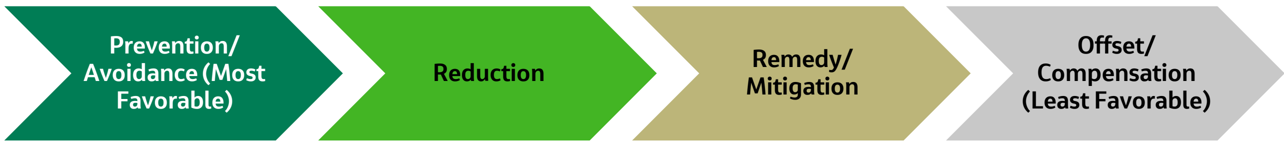


Figure 2-4: Mitigation Hierarchy

The priority of the Mitigation Hierarchy is to first apply feasible prevention/ mitigation/ control measures to the source of impact, i.e. avoid or reduce the magnitude of impact or alleviate the significance of any negative impacts identified from the associated design initiatives, construction method approach, construction activities and operation events to as low as reasonably practicable (ALARP) using the types of control method presented in **Figure 2-5**.

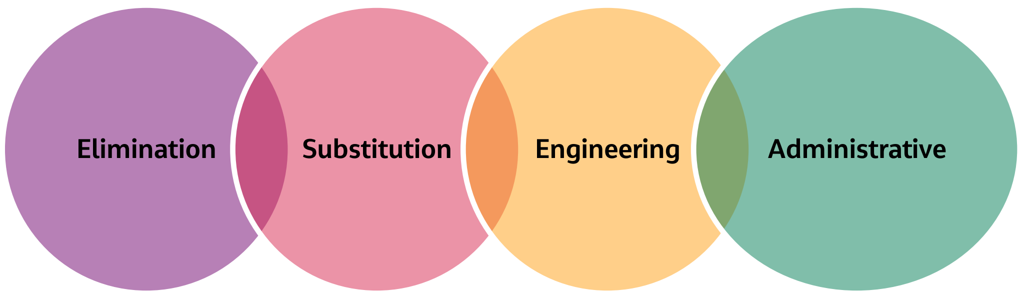


Figure 2-5: Control Method

The recommended mitigation measures will consider its effectiveness, safety, practicality, and suitability for implementation of the Project initiatives, construction methodology, timeline, and site space. Any resultant effects to the specific environmental aspects/ resources/ receptor will be addressed via abatement, compensatory measures, or offset.

Physical or procedural controls (embedded control measures) that are planned as part of the Project design in complying to applicable statutory legislation but not added solely based on mitigation measure identified by the impact assessment process are distinguished from mitigation measures in the impact significance assigned for the potential impacts of the Project.

Once embedded control measures and mitigation measures are declared, the next step will be to assign residual impact significance. Any residual impacts, following the implementation of the proposed mitigation measures and their significance, will also be assessed.

The RIAM method impact assessment approach has considered cumulative impacts/ effects to which the Project may contribute. The approach for assessing cumulative impacts and effects resulting from the Project and its associated facilities with another activity affecting the same resource/ receptor is based on consideration of the approval/ existence status of the other activities and the nature of information available to aid in predicting the magnitude of impact from the other activities.

3. Project Description

3.1 Project Overview

The Project scope shown in **Figure 3-1** comprises:

- Lam Sam Flyover Widening
- KJE Bridge Widening and Twin Cell Culvert
- KJE Realignment / Widening
- Road Interchange (Grade Separated)
- New Dual-3 Lane Road
- Vehicular Bridge (Grade Separated)

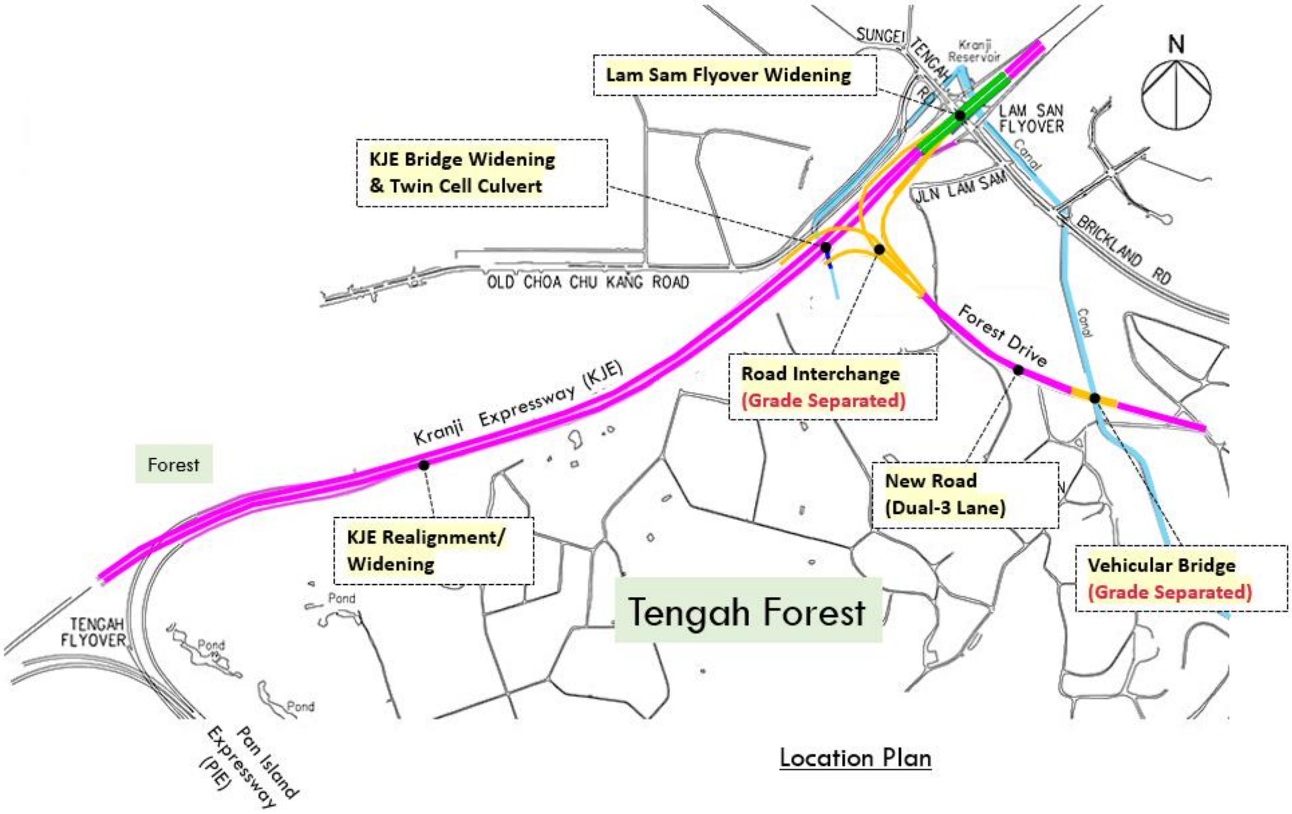


Figure 3-1: Overview of DE170 Design and Build Project Scope

3.2 Land Use

The Project development is in Tengah Planning Area. It is accessible via Jalan Lam Sam Road. The Contract Boundary is approximately 503,075 square meters (m^2) where approximately 284,296 m^2 encompasses Kranji Expressway (KJE) with side table (roads), and approximately 218,779 m^2 comprises Tengah Forest (**Figure 3-2**).

3.2.1 Current Land Use

The Contract Boundary consists of roads and forested area. The major land cover of the forested Site is composed predominantly of woodlands of abandoned kampong, while smaller areas of shrubland and grasslands also exist. Non-vegetated areas represent a very small fraction of the forested site and consist of a monsoon canal and dirt tracks.

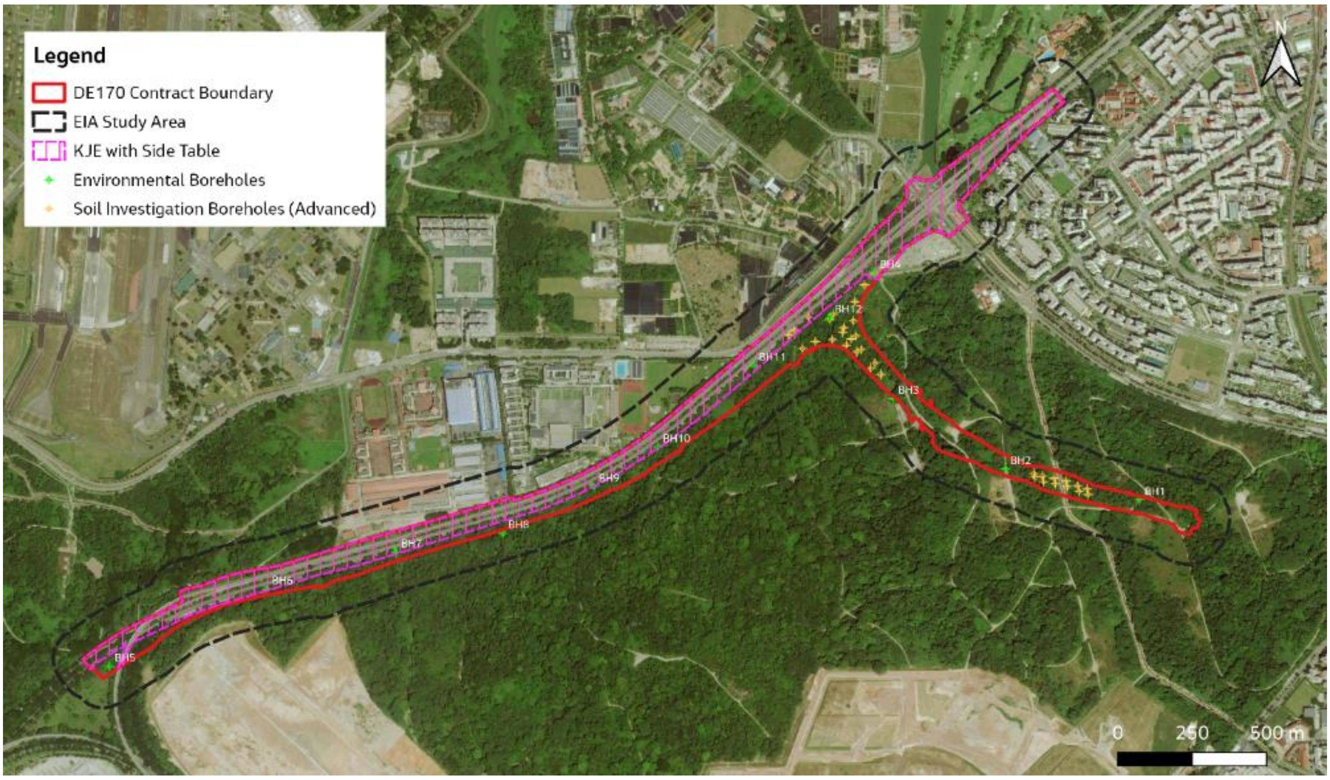


Figure 3-2: Site Current Land Use
Source: ESRI

3.2.1.1 Description of Structures, Roads, Other Site Features

There are no structures observed at the Contract Boundary during the site reconnaissance. Abandoned structures of what seemed to be remnants of the previous village houses were observed in some areas of the site. The access roads are observed to be gravel filled. A paved access road is noted at the central part of the Site which is utilised by Jurong Region Line (JRL) J102 Contract Current Land Use. There are no water and electrical supply currently supplied at the Site.

The northern part of the Project comprises an expressway and side table. This expressway, KJE, connects from another expressway, Bukit Timah Expressway (BKE) in Bukit Panjang and travels south-west to join with the Pan-island Expressway (PIE) in Jurong West.

3.2.2 Surrounding Land Use

The EIA Study Area is surrounded by residential, civic and community institutions, and special use areas (**Figure 3-3**). The immediate neighbours are:

Table 3-1: Surrounding Land Use

Direction	Location	Type of Land Use
North	Keat Hong Camp, Home Team Academy (adjacent) Farms and Nursery (adjacent) Warren Golf Course (adjacent)	Institutional, Residential Agricultural Recreational
East to South	J102 Contract (adjacent) Brickland Road (adjacent) Block 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465 Choa Chu Kang Avenue 4 (100 m) Hai Inn Temple (100 m) Concord Primary School, 3 Choa Chu Kang Avenue 4 (70 m) Blocks 442, 443, 444, 445, 446, 447, 448 Choa Chu Kang Avenue 4 (70 m)	Construction site Road Residential Cultural School Residential
South	Tengah Forest (adjacent)	Ecological
West	Forest (adjacent)	Ecological

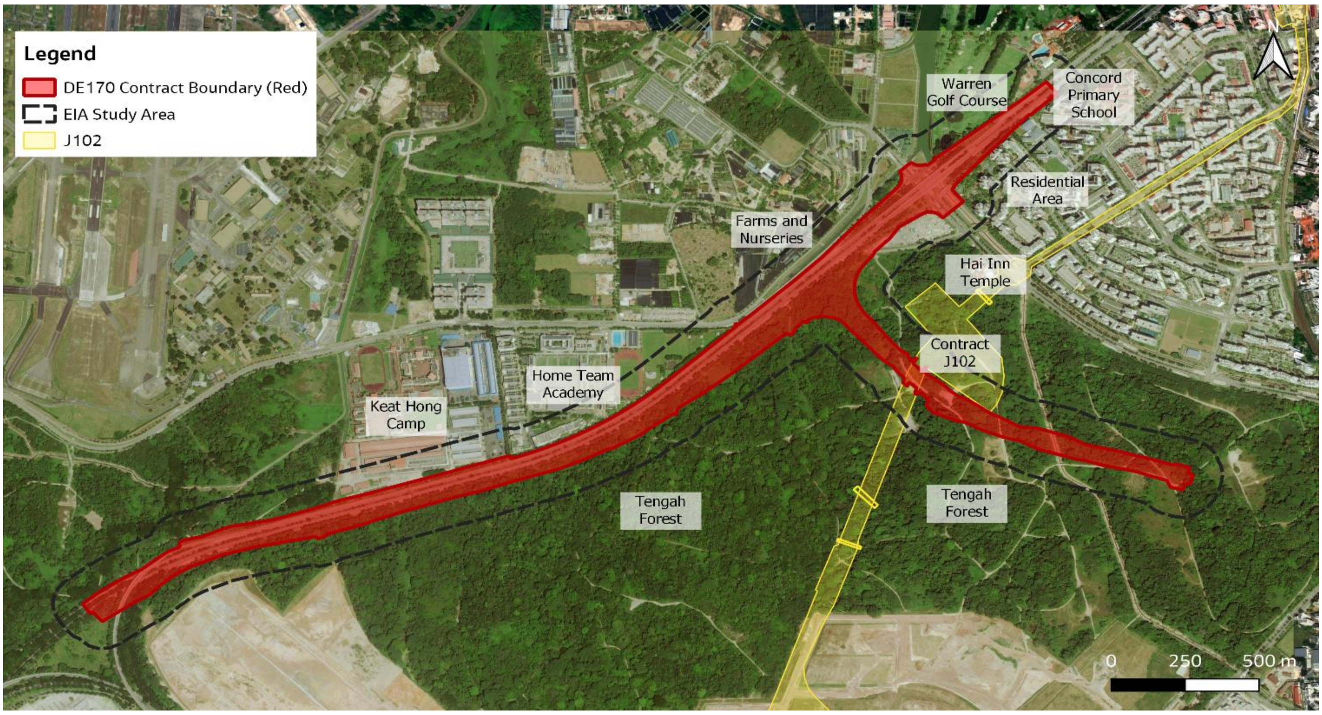


Figure 3-3: Site Vicinity Map

Source: ESRI

3.2.3 Historical Land Use

A review of topographical maps, land use maps, satellite maps and historical street directories available from publicly available sources is conducted to establish changes to the site over the years.

Tengah was a "chu kang"[2] formerly called "Teng Chu Kang" or sometimes recorded as "Ten Ah Kang" in 1800s (Tann J., 2017; and The Straits Times, 1855) (see **Figure 3-4** for the location of "Teng Chu Kang". The owner (known as "Kangchu"[3] in 1800s) of the "Teng Chu Kang" farm called Teng Ah Ting, was then colloquially called "Teng-Ah". The tributary river beside the farm of "Teng Chu Kang" came to be called the Teng-Ah River. In time, it was simply called "Teng-ah" (Tengah) lke'(Tann J., 2017).

Figure 3-4: Location of "Teng Chu Kang" in 1885 Map of Singapore (abstracted from Tann J., 2017)

Tengah area was established as a gambir and pepper farm in the 1850s (Tann J., 2017; and The Straits Times, 1855). Gambier and pepper were the main cash crops which fuelled Singapore's early prosperity in the 1800s due to the great demand for gambier by the dyeing and tanning industry. The symbiotic relationship between gambier and pepper, which was widely used as a condiment, resulted in them being grown together. However, gambier was a crop that rapidly exhausted the fertility of the land, which resulted in large swaths of local forest being cut down to make way for new plantations. The lucrativeness of these crops died out around 1905 as gambier supply had rapidly expanded in Johor, and pineapple and rubber demand had increased, which saw many local farmers switching crops (Thulaja, 2019).

In Tengah, as plantations grew less lucrative, villages, small scale farms, brickwork factories, and coconut plantations moved in to replace the abandoned land until the plans to develop it into a town estate were

[2] By the 1840s, large farming concessions, known as "Chu Kangs" (Tann J., 2017)

[3] The holder of large farming concession was called a 'Kangchu' (master of the river) who was given full local authority over the running of the concession, including farming, rentals, the right to brew liquor and sell pork, and even to establish brothels (Tann J., 2017)

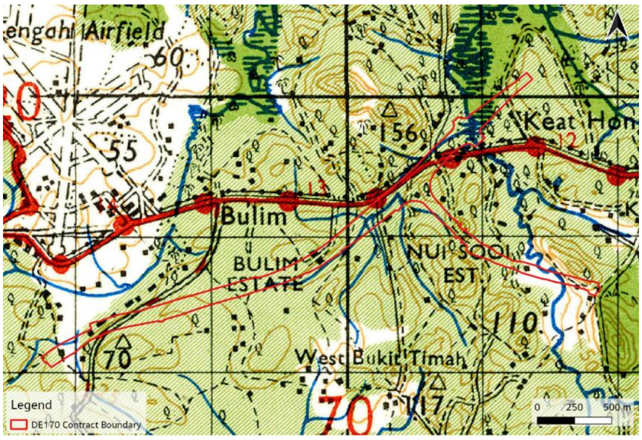
announced. A brief time summary of major developments within Tengah where the EIA Study Area is located, as described on **Table 3-2,** is based on a mix of historical maps, photographs, and research. A progression of historical maps is also shown in **Figure 3-5**.

Table 3-2: Timeline Summary of Major Development at the Site

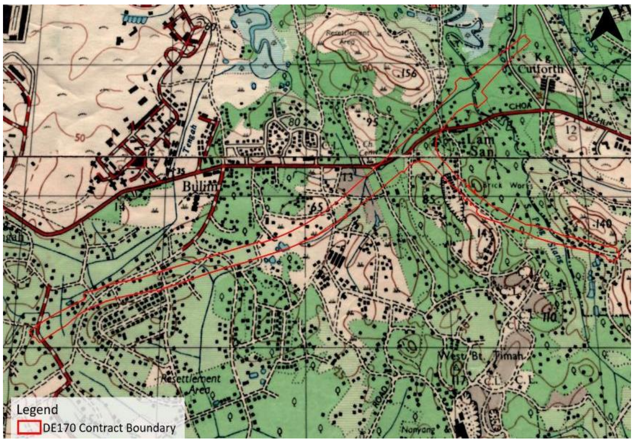
Year	Major Development
1853	Established as part of a riverside farm with gambier and pepper plantations.
1900s	Transition from gambier and pepper plantations towards rubber plantations.
1945	The area is largely devoted to rubber plantations, with a small segment of forested area and Bulim and Nui Sooi Estates were developed within the EIA Study Area.
1966	The extent of the rubber plantation has been reduced, with a portion of land marked out as sundry[4]. Brickwork factories have been built around Tengah and Asia Brickworks was located at the eastern portion of the Site. A large portion of land has transitioned to grassland. A much larger number of inhabitants resided in the area. School and Cemetery were built in the vicinity of the residential area.
1978	Rubber plantations are much more limited in the area, with mostly minor cultivation or sundry as well as a small coconut plantation. Resettlement area has become larger
1980s	Villagers in Tengah were progressively relocated under Singapore's government resettlement plans, demolishing much of the Kampongs which resided there.
1990s	Construction of Kranji Expressway
1998	All brickworks factory ceased operations in the late 1990s. Settlements have mostly shifted out and the area allowed to revegetate.
2005	The Tengah site including the EIA Study Area is completely closed off to the public.
2008	Construction of Brickland Road

Source: https://libmaps.nus.edu.sg

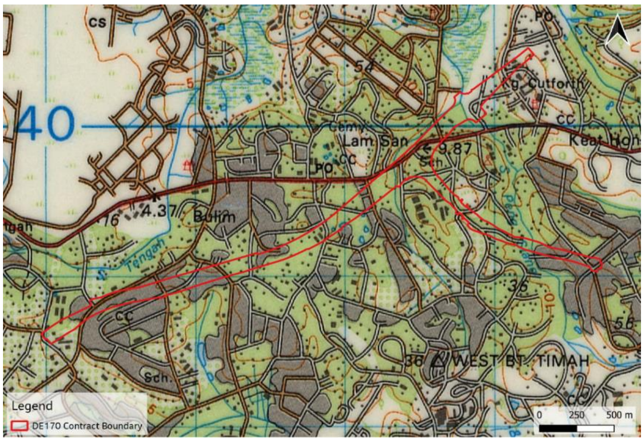
[4] Common term used in old topographical maps to represent abandoned land forest which would largely be abandoned plantations, kampungs or orchards and would mainly compromise of remnant rubber, fruit and ornamental trees (Yee et al., 2016).



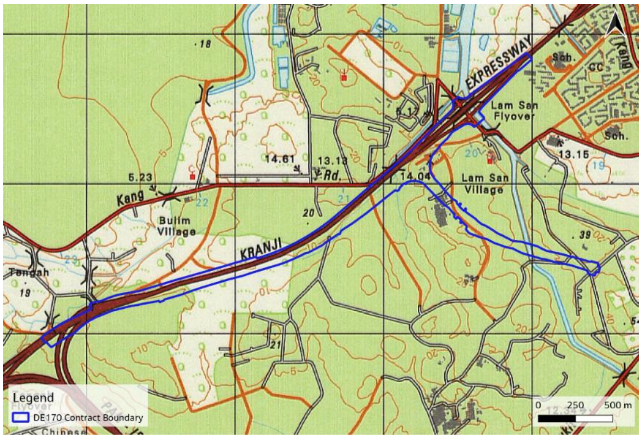
(a) 1945 Topographical Map



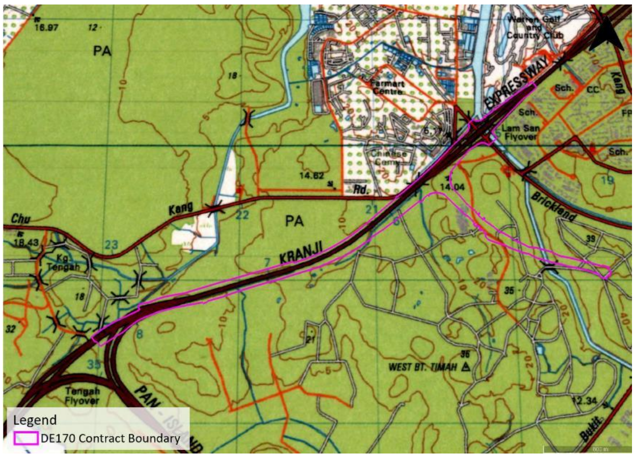
(b) 1966 Topographical Map



(c) 1978 Topographical Map



(d) 1998 Topographical Map



(e) 2010 Topographical Map

Figure 3-5: Historical Topographical Map for Tengah during year 1945, 1966, 1978, 1998 and 2010

3.3 Identified Sensitive Receivers

Potential environmental and community sensitive receptors were identified as:

- Flora and Fauna communities in Tengah Forest
- Dormitory located in Home Team Academy located adjacent north of the Project
- Residential areas located adjacent east of the Project
- Concord Primary school located about 70 m to the east of the Project
- Sungei Peng Siang (adjacent to the north) drains to Kranji Reservoir for storage as a source of water supply, along with other tributaries, Sungei Kangkar, Sungei Tengah, and Pang Sua Canal

3.4 Environmental Setting

3.4.1 Site Geology and Hydrogeology

Based on Singapore Geology (BCA & BGS, 2021), the EIA Study Area is underlain by the Bukit Batok Formation, Choa Chu Kang Garnodiorite-tonalite Pluton, Boon Lay Formation, Pandan Formation, Jalan Besar Formation, and Kranji Formation as shown in **Figure 3-6**.

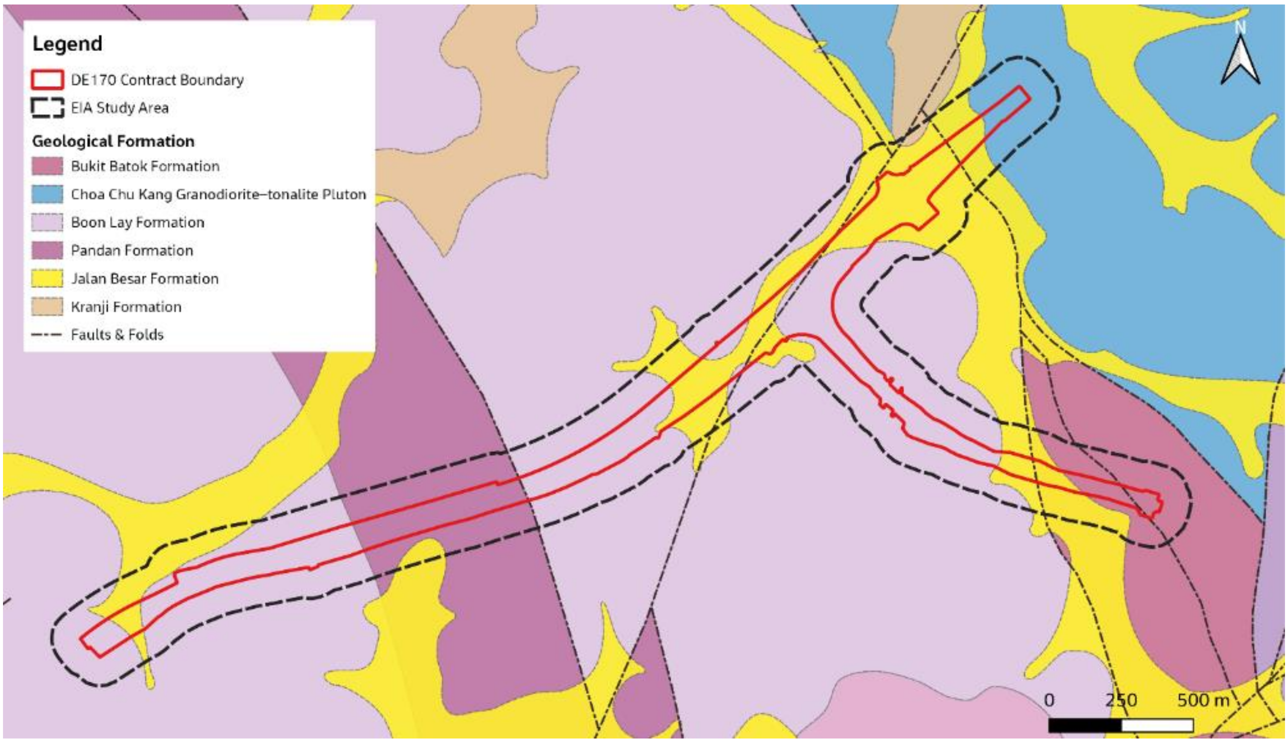


Figure 3-6: Geological Formation in the EIA Study Area
Source: Singapore Geology (BCA & BGS, 2021)

The formations are described as follows:

- Bukit Batok Formation: interbedded sandstone and mudstone
- Choa Chu Kang Garnodiorite-tonalite Pluton: granodiorite and tonalite

- Boon Lay Formation: sandstone; subordinate interbedded mudstone, pyroclastic rock, and volcaniclastic rock
- Pandan Formation: limestone; subordinate beds of carbonate-cemented sandstone and mudstone
- Jalan Besar Formation: silt to coarse sand
- Kranji Formation: peat-rich clay and silt

Available soil investigation reports from previous studies indicate groundwater level ranged from 2.5 meter below ground surface (mbgs) to 3.6 mbgs.

3.4.2 Site Topography

The ground at the forested areas is generally undulating. Based on the topographical surveys provided by LTA, the ground elevations are varying from reduced level (RL)+104m to RL+114m along the south of KJE and from RL+111m to RL+118m at the east of the Project.

3.4.3 Waterbodies

Waterbodies observed within the Tengah Forest drains to Sungei Peng Siang, that leads to Kranji Reservoir for storage as a source of water supply, along with other tributaries, Sungei Kangkar, Sungei Tengah, and Pang Sua Canal, and eventually Johor Straits.

We have identified six (6) major clusters of waterbodies within the EIA Study Area, i.e., WQ1, WQ1a and WQ2 (west of EIA Study Area), WQ3 (west-northeast of EIA Study Area), WQ4 (central part of the EIA Study Area) and WQ5 (southeast of the EIA Study Area) as shown in **Figure 3-7** and in **Photograph 3-1** to **Photograph 3-5**.

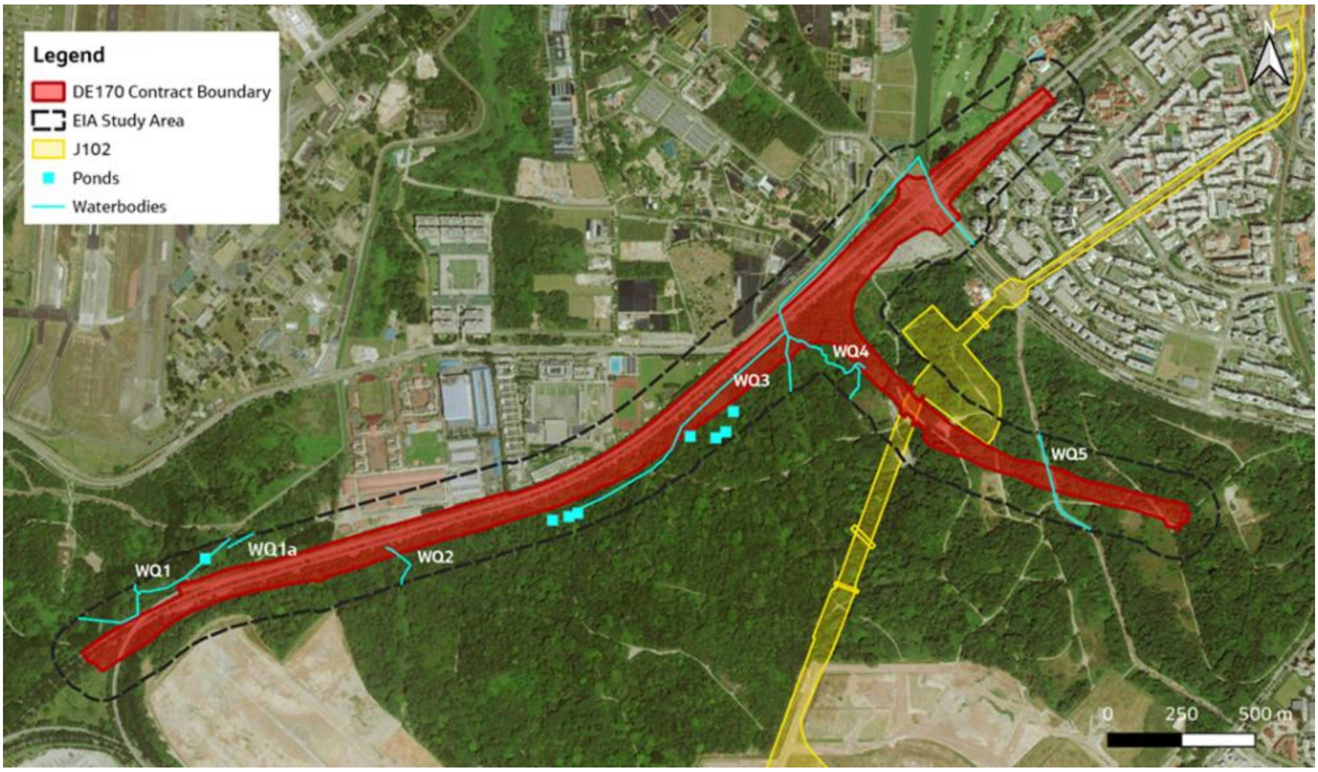


Figure 3-7: Identified Waterbodies
Source: ESRI

Photograph 3-1: WQ2

Photograph 3-2: WQ3 (within the forest)

Photograph 3-3: WQ3 (eastern side)

Photograph 3-4: WQ4

Photograph 3-5: WQ5

3.5 Project Phases

3.5.1 Pre-construction Phase

The pre-construction phase refers to the advanced works prior to construction phase of the Project. The advanced work activities are proposed to support the EIA and EMMP and aid in the design phase for construction planning and methodology. The resulting design will also be considered in the assessment of impacts of the Project. The proposed advanced works include the following:

- Soil Investigation Works
- Environmental Site Assessment Works
- Trial Trench
- Construction of associated access for Soil Investigation Works and Trial Trenching
- Construction of access from Brickland Road to proposed Bridge in Zone 5

3.5.2 Construction Phase

The work activities during the construction phase include:

- Enabling Works/ Preliminary Construction Works
- Earthworks and Foundation
- Civil and Structural Works

Specific construction phase activities are further described in **Section 3.6.**

3.5.2.1 Enabling Works/ Preliminary Construction Works

Preparation of land for construction of temporary structures, and permanent structures such as road and bridge elements involve site and wastes clearance. Site clearance involves the clearing of above-ground vegetation and soil levelling work within the permitted construction footprint.

A considerable volume of waste found across the EIA Study Area (see **Section 3.2.1.1**) from previous land use are to be cleared, as well. These waste materials include broken glass, large tyres, concrete, metal and plastic pipes, corrugated zinc sheets, plastic items, and a wide variety of old village remnants.

Other preliminary construction activities include construction of access, laydown area, and temporary facilities, installation of Earth Control Measures (ECM), installation of noise barrier, and construction of temporary wildlife crossing.

3.5.2.2 Earthworks and Foundation

Earthworks are necessary to prepare the site for construction with the intention to flatten the undulating ground for ease of construction. These include excavation, formation of a new slope or embankment, and cut and fill operations. The site formation works will be carried out mostly by cut and fill operation.

Other earthworks involve excavation such as stripping, roadway excavation, drainage excavation and diversion, footing excavation, and backfilling. Deep excavation for foundation works employed for the proposed Project includes bored piling and installation of Earth Retaining or Stabilising Structures (ERSS) to facilitate construction of pile caps. Bored piles, pile caps, and abutments will be cast-in-situ.

With the proposed KJE realignment and widening, the existing concretised drain within Tengah Forest parallel to KJE will be shifted to the south and connected to the proposed twin cell box culvert, and still drain towards Sungei Peng Siang. An existing earth drain is also proposed to be diverted to run towards the twin cell box culvert, crossing the widened and realigned KJE.

Soil investigation works, work area set up, and demolition works (i.e., demolition existing roadside drain at KJE and bridge parapet wall in Zones 1 – 4, demolition and reinstatement of heavy vehicle parking [HVP]) also fall under this construction stage.

3.5.2.3 Civil and Structural Works

The choice of construction method is influenced by optimum construction progress, which has brought about combination of cast-in-situ, semi-precast with infill, and precast in reinforced concrete (RC) structure installations. Upon the establishment of foundation works and necessary ERSS, pier and column construction, crosshead, and girder erection follow.

Other civil and structural works carried out for the proposed Project includes pavement of carriageway and slip roads, drain, and box culvert construction.

3.5.3 Operation Phase

The operation phase activities of the Project development will predominantly involve maintenance of at-grade road and bridge. These activities are not expected to involve the use of heavy machinery.

3.6 Construction Methodology

3.6.1 Construction Activities

Primary construction sequence is divided into five (5) zones (**Figure 3-8**) to optimize construction planning. Each construction zone is further apportioned into different construction activities as presented on **Table 3-3**. Under the medium-term development broad planning of Tengah Town, the Project has been planned to commence in 2023.

Table 3-3: Construction Activities for Each Construction Zone

Construction Zone	Estimated Duration	Project Scope	Construction Activities
Zone 1	32 Months	KJE Realignment / Widening	• Soil and geotechnical investigation • Work area setup • Demolition of existing road side drain and box culvert at KJE • Construction of drains and retaining walls
			• Construction of drainage including box culverts • Construction of pavements • Construction of slip road to PIE • Construction of temporary pavements for traffic diversion • Construction of proposed ramp • Raising and recambering of roads

Construction Zone	Estimated Duration	Project Scope	Construction Activities
Zone 2	11 Months	KJE Realignment / Widening	• Soil and geotechnical investigation • Work area setup • Demolition of existing roadside drain and box culvert at KJE • Construction of drains and retaining walls
			• Construction of proposed pavements • Construction of proposed drainage • Raising and recambering of roads
Zone 3	32 Months	KJE Bridge Widening Twin Cell Culvert	• Soil and geotechnical investigation • Work area setup • Demolition of existing roadside drain and box culvert at KJE • Demolition of existing parapet wall at KJE • Demolition and reinstatement of HVP • Construction retaining wall and pavement • Bored piling • Construction of pile caps
			• Construction of proposed pavements • Construction of proposed drainage including RCU Drain, box culverts and drains • Construction of ramp • Construction of temporary pavements • Construction of flyover foundation and piers • Installation of precast crosshead and box girder segments • Raising and recambering of roads
Zone 4	41 Months	Lam Sam Flyover Widening	• Soil and geotechnical investigation • Work area setup • Demolition of existing parapet wall at KJE • Construction of retaining wall • Bored piling • Construction of pile cap
			• Construction of flyover foundation and piers • Installation of precast crosshead and box girder segments • Raising and recambering of roads

Construction Zone	Estimated Duration	Project Scope	Construction Activities
Zone 5	40 Months	Vehicular Bridge Flyover New Road Construction	• Soil and geotechnical investigation • Work area setup • Modification of existing ground with hard base and slope protection • Preliminary test piles for bored piles • Bored piling • Construction of drains and road works • Installation of ERSS for strutted excavation • Construction of pile cap
			• Installation of precast crosshead and box girder segments • Installation of flyover/ bridge • Installation of the precast parapets and necessary deck furniture • Construction of new roads • Cambering of new road

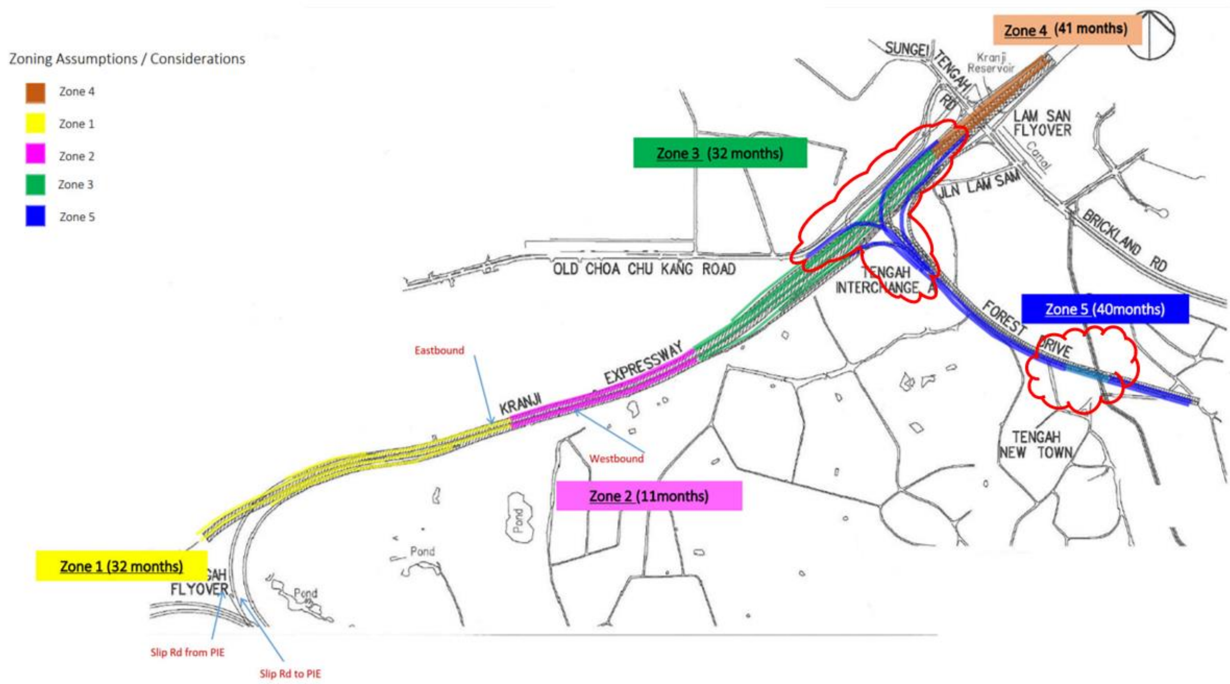


Figure 3-8: DE170 Project Zoning

Note: Red outlined clouded area indicated specific area within Zones 3 and 5 which is likely to have night works of safety and quality critical concerns. ECM facilities will be operated during the safety and quality critical night works within Zones 3 and 5 and/or during heavy rain at night at all zones

3.6.2 Construction Resources

Each construction activity will require manpower and equipment resources to render the required civil and structural works of the proposed vehicular interchange. A preliminary summarised inventory of resources planned for the pre-construction and construction phases is presented on **Table 3-4**.

Table 3-4: Major Resources for Construction Activities

S/N	Work Description	Estimated Duration (months)	Machineries, Equipment and Plants Type	Quantity
1	Work Area Set up (Zone 1 to Zone 5)	3	Excavator	2
			Vibratory roller	1
			Dump truck	4
			Welding	1
			Electric drill	2
			Generator	1
2	Soil and Geotechnical Investigation (Zone 1 to Zone 5)	3	Drilling machine (A-frame)	5
			Air Compressor	5
			Pump	5
			Generator	5
3	Drainage and Utilities Diversion (Zone 1 to Zone 5)	15	Excavator	2
			Crawler crane	1
			Generator	1
4	Bored Pilling Works (Zone 3 to Zone 5)	17	Boring Rig	3
			Crawler Crane	3
			Vibro-hammer	3
			Hydraulic excavator breaker	1
			Steel Casing	9
			Excavator	3
			Lorry Crane	1
			Dump Truck	8
			Water pump	3
			Generator	3
			Welding Machines	2
			Oxy-cutter	3
5	RC Works (Flyover/ Vehicular Bridge /Retaining Wall) (Zone 3 to Zone 5)	30	Excavator	8
			Dump Truck	10
			Mobile Crane	4
			Lorry Crane	3
			Concrete Pump	4
			1 ton Roller	4

S/N	Work Description	Estimated Duration (months)	Machineries, Equipment and Plants Type	Quantity
			Silent Piler	2
			Pre-boring Rig	2
			Vibrators	24
			Air Compressor	4
			Generator	7
			Water pump	4
			Bar Bender Machine	4
			Bar Cutter Machine	4
6	Drainage Works (RCU Drain/Box Culvert) (Zone 1 to Zone 5)	48	Excavator	10
			Dump Truck	15
			Lorry Crane	2
			1 ton Roller	4
			Silent Piler	2
			Pre-boring Rig	2
			Vibrators	24
			Air Compressor	4
			Generator	7
			Water pump	10
			Bar Bender Machine	2
			Bar Cutter Machine	2
7	Segmental Box Girder Installation (Zone 3 to Zone 5)	32	Mobile/Crawler Crane	2
			Lifting Frames	4
			Lorry Crane	2
			Excavator	2
			Air Compressor	1
			Trailer/Low bed Truck	4
			Generator	2
			Drill Machines	2
			Electrical Breakers	2
			Welding Set	2
8	Precast Crosshead, Precast PSPC Beam/Girder and Precast Parapet/ Flower Trough Installation (Zone 3 to Zone 5)	24	Mobile/Crawler Crane	6
			Lorry Crane	3
			Excavator	4
			Air Compressor	2
			Trailer/Low bed Truck	6
			Generator	2
			Drill Machines	4

S/N	Work Description	Estimated Duration (months)	Machineries, Equipment and Plants Type	Quantity
			Electrical Breakers	4
			Welding Set	2
			Forklift	2
			Boom Lift	4
9	Road Works (Kerb/ Scupper pipe/ Subgrade/ Subbase) (Zone 1 to Zone 5)	44	Excavator	12
			Dump Truck	24
			Lorry Crane	2
			Vibratory Tandem Roller	4
			Concrete Cutting Saw	4
			Vibrators	12
			Air Compressor	2
			Generator	4
			Water pump	4

3.6.3 Night Works

There may be ad hoc works at night that may not be possible to complete within the stipulated daylight working hours due to safety critical and quality related issues (i.e., bored pilling that cannot be stopped halfway and beam launching where road closures are required) as well as other unforeseen circumstances (e.g., weather, etc.), in which case lights may be required to be turned on. The identified ad-hoc night works that may potentially happen is listed below with their designated area shown in **Figure 3-8**.

- Bored piling works in Zone 3 and Zone 5
- RC Works (Flyover/ Vehicular Bridge / Retaining Wall/ Pile cap/ RC Column) in Zone 3 and Zone 5
- Segmental Box Girder Installation in Zone 3 and Zone 5
- Precast Crosshead, Precast PSPC Beam/Girder and Precast Parapet/ Flower Trough Installation in Zone 3 and Zone 5

ECM facilities will be operated during the above-mentioned safety and quality critical night works and/or during heavy rain at night time.

4. Assessment of Geomorphology, Soil and Groundwater

This section assesses the potential changes in soil infiltration capacity, hydrogeology, and soil erosion impact related to the activities from the proposed construction and operation activities. It includes a description of the available topographical, geological, and hydrogeological baseline, methodology, and criteria used for the assessment. Appropriate mitigation measures are proposed, where necessary.

4.1 Applicable Legislation and Standards

There is no specific legislation and standard in Singapore that describes the impact assessment requirements for geomorphology, hydrogeology, and soil erosion associated with the environmental impacts. The EPMA and the Code of Practice (COP) on Surface Water Drainage are referred to for the assessment. Both the EPMA and COP prescribes the prevention and alteration to the natural baseline drainage morphology and provision of monitoring of surface water resources particularly on the aspects of flow, discharge value, and quality.

There is no legislation in Singapore presently that describe the methodology for soil and groundwater qualities assessment. We have therefore referred to Singapore Land Authority's (SLA's) Environmental Site Assessment (ESA) Guidelines (Second Edition) which is commonly used in Singapore as the methodology for soil and groundwater quality assessment. The SLA ESA Guidelines (Second Edition) provides the framework in the conduct of environmental assessment to establish the existing soil and groundwater conditions beneath a certain site. It consists of systematic process that include records review, site reconnaissance, interviews, and report preparation to identify Areas of Potential Concern (APC) in connection with a site. The recommended approach in this guideline has considered NEA and internationally recognised practices, guidelines, standards, and technical approaches.

4.2 Assessment Methodology

The geomorphologic assessment involves the evaluation of landforms, and in particular, their nature, origin, processes of development, and material composition. Material composition includes both the geology and, where present, the soil. Geomorphologic assessment, therefore, includes the evaluation of topography, the factors that have formed the land to the present profile, including soils in relation to the erosion, or subsidence. It should be noted that for the EIA Study Area, a baseline assessment of the "pristine" plain and drainage system is no longer possible as the EIA Study Area has undergone land use changes and development.

The topographical map provided in the Contract documents prepared by the SLA licensed surveyor with terrain levels within the EIA Study Area was assessed and processed to generate a Digital Elevation Model (DEM). The DEM enables the visualisation of slopes with the proposed parcellation overlain. A generalized terrain analysis is made upon this DEM to evaluate its implication to the proposed development activities.

Singapore Geological map (BCA & BGS, 2021) and Project topographical map were assessed and processed through GIS to generate a thematic map and likewise overlain with the Project development. This will indicate potential ground conditions to assess its implication to each project component.

For soil erodibility, the Revised Universal Soil Loss Equation (RUSLE) is used to assess the potential erodibility of soils within the Project alignment. As the assessment for geology and soils are mostly desktop, the values used for the RUSLE are derived from the results of the DEM and published materials from the PUB and United States Department of Agriculture (USDA) Natural Resources Conservation Service Food Security Manual Fourth Edition for Highly Erodible Land (HEL) determination. The potential impacts on geomorphology and soil erodibility identified in this EIA is to be further verified during the project construction and operation. As such, the EMMP would need to be regularly reviewed and modified as necessary to address actual project conditions.

The soil and groundwater assessment methodology comprises the following key survey tasks in order to identify and evaluate the potential of land contamination within the EIA Study Area:

- A desktop review to appraise the current and historical land uses within the EIA Study Area in connection with land uses and potential activities leading to soil and groundwater contamination with the aid of aerial photographs, survey maps, and the geological maps.
- A site reconnaissance to identify any visual contamination and sensitive receivers which could be potentially affected by soil and groundwater contamination. Sensitive receivers include but not limited to identifying groundwater extraction wells, surface watercourse, residences, schools, hospitals, and elderly housing. These are areas where the occupants are more susceptible to the adverse effects of the contamination.
- Identification of potential areas of concern based on the information obtained from the documentary reviews and site reconnaissance.
- Collect soil samples for laboratory analysis by drilling boreholes, install groundwater monitoring wells, and collect groundwater samples for laboratory analysis.
- Interpretation and assessment of the soil and groundwater analytical results following the philosophy of the Dutch Standards which estimate the extent of remediation required to the level of risk under certain land uses for the protection of human health.
- Recommendation of any necessary contamination remediation works for the Project development based on the conclusion of the assessment of soil and groundwater qualities.
- Identification of potential impacts on soil and groundwater qualities as a result of the construction activities of the Project development.
- Recommendation of mitigation measures to minimise any identified adverse impacts of the Project development on soil and groundwater qualities.

4.3 Pre-construction Baseline

4.3.1 Site History

The Project development which traverses the present Tengah Forest Zone was previously settlement and agricultural area. This indicates that the area has undergone extensive land use changes hence the current soil cover indicates varying levels of disturbance prior to the proposed activities that dates back from 1855 (**Section 3.2.3**).

Similar conditions apply to the geomorphology of the Project development, wherein the surface terrain retain much of the characteristics from the 2010 topography as no other surface disturbance has taken place at the area post-2010 other than the presence of dirt road tracks, developed natural drains and constructed earth drains.

4.3.2 Desktop Study

Site reconnaissance was conducted on 26 January, 25 February, 10, 11 and 17 March 2022 to identify sensitive receivers, EIA Study Area features and any visual contamination which could potentially affect soil and groundwater conditions. The results of the site reconnaissance are presented in **Section 1.1** to **Section 3.4**.

Based on desktop review, the most dominant rock formations as indicated on the geological map (**Figure 3-6**) are the Jalan Besar, Boon Lay, and Pandan Formations comprising the Intersection area, and the southwest and southeast extents. A small portion of the northeast extent is underlain by the Choa Chu Kang Granodiorite-tonalite unit, which is also the same for the Bukit Batok Formation at the southeast tip of the Project extent. The 2.5 mbgs to 3.6 mbgs groundwater level as described from previous soil investigation reports can be potentially expected at the areas underlain by the three main formational units. This will be confirmed upon the completion of the soil investigation survey undertaken during the pre-construction phase.

4.3.2.1 Topography

The topography of the EIA Study Area is comprised of two different morphologies. The Southwest-Northeast oriented Kranji Expressway alignment has a generally rolling terrain, while the Forest Drive (Zone 5) has an undulating terrain as the road plan transects two relatively steep hills. A two-dimensional Digital Elevation Model (DEM) is presented in **Figure 4-1** below to visualize the surface morphology traversed by Project.

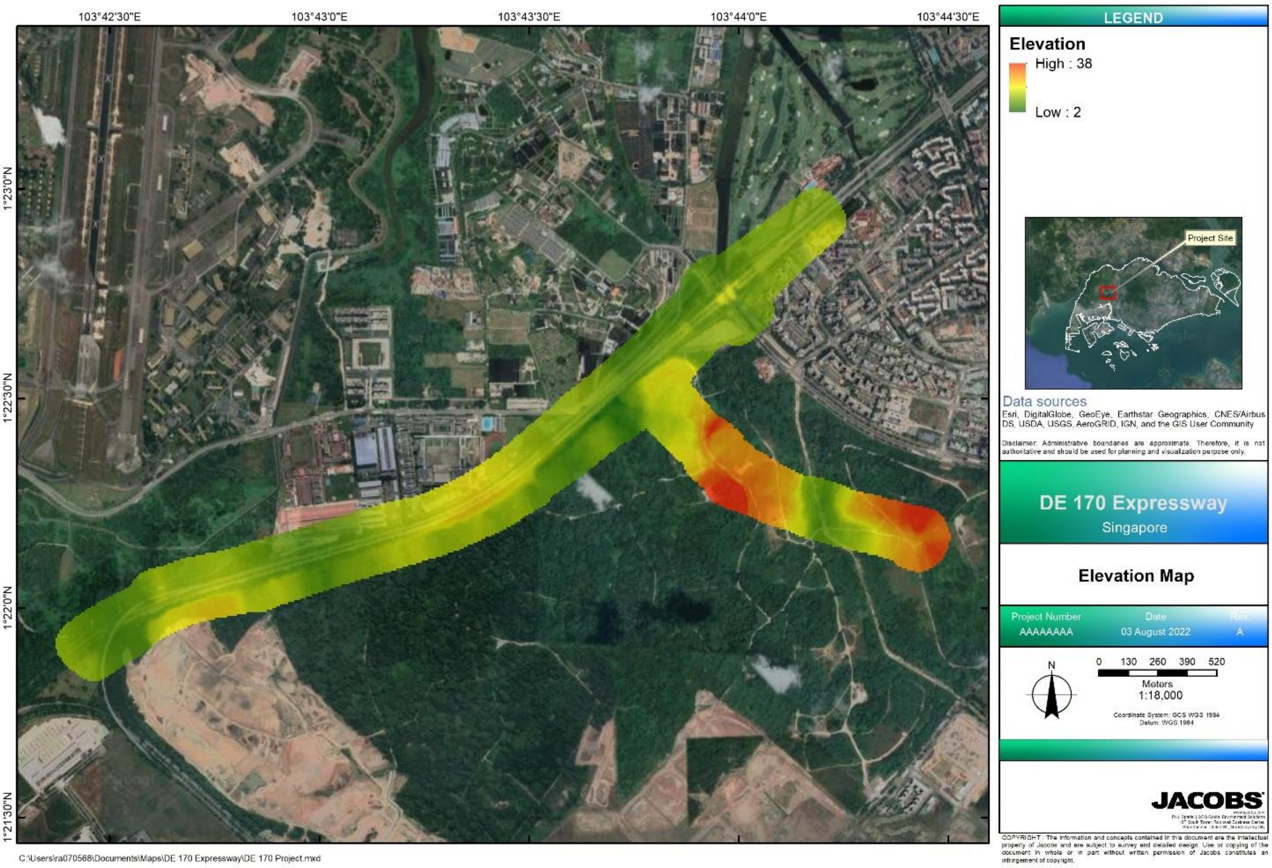


Figure 4-1: Digital Elevation Model (DEM) Two-Dimensional Visualization of the Study area at 0.5 m Vertical Exaggeration.

4.3.2.2 Review of Site Investigation Reports

Site Investigation (SI) works were conducted to evaluate the subsurface conditions and present the knowledge of the geotechnical, geological, and hydrogeological conditions beneath the Project development.

The boreholes were drilled using the rotary method, employing drilling fluid pumped into the rotary drill rods and cutting bit to drive it into the subsurface and wash out the soil remnants. The borehole diameter is at 100 mm. The disturbed soil samples were taken using a split spoon sampler, and undisturbed samples were collected using thin-walled samplers for soils with particular sensitivity to sampling disturbance. This consist of thin-walled steel tube with a lower end shaped to form a cutting edge with a small clearance inside. Soil testing includes Moisture Content, Particle Density, Bulk Density, Dry Density, and Grain Size Distribution.

Water standpipes were installed in selected boreholes to measure the level of the water table. The measured groundwater levels varied from 4.752 metres below ground surface (mbgs) to 13.997 mbgs.

Table 4-1: Summary of Soil Laboratory Tests from Soil Investigation

WSP No.	Sample Depth (m)	Moisture Content (%)	Particle Density (mg/m^3)	Bulk Density (mg/m^3)	Dry Density (mg/m^3)	Grain Size Distribution			
						Gravel %	Sand %	Silt %	Clay %
KJP-63	3.0	41	2.7	1.85	1.31	0	9	26	65
	6.0	29	2.69	1.95	1.51	2	37	41	20
KJP-68	3.0	34	2.69	1.89	1.42	3	44	35	18
	8.0	17	2.67	-	-	26	51	19	4
KJP-71	5.0	13	2.73	-	-	18	48	23	11
	8.0	10	2.67	-	-	29	49	16	6
	14.0	7	2.7	-	-	31	49	17	3
KJP-72	3.0	23	2.75	-	-	7	25	54	14
	6.0	13	2.77	-	-	21	30	38	11
KJP-80	6.0	31	2.74	2	1.53	0	1	44	55
	14.0	24	2.72	2.04	1.65	0	19	45	36
	20.0	26	2.71	1.98	1.57	2	27	44	27
KJP-89	3.0	47	2.68	1.84	1.25	0	6	42	52
	9.0	-	2.71	2	-	0	28	72	72
	24.0	-	2.71	2.26	-	4	53	43	43
KJP-90	6.0	25	2.72	1.98	1.58	0	33	41	26
	9.0	28	2.76	1.95	1.52	0	3	65	32
KJP-205	3.0	30	2.66	-	-	0	53	13	34
	4.0	26	2.65	2.02	1.6	0	56	14	30
	6.0	19	2.66	-	-	0	82	13	5
	8.5	42	2.74	-	-	0	21	31	48
	14.5	15	2.68	-	-	0	29	58	13

Along the KJE area, the silty Clay represents most of the soil at the shallower horizon at a depth range of about 3.0 mbgs, followed by silty Sand, sandy Silt and clayey Sand. The lower horizon is comprised mainly of sandy Silt which is prominently encountered at depths of about 6.0 mbgs, with intermittent presence of silty clay and silty Sand in other boreholes at 5.0 as well as 6.0 mbgs, respectively. The deeper horizons are widely varied depending on location, from 8.0 mbgs up to the deepest at 24 mbgs. These are silty Sand, gravelly Sand, sandy Silt, and clayey Silt.

Along the proposed Forest Drive area, clayey Sand is encountered at 3 mbgs to 4 mbgs, which transitions to silty Sand and silty Clay with Sand from 4.0 mbgs to 6.0 mbgs and 8.5 mbgs. Sandy Silt is dominant beyond the 8.5 mbgs up to the maximum drilling limit of 14.5 mbgs.

4.4 Impact Assessment

4.4.1 Construction Phase Impacts

4.4.1.1 Evaluation of Geomorphology and Hydrogeology Impacts

The construction activities may involve at least one or a combination of the following activities:

- Stripping or removal of soil cover
- Ground/subsurface excavation, cut and fill
- Earthmoving of excavated materials
- Temporary soils and spoil stockpiling
- Ground compaction and sealing

These activities have a direct impact on the soil infiltration capacity, soil loss and erosion, and hydrogeological conditions. These are further described as follows.

4.4.1.1.1 Changes to Soil Infiltration Capacity

Soil compaction is expected to occur resulting from any, or a combination, of the construction activities previously mentioned at the Project Footprint and temporary work areas within the bounds of the EIS Study area. This can translate to a temporary or permanent reduction of the soil infiltration capacity.

Areas where pavement or ground sealing for the road structure will be constructed are expected to permanently lose the infiltration potential of the soil and subsurface beneath it and will be variably reduced in areas where components of elevated structures will be built. Depending on the degree of ground compaction, lateral Hydraulic conductivity across the subsurface may or may not be reduced which will have an impact on groundwater.

Table 4-2: Impact Significance for Soil Infiltration Capacity during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Soil infiltration capacity value is important to the area immediately outside the Contract Boundary.
A2.1: Impact Nature	-1: Negative	Loss or reduction of infiltration capacity in all development areas for permanent structures will occur.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.2: Magnitude of Changes	2: Medium	Changes in infiltration capacity in all areas where earthmoving and construction activities will take place. This may alter the groundwater recharge specific to the infrastructure footprint; however, infiltration may increase at the surrounding areas where no ground disturbance took place and surface runoff from the developed zones may be diverted into.
A2.3: Impact Extent	1: Local	Impact is limited within the disturbance areas where temporary and permanent earthworks will take place.
B1: Permanence	4: Long-term	Permanent loss or reduction of infiltration capacity where the surface and subsurface will be stripped or excavated, and permanent structures will be built.
B2: Impact Pathway	3: Direct	Ground disturbance will directly involve stripping of surface material including topsoil cover, and ground excavation which will remove bedrock material.
B3: Reversibility	3: Irreversible	Removed soil and spoil materials cannot be returned to their original locations where infrastructures have been completed.
B4: Cumulative	2: Non-Cumulative	Change in conditions for soil infiltration capacity remains after completion of all earth-moving and construction activities within disturbance area for each phase and development taking place within the DE170 Contract Boundary.
Environmental Score (ES)	**(at=-4) x (bt=12) = -48**	
Range Bands ES/ Impact Significance	Slight Negative Impact	

4.4.1.1.2 Soil Loss and Erodibility

Soil Loss and erodibility is a natural process affecting soil material and cover as a response to surface processes that involve the transport and reworking by wind, water, and mechanical disturbance. The potential for soil erosion is influenced by several factors, including:

- Rainfall characteristics – intensity, frequency, duration
- Climate – soil temperatures, types of native vegetation, time of year
- Soil erodibility – Soil texture, structure, permeability, organic matter content
- Topography – Slope length and steepness
- Ground cover – Type and quality and areal density of cover

Construction activities are usually estimated to increase the prevailing soil loss rate to a range of between 10 and 20 times (Pudasaini, 2004) the current value, depending on the degree of ground disturbance and other earth-moving activities. Areas where no activities will take place retains the current rate of soil loss that will be determined upon the completion of the soil assessment. Additional factors such as current and future land cover, land use, and percentage of permanent surface structures that will occupy the land area that will restrict sediment transport from point sources should also be considered. The erodibility potential serves mainly as a guide on the susceptibility of the area to soil loss given available assessment.

For this impact assessment, the Revised Universal Soil Loss Equation (RUSLE) was used to estimate soil erosion class and potential soil loss in tons/ha/year. The RUSLE is computed as:

$A = R \times K \times Ls \times C \times P$

where: A = Annual average soil erosion rate in t/ha/yr;

R = Rainfall erosivity factor which is based on global rainfall erosivity assessment based on high temporal rainfall records (Panagos, et.al., 2017);
K = Soil erodibility in tons/ha which is based on predetermined soil erodibility factors for sandy clay substrate with average organic matter content;
Ls = Slope gradient which is considered within the range of 10 to 15%;
C = Crop type and tillage factor. As the project site is not agricultural, the vegetation cover was compared instead to the most similar crop and tillage consisting of untilled grassland and trees;
P = Support factor which considers support practices to maintain vegetation cover and soil integrity such as contours, stripping, or crop rotation. Given the present land use, no support factor (default value of 1) was considered.

To conduct the assessment, a Digital Terrain Model (DTM) was generated to provide site specific assessment of slope gradient. Satellite data was used to eliminate the effect of buildings and other surface infrastructure to the slope gradient **(Figure 4-2**). The DTM agrees with the baseline phased DEM model and shows predominant slope not exceeding 10%.

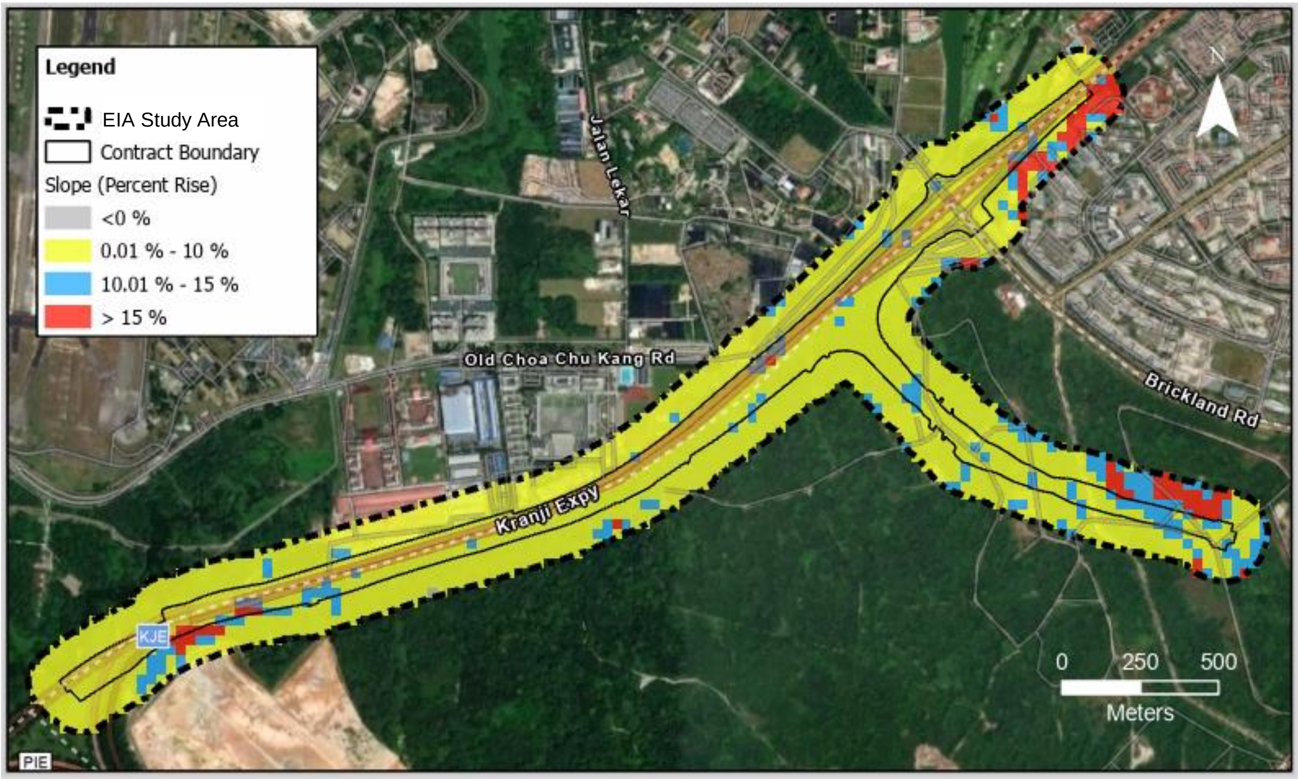


Figure 4-2: Digital Terrain Model using SRTM data

Resulting RUSLE value is 658.06 tons/ha/year. This value is considered very low or tolerable soil erosion (<6,700 tons/ha/yr). Soil loss and erosion is considered a natural occurrence albeit in tolerable levels regardless of the land use within the project site. With the project activities during the construction phase, the impacts attributed to the project are considered medium term. The potential increase of 658.06 tons/ha/yr was computed without any intervention accounted (support factor). With mitigation, the estimated soil loss will be managed.

Table 4-3: Impact Significance for Soil Loss and Erodibility during Construction

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Soil cover value is important to the area immediately outside the Contract Boundary.
A2.1: Impact Nature	-1: Negative	Soil loss and erosion is certain to occur not only as a consequence of the Project but as a result of natural and current land use ground disturbance.
A2.2: Magnitude of Changes	1: Low	The soil loss and erodibility potential computed for the Project is considered very low or tolerable in terms of soil erosion class. The magnitude of change may also be considered as negligible or no change. However, the negative impact is anticipated to be more pronounced without intervention hence a rating of low impact.
A2.3: Impact Extent	1: Local	Impact is limited within the disturbance areas where temporary and permanent earthworks will take place.
B1: Permanence	3: Medium-term	The duration of the Project is considered medium term as the potential increase in soil loss will be during the construction period of 3 to 10 years.
B2: Impact Pathway	3: Direct	Soil loss and erodibility is limited within the earthworks and ground preparation area.
B3: Reversibility	3: Irreversible	Eroded soil cannot be returned to its original location though preventive measures can be applied to minimise the magnitude of soil loss. It should be noted that soil loss and erosion is a natural occurrence that alters the geomorphology of an area corresponding to its land use and will likewise still occur with the "no project" alternative.
B4: Cumulative	2: Non-Cumulative	Soil erosion attributed to the Project is non-cumulative as its impact is limited within the disturbance area and with mitigation, the soil loss potential is not altered within the rest of the catchment not impacted by the Project. It should be recognized that soil loss and erosion will occur at nearly similar rates within the catchment due to rainfall erosivity, soil quality and geology, land use, and vegetation cover.
Environmental Score (ES)	**(at=-2) x (bt=11) = -22**	
Range Bands ES/ Impact Significance	Slight Negative Impact	

4.4.1.1.3 Changes in Hydrogeology

The subsurface hydrogeological dynamics is foreseen to be affected by the construction activities such as earthmoving, cut and fill, bore piles installation, and ground pavement.

Cut and Fill operations involving the grading of high-elevation slopes and backfilling of low-lying areas may observe a reduction of the hydrostatic pressures across areas with the elevation difference. The unsealed/open areas where surface water is allowed can percolate into the subsurface will be restricted by the pavement, surface sealing and compaction as part of the road construction. Also, since the widening of at-grade sections of the expressway, as well as the construction of at-grade road along the proposed Forest Drive cover the ground, the precipitation is not allowed to infiltrate. While in the other way, the rain gutter of the ramps and bridge may drain the rainwater into the specified locations. In the absence of intervention measures, the accumulating surface runoff will find its way into the closest draining point and percolate up to the saturation limits of the soil/subsurface material until it gets diverted to the surrounding areas. Any surface water features such as ponds and wetlands located near or within the EIA Study Area that are dependent or sustained by groundwater aquifers leaking to the surface may dry up temporarily or permanently.

The earthmoving, excavation, bore piles installation, and ground pavement will have a direct negative impact to the groundwater. The magnitude of change is considered low as the groundwater might affect up to the outside of the contract boundary during the construction and may restore to the initial condition after completion of the work. Thus, the duration of the impact is considered as medium-term since the geotechnical works (bored piling works) will be done around 17 months and earthmoving, excavation and ground pavement works will carry on during the construction period of 3 to 10 years.

Table 4-4: Impact Significance for Changes to Hydrogeology during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Hydrogeology value is important to the area immediately outside the Contract Boundary.
A2.1: Impact Nature	-1: Negative	Initial hydrogeological conditions will be impacted negatively as a response to the proposed earthmoving, surface grading/stripping, various subsurface excavations, compaction, and surface sealing.
A2.2: Magnitude of Changes	1: Low	Groundwater flow direction may be temporarily diverted away from areas where it originally flows during the construction due to ground disturbance. However, the groundwater flow direction may be restored to the initial condition at the cessation of construction activities or after the completion of construction.
A2.3: Impact Extent	2: Buffer Area	The change in hydrostatic conditions within the Project may partially affect the dynamics of aquifers outside of the local area as these are very likely interrelated.
B1: Permanence	3: Medium-term	Hydrogeological dynamics is expected to be affected by the construction activities for 3 to 10 years and the presence of a permanent structure/surface alteration (i.e., soil compaction, pavement laying, bored piles)
B2: Impact Pathway	3: Direct	Ground disturbance will directly affect the aquifer-hosting bedrock

Assessment Criterion	Score Rating	Rating Justification/ Definition
B3: Reversibility	3: Irreversible	Changes in hydrogeological conditions after completion of all earthworks, excavation and construction activities that will disturb host rock aquifers remains permanent, however these changes are considered minor. Permanent change in hydrogeological conditions will occur where major excavation and earthmoving for infrastructures will take place. Any subgrade developments will affect bedrock including aquifers in turn, affecting groundwater flow and level. Note, however, that groundwater will migrate to unaffected bedrock and will seek its level once construction activities are completed.
B4: Cumulative	3: Cumulative	Ground disturbance of each development sector in succession will result to gradual changes in hydrogeological dynamics, such as groundwater levels, hydrostatic pressures and groundwater flows across the EIA Study Area and the surrounding region where its subsurface could be characteristically contiguous with the aquifer units. These are, however, considered minor and part of the previous hydrogeologic conditions may return to its original state.
Environmental Score (ES)	**(at=-4) x (bt=12) = -48**	
Range Bands ES/ Impact Significance	Slight Negative Impact	

4.4.1.2 Evaluation of Soil and Groundwater Quality Impacts

Construction activities have the potential to result in adverse impacts on soil and groundwater quality. Potential sources of impacts include:

- Pollutive substances (chemicals associated with vehicle maintenance and workshops such as fuels, oil, solvents)
- Improper disposal of construction, chemical materials, and wastes
- Existing soil and groundwater contamination

4.4.1.2.1 Land Contamination due to Pollutive Substances Leaks or Spills

The construction activities are anticipated to require the onsite use, storage, and handling of diesel for the generator sets, lubrication oil to maintain the equipment used onsite. If not properly stored and handled, spillage of chemicals may seep into the soil and groundwater. Thus, adversely impact the soil and groundwater quality. No hazardous chemicals as defined in EPMA (Hazardous Substances) regulations are expected to be used in the construction activities.

The impact from spillages and leaks relating to the presence of chemical storage during construction will have a negative direct impact to the quality of soil and groundwater which interfaces to the immediate area outside the Contract Boundary. The geographical extent of this impact is considered to be extended outside of the Contract boundary through potential migration of contaminants. The duration of the impact is medium term and will cease on the completion of the construction. Spill or leak events to the immediate area requires removal of soil and disposed appropriately. The impact is considered cumulative as there are other development in the vicinity of the Project that may have bulk storage facilities for pollutive substances.

Table 4-5: Impact Significance for Pollutive Substances Leaks or Spills during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Soil and groundwater quality value is important to the area of outside the Contract Boundary
A2.1: Impact Nature	-1: Negative	The soil and groundwater will have a negative impact from the spills and leaks of contaminant.
A2.2: Magnitude of Changes	1: Low	No bulk storage facilities for storing fuel onsite during construction.
A2.3: Impact Extent	2: Buffer Area	The impact may migrate to the outside of the contract boundary if the contaminant from the soil has reached the groundwater.
B1: Permanence	3: Medium-term	Impact only occurs during the construction phase, which will take place over a period of more than 3 years but less than 10 years.
B2: Impact Pathway	3: Direct	Spillage and leakage will directly impact the soil and groundwater.
B3: Reversibility	2: Reversible	The impacted soil and groundwater may be reversed to the natural condition by conducting the soil and groundwater remediation. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	The potential spill and leakage may be gradually increased with other project developments in the vicinity have construction activities where the fuel storage will be placed for handling the diesel and lubricant oil.
Environmental Score (ES)	**(at=-4) x (bt=11) = -44**	
Range Bands ES/ Impact Significance	Slight Negative Impact	

4.4.1.2.2 Land Contamination due to Hazardous or Toxic Industrial Wastes

The proposed construction activities are expected to dispose contaminated material, waste material, and made ground. Onsite dumping or leaving these materials onsite or mixing with onsite soil may have the potential to result in adverse impacts on soil and groundwater which interfaces to the immediate area outside the Contract boundary. The magnitude is considered moderate impact to soil and groundwater. The geographical extent is considered to be local, within the DE170 Contract boundary. The impact is medium-term and lasts for a period until completion of the construction. Waste disposal in the immediate area require clean-up of the affected area. The impact is cumulative as there are visible areas of waste dumping observed within the EIA Study Area. The significance of this impact is considered slight negative.

Assessment of impact of hazardous waste is also discussed in Assessment of Waste Section (**Section 10**) to include its associated effect as fire hazard.

Table 4-6: Impact Significance for Hazardous or Toxic Industrial Wastes during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Soil and groundwater quality value is important to the area of outside the Contract Boundary.
A2.1: Impact Nature	-1: Negative	The soil and groundwater will have a negative impact from the disposal of wastes containing contaminants.
A2.2: Magnitude of Changes	1: Low	Volume of generated hazardous wastes expected onsite during construction is anticipated to be low.
A2.3: Impact Extent	2: Buffer Area	The impact may migrate to the outside of the contract boundary if the contaminant from the soil has reached the groundwater.
B1: Permanence	3: Medium-term	Impact only occurs during the construction phase, which will take place over a period of more than 3 years but less than 10 years.
B2: Impact Pathway	3: Direct	Hazard directly affects soil and groundwater.
B3: Reversibility	2: Reversible	The impacted soil and groundwater may be reversed ato the natural condition by conducting the soil and groundwater remediation. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Land contamination attributed from hazardous and toxic industrial wastes of the Project development is cumulative with existing waste dumping areas in the vicinity
Environmental Score (ES)	**(at=-4) x (bt=11) = -44**	
Range Bands ES/ Impact Significance	Slight Negative Impact	

4.4.2 Operation Phase Impacts

Operational impacts within the EIA Study Area will potentially be from the use of the interchange and its periodic servicing or maintenance. Heavy construction vehicles are not anticipated to be used during such maintenance activities. As such, these operation phase activities will not use or generate large volumes of hazardous substances and wastes.

Potential short-term operation phase impacts would possibly occur should there be major repairs, especially if heavy machineries are required. This would create potential sources of soil and groundwater contaminants. However, it is expected that such short-term operation impacts will only last for the duration of the maintenance works and would be limited in scope.

It is assumed that previously disturbed areas such as access and temporary staging areas will be rehabilitated. Maintenance activities, which are limited to utilities installation, paving works, and other surface works will not impact groundwater conditions.

4.5 Recommendation of Preventive and Mitigation Measures

4.5.1 Geomorphology and Hydrogeology

A number of mitigation measures may be adopted to minimise, if not completely eliminate, changes that may affect soil infiltration capacity, soil loss, hydrogeology, and geomorphology. These may be implemented individually or in combination, as applicable.

- *Develop and undertake a programmatic Excavation, Cut and Fill and Earthmoving plan*. Construction activities are recommended for implementation in stages and programmed segments to minimize the area disturbed at any given time. By minimizing the disturbance area affected by excavation and earthworks to what is only necessary, potential erosion and topsoil loss can be reduced.
- *Engagement of a Qualified Person (QP)/Professional Engineer to conduct slope stability and soil compaction studies* within and adjacent to the areas of concern prior to any clearing and earthworks. The results of this assessment will be incorporated to the operational manual during earth-moving and excavation activities.
- *Stockpile stripped topsoil in a designated area strategically placed within the Contract Boundary* and cover the area as necessary to reduce or prevent soil loss from secondary erosion from wind or runoff. Soil conserved can be ameliorated and reused afterwards for backfilling and improvement of vegetation in previously disturbed and cleared areas. Excess soil material can be exported outside of the EIA study area for further reuse. Spoil materials are recommended to be separately stockpiled, which can be used as backfill materials within the development areas as necessary or outside where it can be of use.
- *Placement of Erosion and Sediment Control (ESC) structures (i.e., biodegradable Erosion Control Blanket (ECB)) at open area*s where applicable. ESC structures can likewise be strategically built adjacent to cut and fill, excavation and stockpiling sites.
- *Rehabilitate temporary construction areas* such as staging and stockpiling zones as close as practicable to its pre-construction conditions that can be revegetated.
- *Placement of piezometers and monitoring wells adjacent to work areas* where groundwater hydrostatic pressure is expected to become potentially high that these may also affect the subsurface-related construction activities. The monitoring wells can be added by converting from the proposed boreholes**.** Shoring and dewatering with pumps may be undertaken as needed where increased hydrostatic pressure is expected to cause leaching into construction areas. Automatic pumps may be installed which will operate when critical piezometric levels are exceeded.

4.5.2 Soil and Groundwater Quality

The emphasis for soil and groundwater contamination is on controlling the potential impacts from the construction works on soil and groundwater quality using good practices for construction sites. The overall approach to mitigating the soil and groundwater contamination impact from construction activities will involve the following:

- *Prepare spoil (soil and concrete debris) management and disposal plan*. The plan should define the area where the construction spoil will be temporarily stored, the mode of disposal chosen, and any further testing required by the accepting party (e.g., concrete recycling company).
- *Maintain records of all spoil removed from site*. Such records should include, but not limited to, disposal site, spoil classification, volume or weight of soil, vehicle identification, and the date and time the vehicle left the worksite.

- *Avoid mixing different types of spoil* unless they are to be disposed of at the same location within the same facility.
- *Only licensed and approved waste haulers should be used to collect and transport any contaminated material* to an appropriate disposal site.
- *Store chemical materials and wastes in a sheltered and locked area with secondary containment*. Appropriate spill absorption material should be stored near the storage area to clean up any minor spill events. The risks associated with the storage and handling of chemicals can be further minimized by:
  - Provision of an appropriate, well ventilated storage area
  - Careful handling of waste fuel and oil residues
  - Storage of wastes remote from sensitive receivers (e.g., forest area, waterbody)
  - Training of workers on the concepts of site cleanliness and appropriate chemical handling procedures
- *Workers handling soil should wear appropriate Personal Protective Equipment (PPE)* such as boots, overalls, rubber gloves, goggles, and implement good personal hygiene practices to minimise accidental ingestions, direct contact, and inhalation of contaminants, if identified.
- *Prepare and implement a dewatering management plan of removed groundwater from the excavation*. The management plan shall have protocol of no direct discharge of groundwater from dewatering process into any public sewer line. Pumped water (groundwater) should undergo analytical test based on baseline condition from the result of soil and groundwater study to determine the method of treatment or disposal.

4.6 Residual Impact

With the implementation of the recommended mitigation measures, the following residual impacts in affected areas will be:

- Permanent reduction of land area with soil cover
- Permanent change in hydrogeological dynamics
- Amelioration of conserved soil

With the expected change in hydrogeological dynamics, the mitigation measures mentioned above will help to recover and sustain some of the groundwater in areas by managing the conditions through piezometers. The reduction of open areas due to the Project to within the buffer areas can serve as groundwater recharge zones. Soil amelioration helps the soil recover some of the reduction in quality, and manage loss through erosion and surface runoff, and contribute to the recovery of lost soil infiltration capacity.

Following the adoption of the applicable embedded control measures and mitigation measures recommended above will assist to reduce the magnitude of the soil and groundwater quality by controlling the potential harmful impacts and reducing the amount of such hazards contaminating soil and groundwater or by reducing the migration from buffer area to Contract Boundary.

Table 4-7: Summary of Evaluation of Residual Impacts for Geomorphology, Soil, and Groundwater Quality

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Impact Significance)	
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Environmental Score (ES)	Range Band of ES / Impact Significance
G-I1	Changes to Soil Infiltration Capacity	-48	Slight Negative Impact	-24	Slight Negative Impact
G-I2	Soil Loss and Erodibility	-22	Slight Negative Impact	-20	Slight Negative Impact
G-I3	Changes in Hydrogeology	-48	Slight Negative Impact	-36	Slight Negative Impact
G-I4	Land Contamination due to Pollutive Substances Leaks or Spills	-44	Slight Negative Impact	-22	Slight Negative Impact
G-I5	Land Contamination due to Hazardous or Toxic Industrial Wastes	-44	Slight Negative Impact	-22	Slight Negative Impact

5. Assessment of Water Quality and Waterbodies

This section provides the applicable legislation and standards in assessing the potential water quality impact related to the activities from construction and operation phases. It includes a description of the existing water quality conditions within the EIS Study Area, methodology and criteria used for the assessment. Appropriate mitigation measures are recommended, where necessary.

5.1 Applicable Legislation and Standards

NEA administers the *Environmental Protection and Management Act* (EPMA) and the E*nvironmental Protection and Management (EPM) (Trade Effluent) Regulations* which regulates the discharge of wastewater into open drains, canals, and rivers and specify the allowable limits for trade effluent discharge to various types of watercourses. The trade effluent discharge nature or type must be approved by NEA prior to discharge into any watercourse. The effluent quality must be treated before discharge and comply with the water quality specified in the regulations.

The waterbodies in the EIA Study Area ultimately drain into Kranji Reservoir, one of the 17 reservoirs in Singapore. As Kranji Reservoir is a watercourse from which potable water supplied by PUB under the Public Utilities Act is obtained, it is classified as a controlled watercourse. Therefore, the allowable limit (**Table 5-1**) for controlled watercourse is applied in this EIA. In addition, the following guideline levels are adopted for parameters not listed in the EPM Trade Effluent Regulations as concurred in the *EIA DE170 Inception Report_Rev 4 (20220326)*.

- *NEA's Water Quality Guidelines for Popular Recreational Beaches* for Enterococcus
- *PUB Internal Guidelines for Water Treatment* for Total Organic Carbon
- *PUB Internal Guidelines for Reservoir Water Quality* for Ammoniacal Nitrogen

Table 5-1: EPM Discharge Limits to Controlled Watercourse

Item of Analysis	Standard	Discharge Limit Controlled Watercourse, mg/L
Turbidity	*In-situ*	-
Conductivity	*In-situ*	-
pH value	*In-situ*	6-9
Dissolved Oxygen	*In-situ*	-
5-day Biochemical Oxygen Demand (BOD) at 20°C	APHA 5210B	20
Chemical Oxygen Demand	APHA 5220B/HACH 8000	60
Total Suspended Solids	APHA 2540D	30
Total Dissolved Solids	APHA 2540C	1,000
Phosphate (PO4) as P	APHA 4110B / 4500-P(G)	2
Nitrate (NO3) as N	APHA 4500-NO3 (I)	20

Item of Analysis	Standard	Discharge Limit Controlled Watercourse, mg/L
Total N	APHA 4500-N (C)	-
Total P	APHA 4500-P (H)	-
Aluminium	APHA 3500-Al	-
Ammoniacal-N	APHA 4500-NH3-N	0.5
Enterococcus	APHA 9230	200 cfu/100 ml
Total organic carbon	Method 5310	10
Arsenic	APHA 3500-As	0.01
Barium	APHA 3500-Ba	1
Tin	APHA 3500-Sn	5
Iron (as Fe)	APHA 3500-Fe	1
Beryllium	APHA 3500-Be	0.5
Boron	APHA 3500-B	0.5
Manganese	APHA 3500-Mn	0.5
*Cadmium	APHA 3500-Cd	0.003
*Chromium (trivalent and hexavalent)	APHA 3500-Cr	0.05
*Copper	APHA 3500-Cu	0.1
*Lead	APHA 3500-Pb	0.1
*Mercury	APHA 3500-Hg	0.001
*Nickel	APHA 3500-Ni	0.1
*Selenium	APHA 3500-Se	0.01
*Silver	APHA 3500-Ag	0.1
*Zinc	APHA 3500-Zn	0.5
*Metals in Total	Method 3120B	0.5

For parameters where limits are not specified within the regulations, the baseline monitoring results shall be analysed and correlated with other parameters and the existing site conditions. These parameters include turbidity, conductivity, dissolved oxygen, total phosphorus, total nitrogen, and aluminium.

The *Sewerage and Drainage Act* (SDA) authorizes PUB to construct, maintain and improve sewerage and drainage systems, to regulate the discharge into these systems, and to issue codes of practice or specifications. It mandates the supervision of works requiring a clearance certificate under this Act by a Qualified Person. The Act also confers PUB with enforcement powers.

The Code of Practice (COPs) and guidelines that are relevant to discharges into waterbodies are listed below:

- COP for Environmental Control Officer (ECO) issued by NEA
- COP on Surface Water Drainage (revised 2007) issued by PUB
- Guidebook on Erosion and Sediment Control at Construction Sites, issued by PUB
- Guidebook for Qualified Erosion Control Professional (QECP), issued by PUB

5.2 Methodology of Water Quality Assessment

This EIA focuses on the assessment of potential water quality impacts during the construction and operation phase activities of the proposed Project. There is no legislation and standard in Singapore presently that describe the methodology for water quality impact assessment. Thus, as proposed and agreed in the scoping stage, we have used the *Technical Memorandum Annex 14: Guidelines for Assessment of Water Pollution* published by Hong Kong's Environmental Protection Division (HK EPD) adapted to Singapore situation. The Technical Memorandum Annex 14: Guidelines for Assessment of Water Pollution was chosen as it provides guidance on identification of potential water pollution sources associated with the Project development and prediction and assessment of potential water pollution impact.

The potential impacts from the construction and operation on water quality is undertaken in a qualitative manner, as specific discharge quantities and discharge points are not known at this time as well as the baseline water quality results are not available. The assessment on potential water quality impacts involves the following tasks:

- Identifying watercourse within the EIA Study Area
- Establish baseline conditions for water quality at receiving watercourse based on specification and methodology approved in the Inception Report
- Specifying construction activities with the potential to affect water quality and assess their impacts
- Recommending mitigation measures to minimise any identified adverse impacts on the water quality by the construction activities and identify appropriate monitoring requirements during construction phase

5.3 Pre-construction Baseline

5.3.1 Climate and Meteorological Data

5.3.1.1 General Climate in Singapore

Situated near the equator, Singapore has a tropical climate with abundant rainfall, relatively high and uniform temperatures, and high humidity all year round. The climate is characterised by two monsoon seasons and two inter-monsoonal periods:

- **Northeast monsoon season (December to early March) –** The early part of the northeast monsoon is the wetter period of the year when monsoon surges with moderate to heavy rain and gusty winds from December to early January. The late part of the northeast monsoon is windy and relatively dry.
- **Inter-monsoon period (late March to May) –** Afternoon thunderstorms are common in the afternoon and early evening. Hot afternoons with maximum temperature above 32 degree Celsius (°C) can occur.

- **Southwest monsoon season (June to September) –** Occasional gusty winds associated with Sumatra squalls occur between predawn hours and midday. Short duration showers or thunderstorms in the afternoon are common.
- **Inter-monsoon period (October to November) –** This inter-monsoon period is generally wetter than the earlier inter-monsoon period. Thunderstorms occur in the afternoon and early evening.

Average rainy days (total rainfall of the day is at least 0.2 mm) in Singapore is 167 days of the year. The 1981-2010 long-term average annual rainfall was 2,166 mm.

The minimum daily temperature in Singapore does not usually fall below 23-25°C during the night and the maximum does not rise above 31-33°C during the day. May and June are the hottest months with a mean monthly temperature of 27.8°C. December and January are the coolest months with a mean monthly temperature of 26.0°C. Due to the proximity of the sea, Singapore has a coastal climate that moderately influences its climate. During the afternoons, conditions at the coast are often relieved by sea breezes.

Relative humidity in Singapore is fairly uniform throughout the year and does not vary much from month to month. During days where there is no rain, the daily relative humidity varies from more than 90% in the morning just before sunrise and falls to around 60% in the mid-afternoon. The mean annual relative humidity is 83.9%. Relative humidity frequently reaches 100% during prolonged periods of rain.

5.3.1.2 Site Specific Rainfall during Baseline Study

The rainfall for the EIA Study Area from March to June 2022 was obtained from publicly available data from the Meteorological Service Singapore (MSS) of NEA (http://www.weather.gov.sg/climate-historical-daily/) and presented in. Three nearest Meteorological Stations (Met Stations) were selected (**Figure 5-1**).

Figure 5-1: Locations of Met Stations nearest to the EIA Study Area

Source: ESRI

The site-specific rainfall was obtained from Choa Chu Kang Central Meteorological Station (S114), Choa Chu Kang South Meteorological Station (S121), and Tengah Meteorological Station (S23). S114 is located 0.1 km east of the EIA Study Area, S121 is immediately at the edge of the EIA Study Area, while S23 is located 1.8 km north of the EIA Study Area.

Based on the weather data recorded from March to June 2022, the site-specific weather can be described as follow:

- The highest daily rainfall total recorded was 116 mm at S114 on 7 March 2022, 125 mm at S121 on 7 March 2022 and 117 mm at S23 on 7 March 2022.
- The highest 1-hour rainfall recorded was 93 mm across the three (3) meteorological stations on 7 March 2022.

5.3.1.3 Site Specific Historical Rainfall

Year-to-year rainfall in Singapore is highly variable. On a longer-term basis, annual rainfall total for Singapore since 1980 has increased at an average rate of 67 mm per decade.

From April 2011 to June 2022, the highest monthly rainfall total recorded was 720 mm at S114 in August 2021, 484 mm at S121 in August 2021 and 527 mm at S23 in December 2012 (**Figure 5-2**). The average monthly rainfall total over the same period is 234 mm at S23, 218 mm at S114, and 219 mm at S121.

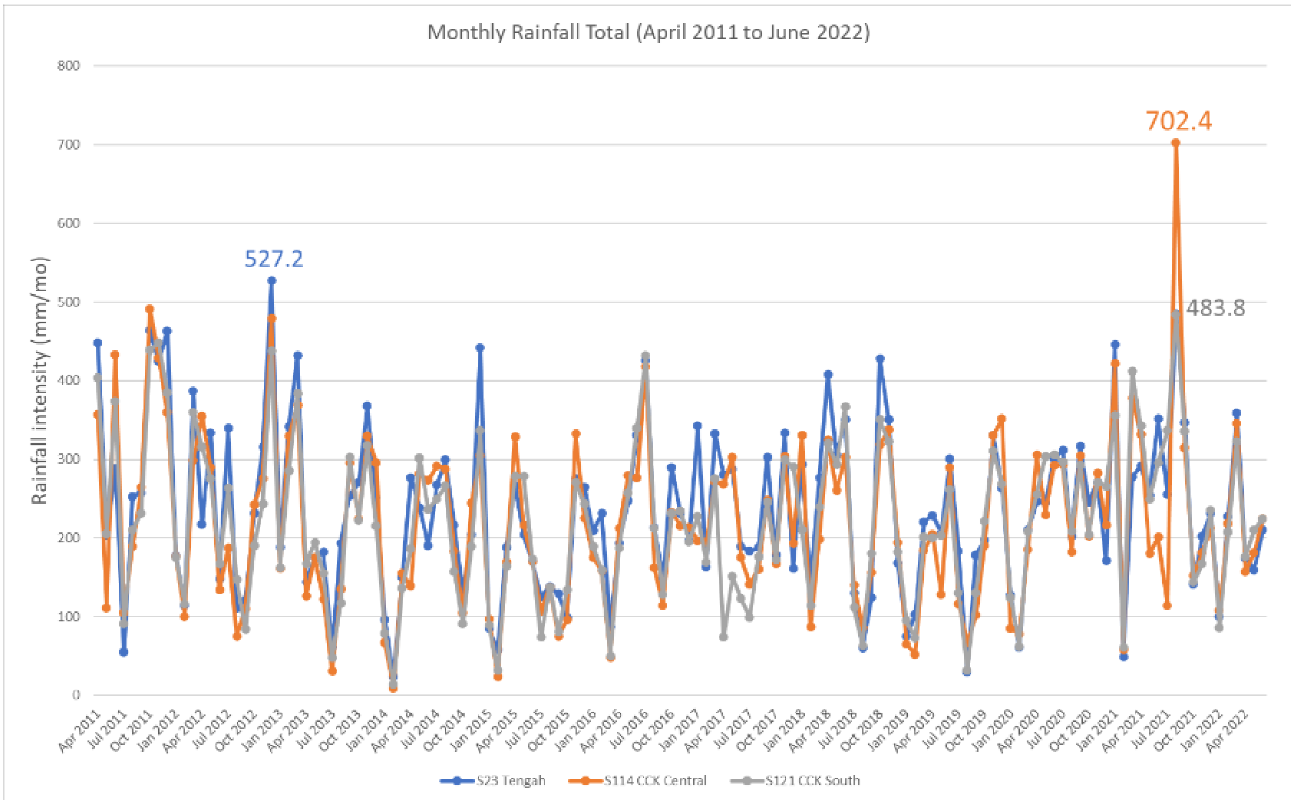


Figure 5-2: Monthly Rainfall Data from April 2011 to June 2022

5.3.2 Identification of Waterbodies

Based on preliminary desktop study and preliminary site reconnaissance, most waterbodies observed within the Tengah Forest flows towards Sungei Peng Siang and drains to Kranji Reservoir for storage as a source of water supply, along with other tributaries, Sungei Kangkar, Sungei Tengah, and Pang Sua Canal, and eventually Johor Straits.

We have identified six (6) major clusters of waterbodies within the EIA Study Area, i.e., WQ1, WQ1a and WQ2 (west of EIA Study Area), WQ3 (west-northeast of EIA Study Area), WQ4 (central part of the EIA Study Area) and WQ5 (southeast of the EIA Study Area) as shown in **Figure 5-3**.

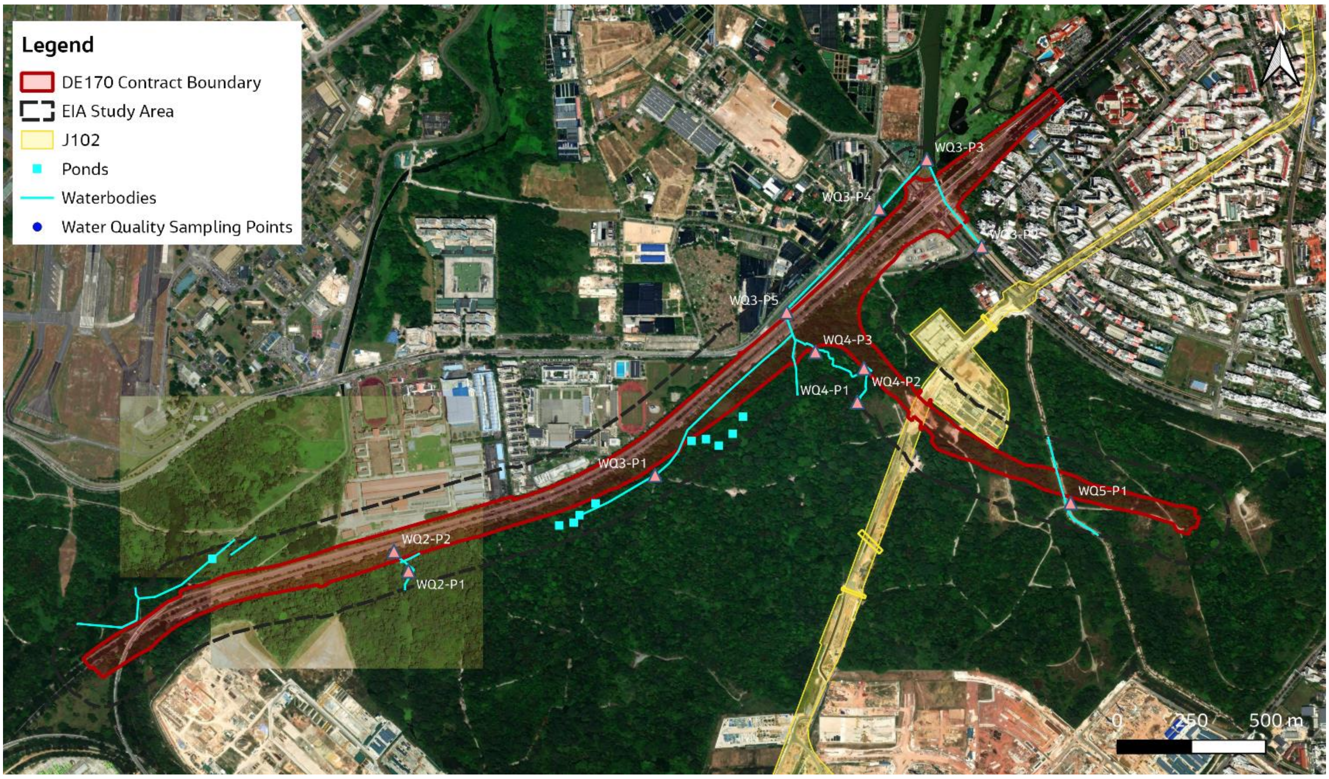


Figure 5-3: Identified Waterbodies within the EIA Study Area

Source: ESRI

Baseline surveys have been carried out to identify streams within the EIA Study Area, where various features of these waterbodies are documented during the survey. The waterbody features noted during the baseline survey are presented on **Table 5-2**.

Table 5-2: Baseline Waterbodies Survey Dates and Observations

Survey Date	Location	Description	Photo ID (refer to Figure 5.3)	Photograph
11 March 2022	WQ2 (1.36787, 103.71692)	Earth drain, with vegetation at the banks, shallow to deep, medium to low flow	WQ2-P1	
23 March 2022	WQ2 (1.36847, 103.71648)	Earth drain, with vegetation at the banks, shallow to deep, medium to low flow	WQ2-P2	
24 January 2022	WQ3 (1.37077, 103.72438)	Medium concrete-lined drain parallel to KJE, shallow, little to no flow	WQ3-P1	
26 January 2022	WQ3 (1.37769, 103.73426)	Large monsoon canal parallel to Brickland Road that flows towards Sungei Peng Siang, shallow, low flow	WQ3-P2	

Survey Date	Location	Description	Photo ID (refer to Figure 5.3)	Photograph
26 January 2022	WQ3 (1.38032, 103.73260)	Sungei Peng Siang, exhibits eutrophication	WQ3-P3	
26 January 2022	WQ3 (1.37883, 103.73116)	Monsoon canal parallel to KJE that flows towards Sungei Peng Siang, low flow, exhibits eutrophication	WQ3-P4	
10 March 2022	WQ3 (1.37570, 103.72836)	Monsoon canal parallel to Old Choa Chu Kang Road, turbid, medium to low flow	WQ3-P5	
25 March 2022	WQ4 (1.37298, 103.73050)	Earth drain, little to no vegetation along the banks, very shallow, low flow	WQ4-P1	
25 March 2022	WQ4 (1.37400, 103.73070)	Earth drain, little to no vegetation along the banks, dry	WQ4-P2	

Survey Date	Location	Description	Photo ID (refer to Figure 5.3)	Photograph
25 March 2022	WQ4 (1.37450, 103.72923)	Earth drain, whitish substrate, bare earth bank, low flow	WQ4-P3	
24 January 2022	WQ5 (1.36993, 103.73695)	Large monsoon canal that flows towards Brickland Road, shallow, low flow	WQ5-P1	

5.3.2.1 Locations of Baseline Water Quality Monitoring

Water quality monitoring is carried out at every 50 m interval for natural streams and other natural waterbodies, and at the start of every stream (i.e., upstream of works), on the lower portion of the stream (as downstream as possible), and where a stream has multiple tributaries, within the EIA Study Area (**Figure 5-4** and **Appendix 5C**).

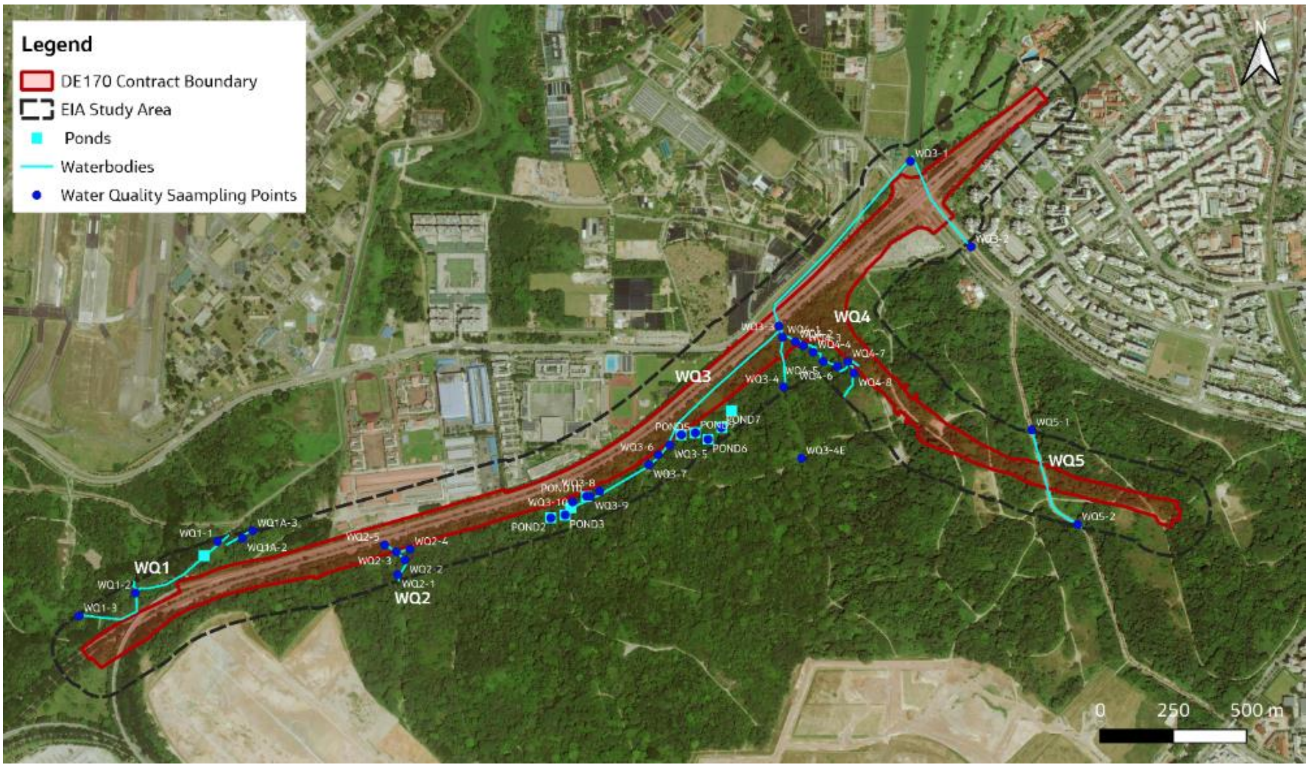


Figure 5-4: Identified Waterbodies and Water Quality Monitoring Locations within the EIA Study Area
Source: ESRI

Rationales for each surface water monitoring locations are shown on **Table 5-3** below.

Table 5-3: Description of Surface Water Monitoring Locations

WQ Cluster	Monitoring Point	Description of Location	Rationale
WQ1	WQ1-1	Downstream of WQ1	Provide data of the surface water quality of the downstream of WQ1
	WQ1-2	Upstream of a WQ1 tributary coming from north of WQ1	Provide data of the surface water quality of the upstream of a WQ1 tributary coming from north of WQ1
	WQ1-3	Upstream of WQ1	Provide data of the surface water quality of the upstream of WQ1
	WQ1A-1	Downstream of WQ1A-1	Provide data of the surface water quality of the downstream of WQ1A-1
	WQ1A-2	Middle course of WQ1A-2	Provide data of the surface water quality of the middle course of WQ1A-2

WQ Cluster	Monitoring Point	Description of Location	Rationale
	WQ1A-3	Upstream of WQ1A-3	Provide data of the surface water quality of the upstream of WQ1A-3
WQ2	WQ2-1	Downstream of WQ2	Provide data of the surface water quality of the downstream of WQ2
	WQ2-2	Middle course of WQ2	Provide data of the surface water quality of the middle course of WQ2
	WQ2-3		
	WQ2-4	Upstream of a WQ2 tributary coming from east of WQ2	Provide data of the surface water quality of the upstream of a WQ2 tributary coming from east of WQ2
	WQ2-5	Upstream of WQ2	Provide data of the surface water quality of the upstream of WQ2
WQ3	WQ3-1	Downstream of WQ3 before merging with the other tributaries of Kranji reservoir	Provide data of the surface water quality of the WQ3 before merging with the other tributaries of Kranji reservoir
	WQ3-2	Upstream of WQ3 at the northeast of the EIA Study Area	Provide data of the surface water quality of the upstream of WQ3 at the northeast of the EIA Study Area
	WQ3-3	Confluence in WQ3	Provide data of the surface water quality of the middle-course of WQ3
	WQ3-4	Upstream of a WQ3 tributary coming from Tengah Forest	Provide data of the surface water quality of the upstream of tributary coming from Tengah Forest where twin cell culvert will be constructed
	WQ3-4E	Upstream of WQ3 which is impacted by the works downstream	Provide data of the surface water quality of the upstream of WQ3-4
	WQ3-5	Downstream of naturalised portion of the canal	Provide data of the surface water quality of the downstream of the naturalised canal in WQ3
	WQ3-6		
	WQ3-7		
	WQ3-8	Upstream of WQ3 where substrate is earth	Provide data of the surface water quality within the upstream of WQ3
	WQ3-9		
	WQ3-10		
WQ4	WQ4-1	Downstream of WQ4	Provide data of the surface water quality within the downstream of WQ4
	WQ4-2		
	WQ4-3		
	WQ4-4	Middle course of WQ4	Provide data of the surface water quality of the middle-course of WQ4
	WQ4-5		
	WQ4-6		
	WQ4-7		
	WQ4-8	Upstream of WQ4	

WQ Cluster	Monitoring Point	Description of Location	Rationale
	WQ4-9		Provide data of the surface water quality within the of the upstream of WQ4
	WQ4-10		
WQ5	WQ5-1	Downstream of WQ5	Provide data of the surface water quality of the downstream of WQ5
	WQ5-2	Upstream of WQ5	Provide data of the surface water quality of the upstream of WQ5
Ponds	Pond 1	Ephemeral pond	Provide data of the surface water quality of Pond 1
	Pond 2	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 2
	Pond 3	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 3
	Pond 4	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 4
	Pond 5	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 5
	Pond 6	Open country pond	Provide data of the surface water quality of Pond 6
	Pond 7	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 7
	Pond 8	Ephemeral pond	Provide data of the surface water quality of Pond 8
	Pond 9	Open country pond	Provide data of the surface water quality of Pond 9
	Pond 10	Closed canopy pond (with duckweed)	Provide data of the surface water quality of Pond 10
	Waterlogged Area	Swampy area	Provide data of the surface water quality of waterlogged area

5.3.2.2 Water Quality Baseline Weather Events

As concurred in the Inception Report, water samples will be collected in both dry (no rain event in the preceding 48 hours) and wet seasons (within 2 hours of a significant rainfall [10 mm/hr]). There will be two (2) events of dry weather sampling and one (1) wet weather sampling. However, due to limited access into the Tengah Forest and suitable weather conditions, only WQ1, WQ1A, WQ2, WQ4 and WQ5 have completed two (2) rounds of dry weather sampling and one (1) round of wet weather sampling. WQ3 have completed at least one (1) round of dry weather sampling, and one round of wet weather sampling, thus far.

Details on sampling date, location, activity is summarised on **Table 5-4**. Photographic documentation of the sampling event is presented in **Appendix 5C**.

Table 5-4: Details of Surface Water Baseline Weather Events

WQ Cluster	Monitoring Point	Wet Weather Event		Dry Weather Event 1		Dry Weather Event 2	
		Sampling Date	Weather Condition	Sampling Date	Weather Condition	Sampling Date	Weather Condition
WQ1	WQ1-1	20-Jul-22	Total rainfall of 10.2 mm within 2 hrs of sampling	1-Jun-22	No rain for 48 hours before sampling	19-Jul-22	No rain for 48 hours before sampling
	WQ1-2						
	WQ1-3						
WQ1A	WQ1A-1	20-Jul-22	Total rainfall of 10.2 mm within 2 hrs of sampling, WQ1A-1 has insufficient water for sampling	1-Jun-22	No rain for 48 hours before sampling, WQ1A-1 was dry during sampling	19-Jul-22	No rain for 48 hours before sampling, WQ1A-1 was dry during sampling
	WQ1A-2						
	WQ1A-3						
WQ2	WQ2-1	5-Sep-22	Total rainfall of 28.4 mm within 2 hrs of sampling	31-May-22	No rain for 48 hours before sampling	1-Sep-22	No rain for 48 hours before sampling
	WQ2-2						
	WQ2-3						
	WQ2-4						
	WQ2-5						
WQ3	WQ3-1	5-Oct-22	Total rainfall of 69.8 mm within 2 hrs of sampling	28-Apr-22	No rain for 48 hours before sampling	12-Aug-22	No rain for 48 hours before sampling
	WQ3-2						
	WQ3-3						
	WQ3-4						
	WQ3-4E						
	WQ3-5	6-Oct-22	Total rainfall of 17.4 mm within 2 hrs of sampling	30-May-22	No rain for 48 hours before sampling	10-Jan-23	No rain for 48 hours before sampling
	WQ3-6						
	WQ3-7						
	WQ3-8	5-Dec-22	Total rainfall of 18.8 mm within 2 hrs of sampling				
	WQ3-9						
	WQ3-10						
WQ4	WQ4-1	5-Oct-22	Total rainfall of 69.8 mm within 2 hrs of sampling	28-Apr-22	No rain for 48 hours before sampling, WQ4-9 and WQ4-10 were dry	12-Aug-22	No rain for 48 hours before sampling, WQ4-9 and WQ4-10 were dry
	WQ4-2						
	WQ4-3						
	WQ4-4						
	WQ4-5						
	WQ4-6						

WQ Cluster	Monitoring Point	Wet Weather Event		Dry Weather Event 1		Dry Weather Event 2	
		Sampling Date	Weather Condition	Sampling Date	Weather Condition	Sampling Date	Weather Condition
	WQ4-7				during sampling		during sampling
	WQ4-8						
	WQ4-9						
	WQ4-10						
WQ5	WQ5-1	5-Sep-22	Total rainfall of 28.4 mm within 2 hrs of sampling	28-Apr-22	No rain for 48 hours before sampling	1-Sep-22	No rain for 48 hours before sampling
	WQ5-2						
Ponds	Pond 1	20-Jul-22	Total rainfall of 10.2 mm within 2 hrs of sampling, Pond 1 has insufficient water for sampling	1-Jun-22	No rain for 48 hours before sampling, Pond 1 was dry during sampling	19-Jul-22	No rain for 48 hours before sampling, Pond 1 was dry during sampling
	Pond 2	5-Dec-22	Total rainfall of 18.8 mm within 2 hrs of sampling	30-May-22	No rain for 48 hours before sampling, Pond 4, Pond 8 and waterlogged area were dry		
	Pond 3						
	Pond 4						
	Pond 5	6-Oct-22	Total rainfall of 17.4 mm within 2 hrs of sampling Pond 8 has insufficient water for sampling			10-Jan-23	No rain for 48 hours before sampling, Pond 6 was dry
	Pond 6						
	Pond 7						
	Pond 8						
	Pond 9						
	Pond 10	5-Dec-22	Total rainfall of 18.8 mm within 2 hrs of sampling				
	Waterlogged	6-Oct-22	Total rainfall of 17.4 mm within 2 hrs of sampling Waterlogged area has insufficient water for sampling			10-Jan-23	No rain for 48 hours before sampling, Waterlogged area was dry

Based on the surveys and water sampling events, WQ1A-1 and Pond 1 are classified as ephemeral streams. WQ4-9, WQ4-10, Pond 4, Pond 6 and Pond 8 are suspected as ephemeral streams given the state that they have occasional water flowing.

5.3.2.3 Results of Baseline Water Quality Monitoring

Dry weather surface water quality monitoring has been carried out on 28 April, 30 May, 31 May, 1 June, 19 July, 12 August, 1 September 2022 and 10 January 2023, where no rain has occurred for the preceding 48 hours of each sample collection day. Wet weather surface water quality monitoring has been carried out on 20 July and 5 September, 5 October, 6 October and 5 December 2022, where sampling was carried out within 2 hours of rain with intensity of more than 10 mm/hr. A total of 119 water monitoring locations have been surveyed but only 104 water samples were collected and submitted for laboratory analysis as some locations were dry or have insufficient water for sampling.

Water analytical results has reported that pH, total suspended solids (TSS), enterococcus, arsenic (As), iron (Fe), ammoniacal nitrogen (NH3-N), total organic carbon (TOC), have exceeded the limit for discharge into a controlled watercourse in at least one of the water samples collected during areas with monitoring event.

A complete summary of water analytical results (detects and non-detects) and comparison with the water quality criteria are presented in **Appendix 5A** while the laboratory reports are shown in **Appendix 5B**. Summary of water analytical results showing the exceeded parameters are shown on **Table 5-5**. Photographic documentation during the water quality monitoring is exhibited in **Appendix 5C.**

Table 5-5: Analytes with Concentrations in Exceedance of Water Quality Criteria

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
WQ1 (WQ1-1 to WQ1-3)	• Enterococcus reported in all monitoring points at concentrations ranging from 11,400 cfu/100 ml (WQ1-3) to 43,000 cfu/100 ml (WQ1-1), exceeded the allowable limit of 200 cfu/100 ml • TOC reported in WQ1-1 at concentration of 10.2 mg/L exceeded the allowable limit of 10 mg/L. • Arsenic reported in WQ1-3 at concentration of 0.011 exceeded the allowable limit of 0.01 mg/L	• pH reported in WQ1-1 at concentration of 9.52 mg/L is outside the allowable limit of 6 to 9. Upstream monitoring points are relatively on the basic side (8.02 and 8.67) • Enterococcus reported in all monitoring points at concentrations ranging from 7,400 cfu/100 ml (WQ1-2) to 22,000 cfu/100 ml (WQ1-1), exceeded the allowable limit of 200 cfu/100 ml • Arsenic reported in WQ1-1 at concentration of 0.023 exceeded the allowable limit of 0.01 mg/L	• pH reported in WQ1-1 at concentration of 9.21 mg/L is outside the allowable limit of 6 to 9. • Enterococcus reported in all monitoring points at concentrations ranging from 7,400 cfu/100 ml (WQ1-2) to 22,000 cfu/100 ml (WQ1-1), exceeded the allowable limit of 200 cfu/100 ml • TOC reported in in all monitoring points at concentrations ranging from 10.7 mg/L (WQ1-1) to 12.1 mg/L (WQ1-2) exceeded the allowable limit of 10 mg/L. • Fe reported in WQ1-3 at concentration of 2.63 mg/L exceeded the allowable limit of 1 mg/L
WQ1A (WQ1A-2 to WQ1A-3) WQ1A-1 was observed dry	• COD reported in WQ1A-2 at concentration of 67 mg/L exceeded the allowable limit of 60 mg/L • TSS reported in WQ1A-2 at concentration of 65.6 mg/L exceeded the allowable limit of 30 mg/L • PO_4 reported in WQ1A-2 at concentration of 2.53 mg/L exceeded the allowable limit of 2 mg/L • NH_3-N reported in WQ1A-2 at concentration of 4.81 exceeded the allowable limit of 0.5 mg/L • Enterococcus reported in WQ1A-2 and WQ1A-3 at concentrations of 5,600 cfu/100 ml and	• Enterococcus reported in WQ1A-2 and WQ1A-3 at concentrations of 600 cfu/100 ml and 1,700 cfu/100 ml, respectively, exceeded the allowable limit of 200 cfu/100 ml • TOC reported in WQ1A-2 and WQ1A-3 at concentrations of 10.9 mg/L and 10.5 mg/L, respectively, exceeded the allowable e limit of 10 mg/L	• TSS reported in WQ1A-2 at concentration of 39.0 mg/L exceeded the allowable limit of 30 mg/L • PO_4 reported in WQ1A-2 at concentration of 3.64 mg/L exceeded the allowable limit of 2 mg/L • NH_3-N reported in WQ1A-2 at concentration of 5.67 exceeded the allowable limit of 0.5 mg/L • Enterococcus reported in WQ1A-3 at concentration of 510 cfu/100 exceeded the allowable limit of 200 cfu/100 ml • TOC reported in WQ1A-2 and WQ1A-3 at concentrations of 17.3 mg/L and 11.5 mg/L,

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
	1,800 cfu/100 ml, respectively, exceeded the allowable limit of 200 cfu/100 ml • TOC reported in WQ1A-2 and WQ1A-3 at concentrations of 14.8 mg/L and 11 mg/L, respectively, exceeded the allowable limit of 10 mg/L • Arsenic reported in WQ1A-2 at concentration of 0.020 exceeded the allowable limit of 0.01 mg/L • Fe reported in WQ1A-2 at concentration of 1.36 mg/L exceeded the allowable limit of 1 mg/L		respectively, exceeded from the allowable limit of 10 mg/L • Arsenic reported in WQ1A-2 at concentration of 0.019 exceeded the allowable limit of 0.01 mg/L
WQ2 (WQ2-1 to WQ2-5)	• pH value reported in WQ2-1 and WQ2-2 at concentrations of 5.57 and 5.93, respectively, is outside the allowable limit of 6 to 9. • TSS reported in WQ2-1 and WQ2-2 at concentrations 40.5 mg/L and 34.0 mg/L, respectively, exceeded the allowable limit of 30 mg/L • Enterococcus reported in all monitoring points at concentrations ranging from 4,800 cfu/100 ml (WQ2-3) to 14,000 cfu/100 ml (WQ2-1 and WQ2-2), exceeded the allowable limit of 200 cfu/100 ml • TOC reported in WQ2-4 at concentration of 10.5 mg/L exceeded the allowable limit of 10	• TSS reported in WQ2-3 and WQ2-4 at concentrations 38.3 mg/L and 34.3 mg/L, respectively, exceeded the allowable limit of 30 mg/L • Enterococcus reported in all monitoring points at concentrations ranging from 700 cfu/100 ml (WQ2-2) to 6,000 cfu/100 ml (WQ2-4), exceeded the allowable limit of 200 cfu/100 ml • Arsenic reported in all monitoring points except WQ2-5 at concentrations ranging from 0.011 mg/L (WQ2-2) to 0.020 (WQ2-4) exceeded the allowable limit of 0.01 mg/L • Fe reported in in all monitoring points except WQ2-5 at concentrations ranging from 1.39	• pH reported in WQ2-1 at concentration of 5.37 mg/L is outside the allowable limit of 6 to 9. • Enterococcus reported in all monitoring points at concentrations ranging from 330 cfu/100 ml (WQ2-5) to 1,000 cfu/100 ml (WQ2-2 and WQ2-3), exceeded the allowable limit of 200 cfu/100 ml • Arsenic reported in WQ2-4 at concentration of 0.014 exceeded the allowable limit of 0.01 mg/L • Fe reported in in all monitoring points except WQ2-5 at concentrations ranging from 1.317 mg/L (WQ2-3) to 1.43 mg/L (WQ2-1), exceeded the allowable limit of 1 mg/L

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
	mg/L. Upstream monitoring point is low at 4.62 mg/L • Fe reported in WQ2-1, WQ2-2 and WQ2-4 at concentrations 1.19 mg/L, 1.07 mg/L, and 1.77 mg/L, respectively, exceeded the allowable limit of 1 mg/L	mg/L (WQ2-3) to 4.10 mg/L (WQ2-4), exceeded the allowable limit of 1 mg/L	
WQ3 (WQ3-1 to WQ3-10)	• High concentrations of TSS including exceeding allowable limit of 30 mg/L in WQ3-1 and WQ3-3 to WQ3-6, ranging from 30 mg/L to 180 mg/L • Enterococcus is found in high concentrations in all sampling points, ranging from 1,500 cfu/100 ml (WQ3-10) to 18,000 cfu/100 ml (WQ3-4), exceeding the allowable limit of 200 cfu/100 ml in all locations • Fe exceeds allowable limit of 1 mg/L in all locations except WQ3-2 (0.81 mg/L). Other sampling points range from 1.15 mg/L (WQ3-6) to 2.96 mg/L (WQ3-4E)	• Enterococcus reported in all monitoring points except WQ3-1 at concentrations ranging from 2,200 cfu/100 ml (WQ3-10) to 2,600 cfu/100 ml (WQ3-5), exceeded the allowable limit of 200 cfu/100 ml • Fe reported in seven (7) out of eleven (11) monitoring points at concentrations ranging from 1.12 mg/L (WQ3-8) and 2.76 mg/L (WQ3-10), exceeded the allowable limit of 1 mg/L	• WQ3-1 to WQ3-4 - Enterococcus reported in three (3) out of five (5) monitoring points at concentrations ranging from 250 cfu/100 ml (WQ3-10) to 800 cfu/100 ml (WQ3-4), has exceeded the allowable limit of 200 cfu/100 ml - Fe reported in WQ3-3 and WQ3-4E at concentrations 1.80 mg/L (WQ3-3) and 1.62 mg/L (WQ3-4E), respectively, exceeded the allowable limit of 1 mg/L • WQ3-5 to WQ3-10 – For water sampling waiting for suitable weather event
WQ4 (WQ4-1 to WQ4-8) WQ4-9 and WQ4-10 were observed dry	• TSS reported in WQ4-1 to WQ4-3 at concentrations 41.5 mg/L, 44 mg/L, and 33.5 mg/L respectively, has exceeded allowable limit of 30 mg/L • Enterococcus exceeds allowable limit of 200 cfu/100 ml in all locations ranging from 3,200	• TSS reported in WQ4-2 only at concentration of 42.7 mg/L has exceeded the allowable limit of 30 mg/L • Enterococcus reported across WQ4 at concentrations ranging from 550 cfu/100 ml (WQ4-5) to 20,000 cfu/100 ml (WQ4-4) exceeded the allowable limit of 200 cfu/100 ml	• TSS reported in WQ4-3, WQ4-4 and WQ4-7 at concentrations of 126 mg/l, 54 mg/L and 54.2 mg/L, respectively, exceeded the allowable limit of 30 mg/L • Enterococcus reported across WQ4 at concentrations ranging from 230 cfu/100 ml

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
during dry weather events	cfu/100 ml (WQ4-6) to 12,000 cfu/100 ml (WQ4-4 and WQ4-10) • Fe reported in WQ4-10 of concentration 3.22 mg/L exceeds allowable limit of 1 mg/L	• Arsenic reported in four (4) out of eight (8) monitoring points at concentrations ranging from 0.012 mg/L (WQ4-4) to 0.021 (WQ4-3) exceeded the allowable limit of 0.01 mg/L • Fe reported in WQ4-2, WQ4-6 and WQ4-7, at concentrations 1.44 mg/L, 1.59 mg/L and 1.61 mg/L, respectively, exceeded the allowable limit of 1 mg/L	(WQ4-8) to 2,900 cfu/100 ml (WQ4-4) have exceeded the allowable limit of 200 cfu/100 ml • Fe reported in five (5) out of eight (8) monitoring points, at concentrations ranging from 1.08 mg/L (WQ4-5) to 5.0 mg/L (WQ4-6) exceeded the allowable limit of 1 mg/L
WQ5 (WQ5-1 and WQ5-2)	• Enterococcus reported in WQ5-1 and WQ5-2 at concentrations 3,500 cfu/100 ml and 4,600 cfu/100 ml, respectively, exceeded the allowable limit of 200 cfu/100 ml	• pH value reported in WQ5-1 and WQ5-2 at concentrations 9.12 mg/L and 9.21 mg/L, respectively, exceeded the allowable limit of 6 to 9 • Enterococcus reported in WQ5-1 and WQ5-2 at concentrations 310 cfu/100 ml and 630 cfu/100 ml, respectively, exceeded the allowable limit of 200 cfu/100 ml	• Enterococcus reported in WQ5-1 and WQ5-2 at concentrations 780 cfu/100 ml and 1,100 cfu/100 ml, respectively, exceeded the allowable limit of 200 cfu/100 ml
Pond 2	Water analytical results in Pond 2 reported concentrations of enterococcus (1,100 cfu/100 ml) and Fe (5.62 mg/L) have exceeded the allowable limit of 200 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 2 reported concentrations of COD (97 mg O_2/L), TSS (60.3 mg/L), enterococcus (1,800 cfu/100 ml) and TOC (10.60 mg/L), have exceeded the allowable limits of 60 mg O_2/L, 30 mg/L, 200 cfu/100 ml, 10 mg/L, respectively.	For water sampling waiting for suitable weather event

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
Pond 3	Water analytical results in Pond 3 reported concentrations of TSS (39.3 mg/L), enterococcus (4,100 cfu/100ml), and Fe (1.60 mg/L) have exceeded the allowable limit of 30 mg/L, 200 cfu/100 ml, and 1 mg/L, respectively.	Water analytical results in Pond 3 reported concentration of Fe (1.40 mg/L) has exceeded from the allowable limit of 1 mg/L.	For water sampling waiting for suitable weather event
Pond 4	Water analytical results in Pond 4 reported concentrations of enterococcus (1,300 cfu/100 ml) and Fe (1.45 mg/L) have exceeded the allowable limit of 200 cfu/100 ml and 1 mg/L, respectively.	Dry, no sample collected	For water sampling waiting for suitable weather event
Pond 5	Water analytical results in Pond 5 reported concentrations of enterococcus (1,300 cfu/100 ml) and Fe (1.30 mg/L) have exceeded the allowable limit of 200 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 5 reported concentrations of enterococcus (900 cfu/100 ml), and Fe (1.55 mg/L) have exceeded the allowable limits of 200 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 5 reported concentrations of TSS (165 mg/L), and Fe (3.43 mg/L) have exceeded the allowable limits of 30 mg/L and 1 mg/L, respectively.
Pond 6	Water analytical results in Pond 6 reported concentrations of enterococcus (2,200 cfu/100 ml) and Fe (1.62 mg/L) have exceeded the allowable limit of 200 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 6 reported concentrations of NH_3-N (0.900 mg/L), enterococcus (2,800 cfu/100 ml), and Fe (1.80 mg/L) have exceeded the allowable limits of 0.5 mg/L, 200 cfu/100 ml and 1 mg/L, respectively.	Dry, no sample collected
Pond 7	Water analytical results in Pond 7 reported concentrations of TSS (61.7 mg/L), enterococcus (7,900 cfu/100 ml), and Fe (2.30 mg/L) have exceeded the allowable limits of 30 mg/L, 00 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 7 reported concentration of Fe (6.03 mg/L) has exceeded the allowable limit of 1 mg/L.	Water analytical results in Pond 7 reported concentrations of TSS (263 mg/L), enterococcus (540 cfu/100 ml), and Fe (12.10 mg/L) have exceeded the allowable limits of 30 mg/L, 00 cfu/100 ml and 1 mg/L, respectively.

WQ Cluster	Wet Weather Event 1	Dry Weather Event 1	Dry Weather Event 2
Pond 8	Insufficient volume for sampling	Dry, no sample collected	Water analytical results in Pond 8 reported concentrations of Fe (12.30 mg/L) have exceeded the allowable limits of 1 mg/L.
Pond 9	Water analytical results in Pond 8 reported concentrations of TSS (39.7 mg/L), enterococcus (1,100 cfu/100 ml), TOC (10.6 mg/L), and Fe (4.35) have exceeded the allowable limit of 30 mg/L, 200 cfu/100 ml), 10 mg/L, and 1 mg/L, respectively.	Water analytical results in Pond 9 reported concentrations of enterococcus (340 cfu/100 ml), TOC (10.30 mg/L) and Fe (4.39 mg/L) have exceeded the allowable limits of 200 cfu/100 ml, 10 mg/L and 1 mg/L, respectively.	For water sampling waiting for suitable weather event
Pond 10	Water analytical results in Pond 10 reported concentrations of enterococcus (200 cfu/100 ml) and Fe (1.22 mg/L) have exceeded the allowable limit of 200 cfu/100 ml and 1 mg/L, respectively.	Water analytical results in Pond 10 reported concentration of Fe (1.19 mg/L) has exceeded the allowable limit of 1 mg/L.	For water sampling waiting for suitable weather event

In general, the streams reported significant concentrations of enterococcus across the EIA Study Area. Enterococcus is an indicator of the presence of faecal material in water. The enterococcus in the runoff could be associated from the feral pigs inhabiting and defecating within the forest. Ponds being small and enclosed consists of living organisms and organic matter that contributes to changes in water quality when decomposition occur. Iron concentrations are released from anoxic surface water conditions potentially due to extremely low to still flow.

WQ1 Cluster (concretised drain) – The exceedance in pH reported downstream of WQ1 may be attributed to weathering of drain substrate at WQ1-1 as it was consistent in both dry weather events. The occurrence of elevated TOC across WQ1 during the second dry weather event sampling may be associated with an occurrence of organic matter decomposition. Arsenic and iron may be one off from unknown runoff areas containing traces of these metals.

WQ1A Cluster (earth drain) – The occurrence of elevated TOC, phosphates, ammoniacal nitrogen across WQ1A at all sampling events may be associated with the presence of organic matter decomposition along the stream. Arsenic being consistent in one location may be natural occurrence. TSS and COD may be attributed from unknown sources that runoff towards the stream.

WQ2 Cluster (earth drain) – Arsenic and iron concentrations were consistently reported in both dry weather events could be associated as natural occurrence along the stream. Low pH value at the downstream may be due to the organism respiration and decomposition. TSS may be attributed to the patches of exposed earth upstream.

WQ3 Cluster (upstream of WQ3 is observed to be naturalised while the downstream towards Peng Siang River) – Concentrations of iron along the naturalised parts of WQ3 may be attributed to the release from the anoxic surface condition of the stream, potentially due to extremely low to still flow during dry weather or could be natural occurrence.

WQ4 Cluster (earth drain) – Iron concentrations along the stream may be attributed to the anoxic surface condition occurring intermittently, potentially due to extremely low to still flow. TSS concentrations may be due to the patches of exposed earth banks at certain locations along the stream.

WQ5 (concretised canal) – The occurrence of high pH in one of the sampling events is one off and may be due to the unknown sources upstream of the canal

Concentrations of BOD, COD, TDS, TP, TN, NO_3, PO_4, As, Ba, Sn, Be, B, Mn, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn and total metals are reported within the water quality limits stipulated on **Table 5-1**.

5.3.3 Determination of Catchment Basins

Review of the Tengah Environmental Baseline Study showed that the water catchment within the EIA Study Area is subdivided into the Kranji Catchment and its sub-catchments (approximately 131 ha) at the north and Jurong Catchment and its sub-catchments (approximately 32 ha) at the south (**Figure 5-5**). Streams will be characterised through details in an interval of 20 metres include stream cross-section, pool length and depth, substrate type, riparian vegetation composition, wetted width and estimated flow velocity

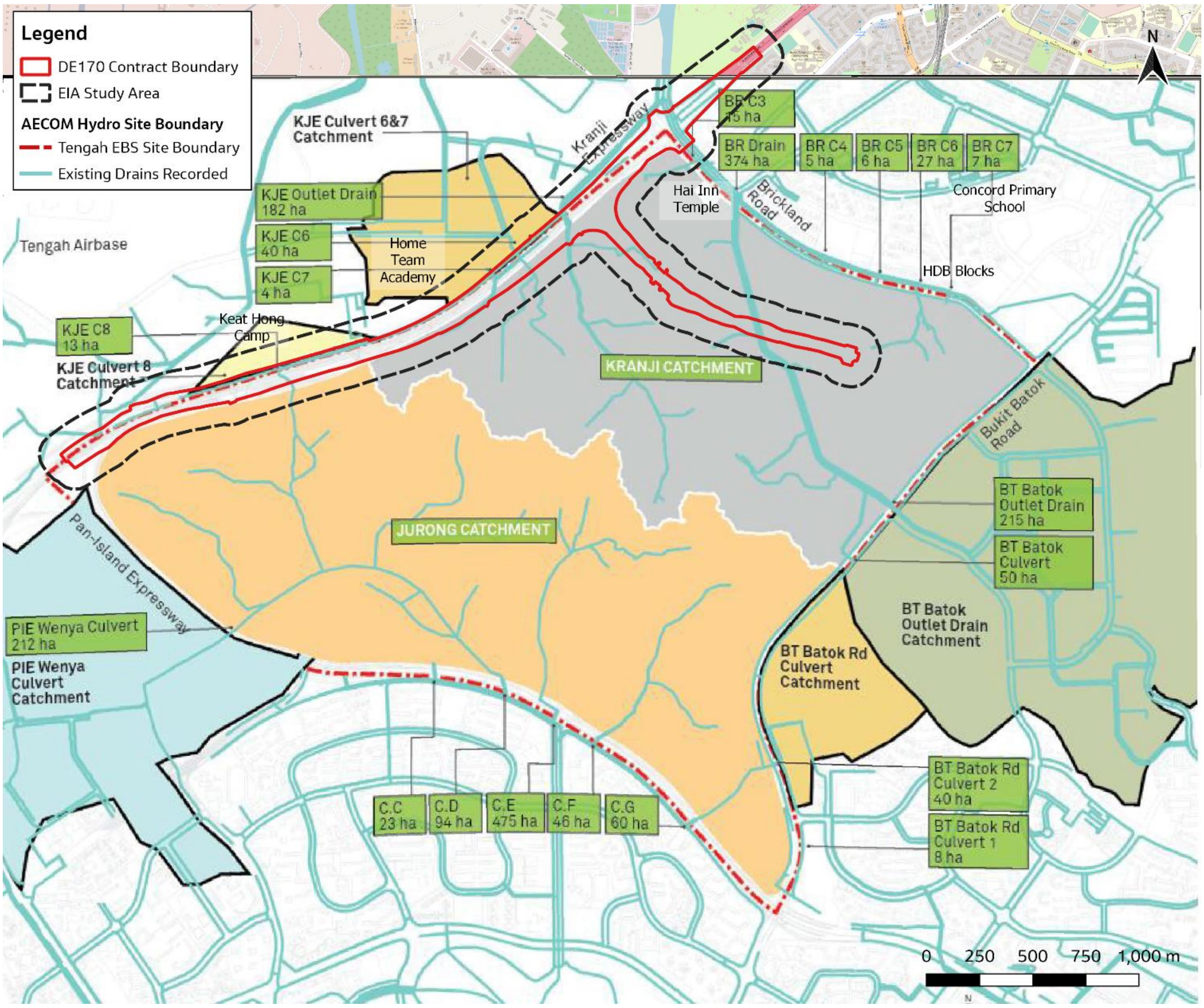


Figure 5-5: Water Catchments within the EIA Study Area

Source: Tengah Environmental Baseline Study – Final Report, AECOM (2017)

5.4 Impact Assessment

5.4.1 Construction Phase Impacts

5.4.1.1 Evaluation of Change in Water Quality

The construction activities listed in **Section 3.6.1** have the potential to result in adverse impacts on water quality, where the release of silt and sediments, chemicals, or other contaminants into the waterway cause water pollution. Potential impacts include:

- Surface runoff from the construction site
- Diesel, oil, and other pollutive substances spills
- Sedimentation of streams due to soil loss/ disturbance of topsoil

Impacts to water quality of the streams as a result of discharges related to the Project development were assessed with reference to the Environmental Protection and Management (Trade Effluent) Regulations. The assessment is based on available information regarding the construction phase activities. The identified potential sources of impacts include the following:

- Exposed areas of ground from earthworks and foundation activities – including the associated works such as site preparation, securing or formation of road access, vegetation clearance, temporary storage areas, excavation, and piling works and from civil and structural works activities such as stockpiling and backfilling works.
- Preparation of land for road access, earthworks, and foundation works will involve excavations and the removal of surface vegetation and topsoil. These may lead to soil erosion releasing high level of organic matters into adjacent watercourses and ponds during the wet season. Increased surface runoff with high suspended solids loading may also be resulted.
- Demolition of existing structures may cause water pollution due to accidental entry/ spillage of waste materials into adjacent watercourses. Moreover, demolition may require spraying of water for dust suppression. This may generate surface runoff consisting suspended solids and greases.
- Temporary storage areas are required for materials used in carrying out construction phase activities, and maintenance of equipment on site. These include storage and use of diesel, hydraulic oil, and chemicals. Spillage of chemicals and storm water runoff from laydown areas, if directly discharged into nearby watercourses, cause contamination of water.
- Diversion of streams may result in sedimentation in streams due to loss/ disturbance of topsoil.
- Wastewater from washing down of mixer trucks used for casting and concreting works. The washing down of mixer trucks following the delivery of pre-mixed concrete will produce high pH, suspended solids and COD if allowed to run over exposed ground.
- Wheel washing water from vehicles prior to leaving the site. The washing of wheels and subframe of vehicles leaving the site to travel on public roads is required to minimise dust impact along adjacent roads. The wheel wash water will contain suspended solids and possibly oils and grease from the under chassis.
- Domestic sewage generated due to the remoteness or inaccessibility of the site may affect water quality by the increase in *Escherichia coli* and BOD.

The qualitative assessment of potential water quality impact considers the construction phase activities of the Project development, and distinguishes between those that are positive or negative, direct or indirect and whether they are long or short term. Impacts that are cumulative, unavoidable, or irreversible are also identified. The potential water quality impacts identified are also assessed to determine the significance of these impacts. Evaluation of the above identified impacts are discussed below.

5.4.1.1.1 Water Quality Deterioration due to Soil Erosion and Surface Runoff from Construction Sites

Sediment introduced into waterways from construction phase activities through surface runoff may cause water pollution and potentially affect the water quality of the receiving watercourse. The surface runoff from the construction phase activities may occur during rainfall event at exposed earth locations, disturbed soils, and unprotected soil stockpiles. These exposed surfaces (from vegetation clearance, backfilling, excavation, and stockpiles of soil and vegetation debris) may be eroded and contribute silt and sediment to the watercourse. Thus, the construction phase activities may cause an increase in loading of sediments and other pollutants to the receiving watercourse within the EIA Study Area.

Table 5-6: Impact Significance for Soil Erosion and Surface Runoff during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The water quality sensitive receiver Sungei Peng Siang, which is a tributary of Kranji Reservoir, one of Singapore's national water supply reservoirs is of national importance.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to surface runoff from construction activities.
A2.2: Magnitude of Changes	3: High	Surface runoff during rainfall on exposed surfaces from vegetation clearance, backfilling, excavation, and on exposed stockpiles of soil and vegetation debris will have considerable increase in TSS concentrations and affected water quality parameters such as DO and TOC
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary.
B1: Permanence	3: Medium-term	Impact will occur during the construction phase and will persist within a period of 3 years to 10 years.
B2: Impact Pathway	3: Direct	Soil erosion and surface runoff is a direct impact on the water quality
B3: Reversibility	2: Reversible	The water quality impacts due to surface runoff are reversible when earthworks at construction activities stop. The impacted surface water may be reversed as the natural condition by surface water clean-up. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the Project development with interconnecting water courses and generate soil erosion and runoffs
Environmental Score (ES)	(-18) x (11) = -198	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

5.4.1.1.2 Water Quality Deterioration due to Diesel, Oil, and Other Pollutive Substances Spills

The construction phase activities are anticipated to require onsite storage and handling of diesel for the drilling machine, lubrication oil to maintain the equipment used onsite, and water pollutive substances such as bentonite used in soil investigation works and polymer used in bored piling. If these substances are not properly stored or handled (i.e., accidentally spilled, poor handling practices, leaks or insufficient safeguards provided), they could be spilled and directly or indirectly washed into the surrounding water streams, causing an adverse impact to the receiving watercourse and affect existing aquatic species.

Diesel and lubrication oil as well as bentonite or polymers, if it enters watercourses will have significant effects on pH, COD, DO and other water quality parameters. Diesel is readily and completely degraded by naturally occurring microbes, over a period of time. Bentonite swells and gels when dispersed in water and can be cleaned up effectively with appropriate clean-up methods.

Table 5-7: Impact Significance for Diesel, Oil and Other Pollutive Substances Spills during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The water quality sensitive receiver Sungei Peng Siang, which is a tributary of Kranji Reservoir, one of Singapore's national water supply reservoirs is of national importance.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to diesel and other pollutive substances spill from construction activities.
A2.2: Magnitude of Changes	2: Medium	The construction works is required to store and use pollutive substances that may alter water quality parameters if released in watercourse
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary where watercourses are located.
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist for a period of 3 to 10 years.
B2: Impact Pathway	3: Direct	Pollutive substances spill is a direct impact on the water quality
B3: Reversibility	2: Reversible	The water quality impacts due to diesel and pollutive substances are reversible when earthworks at construction activities stop. The impacted surface water may be reversed as the natural condition by surface water clean-up. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the Project development with interconnecting watercourses and pollutive substances spill
Environmental Score (ES)	(-12) x (11) = -132	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

5.4.1.1.3 Water Quality Deterioration due to Trade Effluent Discharge

The Project development is expected to generate trade effluent from piling works and concreting works. The trade effluent includes wastewater such as bentonite or polymer slurry, concrete washout, excess grouting materials from construction activities and wheel wash wastewater. Such process wastewater is alkaline (with pH of around 12), consists of fine particles and may contain heavy metals, oil and grease.

Discharge of untreated trade effluent into the watercourse either directly or indirectly could negatively impact the water quality of the receiving watercourse. It results in the degradation of the receiving watercourse quality as it potentially increases the pH, COD, TSS, turbidity, and metals in the water.

This trade effluent must not be discharged to any receiving watercourse without prior treatment and must be treated separately from surface runoff before being discharged. The Project development being in the vicinity of Kranji Reservoir is also prohibited from discharging treated trade effluent without authorisation. The source of these impacts is expected to be short term, reversible and exist for the duration of the construction phase activities only. Trade effluent from other construction sites located near the Project development will potentially have a cumulative effect if the discharge flows into the same network of watercourse.

Table 5-8: Impact Significance for Trade Effluent Discharge during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The water quality sensitive receiver Sungei Peng Siang, which is a tributary of Kranji Reservoir, one of Singapore's national water supply reservoirs is of national importance.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to wastewater discharge from construction activities.
A2.2: Magnitude of Changes	3: High	The construction works is anticipated to generate trade effluent from piling and concreting works which may alter water quality parameters if released in watercourse
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary.
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist within a period 3 years to 10 years.
B2: Impact Pathway	3: Direct	Wastewater discharge is a direct impact on the water quality
B3: Reversibility	2: Reversible	The water quality impacts due to effluent discharge are reversible when earthworks at construction activities stop. The impacted surface water may be reversed as the natural condition by surface water clean-up. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the Project development with interconnecting watercourses with potential trade effluent discharge
Environmental Score (ES)	(-18) x (11) = -198	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

5.4.1.1.4 Water Quality Deterioration due to Sedimentation of Streams from Loss/Disturbance of Topsoil

Potential impacts from stream diversion to sedimentation due to loss/ disturbance of topsoil include:

- Increase in suspended solids and turbidity
- Flooding due to reduced ability of the stream to hold water

During stream diversion in areas where road realignment and widening require diversion of WQ2, WQ3, and WQ4, bank erosion/topsoil loss or entry of significant amounts of silt into the stream or surface drains could potentially affect the flow conditions. This causes certain areas of the stream and surface drain to be choked, thereby potentially leading to negative impacts on the water quality of the streams and surface drains, and in particular, reducing the capacity of the surface drain system due to sediment build up.

Table 5-9: Impact Significance for Sedimentation of Streams from Loss/Disturbance of Topsoil

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The water quality sensitive receiver Sungei Peng Siang, which is a tributary of Kranji Reservoir, one of Singapore's national water supply reservoirs is of national importance.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to sedimentation from drain diversion works.
A2.2: Magnitude of Changes	2: Medium	Stream diversion may result to bank erosion and disturbance of topsoil that contribute silt and sediment to watercourse and cause flooding of the surface drain system due to sediment build up
A2.3: Impact Extent	2: Buffer Area	Stream diversion will occur only on affected streams within the Contract Boundary. However, sedimentation impacts will extend to the buffer area outside the Contract Boundary
B1: Permanence	2: Short-term	Stream diversion will be completed within a period of 3 years.
B2: Impact Pathway	3: Direct	Sedimentation is a direct impact on the water quality
B3: Reversibility	2: Reversible	The water quality impacts due to sedimentation are reversible when earthworks at construction activities stop. The impacted surface water may be reversed as the natural condition by surface water clean-up. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the Project development with interconnecting water courses and similar drain diversion activities
Environmental Score (ES)	(-12) x (10) = -120	
Range Bands ES/ Impact Significance	Minor Negative Impact	

5.4.1.1.5 Sewage Discharge during Construction Phase

The construction sites generate sewage from sanitary facilities installed onsite. In cases where the worksite is remote from the designated sanitary facilities, discharge of sewage into the surrounding water streams either directly or indirectly could adversely impact the water quality of the receiving waterbody. Sewage comprises high levels of BOD, ammonia, and *Escherichia coli* traces. Under no circumstances shall this sewage be discharged into any receiving watercourse and must be treated separately from the surface runoff. Assessment of impact of sewage is further discussed in Assessment of Waste Section (**Section 10**).

5.4.1.2 Evaluation of Change in Hydrology

An evident impact of construction works is the temporary increase in surface run-off as a result of vegetation clearing and earthmoving. The increase in surface run-off is also proportional with the amount of precipitation.

The temporary increase in run-off will affect existing drainage systems adding to the capacity required for the water to flow out of the site. To estimate the resulting run-off, a high-level run-off volume calculation was conducted based on the disturbance area, daily rainfall, and the run-off coefficient based on the type of ground cover. Soil erosivity factors were taken from Stone and Hillborn (2000) following the Universal Soil Loss Equation (USLE). The run-off computation is based on published run-off rainfall correlation values. Run-off is computed as K x Annual Rainfall in m where K is a constant value for parks ground cover (0.5). Annual run-off is estimated at 1.03 m. Total annual run-off volume for the disturbance area is 544,749 cubic meter (m^3) per construction year. Run-off volume from the catchment area, however, is estimated at 2,549,382 m^3. The catchment area is determined from the topography and surface hydrology and extends beyond the study area. This estimated volume includes the disturbance area and would be regarded similar to the estimated run-off volume with the “no project” alternative as the current EIA Study Area is characterized by mixed land use including concrete paved areas and bare soil which would have similar infiltration capacity and run-off coefficient as the construction area. Compared to the overall run-off volume of the catchment area annually, the contribution of the construction run-off is considered low.

Table 5-10: Impact Significance for Changes in Hydrology during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	The potential change in hydrology is significant to the immediate area beyond the Project development
A2.1: Impact Nature	-1: Negative	While low to negligible, the contribution of run-off within the contract area is considered a negative impact compared to its baseline run-off volume if vegetation cover was intact.
A2.2: Magnitude of Changes	1: Low	The run-off volume within the contract boundary is considered very low impact in terms of run-off volume addition to the rest of the catchment. The magnitude of change may also be considered as negligible or no change since the catchment’s run-off coefficient will be the same as the disturbance area due to various land use and vegetation cover. However, the negative impact is anticipated to be more pronounced without intervention hence a rating of low impact.
A2.3: Impact Extent	2: Buffer Area	Impact potentially extends beyond permanent development area to greater catchment location
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist for a period of 3 to 10 years.
B2: Impact Pathway	3: Direct	Run-off volume has direct impact the catchment area
B3: Reversibility	3: Irreversible	Soil infiltration, ground cover, and pre-project characteristics that influence run-off volume cannot be restored.
B4: Cumulative	2: Non-Cumulative	Impact is limited within the contributing area of the catchment and the estimated volume includes the disturbance area and would be regarded similar to the estimated run-off volume with the “no project” alternative
Environmental Score (ES)	(-4) x (11) = -44	
Range Bands ES/ Impact Significance	Slight Negative Impact	

5.4.2 Operation Phase Impacts

5.4.2.1 Evaluation of Change in Water Quality

Operational impacts within the EIA Study Area will potentially be from the use of the interchange and its periodic servicing or maintenance. Heavy construction vehicles are not anticipated to be used during such maintenance activities. As such, these operation phase activities will not generate significant amounts of pollutants that will negatively impact waterbodies within the EIA Study Area.

Potential short-term operation phase impacts would possibly occur should there be major repairs, especially if repair requires earthwork or excavation. This would create potential sources of sediment runoff into the surface drains. However, it is expected that such short-term operation impacts will only last for the duration of the maintenance works and would be limited in scope.

5.4.2.2 Evaluation of Change in Hydrology

It is assumed that rehabilitation activities will be undertaken at all the disturbed areas that will not be utilized for permanent development, such as access and temporary staging areas. Maintenance activities to accommodate repairs are considered to have very minor impact on the geomorphology, soil, and groundwater conditions, as these will be mostly limited to within the permanent development areas. However, the permanent development areas will have a different ground cover and gradient which may impact the volume and quality of run-off from the catchment. Considering the ground cover for the development areas is concrete or similar with low infiltration, the run-off coefficient will increase from K of 0.5 for parks ground cover use setting to K of 0.85 for urban/mixed ground cover. Assuming the contract boundary is the same as the permanent development area, the run-off volume that will be generated is approximately 926,073 m^3 per year or a 70% increase from construction levels. As the development area is a portion only of the greater catchment which would have similar pre-project land use, the increase in run-off volume for the catchment area is estimated at 2,930,706 m^3 per year or just about 15% increase to the run-off volume of the entire catchment pre-operations. This increase is considered a cumulative impact as it permanently alters the run-off volume within the catchment and can be further exacerbated by other proposed development within the area which may convert existing vegetated cover to urban use. Increase in run-off volume potentially puts a strain on the existing drainage system and its capacity to efficiently contain and convey water away from the development area. Climate change projections for annual rainfall should also be considered in detailed design as a general increase will also impact the capacity and efficiency of existing drainage. The proposed drain size for the Project is based on the overall Tengah drainage masterplan.

Table 5-11: Impact Significance for Changes in Hydrology during Operation Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	The potential change in hydrology is significant to the immediate area beyond the Project development to greater catchment location
A2.1: Impact Nature	-1: Negative	Increase in run-off volume is considered negative as it potentially puts a strain on the existing drainage system.
A2.2: Magnitude of Changes	2: Medium	While the increase in run-off volume within the development area is approximately 70% per year the overall increase for the greater catchment is about 15% per year.
A2.3: Impact Extent	2: Buffer Area	Impact extends beyond the Project development.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B1: Permanence	4: Long term	The run-off volume cannot be restored to pre- project levels
B2: Impact Pathway	3: Direct	Run-off volume has direct impact the catchment area
B3: Reversibility	3: Irreversible	Soil infiltration, ground cover, and pre-project characteristics that influence run-off volume cannot be restored.
B4: Cumulative	3: Cumulative	Impact is considered cumulative as it permanently alters the run-off volume within the catchment and can be further exacerbated by other proposed development within the area which may convert existing vegetated cover to urban use.
Environmental Score (ES)	(-8) x (13) = -104	
Range Bands ES/ Impact Significance	Minor Negative Impact	

5.5 Recommendation of Prevention and Mitigation Measures

5.5.1 Water Quality

A number of mitigation measures may be adopted to eliminate, minimise, or reduce the potential impacts on water quality during the construction activities of the Project development.

The primary emphasis for water pollution control is on controlling the potential harmful impacts from construction works on water quality, adhering to the COP on Surface Water Drainage and using good practices for construction sites. No obstruction of the drain is allowed.

As required by Regulation 4 of the *Sewerage and Drainage (Surface Water Drainage) Regulations*, every contractor must comply with the COP on Surface Water Drainage. Together with the Guidebook on Erosion and Sediment Control at Construction Sites and the Guidebook for Qualified Erosion Control Professional, the references form the basis for developing, implementing and monitoring earth control measures (ECM) at the construction sites.

The overall approach to mitigating the water quality impact of surface runoff from construction sites will involve the following approaches:

- **Erosion Control**: The objective is to reduce the volume of sediments that could be generated or are available to be washed off during rainfall. The key strategies are to minimise the extent and duration of bare earth areas (erodible surfaces) on-site and to protect the unavoidable bare earth surfaces.
- **Sediment Control**: The objective is to capture the sediments washed down from the site and reduce TSS in surface water discharges. The key strategies are to contain and treat the surface runoff from the site before discharge to the drains.
- **Management of Pollutive Substances**: The objective is to control the storage, use and disposal of hazardous substances used on-site.

- **Trade Effluent Management**: The objective is to control discharge of wastewater onsite.

The mitigation measures to eliminate, minimise, or reduce the impacts on water quality during the construction activities of the Project development are further discussed below

- Install site boundary hoarding with embedded silt fence at the bottom hoarding to enclosed construction working space. This will contain silty water generated from construction phase activities including any bentonite slurry overflow from bored piling works
- All exposed earth created should be covered with Earth Control Blankets (ECB) or other methods. Only fully biodegradable ECBs are to be deployed within Tengah Forest
- Before work commences, submit the ECM proposal duly endorsed by his Qualified Erosion Control Professional (QECP) to PUB and copied to LTA indicating:
    - exposed surfaces will be minimised according to the construction activities
    - effective sediment control facilities (including storage and treatment facilities) will be implemented
    - a system of ECM will be in place before work commences
    - Clearance Certificate to commence earthworks is obtained
    - during construction, ECM will be revised/updated and put in place to control silty discharge, as the need arises
- Spill containment shall be provided at all discharge point. ECM design, included trade effluent treatment system shall recommend the type of spill containment in the event of non-complying discharges
- Cleared vegetation in particular at sloped areas, will be covered with ECB to control erosion of exposed soil. Re-vegetate exposed ground as soon as possible to stabilise surfaces and minimise erosion of soil to watercourses
- Put in place a response plan to cater for accidental spillages into any watercourse. This plan shall be communicated to all personnel. Training shall be provided for all staff in spill response measures
- All spill containment facilities and spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances
- All spills must be cleaned within the same day or immediately for under wet weather conditions
- Safety Data Sheet (SDS) for all hazardous materials shall be compiled and stored on site and available for viewing
- Spill management kits shall be provided at worksites (in accordance with the type of hazardous materials to be used, include but not limited to rags, sands, eyewash, protective gloves etc.) at where hazardous materials, equipment and machinery will be stored and used
- Hazardous materials shall be stored in bunded and covered areas in accordance with the manufacturer's safety requirements. Storage of hazardous materials on-site should be limited to the minimum necessary to reduce the impact of any spillage or mitigation failure
- Stream diversion works (i.e., ground preparation, vegetation clearing, topsoil removal, excavation, and concreting) should be done in phased manner to minimise the area disturbed at any given time. If the stream to be diverted is long, the alignment may be subdivided into segments for which drain construction works can be scheduled and completed before moving on to the next segment
- Topsoil removed should be harvested and stockpiled in a designated area and covered to prevent soil loss. Soil conserved can be used for backfilling and planting of riparian vegetation for WQ4 diversion, in consultation with a biodiversity specialist

- Trade effluent generated shall be collected and disposed off-site. No discharge to watercourse unless the treated trade effluent complies to Trade Effluent Regulations (TER) limits as stipulated in the EPMA.
- Appropriate concrete washout water containers should be provided and stored away from any streams for offsite disposal through licensed waste treatment contractors
- Bentonite slurry in IBC tanks used in SI works should be stored away from any streams or drains and disposed offsite through licensed waste treatment contractors
- Wheel wash wastewater to be diverted into ECM facilities for reuse as wheel washing.
- Temporary sanitary facilities to be provided for on-site workers during the construction phase period. Workers to be trained on the necessity of portable sanitary facilities
- Regular clearance of domestic waste generated in the temporary sanitary facilities to avoid wastewater spillage. Locations of temporary sanitary facilities must be accessible by NEA-licensed portable toilet company for servicing (e.g., collection and disposal of sewage).

5.5.2 Hydrology

The impact to the hydrological property of surface water flow and discharge rates were similarly considered as a response to the development plan which will both involve changes on landform and surface properties where the infrastructures will be built particularly in areas where water bodies or discharge drains are present. These impacts can be minimised with either any or a combination of the following mitigations.

- Develop comprehensive and sound Excavation, Cut and Fill and Earthmoving Plan. The execution of construction work should be done accordingly in stages and programmed segments to avoid formation of uneven slopes or terrain that can influence surface flows into the existing as well as diverted or improved drains. This will also avoid the unnecessary increase in surface water flow rate on temporary or permanent water features or drains.
- Minimize the disturbance area affected by excavation and earthworks to what is only necessary and defined in accordance with the Site Construction Plan.
- Strategically designate temporary diversion channels within construction work areas to manage and direct surface flows and avoid surface water ponding that may cause temporary flooding.
- The Site Construction Plan is recommended to consider allocation of some of the available land resource, where possible, that can naturally accommodate excess surface runoff and thereby reduce the surface water flow rates entering drains and waterways and reducing the need for auxiliary equipment e.g., pumps, during peak rainfall regimes.

5.6 Residual Impact

With the implementation of recommended measures to reduce the impacts, the following residual impacts will be observed:

- Permanent change in surface hydrological dynamics such as increase in run-off volume
- Conservation of remaining buffer areas and inflow-dependent water features

Implementation of requirements or standard practices of controls commonly instigated in Singapore for similar activities and the recommended mitigation measures in the previous sub-section will contribute to reduce the magnitude of the water quality impacts by regulating the potential adverse impacts and reducing the likelihood and/or extent of such hazards polluting the watercourses. It also provides remedial measures for recovery should the impacts occur notwithstanding implementation of best practices. Consequently, it is expected that water quality should only be impacted to a minor extent during this Project.

Table 5-12: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Impact Significance)	
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Environmental Score (ES)	Range Band of ES / Impact Significance
WQ-I1	Water quality deterioration due to soil erosion and surface runoff from construction site	-198	Moderate Negative Impact	-120	Minor Negative Impact
WQ-I2	Water quality deterioration due to diesel, oil and other pollutive substances spill	-132	Moderate Negative Impact	-66	Minor Negative Impact
WQ-I3	Water quality deterioration due to trade effluent discharge	-198	Moderate Negative Impact	-120	Minor Negative Impact
WQ-I4	Water quality deterioration due to sedimentation of streams from loss/disturbance of topsoil	-120	Minor Negative Impact	-60	Slight Negative Impact
WQ-I5	Change in hydrology during Construction Phase	-44	Slight Negative Impact	-22	Slight Negative Impact
WQ-I6	Change in hydrology during Operation Phase	-104	Minor Negative Impact	-52	Slight Negative Impact

6. Ecology

This section describes the regulations and standards for ecology and biodiversity that are applicable to the Project development during the construction phase and operation phases and the methodology used for the biodiversity baseline assessment. It also discusses the ecology and biodiversity baseline data obtained and assesses the potential ecology and biodiversity impacts associated with the construction and operation phases of the Project development. Appropriate mitigation measures and monitoring requirements have also been identified.

6.1 Applicable Standards

NParks administers the *Parks and Trees Act* which regulates the planting, maintenance and conservation of trees and plants within national parks, nature reserves, tree conservation areas, heritage road green buffers and other specified areas and the *Wildlife Act* which enacts protection, preservation, and management of wildlife for the purposes of maintaining a healthy ecosystem.

There is no legislation in Singapore presently that describe the methodology for ecology and biodiversity impact assessment study. However, NParks released a Biodiversity Impact Assessment (BIA) Guidelines, a non-prescriptive guide, as reference to recognise the basic requirements for the biodiversity component of an EIA.

6.2 Methodology of Ecological Assessment

The EIA focuses on the assessment of the potential impacts on flora and fauna that will be observed and documented during the ecology field surveys as a result of the proposed construction activities. It includes a description of guidelines and methodology used for the assessment. These methods have been based on current available information of the sites and may be modified if additional information becomes available and/or following consultation with stakeholders or government agencies.

Field investigations on ecology found within the EIA Study Area are carried out. It aims to establish baseline biodiversity information of the EIA Study Area. Baseline information are first gathered through reviews of past and present biodiversity records, published literature, and in consultation with taxonomic experts. Actual field surveys are then carried out to verify and supplement the data. Through desktop and field assessments, important habitats, species of flora and fauna of conservation significance are identified. Specific details of the ecology baseline survey are as detailed in the sections below.

6.2.1 Detailed Site Reconnaissance Survey

Site reconnaissance surveys were conducted to obtain a better understanding of the EIA Study Area to assist in the planning and inform the methods for carrying out the biodiversity studies. The objectives of the reconnaissance survey are as follows:

- Perform preliminary vegetation type assessment to decide whether stratified sampling is needed; stratified sampling will be conducted if the sites have very heterogeneous habitats.
- Identify and map out the locations and boundaries of existing streams, ponds, and swampy areas (if any).
- Determine the layout of the habitats, accessibility of existing roads/ tracks, sampling transects and points, as well as obtain an initial comprehension of the flora and fauna diversity.

6.2.2 Desktop Assessment

6.2.2.1 Conservation Significance Species of Probable Occurrence

A list of faunal species of conservation significance that are likely to occur at the EIA Study Area (termed thereafter as "CS species of probable occurrence") was generated using information on past faunal records and existing habitat types and past fauna records up to 2 km from the EIA Study Area.

6.2.2.2 Taxonomy and Nomenclature

Past and present floristic as well as faunistic species composition were examined using relevant key references that include books, scientific publications, unpublished literature, online databases, as well as the published previous EIS report prepared by Jacobs in 2021. Sources of databases include The Biodiversity of Singapore by the Lee Kong Chian Natural History Museum, Flora and Fauna Web by the NParks and iNaturalist. Other key references include the Singapore Red Data Book (Davison et al., 2008), NParks Species List (2021), Singapore Biodiversity Records, encyclopaedia on Singapore's biodiversity (Ng et al., 2011). Key local and/ or regional references for the various taxonomic groups are listed on **Table 6-1** below.

Table 6-1: Key references for the nomenclature and taxonomy for each taxonomic group

Taxon	Key References
Plants	Lindsay et al. (2022); Chong et al. (2009); NParks Flora and Fauna Web (2020b)
Aculeata	Ascher & Pickering (2018), Ascher et al. (2020)
Odonates	NParks Species List (2021)
Butterflies	Khew (2015)
Herpetofauna	NParks Species List (2021)
Birds	Gill and Donsker (2020)
Mammals	NParks Species List (2021)
Freshwater fish	Kottelat (2013); Suzuki et al. (2015); Ho et al. (2016)
Freshwater molluscs	World Register of Marine Species (2020)
Freshwater decapod crustaceans	Ng (1997); Cai et al. (2007); Wowor & Ng (2010), Ho et al. (2016)

6.2.2.3 Species of Conservation Significance

The assessment of the conservation significance of species is important for highlighting the need and priorities for their conservation.

Threatened species of flora - i.e., listed in Chong et al. 2009 (Chong et al., 2009) as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery) - will be assessed to determine whether they are of conservation significance. While the national conservation status of threatened species is true of wild populations that originate in an area without direct or indirect human intervention, some populations may be relics that persist from past cultivation or escapees from present-day cultivation that do not belong to native genetic stock. The assessment of whether a threatened species is of conservation significance will be based on, but not limited to, information on the following: (i) land use history, (ii) presence of large parent tree(s), (iii) commercial availability, (iv) data from previous environmental impact assessments, (v) reforestation efforts, (vi) natural range, and (vii) importance for associated fauna. If the origin of a threatened species population is disputable or difficult to determine, we will corroborate findings from field surveys of fauna and/ or adopt the more conservative approach by considering them of conservation significance. In carrying out such assessments, we are then able to prioritise conservation needs and focus resources in conserving them.

Faunal species of conservation significance are threatened species which are listed as nationally or globally Vulnerable, Endangered, Critically Endangered, or Extinct. The national conservation statuses reference the Singapore Red Data Book (SRDB; Davison et al., 2008) and other more updated local checklists, where available, such as Ascher et al. (2022) for bees, Jain et al. (2018) for butterflies and NParks Species List (2021) for various taxa. The NParks Species List (2021) displays the updated national conservation status for odonates, amphibians, reptiles, birds and mammals as part of the upcoming revised edition of the SRDB; the remaining taxa are still undergoing assessment. The global conservation status references the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN, 2022).

6.2.3 Ecology Field Assessment

Ecology field assessment for the EIA Study Area was conducted between 19 March and 14 July 2022. Migratory bird survey was carried out during migratory bird season in Oct and Nov 2022.

6.2.3.1 Flora Field Assessment

The field assessment for flora consists of i) Habitat and vegetation mapping, ii) General walking floristic surveys and iii) Vegetation plot sampling.

6.2.3.1.1 Habitat and Vegetation Mapping

A preliminary vegetation map was first prepared based on visual interpretations of satellite images from ESRI Satellite on QGIS v.3.4 (Quantum Geographic Information System Development Team, 2019). Preliminary classification of the vegetation types was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were then made to the preliminary maps according to actual observations during ground truthing. Ground truthing was conducted throughout the survey area with the aid of a Global Positioning System (GPS) receiver (Garmin GPSMap® 64s). Photographs of the vegetated areas were also be taken. The boundaries of each vegetation type were tracked on the GPS receiver and mapped out on QGIS v.3.4 (Quantum GIS Development Team, 2019). The classification of vegetation type references NParks' Biodiversity Impact Assessment Guidelines (NParks, 2020a).

6.2.3.1.2 General Walking Floristic Surveys

All plants observed in the EIA Study Area during floristic surveys were identified to species whenever possible. A checklist of all the plant species recorded from the present floristic surveys was compiled. The nomenclature and national conservation status follow that of Chong et al. (2009), and/ or other published papers with information on the updated assessment of the species nomenclature and/ or conservation status. Other information on the plant species was also crosschecked with online databases, namely, the NParks Flora and Fauna Web and Singapore Biodiversity Online.

For plants that could not be immediately identified with certainty in the field, photographs and/ or voucher specimens were taken. They were then identified using identification keys, taxonomic descriptions, online plant photo databases, with the help of taxonomic experts, and/ or by matching the pressed and dried collected specimens with existing specimens in the Singapore Botanic Gardens' Herbarium (SING).

For very tall unidentifiable trees with leaves that are too high in the canopy to photograph, dried leaves matching these trees were collected from the forest floor and used to aid in species identification.

Species of Conservation Significance

The geographic coordinates of plants of conservation significance were marked using GPS receiver (Garmin GPSMap® 64s), which records locations with accuracy of ± 4 m, during floristic surveys. Where there are clusters of plants of conservation significance - i.e., more than one individual occurring within 5 m or less of another individual - the geographic coordinates of the approximate centre of the area was marked using the GPS receiver.

Large Plant Specimens

Similarly, the GPS receiver was used to record locations of all trees of ≥ 3 m girth, as well as bamboo clusters, palm clusters, and strangling Ficus species of ≥ 3 m spread. Individuals were identified to species and whenever possible, measure girth (for trees)/estimate spread (for bamboo clusters, palm clusters, and strangling Ficus species), estimate height and tag them with unique serial numbers. Ten exotic trees listed as follow were not mapped or included in the list of large plant specimens, but included in the overall plant species list for the site: African tulip (*Spathodea campanulata*), albizia (*Falcataria falcata*), earleaf acacia (*Acacia auriculiformis*), silver wattle (*Acacia mangium*), betel-nut palm (*Areca catechu*), wild tamarind (*Leucana leucocephala*), coconut (*Cocos nucifera*), papaya (*Carica papaya*), oil palm (*Elaeis guineensis*) and Macarthur palm (*Ptychosperma macarthurii*).

Other Specimens of Value

Locations of other plants that are of value but do not meet the minimum size requirement, as detailed in the above sub-section, were recorded using the GPS receiver. Examples of such include bamboo clusters of < 3 m spread that may be important refugia for rare bamboo bats, exotic albizia trees (*Falcataria falcata*) with raptor nests, amongst others.

6.2.3.1.3 Vegetation Plot Sampling

A total of 15 20 × 20 m plots was identified. It was determined based on the sampling density of one plot for every 5 ha of spontaneous vegetation.

Locations of vegetation plots was randomly generated (**Figure 6-1**), and the actual locations subsequently adjusted on-site based on accessibility and suitability, i.e., not covered in dense vegetation and/ or tree falls that would render the plot inaccessible. All woody tree and shrub specimens as well as single-stemmed palms of ≥ 0.05 m girth were identified to species and their girth measured. The number of specimens with < 0.05 m girth were counted, but the exact girth were not recorded. For *Ficus* stranglers and palm clusters, the circumference of each woody aerial root or stem, respectively, of ≥ 0.05 m stem diameter at breast height (DBH) was measured. All other plant species observed in the plots were also be recorded.

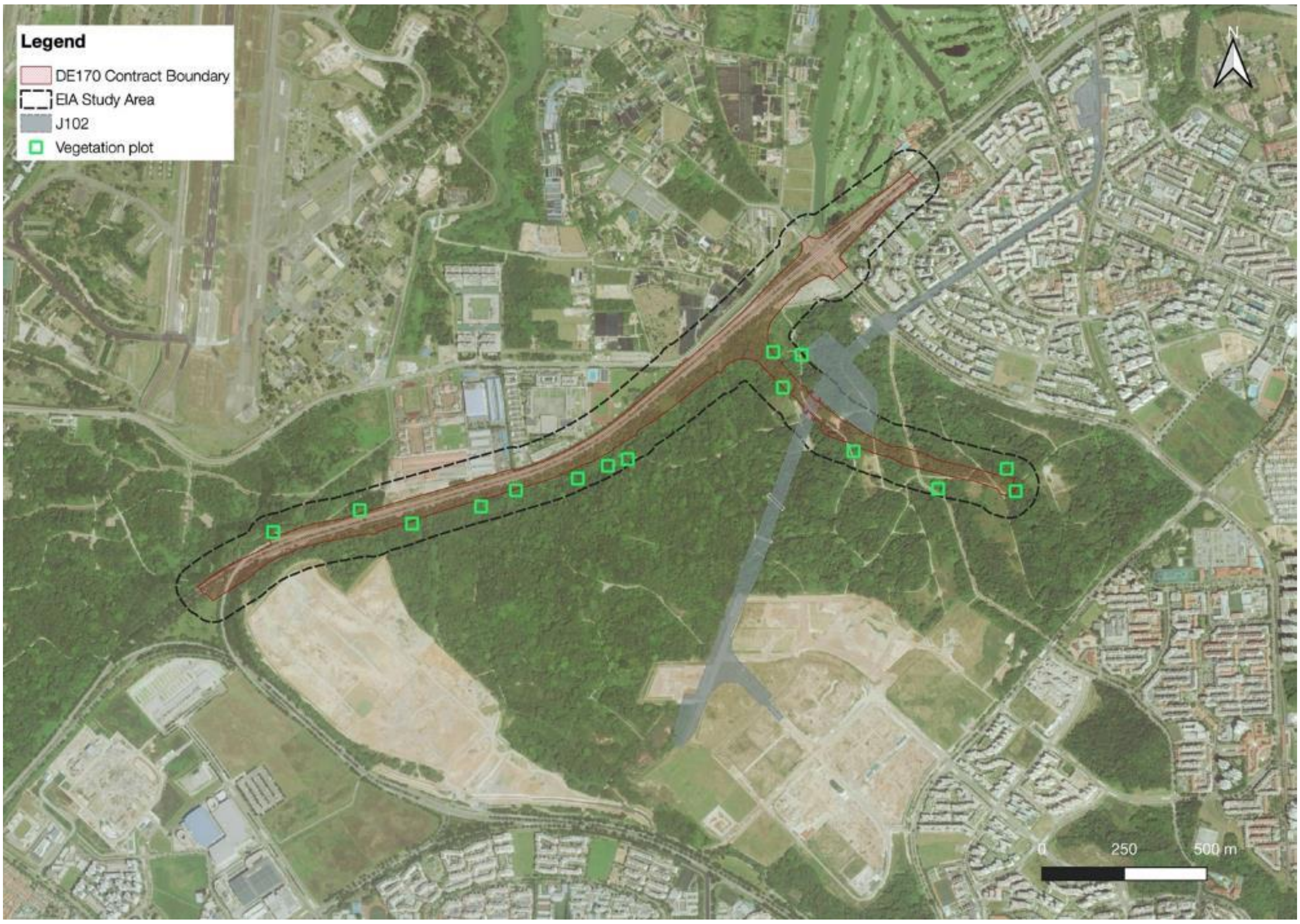


Figure 6-1: Location of Vegetation Plots

Source: ESRI

6.2.3.2 Faunal Field Assessment

Targeted faunal field surveys were carried out for the following taxa: i) butterflies, (ii) odonates (damselflies and dragonflies), (iii), aculeata, (iv) herpetofauna (amphibians and reptiles), (v) birds, (vi) mammals, (vii) mammals (bats only), (viii) Freshwater aquatic fauna (fish, decapod crustaceans and molluscs). All observations of notable species from the aforementioned taxa were also be recorded if seen outside the stated survey times.

Table 6-2 summarises all the surveys that were carried out for fauna. Each survey was performed by at least two (maximum three) surveyors. All fauna encountered were identified to species, or to the next lowest taxonomic level possible, and the location of each individual was recorded using a handheld GPS (Garmin GPSMAP 64s). The number of individuals observed was also documented.

Data from transect surveys (T5 and T6) conducted for the previous EIS were also used. Locations of sampling units are provided in **Figure 6-2** and **Figure 6-3**.

Table 6-2. Summary of Surveys of Fauna

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Diurnal transect surveys	Butterflies	0900–1500	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
	Odonates (damselflies, dragonflies)	0900–1500	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
	Aculeata (bees, stinging wasps)	0900–1500	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
Diurnal and nocturnal transect surveys	Herpetofauna (amphibians, reptiles)	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
	Birds	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
	Mammals (non-volant)	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
Diurnal aquatic point counts	Odonates (damselflies, dragonflies)	0900–1500	10 minutes per point	10-m sampling transect at 50-m intervals along waterbodies where applicable	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
Diurnal and nocturnal aquatic point counts	Herpetofauna (amphibians, reptiles)	0900–1500; 2000–2300	10 minutes per point	10-m sampling transect at 50-m intervals along waterbodies where applicable	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
	Aquatic fauna (fish, decapod crustaceans, molluscs)	0900–1500; 2000–2300	10 minutes per point	10-m sampling transect at 50-m intervals along waterbodies where applicable	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
Camera trapping	Mammals (non-volant)	24 hours a day	60 days	One trap per 6.25 ha	Infrared motion sensing
Bioacoustics surveys	Mammals (bats)	2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Auditory only
Bat trapping	Mammals (bats)	1930-2100	-	Two harp traps, two mist nets	Trapping
Roost emergence surveys	Mammals (bamboo bats only)	1830–2100	-	Bamboo clusters within worksite (if any)	Visual and auditory
Push and scoop netting	Aquatic fauna (fish, decapod crustaceans, molluscs)	Daytime	-	10-m sampling transect at 50-m intervals along waterbodies where applicable	-
Minnow trapping	Aquatic fauna (fish, decapod crustaceans)	Overnight	One day one night	Traps at 50-m intervals along waterbodies where applicable	Baited

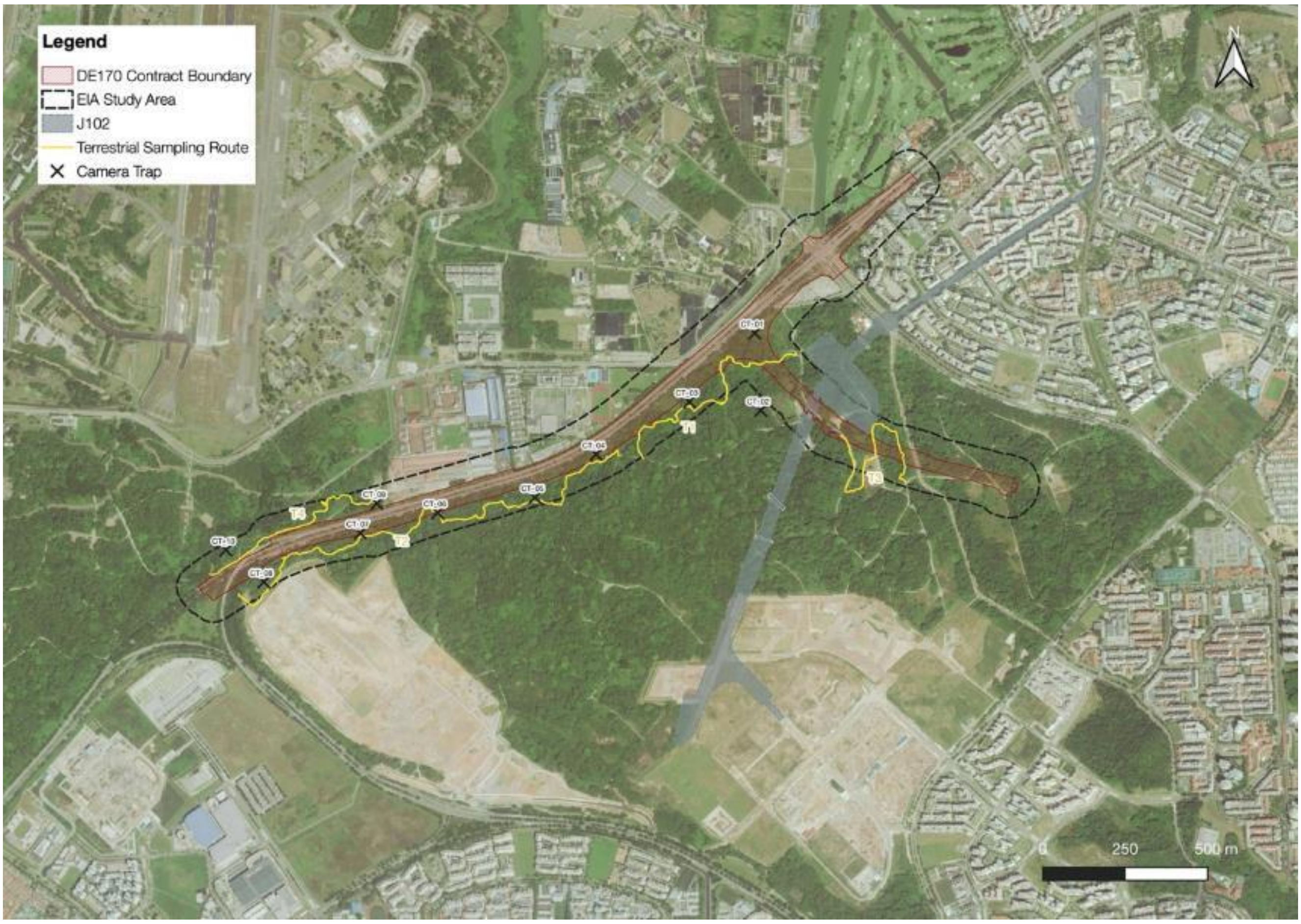


Figure 6-2: Locations of Terrestrial Sampling Routes and Camera Traps

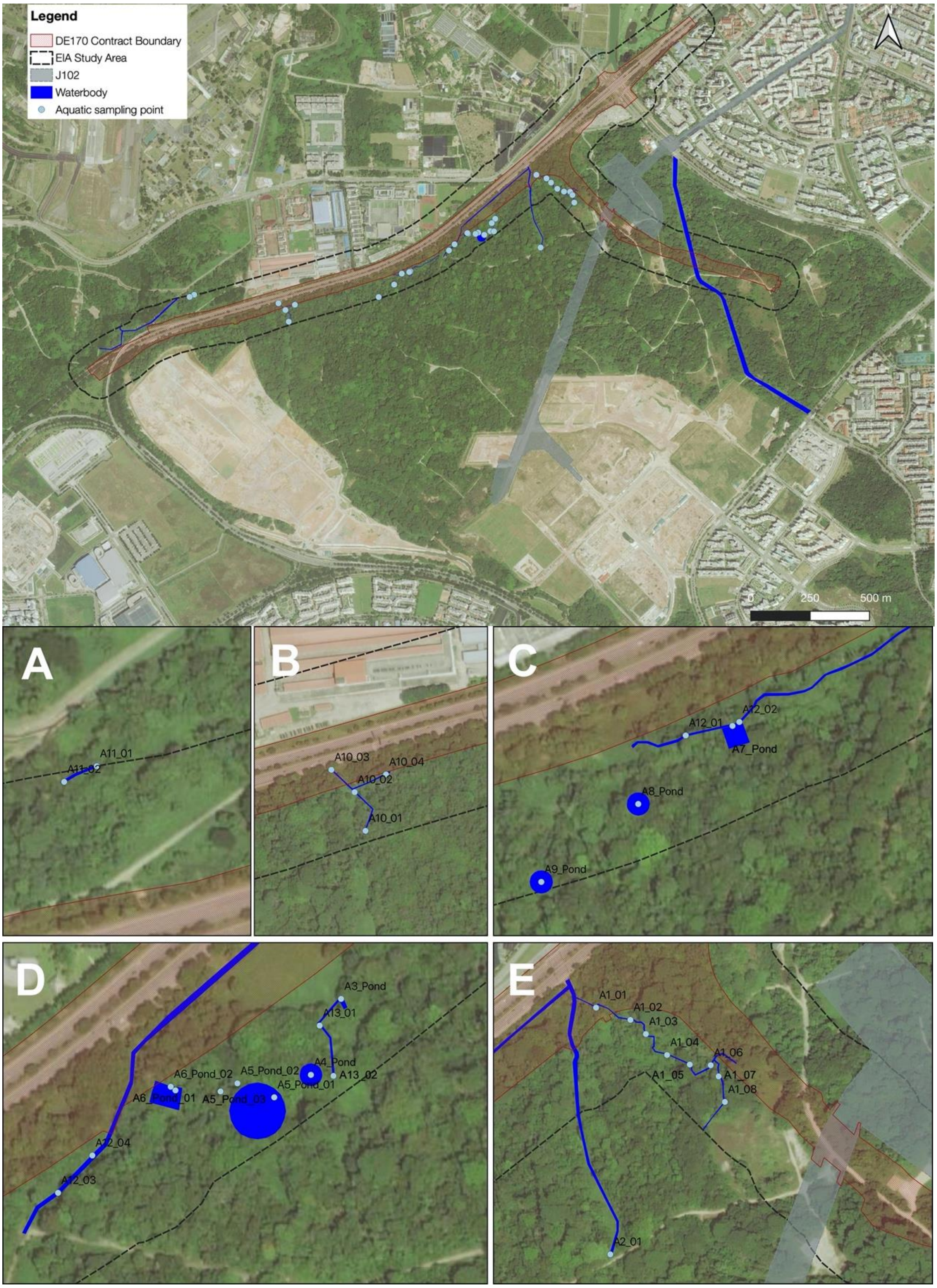


Figure 6-3: Locations of Aquatic Sampling Points

Source: ESRI

a) Butterflies

Diurnal transect surveys were carried out for adult butterflies along 200-m continuous transects on terrestrial sampling routes between 0900h and 1500h. Butterfly caterpillars, pupae, eggs, and host plants were also recorded when observed. Adult butterflies were identified visually (with binoculars where necessary), photographed, or caught using insect nets, if required. Captured individuals were released immediately after identification.

b) Odonates (Dragonflies and Damselflies)

Diurnal transect surveys were carried out for adult damselflies and dragonflies along 200-m continuous transects on terrestrial sampling routes. Along the waterbodies, surveys were carried out for 10 mins at each aquatic sampling point by three surveyors. The sampling transects were placed at 50-m intervals along the waterbodies. All surveys were conducted between 0900h and 1500h. Owing to difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Adult odonates were identified visually (with binoculars where necessary), photographed or caught using insect nets, if required. Captured individuals were released immediately after identification.

c) Aculeata (Bees and Stinging Wasps)

Diurnal transect surveys will be carried out for aculeata (bees and stinging wasps) along 200 m continuous transects on a sampling route between 0900h and 1500h. Aculeata were identified visually (with binoculars where necessary), photographed, or caught using insect nets, if required. Captured individuals were released immediately after identification. When identification in the field is not possible, live specimens were collected and examined post-hoc under a microscope. The specimens were identified to the lowest taxonomic level using relevant references, identification keys, or in consultation with taxonomic experts.

d) Herpetofauna (Amphibians and Reptiles)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for amphibians and reptiles along 200-m continuous transects on terrestrial sampling routes. Along the waterbodies, surveys were carried out for 10 mins at each aquatic sampling point by three surveyors. The sampling transects were placed at 50-m intervals along the waterbodies. As herpetofauna occupy a wide range of habitat types, both the diurnal and nocturnal surveys also involved active searches for individuals on the ground, below rocks, logs, leaf litter and debris, in the water, and/ or on vegetation. Torches and/ or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising fauna were located or identified by call recognition, whenever possible. For species that are capable of quick retreats and escapes, the individuals were captured by hand, or using hooks, tongs, or dip nets for identification. Captured individuals were released immediately after identification.

e) Birds

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for birds along 200-m continuous transects on terrestrial sampling routes. Birds were identified visually and photographed, whenever possible. Torches and/ or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising birds were also located or identified by call recognition, whenever possible.

f) Mammals (Non-Volant)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for non-volant mammals along 200-m continuous transects on terrestrial sampling routes. Both the diurnal and nocturnal surveys involved searches in burrows and tree holes. Tracks, scats and holts were also be recorded. Mammals were identified visually and photographed. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising mammals, such as the squirrels, were also located or identified by call recognition, whenever possible.

Ten camera traps were systematically deployed within the EIA Study Area. The camera traps are kept at least 20 m away from the transects, whenever possible. Data from three camera traps (CT11, CT12, and CT13) deployed for the previous study (Jan–Aug 2020) were used for this assessment as no major changes to the site were observed during site reconnaissance. Locations of the camera traps within the EIA Study Area are reflected in **Figure 6-2.**

Each camera trap was set up at approximately 20–30 cm above ground (See **Figure 6-4**). They operated 24 hours a day and were programmed to record 10-second footage per motion trigger with a 10-second quiet period following each trigger. Each camera trap was deployed for at least 60 days. The camera trap model used was Dark Ops HD Pro X BTC-6HDPX.

Figure 6-4: Example of Camera Trap Set Up, at CT06

g) Mammals (Bats Only)

Acoustics surveys were carried out for bats along 200-m continuous transects on a sampling route between 2000h and 2300h. The Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.) were used to record, stream, and attenuate ultrasonic calls between 18 and 192 kHz at a sampling frequency of 384 kHz to low frequency signals below 20 kHz, a range that is audible to the human ear.

Owing to the difficulty in finding roost sites and the inability to visually identify bats to the species-level in flight, bats were sampled using live-trapping and acoustic detection. Two harp traps and two mist nets were deployed (**Figure 6-5; Figure 6-7**). Mist nets target the larger-sized megabats, while harp traps target the smaller microbats. Typically, each ground mist net and harp trap are placed near each other. Traps were set up between 1730h–1930h and trapping lasted from 1930h–2100h, during which traps will be repeatedly checked. Mist nets were disassembled by 2100h, while harp traps will be left overnight and checked the following morning between 0800h and 0900h and removed. Bats collected in the traps were identified and released immediately.

A set of bat traps was deployed approximately 100m away from the study boundary. The location was deemed optimal for bat sampling due to sufficient space and presence of potential flyways for bats. The habitat here is similar to that present in the EIA Study Area. During bat sampling, potential flyways are typically targeted to improve chances of detecting species. Since bats are mobile and cover a larger area, species found in the bat trap location are likely to be representative of the bats that can be found in the EIA Study Area.

Roost emergence surveys was also carried out between 1830h and 2100h for bamboo bats, specifically, at one bamboo cluster in the central part of the EIA Study Area **(Figure 6-6; Figure 6-7**). Bamboo bats were identified visually and calls recorded using the Echo Meter Touch 2 Pro detector (**Figure 6-6**). Presence of bamboo slits that are at least 1 cm wide were noted.

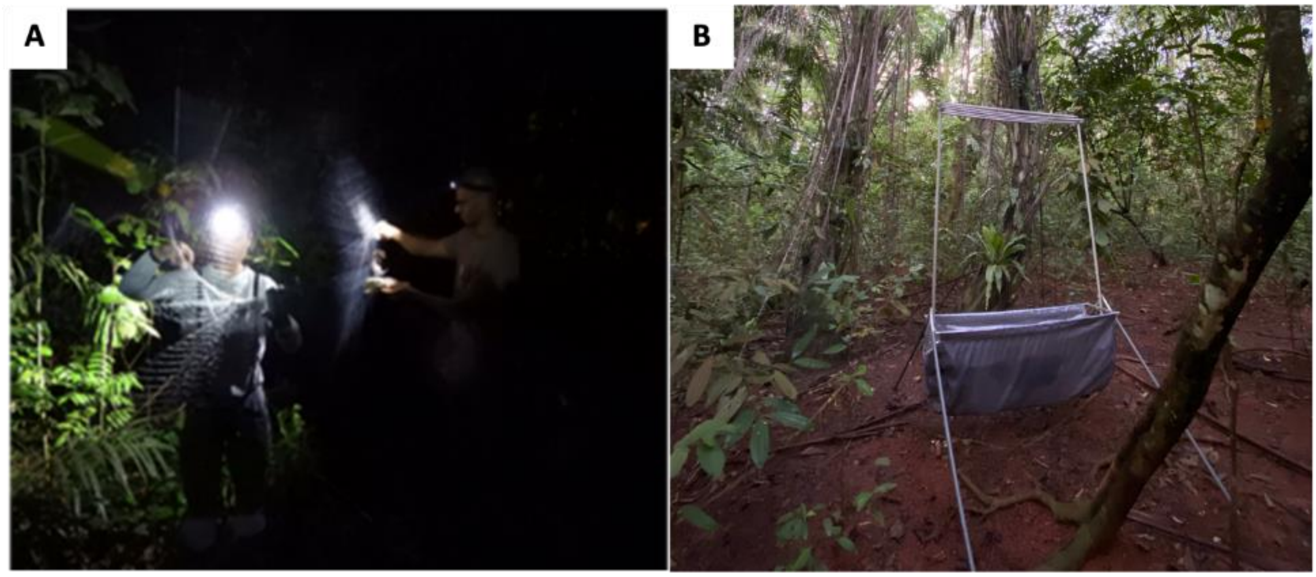


Figure 6-5: Setup of (A) Mist Net and (B) Harp Trap during Bat Trapping

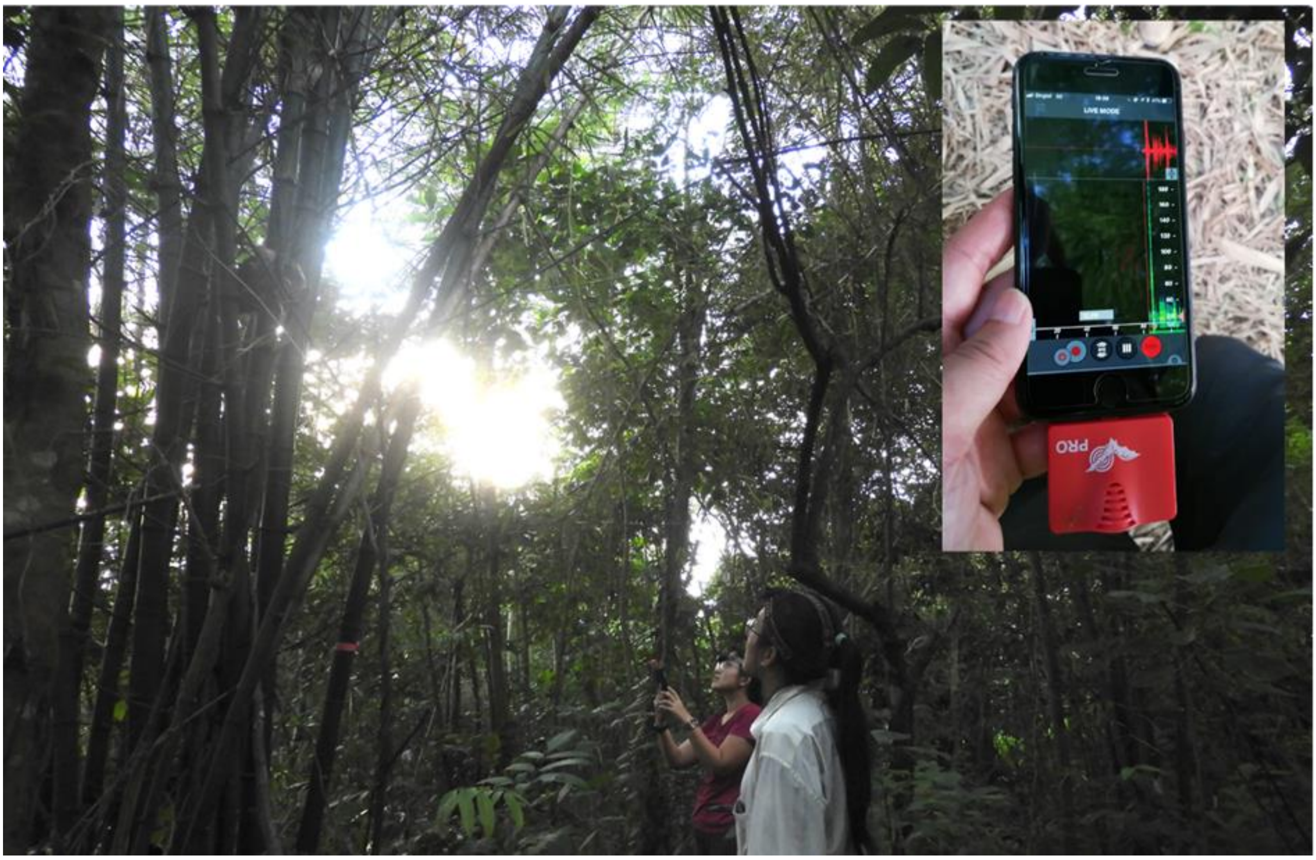


Figure 6-6: Roost Emergence Surveys with the Use of Acoustic Detector

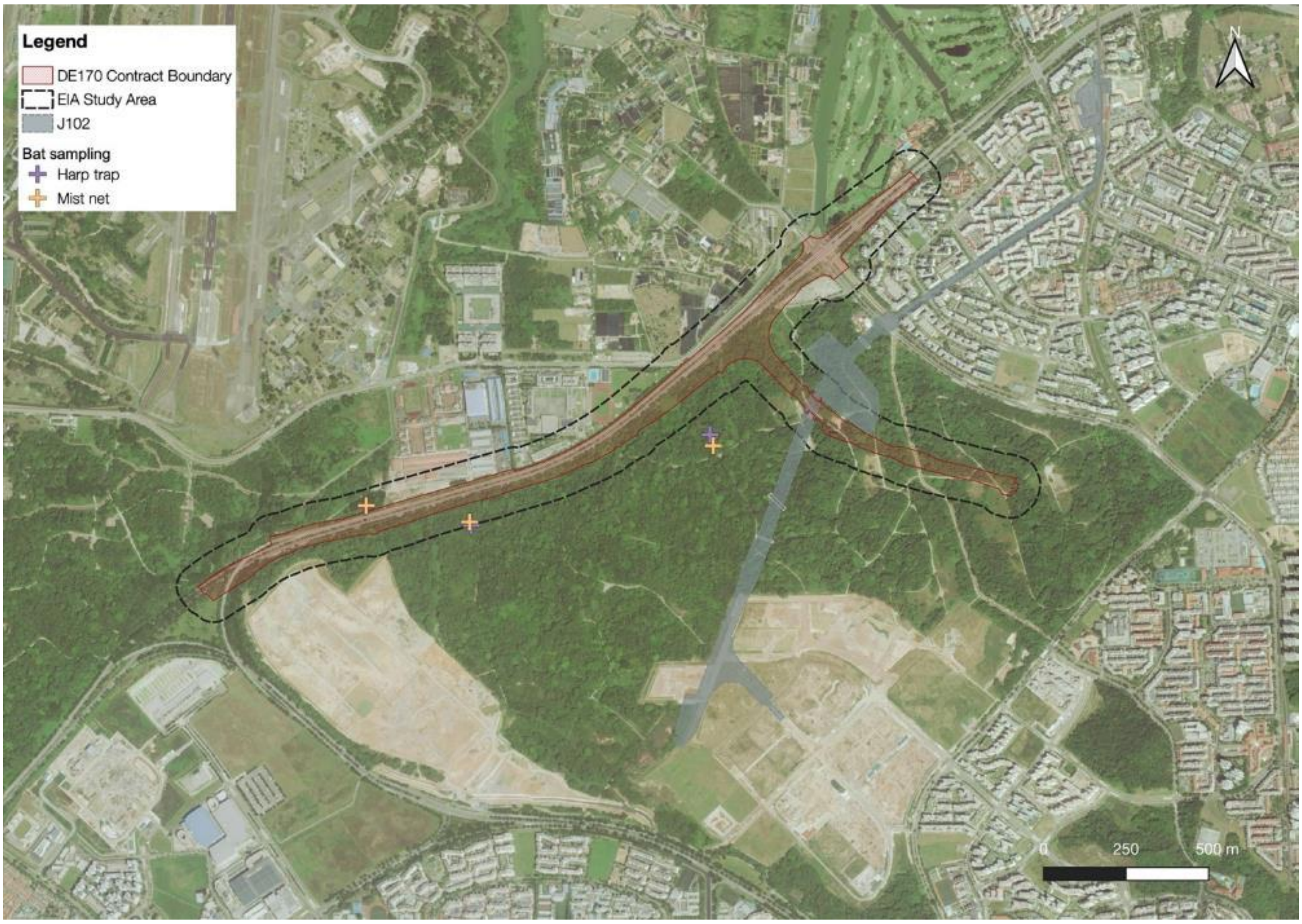


Figure 6-7: Location of Harp Traps and Roost Emergence Survey
Source: ESRI

h) Freshwater Aquatic Fauna (Fish, Decapod Crustaceans and Molluscs)

The freshwater fauna that were surveyed are freshwater fish, decapod crustaceans, and molluscs.

Diurnal and nocturnal 10-minute point counts were conducted by three (3) surveyors for freshwater fish and decapod crustaceans at aquatic sampling points of every 50 m interval for natural and naturalised streams between 2000h and 2300h. Torches and/ or headlamps were used to elicit eyeshine during nocturnal surveys.

Push and/ or scoop netting were carried out for freshwater fish, decapod crustaceans, and molluscs at aquatic sampling points placed at 50-m intervals along streams and ponds. At each aquatic sampling point, surveys were carried for 10-minutes by three (3) surveyors for a 10-m stretch. Push netting were carried out, usually in deeper waters, using a rigid-frame tray net (61 × 49 cm; 5 mm mesh) to catch specimens on the banks or the streambed where accessible (**Figure 6-8A**). Scoop netting was carried out, usually in shallower waters, using hand nets (net size 25 × 18 cm; 2 mm mesh) to catch specimens within the stream column. Captured individuals were released immediately after identification.

Minnow traps baited with halal meat (e.g., sausage or liver) were also deployed at 50-m intervals along streams and ponds (**Figure 6-8B**). The traps were left overnight, then checked and removed the following morning and all caught individuals were released immediately. At ponds where push and/ or scoop netting could not be conducted due to soft substrate, low visibility of water and deep waters, additional minnow traps may be deployed depending on habitat suitability.

Figure 6-8: (A) Push Netting; (B) Minnow Trapping

6.2.3.3 Data Analysis

6.2.3.3.1 Species Distribution Maps

The distribution of species of conservation significance were mapped using QGIS v.3.4 (Quantum GIS Development Team, 2019).

6.2.3.3.2 Camera Trapping

Camera trap location, species identity, and the number of individuals were recorded for each video with a positive capture of fauna. An independent detection constitutes video of one or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap. The number of independent detections was used to calculate detection rate of each mammal species.

6.2.3.3.3 Bat Sound File Analysis

All bat sound files were processed using Kaleidoscope v.4.5.4 (Wildlife Acoustics, Inc.) to separate extraneous noise from files with bat echolocation calls. The signal parameters for recognising a potential bat echolocation call were configured as follows: frequency range of 20–200 kilohertz (kHz), duration of 2–500 milliseconds (ms), maximum inter-syllable gap of 500 ms, and a minimum of 2 pulses. These files were visually processed to identify bat species based on call structures, peak frequency, minimum frequency, and call duration (Pottie et al., 2005). They were identified with reference to those in Pottie et al. (2005), which provides echolocation signatures for bats in Singapore, and other relevant references (Collen, 2012; Hughes et al., 2011).

6.2.3.3.4 Taxon Sampling Curves

Taxon sampling curves were plotted for selected taxa with sufficient occurrences as large sample sizes are required for the estimation of sample coverage to be robust (Chao & Jost, 2012). The observed sample of incidence data was used to estimate sample coverage and species richness. Only targeted transect or point count data was used for the analysis (i.e., incidental records were removed). Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/ survey adequacy, i.e., how extensively we have sampled the species in the community. Sample coverage refers to "the proportion of the total number of species in a community that belongs to the species represented in the sample" (Chao & Jost, 2012). The curve was extrapolated to provide an estimation of species richness and sample coverage if sample size was doubled. The associated standard error and 95% confidence interval were also computed. Standard error represents the range of uncertainty of the estimate, while 95% confidence interval is the interval in which there is a 0.95 probability of containing the estimated true species richness. As some species will always remain undetected, total species richness had to be estimated via extrapolation. This was done using the Chao estimator. All statistical analyses were carried out in the statistical programming environment R version 3.4.3 using the "iNEXT" package 2.0.20 (Hsieh et al., 2019).

6.2.4 Baseline Results

This section presents the preliminary biodiversity baseline findings for the EIA Study Area conducted between 10 March and 14 July 2022. It also includes biodiversity data within the overlapping area for previous EIS conducted between Jan to Aug 2020.

6.2.4.1 Habitat Description

The EIA Study Area comprises eight habitat types (**Table 6-3; Figure 6-9**). The habitat type that occupies the largest area is infrastructure, which took up 50.8 ha (31.5%). Majority of the infrastructure were found on the north and northwestern region, including the KJE. This is followed by abandoned-land forest and scrubland, covering 40.1 ha (24.9%) and 30.1 ha (18.7%) respectively. Both of the habitat types can be found throughout the EIA Study Area. The urban area occupied 20.1 ha (12.5%) of the total EIA Study Area, where majority were concentrated on the northwestern portion. Similarly, most of the exotic-dominated secondary forest area were located on the eastern region, taking up approximately 11.3 ha (7.0%). The remaining habitat types adds to less than 10.0%, namely in descending order, construction works, cleared area and waterbodies.

Table 6-3: Absolute (ha) and Relative (%) Size of Each Habitat and Vegetation Type in the EIA Study Area

Habitat and Vegetation Type	Absolute size (ha)	Relative size (%)
Others (Infrastructure)	50.80	31.5
Abandoned-land Forest	40.09	24.9
Scrubland	30.13	18.7
Urban Vegetation	20.15	12.5
Exotic-dominated Secondary Forest	11.32	7.0
Others (Construction)	4.99	3.1
Cleared Area (Non-vegetated)	2.39	1.5
Waterbodies (Streams, Ponds)	1.46	0.8
Total	161.3	100

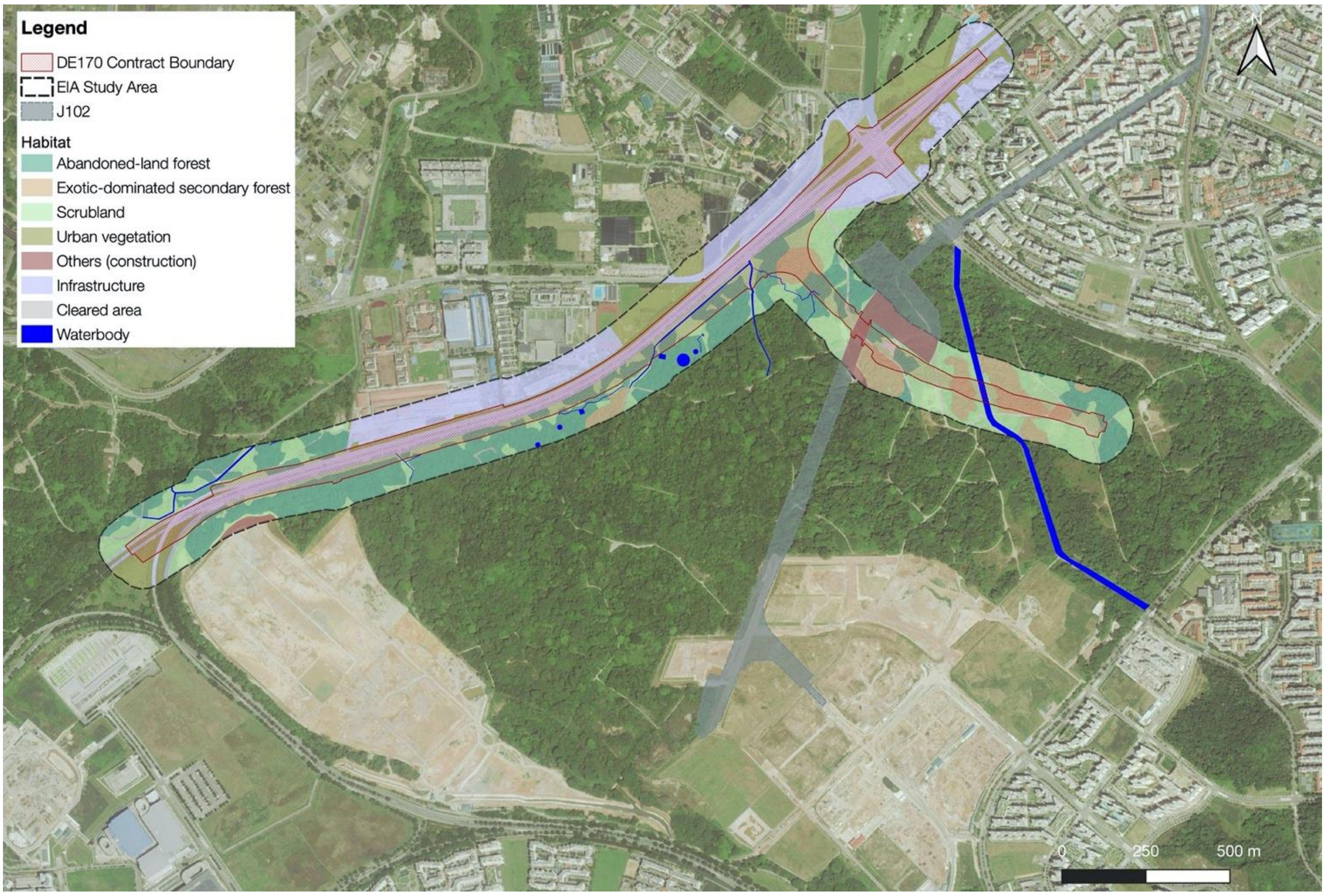


Figure 6-9: Habitats within the EIA Study Area

Source: ESRI

6.2.4.1.1 Others (Infrastructure)

Infrastructure is the largest habitat found, covering about 50.8 ha (31.5%) of the EIA Study Area. Most of the infrastructure are taken up by KJE, Old Choa Chu Kang Road, Jalan Lam Sam Road and Call Lade Enterprises Heavy Vehicle Park (**Figure 6-10**). The remaining areas were occupied by farms, canals and residential property found within the EIA Study Area.

Figure 6-10: Call Lade Enterprises Heavy Vehicle Park in the EIA Study Area

6.2.4.1.2 Abandoned-land Forest

Abandoned-land forest (40.1 ha; 24.9%) is the second largest habitat type found in the EIA Study Area. Its floristic composition is characterized by fruit trees and other crop plants that have persisted from past cultivation. Although abandoned-land forests are generally dominated by exotic cultivated species, existing and recruited native forest species can establish themselves over time.

Within the EIA Study Area, patches of abandoned-land forest are scattered along the southern and western side of the KJE, with smaller patches at the northern and eastern ends of the proposed Forest Drive (**Figure 6-11**). According to topographical maps from 1945 (**Section 3.2.3**), these areas were mainly covered by rubber (*Hevea brasiliensis*) plantations and/or "sundry tree cultivation", which is a term previously used to refer to "abandoned-land forest" (Yee et al., 2016). In the past, these plantations may have been cultivated by villagers in nearby villages (e.g., Lam Sam village).

At present, majority of the trees located at the southern side of the KJE were occupied by species such as rubber (*Hevea brasiliensis*), durian (*Durio zibethinus*), and African tulip (*Spathodea campanulata*) (**Figure 6-11A**). Whereas for the trees located at the western side of the KJE, majority were dominated by raintrees (*Samanea saman*) (**Figure 6-11B**). Similarly, the understorey layer is largely dominated by saplings of cultivated species, including durian, wild cinnamon (*Cinnamomum iners),* rambutan (*Nephelium lappaceum*), cacao (*Theobroma cacao*), mango (*Mangifera indica*), rambai (*Baccaurea motleyana*), and *Syzygium* species.

The commonly encountered native species in the abandoned-land forest patches include *Claoxylon indicum*, *Terminalia catappa*, *Leea indica*, and *Cinnamomum iners*. Native forest species of conservation significance have also been recorded. Several clusters of nationally Vulnerable species, such as *Bridelia stipularis*, *Oxyceros longiflorus*, and *Macaranga griffithiana*, were recorded throughout the forest areas. Nationally Endangered species, including *Ardisia elliptica*, *Ficus vasculosa*, and *Sandoricum koetjape*, were discovered. Nationally Critically Endangered species were also discovered, including *Connarus semidecandrus*, *Crytococcum patens*, and *Leea angulata*. Notably, individuals of the nationally Critically Endangered *Melicope luna-ankenda* were only encountered in the abandoned-land forest patches at the northern and eastern end of the proposed Forest Drive, respectively.

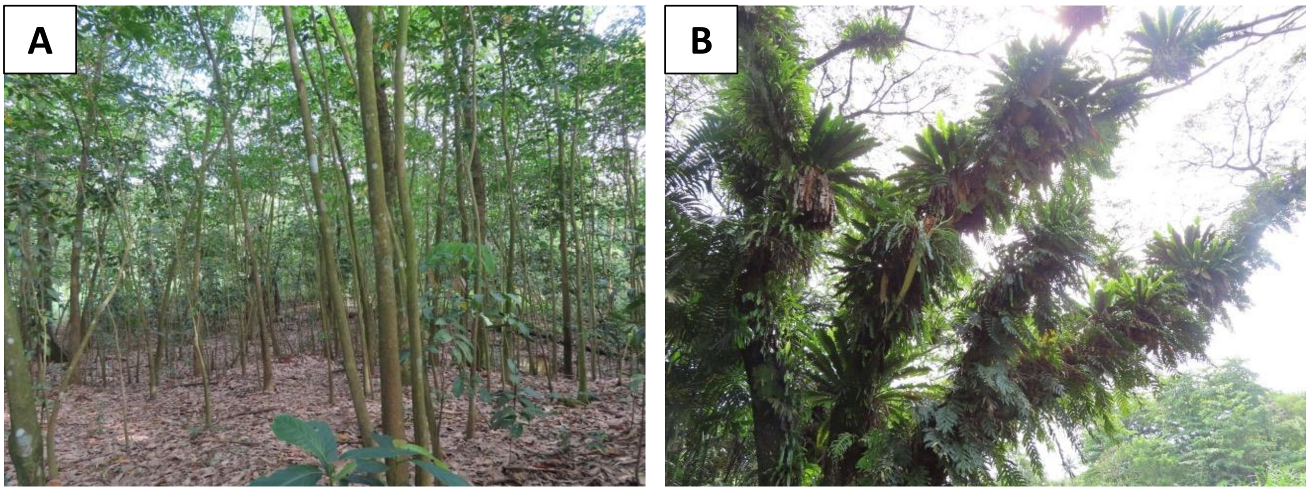


Figure 6-11: Abandoned-Land Forest in the EIA Study Area, (A) Dominated by Rubber (*Hevea brasiliensis*); (B) Dominated by Raintree (*Samanea saman*)

6.2.4.1.3 Scrubland

Scrubland took up about 30.1 ha (27.3%) of the EIA Study Area. There were numerous large patches of scrubland scattered across the EIA Study Area. Most of these patches consist of a mixture of grassland and fern-dominated scrubland (**Figure 6-12A**), characterised by a single vegetated layer. Majority of these scrubland were located in open canopy areas with no shades from trees and are exposed to high light incidence. This encourages the growth of fast-growing and sun-loving species that can tolerate high temperature levels. Therefore, species such *Urochloa mutica*, *Paederia foetida*, *Isachne globosa*, *Scleria ciliaris*, *Panicum repens* and *Nephrolepis biserrata* that tends to thrive in such conditions were found dominated in these scrublands.

A small patch of simpoh air (*Dillenia suffruticosa;* **Figure 6-12B**) dominated scrubland was also observed north-west of the infrastructure area (i.e., J102), located in the eastern arm of the DE170 Contract Boundary. The scrubland located in the west, as well as along the edges of the canal to the west, is largely dominated by elephant grass (*Pennisetum purpureum*; **Figure 6-12C**). Additionally, a higher concentration of nationally Vulnerable *Glochidion zeylanicum* var. *zeylanicum* was found within the scrubland habitat type, especially towards the end of eastern region.

Figure 6-12: Scrubland in the EIA Study Area. (A) Grassland and Fern-dominated Scrubland Habitat; (B) Simpoh Air (*Dillenia suffuticosa*) Dominated Habitat; (C) Elephant Grass (*Pennisetum purpureum*) Dominated Habitat

6.2.4.1.4 Urban Vegetation

Urban vegetation occupies about 12.5% (20.1 ha) of the total EIA Study Area. They are mainly found in the north western region, along and/ or between Kranji-Express Way (KJE) and Old Choa Chua Kang Road. This habitat type is typically covered with planted roadside trees and/ or turf areas that are regularly maintained. A small portion of the urban vegetation consist of golf course range, Keat Hong Park and cemetery area.

6.2.4.1.5 Exotic-dominated Secondary Forest

Exotic-dominated secondary forest takes up about 7.0% (11.3 ha) in the EIA Study Area. This habitat type is mainly located across the northern portion of the forest. Exotic-dominated secondary forest usually comprises of fast-growing and exotic-dominated species that regenerates from cleared land or found in areas that are highly disturbed. The floristic composition of this habitat type is dominated by the albizia trees (*Falcataria falcata;* **Figure 6-13**) and African tulip (*Spathodea campanulata*). Within the understorey, a mixture of native saplings was observed. This includes, *Syzygium* species, *Ficus* species, *Leea indica* and *Claoxylon indicum*. There were also multiple clusters of nationally Critically Endangered *Leea angulata* within this habitat type.

Figure 6-13: Exotic-dominated secondary forest in the EIA Study Area, dominated by Albizia (*Falcataria falcata*)

6.2.4.1.6 Others (Construction)

An approximately 3.1% of the area is occupied by J102 construction site located in the middle of the EIA Study Area (see **Section 2.1** for more details). There is also another small hoarded area found in the western area for the JRL depot construction.

6.2.4.1.7 Cleared Areas

The cleared area are non-vegetated pathways used as roads throughout the EIA Study Area, which only takes up a small portion of the overall area (1.7 ha, 2.3%).

6.2.4.1.8 Waterbodies

A variety of waterbodies including concrete and naturalised canals, forest and open-country streams, ponds, and ephemeral waterways are present within the EIA Study Area. There are six streams, seven ponds and two naturalised canals in the EIA Study Area. Habitat descriptions are provided for waterbodies where surveys have commenced. The locations of the waterbodies are shown in **Figure 6-3** and images of the waterbodies within the EIA Study Area in **Figure 6-14** and **Figure 6-15**.

Table 6-4: Description of Waterbodies within the EIA Study Area

Type	Stream [Reference in Section 5.3.2.1]	Description
Closed-canopy streams	A1, A11, upstream of A12, A13 [WQ4]	A1 (**Figure 6-15A**) is a slow-flowing closed-canopy stream in the north eastern side of the EIA Study Area, flowing in the north-western direction. It is characterised by high canopy cover, lower temperatures, and accumulation of leaf litter. This stream has steep, silty, eroded and bare banks. The eroded banks contribute to the silty substrate at the bottom of the stream. Shallow at most points, the stream has some deeper wider sections that are almost like small ponds, for example at A1_01(**Figure 6-15A**). The banks downstream of A1 are also littered with debris which may be remnants of its historical land use, when Tengah was a kampong. The stream is now naturalized with canopy cover and leaf litter. Stream A12 (**Figure 6-15E**) is elevated upstream as it becomes a completely natural forest stream with deep and steep banks, but water levels remain shallow and almost runs dry at some sections during dry weather. A12 flows in the easterly direction. Stream A13 (**Figure 6-15F**), similar to A11 is fed by ephemeral streams within an area that gets waterlogged during wet seasons and is generally stagnant otherwise.
Open-country stream	A10 [WQ2]	This is a slow-flowing open-country stream with low canopy cover and the deepest stream within the EIA Study Area. Stream A10 (**Figure 6-15B**) is situated close to the highway with a deep wide channel filled with aquatic plants and grassy banks. Upstream of this naturalised stream is a concrete drain running parallel to KJE. This stream flows southwards, towards Jurong Lake.
Closed-canopy & semi open-country ponds	A3, A4, A5, A6, A7, A8 [Pond 7, Pond 9, Pond 6, Pond 5, Pond 4, Pond 3]	Pond A3 (**Figure 6-14A**) is a small pond situated within a waterlogged area. It has well vegetated banks and is situated at the edge of the forest within a patch of scrubland and herbaceous vegetation with some canopy cover. Pond A3 leads out to 2 smaller channels towards south-east and south-west. Pond A4 (**Figure 6-14B**) is a larger pond located within a forest patch and is dominated by small floating aquatic plants (duckweed) with sparse banks consisting of low-lying riparian vegetation. Due to the size of the pond and surrounding low canopy, canopy cover is sparse. In close proximity to pond A4 lies pond A5 (**Figure 6-14C**), which is shallower and has a leaf litter laden bottom. Its sparse banks are surrounded by tall trees with wide canopy therefore pond A5 was well-shaded. Pond A6 (**Figure 6-14D**), similar to pond A4 was fully covered in duckweeds and under partial shade. When water levels are high, the pond overspills into an adjacent low-lying area of leaf litter covered substrate, creating marshy conditions. Pond A7 (**Figure 6-14E**) is located behind the concrete to naturalised stream A12 and receives inflow from stream A12. The water level within pond A7 fluctuated drastically during the period of survey (March to July 2022).

Type	Stream [Reference in Section 5.3.2.1]	Description
		Pond A8 (**Figure 6-14F**) is relatively shallow with soft muddy banks and was located within an oil palm field, receiving only partial shade. Both ponds A7 and A8 were dominated by duckweed.
Open-country ponds	A9 [Pond 2]	Pond A9 (**Figure 6-14G**) is a large open-country pond situated in an area of scrubland and herbaceous vegetation. The vegetation on the edge of the pond is very lush and the pond is barely shaded.
Canal with naturalized sections	A2, downstream of A12 [WQ3]	Drain A2 (**Figure 6-15B**) bisects the EIA Study Area from north to south while A15 runs parallel to KJE. Most of the canal is open and unvegetated, however some parts of the canal were soft-bottomed and overgrown with vegetation. The water is sometimes fast-flowing and the water level does not seem to exceed the baseflow channel. During wet weather there is ponding of water downstream of drain A2, where the water is silty with slow flow and the pond is only partially shaded. It is continuous with a semi open-country stream running south, outside of the EIA Study Area. A2 flows north towards KJE. Drain A12 (**Figure 6-15G**) is a deep concrete drain upstream and although the concrete has not given way, enough substrate has accumulated at certain sections to give it the characteristics of a soft bottom stream, nested between dense vegetation growth that has reached beyond the concrete slopes of the drain. A12 is more naturalised in its upstream, which are considered closed-canopy (see closed-canopy streams above).

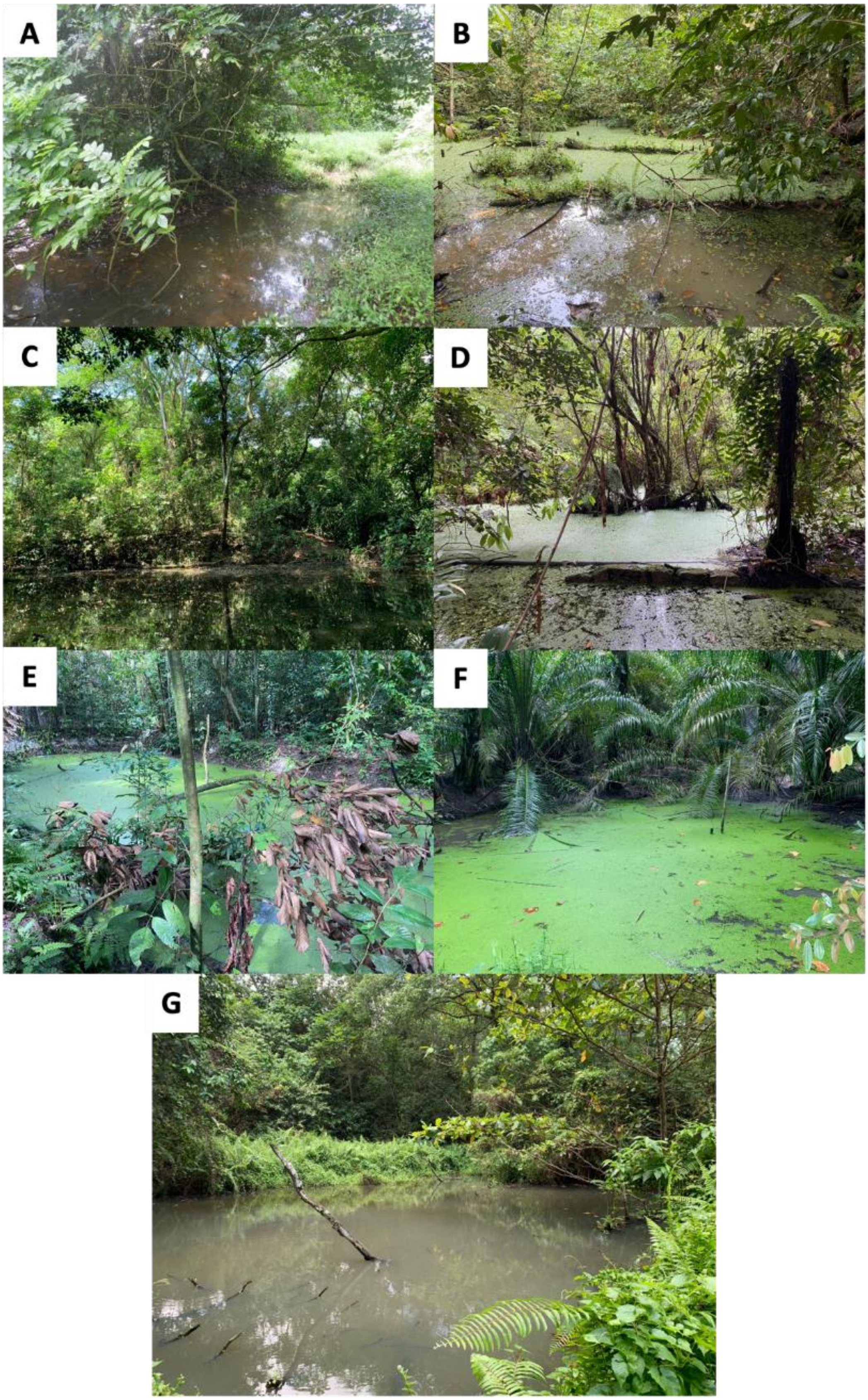


Figure 6-14: Closed Canopy and Semi Open-country Ponds, Ponds A) A3, B) A4, C) A5, D) A6, E) A7, F) A8, G) A9

Figure 6-15: Closed Canopy Forest Streams A) A1_01, B) A10, C) Downstream of A12, D) A13, Naturalised Canal E) A2, F) Upstream of A12 and Open Country Stream

6.2.4.2 Floristic Baseline Results

6.2.4.2.1 Overall Floristic Findings

A total of 217 species and one species group (i.e., plants that could not be identified to species with certainty), belonging to 77 families were recorded from the overall EIA Study Area (**Table 6-5**). The one species group is also known as *Schizostachyum* cf. *brachycladum*. Of these 217 species, about half of the species recorded are native (114 species; 52.5%), 92 are exotic (42.4%) and 11 (5.1%) are cryptogenic (i.e., of unknown or uncertain origin despite being a known species). The list of flora species is provided in **Appendix 6A**.

Native threatened species comprise species that have been accorded the following statuses: Vulnerable, Endangered, Critically Endangered, Presumed Extinct. For overall findings, however, a distinction was not made as to whether threatened species are from native wild populations or are cultivated locally and/or relics from past cultivation. Species belonging to the latter category are not of conservation significance even though they have been accorded with a threatened status. This is discussed in greater detail in **Sections 6.2.2.3** and **6.2.4.2.2**.

Table 6-5: Number and Percentage of Species Belonging to Each Category

Origin	Status	Number of Species	Percentage (%)
Native		114	52.5
	Common	81	37.3
	Vulnerable	19	8.8
	Endangered	4	1.8
	Critically Endangered	9	4.1
	Presumed Extinct	1	0.5
Exotic		92	42.4
	Cultivated Only	17	7.8
	Casual	28	12.9
	Naturalised	45	20.8
	Not assessed	2	0.9
Cryptogenic		11	5.1
	Total	217	100

6.2.4.2.2 Species of Conservation Significance

Of the 33 threatened native species, 21 are considered of conservation significance in the EIA Study Area (**Table 6-6; Appendix 6B**). Altogether, 408 specimens and/ or clusters of specimens belonging to these species of conservation significance were recorded (**Table 6-7**). Some species, though listed as nationally threatened, were not considered of conservation significance in this study because they are most likely escapees from present-day cultivation or relics that has persisted from past cultivation. The assessment of whether a threatened plant species is of conservation significance was carried out based on the criteria detailed in **Section 6.2.2.3.**

Table 6-6: Number of Threatened Species within the EIA Study Area

Species Conservation Status*	VU	EN	CR	EX
Non-cultivated Threatened Species	15	1	5	0
Cultivated Threatened Species	5	3	4	0

Note: VU – Vulnerable; EN – Endangered; CR– Critically Endangered; EX – Presumed Extinct

Table 6-7: Number of Plant Specimens and Species of Conservation Significance in the EIA Study Area

Habitat	Number of Individuals and Clusters	Number of Species

	VU	EN	CR	EX	Total	VU	EN	CR	EX	Total
Abandoned-land Forest	217	11	8	0	236	10	3	4	0	17
Exotic-dominated Secondary Forest	76	0	15	0	91	5	0	3	0	8
Scrubland	60	2	2	0	64	10	1	2	0	12
Waterbody	9	0	0	0	9	3	0	0	0	3
Cleared Area	6	0	0	0	6	2	0	0	0	2
Others (Construction)	2	0	0	0	2	2	0	0	0	2

Note: Total species richness of the EIA Study Area is not the sum of species richness per vegetation type as some species occur in more than one vegetation type. VU – Vulnerable; EN – Endangered; CR – Critically Endangered.

Majority of the specimens are either found within the abandoned-land forest or exotic-dominated secondary forest (**Table 6-7**). There are some species of conservation significance that are of interest within the EIA Study Area, this includes *Ardisia elliptica* **(Figure 6-17A)**, *Glochidion zeylanicum* var. *zeylanicum* (**Figure 6-17B**) and *Leea angulata* (**Figure 6-17C**).

The nationally Vulnerable *G. zeylanicum* var. *zeylanicum and* nationally Endangered *A. elliptica*, are also host plant to threatened butterfly species. *A. elliptica* is the caterpillar host plant for harlequin (*Taxila haquinus haquinus*) while *G. zeylanicum* var. *zeylanicum* is the host plant for Malay staff sergeant (*Athyma reta moorei*). A total of eight clusters of *A. elliptica* (0.05–0.1 m girth) were recorded throughout the EIA Study Area, majority of the plant specimens was observed in the northern region of the EIA Study Area (**Figure 6-17**). The harlequin was recorded near where most *A. ellipitica* was located at, as discussed in **Section 6.2.4.2.2**. Similarly, there were 18 clusters of individuals and/or clusters of *G. zeylanicum* var. *zeylanicum* (0.05–0.2 m girth) found in the EIA Study Area. These clusters were mainly discovered in the eastern region of the EIA Study Area.

For the nationally Critically Endangered *L. angulata*, a small concentration of individuals was found within the exotic-dominated secondary forest habitat. The trunk and branches of this species was characterised with sharp triangular prickles (Lok et al., 2011). Based on herbarium records, although *L. angulata* was previously found in multiple locations in Singapore, the population seems to have reduced to being restricted within Temenggong Road in the recent years (Lok et al., 2011). Hence, this makes the discovery and conservation of this species important.

Other species of conservation significance recorded include the nationally Critically Endangered *Crytococcum patens* (**Figure 6-17D**), *Connarus semidecandrus* (**Figure 6-17E**) and *Melicope lunu-ankenda* (**Figure 6-17F**).

Figure 6-16: Species of Conservation Significance Found in the EIA Study Area. (A) *Ardisia elliptica*; (B) *Glochidion zeylanicum* var. *zeylanicum*; (C) *Leea angulata*; (D) *Crytococcum patens*; (E) *Connarus semidecandrus*, and (F) *Melicope lunu-ankenda*

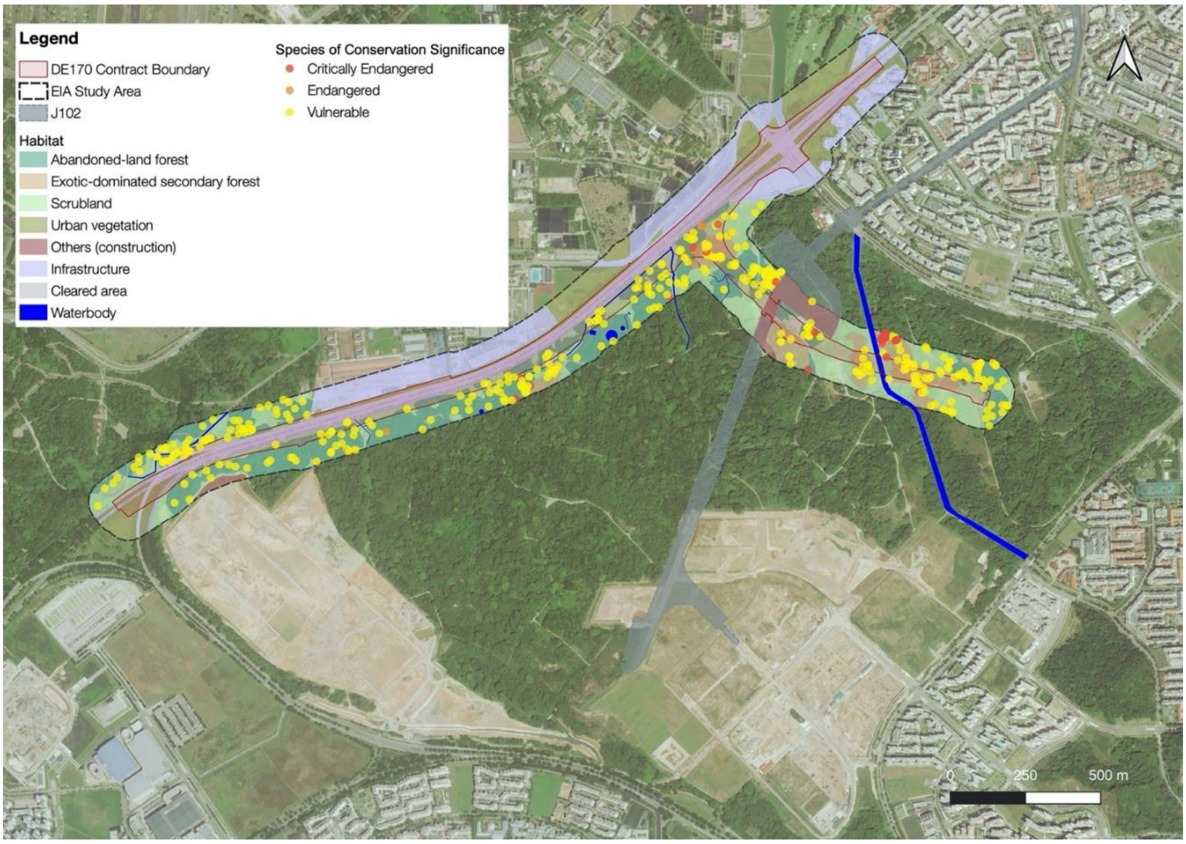


Figure 6-17: Location of Flora Species of Conservation Significance within the EIA Study Area
Source: ESRI

6.2.4.2.3 Large Plant Specimens

A total of 158 large plant specimens were recorded during the floristic surveys in the EIA Study Area. (**Figure 6-18; Table 6-8; Appendix 6C**). Of these specimens, 97 (61.4%) are native, 55 (34.8%) are exotic and 6 (3.8%) are cryptogenic. These specimens consist of 65 (41.1%) large tree specimens (3.0–6.0 m girth), 88 (55.7%) stranglers (3.0–50.0 m spread), and five (3.2%) clusters of *Bambusa heterostachya* (1.0–5.0 m spread).

Ninety-seven (61.4%) of the recorded large plant specimens are native species (**Appendix 6C**). The majority of large native tree specimens consist of the nationally Common *Ficus microcarpa* stranglers, with a total of 82 specimens distributed mostly within the abandoned-land forest patches across the entire EIA Study Area. The large tree specimens include two native species, the nationally Common *Ficus variegata* and nationally Common *Terminalia catappa*. The large specimens of *Ficus variegata* are represented by five trees concentrated at the abandoned-land forest patch near the midsection of the KJE within the EIA Study Area. Ten large specimens of *Terminalia catappa* were encountered within the abandoned-land forest patches on both sides of the KJE.

Exotic species were represented by 55 (34.8%) large plant specimens (**Appendix 6C**). All five large bamboo clusters were found to be the exotic *Bambusa heterostachya*, concentrated within a scrubland area towards the eastern end of the proposed Forest Drive (**Figure 6-18**). The remaining 50 exotic large specimens are all trees, with the majority being *Pterocarpus indicus* specimens that are present across the abandoned-land forest patches along both sides of the KJE and the exotic-dominated secondary forest area located near the midsection of the KJE within the EIA Study Area (**Table 6-8**). The large specimens of *Cananga odorata* and *Samanea saman* are observed to be concentrated in the scrubland and abandoned-land forest habitats at the western end the EIA Study Area. The two large tree specimens of *Hevea brasiliensis* occur within abandoned-land forest patches scattered along the proposed Forest Drive and the southern side of the KJE. The sole large specimen of *Khaya senegalensis* was found in the abandoned-land forest patch near the northwestern end of the EIA Study Area.

Amongst the five large bamboos in the eastern part of the EIA Study Area, presence of nationally Vulnerable bamboo bats was recorded for four of the specimens. For the remaining specimen, presence was not recorded but is considered a potential roosting site for bamboo bats. The findings of roost emergence surveys (for bamboo bats) are documented in detail in **Section 6.2.4.3.11.**

Table 6-8: Number of Large Plant Specimens in the EIA Study Area

Habit	Species	No. of Specimens
Tree	*Cananga odorata*	2
	Ficus variegata	5
	Hevea brasiliensis	2
	Khaya senegalensis	1
	Pterocarpus indicus	32
	Samanea saman	13
	Terminalia catappa	10
Strangler	*Ficus benjamina*	6
	Ficus microcarpa	82
Shrub (Bamboo)	*Bambusa heterostachya*	5
	Total	158

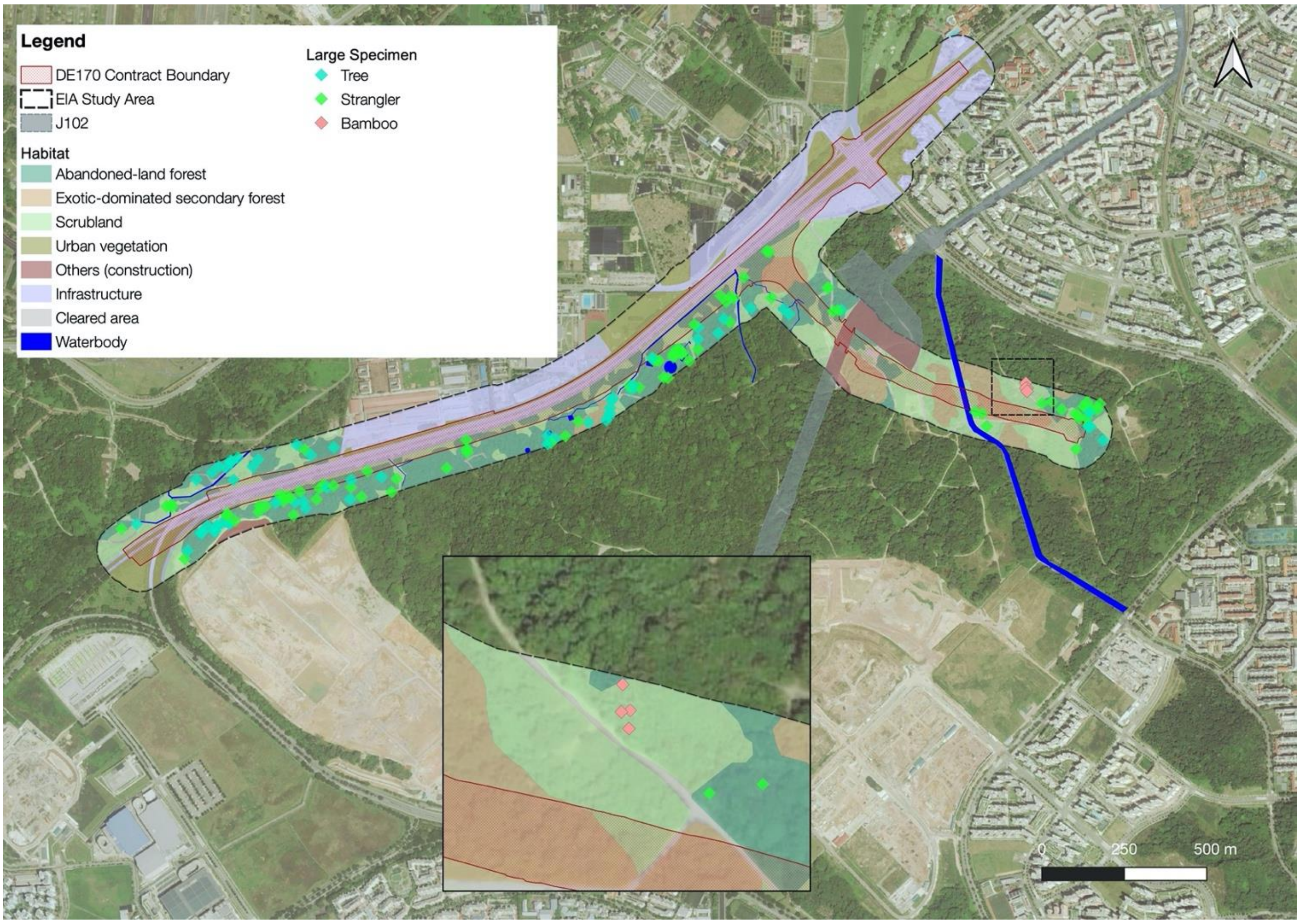


Figure 6-18: Location of Large Plant Specimens in the EIA Study Area
Source: ESRI

6.2.4.2.4 Other Specimens of Value

There were four other specimens of value found within or adjacent to the EIA Study Area (**Figure 6-20**), namely three bamboos and an albizia tree (*Falcataria falcata*) with a raptor nest. Two bamboo clusters (*Schizostachyum* cf. *brachycladum*) were found in the central part of the EIA Study Area, in close proximity to each other. Both clusters were 1.0–2.5 m in spread (**Figure 6-19A–B**). The remaining bamboo was found in the eastern part. These bamboos are not considered as large plant specimens as they have a girth size of <3 m. Instead, they are separately considered as other specimens of value (see **Section 6.2.3.1.2**).

The roost emergence surveys confirmed the presence of bamboo bats (*Tylonycteris* sp.) in the clusters in central part of the EIA Study Area (**Section 6.2.4.3.11**). For the remaining specimen in the eastern part (*Bambusa heterostachya*), presence of bamboo bats was not recorded but is considered a potential roosting site for bamboo bats. The findings of roost emergence surveys (for bamboo bats) are documented in detail in **Section 6.2.4.3.11**.

An albizia tree with the raptor nest was found adjacent to the EIA Study Area in the eastern part (**Figure 6-19C**). It was confirmed to be the nest of the changeable hawk eagle (*Nisaetus cirrhatus*) that was seen perching on the nest and heard regularly in the nearby area during surveys (**Section 6.2.4.3.9**).

Figure 6-19: Other Specimens of Value found in the EIA Study Area (A-B) *Schizostachyum* cf. *brachycladum*; (C) Zoomed-in view of *Falcataria falcata* with raptor nest

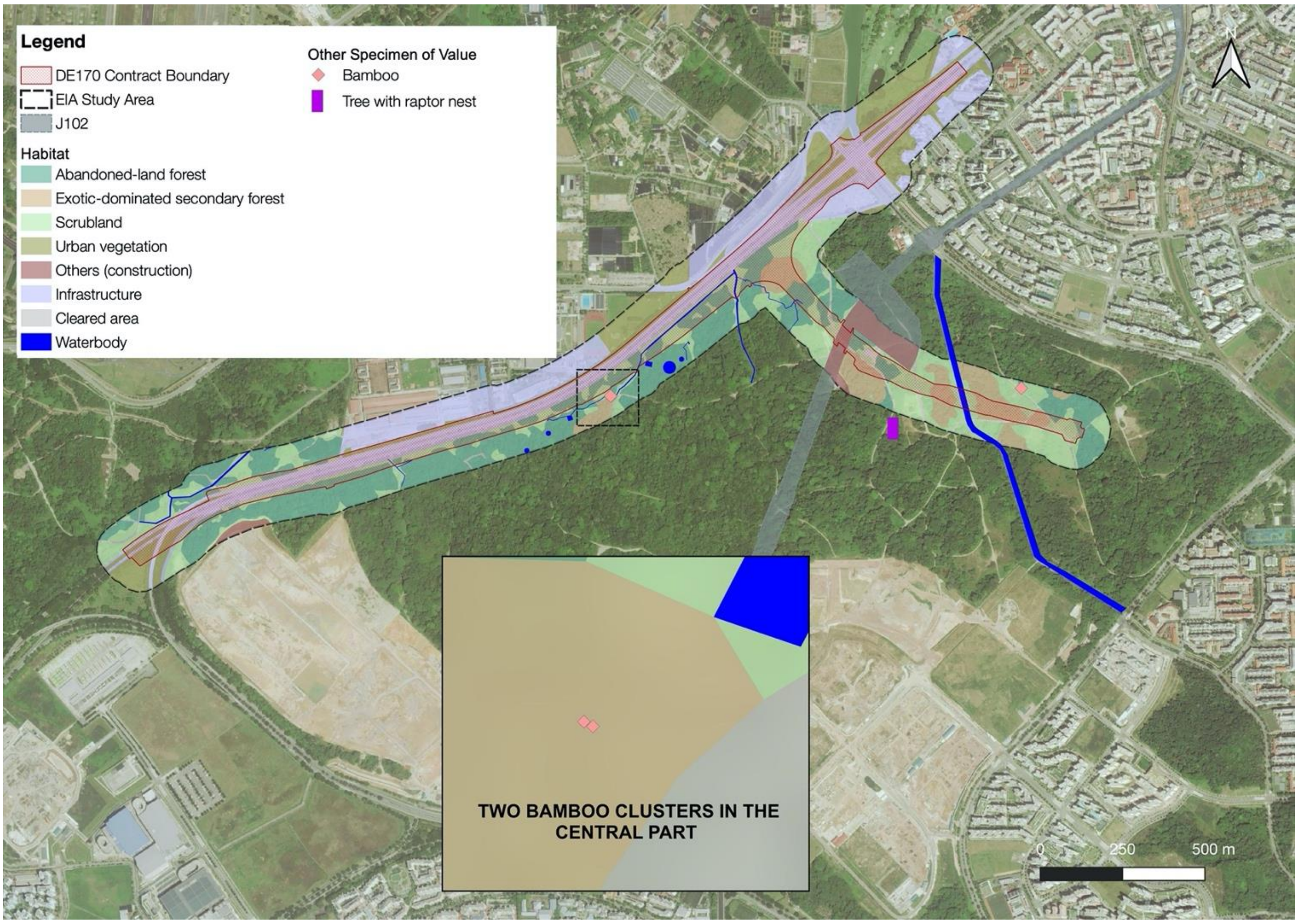


Figure 6-20: Location of Other Specimens of Value in the EIA Study Area

Source: ESRI

6.2.4.2.5 Vegetation Sampling Plots

a) Taxon Sampling Curve

A coverage-based rarefaction curve was plotted using data from the vegetation plots in EIA Study Area (**Figure 6-21**). The sampling coverage was 88.5%, which refers to the proportion of the total number of species in the community belong to those represented in the vegetation plots (Chao & Jost, 2012). Upon extrapolation, i.e., sample size was theoretically doubled using the statistical programme, the sample coverage was increased to 95.5% and species richness was increased to 150.20 (the 95% confidence interval is between 131.48 and 168.93). This implies that even with increased survey effort (vegetation plot sampling), a portion of plant species in the community, i.e., around 4.5%, will remain undetected in the vegetation plots.

The Chao estimator was used to predict the total number of species in the species pool of the EIA Study Area. Using the 'ChaoRichness' function in the iNEXT 2.0.20 package in R (R Development Core Team, 2016), the total species richness of the entire EIA Study Area was estimated to be 169.09 ± 19.07 (standard error). The 95% confidence interval is between 143.74 and 222.72.

The total species richness recorded in this EIA Study Area is 216 (see **Section 6.2.4.2.2**). This figure exceeded the total number of species predicted using the Chao estimator. This is likely because the species that was undetected or absent in the vegetation plots were documented during the general floristic surveys. Therefore, the combined survey effort of general floristic surveys and vegetation plot sampling were enough in documenting the floristic composition in the EIA Study Area.

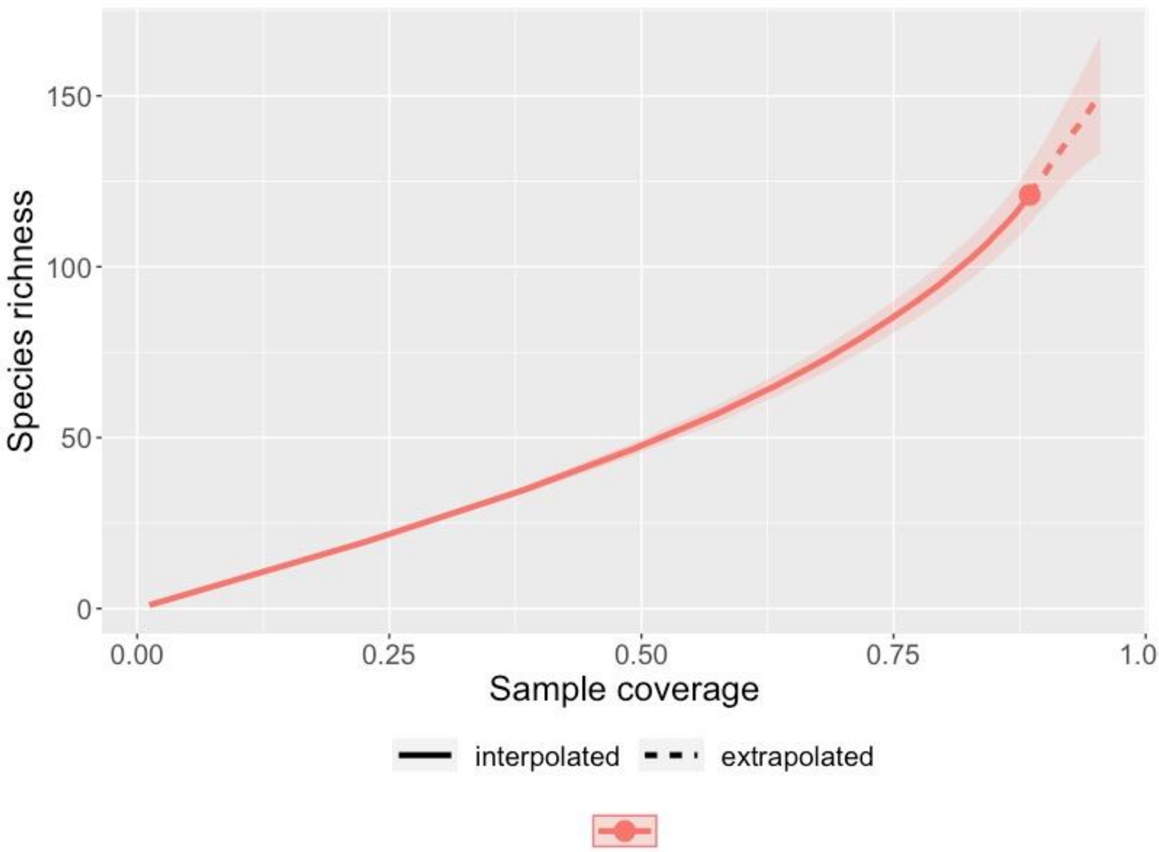


Figure 6-21: Coverage-based Sampling Curve using Data from Fifteen 20 × 20 m Vegetation Plots

b) Non-metric Dimensional Scaling (NMDS)

The NMDS ordination showed that vegetation plots representing abandoned-land forest and exotic-dominated secondary forest were floristically dissimilar to scrubland. Results of the PERMANOVA using Bray–Curtis distance as a measure of dissimilarity indicates that the floristic composition were statistically different (pseudo-F = 2.2326; p-value = 0.005) (**Table 6-9**).

Scrubland was the most species-poor compared to the other two vegetation types. Within this vegetation type, majority of the flora species were made up of exotic species, with a lesser percentage of native species. However, there were also several species of conservation significance found within this habitat type and still possess importance to several fauna species. This includes the nationally Vulnerable *Glochidion zeylanicum* var. *zeylanicum*, which is also a host plant to the rare fauna species Malay staff sergeant (*Athyma reta moorei*). Furthermore, this habitat could also provide a connectivity for other fauna species to travel across the other habitat types, thus holding some value for conservation.

The remaining two habitat types, abandoned-land forest and exotic-dominated secondary forest show some similarities in floristic composition to each other, as seen from the overlapping polygons in the NMDS ordination (**Figure 6-22**). This is rather expected as some of the exotic-dominated secondary forest were found just adjacent to the abandoned-land forest. Some of the seedlings found within the abandoned-land forest may disperse into the exotic-dominated secondary forest area. Given that there were higher percentage of native species found within the EIA Study Area, it could be possible for the forest to regenerate and succeed over exotic species as seedling recruitment takes place overtime if left undisturbed. Considering that majority of the spontaneous vegetation currently found in Singapore are secondary forest (Yee et al., 2011), these forest patches could provide some refugia for the forest-dependent fauna away from the larger urbanised landscape present.

Table 6-9: Results of the Permutational Multivariate Analysis of Variance (PERMANOVA) Comparing Floristic Composition among Habitat Types

Terms	*df*	pseudo-*F*	R^2	*p*-value
Habitat	2	2.2326	0.28872	0.005
Residuals	11	–	0.71128	–

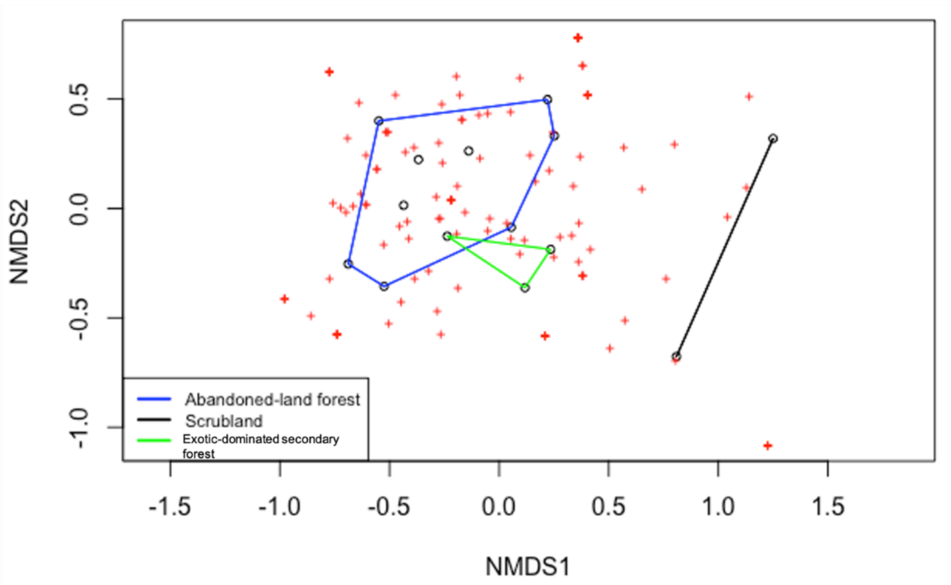


Figure 6-22: NMDS Ordination of 15 Vegetation Plots

6.2.4.3 Faunistic Baseline Results

6.2.4.3.1 Overall Faunistic Findings

The field assessment recorded 295 species, comprising of 40 aculeata, 36 odonate, 65 butterfly, 13 amphibian, 18 reptile, 86 bird, 10 non-volant mammal, 6 bat, 15 fish, 4 mollusc, and 2 decapod species (**Table 6-10**).

Camera traps CT01–CT10 accumulated a total of 656 trap-nights. Data from three camera traps CT11, CT12 and CT13 from previous EIS were also included in this report; they accumulated 143 trap-nights. Across all 13 camera traps, 24 species were recorded, including 13 birds, 8 mammals and 3 reptiles.

The list of recorded species is in **Appendix 6E**. The faunal survey and camera trap data are provided in **Appendix 6F** and **Appendix 6G**, respectively.

Table 6-10: Summary of Recorded Faunal Species

Faunal Group	No. of Recorded Species	
	All Species	CS Species
Aculeata	40	0
Odonates	36	2
Dragonflies	26	0
Damselflies	10	2
Butterflies	65	4
Freshwater Decapod Crustaceans	2	0
Freshwater Fish	15	0
Freshwater Mollusc	4	0
Herpetofauna	31	1
Amphibians	13	0
Reptiles	18	1
Birds	86	11
Mammals	16	4
Non-volant Mammals	10	3
Bats	6	1
Total	295	22

Note: 'CS species' refers to species of conservation significance.

6.2.4.3.2 Species of Conservation Significance

Of the 295 species recorded, 22 species are of conservation significance (CS). This includes 2 odonate, 4 butterfly, 1 reptile, 11 birds, 3 non-volant mammals and 1 bat (**Table 6-11; Figure 6-23**). While not of conservation significance, a noteworthy observation of the *Parischnogaster unicuspata* wasp, possibly the first record for Singapore, was documented (**Section 6.2.4.3.4**).

Species of CS were distributed across the EIA Study Area, with higher observations noted in the central and eastern of the EIA Study Area (**Figure 6-23**). They are discussed further in the subsequent sections.

Table 6-11: List of Faunal Species of Conservation Significance Recorded within the EIA Study Area

Taxon	Scientific name	Common name	Global status	National status	Documented on	
					Survey	Camera Trap
Odonate	*Archibasis melanocyana*	Blue-nosed sprite	Not Assessed	Endangered	Yes	No
Odonate	*Copera vittata*	Variable featherlegs	Least Concern	Vulnerable	Yes	No
Butterfly	*Astictopterus jama jama*	Forest hopper	Not Assessed	Nationally Extinct (Rediscovered)	Yes	No
Butterfly	*Potanthus trachala tytleri*	Detached dart	Not Assessed	Nationally Extinct (Rediscovered)	Yes	No
Butterfly	*Troides helena cerberus*	Common birdwing	Not Assessed; CITES protected (Appendix II)	Vulnerable	Yes	No
Butterfly	*Taxila haquinus haquinus*	Harlequin	Not Assessed	Endangered	Yes	No
Reptile	*Cuora amboinensis*	Malayan box terrapin	Endangered; CITES protected (Appendix II)	Near Threatened	Yes	No
Bird	*Alcedo meninting*	Blue-eared kingfisher	Least Concern	Critically Endangered	Yes	No
Bird	*Chrysococcyx xanthorhynchus*	Violet cuckoo	Least Concern	Endangered	Yes	No
Bird	*Nisaetus cirrhatus*	Changeable hawk-eagle	Least Concern; CITES protected (Appendix II)	Endangered	Yes	No
Bird	*Pycnonotus zeylanicus*	Straw-headed bulbul	Critically Endangered; CITES protected (Appendix II)	Endangered	Yes	No
Bird	*Actitis hypoleucos*	Common sandpiper	Least Concern	Vulnerable	Yes	No

Taxon	Scientific name	Common name	Global status	National status	Documented on	
					Survey	Camera Trap
Bird	*Collocalia affinis*	Plume-toed swiftlet	Least Concern	Vulnerable	Yes	No
Bird	*Ketupa ketupu*	Buffy fish owl	Least Concern	Vulnerable	Yes	No
Bird	*Lanius cristatus*	Brown shrike	Least Concern	Vulnerable	Yes	No
Bird	*Ploceus philippinus*	Baya weaver	Least Concern	Vulnerable	Yes	No
Bird	*Psittacula longicauda*	Long-tailed parakeet	Vulnerable	Near-threatened	Yes	No
Bird	*Zosterops simplex*	Swinhoe's white-eye	Least Concern	Vulnerable	Yes	No
Non-volant mammals	*Prionailurus bengalensis*	Leopard cat	Least Concern; CITES protected (Appendix I)	Critically Endangered	No	Yes
Non-volant mammals	*Manis javanica*	Sunda pangolin	Critically Endangered; CITES protected (Appendix I)	Critically Endangered	No	Yes
Non-volant mammals	*Lutrogale perspicillata*	Smooth otter	Vulnerable; CITES protected (Appendix I)	Endangered	No	Yes
Bat	*Tylonycteris* sp.	Bamboo bat	Least Concern	Vulnerable	Yes	No

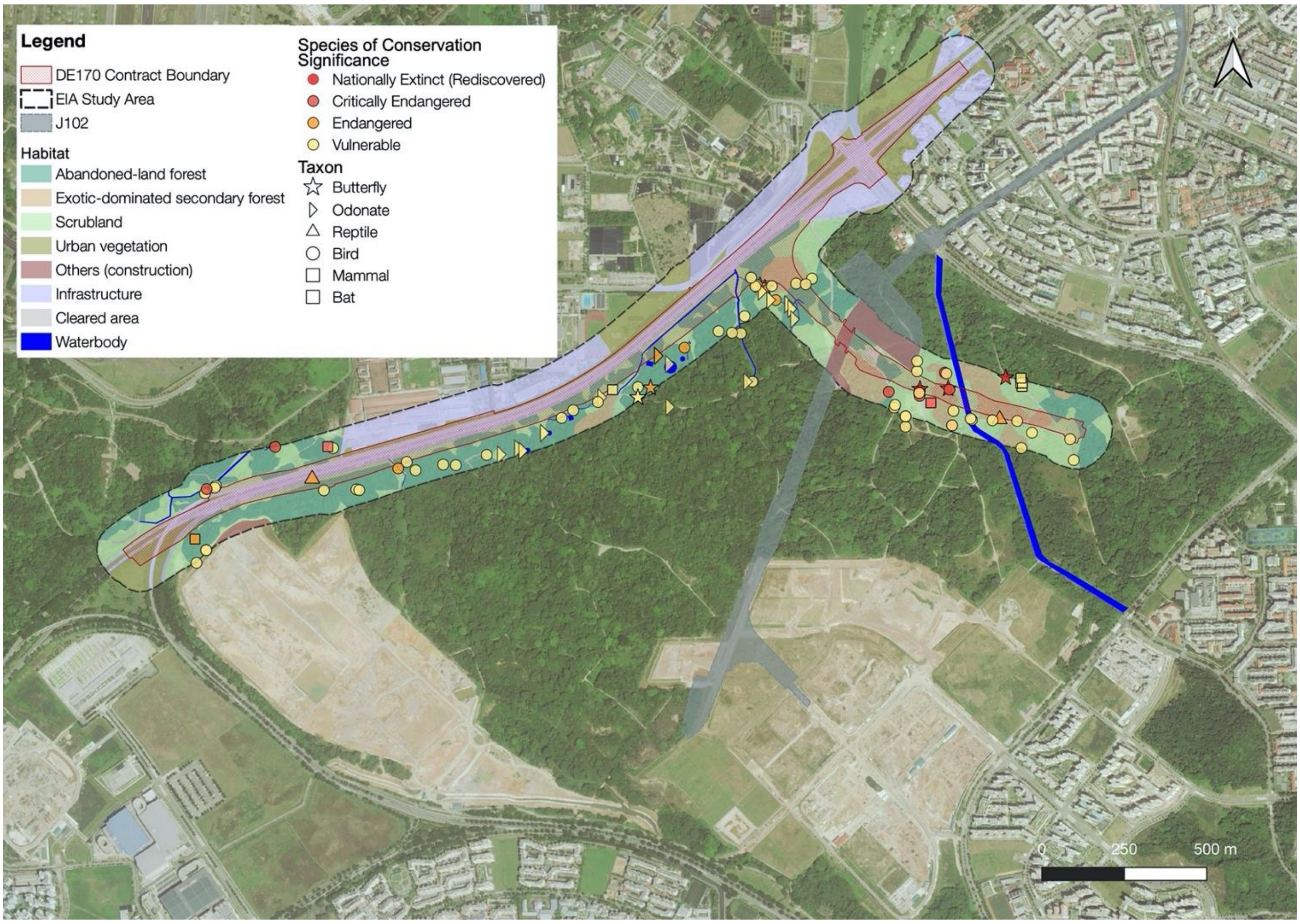


Figure 6-23: Location of All Faunal Species of Conservation Significance (CS) within the EIA Study Area
Source: ESRI

6.2.4.3.3 Taxon Sampling Curve

For transect surveys, sample coverage was generated for the following target taxa: 1) Aculeata 2) odonata, 3) butterfly, 4) amphibian, 5) reptile, 6) bird and 7) mammal (including bats). For camera trapping, sample coverage was generated for mammals only. For aquatic sampling, sample coverage was generated for the following taxa: 1) amphibian, 2) fish, 3) odonata, 4) reptile. Sample coverage was not generated for roost emergence and molluscs were also excluded from aquatic sampling due to its small sample size. Since the taxon sampling curve analysis only considers targeted transect or point count data (i.e., incidental records were removed from analysis) (see **Section 6.2.3.3.4**), the observed richness stated in **Table 6-12** may differ from that stated in **Table 6-10**.

Almost all faunal groups achieved a sample coverage of above 90% for transect surveys and camera trapping, except for aculeata and butterfly at 78.4% and 88.6% respectively for transect surveys. For aquatic sampling, sample coverage was above 90% across all faunal groups except for reptiles at 59.0% (**Table 6-12; Figure 6-24**). With the observed richness obtained via sampling, the estimated richness for each taxon was derived for the EIA Study Area per sampling method.

Table 6-12: Result Summary of Taxon Sampling Analysis

Faunal Group	Sample Coverage (%)	Observed Richness	Estimated Richness (± S.E.)	95% Confidence Interval
Transect Surveys				
Aculeata	78.4%	39	65.75 ± 15.89	48.11 – 117.58
Odonata	91.3%	31	65.94 ± 32.44	38.4 – 194.85
Butterfly	88.6%	60	85.41 ± 13.95	69.35 – 129.03
Amphibian	97.4%	12	14.91 ± 4.39	12.34 - 36.63
Reptile	95.2%	7	7.97 ± 2.18	7.07 – 20.43
Bird	96.5%	67	91.85 ± 17.40	74.21 – 152.69
Mammal (including bats)	100.0%	8	8.00 ± 0.40	8.00 – 9.00
Camera Trapping				
Mammals	93.9%	8	10.77 ± 4.14	8.33 – 31.16
Aquatic Sampling				
Amphibian	93.9%	8	12.35 ± 6.96	8.48 - 47.63
Fish	97.2%	15	17.18 ± 3.29	15.26 - 33.48
Odonata	94.9%	22	34.08 ± 16.58	23.61 - 112.79
Reptile	59.0%	7	16.67 ± 9.77	8.87 - 57.09

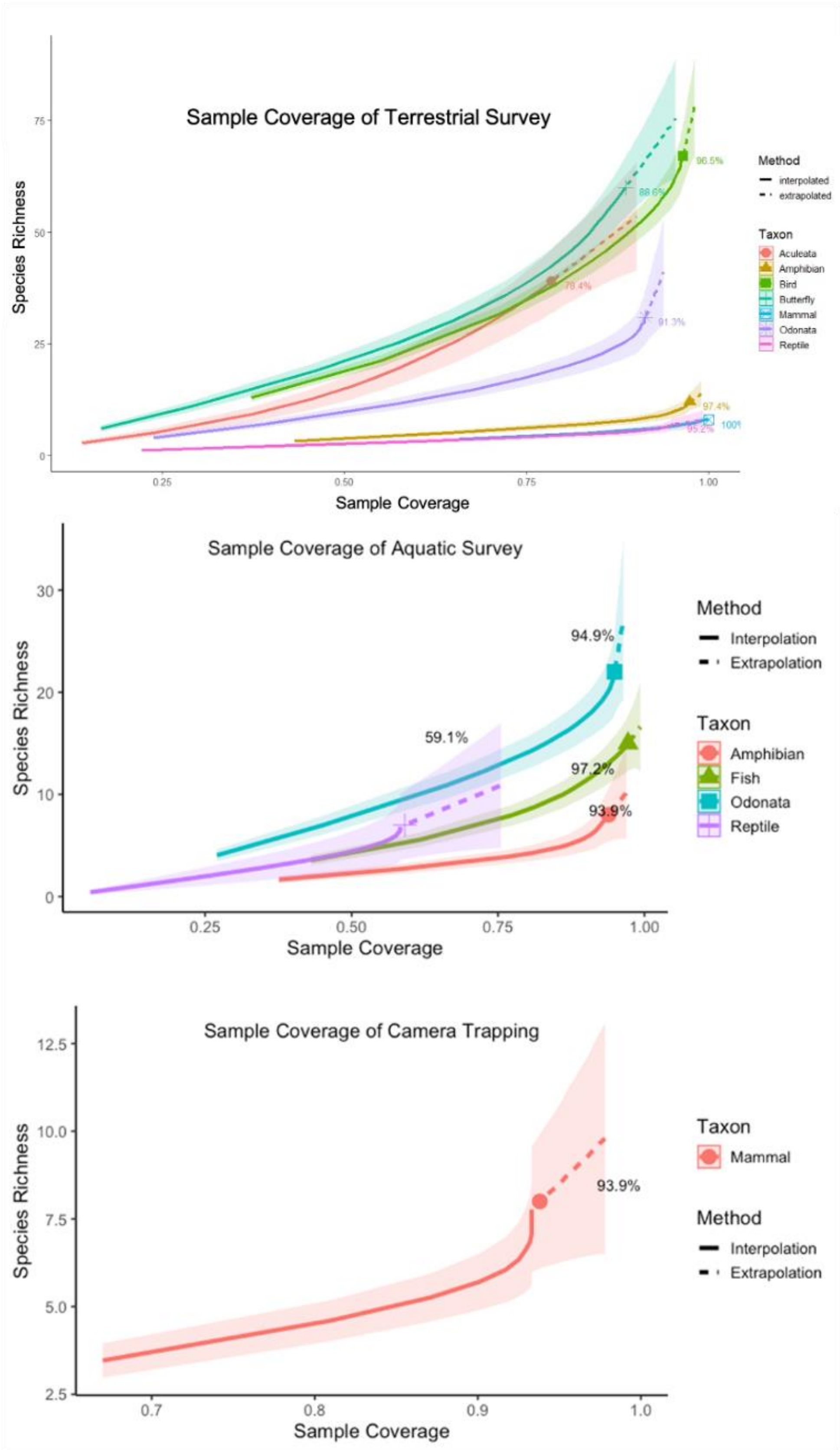


Figure 6-24: Sample Coverage Curves for Each Taxon for Terrestrial and Aquatic Surveys, and Camera Trapping

6.2.4.3.4 Aculeata

A total of 40 aculeata species were recorded. Although no species of conservation significance was recorded, a noteworthy observation was documented. The *Parischnogaster unicuspata* wasp may be a first record for Singapore and was seen on an oil palm beside a waterbody (Stream A13) in the central part of the EIA Study Area. The conservation status of this species is unclear due to data deficiency, but it is highly likely to be of conservation status given its rarity (Lee JXQ, pers comm).

6.2.4.3.5 Odonata

The survey recorded a total of 36 odonate species, with 26 dragonfly and 10 damselfly species, of which two damselfly species are of conservation significance. Most of these species and widespread and common (78%).

The variable featherlegs (*Copera vittata*), and blue-nosed sprite (*Archibasis melanocyana*) (**Figure 6-25**) are nationally Vulnerable and Endangered respectively. The variable featherlegs (*C. vittata*) inhabits sluggish channels and shallow pools in swampy forests (Tang et al., 2010) and both records were north of the EIA Study Area where their occurrences were concentrated at stream A1 (**Figure 6-26**) which is a closed-canopy forest stream. The variable featherlegs is known to occur in the neighbouring Tengah Town, which is in close proximity to the EIA Study Area. The blue-nosed sprite (*A. melanocyana*) is often associated with forest swamps (MyBIS, 2022) and locally restricted to nature reserves (Tang et al., 2010) and therefore was not expected in the EIA Study Area. The occurrence of the blue-nosed sprite (*A. melanocyana*) was specifically recorded within the abandoned-land forest between ponds A5 and A6 (**Figure 6-26**). This area is low-lying and is characterised by muddy substrates, which is occasionally swampy when waterlogged conditions are formed after heavy rain. Apart from a single specimen collected from National University of Singapore at Kent Ridge, the blue-nosed sprite has not been recorded outside of the Central Catchment Nature Reserves (CCNR) (Robin Ngiam, pers. comm, 2022) and this record represents a new locality for this species. Since damselflies are weak fliers, it is likely resident to the EIA Study Area. Therefore, the habitat in the EIA Study Area is likely important to this species. A few other widespread but uncommon dragonfly species were also recorded on site such as the spear-tailed and dingy duskhawker (*Gynacantha* sp.), scarlet adjudant (*Aethriamanta brevipennis*) (**Figure 6-25**) and sapphire flutterer (*Rhyothemis triangularis*).

Figure 6-25: Damselfly species of conservation significance observed. A) Variable featherleg (*Copera vittata*), B) Blue-nosed sprite (*Archibasis melanocyana*) and some uncommon dragonfly C) Scarlet adjudant (*Aethriamanta brevipennis*), D) Dingy duskhawker (*Gynacantha subinterrupta*)

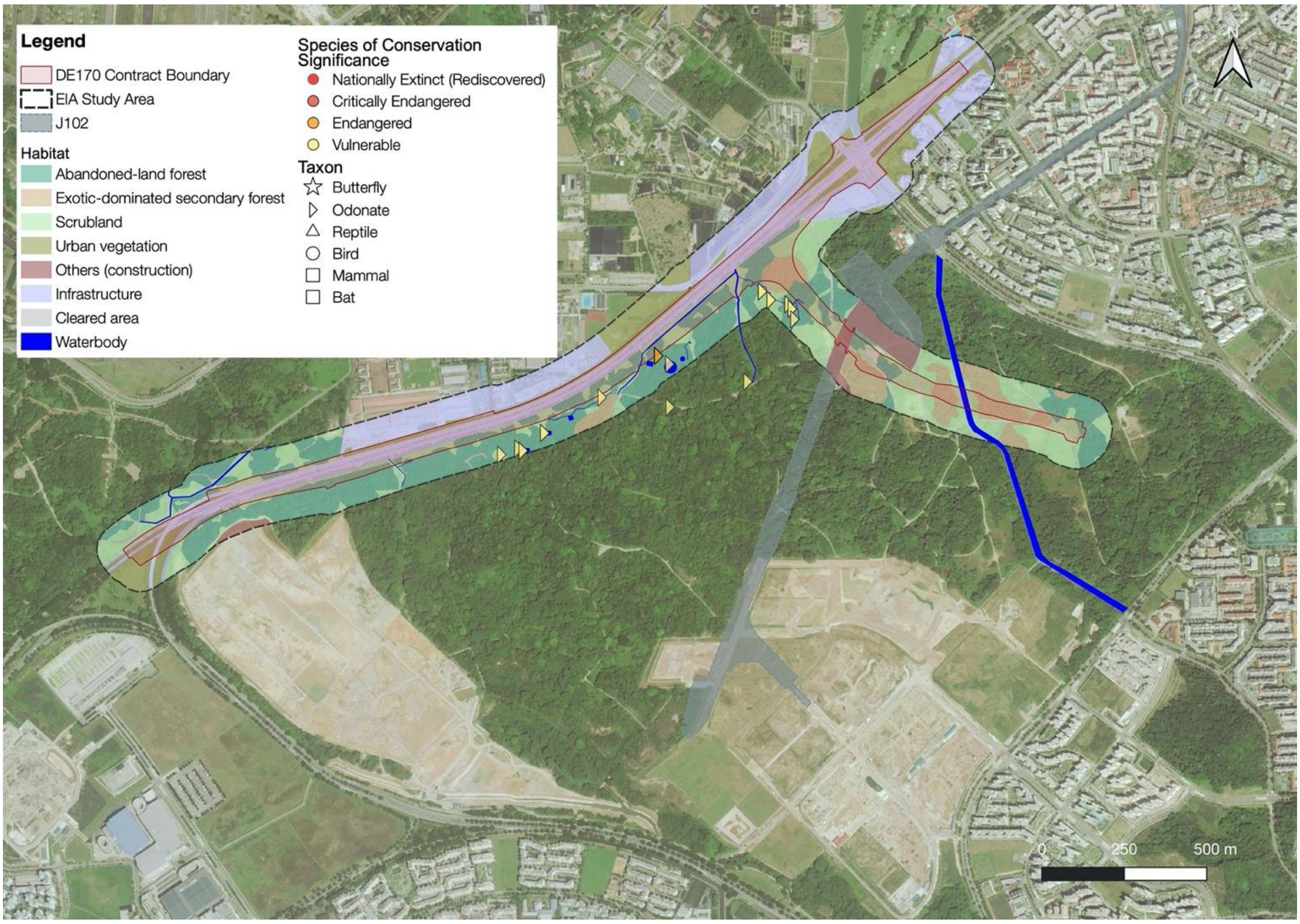


Figure 6-26: Location of Odonate Species of Conservation Significance
Source: ESRI

6.2.4.3.6 Butterflies

A total of 65 butterfly species were recorded and most were common or moderately common (80.30%). Four CS butterflies were found on in the EIA Study Area including the nationally Endangered harlequin (*Taxila haquinus haquinus*), the nationally Vulnerable common birdwing (*Troides helena Cerberus*), the Nationally Extinct and Rediscovered forest hopper (*Astictopterus jama jama)* and the Nationally Extinct and Rediscovered detached dart (*Potanthus trachala tytleri*) (**Figure 6-28**).

The most significant finding is the butterfly, harlequin (*T. haquinus haquinus*) (**Figure 6-27**), a strict forest specialist which has been known only from Cleantech Park on mainland Singapore (Khew, 2007), a site slated for future development (URA, 2019). Despite its known locality being southwest to the EIA Study Area, these butterflies are known to not venture far (Khew, 2007) and were not captured in the previous EIS. Similar to the CS odonates, the three harlequin sightings in the EIA Study Area were concentrated at the northern region (**Figure 6-29**). Two of the sightings were near stream A1, where its host plant, *Ardisia elliptica*, were observed (**Figure 6-29**). This species is not known to be associated with streams. Given the nature of this butterfly species, it is likely that this patch of forest in Tengah is a key habitat for the harlequins (*T. haquinus haquinus*). The nationally Extinct forest hopper (*A. jama jama*) (**Figure 6-27**) was rediscovered in 2014 (Jain et al.). It was spotted in a grass field east of the survey site which is not surprising given that it is predominantly a grassland species (Khew, 2010). The detached dart (*P. trachala tytleri*) is listed as Nationally Extinct in Davison et al. (2008) but has since been rediscovered (Jain et al., 2018), although it remains moderately rare. Its host plants, the Lalang (*Imperata cylindrica*), a common grass species, was observed in the eastern part of the EIA Study Area. The nationally Vulnerable common birdwing (*T. helena cerberus*) is now listed as moderately common (Khew, 2018) and can be found in urban parks and gardens where their host plants *Aristolochia* spp. is planted. It was observed once in the central part of the EIA Study Area. This species was also observed in the previous EIS.

Figure 6-27. Endangered A) Harlequin butterfly (*Taxila haquinus haquinus*) and B) Nationally Extinct and Rediscovered forest hopper (*Astictopterus jama jama*) found in Northern Tengah

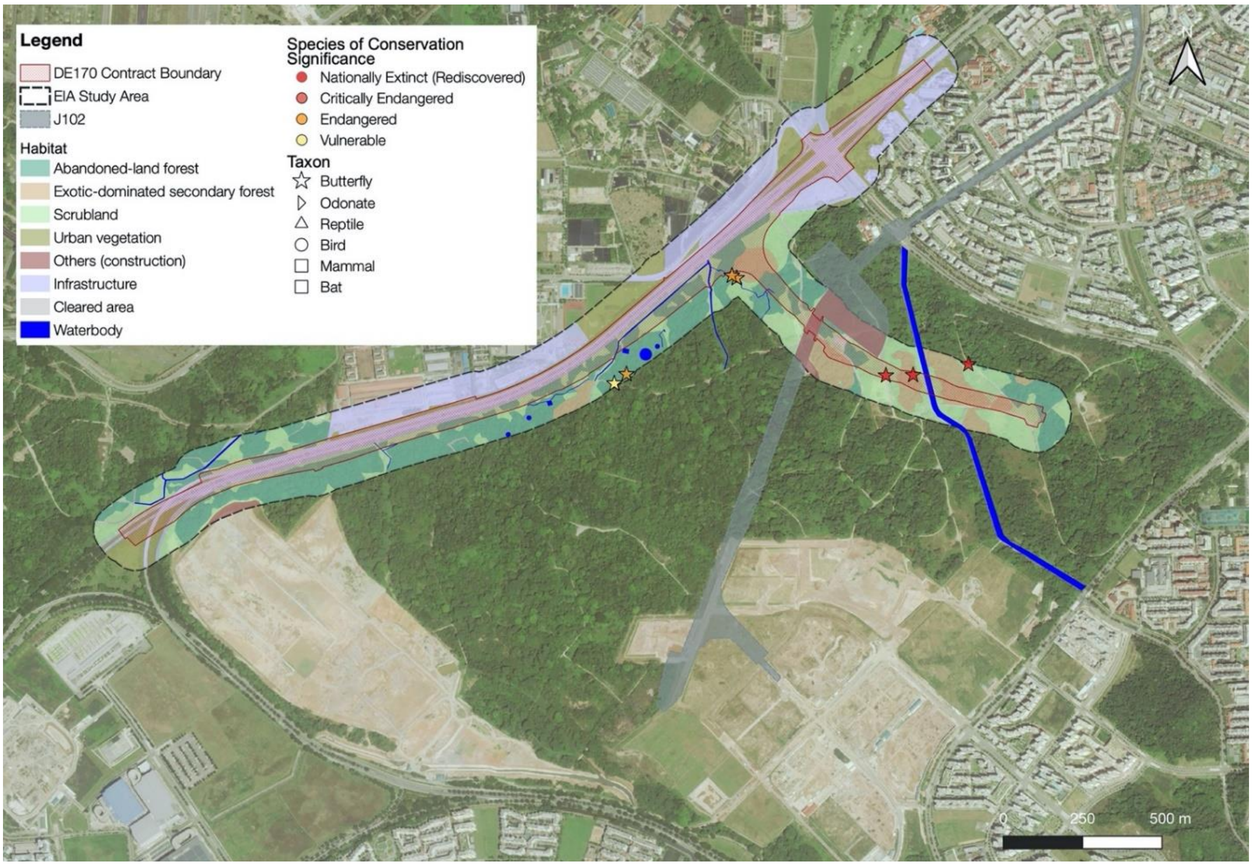


Figure 6-28: Location of Butterfly Species of Conservation Significance

Source: ESRI

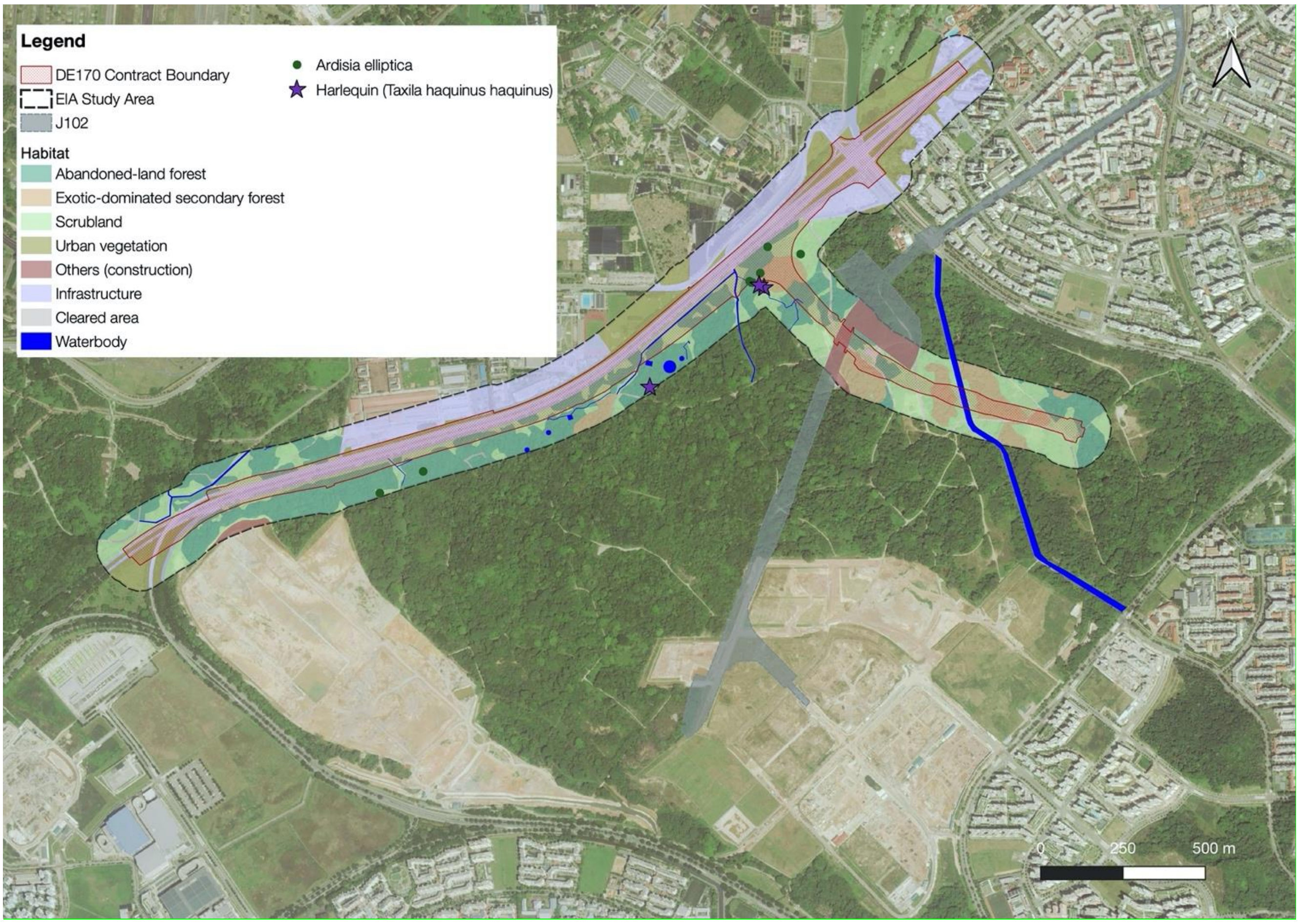


Figure 6-29: Location of the Butterfly, Harlequin (*Taxila haquinus haquinus*) and Its Host Plant, *Ardisia elliptica*
Source: ESRI

6.2.4.3.7 Amphibians

A total of 13 amphibian species were recorded with 12 frogs and one toad and of these, nine are native species. All of these species are widespread and common, except for the non-native restricted and rare East Asian ornate chorus frog (*Microhyla mukhlesuri*), and the widespread but uncommon Guenther's frog (*Sylvirana guentheri*), as well as the native copper-cheeked frog (*Chalcorana labialis*) which is restricted but common. Two other non-native frogs are the greenhouse frog (*Eleutherodactylus planirostris*) and banded bull frog (*Kaloula pulchra*), both of which are highly tolerant of disturbance and often found near human habitation (Baker & Lim, 2012). The EIA Study Area provides habitats for forest-dependent species, such as the copper-cheeked frog (*C. labialis*) and Malayan giant frog (*Limnonectes blythii*). Both species are known to prefer forest streams with flowing water (Baker & Lim, 2012), a habitat present at the EIA Study Area. While the copper-cheeked frog (*C. labialis*) was only seen once during a night survey at pond A4 in the northern part, the Malayan giant frog (*L. blythii*) was a common sight at the forest streams and pond. The presence of these forest-dependent species may point to the value of the site (forest and waterbodies) in supporting these populations locally. Tadpoles belonging to *Microhyla* sp. were also frequently encountered in ephemeral puddles at the site, therefore they are likely reproducing in the area, although we are unable to confirm the species.

6.2.4.3.8 Reptiles

A total of 18 reptilian species was recorded, including one CS reptile, i.e., the Malayan box terrapin (*Cuora amboinensis*) (**Figure 6-31**). Of all the species recorded, four are non-native, including the changeable lizard (*Calotes versicolor*), striped keelback (*Xenochrophis vittatus*) (**Figure 6-30**), red-eared slider (*Trachemys scripta*) and giant Asian pond turtle (*Heosemys grandis*). Most species recorded are widespread and common except the green crested lizard (*Bronchocela cristatella*) which is widespread but uncommon, the widespread but rare common Malayan racer (*Coelognathus flavolineatus*) and the restricted but common clouded monitor (*Varanus nebulosus*).

The Malayan box terrapin *(C. amboinensis)* was encountered twice in this study, once in both the western and eastern region (**Figure 6-32**). It is a globally Endangered species which is locally considered restricted but common, and a large proportion of the population may be released individuals (Baker & Lim, 2012). It is uncertain if the individual recorded in this assessment, was a released individual. Nevertheless, the waterbodies in the EIA Study Area serve as important habitats for this species. While a soft-shell turtle was observed during survey at stream A10, we were unable to confirm its species due to the short encounter and therefore unable to verify if it is of CS status.

The native species encountered here including the Sumatran flying dragon (*Draco sumatranus*) and reticulated python (*Malayopython reticulatus*) are generally tolerant of urban and manmade habitats. (Baker and Lim, 2012).

Figure 6-30: Snakes recorded during faunal field assessment A) Oriental whip snake (*Ahaetulla prasina*), B) striped kukri (*Oligodon octolineatus*), C) striped keelback (*Xenochrophis vittatus*), D) painted bronzeback (*Dendralaphis pictus)*

Figure 6-31: Non-marine turtle observed during field assessment including the A) Giant Asian pond turtle (*Heosemys grandis*) and CS species B) Malayan box turtle (*Cuora ambionensis*)

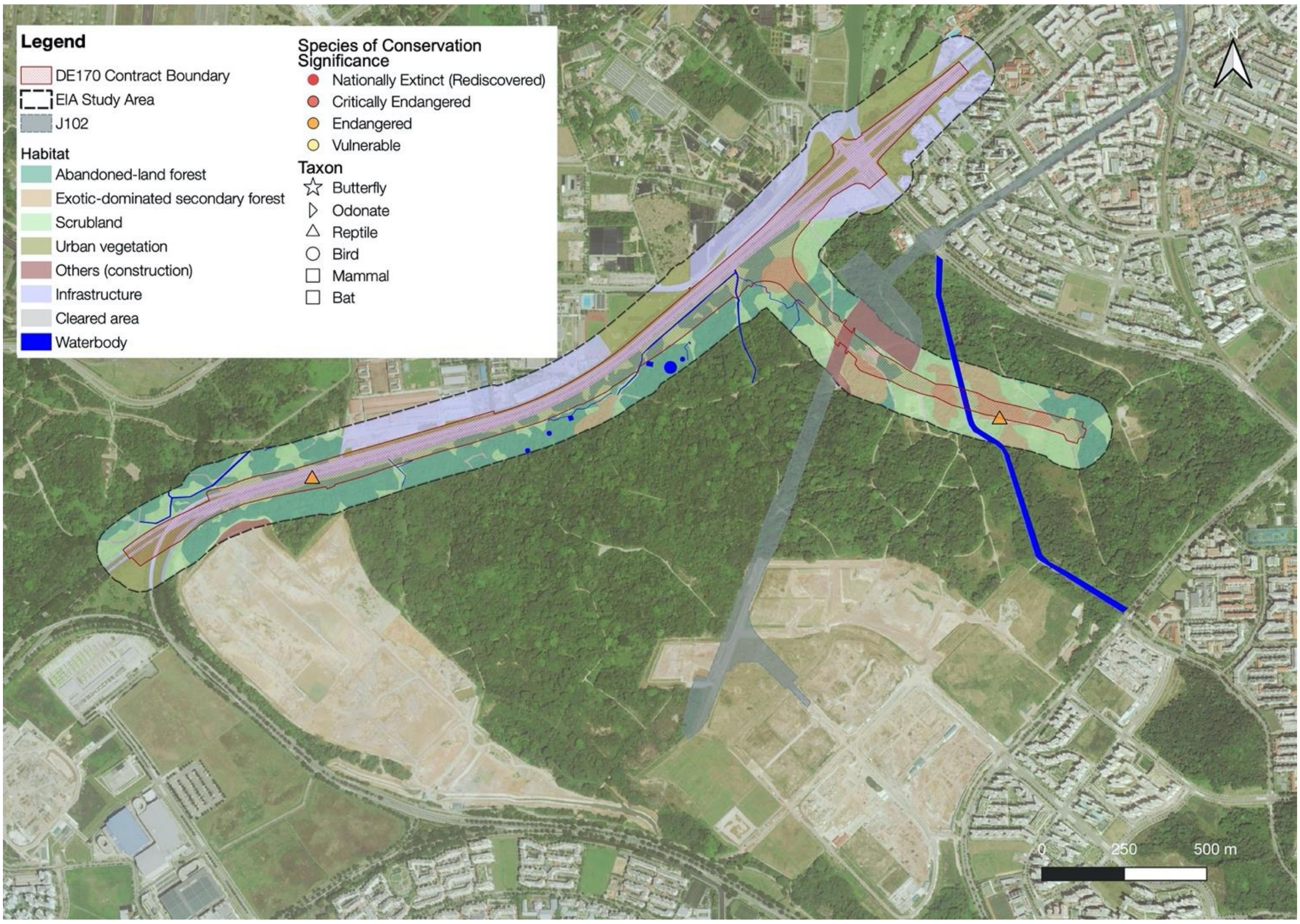


Figure 6-32: Location of Reptilian Species of Conservation Significance
Source: ESRI

6.2.4.3.9 Birds

A total of 86 bird species were recorded, with 11 CS bird species recorded during field assessment. Of this, 61 are resident breeders, 11 are introduced with 10 being introduced resident breeders, 12 are winter visitors and 1 is a migrant breeder. One species, *Aerodramus* sp., was not identified to species level, hence not accorded a native status. CS birds were well distributed all across the EIA Study Area (**Figure 6-34**).

The recorded species of conservation significance include the nationally Endangered straw-headed bulbul (*Pycnonotus zeylanicus) and* blue-eared kingfisher (*Alcedo meninting*), as well as the nationally Vulnerable changeable hawk-eagle (*Nisaetus cirrhatus)*, violet cuckoo (*Chrysococcyx xanthorhynchus*), baya weaver (*Ploceus philippinus*), common sandpiper (*Actitis hypoleucos*), Swinhoe's white-eye (*Zosterops simplex*), plume-toed swiftlet (*Collocalia affinis*), buffy fish owl (*Ketupa ketupu*) and brown shrike (*Lanius cristatus*).

The blue-eared kingfisher (*A. meninting*) (**Figure 6-33**) was recorded at three closed-canopy and open-country streams across the EIA Study Area (A1, A10 and A13), suggesting that it may be utilising the entire EIA Study Area. This species prefers forested habitats near streams. It was seen once skimming the surface of the water at stream A1 in the northern part. On another occasion, a juvenile was seen resting on a branch in the stream A13 in the central part. This species is known to nest in burrows of streams, including excavated banks or sides of contour drain (Robson, 2000; BESG, 2009; Palkar, 2016). Although nesting was not observed during the field assessment, the banks of stream A1 may be a potential nesting site for this species.

The Straw-headed Bulbul which is threatened by songbird trade and loss of forest habitats. Its global conservation status was uplisted from endangered to critically endangered as populations experience rapid decline (BirdLife International, 2022a). According to Yong et al. (2017), the estimated population size in Singapore is slightly over 200 birds, possibly making up one-third of the global population (Neo, 2016). This species experiences low poaching pressure in Singapore, thus showing a stable trend on the main island of Singapore and a slightly increasing trend on Pulau Ubin. Although the straw-headed bulbul (*P. zeylanicus*) appears to have a stable population in Singapore, it is regarded as globally Critically Endangered and habitat loss to development remains a primary threat to this species locally. There were five records of the straw-headed bulbul (*P. zeylanicus*) during the field assessment mainly at the eastern part of the EIA Study Area, within the exotic-dominated secondary forest and abandoned-land forest.

The changeable hawk eagle (*N. cirrhatus*) was seen or heard 11 times across the EIA Study Area. It was seen twice; once in the eastern part and once in the southern part of the EIA Study Area. Another noticeable observation was the presence of a raptor nest on an albizia tree (*Falcataria falcata*) at the eastern part of the EIA Study Area (**Figure 6-33; Figure 6-34**). A changeable hawk-eagle (*N. cirrhatus)* was seen perching on the nest during survey.

The violet cuckoo (*C. xanthorhynchus*), a rare resident, was only heard once and the straw-headed bulbul (*P. zeylanicus)* was heard several times east of the EIA Study Area. The changeable hawk-eagle (*N. cirrhatus)* was both seen and heard across the EIA Study Area.

The baya weaver (*P. philippinus*) was observed once in the eastern part. An incompleted nest was also seen in the central part of the EIA Study Area, within the scrubland. The common sandpiper (*A. hypoleucos*) was seen twice in the canal in the eastern part of the EIA Study Area. This species is also commonly seen urban canals and drains across Singapore. The Swinhoe's white-eye (*Z. simplex*) was observed four times, all in the southern tip of the EIA Study Area. This species occurs in multiple habitat types including secondary forest, forest edges, parks and gardens.

The plume-toed swiftlet (*C. affinis*) was recorded once in the eastern part of the EIA Study Area. A flock of approximately 30 birds was observed flying overhead the scrubland vegetation. The buffy fish owl (*K. ketupu*) was seen once in the morning towards the southern part of the EIA Study Area. It was perched in the understorey. The brown shrike (*L. cristatus*), a migrant bird, was seen once in the scrubland vegetation in the southern tip of the EIA Study Area.

The scrubland and herbaceous vegetation patches east of the EIA Study Area adjacent to the study boundary is a key habitat for the red-wattled lapwing (*Vanellus indicus*), a species that is nationally Near Threatened. This area was previously identified to be a breeding ground for the red-wattled lapwing (*V. indicus*) during the previous EIS as juveniles were observed (**Figure 6-34**). Although juveniles were not observed during this survey, lapwings were still observed in the area. An interesting sunning behaviour was observed in the chestnut-bellied malkoha (*P. sumatranus*) (**Figure 6-33**) which is usually confined to the forest (BirdLife International, 2022b) and rarely observed in the open.

A total of 13 migratory bird species were recorded, comprising of one abundant species (i.e., barn swallow [*Hirundo rustica*]), 8 common species and 4 uncommon species. Common migrant birds include the ashy minivet (*Pericrocotus divaricatus*), blue-throated bee-eater (*Merops viridis*) and arctic warbler (*Phylloscopus borealis*). Uncommon migrant birds include the blue-winged pitta (*Pitta moluccensis*), hooded pitta (*Pitta sordida*), large hawk-cuckoo (*Hierococcyx sparverioides*) and yellow-rumped flycatcher (*Ficedula zanthopygia*).

Figure 6-33: Bird species recorded during faunal field assessment, including the A) Critically Endangered blue-eared kingfisher, B) Near Threatened Chestnut-bellied malkoha (*Phaenicophaeus sumatranus*) and a C) Raptor nest observed east of the EIA Study Area

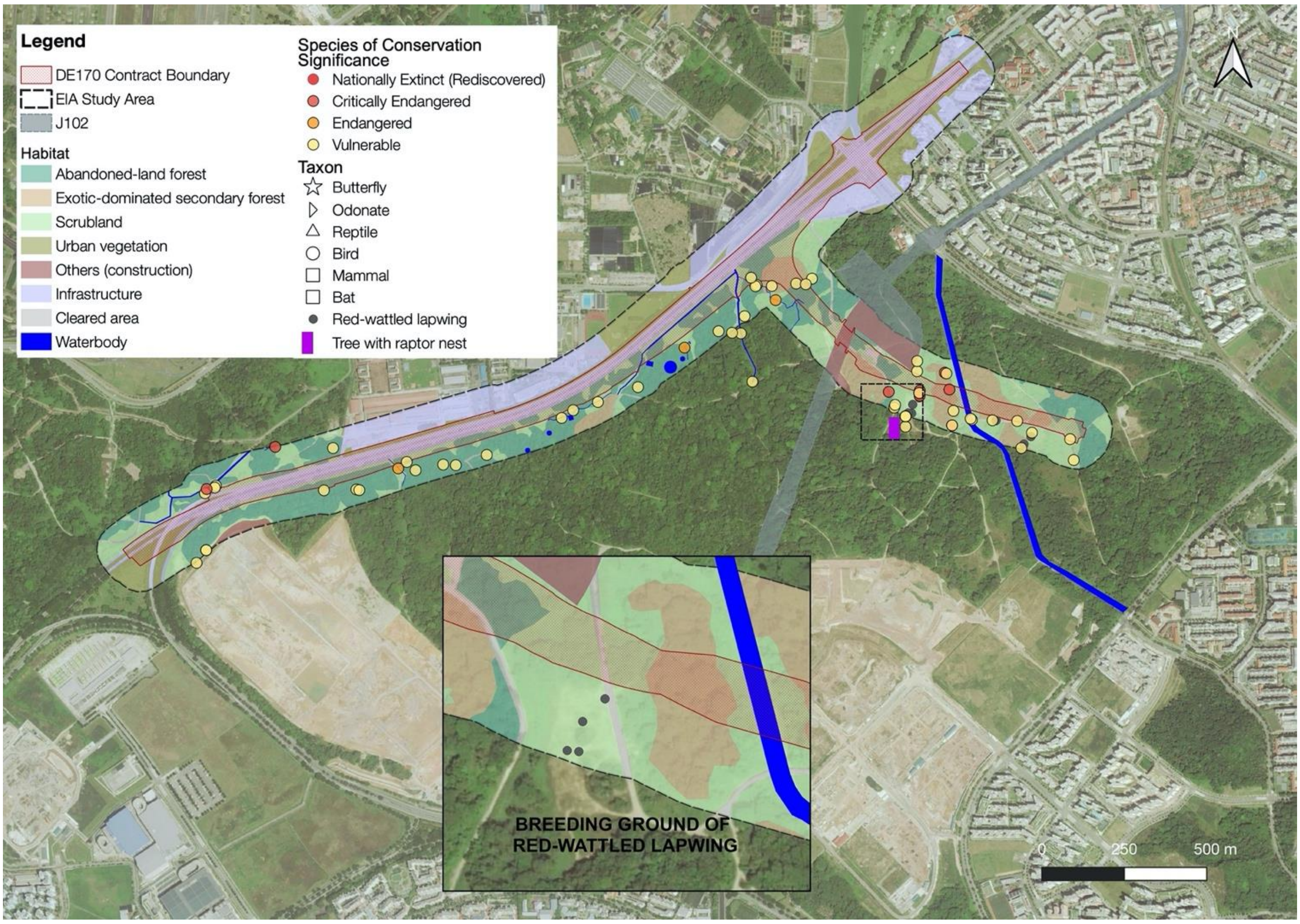


Figure 6-34: Location of Bird Species of Conservation Significance, including Breeding Ground of Red-wattled Lapwing (*Vanellus indicus*)

Source: ESRI

6.2.4.3.10 Non-volant Mammals

A total of 10 non-volant mammal species were recorded from site, with a total of three CS species recorded. They include the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*), nationally Critically Endangered leopard cat (*Prionailurus bengalensis*), and nationally Endangered smooth otter (*Lutrogale perspicillata*). All three CS species were captured only via camera traps (**Table 6-13; Figure 6-35**).

The Sunda pangolin (*M. javanica*) was recorded thrice on camera trap located east of the EIA Study Area during the previous EIA Study (CT11; **Figure 6-35**), however, no individuals were captured during this survey period. Based on the previous EIS Study, this species was also recorded several times in the southern part, which is directly connected to the EIA Study Area, hence it is highly possible that this species can be found within the western part of the EIA Study Area even though it was not detected on camera traps. This species suffers from severe population decline resulting from over-exploitation in other parts of Southeast Asia (Nash et al., 2020). Fortunately, it is relieved from such poaching pressure in Singapore due to local laws and enforcement. Notably, Singapore is a potential stronghold for the Sunda pangolin (*M. javanica*) population and is crucial in contributing to the conservation of pangolin populations globally. The Sunda pangolin has been observed in a wide range of habitat types, including secondary forest and rural sites. Yet, the presence of mature forests with large trees

(>50-cm diameter at breast height) are regarded as important as den sites for the reproduction and thus conservation of Sunda pangolins (Lim & Ng, 2007; Nash et al., 2020).

The leopard cat (*P. bengalensis*) is the last native wildcat left in Singapore. Despite being known to thrive in manmade habitats (Chua et al., 2016), massive deforestation decreased the species population to less than 20 individuals on mainland Singapore and these individuals are mainly restricted to the Western and Central Catchment Area (SWAG, 2022). The species was observed once on camera trap (Figure 6-35).

The smooth otter (*L. perspicillata*) appeared once west to the EIA Study Area unexpectedly at CT08 (Table 6-13; Figure 6-35), given that there was no suitable large waterbody in proximity. The nearest suitable habitat for the otter is north-east of its observed location, at Sungei Peng Siang River which is connected to Kranji reservoir, and the otter likely travelled along the waterway parallel to KJE westwards. It is possible that the changes in the landscape affected its navigation, especially since it was sighted adjacent to the hoarding of an active construction site.

The Eurasian wild boar is the most commonly recorded mammal on camera trap, with 857 independent detections across all camera traps. This is followed by the plantain squirrel and common treeshrew with 198 and 80 independent detections respectively. The number of independent detections for each mammalian species (excluding fauna unidentified to species level) is shown on **Table 6-14**.

Figure 6-35: A) Sunda pangolin (*Manis javanica*) captured on camera trap in the eastern part of EIA Study Area and B) Leopard cat (*Prionailurus bengalensis*), C) Smooth otter (*Lutrogale perspicillata*)

Table 6-13: Mammalian Species Recorded on Camera Traps

Species	Common Name	Species of CS	Locations
Callosciurus notatus	Plantain squirrel	No	CT02, CT03, CT04, CT05, CT06, CT07,CT09, CT10, CT11, CT12, CT13
Paradoxurus musangus	Sumatran palm civet	No	CT02, CT04, CT06, CT07, CT09, CT10 , CT11
Sus scrofa	Eurasian wild boar	No	All CT locations
Manis javanica	Sunda pangolin	Yes (Globally and Nationally Critically Endangered)	CT11
Tupaia glis	Common treeshrew	No	CT02, CT04, CT05, CT10 , CT11, CT12, CT13

Species	Common Name	Species of CS	Locations
Lutrogale perspicillata	Smooth-coated otter	Yes (Globally Vulnerable and Nationally Endangered)	CT08
Canis lupus familiaris	Feral dog	No	CT02, CT03, CT04, CT05
Prionailurus bengalensis	Leopard cat	Yes (Nationally Critically Endangered)	Undisclosed
Rattus tiomanicus	Malaysian wood rat	No	CT04, CT05, CT06, CT10

Table 6-14: Number of independent detections of mammalian species on camera traps

Species	Common Name	Number of Independent Detections Across All Camera Traps
Sus scrofa	Eurasian wild boar	857
Callosciurus notatus	Plantain squirrel	198
Tupaia glis	Common treeshrew	80
Paradoxurus musangus	Common palm civet	20
Rattus tiomanicus	Malaysian wood rat	13
Canis lupus familiaris	Feral dog	4
Manis javanica	Sunda pangolin	3
Prionailurus bengalensis	Leopard cat	1
Lutrogale perspicillata	Smooth otter	1

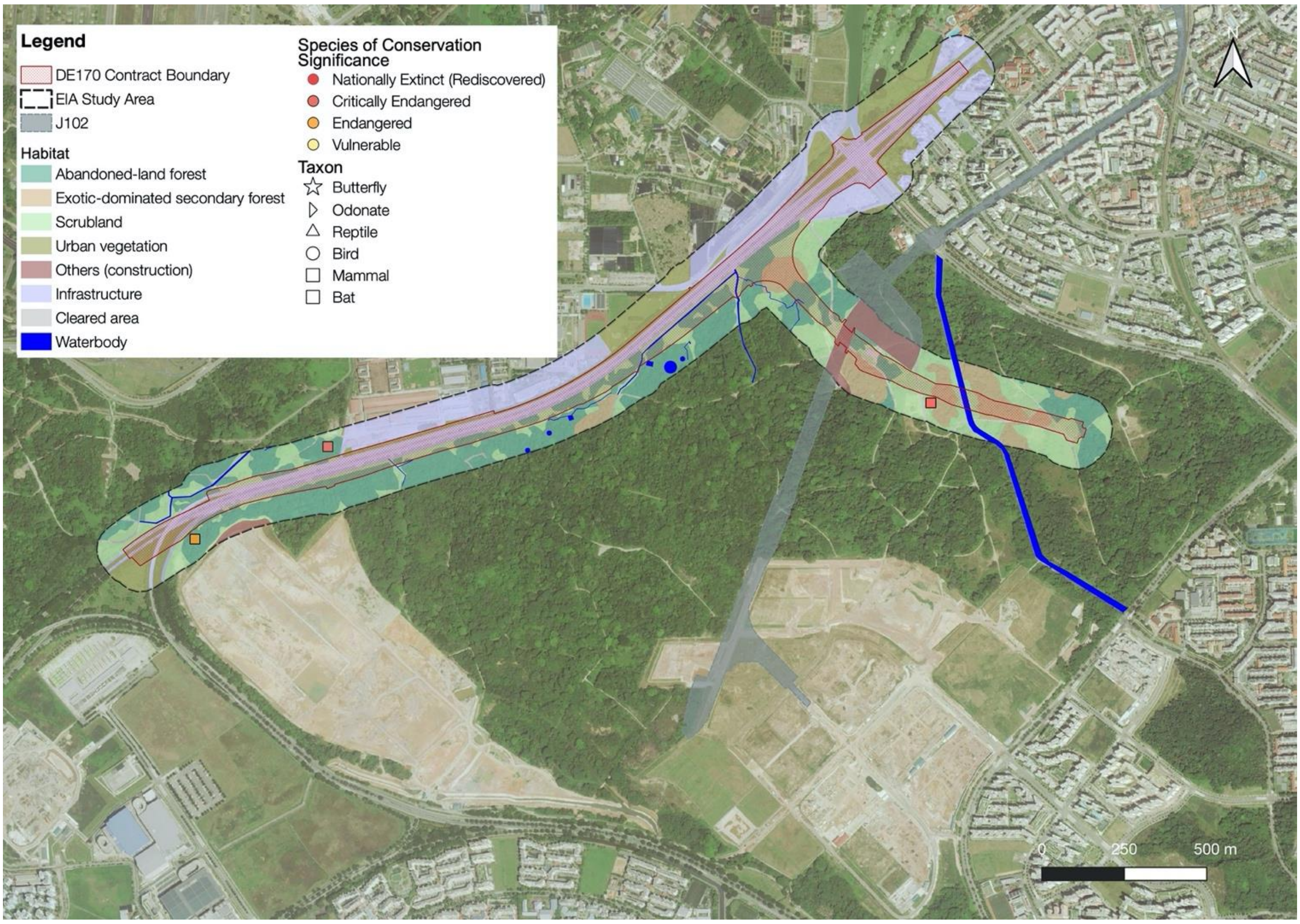


Figure 6-36: Location of Mammalian Species of Conservation Significance
Source: ESRI

6.2.4.3.11 Bats

A total of six bat species was recorded, with one CS species documented during survey, which was the nationally Vulnerable bamboo bat (*Tylonycteris* sp.). There are two bamboo bat species in Singapore. However, since the acoustic signatures of the lesser bamboo bat (*T. fulvida*) and the greater bamboo bat (*T. malayana*) overlap, it is difficult to differentiate the species based on the acoustic recordings. Nevertheless, both species are nationally Vulnerable and of conservation significance. Bamboo bats are known to roost in bamboo internodes and are especially susceptible to injury or mortality if their roosts are removed/ damaged during developments.

Of the eight bamboo clusters observed in the EIA Study Area, roosting was confirmed for one (BB_15) in the eastern part. Slits were observed (**Figure 6-37**) in the bamboo, and therefore the cluster is likely to be a roosting site.

For five of the specimens in the central and eastern part, presence was recorded either acoustically or visually (BB_01, BB_02, BB_13B, BB_13C and BB_14A). No bats were recorded either acoustically or visually for the remaining two specimens, but are considered potential roosting sites for the bamboo bats (BB_14B and BB_14C). At BB_01 and BB_02 in the central part, three individuals were seen flying out from the clusters. Due to its close proximity, it could not be determined which cluster the bats were seen flying out from. At BB_15 in the eastern part, three individuals were also seen roosting in the bamboo. The findings are presented in **Figure 6-38**.

Figure 6-37: Bamboo Cluster (BB_15) observed within the Central Part of the EIA Study Area

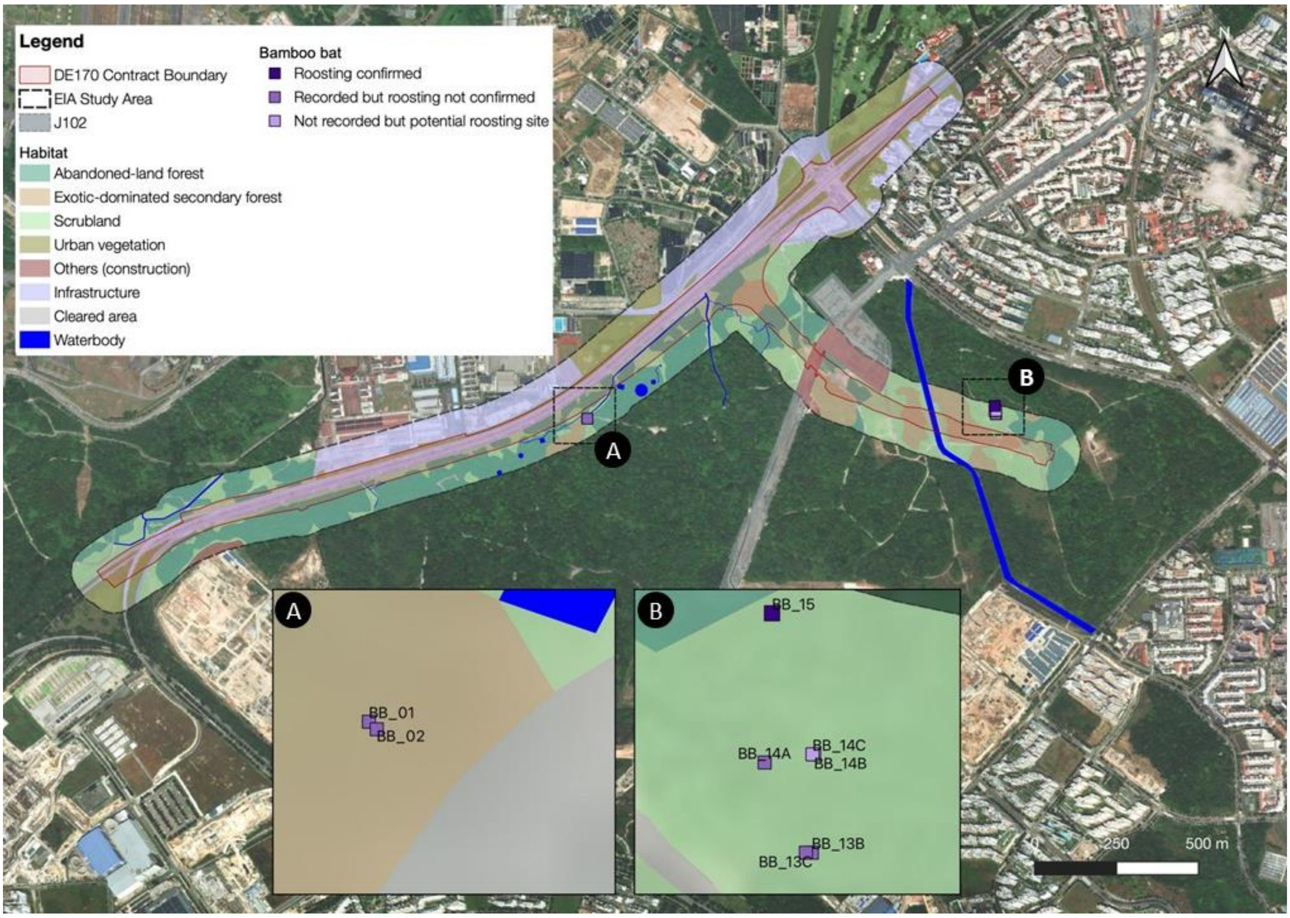


Figure 6-38: Location of Bamboo Bats

Source: ESRI

6.2.4.3.12 Freshwater Fish

A total of 15 freshwater fish species was recorded from the EIA Study Area. No CS species were recorded. Of the 15 recorded species, eight were non-native, including three from the Cyprinidae family (Indochinese spotted barb, pearl danio, red-tailed rasbora), two from Poeciliidae (mosquitofish, guppy) and one each from Cichlidae (Nile tilapia), Clariidae (sharp-tooth walking catfish) and Gobiidae (barcheek goby). Native species observed on site include disturbance tolerant species such as both the threespot and croaking gourami (*Trichopodus trichopterus, Trichopsis vittata*), common snakehead and walking catfish (*Channa striata, Clarias* cf. *batrachus*), oriental climbing perch (*Anabas testudineus*), Asian swamp eel (*Monopterus albus*) and sunda pygmy halfbeak (*Dermogenys colletei*) (**Figure 6-39**).

The highest diversity of fishes was recorded from stream A10, an open country stream that was deep and wide next to KJE to the western side of the EIA Study Area, with nine fish species present. It also had fish species unique to the waterbody within the EIA Study Area such as the native Sunda pygmy halfbeak (*D. colletei*). The species assemblage at A10 was typical of an open country stream. The second richest in diversity was stream A12, with seven species and stream A1 with six species. The Asian swamp eel (*M. albus*) was found exclusively in stream A1. Both of these are shaded forest streams with silty eroded banks and low flow. The lowest freshwater fish diversity was at pond A11, which only had common snakehead (*C. striata*). Given that this pond was small and at times extremely shallow during dry weather, the low diversity was not surprising.

The threespot gourami (*T. trichopterus*) was found in large numbers in pond A9 but were also present in pond A5 and streams A10, A12, A13. Although the threespot gourami (*T. trichopterus*) is considered native to Singapore, various artificial colour varieties are widely sold in the aquarium trade (Low & Lim, 2012). Of notable interest is their ability to breathe air using a specialised auxiliary respiratory organ, making them highly tolerant of hypoxic conditions. The common walking catfish (*Clarias* cf. *batrachus*) was a previously widespread species in the non-forested waterways of Singapore but has seen a marked decline in its populations outside of the central reserves due to competition and displacement from the invasive African sharptooth catfish (*Clarias gariepinus*) (Tan et al., 2020). The presence of the common snakehead (*C. striata*) suggests it is the main piscine predator in the EIA Study Area. This was further supported by field observations of their hunting behaviour during night surveys.

Given the historical land usage at Tengah being plantations and Kampung, it is very likely that the non-native as well as some of the native species were deliberately introduced on or off-site due to the aquarium trade and mosquito control purposes within the ponds (Ho et al., 2016), especially the guppy (*Poecilia reticulata*) and mosquitofish (*Gambusia affinis*) (Tan et al., 2020).

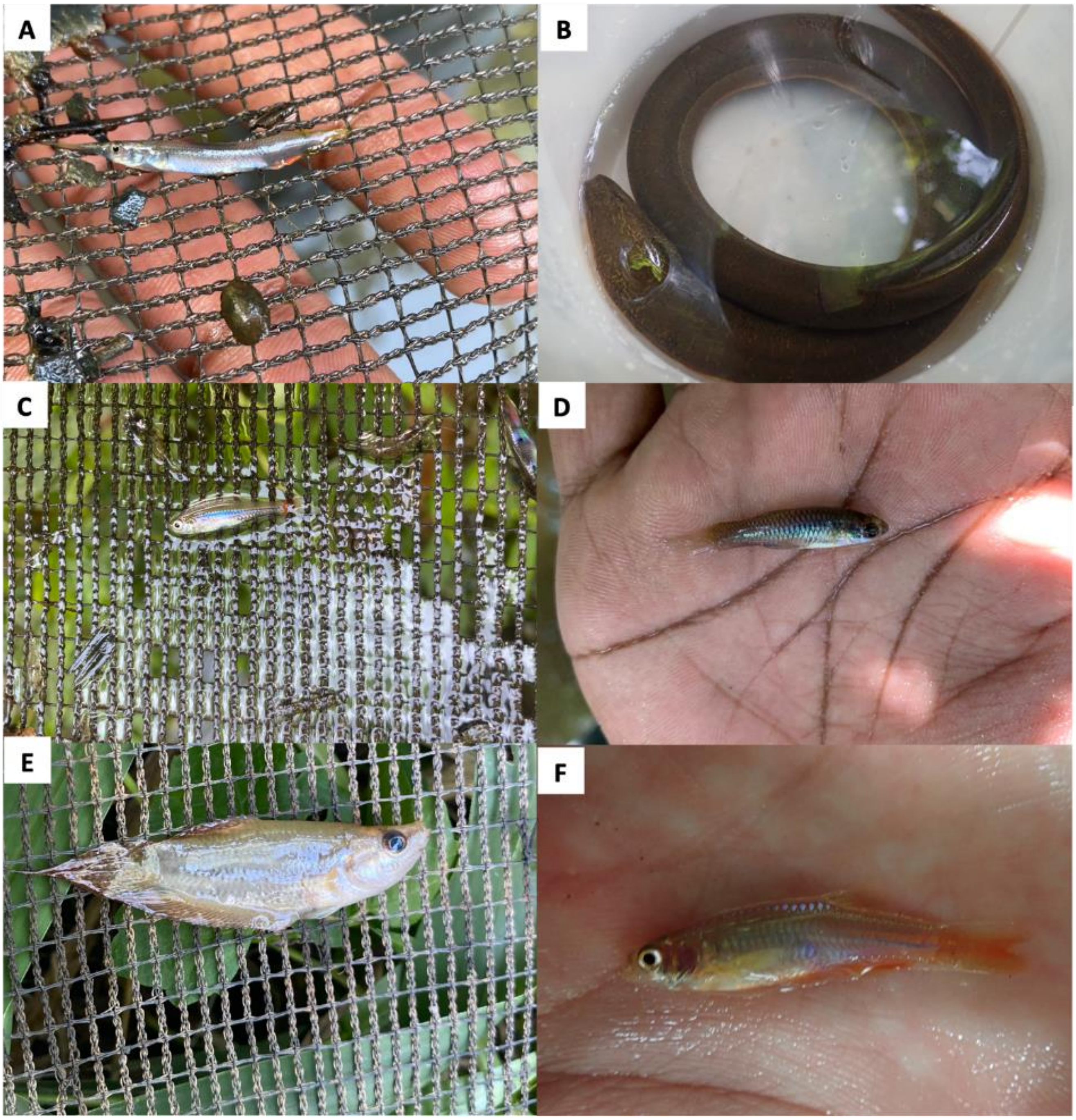


Figure 6-39: Fishes collected via tray netting A) Sunda pygmy halfbeak (*Dermogenys collettei*), C) Red-tail rasbora (*Rasbora borapetensis*), E) Croaking gouramy (*Trichopsis vittata*) and in bullet traps B) Asian swamp eel (*Monopterus albus*), D) Mosquitofish (*Gambusia affinis*), F) Pearl danio (*Brachydanio albolineata*)

6.2.4.3.13 Freshwater Decapod Crustaceans

Two decapod crustacean species were recorded within the EIA Study Area. No CS species was recorded. Through tray netting, a non-native riceland shrimp (*Macrobrachium lanchesteri*) was found at stream A15 and many shrimps belonging to the genus *Caridina* at stream A10. While we were not able to identify them down to species, they are likely to be *Caridina johnsoni* given the habitat type. If so, this would be a native species.

6.2.4.3.14 Freshwater mollusc

Four families of snails were collected via tray netting with no CS species recorded. Only the family Thiaridae was identified down to species *Melanoides tuberculata* as detailed operculum analysis was required to identify the other three families of snail belonging to family Planorbidae, Viviparidae and Physidae (**Figure 6-40**). While *Melanoides tuberculata* is a native species, the other three families are not. However, it is a species commonly found in local waterbodies (Ng et al, 2016).

Figure 6-40: Snails Caught via Tray Netting Identified Down to Family A) Planorbidae, B) Viviparidae, C) Physodine

6.2.5 Assessment of Ecological Value

Habitats and species within the EIA Study Area were assessed for their ecological value. Habitats and species accorded with higher ecological value were regarded of greater importance for conservation relative to other habitats and species, respectively, within the EIA Study Area. The assessment was carried out using biodiversity baseline findings.

The ecological value assessment framework for habitats is described on **Table 6-15**. The ecological value assessment framework for plant and faunal species is described below, as well as **Table 6-16** for plant species.

Table 6-15: Criteria for Assessing the Ecological Value of Habitats

Criterion	Definition	Classification		
		High	Medium	Low
Size	Area occupied by the habitat relative to the EIA Study Area	>40%	10–40%	≤ 10%
Naturalness	Degree to which the habitat has been modified or disturbed as a result of human activities	Habitat with minimal human disturbance	Moderately disturbed habitat that has been modified to some extent	Highly disturbed habitat that has been modified to a large extent

Criterion	Definition	Classification		
		High	Medium	Low
Abundance of species of conservation significance	Number of plant specimens recorded within the habitat relative to the number of plant specimens recorded in the EIA Study Area; number of recorded faunal species of conservation significance that able to utilise the particular habitat type in the EIA Study Area	>40%	10–40%	≤ 10%
Abundance of large and other plant specimens of value	Number of large and other plant specimens of value recorded within the habitat relative to the total number of large and other plant specimens of value recorded in the EIA Study Area	>40%	10–40%	≤ 10%
Ecological linkage	The value of a habitat increases if it lies in close proximity and/ or links functionally to a highly valued habitat of any type	Able to connect to high value habitats within the EIA Study Area	Able to connect to habitats within the EIA Study Area	Not able to connect to habitats within the EIA Study Area, i.e., isolated.
Recreatability	Level of difficulty in re-constructing the habitat through human intervention	Very difficult	Moderately difficult	Easy

All plant species were first accorded with a tentative ecological value, i.e., high, medium, or low, based on the following basic framework:

- High ecological value (Priority 1): Species of conservation significance
- Medium ecological value (Priority 2): All other native species
- Low ecological value (Priority 3): Exotic and cryptogenic species

Species that were tentatively assigned medium (all other native species) or low (exotic and cryptogenic species) ecological value were then evaluated individually based on the criteria listed on **Table 6-16**. The evaluation of individual species served to either maintain or raise the pre-assigned ecological value. The following paragraphs detail how each criterion was considered in the evaluation.

Association with important fauna (native, exotic, and cryptogenic species): The ecological value of plant species that directly support the growth and survival of important fauna at one or various life cycle stages were raised to high, irrespective of plant species origin, cultivation intensity and effects, as well as national distribution. Examples of such plant species include caterpillar host plants for rare butterfly species and bamboos that are refugia for nationally threatened bamboo bats. The ecological value of plant species without associations with important fauna was maintained at the original level, i.e., medium or low.

Cultivation intensity and effects (native species only): The ecological value of all native species previously or presently cultivated and/ or with populations of relics or escapees, respectively, present in the secondary forests of Singapore were maintained at the medium level. Otherwise, those that are associated with important fauna were raised to high ecological value.

National distribution (non-cultivated native species only): The ecological value of non-cultivated native plant species with restricted national distribution—i.e., largely found in certain forest patches in Singapore or offshore islands, such as the primary and old growth secondary forests of the CCNR—were raised from the original medium level to high. On the other hand, that of non-cultivated plant species that are nationally widespread—i.e., occur at several secondary forest patches throughout Singapore—were maintained at the medium level.

There are, however, a few exceptions in which the highest ecological value was automatically assigned to species regardless of the criteria listed below. They are (1) species endemic to Singapore and (2) species planted for reforestation and/or previously thought to be extinct and are planted for species reintroduction. Exotic rain tree (*Samanea saman*) was also automatically raised from low to medium ecological value given that it often supports the growth of epiphytes that provide habitats for fauna species.

Finally, keystone species, such as Ficus spp., are also allocated with the highest ecological value during the assessment. Keystone species is defined as "important plants that other animal in the community depend heavily on" (Lok et al., 2013). Essentially, the removal of these species can potentially cause an extirpation of dependent animals, such as pollinators and seed dispersers (Mills et al., 1993) and possibly re-shape or collapse the existing ecosystem. Ficus spp., or figs, regarded as keystone species as monoecious figs (i.e., species that bear both male and female reproductive organs within the same individual), are able to produce fruits all year round. This makes figs an important food source for many frugivores, especially during the time of the year where no other fruits are available. As for dioecious figs, they provide food for numerous avian insectivores that feeds on fig wasps (Mills et al., 1993; Lok et al., 2013).

Table 6-16: Criteria for Assessing the Ecological Value of Flora Species

Criterion	Definition
Conservation Significance	Listed as nationally threatened, i.e., Vulnerable, Endangered, Critically Endangered, or Extinct, and are considered of conservation significance in this study
Association with Important Fauna	Directly associated with the survival of important fauna at one or various life cycle stages
Cultivation Intensity and Effects	Cultivated previously or presently—for various purposes such as reforestation, landscaping, species reintroduction, commercial sale, etc—and populations of relics and/or escapees are present/absent in forests
National Distribution	Extent of spread and/or occurrence at one or multiple forest patches in Singapore
Keystone Species	Important species that other animal in the community depend heavily on (Lok et al., 2013). Removal of these species would most likely cause an extirpation of dependent animals and possibly re-shape or collapse the existing ecosystem (National Environmental Treasure, 2021)

All recorded faunal species were accorded an ecological value based on its conservation significance and species origin:

- High ecological value (Priority 1): Species of conservation significance
- Medium ecological value (Priority 2): All other native and migratory bird species, and species of indeterminate status
- Low ecological value (Priority 3): Exotic species

6.2.5.1 Habitat

The ecological value of four terrestrial habitats and five waterbodies within the EIA Study Area was assessed. For the assessment of terrestrial habitats, habitat preference of terrestrial fauna was considered, and likewise for aquatic fauna in aquatic habitats. No large plant specimen and other plant specimens of value were recorded from aquatic habitats.

One terrestrial habitat (abandoned-land forest) was assessed to have overall high ecological value, and therefore, assigned with A1 value of 3. One terrestrial habitat (exotic-dominated secondary forest) and three waterbodies (closed-canopy stream, open-country stream, as well as closed-canopy and semi open-country ponds) were assessed to have medium ecological value. They were assigned with A1 value of 2. Two terrestrial habitats (scrubland and urban vegetation) and two waterbodies (open-country ponds, and canal with naturalized sections) were assessed to have low ecological value. They were assigned with A1 value of 1.

A summary of the assessment of ecological value is detailed on **Table 6-17** and **Table 6-18** for terrestrial habitats and waterbodies respectively. The paragraphs below summarise assignation of ecological value for each habitat type.

Table 6-17: Assessment of Ecological Value of Each Terrestrial Habitat within the EIA Study Area

Criterion	Abandoned-land Forest	Exotic-dominated Secondary Forest	Scrubland	Urban Vegetation
Size	Medium: 24.9 % (40.10 ha)	Low: 7.02 % (11.32 ha)	Medium: 18.9 % (30.13 ha)	Medium: 12.5% (20.15 ha)
Naturalness	Medium: Moderately disturbed habitat that has been modified to some extent	Medium: Moderately disturbed habitat that has been modified to some extent	Medium: Moderately disturbed habitat that has been modified to some extent	Low: Highly disturbed habitat that has been modified to a large extent
Abundance of species of conservation significance	High Flora: 50.5 % (260) Fauna: 31.0 % (36)	Medium Flora: 23.3 % (95) Fauna: 30.2 % (35)	Low Flora: 17.6 % (72) Fauna: 22.4 % (26)	Low Flora: – Fauna: 16.4 % (19)
Abundance of large and other plant specimens of value (including keystone species)	High Large: 82.7 % (124) Others: 81.9 % (86) Total: 82.4 %	Low Large: 5.3 % (8) Others: 3.8 % (4) Total: 4.7 % (12)	Low Large: 12.0 % (18) Others: 14.3 % (15) Total: 12.9 %	–
Ecological linkage	High: Able to connect to high value habitats within the EIA Study Area	Medium: Able to connect to habitats within the EIA Study Area	High: Able to connect to high value habitats within the EIA Study Area	Low: Not able to connect to habitats within the EIA Study Area, i.e., isolated
Difficulty in recreatability	High: Very difficult	Medium: Moderately difficult	Low: Easy	Low: Easy
Total	High x4 Medium x2	Medium x4 Low x2	High x1 Medium x2 Low x3	Medium x1 Low x4
Ecological value	High	Medium	Low	Low

Table 6-18: Assessment of Ecological Value of each Waterbody within the EIA Study Area (excluding canals)

Criterion	Closed-canopy stream (A1, A11, downstream of A12, A13)	Open-country stream (A10)	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	Open-country ponds (A9)	Canal with naturalised sections (A2, upstream of A12)
Size	Low: 0.12 % (0.20 ha)	Low: 0.03 % (0.042 ha)	Low: 0.21 % (0.343 ha)	Low: 0.02 % (0.031 ha)	Low: 0.11 % (0.17 ha)
Naturalness	Medium: Moderately disturbed habitat that has been modified to some extent	Medium: Moderately disturbed habitat that has been modified to some extent	Medium: Moderately disturbed habitat that has been modified to some extent	Medium: Moderately disturbed habitat that has been modified to some extent	Low: Highly disturbed habitat that has been modified to a large extent
Abundance of species of conservation significance	Medium Flora: – Fauna: 66.7 % (32)	Low Flora: – Fauna: 4.2 % (2)	Low Flora: – Fauna: 6.3 % (3)	Low Flora: – Fauna: 4.2 % (2)	Low Flora: – Fauna: 18.8% (9)
Abundance of large and other plant specimens of value (including keystone species)	–	–	–	–	–
Ecological linkage	Medium: Able to connect to habitats within the EIA Study Area	Medium: Able to connect to habitats within the EIA Study Area	Medium: Able to connect to habitats within the EIA Study Area	Medium: Able to connect to habitats within the EIA Study Area	Medium: Able to connect to habitats within the EIA Study Area
Difficulty in recreatability	Medium: Moderately difficult	Medium: Moderately difficult	Medium: Moderately difficult	Low: Easy	Low: Easy
Total	Medium x4 Low x1	Medium x3 Low x2	Medium x3 Low x2	Medium x2 Low x3	Medium x1 Low x4
Ecological value	Medium	Medium	Medium	Low	Low

a) Abandoned-land Forest (High Ecological Value)

The abandoned-land forest occupies the largest terrestrial habitat (24.9%, 40.10 ha) in the EIA Study Area. It is ranked medium on naturalness. This habitat also contains a higher abundance of floral (61.9%) and faunal (31.0%) species of conservation significance. Plant species of conservation significance recorded here include the nationally Vulnerable *Bridelia stipularis*, and *Macaranga griffithiana*; nationally Endangered *Ardisia elliptica*; as well as the nationally Critically Endangered *Leea angulata* and *Melicope luna-ankenda*. Faunal species recorded include the nationally Endangered harlequin, Endangered blue-nosed sprite, Critically Endangered leopard cat and Endangered smooth otter were also observed within the abandoned-land forest.

This habitat also has higher abundance of large and other plant specimens of value, including keystone species, which represents 82.4% of the EIA Study Area. Since the abandoned-land forest spans across a large area across the site, it is considered to have high ecological linkage. This habitat is difficult to recreate.

Abandoned-land forest is ranked high for five criteria (size, abundance of species of conservation significance, abundance of large and other plant specimens of value, ecological linkage and difficulty in recreatability), and medium for one criteria (naturalness). Overall, abandoned-land forest is considered to have high ecological value.

b) Exotic-dominated Secondary Forest (Medium Ecological Value)

The exotic-dominated secondary forest occupies only 7.02% (11.32 ha) of the EIA Study Area. The habitat is ranked medium on naturalness. It is ranked medium on abundance of floral (21.5%) and faunal (30.2%) species of conservation significance. There were multiple clusters of nationally Critically Endangered *Leea angulata* within this habitat type.

The nationally Extinct and Rediscovered forest hopper and, Critically Endangered Sunda pangolin was recorded within this habitat. It comprises a low abundance of large plants and other plants of value (4.7%). It has medium ecological linkage. In term of ease of recreatability, it is moderately difficult.

Exotic-dominated secondary forest is ranked medium for four criteria (naturalness, abundance of species of conservation significance, ecological linkage and difficulty of recreatability) and low for two criteria (size; and abundance of large and other plant specimens of value). Overall, the exotic-dominated secondary forest is assessed to be of medium ecological value.

c) Scrubland (Low Ecological Value)

The scrubland is second highest is size (18.68%; 30.13 ha) within the EIA Study Area. Although only moderately disturbed, this habitat contains a low abundance of plant (16.7%) and faunal (22.4%) species of conservation significance, as well as for large and other plant specimens of value (12.9%). A higher concentration of nationally Vulnerable *Glochidion zeylanicum* var. *zeylanicum* was found within the scrubland, especially towards the end of eastern region.

The scrubland has high ecological linkage due to connectedness with abandoned-land forest, a high ecological value habitat, across the EIA Study Area. It is considered easy to recreate. Scrubland is ranked high for one criterion (ecological linkage), medium for two criteria (size and naturalness) and low for three criteria (abundance of species of conservation significance, and abundance of large and other plant specimens of value; and difficulty in recreatability). Overall, the scrubland is assessed to be of medium ecological value.

d) Urban Vegetation (Low Ecological Value)

The urban vegetation occupies a relatively large extent (12.49%; 20.15 ha) across the EIA Study Area. It is largely found outside of Tengah Forest, around KJE and Choa Chua Kang residential estate. It is a highly disturbed landscape with low abundance of species of conservation significance. As a human-modified landscape, it is easy to recreate. It is not well-connected to other habitats in the EIA Study Area, and therefore, considered to have low ecological linkage.

Urban vegetation is ranked medium for one criterion (size), and low for three criteria (naturalness, abundance of species of conservation significance; and ecological linkage). Overall, the urban vegetation is assessed to be of low ecological value.

e) Closed-canopy Stream (Medium Ecological Value)

The closed-canopy stream makes up only 0.12% (0.20 ha) of the EIA Study Area. It is considered moderately disturbed. However, it contains a medium abundance of species of conservation significance (68.9%), all from the A1 stream. A1 is the longest stream habitat within the EIA Study Area, which may explain the higher abundance of the nationally Vulnerable variable featherlegs (*C. vittata*) observed. Up to eight individuals were observed at A1_06 along the A1 stream. The nationally Critically Endangered blue-eared kingfisher was also recorded at A13. No species of conservation significance was recorded for A11 and downstream of A12, although the globally Near Threatened Malayan giant frog was recorded at A12.

These streams are ranked medium for ecological linkage as it is connected to other habitats in the EIA Study Area. Such closed-canopy waterbodies are considered moderately difficult to recreate as it takes time to establish such conditions.

This habitat is ranked medium for four criteria (naturalness, abundance of species of conservation significance, ecological linkage and difficulty in recreatability), and low for one criterion (size). Overall, the closed-canopy stream is assessed to have medium ecological value.

f) Open-country Stream (Medium Ecological Value)

The open-country stream occupies only 0.03% (0.042 ha) within the EIA Study Area. It is considered moderately disturbed. It contains a low abundance of species of conservation significance (2.2%). Only two species of conservation significance was recorded here. This includes one individual of the variable featherlegs (*Copera vittata*) and blue-eared kingfisher (*Alcedo meninting*). This stream also contains the native Sunda pygmy halfbeak, which is an indicator that the waterbody is possibly suitable for other native and forest-dependent aquatic species, contributing towards its medium ecological value.

It is connected to other habitats in the EIA Study Area since it runs through a scrubland habitat. It is considered moderately difficult to recreate as it is well-vegetated along its edges and connected to the adjacent forest. It also takes time to establish the conditions suitable for its aquatic communities.

This habitat is ranked medium for three criteria (naturalness, ecological linkage and difficulty in recreatability), and low for two criteria (size and abundance of species of conservation significance). Overall, the open-country stream is assessed to have medium ecological value.

g) Closed-canopy and Semi Open-country Pond (Medium Ecological Value)

The closed-canopy and semi open-country ponds occupy 0.21 % (0.343 ha) within the EIA Study Area. It is considered moderately disturbed. It contains a low abundance of species of conservation significance (2.2%). Only one species of conservation significance, the nationally Vulnerable variable featherlegs, was recorded at A5 pond and A8 pond. A total of three individuals were observed.

It is connected to other habitats in the EIA Study Area. Such forested waterbodies are considered moderately difficult to recreate as it takes time to establish such conditions.

This habitat is ranked medium for three criteria (naturalness, ecological linkage and difficulty in recreatability), and low for two criteria (size and abundance of species of conservation significance). Overall, the closed-canopy and semi open-country ponds is assessed to have medium ecological value.

h) Open-country Pond (Low Ecological Value)

The open-country pond occupies 0.02 % (0.031 ha) within the EIA Study Area. It is considered moderately disturbed. It contains a low abundance of species of conservation significance (2.2%). Only one species of conservation significance, the nationally Vulnerable variable featherlegs, was recorded.

It is connected to other habitats in the EIA Study Area. The difficulty in recreatability is low.

This habitat is ranked medium for two criteria (naturalness and ecological linkage), and medium for three criteria (size, abundance of species of conservation significance and difficulty in recreatability). Overall, the open-country pond is assessed to have low ecological value.

i) Canal with Naturalised Sections (Low Ecological Value)

The canal with naturalised sections occupies 0.11 % (0.17 ha) within the EIA Study Area. It is considered moderately disturbed. It contains a low abundance of species of conservation significance (2.2%). Only one species of conservation significance, the nationally Vulnerable variable featherlegs, was recorded. A relatively high abundance of nine individuals was recorded at A2. No species of conservation significance was recorded upstream of A12.

It is connected to other habitats in the EIA Study Area. The difficulty in recreatability is low.

This habitat is ranked medium for two criteria (naturalness and ecological linkage), and medium for three criteria (size, abundance of species of conservation significance and difficulty in recreatability). Overall, the canal with naturalised section is assessed to have low ecological value.

6.2.5.2 Flora

A total of 217 species were assessed for their ecological value in the overall EIA Study Area. Of all flora species, 31 were assessed with high ecological value; 88 was assessed with medium ecological value and the remaining 98 were assessed with low ecological value. The list of species is available in **Appendix 6A**.

<u>Flora of Conservation Significance</u>

All 20 flora species of conservation significance were assessed with high ecological value.

Association with Important Fauna

The sensitivity level of two flora species (i.e., *Schizostachyum* cf. *brachycladum* and *Bambusa heterostachya*) was raised from low to high ecological value due to its association with nationally Vulnerable bamboo bats (*Tylonycteris* spp.).

Keystone Species

The ecological value of five native Ficus spp. (*F. fistulosa*, *F. grossularioides*, *F. heteropleura*, *F. microcarpa* and *F. variegata*) was raised from medium to high. As for exotic *Ficus* sp. such as *F. benjamina* and *F. hispida*, their ecological value was raised from low to high.

6.2.5.3 Fauna

The ecological value of all 295 faunal species—274 terrestrial and 21 freshwater, including 22 species of conservation significance recorded from the baseline assessment, as well as all 31 species of conservation significance deemed of probable occurrence were assessed.

For terrestrial species, 50 species were deemed of high ecological value, 234 species of medium ecological value and 21 species of low ecological value. This includes the 274 terrestrial species recorded and additional 31 species of probable occurrence. For aquatic species, 9 species were deemed of medium ecological value, and 12 species were deemed with low ecological value. There are no aquatic species of conservation significance. All 22 species of conservation significance recorded from baseline assessment was deemed of high ecological value. This list of species and its ecological value is presented in **Appendix 6E**.

6.2.6 Potential Impacts Pathway on Biodiversity

Potential impact pathway to biodiversity arising from construction and operational activities are assessed in this section.

The impacts for the construction and operational phases were separately assessed for biodiversity sensitive receptors identified in **Section 6.2.5**, with a description of potential impacts given in **Section 6.2.6**. There are two main categories in which the impacts fall into:

1) Direct, i.e., impacts to habitats and species within the DE170 Contract Boundary; and
2) Indirect, i.e., impacts to habitats and species outside the DE170 Contract Boundary but within the impact zone. Impact zones for habitat and species receptors are defined as areas within 30 m from Contract Boundary of the DE170 Project (**Figure 6-41**). The 30-m impact zone is based on the assumption that edge effects in habitats directly adjacent to DE170 Contract Boundary are the greatest within 30 m from the Contract Boundary. However, given that faunal species are mobile, species present within the EIA Study Area were assessed and considered possible to occur within the DE170 Contract Boundary and its 30-m impact zone.

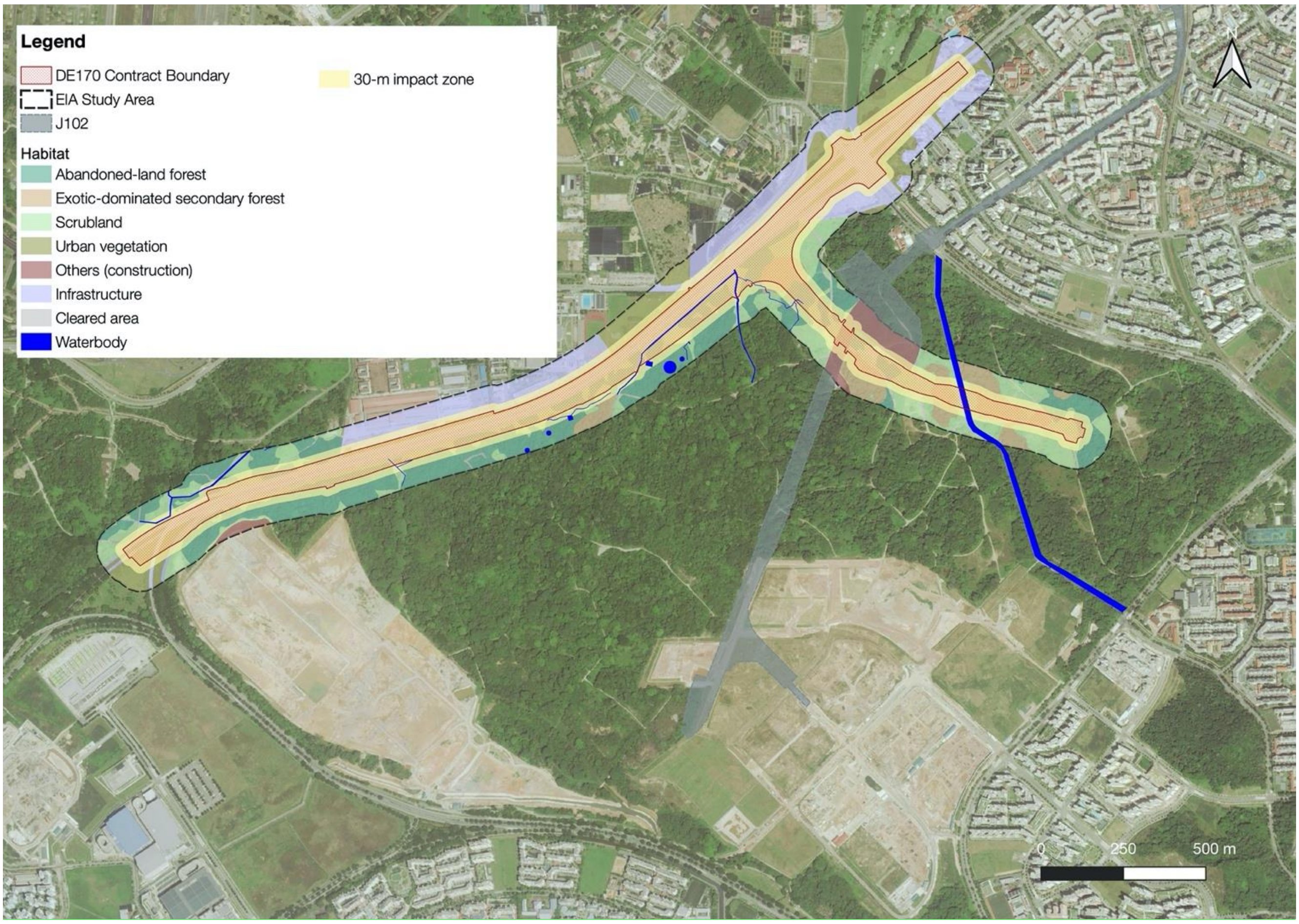


Figure 6-41: 30-m Impact Zone for Habitat and Plant Species Receptors
Source: ESRI

Table 6-19: List of Potential Impacts during Construction and Operational Phases

Phase	Receptor	Impact Type	Description
Construction	Habitat	Loss of vegetation	Direct removal of vegetation (with extensive underground root systems that protect against soil erosion) to create space for construction activities
		Habitat degradation	Improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in hydrology
		Change in species composition	Formation of forest edge habitats that favour the growth of certain exotic plants and fauna, and accidental introduction of exotic species from construction materials (such as soil with seeds or bio-degradable erosion blankets with insect eggs)
	Flora Species	Injury	Direct removal of vegetation to create space for construction activities
		Impediment to seedling recruitment	Pollution of habitats from improper disposal of construction waste and accidental release of hazardous materials (such as construction slurry, paint, and/or solvents)
		Competition from exotic plant species	Formation of forest edge habitats that favour the growth of certain exotic plants and accidental introduction of exotic species from construction materials (such as soil with seeds)
		Decline in plant health and survival	Changes in microclimatic conditions (i.e., dust, noise, and light, temperature, and humidity) and surface water quality
	Faunal Species	Loss of/ reduction in habitats and food sources	Direct removal of vegetation, nests or roost sites to create space for construction activities
		Accidental injury or mortality	Collisions with machineries, entrapments in construction materials (such as non-biodegradable erosion control blankets) and structures (such as exposed pits or drains), and accidental kills by construction personnel, including roadkills
		Human-wildlife conflict	Negative consequences of human-wildlife interactions, such as deliberate killing and depopulation of faunal species perceived as nuisances or threats by construction personnel
		Loss/ reduction of ecological connectivity for faunal movement	Habitat fragmentation from the removal of vegetation
		Light disturbances	Increase in light levels from construction activities
		Human disturbances	Increase in human traffic flow, such as workers and site personnel

Phase	Receptor	Impact Type	Description
Operation	Habitat	Change in species composition	Long-term changes in light, temperature, and humidity in habitats surrounding facility structures
		Habitat degradation	Trampling on vegetation, pollution (e.g., contamination of surface waterbodies, dust, litter) from increased human activities
	Flora Species	Mortality	Plant mortality due to long-term changes in microclimate
		Poaching	Stealing/ poaching of plants by humans due to ethnobotanical value (e.g., ornamental, medicinal, food, craft)
		Competition from exotic plant species	Accidental and/or intentional release of exotic plants by humans. Eventual colonisation of invasive or 'self-sustaining' exotic plant species within bare/sparsely vegetated area which was previously cleared during construction phase.
	Faunal Species	Accidental injury or mortality	Navigation failures into the wrong areas and entrapment in facility structures, including bird collision into buildings (distorted perceptions of reflective surfaces on buildings as flyways, greenery, and/or water) and roadkills
		Human-wildlife conflict	Negative consequences of human-wildlife interactions, such as deliberate killing and depopulation of faunal species perceived as nuisances or threats by members of the public
		Poaching	Poaching of fauna by humans
		Loss of ecological connectivity for faunal movement	Impediment to faunal movement by presence of buildings, infrastructure, and human activity
		Light disturbances	Increase in light levels from development
		Human disturbances	Increase in human traffic flow, such as residents and visitors
		Change in species composition	Formation of forest edge habitats that favour the growth of certain exotic plants and fauna, and accidental introduction of exotic species from construction materials (such as soil with seeds or bio-degradable erosion blankets with insect eggs)

6.2.7 Minimum Control Measures

This section lists biodiversity-specific minimum controls commonly implemented in Singapore for similar construction and operational activities. These are assumed to be implemented for the impact assessment. Minimum controls for each potential impact occurring from the construction and operational phases are listed on **Table 6-20**. These measures should be proposed in tandem with other environmental receptors (e.g., air and noise).

Table 6-20: Description of Minimum Controls Implemented at Construction and Operational Phases

Work Activities	Minimum Controls
Construction Phase	
General	• Install hoarding to delineate worksite. • Avoid fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles, e.g., providing well-maintained pitched roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, ensure effective drainage flow. • Daily checks by Environmental Checker on site, including but not limited to: - Visual checks for animal entrapments on-site, particularly within TPZs, ECM sedimentation tanks, erosion control blankets (ECBs) and among construction materials and equipment - Gaps in hoarding • Execute wildlife response plan when a trapped/ injured/ dead/ dangerous animal is encountered around or within the worksite according to Table 1-1, Section 10 of Wildlife Act.
Vegetation Clearance	• Set up Tree Protection Zones (TPZs) around trees or other plant specimens to be retained within the DE170 Contract Boundary, within which no construction works are allowed. This should be executed by certified arborists and in accordance with NParks' guidelines (NParks, 2019). • Conduct inspections of fauna prior to felling or removal of vegetation. This should be done by an ecologist who is able to identify wildlife and/ or active nesting structures, such as bird nests, tree hollows and/or burrows, and bamboo clusters. • Implement soil erosion control measures as soon as vegetation has been removed and soil is exposed (refer to Section 5.5.1). • Engage a Qualified Erosion Control Professional (QECP) to formulate and implement an Earth Control Measures (ECM) plan in accordance with PUB requirements.
Earthworks (Excavation, above and below ground construction)	• Implement soil erosion control measures (refer to Section 5.5.1) • Ensure proper storage of materials likely to leach harmful chemicals and fuel-powered equipment. Store them away from waterbodies and/or sensitive habitats (refer to Section 5.5.1). • Implement dust control measures (refer to Section 7.5.1) • Ensure noise levels are within approved limits, and to implement noise barriers where required (refer to Section 8.7.3)
Operational phase	
General	• Ensure noise levels are within approved limits (refer to Section 8.1) • Ensure dust levels are within approved limits (refer to Section 7.1) • Avoid fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles, e.g., providing well-maintained pitched roofs, clearing discarded items daily, storing materials appropriately, leveling up ground depression/ uneven surfaces, ensuring effective drainage flow.

6.2.8 Impact Assessment

In this section, the identified biodiversity sensitive receptors were evaluated based on Group A and Group B criteria in order to derive the impact significance.

6.2.8.1 Assessment of Biodiversity-Sensitive Receptors

The definition and scoring of each assessment criterion for biodiversity-sensitive receivers follows that described on **Table 2.1.** However, the definition for two criteria A1 (Value) and A2.2 (Magnitude of Changes) in relation to ecology are refined to represent the ecological value of an impact receiver and impact significance respectively. These ecological criteria are further explained below.

a) The A1 value of each biodiversity-sensitive value is categorised according to its ecological value evaluated on **Table 6-17** and **Table 6-18**. They are categorised as follows:

- 4 for habitat or species with high ecological value and has international importance
- 3 for habitat or species with high ecological value
- 2 for habitat or species with moderate ecological value
- 1 for habitat or species with low ecological value
- 0 for feature with no ecological value

b) Positive impact significance under criterion A2.2 are defined as follows:

- 2 for enhancement or creation of habitats in a forested site that is likely to significantly improve ecological functions.
- 1 for planting within a managed landscape context or small localised areas, or ecological features, with potential but limited value in improving ecological functions.

c) The criterion A2.2 (Magnitude of Changes) factors in the likelihood of occurrence.

- The preliminary magnitude of change is first derived (Impact Intensity), and subsequently multiplied with its likelihood of occurrence. The final value is assigned a score for the Magnitude of Change.
- The impact intensity is given a score ranging from 0 to 3 as follows – No Change (0), Minor (1), Moderate (2) and Major (3)
- The likelihood is given a score ranging from 0 to 5 as follows – Unlikely/Remote (0), Less Likely/Rare (1), Possible/Occasional (2), Likely/Regular (3) and Certain/Continuous (4).
- The impact intensity and likelihood are then multiplied and assigned with a score under Magnitude of Change – No Change (0), Low (1–3), Medium (4–6) and High (8–12).
- Given that several projects are occurring in the vicinity, such as J102, southern depot and other in Tengah Town developments, all ecological impact types are deemed as cumulative/synergistic as each successive negative impact is increasingly damaging to the environment.
- The various levels of impact intensity and likelihood during the construction and operational phases are defined for the biodiversity sensitive receptors in the following sections.

d) The impact extent (A2.3) for all biodiversity impacts is assumed to be of a national level (3) since loss of habitats and populations is regarded as a national impact.

For both construction and operational phases, the full list of the values assigned for each criterion in the RIAM as well as the resulting impact significance for the habitat, flora and fauna receptors is provided in **Appendix 6H**.

6.2.8.2 Construction Phase

6.2.8.2.1 Habitats

The definition of impact intensity and likelihood of impacts for habitat receptors during construction is provided on **Table 6-21** and **Table 6-22** respectively.

Two assumptions were made:

- Habitats within 30 m from the DE170 Contract Boundary are assumed to experience the greatest extent of edge effects, though some studies have shown that edge effects could be up to 150 m (refer to **Section 6.2.6** for the definition of impact zone).
- The likelihood of habit degradation [i.e., improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in forest hydrology] is presumed to be Less Likely for habitat receptors, based on the assumption that all minimum controls (**Section 6.2.7**) are adequately and properly implemented.

Table 6-21: Definitions of Each Level of Impact Intensity for Habitat Receptors during Construction

<table>
<tr><th>Impact Type</th><th>No Change</th><th>Minor</th><th>Moderate</th><th>Major</th></tr>
<tr><td>Loss of vegetation</td><td>The habitat does not overlap with the Contract Boundary</td><td>≤ 10% of the habitat overlaps with the Contract Boundary</td><td>10–40% of the habitat overlaps with the Contract Boundary</td><td>> 40% of the habitat overlaps with the Contract Boundary
Contract Boundary overlaps with waterbody.</td></tr>
<tr><td>Habitat degradation</td><td rowspan="2">The habitat does overlap with areas 30 m from the Contract Boundary</td><td rowspan="2">≤ 10% of the habitat overlaps with areas 30 m from the Contract Boundary</td><td rowspan="2">10–40% of the habitat overlaps with areas 30 m from the Contract Boundary</td><td rowspan="2">> 40% of the habitat overlaps with areas 30 m from the Contract Boundary</td></tr>
<tr><td>Change in species composition</td></tr>
</table>

Table 6-22: Definitions of Each Level of Likelihood for Habitat Receptors during Construction

Likelihood	Loss of Vegetation	Habitat Degradation	Change in Species Composition
Unlikely/ Remote	The habitat does not overlap with the Contract Boundary	N.A.	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the forest)
Less Likely/ Rare	N.A.	Assumption that all minimum controls are adequately and properly implemented.	Formation of scrubland edges in scrubland areas only
Possible/ Occasional	N.A.	N.A.	Formation of some forest and scrubland edges in a mix of managed vegetation, scrubland and forested areas

Likelihood	Loss of Vegetation	Habitat Degradation	Change in Species Composition
Likely/ Regular	N.A.	N.A.	Formation of new forest edges (i.e., complete clearance within forested areas)
Certain/ Continuous	The habitat overlaps with the Contract Boundary	N.A.	N.A.

Three construction phase impacts were identified and assessed for the habitat receptors: (1) loss of vegetation, (2) habitat degradation and (3) change in species composition.

Loss of vegetation

Vegetation clearance will occur in all terrestrial habitat types – abandoned-land forest, exotic-dominated secondary forest, scrubland, and urban vegetation. on the area of clearance (**Table 6-23**), the impact magnitude is medium for all terrestrial habitats, closed-canopy and open-country stream. It is minor for the closed-canopy and semi open-country pond. Overall, the impact significance of loss of vegetation is **Major Negative** for abandoned-land forest, **Moderate Negative** for exotic-dominated secondary forest, all waterbodies (except canal with naturalised sections and open-country pond) and **Minor Negative** for scrubland and urban vegetation. The remaining habitat types are not affected.

Habitat degradation

All habitat types are present in areas within 30 m from the DE170 Contract Boundary except for the open-country pond that lies outside of DE170 Contract Boundary. Given that it is assumed that habitat degradation is less likely to occur given proper implementation of minimum controls, impact magnitude is expected to be low for all habitat types, except for open-country stream which is medium. The open-country pond is not impacted. Overall, the impact significance is **Slight Negative** for affected habitats.

Change in species composition

All habitat types are present in areas within 30 m from the DE170 Contract Boundary. No impacts are expected to open-country pond. Changes in species composition is considered likely to occur for open-country stream and closed-canopy stream. For the remaining habitat types, changes in species composition is considered possible to occur. Therefore, the impact magnitude is expected to be medium for all affected habitat types. Overall, the impact significance is expected to be **Moderate Negative** for five habitat types (abandoned-land forest, exotic-dominated secondary forest, closed-canopy stream, open-country stream; and closed-canopy and semi open-country pond). The impact significance for the three other habitat types (scrubland, urban vegetation, and canal with naturalised sections) is expected to be **Minor Negative**.

Table 6-23: Summary of Impact Significance of Habitat Receptors from Direct and Indirect Impacts during Construction

Habitat Receptor	Ecological Value	% of Total Habitat Type Within the EIA Study Area Directly Impacted	% of Total Habitat Type Within the EIA Study Area Indirectly Impacted	Most Severe Impact Significance
Abandoned-land forest	High	9.16 ha (22.9%)	9.15 ha (22.8%)	Major Negative
Exotic-dominated secondary forest	Medium	3.84 ha (33.9%)	2.47 ha (21.8 %)	Moderate Negative
Scrubland	Low	8.29 ha (27.5%)	6.40 ha (21.2%)	Minor Negative

Habitat Receptor	Ecological Value	% of Total Habitat Type Within the EIA Study Area Directly Impacted	% of Total Habitat Type Within the EIA Study Area Indirectly Impacted	Most Severe Impact Significance
Urban vegetation	Low	5.25 ha (26.0%)	27.24 ha (10.7%)	Moderate Negative
Closed-canopy stream	Medium	0.02 ha (10.5%)	0.13 ha (66.0%)	Moderate Negative
Open-country stream	Medium	0.01 ha (19.0%)	0.02 ha (50.0%)	Moderate Negative
Closed-canopy & semi open-country pond	Medium	0 ha	0.06 ha (17.5%)	Moderate Negative
Open-country ponds	Low	0 ha	0 ha	No change
Canal with naturalised sections	Low	0 ha	23.5 ha (0.04%)	Minor Negative

6.2.8.2.2 Flora

One assumption was made in defining the levels of impact intensity for flora receptors during the construction phase:

- Habitats within 30 m from the DE170 Contract Boundary are assumed to experience the greatest extent of edge effects, though some studies have shown that edge effects could be up to 150 m (refer to Section 7.7 for the definition of the impact zone). However, the effects of forest edges may be experienced by species more sensitive to microclimatic changes more than 30 m away from the DE170 Contract Boundary; these are considered during species-specific impact evaluations.

The definition of impact intensity and likelihood of impacts for flora receptors during construction is provided on **Table 6-24** and **Table 6-25** respectively.

Table 6-24: Definitions of Each Level of Impact Intensity for Flora Receptors during Construction

Impact Type	No change	Minor	Moderate	Major
Mortality	No plant specimens of this species are within the Contract Boundary	Less than 50% of all plant specimens of this species are within the Contract Boundary	More than or exactly 50% of all plant specimens of this species are within the Contract Boundary	All plant specimens of this species are within the Contract Boundary
Impediment to seedling recruitment	No specimens of this species are within 30 m from the Contract Boundary	Less than 50% of all plant specimens of this species are within 30 m from the Contract Boundary	More than or exactly 50% of all plant specimens of this species are within 30 m from the Contract Boundary	All specimens of this species are within 30 m from the Contract Boundary
Competition from exotic species				
Decline in plant health and survival				

Table 6-25: Definitions of Each Level of Likelihood for Flora Receptors during Construction

<table>
<tr><th>Likelihood</th><th>Mortality</th><th>Impediment To Seedling Recruitment</th><th>Competition from Exotic Species</th><th>Decline In Plant Health and Survival</th></tr>
<tr><td>Unlikely</td><td>No plant specimens of this species are within the Contract Boundary</td><td>Plants are epiphytes and/ or do not grow on soil</td><td colspan="2">No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the forest)</td></tr>
<tr><td>Less Likely</td><td>N.A.</td><td>N.A.</td><td colspan="2">Formation of scrubland edges in scrubland areas only</td></tr>
<tr><td>Possible</td><td>No count data and/ or locations of specimens of this species is available, but specimens could possibly be within the Contract Boundary</td><td>Plants that grow on soil and whose dispersals are not restricted, i.e., they disperse via wind, water, and/or terrestrial fauna</td><td colspan="2">Formation of some forest and scrubland edges in a mix of urban vegetation, scrubland and forested areas</td></tr>
<tr><td>Likely</td><td>N.A.</td><td>N.A.</td><td colspan="2">Formation of new forest edges (i.e., complete clearance within forested areas)</td></tr>
<tr><td>Certain</td><td>Plant specimens of this species are within the worksite</td><td>Plants that grow on soil whose dispersals are restricted owing to environmental factors and/or growth strategies (e.g., bamboos that propagate via underground rhizomes and ground orchids)</td><td colspan="2">N.A.</td></tr>
</table>

Four construction phase impacts were identified and assessed for flora receptors: (1) mortality, (2) impediment to seedling recruitment, and (3) competition from exotic species, and (4) decline in plant health and survival. The impact significance ranged from No Change to **Major Negative** as summarised on **Table 6-26**. Only the most substantive impact for each impact type is presented below.

A total of 35 sensitive flora species recorded in the EIA Study Area were selected for the assessment of ecological impacts. They were selected based on these considerations:

- Species present within 30m from Contract Boundary (including those within Contract Boundary), regardless of ecological value
- Keystone species with high ecological value
- Species associated within important fauna, i.e., with high ecological value
- Species of conservation significance that make up ≤ 1% of the total specimen count for species of conservation significance

The impact assessment is summarised below and the detailed evaluation for all species are provided in **Appendix 6H**.

Table 6-26: Summary of Construction Impacts to Flora Receptors with Number indicating Number of Species

Impact Type	No Change	Slight Negative	Minor Negative	Moderate Negative	Major Negative
Mortality	18	1	3	8	5
Impediment to seedling recruitment	17	6	12	—	—
Competition from exotic species	21	2	12	—	—
Decline in plant health and survival	17	6	8	4	—

<u>Mortality</u>

Direct clearance of vegetation within DE170 Contract Boundary will cause mortality, as it is almost certain that the specimens found within the Contract Boundary would be removed from construction activities. There are five species that are likely to experience **Major Negative** impact significance and eight species with **Moderate Negative** impact significance. All of these species have high ecological value, for which mortality of these specimens would be detrimental to the overall national population. Those species resulting in **Major Negative** impact significance either have 50% (*Ardisia elliptica* and *Cyclosorus polycarpus*) or the entire population of specimens (*Connarus semidecandrus*, *Crytococcum patens* and *Selaginella willdenowii*) located within the DE170 Contract Boundary. The eight species that experience **Moderate Negative** impact significance have less than 50% of the population located within the DE170 Contract boundary.

There are also three species with **Minor Negative** impact significance and one species with **Slight Negative** impact significance. The remaining 18 species are not found within the DE170 Contract Boundary, and therefore, impact significance is expected to be of **No Change**.

<u>Impediment to seedling recruitment, competition from exotic species</u>

With minimum control measures in place, the likelihood of pollution and accidental release of exotic species from construction materials are considered less likely. Therefore, the most severe impact significance from impediment to seedling recruitment and competition to exotic species expected to be **Minor Negative** and **Slight Negative** respectively. The remaining species (i.e., 17 species for impediment to seedling recruitment and 21 species for competition from exotic species) were found 30 m outside of the DE170 Contract Boundary, and therefore impact significance is expected to be of **No Change**.

<u>Decline in plant health and survival</u>

Clearance of vegetation would most likely cause changes in microclimatic conditions. Impact significance for four species, *Aporosa benthamiana*, *Cayratia trifolia*, *Ficus vasculosa* and *Oncosperma tigillarium*, are expected to be **Moderate Negative**. These four species have high ecological value, and either have more than 50% or the entire population situated within 30 m of the DE170 Contract Boundary, which gives either a medium or high impact intensity. Another 14 species would either experience **Minor Negative** or **Slight Negative** impact significance. The remaining 17 species will not be impacted because they are found outside of the 30-m impact zone from DE170 Contract Boundary (i.e., **No Change**).

6.2.8.2.3 Fauna

The definitions for impact intensity and likelihood for faunal species receptors of conservation status are presented on **Table 6-27** and **Table 6-28** respectively.

Table 6-27: Definitions of Each Level of Impact Intensity for Faunal Receptors of Conservation Significance (CS Species) during Construction

Impact Type	No Change	Minor	Moderate	Major
Loss of/ reduction in habitats and food sources	No loss of original habitat, nests, or roosts	Loss of <10% of original habitat, nests, or roosts	Loss of 10–40% of original habitat, nests, or roosts	Loss of >40% of original habitat, nests, or roosts
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc,) and roadkills	Species with low susceptibility to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: • Volant species (e.g., odonates, butterflies, highly volant birds, raptors and most bats) • Aquatic species (most fishes, crabs, shrimps)	Species that are mobile but possibly susceptible to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills. These species are terrestrial in habit but has high mobility to escape from impact. • Less volant birds • All amphibians • Some mammals (e.g., squirrels, shrews)	Species with high susceptibility to accidental injury/ mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills. This includes species that may be capable of entering and using the construction site, and species with low mobility. • Reptiles • Some mammals (e.g., Sunda pangolin, long-tailed macaque, smooth otter) • Ground-dwelling birds • Nesting birds • Bamboo bats

Impact Type	No Change	Minor	Moderate	Major
Human-wildlife conflict	Species that are not perceived as nuisances or threats by construction personnel • Odonates • Butterflies • Most birds • Aquatic species	Species that are possibly perceived as both nuisances and threats by construction personnel, less tolerant of human presence and urban environments: • Some reptiles • Most amphibians • Most bats	Species that are typically perceived as nuisances and possibly as threats by construction personnel, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict: • Smooth otter • Aculeate hymenopterans	Species that are typically perceived as both nuisances and threats by construction personnel, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict: • Long-tailed macaque • Some snakes (e.g., vipers, cobras)
Loss of/ reduction in of ecological connectivity for faunal movement	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructures if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Light disturbances	Species that are not sensitive to changes in light levels: aculeate hymenopterans, most aquatic and marine species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles and mammals	Species that are extremely sensitive to changes in light levels: nocturnal, crepuscular fauna
Human disturbances	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are sensitive to human presence	Species that are extremely sensitive to human presence, and nesting birds

Table 6-28: Definitions of Each Level of Likelihood for Faunal Receptors of Conservation Significance (CS Species) during Construction Phase

Likelihood	Definition
Unlikely/ Remote	Impact is not expected to happen during the construction phase of the project
Less Likely/ Rare	Impact is not likely to happen during the construction phase of the project
Possible/ Occasional	Impact could possibly happen or known to occur during the construction phase of the project
Likely/ Regular	Impact is a common occurrence during the construction phase of the project
Almost Certain/ Continuous	Impact is a continual or repeated process during the construction phase of the project

Six construction phase impacts were identified and assessed for fauna receptors: (1) Loss of/reduction in habitats and food sources, (2) Accidental injury or mortality, (3) Human wildlife conflict, (4) Loss/reduction of ecological connectivity for faunal movement, (5) Light disturbances and (6) Human disturbances. The impact significance ranged from **Minor Negative** to **Major Negative**. The more substantial impacts arising from each impact type are briefly summarised below. A summary of the impact on fauna receptors is given on **Table 6-29**, with the numbers indicating the number of species that experience that magnitude of impact.

A total of all 50 fauna species of high ecological value recorded and of probable occurrence in the EIA Study Area (**Section 6.2.5.3**) were selected for the assessment of ecological value impacts. They are used to represent and guide the impact assessment The impact assessment is summarised below and the detailed evaluation for all species are provided in **Appendix 6E**.

Table 6-29: Summary of Construction Impacts to Fauna Receptors with Number indicating Number of Species

Impact Type	No Change	Minor Negative	Moderate Negative	Major Negative
Loss of/ reduction in habitats and food sources	0	21	28	1
Light disturbances	0	15	35	0
Accidental injury or mortality	0	43	7	0
Loss/reduction of ecological connectivity for faunal movement	0	49	1	0
Human disturbances	0	50	0	0
Human wildlife conflict	0	50	0	0

<u>Loss of/ reduction in habitats and food sources</u>

Minor Negative to **Major Negative** impacts are expected from loss of/ reduction in habitats or food sources. While most faunal species will experience **Minor Negative** to **Moderate Negative** impact. One species, the harlequin butterfly (*Taxila haquinus haquinus*) will suffer **Major Negative** impact as the construction works will directly affect the butterfly's host plant, the *Ardisia elliptica*, which only has a few clusters concentrated around the work site (**Figure 6-29**).

Twenty-eight species will experience Moderate Negative impact significance due to loss of habitats. An example is the blue-eared kingfisher (*Alcedo meninting*) Since the stream A1 is partially impacted which is a potential nesting site for the blue-eared kingfisher (*Alcedo meninting*), impact significance is considered **Moderate Negative**. The remaining 21 species will experience only **Minor Negative** impacts as less than 10% of their habitat will be cleared. This includes the bamboo bats which will not be impacted as it lies outside the Contract Boundary.

Light disturbances

Disturbances from light are likely to result in **Moderate Negative** impact significance for 35 species and **Minor Negative** impact significance for 15 species.

Night works are expected to be carried out in a moderate frequency for activities such as bored piling, and therefore, the likelihood was assessed to be possible. Species that are considered sensitive to changes in light levels, including nocturnal fauna such as the buffy fish owl (*Ketupa ketupu*), spotted wood owl (*Strix seloputo*), Sunda pangolin (*Manis javanica*), leopard cat (*Prionailurus bengalensis*); and species that migrate at night such as the violet cuckoo (*Chrysococcyx xanthorhynchus*), are expected to experience major impact intensity. The violet cuckoo is a winter visitor, and any light disturbance may affect its navigation. Therefore, impact significance for these 32 species are considered **Moderate Negative**. While bamboo bats are nocturnal, the bamboos are located >30 m away from the DE170 Contract Boundary, hence likelihood of light disturbances is considered less likely, and therefore impact significance is Minor Negative. Other species that are less sensitive to light levels, including diurnal birds, reptiles and mammals, are expected to experience medium impact intensity. The impact significance for 15 species is considered **Minor Negative**.

Accidental injury or mortality

Vegetation clearance and heavy machineries involved in the construction of KJE and the culvert is expected to create impacts for accidental injury or mortality for all assessed species. Given minimum controls are in place (pre-felling fauna inspection, wildlife response plan and biodiversity training), impact significance is expected to be **Minor Negative** to **Moderate Negative.**

Four mammals and three reptiles will be subjected to **Moderate Negative** impacts. This includes species such as highly threatened pangolin (*Manis javanica)*, leopard cat (*Prionailurus bengalensis*), black-headed collared snake (*Sibynophis melanocephalus*) and Malayan box terrapin (*Cuora amboinensis*). Since the non-volant mammals and reptiles are more mobile, it is possible for these terrestrial species to be encountered within and around the worksite, and possibly subjected collisions with vehicles (i.e., roadkills). Assuming that bamboos will not be cleared at all, the two bamboo bat species, together with the remaining 43 species will experience only **Minor Negative** impact.

Loss/reduction of ecological connectivity for faunal movement

Minor Negative to **Moderate Negative** impacts were expected from reduction of ecological connectivity for faunal movement. This impact is considered possible to occur for three species that are medium-sized and ground-dwelling in nature, i. e., the smooth otter (*Lutrogale perspicillata*), Sunda pangolin (*Manis javanica*) and leopard cat (*Prionailurus bengalensis*). Since the smooth otter has ability to traverse urban infrastructures, the impact intensity is considered minor and impact significance is **Minor Negative.** The Sunda pangolin requires connected habitats for dispersal. The DE170 construction works in the eastern part, together with the other ongoing developments, will result in loss/reduction in ecological connectivity. Therefore, likelihood is certain and impact significance is **Moderate Negative**. Hence, impact significance **is Minor Negative**. The impact significance is **Minor Negative** for remaining 49 species.

Human disturbances

Human disturbance is expected to result in **Minor Negative** impacts for all 50 species. Given that the site will be hoarded up and works will be strictly within the hoarded zone, the impacts of human disturbances to fauna using surrounding habitats is considered less likely.

Human wildlife conflict

Given minimum controls are in place (biodiversity training and wildlife response plan), human-wildlife conflict is expected to be **Minor Negative** for all species.

6.2.8.3 Operational Phase

For the impact assessment, only the portion of forest adjacent to DE170 Contract Boundary within the EIA Study Area, will be assessed.

6.2.8.3.1 Habitats

The definitions for impact intensity and likelihood for habitat receptors are given on **Table 6-30** and **Table 6-31** respectively. One assumption was made:

- The forest adjacent to DE170 Contract Boundary is not accessible to the public.

Table 6-30: Definitions of Each Level of Impact Intensity for Habitat Receptors during Operational Phase

Impact Type	No Change	Minor	Moderate	Major
Habitat degradation	Developed area is not accessible to public and no long-term degradation is expected. e.g., core conservation areas with no public access, infrastructure works with no public access	Developed area is designed with the intention for the public to use or visit and will increase human accessibility to the surrounding natural habitats. Limited or controlled degradation is expected near areas of higher human activity. E.g., nature parks	Developed area is designed for members of the public to visit. E.g., parks. Degradation is expected to occur within at least 50% of the habitat	Developed area and surroundings are designed for large groups of people to live or work in the long run. Degradation is expected to occur throughout 100% of the habitat. E.g., residential estates
Change in plant species composition	Development footprint is temporary and/or operational activities are fully underground (e.g., train alignment)	Development footprint is permanent and small relative to the size of the surrounding habitats (i.e., ≤ 10%)	Development footprint is permanent and medium-sized relative to the size of the surrounding habitats (i.e., 10-40%)	Development footprint is permanent and large-sized relative to the size of the surrounding habitats (i.e., ≥ 40%)

Table 6-31: Definitions of Each Level of Likelihood for Habitat Receptors during Operational Phase

Likelihood	Habitat Degradation	Change in Plant Species Composition
Unlikely/Remote	Surrounding natural habitats are not accessible to public	Development is largely green and human activity is limited (e.g., Thomson Nature Park). The habitat is already exotic-dominated such that introduction of exotic species has no impact on the habitat.
Less Likely/ Rare	Surrounding natural habitats are accessible but public use is restricted/ controlled	Development involves the building of urban structures but will be heavily landscaped (e.g., Gardens by the Bay). The habitat is already exotic-dominated such that introduction of exotic species has some impact on the habitat.
Possible/ Occasional	Surrounding natural habitats are accessible and have infrastructure for the public to use, such as boardwalks (but people can still stray off track)	Development involves the building of structures that are designed to release heat, light, noise or dust (e.g., ventilation shafts). Introducing exotic species will change the balance of exotic vs native species within the habitat.
Likely/ Regular	Surrounding natural habitats are easily accessible and do not have infrastructure for the public to use, such as boardwalks (thus public are likely to stray off track)	Development involves the building of extensive pavements, structures, and other infrastructure with surfaces that absorb and retain heat, constantly produce dust and noise disturbances (e.g., residential estate). Introducing exotic species will be detrimental to the native-dominated habitat and its surrounding native-dominated habitats.
Certain/ Continuous	N.A	N.A

Habitat degradation

It is assumed that the forest adjacent to DE170 Contract Boundary is largely for wildlife usage, and not accessible to the public. As limited or controlled degradation is expected from the road or vehicular footprint, impact intensity is considered minor, and likelihood is considered less likely. Therefore, the impact significance is considered **Slight Negative** for all habitat types.

Change in plant species composition

Since the development footprint is permanent and medium-sized relative to the surrounding habitats, impact intensity is considered minor. The likelihood of occurrence is possible. The impact significance is **Moderate Negative** for five habitat types (abandoned-land forest, exotic-dominated secondary forest, open-country stream, closed-canopy stream; and closed canopy and semi open-country pond), and **Minor Negative** for four habitat types (canal with naturalised sections, open-country pond, scrubland and urban vegetation).

6.2.8.3.2 Flora

The definitions for impact intensity and likelihood for flora receptors are given on Table 6-32 and Table 6-33. One assumption was made:

- The forest adjacent to DE170 Contract Boundary is not accessible to the public.

Table 6-32: Definitions of Each Level of Impact Intensity for Flora Receptors at the Operational Phase

Impact Type	No Change	Minor	Moderate	Major
Mortality	No microclimatic changes within the remaining habitat are expected, no plant specimens are expected to be impacted.	Microclimatic changes within the remaining habitat affect less than 50% of the specimens.	Microclimatic changes within the remaining habitat affect more than or exactly 50% of the specimens.	Microclimatic changes within the remaining habitat affect all specimens. (i.e., the habitat is expected to no longer be the same as the original condition and is not favourable for species of interest)
Poaching	No plant specimens of this species are removed from site (i.e., no extrinsic ethnobotanical value), plant locations are not published or inaccessible, plants that are too large to remove from site (i.e., large plants)	Less than 50% of plant specimens of this species can be removed from site (i.e., species has some ethnobotanical value such as common ornamental plants)	More than or exactly 50% of all plant specimens of this species can be removed from site (i.e., charismatic plants such as orchids, pitcher plants with seemingly higher extrinsic ethnobotanical value)	All plant specimens of this species can be removed from site (i.e., charismatic plants such as orchids, pitcher plants with seemingly higher extrinsic ethnobotanical value)
Competition from Exotic Species	Species is cryptogenic, or exotic and listed as "Naturalised"	Species is exotic and listed as "Casual" or not assessed	Species is exotic and listed as "Cultivated Only"	Species is native

Table 6-33: Definitions of each level of likelihood for flora receptors at the operational phase

Likelihood	Mortality	Poaching	Competition from Exotic Species
Unlikely	Long term microclimate of habitat is expected to be the same as pre-development conditions	Species not known to have been stolen before	Original vegetation mostly retained with no new landscaping
Less Likely	N.A.	N.A.	Some original vegetation retained with some new landscaping using only native species, or original vegetation mostly cleared with new large-scale landscaping using both native and exotic species
Possible	Long term microhabitat is expected to remain similar but may experience edge effects, some mortality of individuals is expected	Flowering species known to have been stolen before	Some original vegetation retained with some new landscaping using exotic species

Likelihood	Mortality	Poaching	Competition from Exotic Species
Likely	N.A.	N.A.	Original vegetation mostly cleared with new large-scale landscaping using exotic species.
Certain	Long term microclimate is expected to be completely different such that the species are unable to adapt to new conditions	"Charismatic species" known to be stolen most of the time (i.e., pitcher plants and orchids)	N.A.

Three operational phase impacts were identified and assessed for flora receptors: (1) mortality, (2) poaching, and (3) competition from exotic species. The impact significance ranged from **No Change** to **Moderate Negative**. Only the most substantive impact for each impact type is presented below and summarized on **Table 6-34**.

There 35 sensitive flora species selected for the assessment of ecological value impacts were assessed to have the following impacts.

Table 6-34: Summary of Operational Phase Impacts to Flora Receptors with Numbers indicating Number of Species

Impact type	No Change	Slight Negative	Minor Negative	Moderate Negative	Major Negative
Accidental injury or mortality	17	5	1	12	—
Poaching	35	—	—	—	—
Competition from exotic species	21	1	13	—	—

Mortality

Impacts from mortality ranges from **No Change** to **Moderate Negative** impact. There are 12 species likely to experience **Moderate Negative** impact significance. With vegetation clearance, the long-term microclimate of the site will be altered from pre-development condition, hence the likelihood of this impact is certain. Difficulty of adapting to the new conditions is likely to cause mortality. The remaining 23 species either have **Minor Negative**, **Slight Negative** impact significance or **No Change**.

Poaching

Poaching is unlikely to occur within the forest adjacent to DE170 Contract Boundary due to restricted accessibility of the site.

Competition from exotic species

With the restricted site accessibility for public, it is less likely for accidental and/ or intentional release of exotic plants by humans. In view of site-specific context, it is assumed that there would still be small possibility of exotic plants brought into the site by vehicles. Therefore, 13 species would still be likely to experience **Minor Negative** impact and one species with **Slight Negative** impact significance. The remaining 21 species is expected to have **No Change**.

6.2.8.3.3 Fauna

The definitions for impact intensity and likelihood for fauna receptors is given in **Table 6-35** and **Table 6-36**, respectively. All intensity discussed is to be assumed negative unless mentioned as a positive impact.

Table 6-35: Definitions of Each Level of Impact Intensity for Faunal Receptors during Operational Phase

Impact Type	No Change	Minor	Moderate	Major
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/mortality from operation activities, roadkills	Species with low susceptibility to accidental injury/ mortality from operation activities, roadkills • Volant species (e.g., odonates, butterflies, raptors and bats) • Aquatic species (most fishes, crabs, shrimps)	Species that are mobile but possibly susceptible to accidental injury/mortality from operation activities and roadkills • All amphibians • Some mammals (e.g., squirrels, shrews)	Species with high susceptibility to accidental injury/mortality from operation activities and roadkills • Reptiles • Some mammals (e.g., Sunda pangolin, long-tailed macaque, smooth otter)
Human-wildlife conflict	Species that are not perceived as nuisances or threats by the public • Odonates • Butterflies • Most birds • Aquatic species	Species that are possibly perceived as both nuisances and threats by construction personnel, less tolerant of human presence and urban environments: • Some reptiles • Most amphibians • Most bats	Species that are typically perceived as nuisances and possibly as threats by construction personnel, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict: • Smooth otter • Aculeate hymenopterans	Species that are typically perceived as both nuisances and threats by construction personnel, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict: • Long-tailed macaque • Some snakes
Loss of/ reduction in of ecological connectivity for faunal movement	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructures if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Human disturbances	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are sensitive to human presence	Species that are extremely sensitive to human presence, and nesting birds

Impact Type	No Change	Minor	Moderate	Major
Light disturbances	Species that are not sensitive to changes in light levels: aculeate hymenopterans, most aquatic and marine species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles and mammals	Species that are extremely sensitive to changes in light levels: nocturnal, crepuscular fauna and nesting/hatching sea turtle species
Poaching	Species with negligible susceptibility to poaching	Species with low susceptibility to poaching; not commonly known to be traded as pets	Species that are possibly susceptible to poaching; commonly traded as pets	Species that are highly susceptible to poaching; listed on CITES Appendix I or II

Table 6-36: Definitions of Each Level of Likelihood for Faunal Receptors during Construction

Likelihood	Definition
Unlikely/Remote	Impact is not expected to happen during the construction phase of the project
Less Likely/ Rare	Impact is not likely to happen during the construction phase of the project
Possible/ Occasional	Impact could possibly happen or known to occur during the construction phase of the project
Likely/ Regular	Impact is a common occurrence during the construction phase of the project
Almost Certain/ Continuous	Impact is a continual or repeated process during the construction phase of the project

Six operational phase impacts were identified and assessed for the fauna receptors: (1) Accidental injury or mortality, (2) Human disturbances, (3) Human wildlife conflict, (4) Light disturbances, (5) Poaching and (6) Loss/reduction of ecological connectivity for faunal movement. The negative impact significance ranged from **No Change** to **Moderate Negative**. There is some **Minor Positive** impact significance arising from ecological connectivity for faunal movement. The more substantial negative impacts arising from each impact type are briefly summarised below and positive impacts will be discussed. A summary of the impact on fauna receptors is given on **Table 6-37**.

The 50 fauna species of high ecological value recorded and of probable occurrence in the EIA Study Area selected for the assessment of ecological value impacts had the following impacts. The impact assessment is summarised below and the detailed evaluation for all species are provided in **Appendix 6E**.

Table 6-37: Summary of Operational Phase Impacts to Fauna Receptors with Number indicating Number of Species

Impact Type	No Change	Minor	Moderate	Major	Minor
	Negative				Positive
Light disturbances	0	23	27	0	0
Accidental injury or mortality	37	8	5	0	0
Loss/reduction of ecological connectivity for faunal movement	0	47	0	0	3
Human disturbances	50	0	0	0	0
Human wildlife conflict	50	0	0	0	0
Poaching	50	0	0	0	0

Light disturbances

Light disturbance will likely result in **Minor Negative** to **Moderate Negative** impact. The expansion of KJE increases its proximity to the forest adjacent to DE170 Contract Boundary, resulting in increased glare and light trespass from street lights at the forest edge which will negatively impact the navigation of migratory birds and disrupt foraging behaviour of nocturnal mammals and reptiles. The impact intensity for these species ranges from medium to high. Since the impact is considered possible to occur, the impact significance for these 27 species is **Moderate Negative**. This includes species such as the blue-eared kingfisher (*Alcedo meninting*), changeable hawk-eagle (*Nisaetus cirrhatus*) and Sunda pangolin (*Manis javanica*). For the remaining 23 species, the impact intensity is considered minor as they are not sensitive to light levels, or the likelihood of occurrence is low, therefore impact significance is **Minor Negative**.

Accidental injury or mortality

Impact arising from accidental injury or mortality ranges from **No Change** to **Moderate Negative**, with four non-volant mammal and one reptile species expected to experience **Moderate Negative** impact significance. With the expansion of KJE, vehicular activity is expected to increase, translating into an increase in the likelihood of roadkill for ground-dwelling species such as the smooth otter (*Lutrogale perspicillata*), Sunda pangolin (*Manis javanica)* and leopard cat (*Prionailurus bengalensis)* as well as reptiles including terrapin and snakes.

Loss/reduction of ecological connectivity for faunal movement

The ecological connectivity across fragmented forest patches of Tengah and Western catchment will be improved for some species with the implementation of the KJE culvert. Three species of CS mammals stand to benefit from a **Minor Positive** impact. These are the targeted species for culvert usage including the smooth otter (*Lutrogale perspicillata*), pangolin (*Manis javanica)* and leopard cat (*Prionailurus bengalensis)* which are ground-dwelling and highly mobile are likely to prefer traversing an underground culvert over the busy aboveground highway. While between habitat connectivity is increased by the culvert, the partial removal of the Tengah forest patch will reduce within habitat connectivity for some species like the Harlequin butterfly (*Taxila haquinus haquinus*), resulting in **Minor Negative** impact. The rest of the high ecological value species assessed will not be impacted as the forest adjacent to DE170 Contract Boundary will be maintained for ecological connectivity. In reducing the potential of roadkill and providing a connection between the fragmented Tengah and the Western catchment forest patch, overall connectivity is improved.

Human disturbances

There will be no changes to public access at the forest adjacent to DE170 Contract Boundary, therefore the amount of human traffic will be kept at status quo. There is likely to be no impact from human disturbance.

Human wildlife conflict

Human wildlife conflict is unlikely to occur from the development since there is no increase in human-wildlife interface.

Poaching

Poaching is unlikely to occur within the forest adjacent to DE170 Contract Boundary due to inaccessibility of the site.

6.2.9 Mitigation Measures

6.2.9.1 Design Phase

No avoidance measures could be considered within the DE170 Contract Boundary as that area is planned to be cleared. Instead, the focus is on minimising impacts to the forest adjacent to DE170 Contract Boundary. Compensatory measures through habitat enhancement or creation could also be considered.

6.2.9.1.1 Minimise

a) Minimise impacts of human-wildlife conflict with proper waste and food management, and wildlife response plan during construction phase

Human-wildlife conflicts occur when there are negative interactions between humans and wildlife, e.g., human injury caused by wildlife. One key driver of human-wildlife conflict is access to anthropogenic food sources. Food is a major attractant for wildlife, and anthropogenic sources of food, e.g., rubbish which tend to be easily accessible, of high yields, and a reliable food source for animals. Wildlife attracted to these food sources may come into contact with humans, thus increasing the likelihood of negative human-wildlife interactions. Reducing human-wildlife conflicts would require proper trash and food management within the development. It is important to increase staff's biodiversity awareness and educate site personnel on how to safely interact with wildlife.

The following strategies should be implemented:

- Food should be consumed within indoor area as much as possible.
- For all bins situated outdoors, use wildlife-proof bins. These bins should not be easily accessible to species such as the Eurasian wild boar, long-tailed macaque and rats.
- Rubbish bins with food waste should be regularly cleared.
- Enclose waste management centres to reduce wildlife access to it. For example, rubbish bins could be kept within an indoor shed to prevent wildlife access.
- No feeding of wildlife is allowed.

It is also important to establish a Wildlife Response Plan (**Figure 6-49**) in consultation with NParks Animal Management Centre, to be executed during encounters with trapped, injured or dead wildlife, as well as incidents of human-wildlife conflict within the development, and ensure that this information is disseminated to staff members.

b) Minimise impacts from light disturbances through reducing ecological light pollution during construction phase

Any level of artificial light above that of moonlight, masks the natural rhythms of lunar sky brightness and can thus disrupt the patterns of foraging, mating, as well as the circadian rhythm of wildlife (Bat Conservation Trust, 2018). Artificial lighting at night (ALAN) can disorient birds, bats, and insects, altering their behaviour that results in them being more vulnerable to predation and other risks. For example, ALAN may repel light-adverse bats from lit areas and restrict their use of commuting or feeding space.

If night works are required, the following strategies could be considered:

- Minimise light spills, i.e., light that falls outside the area intended to be lit.

- Direct permanent artificial lightings away from the nature areas.
- Avoid artificial illumination towards and within the nature areas, unless necessary for safety reasons.
- Use a minimal number of luminaires while achieving the necessary lighting levels.
- Optimise the placement of lights by lighting only the object or area intended, and keeping lights close to the ground, directed, and shielded. Accessories such as baffles, hoods or louvres can be used to reduce light spill and direct it only to where it is needed (Bat Conservation Trust, 2018). Lights to be pointed downwards as much as possible to reduce upwards light spillage.
- Configure the location, orientation, and height of buildings and structures (e.g., streetlights) (Bat Conservation Trust, 2018).

- Use wildlife-friendly light properties or features.
  - Use low-glare lighting and lights with reduced or filtered blue, violet, and ultraviolet wavelengths, since most animals are sensitive to ultraviolet/blue/violet light at wavelength of 100-400 nm (Campos, 2017) as mentioned in the National Light Pollution Guidelines for Wildlife (2020) by the Australian Government. Short wavelength light (blue) scatters more readily in the atmosphere and therefore contributes more to sky glow than longer wavelength light. Therefore, as a rule, only lights with little or no short wavelength (400–500 nm) violet or blue light should be used to avoid unintended effects.
  - Employ warm colour temperature light sources to be preferably at < 2,700 Kelvin (Bat Conservation Trust, 2018).
  - Use non-reflective, dark-coloured surfaces to reduce contribution to sky glow.

If night works are required, a lighting management plan should be established in consultation with NParks.

c) Minimise impacts from noise and light disturbances with dense hedge planting at side table during operational phase

Along KJE, impacts from noise and light disturbances generated during the operational phase could be buffered from by dense hedge planting along the side table.

d) Enhance usage of adjacent forest by planting up cleared areas under KJE flyover during operational phase

During operational phase, the open areas under the flyover (FLO5) at Tengah Interchange (**Figure 6-42**) are recommended to be planted up to allow continuity of vegetation with the forest. Since some fauna may shy away from non-vegetated areas, the planted area facilitates movement of fauna along this section of the forest.

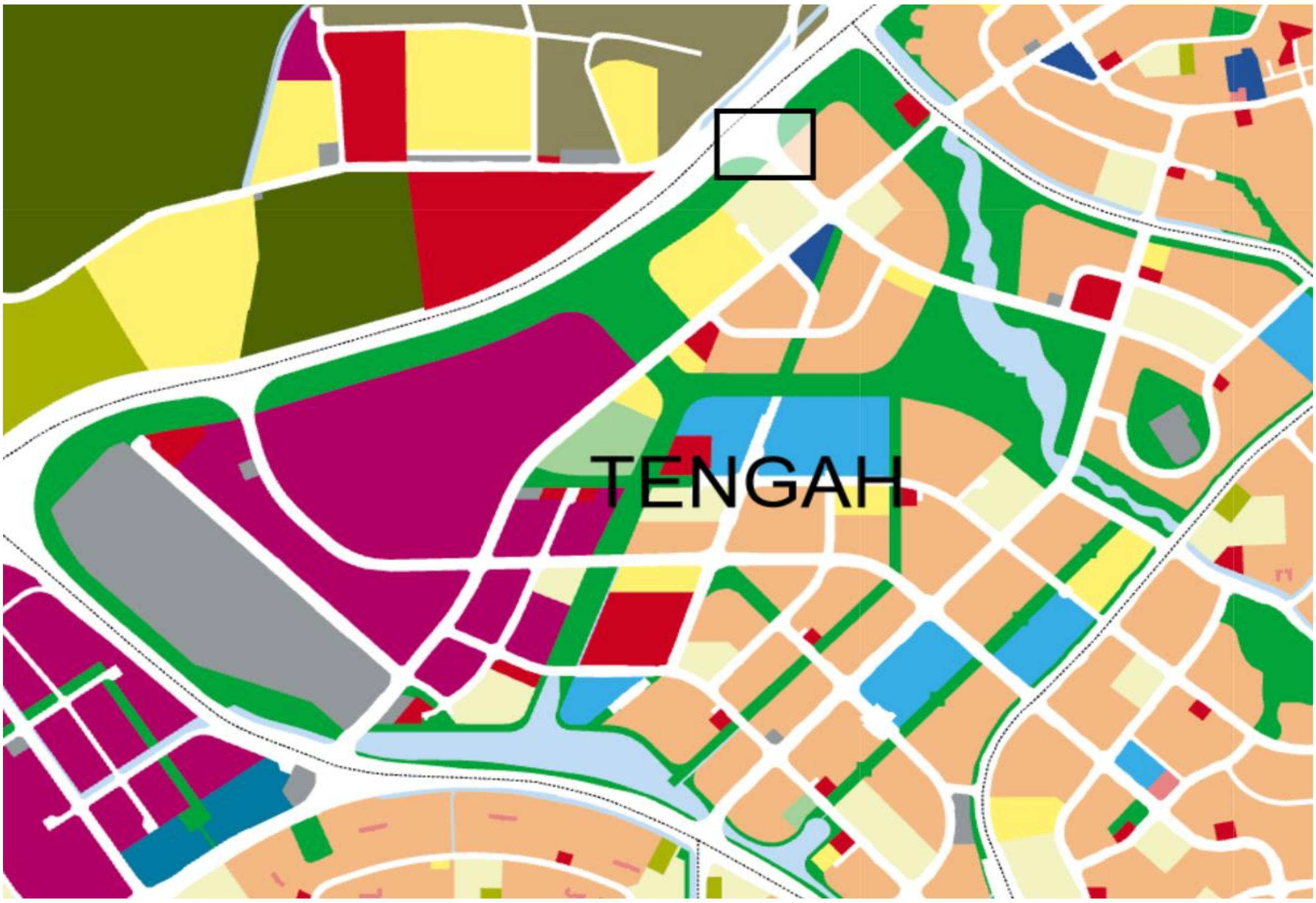


Figure 6-42: Proposed Planting Area on Plan View

6.2.9.2 Construction Phase

The proximity of development to the forest adjacent to DE170 Contract Boundary means that the ecological receptors there may experience indirect impacts from the adjacent construction works at DE170. Key measures to avoid and minimise these impacts are described below and should be implemented as part of the Environmental Monitoring and Management Plan (EMMP) during the construction phase.

6.2.9.2.1 Avoid

In addition to minimum controls in **Section 6.2.7**, **Table 6-38** provides a summary of the key recommended measures to avoid biodiversity impacts during the construction phase.

Table 6-38: Key Recommended Measures to Avoid Biodiversity Impacts during Construction Phase

Receptors	Impact Types	Mitigation Measures
Habitats Flora species Faunal species	• Loss of vegetation • Loss of/reduction in habitats and food sources • Mortality of floral receptors	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite. • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible.

Receptors	Impact Types	Mitigation Measures
Habitats	• Habitat degradation	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, and associated works, outside of worksite. • Ensure that minimum control measures as well as engineering controls are in place to prevent contamination and siltation into the sensitive habitats and waterways (see **Section 5.5**). • Ensure any associated slope stabilisation and grading works will not impact topography of areas outside worksite and, water quality and hydrology of the conserved waterbodies within the EIA Study Area.

6.2.9.2.2 Minimise

In addition to minimum controls in **Section 6.2.7**, **Table 6-39** below provides a summary of the key recommended measures to minimise biodiversity impacts during the construction phase.

Table 6-39: Key Recommended Measures to Minimise Biodiversity Impacts during Construction Phase

Receptors	Impact Types	Mitigation Measures

Habitat	• Loss of vegetation
	• Habitat degradation
		• Conduct regular inspections to ensure contractor compliance to the EMMP, with oversight by the Developing Agency.
		• Ensure minimum control measures stated in **Section 6.2.7** are properly implemented. This includes soil erosion measures, dust control measures, installation of tree protection zones, pre-felling fauna inspection and wildlife response plan.
		• Ensure silt fences and other silt control measures along the worksite hoarding are installed and maintained properly to prevent siltation into conserved waterbodies.
		• Retain ground cover for as long as possible before removal. When ground cover is removed, ECM is to be in place.
		• Ensure no encroachment into forest adjacent to DE170 Contract Boundary
		• Conduct monitoring to identify any impacts to habitats within forest adjacent to DE170 Contract Boundary. This may include:
		  o Visual inspection of terrestrial and aquatic habits
		  o Visual inspection for forest edge effects

Floral species	• Mortality of floral receptors • Decline in plant health	• Transplant or harvest or propagate trees/ saplings of conservation significance if they are to be cleared • Engage flora specialist to monitor health of transplanted individuals • Engage with a certified arborist if pruning is needed for any tree specimens • Conduct regular arboricultural inspections to monitor the health of the retained specimens, if any. • Conduct regular inspections to ensure contractor compliance to the EMMP
Faunal species	• Loss of/reduction in habitats and food sources • Loss of/reduction in ecological	• Conduct pre-felling fauna inspection prior to clearance of affected Ardisia elliptica to rescue caterpillars, larvae and pupae of the harlequin butterfly present on the plants • Implement passive wildlife shepherding through directional site clearance • Establish a Wildlife Response Plan in consultation with NParks Animal Management Centre, to be executed during encounters with trapped, injured or dead wildlife, as well as incidents of human-wildlife conflict

Receptors	Impact Types	Mitigation Measures
	connectivity for faunal movement • Accidental injury or mortality • Human-wildlife conflict	• Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes • Adopt road calming measures such as speed bumps and speed limits to minimise roadkill accidents o During construction phase, vehicular traffic is expected to increase from the development. Speed limits (15–20 km/h) should be adhered to strictly. o In addition, speed bumps could be integrated on key access routes within the site to prevent speeding. • Ensure integrity of hoarding o To minimise entry of fauna into the DE170 Contract Boundary, the integrity of hoarding must be maintained at all times. Gaps in hoarding facilitates entry of fauna into the construction site. Regular inspections should be conducted to ensure there are no gaps in hoarding at all times. • Train site personnel on biodiversity awareness and actions to take when encountering wildlife • Ensure good housekeeping controls such as provision of wildlife-proof bins and indoor eating areas • Conduct regular inspections to ensure contractor compliance to the EMMP and identify potential faunal entrapments • Establish a temporary wildlife crossing to allow faunal movement between forested areas adjacent to DE170 Contract Boundary at night when there are no works (Figure 6-44).
Faunal species	• Light disturbances	• Restrict working hours to 0800H–1800H • Implement lighting plan for night works • Minimise night-time works particularly during bird migratory season (September to February) • Where night-time works are unavoidable, adopt the following measures: o Review construction method statements and site lighting plan with the EMMP Specialist and Ecologist before the commencement of night works and where necessary o Reduce light spillage into adjacent areas by adopting the following measures: o Worksite hoarding to be opaque, and dark-coloured where possible o Increase the height of worksite hoarding, especially in areas adjacent to natural areas o Ensure that no light sources are directly visible from the forest edge as much as possible o Ensure that lighting is only used where really necessary; remainder of worksite to remain dark as much as possible o Lighting to be directed downwards to reduce light spillage upwards, as it may impact migratory birds o To establish a wildlife response plan to be executed when fauna (e.g., disoriented birds) is found on-site during night-time works • For lighting equipment, consider:

Receptors	Impact Types	Mitigation Measures
		o Using warm lighting where possible during construction works after 6 pm (i.e., soft white and warm white light bulbs, preferably at < 2,700 K) o Avoid using high UV and broad-spectrum lights (except for safety reasons)
Faunal species	• Human disturbances	• No entry of site personnel to vegetated areas outside of the agreed working space, including forest adjacent to DE170 Contract Boundary and other parts of Tengah forest.
Harlequin butterfly	• Loss/reduction of ecological connectivity for faunal movement	• Replant cultivated *Ardisia elliptica,* host plant for the CS butterfly species to restore connectivity within Tengah forest.

As part of the effort to minimise impacts of loss of/reduction in habitats and food sources to the harlequin butterfly, additional planting of the *Ardisia elliptica* is proposed within a 30m by 5m vegetation patch that will be retained within the DE170 Contract Boundary. The 30m by 5m proposed planting area is also located nearer where the *Ardisia elliptica* and harlequin butterfly are found. Sixty individuals (new specimens) are to be planted at least 3 weeks before site clearance of affected *Ardisia elliptica*. The new *Ardisia* plants should also be planted as close to the adjacent forest boundary as much as possible (i.e., away from the work site), where there is no vegetation clearance, to provide the harlequin with the optimal shady conditions that the harlequin require. Prior to site clearance of affected *Ardisia elliptica*, Ecologist(s) are to conduct pre-felling fauna inspection to rescue any caterpillars, larvae and pupae present on the plants, which will be shifted over to the proposed planting area. After this is completed, the affected *Ardisia elliptica* present within the DE170 Contract Boundary may then be cleared.

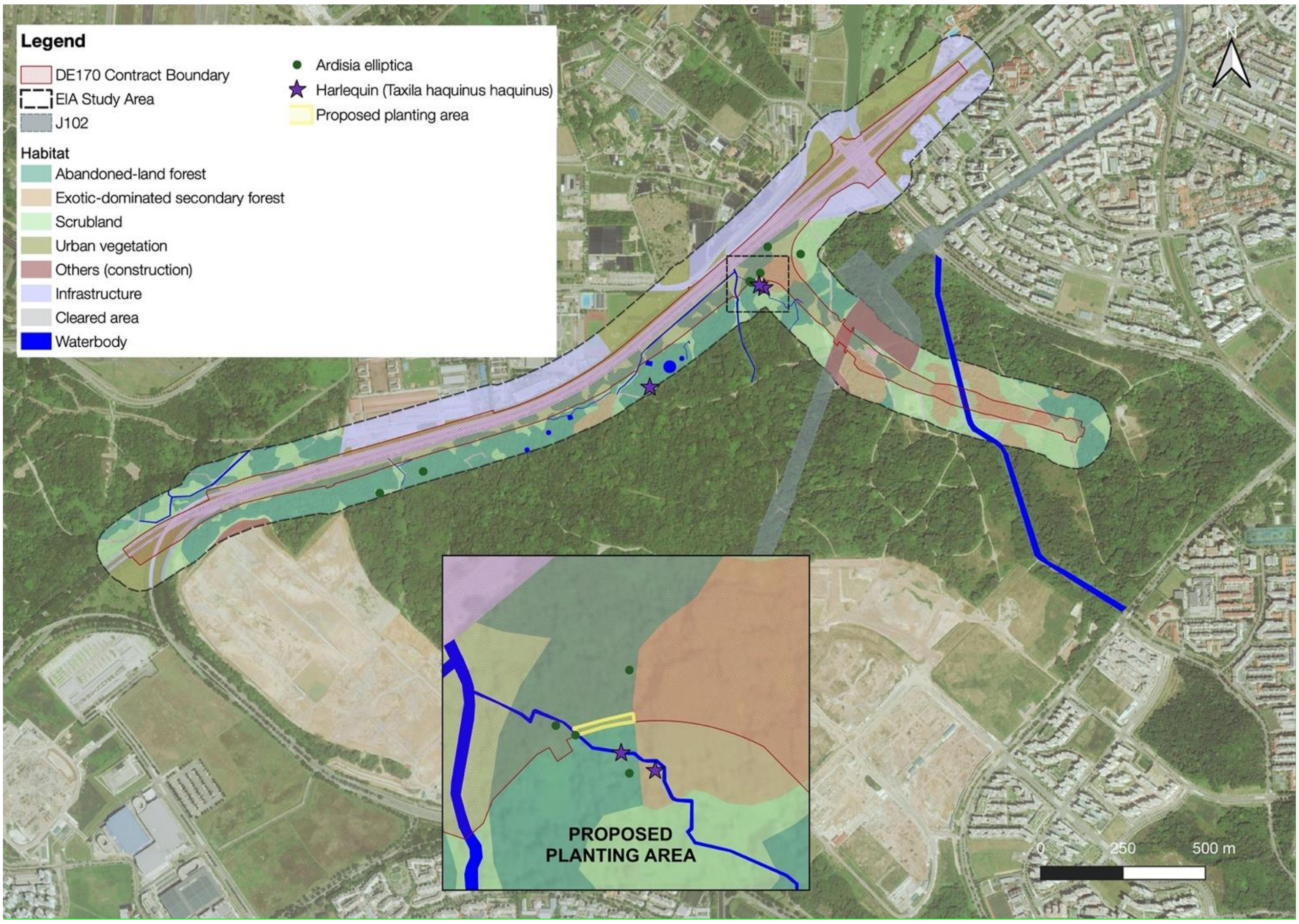


Figure 6-43: Proposed 30m by 5m Planting Area

As multiple concurrent developments will take place in Tengah Town, consideration will need to be taken to maintain ecological connectivity throughout the site, and the establishment of wildlife crossing is recommended. A temporary wildlife crossing is recommended to be established in the eastern part of the DE170 Contract Boundary (**Figure 6-44**). An illustration of a temporary wildlife crossing is provided in **Figure 6-45** and **Figure 6-46**, and detailed below:

- The temporary wildlife crossing should be at least 6-m wide.
- There should be no clearance of vegetation at the entry and exit of the wildlife crossing. Planting at the entry and exit of the wildlife crossing, if necessary, could be considered to improve the quality of the wildlife crossings for fauna.
- The temporary wildlife crossing should be closed during construction hours (0800–1800h) and opened after construction hours (1800–0800h) daily, or when there are no works in the area.
- Prior to the temporary wildlife crossing being closed in the morning, Contractor to walk the entire length of the crossing and ensure that no fauna remains within the crossing; the Wildlife Response Plan to be activated if fauna is presence (**Figure 6-49**).
- Two camera traps should be deployed at the temporary wildlife crossing during the entire period of construction phase to monitor for wildlife usage (**Figure 6-46**). The data from the camera trap will be retrieved monthly.

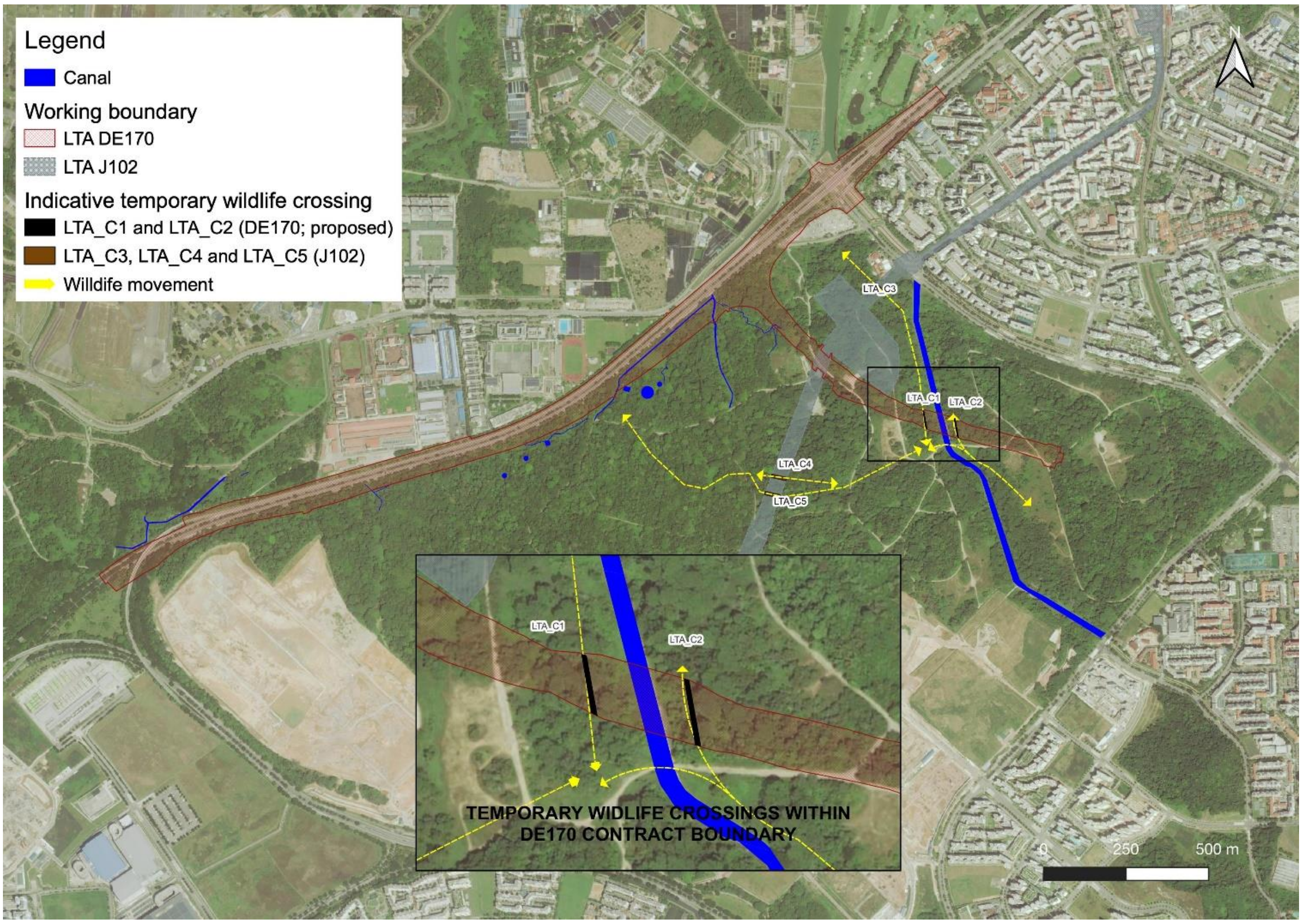


Figure 6-44: Proposed Wildlife Crossings Within DE170 Contract Boundary and Adjacent Projects

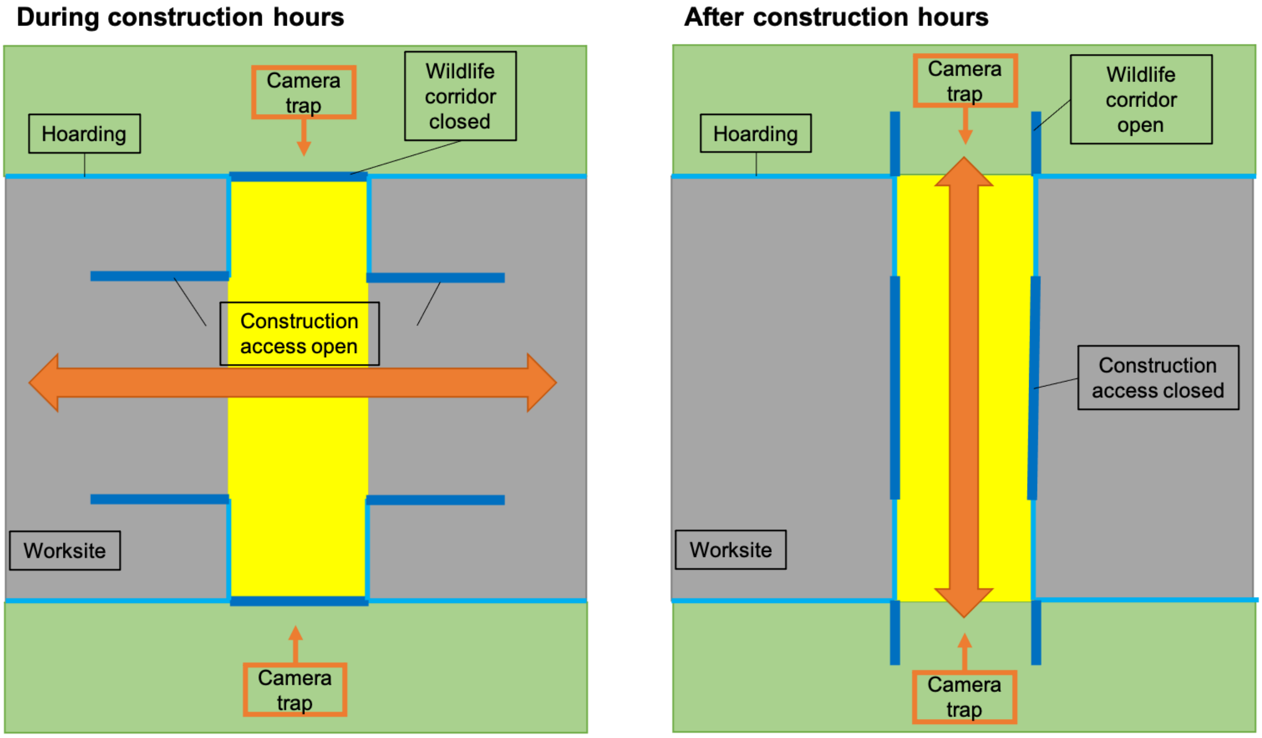


Figure 6-45: Diagrammatic Representation of A Wildlife Crossing with Indicative Location of Camera Traps

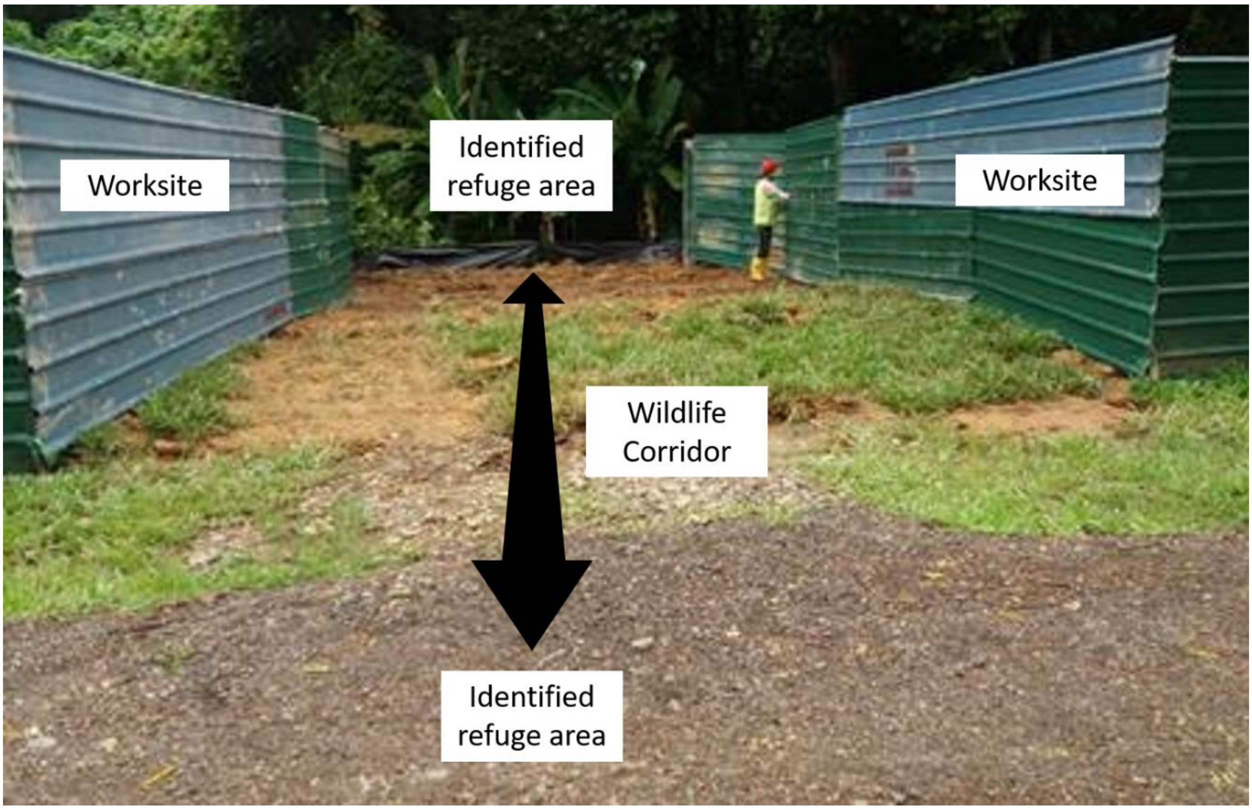


Figure 6-46: Example of a wildlife crossing when opened after construction works

6.2.9.3 Operational Phase

6.2.9.3.1 Minimise/Rehabilitate

In addition to minimum controls in Section **6.2.7, Table 6-40** below provides a summary of the key recommended measures to minimise biodiversity impacts during the operational phase.

Table 6-40: Key Recommended Measures to Minimise Biodiversity Impacts during the Operational Phase

Receptors	Impact Types	Mitigation Measures
Floral species	• Change in plant species composition • Competition from exotic species	• Unused areas and/ or areas which was cleared for works during the construction should be replanted. Adopt a native planting palette considering the existing and surrounding vegetation
Faunal species	• Noise disturbances • Light disturbances	• Minimise light spills of street lamps to forest adjacent to DE170 Contract Boundary • Dense planting along roads to minimise noise and light disturbances to fauna within forest adjacent to DE170 Contract Boundary

6.2.10 Evaluation of Residual Impacts

6.2.10.1 Construction Phase

6.2.10.1.1 Habitats

During the construction phase, loss of vegetation will result in Major negative impact significance and change in species composition will result in Moderate negative impact significance as discussed in **Section 6.2.8.2.1**. Both of these impacts are permanent, irreversible and cannot be mitigated and therefore the highest negative post-mitigation residual impact remains at Major (**Table 6-41**).

Table 6-41: Summary of Residual Impacts to Habitat Receptors during Construction Phase

Potential Ecological Impact	Habitat Receptor	Env. Score (pre-mitigation)	Impact Significance	Mitigation Measures	Env. Score (post-mitigation)	Residual Impact Significance
Loss of vegetation/ habitat	Abandoned-land Forest	-351	Major Negative Impact	No applicable mitigation measures	-351	Major Negative Impact
	Exotic-dominated Secondary Forest	-234	Moderate Negative Impact		-234	Moderate Negative Impact

Potential Ecological Impact	Habitat Receptor	Env. Score (pre-mitigation)	Impact Significance	Mitigation Measures	Env. Score (post-mitigation)	Residual Impact Significance
Loss of vegetation/ habitat	Scrubland	-117	Minor Negative Impact		-117	Minor Negative Impact
	Urban Vegetation	-117	Minor Negative Impact		-117	Minor Negative Impact
	Closed-canopy stream (A1, A11, downstream of A12, A13)	-234	Moderate Negative Impact		-234	Moderate Negative Impact
	Open-country stream (A10)	-234	Moderate Negative Impact		-234	Moderate Negative Impact
	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	-156	Moderate Negative Impact		-156	Moderate Negative Impact
	Open-country pond (A9)	0	No change		0	No change
	Canal with naturalised sections (A2, upstream of A12)	0	No change		0	No change
Habitat degradation	Abandoned-land Forest	-30	Slight Negative Impact	Regular site inspection by Ecologist	-30	Slight Negative Impact
	Exotic-dominated Secondary Forest	-20	Slight Negative Impact		-20	Slight Negative Impact
	Scrubland	-10	Slight Negative Impact		-10	Slight Negative Impact
	Urban Vegetation	-10	Slight Negative Impact		-10	Slight Negative Impact
	Closed-canopy stream (A1, A11, downstream of A12, A13)	-20	Slight Negative Impact		-20	Slight Negative Impact
	Open-country stream (A10)	-40	Slight Negative Impact		-40	Slight Negative Impact
Habitat degradation	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	-20	Slight Negative Impact		-20	Slight Negative Impact
	Open-country pond (A9)	0	No change		0	No change
	Canal with naturalised sections (A2, upstream of A12)	-10	Slight Negative Impact		-10	Slight Negative Impact

Potential Ecological Impact	Habitat Receptor	Env. Score (pre-mitigation)	Impact Significance	Mitigation Measures	Env. Score (post-mitigation)	Residual Impact Significance
Change in species composition	Abandoned-land Forest	-216	Moderate Negative Impact	No applicable mitigation measures	-216	Moderate Negative Impact
	Exotic-dominated Secondary Forest	-144	Moderate Negative Impact		-144	Moderate Negative Impact
	Scrubland	-72	Minor Negative Impact		-72	Minor Negative Impact
	Urban Vegetation	-72	Minor Negative Impact		-72	Minor Negative Impact
	Closed-canopy stream (A1, A11, downstream of A12, A13)	-144	Moderate Negative Impact		-144	Moderate Negative Impact
	Open-country stream (A10)	-144	Moderate Negative Impact		-144	Moderate Negative Impact
	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	-144	Moderate Negative Impact		-144	Moderate Negative Impact
	Open-country pond (A9)	0	No change		0	No change
	Canal with naturalised sections (A2, upstream of A12)	-66	Minor Negative Impact		-66	Minor Negative Impact

6.2.10.1.2 Flora

During construction, **Major Negative** impact significance is expected from mortality. With implementation of mitigation measures, i.e., transplantation of flora specimens, this could be reduced to **Minor Negative**. However, it is to note that this impact significance does not account for the success rate of transplantation or/and salvaging procedures as this is determined by several external factors such as adaptation of the specimens and/or microclimate condition of the new relocation venue.

The residual impact significance for impediment to seedling recruitment and competition to exotic species remains as **Moderate Negative** as mitigation measures, i.e., planting and restoration of adjacent forest, is not being planned for.

The residual impact significance for all impact types is summarised on **Table 6-42**.

Table 6-42: Summary of Construction Phase Residual Impacts to Flora Receptors with Number indicating Number of Species

Impact type	No Change	Slight Negative	Minor Negative	Moderate Negative	Major Negative
Mortality	25	1	9	—	—

Impact type	No Change	Slight Negative	Minor Negative	Moderate Negative	Major Negative
Impediment to seedling recruitment	17	6	12	—	—
Competition from exotic species	21	2	12	—	—
Decline in plant health and survival	17	6	8	4	—

6.2.10.1.3 Fauna

During construction phase, the loss of/ reduction in habitats and food sources will result in **Major Negative** impact significance for the butterfly, harlequin (*T. haquinus haquinus*). Post-mitigation, it could be brought down to **Moderate Negative** impact significance with transplant of the butterfly's host plant, *Ardisia elliptica*

During construction, accidental injury or mortality, and loss/reduction of ecological connectivity for faunal movement will result in **Moderate Negative** impact significance. By reinforcement of Wildlife Response Plan and biodiversity awareness training, and provision of temporary wildlife crossing to provide faunal connectivity for the respective impacts, the impacts can be reduced to **Minor Negative** impact significance.

Lastly, the impact significance from light disturbances remains at **Moderate Negative** as the frequency of night works remain at a moderate level.

The residual impact significance for all impacts is summarised on **Table 6-43**.

Table 6-43: Summary of Construction Phase Residual Impacts to Fauna Receptors with Number indicating Number of Species

Impact Type	No Change	Minor Negative	Moderate Negative	Major Negative
Light disturbances	0	15	35	0
Loss of/reduction in habitats and food sources	0	22	28	0
Loss/reduction of ecological connectivity for faunal movement	0	50	0	0
Accidental injury or mortality	0	50	0	0
Human disturbances	0	50	0	0
Human wildlife conflict	0	50	0	0

6.2.10.2 Operational Phase

6.2.10.2.1 Habitat

During operational phase, five habitat types including closed-canopy and open-country streams, closed-canopy and semi open country ponds, exotic-dominated secondary forest and abandoned-land forest are expected to have **Moderate Negative** impacts due to change in plant species composition. Since no planting plans are considered, the impact significance remains at **Moderate Negative** post-mitigation (**Table 6-44**). Impacts from habitat degradation is expected to have **Slight Negative** to **Minor Negative** impact significance.

Table 6-44: Summary of Residual Impacts to Habitat Receptors during Operational Phase

Potential Ecological Impact	Habitat Receptor	Env. Score (pre-mitigation)	Impact Significance	Mitigation Measures	Env. Score (post-mitigation)	Residual Impact Significance
Change in plant species composition	Abandoned-land Forest	-198	Moderate Negative Impact	Not applicable (since no planting is planned)	-198	Moderate Negative Impact
	Exotic-dominated Secondary Forest	-132	Moderate Negative Impact		-132	Moderate Negative Impact
	Scrubland	-66	Minor Negative Impact		-66	Minor Negative Impact
	Urban Vegetation	-66	Minor Negative Impact		-66	Minor Negative Impact
	Closed-canopy stream (A1, A11, downstream of A12, A13)	-132	Moderate Negative Impact		-132	Moderate Negative Impact
	Open-country stream (A10)	-132	Moderate Negative Impact		-132	Moderate Negative Impact
	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	-132	Moderate Negative Impact		-132	Moderate Negative Impact
	Open-country ponds (A9)	-66	Minor Negative Impact		-66	Minor Negative Impact
	Canal with naturalised sections (A2, upstream of A12)	-66	Minor Negative Impact		-66	Minor Negative Impact
Habitat degradation	Abandoned-land Forest	-33	Minor Negative Impact	No applicable mitigation measures	-33	Minor Negative Impact
	Exotic-dominated Secondary Forest	-22	Minor Negative Impact		-22	Minor Negative Impact
	Scrubland	-11	Slight Negative Impact		-11	Slight Negative Impact
	Urban Vegetation	-11	Slight Negative Impact		-11	Slight Negative Impact
	Closed-canopy stream (A1, A11, downstream of A12, A13)	-22	Minor Negative Impact		-22	Minor Negative Impact
	Open-country stream (A10)	-22	Minor Negative Impact		-22	Minor Negative Impact
	Closed-canopy & semi open-country ponds (A3, A4, A5, A6, A7, A8)	-22	Minor Negative Impact		-22	Minor Negative Impact
	Open-country pond (A9)	-11	Slight Negative Impact		-11	Slight Negative Impact
	Canal with naturalised sections (A2, upstream of A12)	-11	Slight Negative Impact		-11	Slight Negative Impact

6.2.10.2.2 Flora

Since there are no plans for planting of adjacent forest (e.g., in-fill planting or graded canopy line planting) adjacent to the EIA Study Area, impacts from changes in microclimatic conditions cannot be mitigated. Therefore, impact significance remains as **Moderate Negative** for 12 flora species.

None of the flora receptors were deemed to have **Major Negative** or **Moderate Negative** impact significance during operation phase for poaching and competition from exotic species. The residual impact significance is summarised on **Table 6-45.**

Table 6-45: Summary of Operational Phase Residual Impacts to Flora Receptors with Number indicating Number of Species

Impact Type	No Change	Slight Negative	Minor Negative	Moderate Negative	Major Negative
Mortality	17	5	1	12	—
Poaching	35	—	—	—	—
Competition from exotic species	21	1	13	—	—

6.2.10.2.3 Fauna

During operational phase, impact significance from light disturbances is expected to be **Moderate Negative**. With lighting strategies in place to minimise ecological light pollution from street lamps, it is possible to reduce the impact significance to **Minor Negative**. Similarly, impact significance from accidental injury or mortality (i.e., roadkill) could be reduced from **Moderate Negative** to **Minor Negative** with integration of speed-calming measures (speed bumps and speed limits). The residual impact significance is summarised on **Table 6-46**.

Table 6-46: Summary of operational phase residual impacts to fauna receptors with number indicating number of species

Impact type	No Change	Minor	Moderate	Major	Minor
	Negative				Positive
Accidental injury or mortality	37	13	0	0	0
Human disturbances	50	0	0	0	0
Human wildlife conflict	50	0	0	0	0
Light disturbances	0	50	0	0	0
Poaching	50	0	0	0	0
Loss/reduction of ecological connectivity for faunal movement	0	47	0	0	3

6.2.11 Environmental Management and Monitoring Plan (Biodiversity)

6.2.11.1 Flora and Arboriculture Monitoring & Management Programme

6.2.11.1.1 Construction Phase

The flora and arboriculture monitoring aims to assess the impacts of construction to retained vegetation and habitat (i.e., adjacent forest), such as tree health, unauthorised and/ or excessive vegetation removal, edge effects, habitat degradation from soil erosion, and rubbish dumping. The programme should include the following:

- Assess impact of construction on the physiological health and structural stability of vegetation and trees at proximity to the development.
- Identify excessive and unauthorized removal of vegetation and trees beyond the development boundary.
- Monitor and assess potential edge effects (e.g., predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to the development. Make recommendations on mitigating measures where necessary.
- Identify mechanical damage to the trees beyond the development boundary from nearby construction. These would include damage to the canopy, trunk or roots that may impair the structural stability of the trees.
- Visual inspection for soil erosion locations that resulted from construction activities.
- Identify unauthorized dumping of rubbish (e.g., food materials), construction debris and materials, oil/chemical leakage that may contaminate soil and water bodies.

The flora and arboriculture management programme aim to manage all matters related to the adequate and successful conservation of trees and vegetation within and adjacent to the contract boundary (up to 15-m from the contract boundary). The programme should include the following works:

- Conduct inspections at least once a month at construction sites to: ensure tree conditions have not deteriorated; check that integrity of the Tree Protection Zone (TPZ) has not been compromised; verify no mechanical damage to trees has occurred, and; monitor for edge effects at new forest edge.
- Provide a brief monthly report with recommendations of mitigating measure(s) if any. Reports should include photos of tree and condition of TPZs.
- Assessment to determine the need for additional tree removal due to construction constraints and liaise with NParks for permission to remove roots where necessary.
- Review method statements from builders for construction at proximity to trees.
- Liaise and coordinate with selected tree works contractor to carry out tree pruning works and carry out inspection to ensure that works is carried out to NParks' standards.
- Work with architects and structural engineer on design changes and structural solutions at proximity to the trees that will meet NParks' guidelines and help justify the works within the tree protection zone if necessary.

The flora specialists and arborists engaged should meet the following requirements:

- The flora specialist and arborist should have at least 10 years' relevant experience and demonstrate experience in developments of similar forested context, size, and construction complexity;
- The Arboriculture Contractor should meet NParks' safety requirements for work at height and LTA's requirements for temporary works along roadsides. All arboriculture workers engaged by the Arboriculture Contractor to perform tree climbing and chainsaw work shall possess a valid basic tree climbing certification

based upon demonstrated competence in the Workforce Skills Qualifications (WSQ) module conducted by CUGE or an equivalent WSQ-approved training organisation; and

- The arboriculture crew deployed by the Arboriculture Contractor for the Contract shall possess the following valid competences:
    - Operation of chainsaw for ground work (LS-MT-103E-1)
    - Chainsaw safety and maintenance (LS-MT-102E-1)
    - Perform formative pruning of young trees (LS-MT-114E-1)
    - Provide Arboriculture support on site (LS-MT-116E-1)
    - Workplace safety and health – operators (ES-WSH-101G-1)
    - Respond to Emergency (LS-HM-208E-1)
    - Perform advance rigging and climbing techniques (LS-HM-308S-1)
    - Perform aerial tree access and aerial rescue skills (LS-HM-204S-1)
    - Implement and apply appropriate risk and safety management to sector practices (LS- BP-301S-1)
    - Prepare risk assessment report (LS-HM-406S-1)
    - Operate and work from an elevated work platform (CUGE-ARB-3501)

Additionally, the Contractor should fulfil the following:

- The Contractor and the attending arborist shall complete the 'Verification of Tree Protection Checklist' prior to the start of site clearance (refer to **Appendix 6I: Annex A**).
- The Contractor shall instil discipline and raise awareness amongst all personnel on measures and mitigations to prevent damage to retained and protected trees throughout construction by including reminders on tree conservation guidelines within their daily toolbox briefings to workers and crane/ excavator operators.

6.2.11.1.2 Operational Phase

During the operational phase, the flora and arboriculture monitoring could focus on assessing forest edge effects to forest adjacent to DE170 Contract Boundary. This includes examination of tree health in proximity to development. Further management measures such as planting could be carried out to manage forest edge effects. This should be done in consultation with NParks since forest adjacent to DE170 Contract Boundary will be managed by NParks.

6.2.11.2 Fauna Monitoring and Management Programme

Faunistic surveys within the forest adjacent to DE170 Contract Boundary as well as site inspections within the construction site are recommended to be conducted on a monthly basis. The objective is to monitor for possible changes in faunal community using the forest adjacent to DE170 Contract Boundary. The surveys may begin one month prior to construction and extend to two months after reinstatement. The surveys should be developed by fauna specialists and incorporated into the EMMP.

Fauna management consists of managing of concerns related to fauna within and around all designated work areas. It includes pre-site clearance inspections, pre-felling tree inspections for fauna, regular biodiversity awareness training for the site team and workers, and wildlife response plan in event of animal encounters. The objectives of fauna management are as follows:

- Minimize negative impacts to fauna, particularly to species of conservation interest.

- Inspect hoarded areas for any compromises that may allow smaller-sized animals to enter.
- Prevent human-wildlife conflicts.
- Monitor presence of trapped/injured/dead fauna inside hoarded areas.
- Monitor and compare presence of targeted fauna groups within and outside of hoarded areas.

6.2.11.2.1 Construction Phase

a) Site Inspection

The following should be inspected for during monthly fauna site inspections by Ecologist and daily/ regular site inspection conducted by the Environmental Checker and contractor's ECO/ EMMP team:

- Visual inspection of sensitive habitats in the vicinity (e.g., streams, forests) to determine possible impacts from construction.
- Visual checks that construction works are limited to within agreed boundaries, and that construction slurry, chemicals and fuel are contained.
- Visual checks for animal entrapments on-site, particularly within TPZs, ECM sedimentation tanks, erosion control blankets and among construction materials and equipment.
- Inspection of site hoarding to ensure that integrity is maintained throughout the duration of the construction to prevent entry of ground-dwelling fauna.
- Reporting and documentation of all findings and recommendations.

b) Pre-site Clearance Inspection and Wildlife Shepherding

Pre-site clearance inspection involves wildlife shepherding and directional vegetation clearance to passively shepherd animals out of the site, as well as pre-felling tree inspections for fauna before a tree is felled. This minimizes fauna injury and mortality during tree felling and vegetation clearance. In addition, site clearance should be executed outside of the key bird breeding season (March to July) where possible. The protocol for pre-felling tree inspection for fauna is shown in **Figure 6-47** and an example of the pre-felling fauna inspection form is provided in **Appendix 6J**.

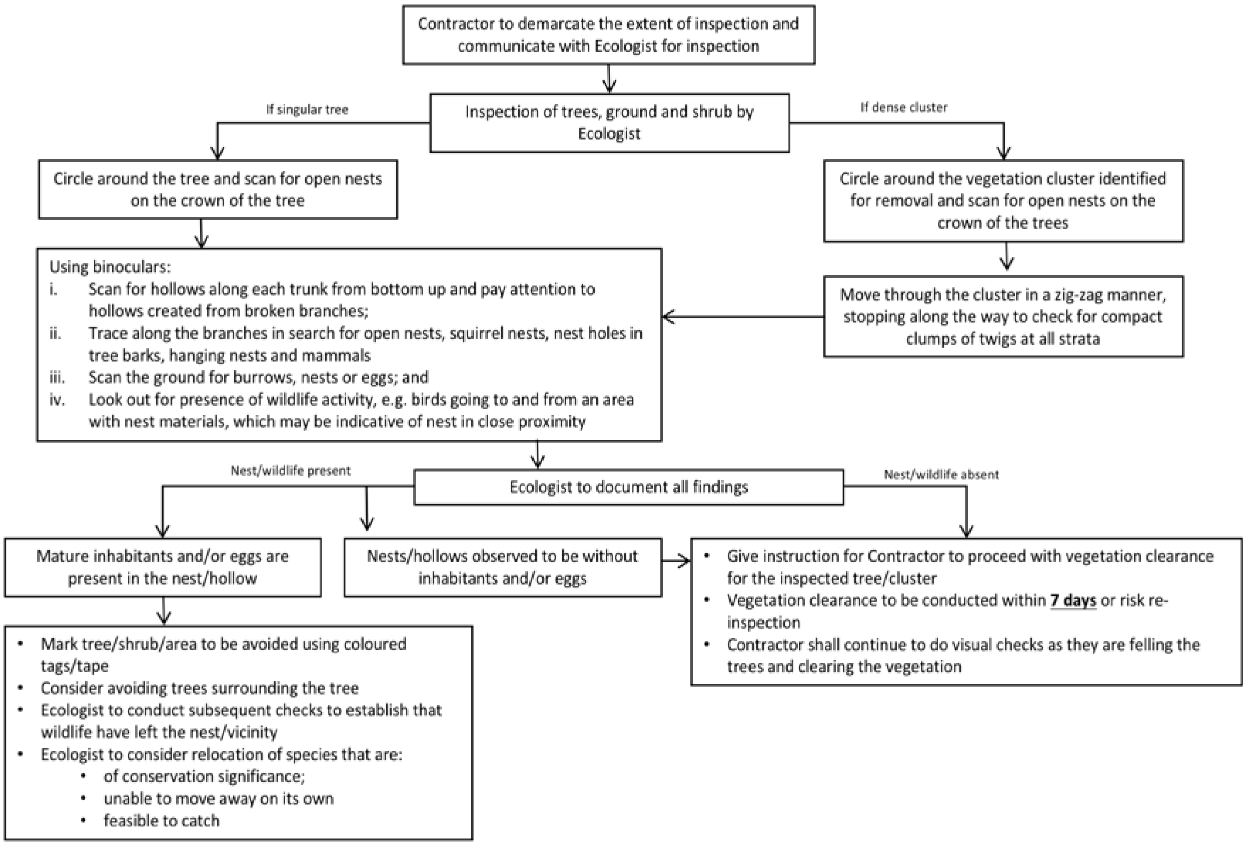


Figure 6-47: Pre-felling Inspection Protocol

During site clearance, passive wildlife shepherding should be carried out via directional site clearance. This involves the clearance of vegetation towards a forested wildlife refuge area. The disturbance generated by site clearance activities is expected to encourage target fauna to move out of the worksite on their own. The objective is to remove target fauna from the worksite before construction works begin to prevent fauna entrapment, injury and mortality, whilst minimising contact between human and wildlife. Target fauna species include ground-dwelling mammals such as the Eurasian wild boar (*Sus scrofa*) and Sunda pangolin (*Manis javanica*), as well as animals that may be implicated in human-wildlife conflicts (e.g., snakes) during passive wildlife shepherding.

Directional site clearance is expected to be carried out for Zone 4, followed by Zone 1, Zone 3, Zone 5 and lastly, Zone 2.

The general proposed sequence and details for directional site clearance is provided below.

i) Hoarding installation

- All zones should be hoarded up with 2.4 m zinc sheets. Subsequently, each zone should be partitioned into smaller parcels (0.5 to 4 ha) for ease of management of directional site clearance. Temporary barriers that are sturdy and at least 1.8m can be used as internal partitions.
- Allow for a 6-m wide exit point in the hoarding where directional site clearance will move towards, to allow exit of fauna. The exit point should be situated at wildlife refuge areas, away from roads and construction activities as much as possible.
- The hoarding must not have any gaps between the panels and are to extend at least 300 mm into the ground.
- The access gates, when shut, must not have any gaps between the panels and must be flushed as close to the ground as possible.

ii) Pre-site clearance fauna inspection

- Prior to site clearance, the Ecologist shall conduct a fauna inspection in areas slated for clearance.
- If fauna is found present, the Wildlife Response Plan is to be activated.

iii) Directional site clearance

- If site clearance is not completed at the end of the day, the exit point should be closed. Subsequently, if the site clearance for the partition has been completed, the exit point can be sealed.
- An example of clearance direction is shown in **Figure 6-48**.

iv) Post-site clearance fauna inspection

- After site clearance has been completed, the Ecologists will visually inspect the site for presence of target fauna species (i.e., ground-dwelling birds and snakes). If there are no remaining fauna on site, the site clearance is then completed. If there are remaining fauna on-site, the Ecologists to develop methods to remove them in consultation with the Contractor and relevant authorities (e.g., NParks).

Prior to site clearance (of affected *Ardisia elliptica*), Ecologist(s) are to conduct pre-felling fauna inspection to rescue any caterpillars, larvae and pupae present on the plants. They will be shifted over to the new 30m by 5m planting area (see **Section 6.2.9.2.2**). The planting area should be established at least 3 weeks prior to site clearance (see **Section 6.2.9.2.2**). Monthly monitoring is recommended to monitor for unauthorised clearance to the proposed planting area, as well as to monitor for the presence of the harlequin butterfly.

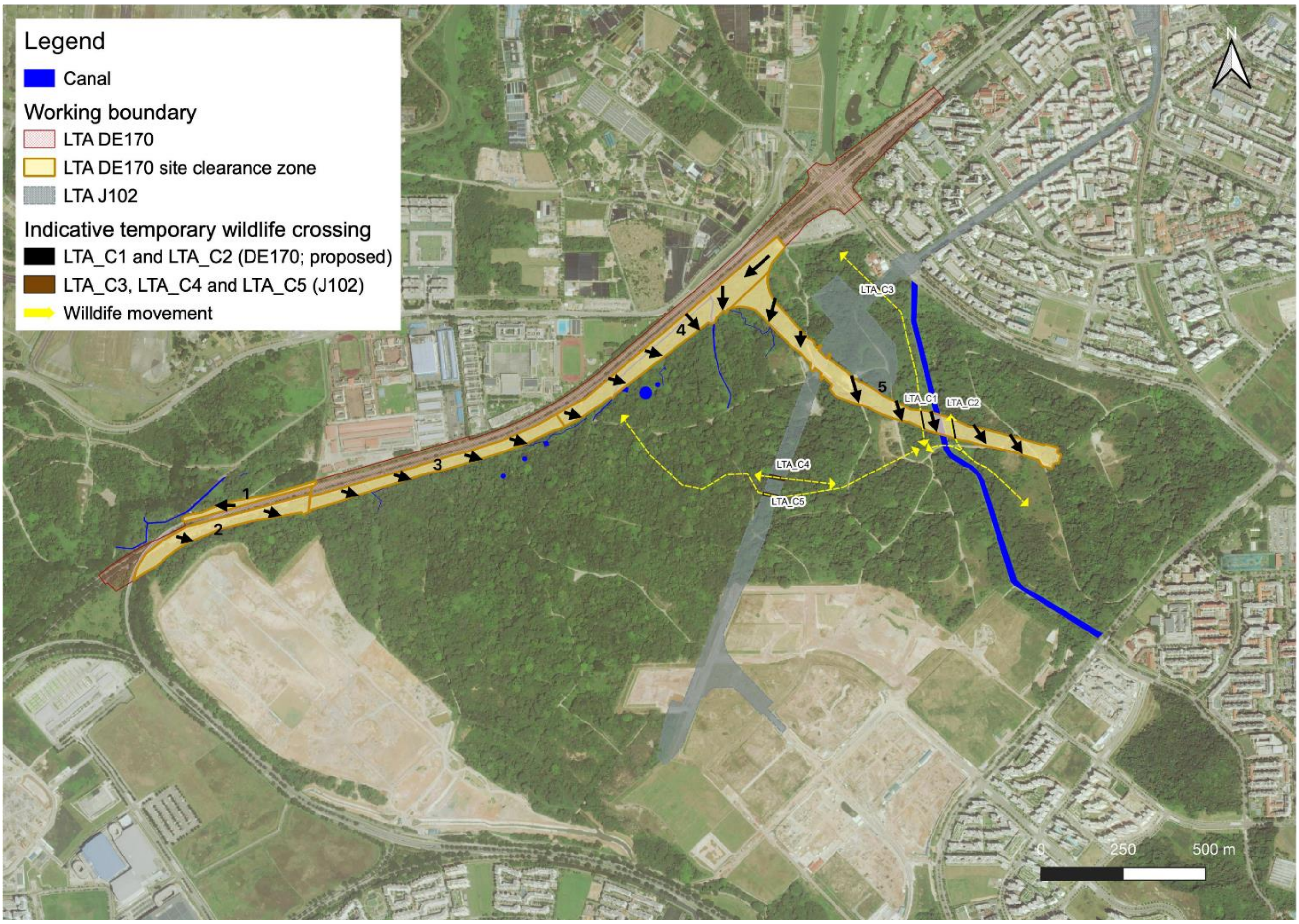


Figure 6-48: Proposed Direction of Passive Wildlife Shepherding through Directional Site Clearance

c) Wildlife Response Plan

The Wildlife Response Plan (**Figure 6-49**) should be executed when a trapped/ injured/ dead/ dangerous animal is encountered around or within the worksite. The objective of the wildlife response plan is to minimise animal injury and mortality by responding appropriately to the different scenarios in **Figure 6-49**. This should be emphasized during the toolbox briefings. All wildlife encounters are to be documented within 24 h using the Wildlife Incident Form (**Appendix 6M**).

Where species of conservation significance are affected by the development, relocation works should be planned (e.g., bamboo bats). where fauna is trapped on-site, options should be explored to remove them from site (e.g., partitioning worksite, use of one-way exit door) (**Figure 6-50**).

In scenarios where certain animal groups are encountered around or within the worksite, external specialists may be contacted to handle the animal. These scenarios are shown below:

- For snakes that require relocation/handling, a trained specialist should be contacted
- For animal carcasses that require disposal, an animal carcass disposal service should be contacted
- For injured animals that require medical attention, a veterinarian should be contacted

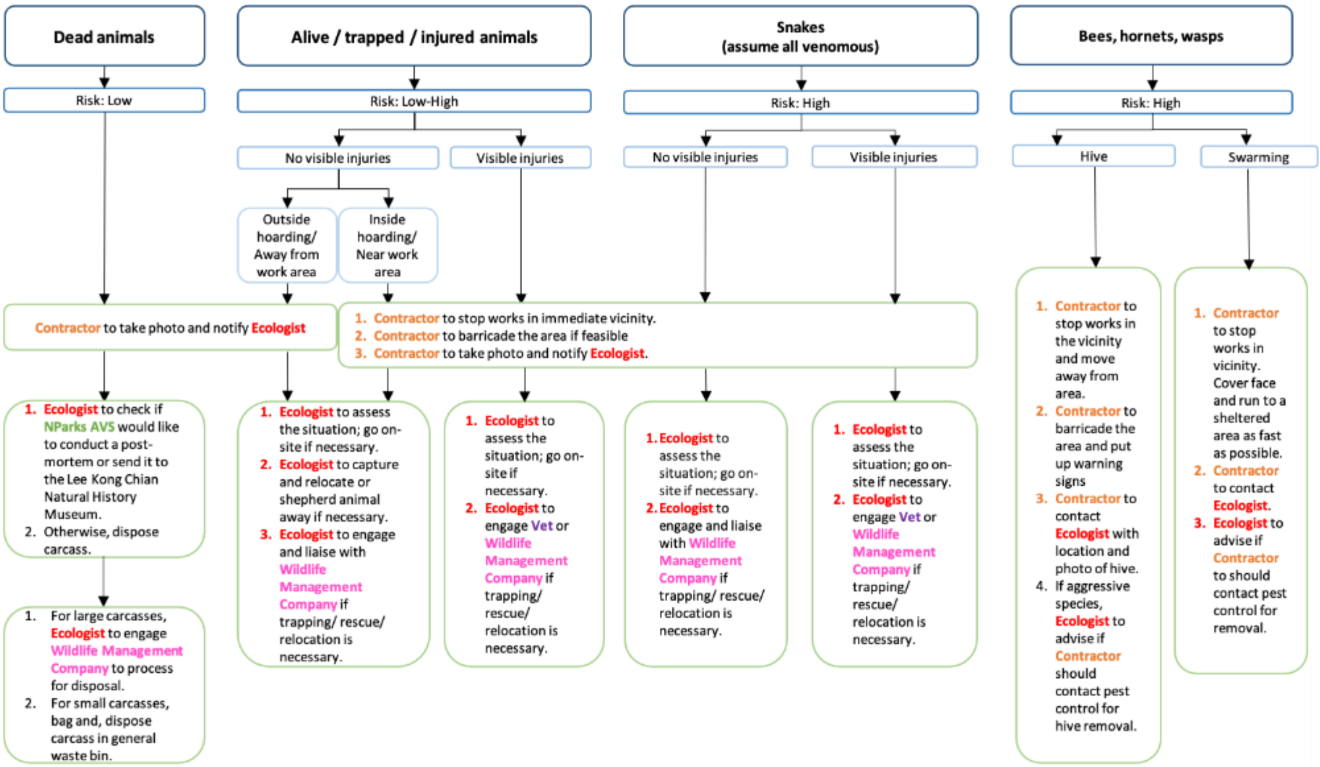


Figure 6-49: A Flowchart of the Wildlife Response Plan

Figure 6-50: Example of One-way Flap Door to allow Fauna to Exit Independently

d) Biodiversity Awareness Trainings

The Ecologist shall conduct regular toolbox briefing to inform site personnel of their responsibilities towards minimising impacts to wildlife and protocol for wildlife encounters.

6.2.11.2.2 Operational Phase

The fauna monitoring aims to assess the impacts of operational works to fauna residing within adjacent forest, and rectify possible issues identified. Faunistic surveys could be carried out to monitor for changes in faunal assemblage from that of baseline or construction phase. It may be required to monitor trees, flora and fauna for at least two months after reinstatement to review the effectiveness of the implemented mitigation measures and rectify problems identified. This should also be done in consultation with NParks as the forest adjacent to the DE170 Contract Boundary would be managed by NParks.

7. Assessment of Ambient Air Quality

This section describes the regulations and standards for air pollution control that are applicable to the Project development during the various Project phase activities and the methodology used for the baseline ambient air quality assessment. It also discusses the baseline ambient air quality data obtained and assesses the potential ambient air quality impacts associated with the construction and operation activities of the Project development. Appropriate mitigation measures are also identified.

7.1 Applicable Legislation Standards

NEA has published Singapore's Air Quality Long-Term Targets based on the World Health Organisation (WHO) Air Quality Guidelines (AQGs). The standard for particulate matter of diameter 10 micrometres or less (PM_{10}), and particulate matter of diameter 2.5 micrometres or less ($PM_{2.5}$) nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and ozone (O_3) are presented on **Table 7-1**.

Table 7-1: Singapore Ambient Air Quality Targets

Pollutant	Singapore's Air Quality Long-Term Targets
Sulphur Dioxide (SO_2)	24-hour mean: 20 µg/m^3 (WHO Final)
Particulate Matter ($PM_{2.5}$)	Annual mean: 10 µg/m^3 24-hour mean: 25 µg/m^3 (WHO Final)
Particulate Matter (PM_{10})	Annual mean: 20 µg/m^3 24-hour mean: 50 µg/m^3 (WHO Final)
Nitrogen Dioxide (NO_2)	Annual mean: 40 µg/m^3 1-hour mean: 200 µg/m^3 (WHO Final)
Carbon Monoxide (CO)	8-hour mean: 10 mg/m^3 1-hour mean: 30 mg/m^3 (WHO Final)
Ozone (O_3)	8-hour mean: 100 µg/m^3 (WHO Final)

NEA also regulates air emissions from industrial plant or trade premises[1] and exhaust emissions from vehicles, and prohibits the use of open fires, through the EPMA and its subsidiary regulations. The EPM (Air Impurities) Regulations repeal the original set of Clean Air Standards that had been in place since 1978. These latest regulations stipulate the emission standards for industrial plant and fuel-burning equipment used in industrial and trade premises.

With effect from July 1, 2012, all off-road diesel engines are required to comply with Japanese Tier I, United States (US) Tier II or European Union Tier II off-road diesel exhaust emission standards. Any equipment or machinery that is equipped with diesel engines as the main or auxiliary prime mover and which is not registered with the LTA for use on public roads is required to have a permit from NEA prior to the import of such equipment (e.g., cranes, excavator, forklift and power generator). This directive will be applicable to generator sets or other diesel-powered construction machinery used at the Project development.

[1] Industrial or trade premises means premises used for any industrial or trade purposes or premises on which matter is burnt in connection with any industrial or trade process, and includes all scheduled premises and construction sites (EPMA, Section 2)

Motor vehicles being a major source of air pollutant, NEA also regulates the type and quality of fuel that can be used in Singapore, and also sets minimum exhaust emission standards for all vehicles. The EPM (Vehicular Emissions) Regulations stipulate the exhaust emission standards for diesel- and petrol-driven vehicles. They also stipulate a mandatory periodic test for in-use vehicles by approved vehicle examiners to demonstrate compliance with exhaust emission standards.

The EPM (Prohibition on the Use of Open Fires) Order stipulates that, open fires in industrial or trade premises are prohibited, except where such open fires are used for firefighting or for the disposal of tail gas from industrial plants. These regulations prohibit the burning of construction wastes and thus are applicable to the construction phase of the Project.

NEA also sets penalties through the Environmental Public Health Act (EPHA) for violations by construction site occupiers that contribute to an air pollution nuisance to the public. These violations include littering, dropping or scattering of sand, earth, gravel, clay, refuse, stone or other similar material at public places such as public roads; and dust pollution, accumulations or deposits that are a nuisance or are injurious or dangerous to the health of the public. The Act also requires persons carrying out any construction or earth works to provide or construct a suitable device or facility for the removal of dirt, earth, sand or other particles from any vehicle used in connection with the construction or earth works.

7.2 Methodology for Air Quality Assessment

This EIA focuses on the assessment of potential ambient air quality impacts during the construction and operation activities of the Project development. There is no legislation and standard in Singapore presently that describes the specific methodology for air quality baseline assessment. Thus, as proposed and agreed in the scoping stage, we have used the Technical Memorandum Annex 12: Guidelines for Air Quality Assessment published by Hong Kong Environmental Protection Department (HK EPD) adapted to the Singapore situation. The Technical Memorandum Annex 12: Guidelines for Air Quality Assessment was chosen as it provides guidance on determination of air sensitive receiver (ASR) and baseline study.

7.2.1 Determination Air Quality Sensitive Receivers

The criteria proposed to determine ASRs are listed below:

- Residential premise
- Hotel and hostel
- Education institution including nursery, kindergarten, school, higher learning institution such as college and university
- Hospital, clinic, convalescence, home for the aged, and orphanage
- Outdoor area used by local community for recreational activities such as park, and
- Sensitive industries such as food and beverage manufacturing, and food vendors / businesses.

The representative ASRs potentially affected by the Project development are identified through a combination of desktop study (i.e., review publicly available street directory and satellite map) and visual site survey.

7.2.2 Baseline Air Quality Monitoring

The six air pollutants designated and monitored by NEA to report Singapore's ambient air quality status were used as the basis for this ambient air quality impact assessment. These six air pollutants are: CO, NO_2, SO_2, O_3, particulate matter of diameter 10 micrometres or less (PM_{10}), and particulate matter of diameter 2.5 micrometres or less ($PM_{2.5}$).

The principal anthropogenic sources of CO, NO_2, PM_{10}, and $PM_{2.5}$ are the combustion of fossil fuels such as in fuel-burning equipment and vehicles. In addition, fugitive dust emissions from construction activities such as soil excavation and backfilling are significant potential sources of PM_{10} and $PM_{2.5}$. SO_2 is related to the combustion of fossil fuels with high sulphur contents.

Combustion engine-powered equipment potentially used at construction sites (such as generator sets) and traffic diversions that may increase traffic congestion and vehicular waiting times can each also contribute to increases in CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ emissions. Fugitive particulate emissions such as dust arising from soil excavation, backfilling, transportation, and handling and storage of excavated soil and other construction debris may also contribute to increases in PM_{10} and $PM_{2.5}$ concentrations.

Unlike the four pollutants mentioned above, O_3 is not emitted directly into the atmosphere but is produced as a secondary air pollutant by the reaction between NO_2, hydrocarbons and sunlight. Thus, emissions of NO_2 and hydrocarbons from fuel burning equipment and vehicles can contribute to an increase in O_3 concentrations.

CO, NO_2, SO_2, and O_3 are monitored using portable AQMesh Air Quality Monitoring System with electrochemical sensor while $PM_{2.5}$ and PM_{10} are monitored using TSI DustTrak Aerosol Monitor 8543M over 24 hours and for seven consecutive days. These are non-USEPA listed monitoring devices. The air quality monitoring method and equipment used is summarized on **Table 7-2**. The equipment is housed in a cabinet and located on site for the duration of monitoring to capture and analyse the air samples.

Table 7-2: Methods and Equipment used for Air Quality Monitoring for Air Pollutants

Monitored Parameters	Method/ Equipment	Unit	Monitoring Period
Particulate matter $PM_{2.5}$	TSI DustTrak Aerosol Monitor 8543M	$\mu g/m^3$	24-hour for 7 days
Particulate matter PM_{10}	TSI DustTrak Aerosol Monitor 8543M	$\mu g/m^3$	24-hour for 7 days
Sulphur dioxide, SO_2	AQMesh Monitor equipped with electrochemical sensor for SO_2	$\mu g/m^3$	24-hour for 7 days
Nitrogen dioxide, NO_2	AQMesh Monitor equipped with electrochemical sensor for NO_2	$\mu g/m^3$	1-hour for 7 days
Carbon monoxide, CO	AQMesh Monitor equipped with electrochemical sensor for CO	mg/m^3	8-hour for 7 days
Ozone, O_3	AQMesh Monitor equipped with electrochemical sensor for O_3	$\mu g/m^3$	8-hour for 7 days

7.3 Pre-construction Baseline

7.3.1 Weather Conditions

7.3.1.1 General Weather Conditions

Singapore lies in north of the Equator near Latitude 1.3 degree north and Longitude 103.8 degree east. Because of its geographical location and maritime exposure, its climate is characterised by uniform temperature and pressure, high humidity and abundant rainfall. The climate of Singapore can be divided into two main seasons, the northeast monsoon and the southwest monsoon season, separated by two relatively short inter-monsoon periods (**Section 5.3.1**).

We have purchased the hourly wind data recorded at Changi Weather Station for the years 2016 to 2020 from Meteorological Service Singapore of NEA. Based on the wind rose generated from recordings at the Changi Weather Station for the years 2016 to 2020 (**Figure 7-1)**, the prevailing wind direction in overall Singapore context over the represented period was from the northeast as indicated by the size of the branch which represents wind coming from that direction. Each branch is divided into segments of different thickness and colour which represents the frequencies of each wind speed category from that direction.

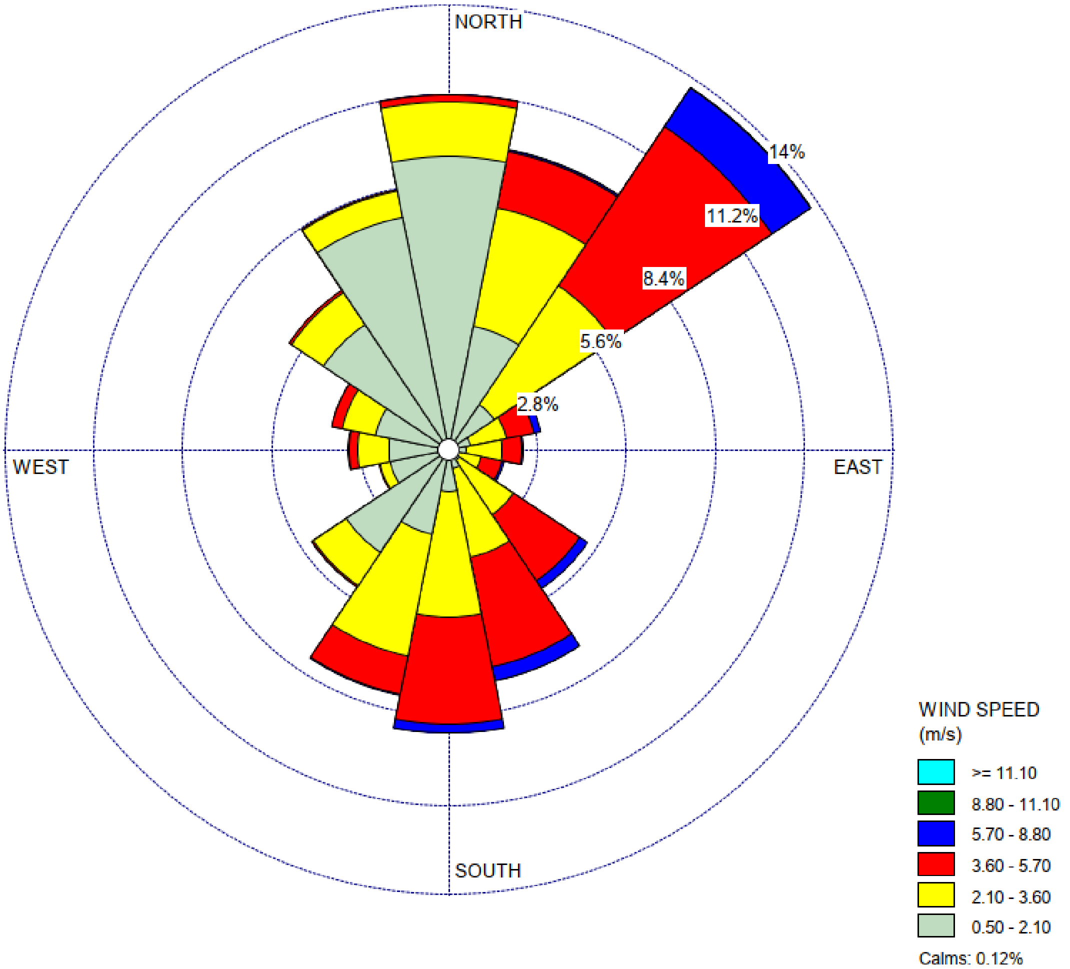


Figure 7-1: Wind Rose Plot – Changi Weather Station from 2016 to 2020

Note: Wind direction indicated by the size and location of each branch. Each branch is divided into segments of different thickness and colour which represents the frequencies of each wind speed category from that direction. Hourly wind data is purchased from Meteorological Service Singapore of NEA.

7.3.1.2 Specific Weather Condition

The nearest weather monitoring stations to EIA Study Area is Choa Chu Kang Weather Station, located 0.9 kilometre (km) north of the Project. However, this station does not record the wind speed and direction during the monitoring period (28 March to 20 April 2022). The weather data recorded at Nanyang Avenue Weather Station (https://data.gov.sg/dataset/realtime-weather-readings), located about 7 km southwest of the Project, is therefore used in this EIA. A wind rose generated from recordings at Nanyang Avenue Weather Station during the monitoring period is presented in **Figure 7-2** below. The wind rose illustrates that the prevailing wind direction, for the represented period, is mainly from the north-northeast as indicated by the size of the branch which represents wind coming from that direction. Each branch is divided into segments of different thickness and colour which represents the frequencies of each wind speed category from that direction.

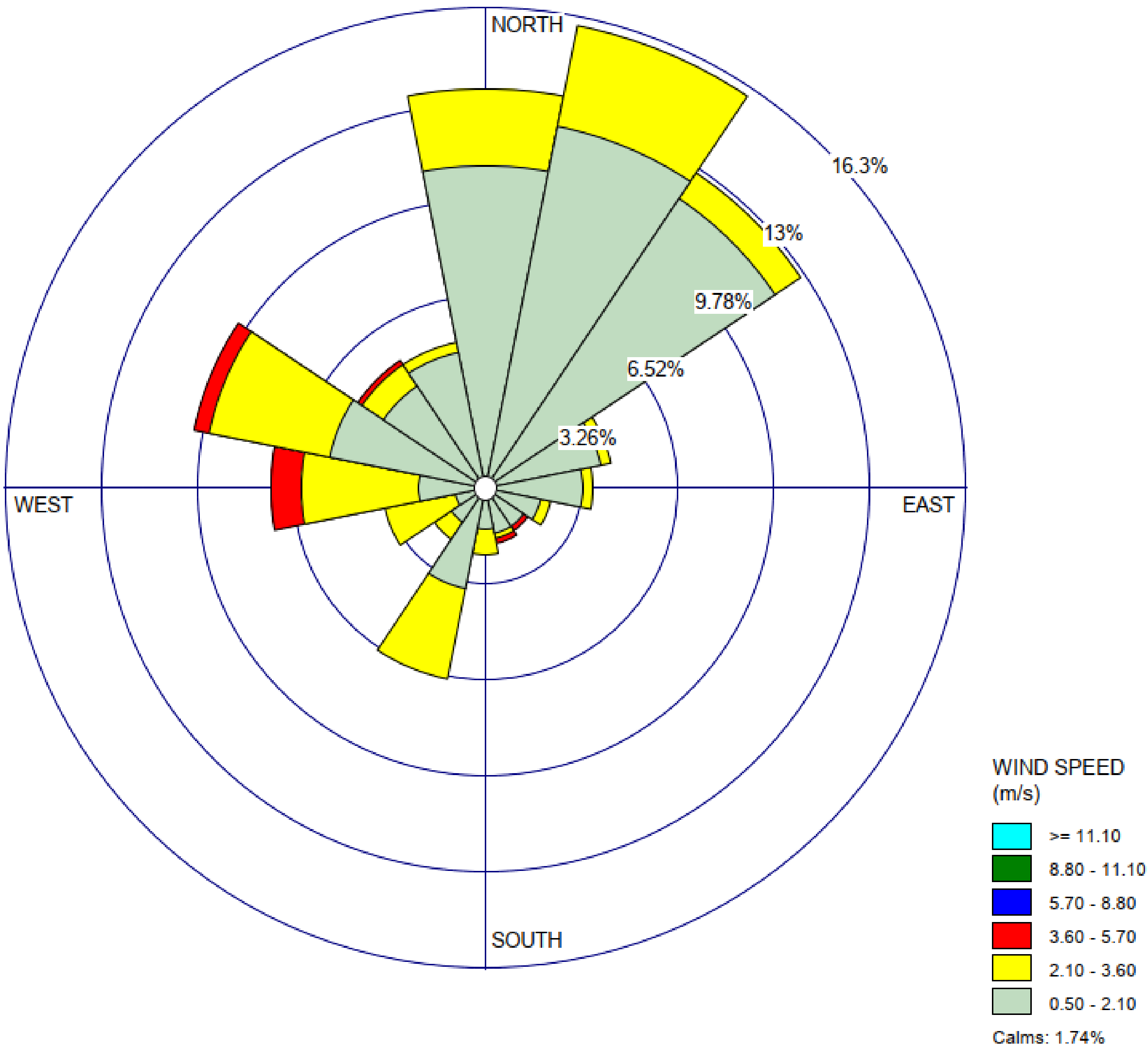


Figure 7-2: Wind Rose Plot – Nanyang Avenue Weather Station from March 28 to April 20, 2022

Note: Hourly wind data is obtained from Nanyang Avenue Weather Station (https://data.gov.sg/dataset/realtime-weather-readings)

7.3.2 Historical Ambient Air Quality Data

The main sources of air pollution in Singapore are from the burning of fossils fuels for energy generation in industries, power stations, and in the transportation sector. Other sources include open burning of waste materials and trans-boundary smoke haze from land and forest fires in the region.

NEA monitors the ambient air quality through the Telemetric Air Quality Monitoring and Management System This system comprises 22 remote air monitoring stations, across the island, linked to a Central Control System via dial-up telephone lines, and provides an efficient means of obtaining air quality data. Eighteen of the stations monitor ambient air quality and four stations monitor roadside air quality.

The monitoring stations monitor both ambient and roadside air quality. The automatic analysers and equipment at the stations monitor the concentrations of major pollutants such as O_3, CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$. Historical ambient air quality data for PM_{10} and $PM_{2.5}$, between 2017 and 2021 provided by Singapore Department of Statistics (Singstat, 2022) are summarized on **Table 7-3**.

Table 7-3: Background Concentration in Singapore from 2017 to 2021

Air Pollutants	2017	2018	2019	2020	2021	Average	Singapore Long Term Target
PM_{10} (Annual Mean), µg/m^3	25	29	30	25	28	27.4	20
PM_{10} (99th percentile 24-hour mean), µg/m^3	57	59	**90**(1)	43	51	52.5	50
$PM_{2.5}$ (Annual Mean)	14	15	16	11	12	13.6	10
$PM_{2.5}$ (99th percentile 24-hour mean), µg/m^3	34	32	**62**(1)	24	28	29.5	25
Sulphur Dioxide (Maximum 24-Hour Mean), µg/m^3	59	65	57	30	89	64.8	50
Nitrogen Dioxide (Annual Mean), µg/m^3	25	26	23	20	25	23.8	40
Nitrogen Dioxide (Maximum 1-Hour Mean), µg/m^3	158	147	156	118	123	140.4	200
Carbon Monoxide (Maximum 8-Hour Mean), mg/m^3	1.7	2	1.7	1.2	1.2	1.56	10
Carbon Monoxide (Maximum 1-Hour Mean), mg/m^3	2.3	2.5	2.3	1.6	1.3	2	30
Ozone, O_3 (Maximum 8-Hour Mean), µg/m^3	191	150	125	145	176	157.4	100

Source: www.singstat.gov.ph (https://tablebuilder.singstat.gov.sg/table/TS/M890641, accessed on 26 April 2022)

Note:

(1): High 24 hours PM concentrations measured in 2019 are not considered because they are related to haze episode that occurred in September 2019.

Figures in **bold red:** Concentration higher than the Singapore Long Term Targets

It is noted that the average O_3, PM_{10}, $PM_{2.5}$ and SO_2 ambient air concentrations measured over the different years have yet to fulfil the Singapore Long Term Target for the annual averaging period.

7.3.3 Determination of Air Sensitive Receiver

Based on the mentioned criteria on **Section 7.2.1** and the site reconnaissance carried out on 26 January 2022, the list of ASRs within the EIA Study Area (i.e., 100 m from the DE170 Contract Boundary) that are potentially affected by the Project development is listed on **Table 7-4** and illustrated in **Figure 7-3**.

Table 7-4: Identified Air Sensitive Receiver (ASRs) for the Project

ASR Cluster	Cluster Description	Type of Receiver	Number of Storeys	Location and Distance of Cluster to the EIA Study Area
ASR Cluster 1	Home Team Academy, 501 Old Choa Chu Kang Road Keat Hong Camp, 611 Old Choa Chu Kang Road	Recreational, Residential	4	Within the central portion of the EIA Study Area, 100 m from DE170 Contract boundary
ASR Cluster 2	Block 450A Choa Chu Kang Avenue 4	Residential	16	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 451 Choa Chu Kang Avenue 4		16	
	Block 452 Choa Chu Kang Avenue 4		16	
	Block 453 Choa Chu Kang Avenue 4		16	
	Block 454 Choa Chu Kang Avenue 4		16	
	Block 455 Choa Chu Kang Avenue 4		16	
	Block 456 Choa Chu Kang Avenue 4		12	
	Block 459 Choa Chu Kang Avenue 4		12	
	Block 460 Choa Chu Kang Avenue 4		16	
	Block 461 Choa Chu Kang Avenue 4		16	
	Hai Inn Temple, 33 Brickland Road	Cultural	4	
ASR Cluster 3	Concord Primary School, 3 Choa Chu Kang Avenue 4	School	4	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 443 Choa Chu Kang Avenue 4	Residential	15	
	Block 444 Choa Chu Kang Avenue 4		15	
	Block 445 Choa Chu Kang Avenue 4		8	
	Block 446 Choa Chu Kang Avenue 4		15	

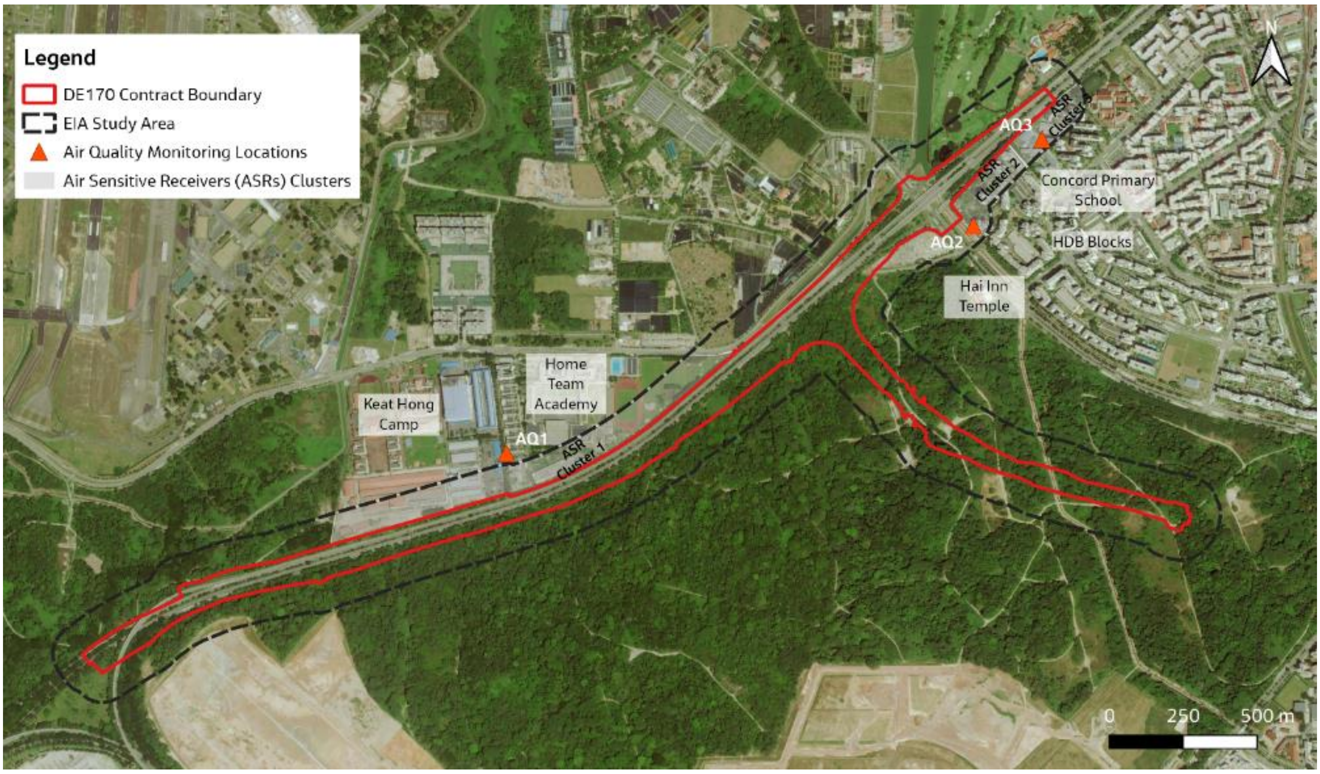


Figure 7-3: Air Sensitive Receiver Cluster and Ambient Air Monitoring Locations
Source: ESRI

7.3.4 Ambient Air Quality Baseline Monitoring

Three ambient air quality monitoring points for affected community are selected. The locations of the baseline ambient air quality monitoring are shown in **Figure 7-3** and described on **Table 7-5**.

Table 7-5: Location of Ambient Air Quality Baseline Measurement Station

Ambient Air Quality Baseline Measurement Station	Description
AQ1	At an open space outside the training facility and dormitory of Home Team Academy
AQ2	At an open space between Block 461 and Block 460 Choa Chu Kang Avenue 4
AQ3	At an open space between Concorde Primary School and multi-story carpark block 446

PM_{10} and $PM_{2.5}$ were monitored using TSI DustTrak Aerosol Monitor Model 8543-M (Serial number 8543210602). The analysers use light scattering laser photometer, providing real time aerosol mass reading and data logging for PM_{10} and $PM_{2.5}$. PM_{10} and $PM_{2.5}$ were measured on a one week on continuous basis to present a representative existing ambient air quality background. Data logging was set at 10-minute intervals and the 24-hour daily averages are computed based on the averaging data obtained and the results are compared against the Singapore Ambient Air Quality Targets.

CO, NO_2, O_3 and SO_2 were monitored using AQMesh Air Quality Monitoring System (Serial number: 2450718). The monitoring system uses electrochemical sensors for all the pollutants, providing real time concentration reading and data logging. Data logging was set at 15-minute intervals while the hourly and 24-hour daily averages are computed based on the averaging data obtained and the results are compared against the Singapore Ambient Air Quality Targets.

7.3.5 Results and Discussion

The ambient air quality baseline measurement was conducted by MLS, a laboratory accredited by the Singapore Accreditation Council and supervised by our environmental engineers from 28 March to 20 April 2022. The results of the ambient air quality baseline monitoring were used to established pre-construction ambient air quality and benchmarked against the Singapore Long Term Targets.

Ambient air quality baseline monitoring reports and photographic logs are provided in **Appendix 7A** and **Appendix 7B** respectively, and summary results are tabulated on **Table 7-6**. The ambient air quality baseline measurement results are summarised below:

- The ambient air quality baseline concentrations at all three monitoring points for CO, NO_2, O_3 and SO_2 comply with their respective Singapore Long Term Targets. However, all three monitoring points have at least one day of exceedance for $PM_{2.5}$ 24-hours and one day of exceedance for PM_{10} 24-hours at monitoring point AQ3.
- Further review of the $PM_{2.5}$ and PM_{10} monitoring data of AQ1, AQ2 and AQ3 with meteorological data, regional ambient air quality data from West region of Singapore, and site-specific conditions is conducted and presented in succeeding subsections.

Table 7-6: Maximum Ambient Air Quality Baseline Results

Ambient Air Quality Baseline Measurement Station	Day	Sulphur Dioxide (SO_2) 24-hour mean	$PM_{2.5}$ ($\mu g/m^3$) 24-hour mean	PM_{10} ($\mu g/m^3$) 24-hour mean	Nitrogen Dioxide (NO_2) Max 1-hour mean	Carbon Monoxide (CO) Max 1-hour mean	Carbon Monoxide (CO) Max 8-mean mean	Ozone (O_3) Max 8-hour mean
AQ1	29-Mar-2022	5.06	14.7	17.9	136.3	0.64	0.32	34.3
	30-Mar-2022	5.59	14.8	17.9	119.3	0.74	0.39	28.2
	31-Mar-2022	2.90	24.9	29.6	127.5	0.71	0.47	37.6
	01-Apr-2022	3.69	19.3	23.2	133.1	0.72	0.42	22.0
	02-Apr-2022	4.38	22.4	26.6	122.3	0.97	0.64	51.6
	03-Apr-2022	6.34	33.4	39.2	133	0.86	0.47	35.7
	04-Apr-2022	7.17	40.9	47.5	103.6	1.13	0.88	27.8
	7-Day Max	7.17	40.5	47.0	136.3	1.13	0.88	51.6
AQ2	05-Apr-2022	0.00	16.3	19.6	76.6	0.59	0.35	31.3
	06-Apr-2022	4.98	16.1	19.5	131.7	0.57	0.38	35.6
	07-Apr-2022	0.04	18.7	22.1	76.6	0.52	0.29	18.2
	08-Apr-2022	1.12	21.4	25.1	115.5	0.52	0.35	41.9
	09-Apr-2022	1.62	12.1	14.7	148.6	0.31	0.27	39.0
	10-Apr-2022	1.14	21.7	25.7	71.5	0.88	0.51	31.7
	11-Apr-2022	1.24	39.3	45.8	114.5	0.76	0.64	19.7

Ambient Air Quality Baseline Measurement Station	Day	Sulphur Dioxide (SO_2) 24-hour mean	$PM_{2.5}$ ($\mu g/m^3$) 24-hour mean	PM_{10} ($\mu g/m^3$) 24-hour mean	Nitrogen Dioxide (NO_2) Max 1-hour mean	Carbon Monoxide (CO) Max 1-hour mean	Carbon Monoxide (CO) Max 8-mean mean	Ozone (O_3) Max 8-hour mean
	7-Day Max	4.98	**38.2**	44.6	148.6	0.88	0.64	41.9
AQ3	13-Apr-2022	14.37	**51.3**	**59.2**	126.2	1.19	0.96	23.2
	14-Apr-2022	4.82	14.9	17.7	120.5	0.81	0.34	32.4
	15-Apr-2022	1.18	18.9	22.0	84.3	0.77	0.52	27.7
	16-Apr-2022	7.13	21.8	25.6	119.8	0.9	0.57	29.4
	17-Apr-2022	2.17	**26.0**	30.3	119.8	0.81	0.65	33.9
	18-Apr-2022	7.22	22.7	26.4	146.6	0.52	0.37	28.9
	19-Apr-2022	2.38	25.0	29.2	109	0.79	0.52	28.8
	7-Day Max	14.37	**49.8**	**57.5**	146.6	1.19	0.96	33.9
Singapore Long Term Targets		20	25	50	200	30	10	100

Note:

(1) 7-Day Max for PM_{10} and $PM_{2.5}$ are the 99th Percentile of the 24 hours mean.

(2) Figures in **bold red:** Concentration higher than the Singapore Long Term Targets

7.3.5.1 Meteorological Data

Wind rose generated from Nanyang Avenue Weather Station during the ambient air quality monitoring period (**Figure 7-2**) indicates that the wind direction was dominantly blowing from the North-Northeast. Thus, AQ2 and AQ3 are located downwind of KJE and the ambient air quality at these two locations might have been affected by vehicles emissions from the expressway. However, AQ1 is located upwind of KJE and there were no other traffic heavy roads nearby of AQ1. Hence, it is unlikely the vehicles emissions from roads to have affected the ambient air quality.

7.3.5.2 Regional Ambient Air Quality

The $PM_{2,5}$ and PM_{10} 24-hours concentration for AQ1, AQ2 and AQ3 are then compared with the regional ambient air quality data from west region of Singapore collected from NEA through https://data.gov.sg/dataset/psi during the same monitoring period (refer to **Table 7-7** and **Figure 7-4** to **Figure 7-9**). The west region encompasses Lim Chu Kang, Choa Chu Kang, Bukit Panjang, Tuas, Jurong East, Jurong West, Jurong Industrial Estate, Bukit Batok, Hillview, West Coast and Clementi.

Table 7-7: Comparison of Site Ambient Air Quality with Singapore Ambient Air Quality for West Region

Ambient Air Quality Baseline Measurement Station	Day	PM_{10} (µg/m^3) 24hr mean		$PM_{2.5}$ (µg/m^3) 24hr mean	
		Project Site	West Region	Project Site	West Region
AQ1	28-Mar-2022	17.9	33	14.7	14
	29-Mar-2022	17,9	33	14.8	12
	30-Mar-2022	29.6	27	24.9	7
	31-Mar-2022	23.2	30	19.3	10
	01-Apr-2022	26.6	27	22.4	10
	02-Apr-2022	39.2	28	33.4	11
	03-Apr-2022	47.5	35	40.9	14
AQ2	05-Apr-2022	19.6	28	16.3	9
	06-Apr-2022	19.5	26	16.1	9
	07-Apr-2022	22.1	24	18.7	9
	08-Apr-2022	25.1	23	21.4	6
	09-Apr-2022	14.7	27	12.1	10
	10-Apr-2022	25.7	28	21.7	9
	11-Apr-2022	45.8	30	39.3	12
AQ3	13-Apr-2022	59.2	48	51.3	21
	14-Apr-2022	17.7	40	14.9	15
	15-Apr-2022	22.0	23	18.9	9
	16-Apr-2022	25.6	21	21.8	8
	17-Apr-2022	30.3	23	26.0	8

Ambient Air Quality Baseline Measurement Station	Day	PM10 (µg/m³) 24hr mean		PM2.5 (µg/m³) 24hr mean	
		Project Site	West Region	Project Site	West Region
	18-Apr-2022	26.4	31	22.7	13
	19-Apr-2022	29.2	28	25.0	11
Singapore Long Term Targets		50		25	

Note: Figures in **bold red**: Concentration higher than the Singapore Long Term Targets

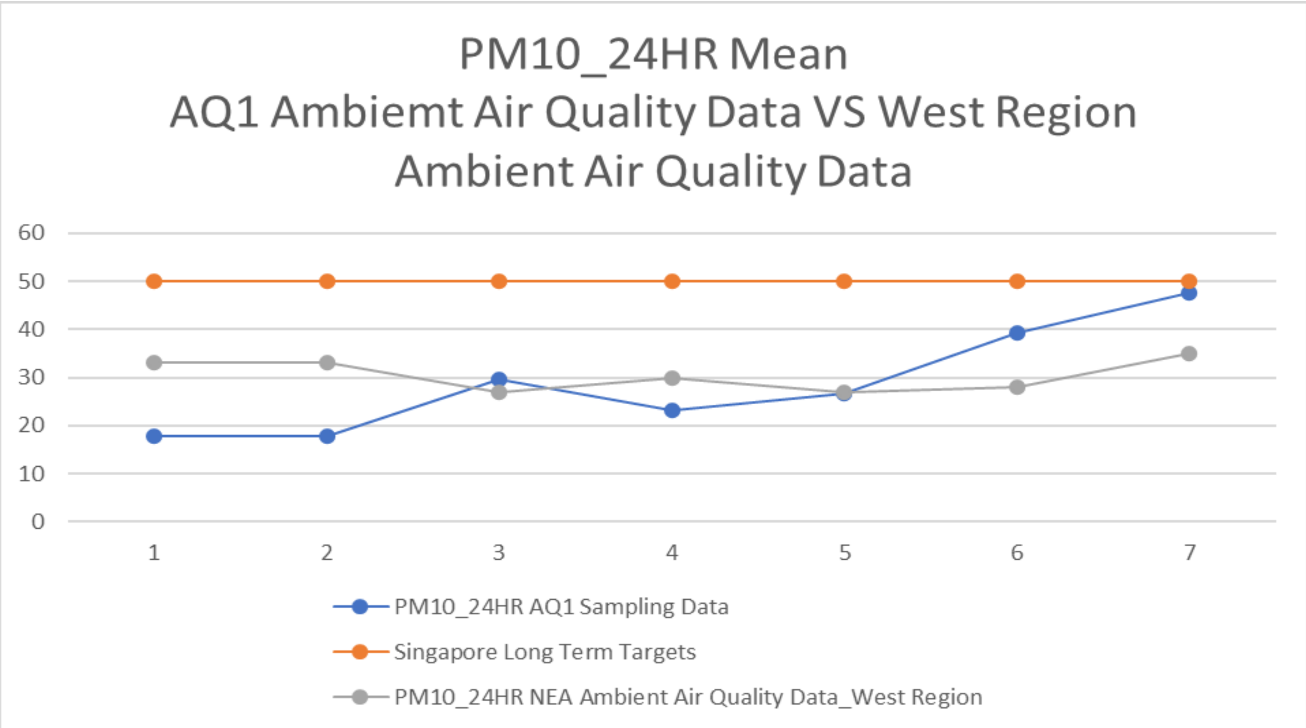


Figure 7-4: PM_{10} 24-hours AQ1 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

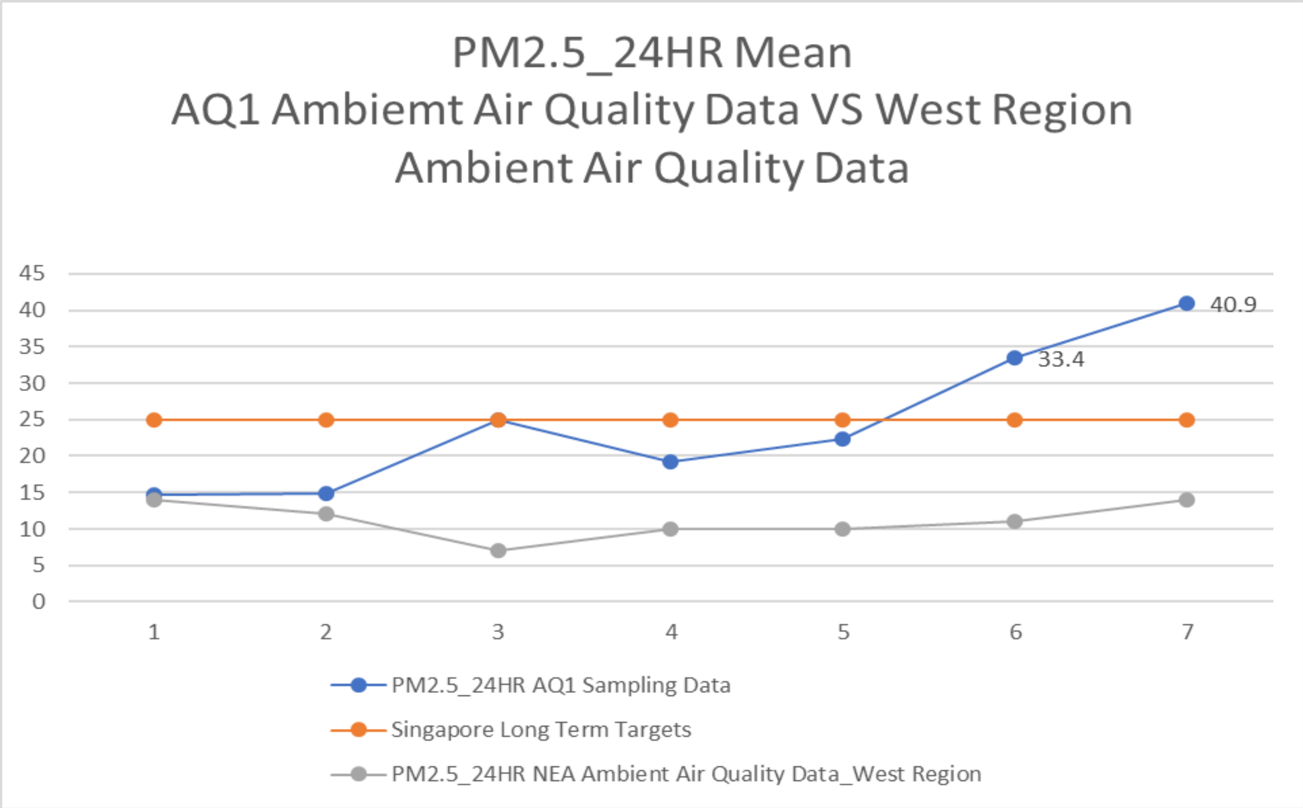


Figure 7-5: $PM_{2.5}$ 24-hours AQ1 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

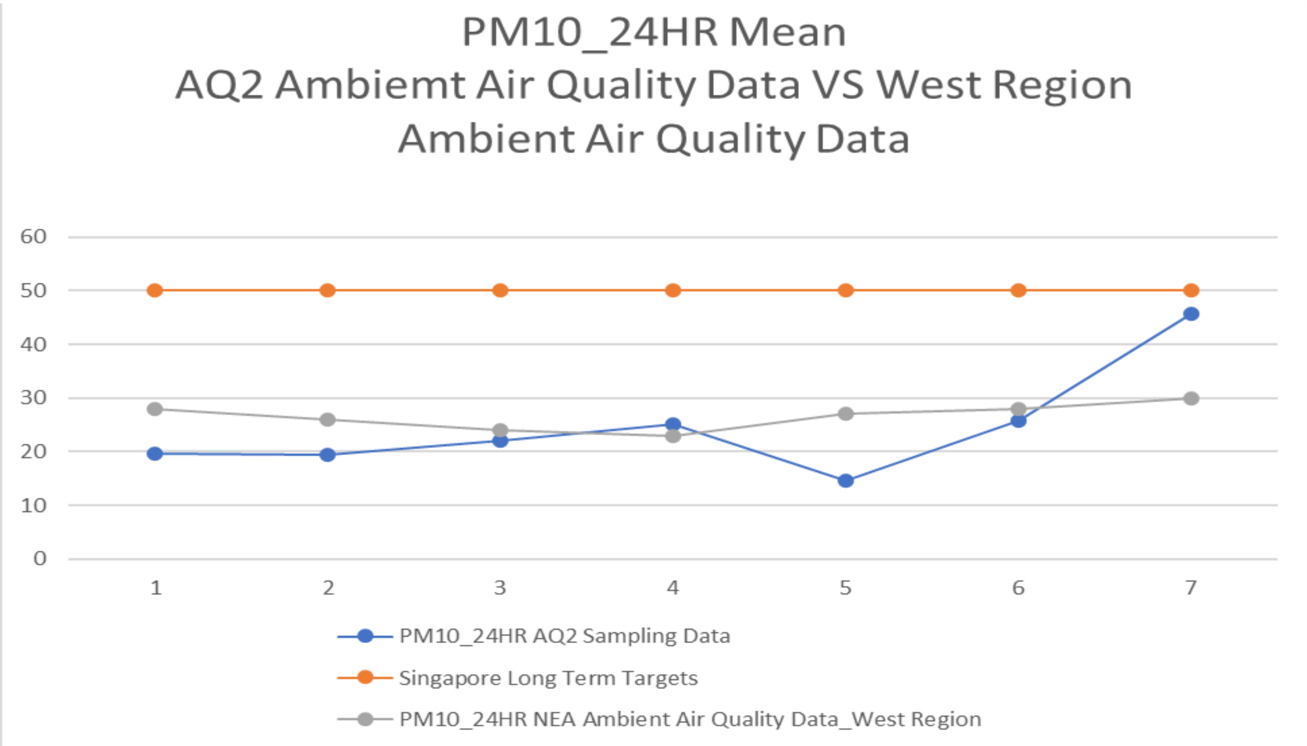


Figure 7-6: PM_{10} 24-hours AQ2 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

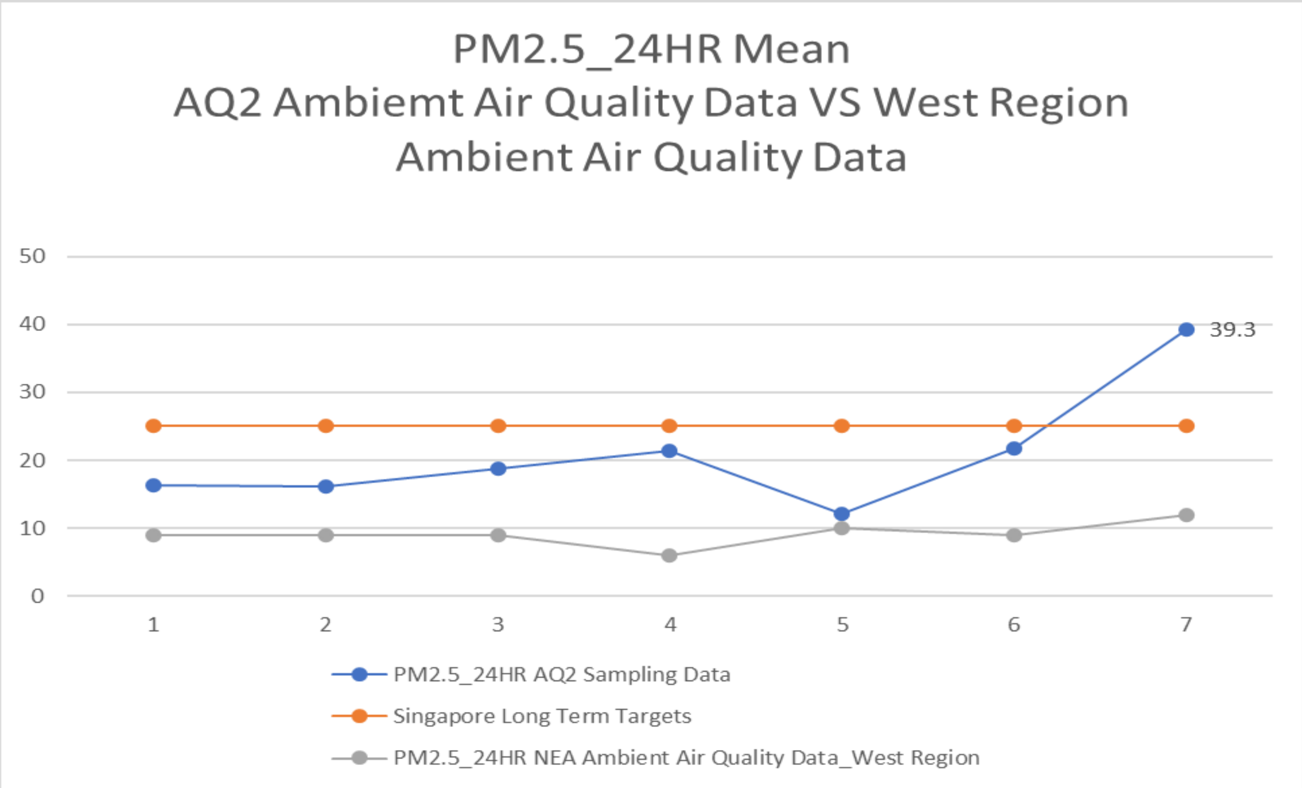


Figure 7-7: $PM_{2.5}$ 24-hours AQ2 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

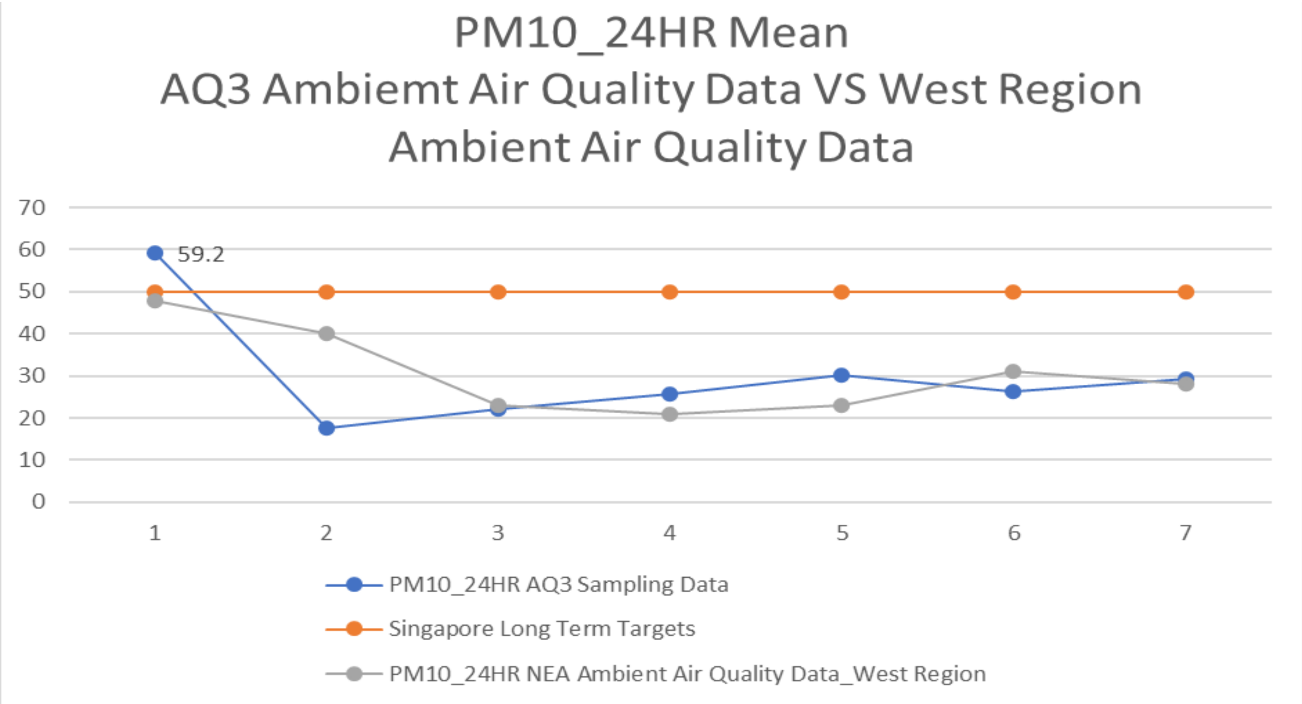


Figure 7-8: PM_{10} 24-hours AQ3 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

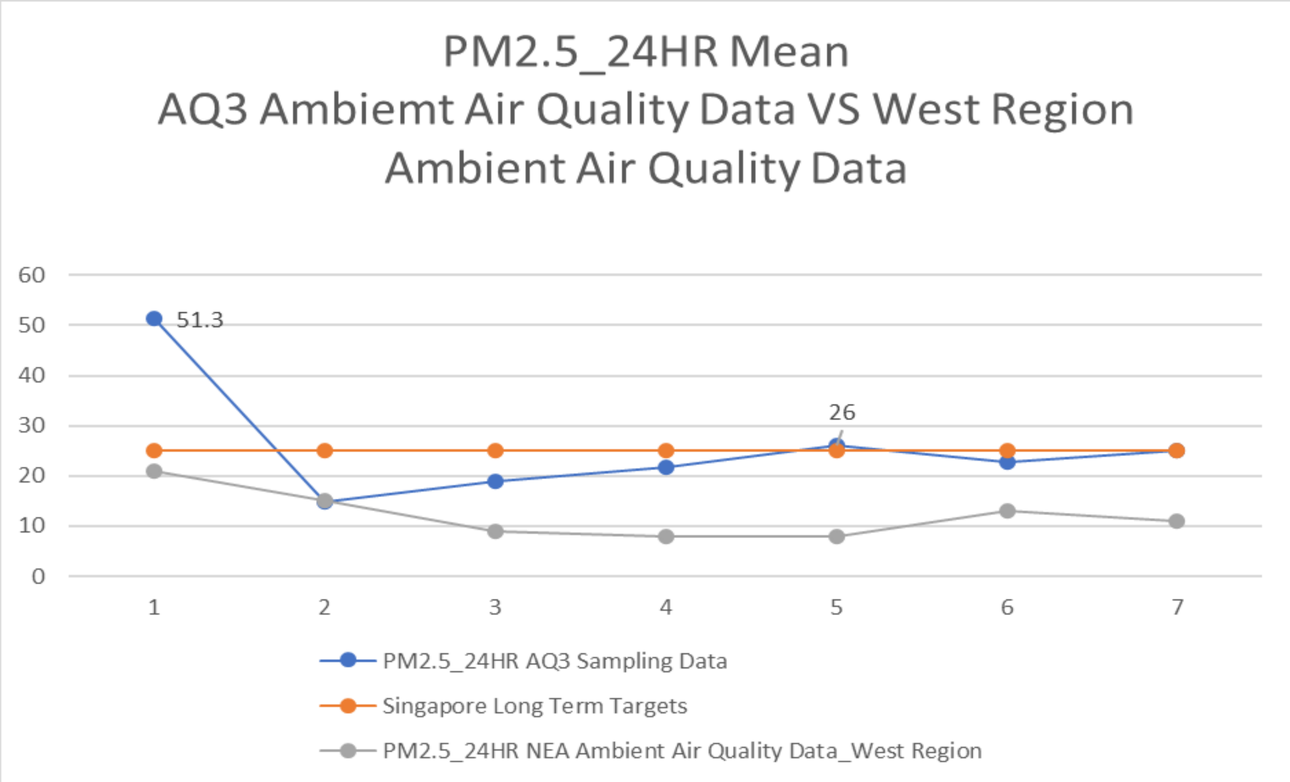


Figure 7-9: $PM_{2.5}$ 24-hours AQ3 Ambient Air Quality Monitoring Comparison with West Region Ambient Air Quality

Based on **Table 7-7** and in **Figure 7-4** to **Figure 7-9**, the regional PM_{10} 24-hours and $PM_{2.5}$ 24-hours concentrations from the west region of Singapore for AQ1, AQ2 and AQ3 are below the Singapore Long Term Targets in all the days of monitoring. For AQ3, PM_{10} 24-hours concentration on day 1 of monitoring reported 59.3 μg/m³ and regional PM_{10} 24-hours concentration was relatively high at 48 μg/m³ on the same day. Nevertheless, there was no distinct trend observed between the monitoring data for both PM_{10} and $PM_{2.5}$ and the regional PM_{10} 24-hours and $PM_{2.5}$ 24-hours concentrations from the west region of Singapore for all three monitoring points.

7.3.5.3 Site Specific Condition

There are spikes of hourly PM_{10} and $PM_{2.5}$ concentrations of unknown specific sources reported on one day in each of the monitoring points AQ1, AQ2 and AQ3 as shown in **Figure 7-10** to **Figure 7-12**. The high peaks are recorded on day 7 of monitoring for AQ1, on day 7 of monitoring in AQ2, and on day 1 of monitoring in AQ3.

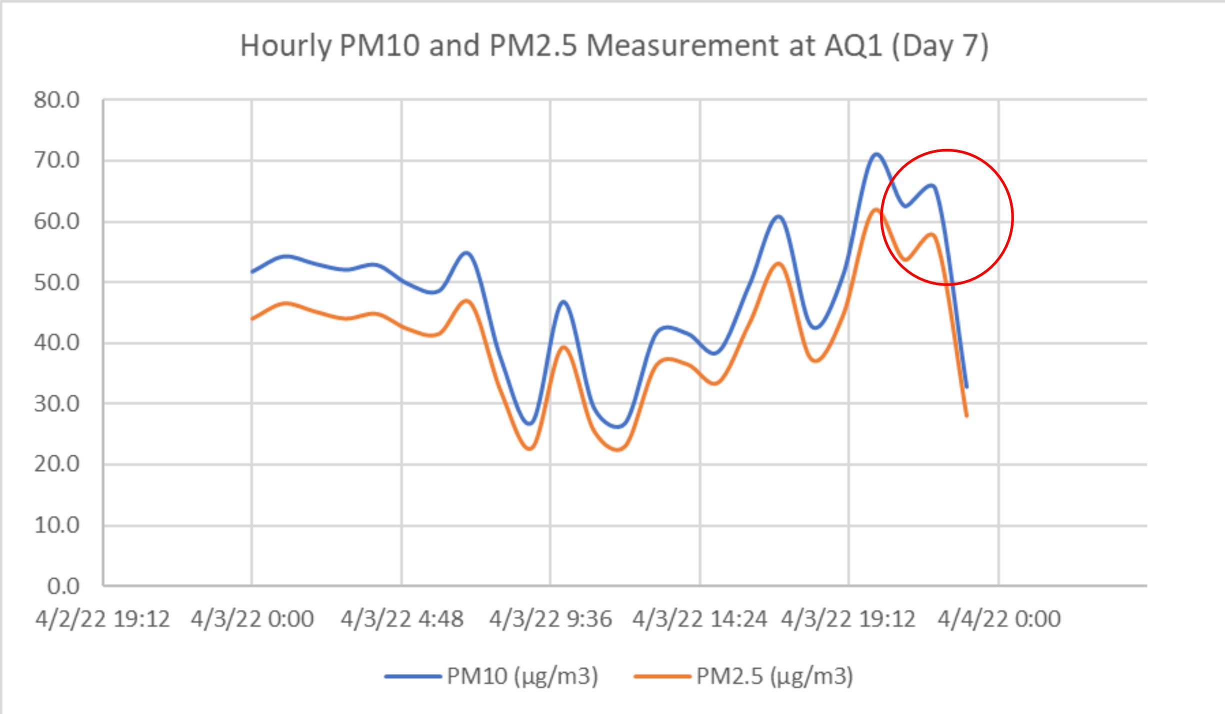


Figure 7-10: Hourly PM10 Concentration on Day 7 at AQ1 Monitoring Point

Note: Red circle indicates the spike in concentration

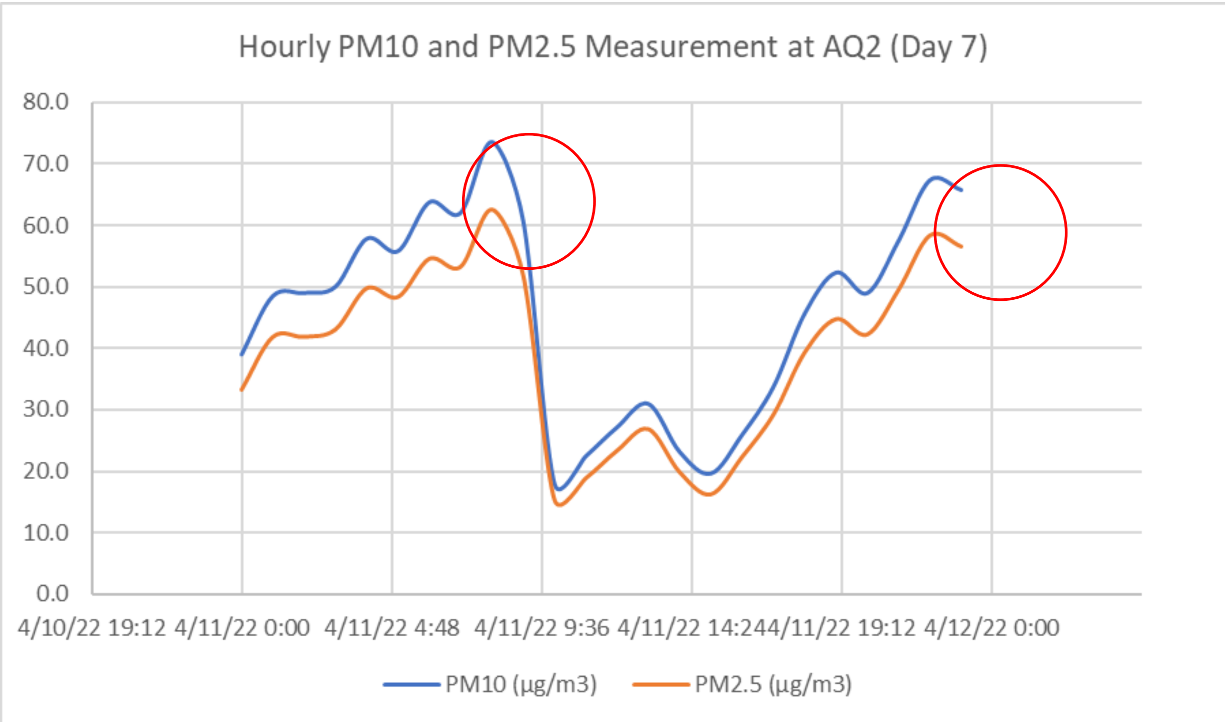


Figure 7-11: Hourly PM10 Concentration on Day 7 at AQ2 Monitoring Point

Note: Red circle indicates the spikes in concentration

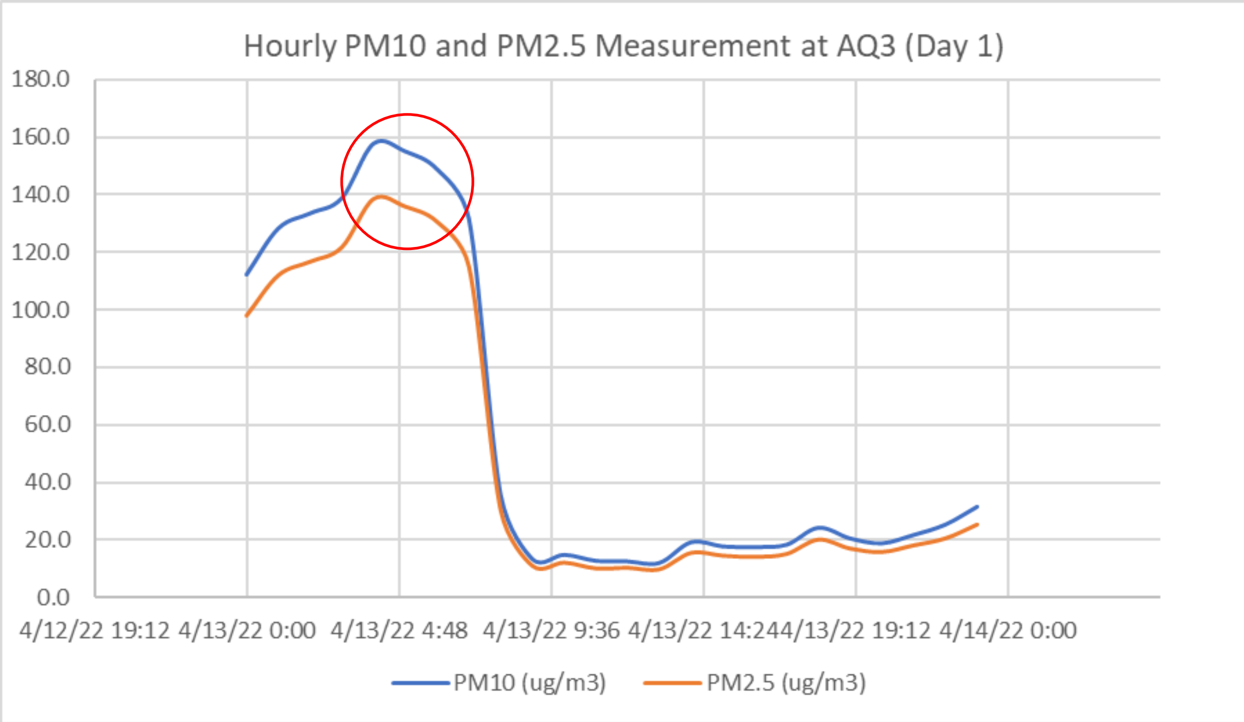


Figure 7-12: Hourly PM10 Concentration on Day 1 at AQ3 Monitoring Point

Note: Red circle indicates the spikes in concentration

Review of the $PM_{2.5}$ and PM_{10} monitoring data of AQ1, AQ2 and AQ3 with meteorological data, regional ambient air quality data from West region of Singapore, and site-specific conditions shows that:

- $PM_{2.5}$ and PM_{10} monitoring data of regional ambient air quality data from West region of Singapore was reviewed and it did not pose strong evidence to have affected the ambient air quality.
- Wind direction was dominantly blowing from the North-Northeast during the monitoring period. Hence the, source of $PM_{2.5}$ and PM_{10} for AQ2 and AQ3 may be due to traffic from the KJE Expressway but not AQ1.
- Some spikes in $PM_{2.5}$ and PM_{10} are observed for AQ1, AQ2 and AQ3. The source of exceedances is unknown.

7.3.6 Ambient Air Quality Baseline Limitation

The monitoring points are sited strategically to provide representative coverage of the Project. The ambient air quality baseline monitoring program covered six criteria air pollutants which are also monitored by NEA. However, the ambient air quality baseline monitoring program has the following limitations:

- The parameters monitored do not cover all of the chemicals resulting from anthropogenic sources (e.g., transportation, construction and industrial activities) and natural sources (e.g., biological decay and forest fires). However, the six air pollutants monitored (CO, NO_2, SO_2, O_3, PM_{10} and $PM_{2.5}$) are criteria air pollutants which have been monitored by NEA. Thus, monitoring data obtained for the six parameters are considered sufficient to represent the ambient air quality baseline of the EIA Study Area.
- For the purpose of this EIA, the ambient air quality baseline monitoring program is limited to three locations for a monitoring duration of seven days. This primary data complimented with the historical ambient air quality data is considered sufficient to provide representative ambient air quality baseline.
- Although some general conclusions can be drawn from the data, many variables may influence ambient air quality such as geographic variation, weather effects, emissions variations from surrounding facilities, changes in road traffic movements and activity around the ambient air quality baseline monitoring points.

7.4 Impact Assessment Before Mitigation Measures

7.4.1 Evaluation of Construction Phase Impacts

The construction activities have the potential to result in adverse impacts on air quality as well as to generate significant local nuisance effects, if uncontrolled. Potential sources of impacts include:

- **Fugitive dust emissions** from tree felling, land clearance, excavation, backfilling, demolition of existing structure, utilities diversion, ground improvement work, stockpiling of construction debris, waste vegetation debris and demolition wastes, construction of piers and columns, and vehicle movements on haul or unpaved roads.
- **Exhaust emissions** from the use of fuel-burning equipment and transport vehicles during construction. Information on specific equipment, machineries and vehicles that will be used for the Project development that potentially cause exhaust emissions are provided on **Table 3-4**. During construction, fuel-burning equipment (e.g., generators, air compressors and welding machines) and heavy vehicle, equipment and machineries (e.g., excavators, piling machines, dozers, drilling machines, cranes, asphalt pavers, rollers, lorry cranes, concrete lorry, concrete pump) will be used and may generate exhaust emissions.

Potential impact assessment of ambient air quality by using the modified RIAM as indicated in **Section 2.3** for affected community is discussed in the following sections.

The qualitative assessment of potential ambient air quality impacts distinguishes between those that are positive or negative nature; major, moderate or minor magnitude of changes; transboundary, national, or local extend; long, medium or short term; direct or indirect pathway; reversible or irreversible; and cumulative or non-cumulative. The ambient air quality impacts may affect ASRs with international, national or local value.

A summary of the ambient air quality impact assessment for affected community is discussed in detail below.

7.4.1.1 Fugitive Dust Emissions

Actual concentrations of fugitive dust emissions from the construction site will depend on several factors, including the frequency of operations, application and effectiveness of in-place control measures, ambient weather conditions (e.g., rainfall, wind speeds and wind directions), and the specific activities carried out. Fugitive dust emissions would therefore be expected to vary significantly from day to day.

Potential impact assessment of ambient air quality by fugitive dust emissions at affected community (ASR 1, ASR 2, ASR 3) during construction phase is presented in **Table 7-8**.

Table 7-8: Impact Significance for Fugitive Dust Emissions during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Fugitive dust emissions are expected to have impact on the ambient air quality at the ASR locations in the 100 m buffer (area immediately outside the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fugitive dust emissions from construction activities.
A2.2: Magnitude of Changes	3: High	PM_{10} and $PM_{2.5}$ concentrations from construction activities are estimated to exceed 50% of the respective Long Term SAAQT (conservative approach).

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	2: Buffer Area	Fugitive dust emissions are anticipated to extend beyond project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	3: Medium-term	Fugitive dust emissions will persist for a period of 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Fugitive dust emissions are a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fugitive dust emissions are reversible when dust-generating construction activities stop.
B4: Cumulative	3: Cumulative	Fugitive dust emissions from other construction projects such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area are expected cause cumulative impacts to the local ambient air quality when happen concurrently.
Environmental Score (ES)	(-12) x (10) = -132	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

7.4.1.2 Exhaust Emission from Fuel Burning Equipment/ Machinery/ Vehicle

Actual air pollutant concentrations from exhaust emissions of fuel-burning equipment and heavy vehicle/ machinery will mainly depend on the type of fuel and the quantity of equipment used.

Potential impact assessment of ambient air quality by exhaust emissions from fuel-burning equipment and heavy vehicle/ machinery at affected community (ASR 1, ASR 2, ASR 3) during construction phase is presented on **Table 7-9**.

Table 7-9: Impact Significance for Exhaust emissions from Fuel Burning Equipment/ Machinery/ Vehicle during Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Fuel burning equipment/ machinery/ vehicle exhaust emissions are expected to have impact on the ambient air quality at the ASR locations in the 100 m buffer (area immediately the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fuel burning equipment/ machinery/ vehicle exhaust emissions from construction activities
A2.2: Magnitude of Changes	2: Medium	PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO concentrations from fuel burning equipment/ machinery/ vehicle exhaust emissions are estimated to be within10% - 50% of the respective Long Term SAAQT.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	2: Buffer Area	Fuel burning equipment/ machinery/ vehicle exhaust emissions are anticipated to extend beyond project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	3: Medium-term	Fuel burning equipment/ machinery/ vehicle exhaust emissions will persist for a period of 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Fuel burning equipment/ machinery/ vehicle exhaust emissions is a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fuel burning equipment/ machinery/ vehicle exhaust emissions is reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Fuel burning equipment/ machinery/ vehicle exhaust emissions from other construction projects (such as the ongoing Contract J102 by LTA, located at the central part of EIA Study Area) and also increase in exhaust emission from traffic congestion due to traffic diversion from the construction activities are expected to cause cumulative impacts to the local ambient air quality as they happen concurrently.
Environmental Score (ES)	(-8) x 10 = -88	
Range Bands ES/ Impact Significance	Minor Negative Impact	

7.4.2 Evaluation of Operation Phase Impacts

Operational impacts within the EIA Study Area will potentially be from the use of the interchange and its periodic servicing or maintenance. Heavy construction vehicles are not anticipated to be used during such maintenance activities. Hence, the operation phase activities are not expected to generate significant amounts of dust or exhaust emissions.

Potential short-term operation phase impacts would possibly occur should there be major repairs, especially if heavy machineries are required. This would create potential sources of fugitive dust and exhaust emissions. However, it is expected that such short-term operation impacts will only last for the duration of the maintenance works and would be limited in scope.

Potential impact assessment of ambient air quality by fugitive dust emissions at affected community (ASR 1, ASR 2, ASR 3) during operation phase is presented on **Table 7-10**.

Table 7-10: Impact Significance for Fugitive Dust Emissions during Operation Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Fugitive dust emissions are expected to have impact on the ambient air quality within project footprint.
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fugitive dust emissions from construction activities.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.2: Magnitude of Changes	2: Medium	PM_{10} and $PM_{2.5}$ concentrations from operation are estimated to be within 10% - 50% of the respective Long Term SAAQT (Conservative Approach).
A2.3: Impact Extent	1: Local	Fugitive dust emissions are anticipated to be within project footprint.
B1: Permanence	1: Temporary	Fugitive dust emissions will be temporary as it will only last for the duration of the maintenance works.
B2: Impact Pathway	3: Direct	Fugitive dust emissions are a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fugitive dust emissions are reversible when dust-generating construction activities stop.
B4: Cumulative	3: Cumulative	Fugitive dust emissions from other construction projects (such as future development projects within Tengah) are expected cause cumulative impacts to the local ambient air quality as they happen concurrently.
Environmental Score (ES)	(-2) x (9) = -18	
Range Bands ES/ Impact Significance	Slight Negative Impact	

Potential impact assessment of ambient air quality by exhaust emissions from fuel-burning equipment and heavy vehicle/ machinery at affected community (ASR 1, ASR 2, ASR 3) during operation phase is presented on **Table 7-11**.

Table 7-11: Impact Significance for Exhaust emissions from Fuel Burning Equipment/ Machinery/ Vehicle during Operation Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Fuel burning equipment/ machinery/ vehicle exhaust emissions are expected to have impact on the ambient air quality within project footprint.
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fuel burning equipment/ machinery/ vehicle exhaust emissions from construction activities.
A2.2: Magnitude of Changes	1: Low	PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO concentrations from fuel burning equipment/ machinery/ vehicle exhaust emissions are estimated to be less than 10% of the respective Long Term SAAQT.
A2.3: Impact Extent	1: Local	Fuel burning equipment/ machinery/ vehicle exhaust emissions are anticipated to be within project footprint.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B1: Permanence	1: Temporary	Fuel burning equipment/ machinery/ vehicle exhaust emissions will be temporary as it will only last for the duration of the maintenance works.
B2: Impact Pathway	3: Direct	Fuel burning equipment/ machinery/ vehicle exhaust emissions is a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fuel burning equipment/ machinery/ vehicle exhaust emissions is reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Fuel burning equipment/ machinery/ vehicle exhaust emissions from other construction projects (such as future development projects within Tengah) are expected cause cumulative impacts to the local ambient air quality as they happen concurrently.
Environmental Score (ES)	(-1) x 9 = -9	
Range Bands ES/ Impact Significance	Slight Negative Impact	

7.5 Recommendation of Application Prevention and Mitigation Measures

7.5.1 Construction Phase Mitigation Measures

The overall approach to eliminate, minimise or reduce the potential impacts on ambient air quality during construction of the Project development involves the following approaches:

- **Dust Control**: The objective is to reduce or eliminate dust emissions from the activities generating fugitive dust and causing erosion such as site clearance and open excavation works.
- **Stockpile Management**: The objective is to minimise erosion and sediment transport from soil stockpiles.
- **Management of Construction Machinery, Vehicles and Equipment**: The objective is to reduce emissions from construction machinery, vehicles and equipment.

Dust Control

There is no specific regulation or guidelines in Singapore regarding height of dust screen. At minimum, the contractor should comply with the LTA's General Specification for Safety, Health and Environment that required a 2.4 m high durable metal perimeter hoarding be provided and maintained around the perimeter of the work site and of all satellite locations since the hoarding could act as barrier and minimize dust movement from the construction site to the nearby ASRs. However, an ECO to be engaged by the contractor is required to prepare a site environmental control plan and should consider installing additional dust screen, if necessary. The ECO needs to take prevailing wind conditions, work activities at different stages of the construction and distance of the dust generating sources to nearby ASRs when determining the appropriate height of the additional dust screen.

Nonetheless, the hoarding and dust screen should not be the only mitigation measure to control adverse dust impact. Other mitigation measures that could be taken by the contractor are described below.

- Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeters are recommended to reduce dust deposition at adjacent areas construction site.
- Construction works including vegetation clearance and tree felling should be done in phases/ segments to minimise the area disturbed at any given time.
- Extent of excavation and soil exposure areas recommended to be kept to minimum required for construction.
- Maintain access roads in the construction site damp (e.g., using sprinkler) with the misting frequency increased during dry periods.
- Exposed earth should be properly treated by compaction, turfing, vegetation planting or sealing with bituminous materials, concrete or other suitable materials as soon as practicable after construction activities have been completed.
- For areas with ongoing earth works, cover exposed earth with impermeable sheeting for short periods (1 to 2 days) or with fully biodegradable ECB in longer periods.
- Construction site perimeters and adjacent roads or lands should be regularly inspected to check for and if necessary, remove dust deposition.
- Vehicle on-site speed restrictions should be imposed by contractor to prevent dust being whipped up by vehicle movements.
- Vehicle washing facilities with high pressure water jets should be provided at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point should be paved with concrete or tarred with bituminous materials by contractor.

<u>Stockpile Management</u>

The ECO needs to take prevailing wind conditions, work activities at different stages of the construction and distance of the dust generating source to nearby ASRs when determining temporary stockpile locations.

- Stockpiles of soil and dusty materials should be located as far as possible from ASRs, considering prevailing wind directions and seasonal variations.
- Any soil or stockpiles of dusty material should be properly stored, covered entirely with impervious sheeting.
- Stockpiles and excavations should be removed, backfilled or reinstated (as appropriate) as soon as practicable following excavation or unloading.
- Any soil and dusty materials remaining after removal of a stockpile should be wetted with water and cleared from surfaces of work areas or roads with the misting frequency increased during dry periods.
- Stockpiles of soil and dusty materials should not extend beyond pedestrian barriers or fencing.

<u>Management of Construction Machinery, Vehicles and Equipment</u>

In general, proper maintenance of construction vehicles and fuel burning equipment and restriction of vehicle speed limit are recommended during construction phase.

- All fuel-burning machinery or transport vehicles should be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke.
- Construction works should be done in phases/ segments to limit the number of fuel-burning machinery at the site at any given time.

- Vehicle and equipment exhaust should be controlled by good practice procedures, such as turning off equipment when not in use.
- Vehicle speed restrictions on site areas or access roads should be imposed, especially on unpaved roads.
- For areas requiring traffic diversion at public roads Traffic Control Plan in accordance with COP for Traffic Control at Work Zone (2019) should be implemented to minimise traffic congestion and vehicular waiting time at traffic diversion sites and contribute to reduction in vehicle exhaust emissions.
- Load of dusty materials on a vehicle leaving a construction site should be covered entirely with impervious sheeting by contractor. Vehicle should not be overloaded and should be cleaned prior to leaving the site.
- Proper cover for vehicle (e.g., tipper lorry) to avoid falling of soil debris. Any skip hoist used to transport dusty materials should be completely enclosed by impervious sheeting.
- Vehicle washing facilities with high pressure water jets should be provided by contractor at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point should be paved.
- If roadways are contaminated with dusty materials from construction site, clean-up should be conducted without delay.
- Vehicle on-site speed restrictions should be imposed by contractor to prevent dust being whipped up by vehicle movements.

Cover lorry when carrying dusty materials

Fuel burning equipment/ machinery/ vehicle should be regularly maintained to prevent dark smoke emission

Dampen construction site with water regularly

Vehicle washing facilities at exit point from construction site

Cover stockpile with canvas

Figure 7-13: Example of Mitigation Measures for Ambient Air Quality Impact during Construction Activities

It is recommended to conduct ambient air quality monitoring for SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ during the different construction scenarios as specified in the **Section 8.5.1**:

- **Scenario 1:** Nov 2023 to Mar 2024
- **Scenario 2:** April 2024 to Nov 2025
- **Scenario 3:** Dec 2025 to May 2026
- **Scenario 4:** Jun 2026 to Aug 2027

Monitoring at AQ1 over a sampling period on one week should be conducted during the southwest monsoon for scenarios 2, 3 and 4 where the upwind receptors are likely to be impacted. Monitoring at AQ2 and AQ3 over a sampling period of one week should be conducted during the northeast monsoon period for scenarios 1, 2, 3 and 4 where the downwind receptors are likely to be impacted. If the ambient air quality level exceeds the long term SAAQT, contractor should investigate the cause and implement more stringent mitigation measure. EMMP consultants shall conduct their own collocation testing and calibration with a USEPA FRM/FEM equipment, to verify the equipment's performance prior to deployment to the Project site.

7.5.2 Operation Phase Mitigation Measures

The direct impacts were assessed to be slight negative; therefore, no mitigation measure is proposed. Should major repairs be undertaken during the operation phase, mitigation measures proposed for the construction phase will apply.

7.6 Residual Impacts

The adoption of the mitigation measures recommended above will assist to mitigate and further reduce the ambient air quality impacts during construction of the Project. After implementation of these suggested mitigation measures, the residual significance of ambient air quality impacts is anticipated to be minor negative impact for fugitive dust emissions and slight negative impacts for exhaust emission from fuel burning equipment/ machinery/ vehicle. A summary of the ambient air quality impact significance pre- and post-mitigation is presented on **Table 7-12**.

Table 7-12: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Environmental Score (ES)	Range Band of ES / Impact Significance
A-I1	Fugitive Dust Emissions during Construction phase	-132	Moderate Negative Impact	-88	Minor Negative Impact
A-I2	Exhaust Emission from Fuel Burning Equipment/ Machinery/ Vehicle during Construction phase	-88	Minor Negative Impact	-44	Slight Negative Impact
A-I3	Fugitive Dust Emissions during Operation phase	-18	Slight Negative Impact	The direct impacts were assessed to be slight negative; therefore, no mitigation measure is proposed	
A-I4	Exhaust Emission from Fuel Burning Equipment/ Machinery/ Vehicle during Operation phase	-9	Slight Negative Impact	The direct impacts were assessed to be slight negative; therefore, no mitigation measure is proposed	

8. Airborne Noise

This section describes the regulations and standards for noise pollution control that are applicable to the Project development during the construction and operation phase activities and the methodology used for the noise impact assessment. It also discusses the noise baseline data obtained and assesses the potential noise impacts associated with the construction and operation phase activities of the Project development. Appropriate mitigation measures are also provided.

8.1 Applicable Legislation Standards

8.1.1 For Affected Community

Noise emissions from construction sites are regulated under Environmental Protection and Management (EPM) (Control of Noise at Construction Sites) Regulations. A set of maximum allowable noise limits are prescribed for different time periods of the day and for different types of affected premises under EPM (Control of Noise at Construction Sites) Regulations, Second Schedule (**Table 8-1**).

Table 8-1: Maximum Permissible Levels

<table>
<tr><th rowspan="2">Period</th><th rowspan="2">Types of Affected Buildings</th><th colspan="3">Maximum Permissible Noise Levels in A-weighted decibels (dBA)</th></tr>
<tr><th>7 am – 7 pm</th><th>7 pm – 10 pm</th><th>10 pm. – 7 am</th></tr>
<tr><td rowspan="6">Monday to Saturday</td><td rowspan="2">(a) Hospitals, schools, institutions of higher learning, homes for the aged, sick etc.</td><td>60
(L_{Aeq} 12 hrs)</td><td colspan="2">50
(L_{Aeq} 12 hrs)</td></tr>
<tr><td>75
(L_{Aeq} 5 mins)</td><td colspan="2">55
(L_{Aeq} 5 mins)</td></tr>
<tr><td rowspan="2">(b) Residential buildings located less than 150 m from the construction site</td><td>75
(L_{Aeq} 12 hrs)</td><td>65
(L_{Aeq} 1 hr)</td><td>55
(L_{Aeq} 1 hr)</td></tr>
<tr><td>90
(L_{Aeq} 5 mins)</td><td>70
(L_{Aeq} 5 mins)</td><td>55
(L_{Aeq} 5 mins)</td></tr>
<tr><td rowspan="2">(c) Buildings other than those in (a) and (b) above</td><td>75
(L_{Aeq} 12 hrs)</td><td colspan="2">65
(L_{Aeq} 12 hrs)</td></tr>
<tr><td>90
(L_{Aeq} 5 mins)</td><td colspan="2">70
(L_{Aeq} 5 mins)</td></tr>
<tr><td rowspan="2">Sunday and Public Holidays</td><td rowspan="2">(a) Hospitals, schools, institutions of higher learning, homes for the aged, sick etc.</td><td>60
(L_{Aeq} 12 hrs)</td><td colspan="2">50
(L_{Aeq} 12 hrs)</td></tr>
<tr><td>75
(L_{Aeq} 5 mins)</td><td colspan="2">55
(L_{Aeq} 5 mins)</td></tr>
<tr><td rowspan="4">Sunday and Public Holidays</td><td rowspan="2">b) Residential buildings located less than 150 m from the construction site</td><td>75
(L_{Aeq} 12 hrs)</td><td colspan="2">-*</td></tr>
<tr><td>75
(L_{Aeq} 5 mins)</td><td colspan="2">55
(L_{Aeq} 5 mins)</td></tr>
<tr><td rowspan="2">(c) Buildings other than those in (a) and (b) above</td><td>75
(L_{Aeq} 12 hrs)</td><td colspan="2">65
(L_{Aeq} 12 hrs)</td></tr>
<tr><td>90
(L_{Aeq} 5 mins)</td><td colspan="2">70
(L_{Aeq} 5 mins)</td></tr>
</table>

* No limits provided by NEA.

With effect from September 1, 2011, construction site is prohibited to commence work from 10 pm every Saturday to 7 am on the following Monday and from 10 pm on the eve of a public holiday to 7 am on the day following the public holiday as stipulated in EPM (Control of Noise at Construction Sites) Regulations, Fourth Schedule.

8.1.2 For Fauna Receptor

There is no specific legislation, standard or widely accepted guidelines in Singapore that prescribed the noise levels or threshold limit for fauna. Humans and faunas have different hearing abilities and acoustic behaviours, and it is not possible to directly extrapolate from human standards to fauna. Thus, as proposed and agreed in the scoping stage, we have assessed fauna's response to continuous, intermittent or instantaneous noise levels based on publicly available literature. However, it should be recognised that amongst and within different fauna taxon, there is substantial variation of auditory capabilities and behaviours which translate to a wide range of physiological and behavioural reactions to sound that current literature has limited coverage over.

Fauna that relies on vocal communication for a range of functions such as mating courtship, prey location, threat detection and navigation are more severely affected by noise pollution. There are a few known fauna exceptions where current research point towards a greater tolerance to noise due to lower hearing capabilities such as odonates (Robert, 2005) and snakes (Christensen et al., 2012) who depend on other sensory faculties. It is also noted that for bats, acoustic interference with bat calls based on frequencies, rather than the specific noise levels, have a larger impact on their response to noise pollution (Bunkley et al., 2015). Indeed, the range of frequencies that fauna can hear differ greatly from humans and amongst themselves. Humans have a hearing range of approximately 64 to 23,000 hertz (Hz) while dogs can hear between 67 and 45,000 Hz, owls between 200 and 12,000 Hz and bats between 2,000 and 110,000 Hz. Different taxons and species have different sound sensitivities, with some able to hear very low or very high frequencies once crossing a certain threshold of sound intensity (Strain, 2017).

In general, the main impacts which are noted in most research are behavioural changes, psychological impacts, auditory damage and masking of auditory signals. A brief summary of selected laboratory and field research which broadly investigate road and construction noise is shown on **Table 8-2** to highlight the broad range of noise levels and their impacts on different taxon.

Table 8-2: Summary of Noise Levels and Impacts on Fauna

Taxon	Noise Levels (in dBA)	Observed Impacts
Non-volant Mammals	43	• Behavioural and psychological responses of fear such as vocalisations and movement away from noise.
	45-58	• Behavioural response such as lowered above-ground activity, reduced foraging and increased vigilance.
	70-90	• Psychological responses of reduced reproductive efficiency.
Avian	45-70	• Behavioural response resulting in decline in species diversity.
	44 – 80	• Acoustic masking resulting in changes in vocalisations and community interactions.
	68	• Psychological response of reduced reproductive success.
Frogs	48-77	• Acoustic masking resulting in possible reduced breeding success.

Taxon	Noise Levels (in dBA)	Observed Impacts
	60 – 72	• Acoustic masking resulting in increased call amplitude and thus increased energy expenditure.

Source: *(Kight et al., 2012; Parris et al., 2009; Rasmussen et al., 2009; Shannon, Crooks, et al., 2016; Shannon, McKenna, et al., 2016; Westlund et al., 2012)*

Pertinent to the information presented on **Table 8-2**, the impact of noise level ranges differs greatly across various species and taxon and impacts can begin from very low noise levels. We therefore take a multi-pronged approach to fauna receptor assessments, by categorising fauna found on site into three groups for assessment based on their noise-sensitivity and conservation significance as shown on **Table 8-3.** Noise sensitive fauna includes those which use auditory communication for survival including for successful reproduction, while non-noise sensitive fauna tends to rely less heavily, or not at all, on auditory means for survival. We take the reasonable assumption that fauna in the EIA Study Area have since adapted to current baseline noise levels, using that as the threshold limit for fauna receptor assessment, even if these levels may differ from what literature suggests.

As described in **Section 6.2.4.3**, the faunistic field assessment recorded 295 species of which 22 are of conservation significance, examples of what species would fall under the different noise sensitivities assessments are shown on **Table 8-3** with the full list of fauna found in **Appendix 6E**.

Table 8-3: Noise-sensitivity and Conservation Significance of Fauna on Site

Fauna	General Taxon	Example of Fauna
Fauna of conservation significance (i.e., threatened species) who are sensitive to sound	▪ Aculeate hymenopterans ▪ Lepidoptera (butterflies/ moths) ▪ Birds ▪ Amphibians ▪ Reptiles (lizards/ geckos/ skinks) ▪ Mammals	▪ Internationally CR and Nationally EN Straw-headed bulbul (*Pycnonotus zeylanicus*) ▪ Internationally and Nationally CR Sunda pangolin (*Manis javanica*)
Fauna of non-conservation significance (i.e., common species) who are sensitive to sound		▪ Eurasian wild boar (*Sus scrofa*) ▪ Zebra dove (*Geopelia striata*) ▪ Lesser Asian house bat (*Scotophilus kuhlii*)
Fauna who have lower sensitivity to sound	▪ Odonates ▪ Fish ▪ Reptiles (Snake)	▪ Nationally EN Blue-noise spite (*Archibasis melanocyana*) ▪ Reticulated python (*Malayopython reticulatus*) ▪ Common snakehead (*Channa striata*)

Note: CR refers to Critically Endangered, EN refers to Endangered

8.2 Methodology of Noise Assessment

The following guidance documents are referenced to determine noise sensitive receivers (NSRs), establish baseline study method, provide maximum permissible noise level, estimate noise level at NSRs and assess the potential noise impacts during the construction activities:

- Singapore Standard SS 602: 2014 Code of Practice for Control of Noise at Construction and Demolition Sites published by Spring Singapore,
- EPM (Control of Noise at Construction Sites) Regulation,
- British Standards BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise, and
- Technical Memorandum Annex 13: Guidelines for Noise Assessment published by HK EPD adapted to Singapore situation.

8.2.1 Determination of Airborne Noise Sensitive Receivers

The criteria considered for determination of NSRs for the Project are listed below:

- Affected community
  - Hospital, clinic, convalescence, home for the aged, and orphanage
  - Education institution including nursery, kindergarten, school, higher learning institution such as college and university
  - Residential premise including temporary housing
  - Hotel and hostel
  - Court of laws
  - Places of worship
  - Library and museum
  - Public meeting hall
  - Auditorium, concert hall, theatre, recording studio, and broadcasting studio
  - Country parks
- Fauna receptor
  - Ground-dwelling and understory fauna
  - Arboreal fauna

The NSRs potentially affected by the Project development are identified through a combination of desktop study (i.e., review publicly available street directory and satellite map) and visual site survey.

8.2.2 Baseline Noise Monitoring

8.2.2.1 Community Receptor

The noise levels are measured using a Type 1 integrating sound level meter in 'A' weighted level (in dBA). The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1-hour and L_{Aeq} 12-hour.

Noise levels are monitored at 5-minute interval over three different periods of time, i.e., daytime (7 am – 7 pm), evening-time (7 pm – 10 pm), and night-time (10 pm – 7 am) for one week (including one weekend) on a continuous basis to present a representative existing noise background in Tengah Forest.

8.2.2.2 Fauna Receptor

The noise levels are measured using a Type 1 integrating sound level meter in 'A' weighted level (in dBA) with 1/1 octave band. The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1-hour and L_{Aeq} 12-hour in 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. frequency. The weighting of the frequency allows us to capture the various frequencies ranges as different fauna are sensitive to noise at different frequency ranges.

Noise levels are monitored at 5-minute interval over three different periods of time, i.e., daytime (7 am – 7 pm), evening-time (7 pm – 10 pm), and night-time (10 pm – 7 am) for one week (including one weekend) on a continuous basis to present a representative existing noise background in Tengah.

8.2.3 Noise Impact Magnitude

The impact magnitude of the exceedance in noise limits are based on the subjective perception in decibel levels by humans as in **Table 8-4**. The table describes their response to changes in dBA levels and are taken as a guide to the impact magnitude on the noise sensitive receptors when noise exceeds the permissible limits. Although fauna is likely to respond differently to these changes in dB levels, there are no known studies that have investigated responses to varying changes, the same impact magnitude criteria is therefore taken.

Table 8-4: Noise Impact Magnitude Table

Exceedance dBA Level	Subjective Response	Impact Magnitude
< 5 dB	Just perceptible	Minor
5-10 dB	Clearly perceptible	Moderate
> 10 dB	More than twice as loud	Major

Source: Adapted from (Murphy & King, 2014)

8.3 Pre-construction Baseline

8.3.1 Determination of Noise Sensitive Receiver

Based on the mentioned criteria on **Section 8.2.1** and the site reconnaissance carried out on 26 January 2022, the list of NSRs within the EIA Study Area (i.e. 100 m from the contract boundary) that are potentially affected by the Project development is listed on **Table 8-5** and illustrated in **Figure 8-1**.

Table 8-5: Identified Noise Sensitive Receiver (NSRs) for the Project

NSR Cluster	Cluster Description	Type of Receiver	Number of Storeys	Location and Distance of Cluster to the EIA Study Area
NSR Cluster 1	Home Team Academy, 501 Old Choa Chu Kang Road Keat Hong Camp, 611 Old Choa Chu Kang Road	Recreational, Residential	4	Within the central portion of the EIA Study Area, 100 m from DE170 Contract boundary
NSR Cluster 2	Block 450A Choa Chu Kang Avenue 4	Residential	16	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 451 Choa Chu Kang Avenue 4		16	
	Block 452 Choa Chu Kang Avenue 4		16	
	Block 453 Choa Chu Kang Avenue 4		16	
	Block 454 Choa Chu Kang Avenue 4		16	
	Block 455 Choa Chu Kang Avenue 4		16	
	Block 456 Choa Chu Kang Avenue 4		12	
	Block 459 Choa Chu Kang Avenue 4		12	
	Block 460 Choa Chu Kang Avenue 4		16	
	Block 461 Choa Chu Kang Avenue 4		16	
	Hai Inn Temple, 33 Brickland Road	Cultural	4	
NSR Cluster 3	Concord Primary School, 3 Choa Chu Kang Avenue 4	School	4	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 443 Choa Chu Kang Avenue 4	Residential	15	
	Block 444 Choa Chu Kang Avenue 4		15	
	Block 445 Choa Chu Kang Avenue 4		8	
	Block 446 Choa Chu Kang Avenue 4		15	
NSR Cluster 4	Fauna community in Tengah	Ecological	N/A	Within the central portion of the EIA Study Area
NSR Cluster 5	Fauna community in Tengah across WQ2	Ecological	N/A	Within the western portion of the EIA Study Area
NSR Cluster 6	Fauna community in Tengah across WQ5	Ecological	N/A	Within the eastern portion of the EIA Study Area

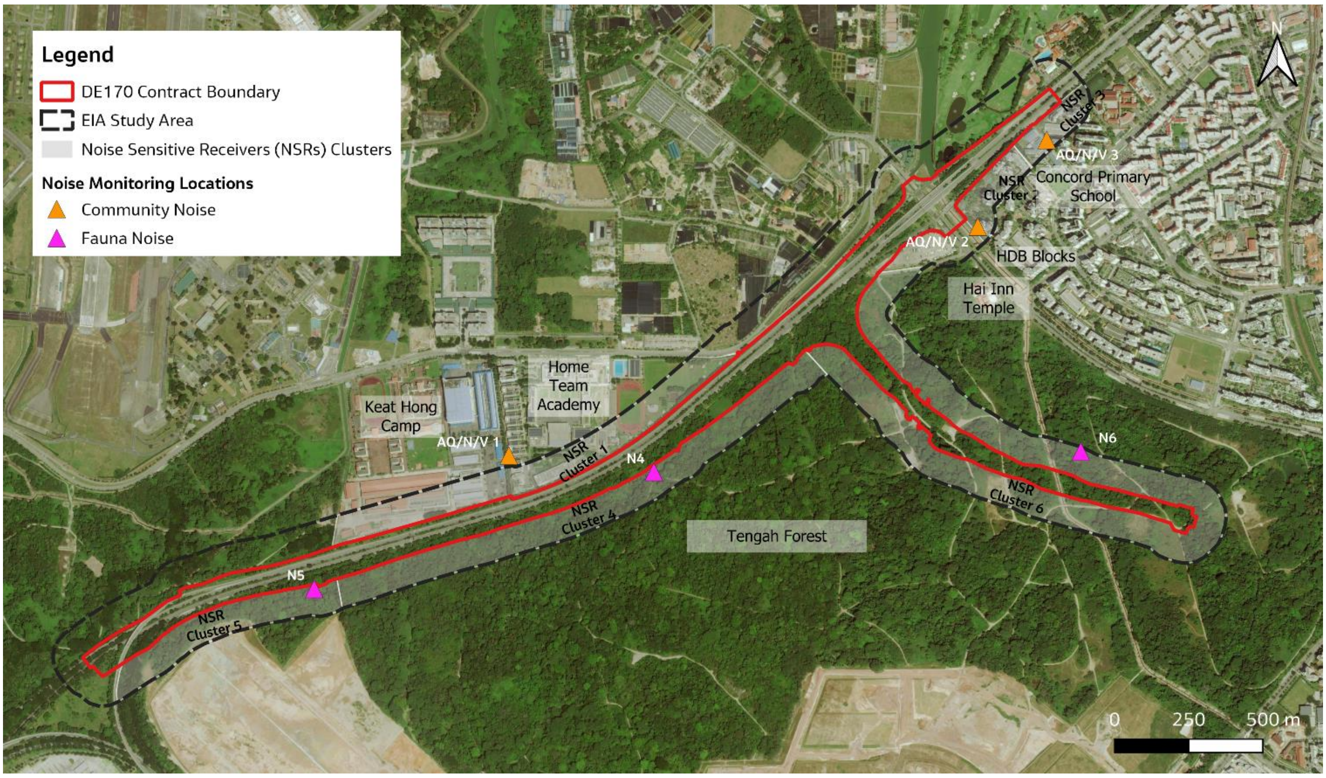


Figure 8-1: Noise Sensitive Receiver Cluster and Noise Monitoring Locations

Source: ESRI

8.3.2 Noise Baseline Monitoring

Three (3) noise monitoring points for affected community and three (3) noise monitoring points for fauna are selected. The locations of the noise baseline monitoring are shown in **Figure 8-1** and described on **Table 8-6**.

Table 8-6: Location of Noise Baseline Measurement Station

Noise Baseline Measurement Station	Description
N1	Home Team Academy
N2	At an open space between Block 461 and Block 460 Choa Chu Kang Avenue 4
N3	At an open space between Concorde Primary School and multistorey carpark Block 446
N4	Within central portion of the EIA Study Area
N5	Within western portion of the EIA Study Area
N6	Within eastern portion of the EIA Study Area (measured in 2020 during the previous EIS)

Note: Based on our site reconnaissance, the major noise source in the vicinity of NSR Cluster 2 and NSR Cluster 3 is traffic noise. Placing the noise meter on the ground floor is preferable as the measured noise level will be the actual perceived levels by the residents staying at the lower floors.

The noise levels for affected community are measured using a Type 1 integrating sound level meter in dBA at 5-minute interval over three different periods of time, i.e., daytime (7 am – 7 pm), evening-time (7 pm – 10 pm), and night-time (10 pm – 7 am) for one week (including one weekend) on a continuous basis to present a representative existing noise background. The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1 hour and L_{Aeq} 12 hour.

The noise levels for affected fauna are measured using Type 1 sound level meter at 5-minute interval over three different periods of time, i.e., daytime (7 am – 7 pm), evening-time (7 pm – 10 pm), and night-time (10 pm – 7 am) for one week on a continuous basis to present a representative baseline of the existing environment. The parameters measured include sound pressure level (in dBA) for each frequency in 1/1 octave band and total sound pressure (in dBA).

8.3.3 Traffic Count

As part of the Traffic Impact Assessment to identify the impacts of the construction of Tengah Vehicular Interchange at Kranji Expressway (KJE) on the surrounding transport network, a traffic count was being carried out. The traffic count was carried out according to the "*Guidelines For Preparation of Traffic Impact Assessment Reports*" by LTA.

Traffic count has been undertaken in both directions at the following roads, which are located nearest to the noise monitoring points:

- Traffic count point 1 (TA): Brickland Road, approximately 50 m west from N2
- Traffic count point 2 (TB): KJE, approximately 50 m north from N3

Traffic Count was carried out over the weekdays on 19, 26, and 28 April 2022 during the baseline noise monitoring to establish a correlation between traffic and baseline noise levels. The traffic count was conducted over weekdays for a more conservative approach as traffic tends to be heavier over the weekdays. A sample duration of 15mins vehicles count was conducted during following time periods:

- Peak Daytime (7 am – 9 am)
- Peak Evening Time (5 pm – 7 pm)
- Off Peak Time (12 pm – 1 pm)

One sample of traffic count was taken for each traffic count points for Morning Peak, Noon Non-peak and Evening Peak. The number of vehicles passed through the traffic count points during the counting periods will be counted using manual tally counters in the following categories:

- Passenger cars and vans
- Light good vehicles with laden weights up to 3 tonnes
- Heavy good vehicles with laden weights more than 3 tonnes
- Small buses up to 30 seats
- Large buses more than 30 seats
- Articulated buses
- Motorcycles

The numbers for each category of vehicles counted are converted into passenger car unit equivalent (PCU) by multiplying the numbers counted[2] with appropriate PCU factors. PCU is a metric used in Transportation

[2] Numbers counted are actual number of vehicles counted within the 15 minutes sampling period

Engineering to assess traffic-flow rate and is essentially the impact that a mode of transport has on traffic variable (such as headway, speed, density) compared to a single passenger car. The PCU factors used for each category of vehicles are following the LTA's Code of Practice for Street Work Proposal Relating to Development Works November 2012 Edition and presented below.

- Passenger cars and vans (PCU factor = 1.0)
- Light good vehicles with laden weights up to 3 tonnes (PCU factor = 1.3)
- Heavy good vehicles with laden weights more than 3 tonnes (PCU factor = 2.5 for arterial road and 2.75 for expressway)
- Small buses up to 30 seats (PCU factor = 1.6)
- Large buses more than 30 seats (PCU factor = 2.5)
- Articulated buses (PCU factor = 2.9)
- Motorcycles (PCU factor = 0.7)

Results obtained from traffic count and the associated PCU are presented in **Appendix 8A** and summarised on **Table 8-7**.

Table 8-7: Vehicle Count Results

Vehicle Count Point	Morning Peak (7 am – 9 am)		Noon Non-Peak (12 pm – 1 pm)		Evening Peak (5 pm – 7 pm)	
	Towards Choa Chu Kang	Towards Tengah	Towards Choa Chu Kang	Towards Tengah	Towards Choa Chu Kang	Towards Tengah
Traffic count point 1 (TA): Brickland Road	302	213	210	216	596	242
	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound
Traffic count point 2 (TB): KJE	1,523	1,094	972	1,010	1,140	2,125

From the Traffic Impact Assessment, it is observed that traffic tends to be the highest during evening peak on the direction towards Choa Chu Kang for Brickland Road. As for the KJE, it is observed that traffic tends to be the highest during evening peak for eastbound and highest during morning peak for westbound. Noise generated from passing vehicles is captured during the noise baseline monitoring and identified as background noise. Thus, PCU recorded is not considered in the noise modelling.

8.3.4 Pre-construction Baseline Monitoring Results and Discussion

8.3.4.1 Affected Community

The noise baseline measurement for affected community was conducted from 5 April to 29 April 2022. Noise baseline result and photographic logs are provided in **Appendix 8B** and **Appendix 8C**, respectively, and summary results are tabulated on **Table 8-8**.

General observation from the baseline monitoring at community receptors indicating that the major source of noise for NSR clusters 1, 2, and 3 are from vehicular traffic. Other source of noise at NSR 1 includes low flying aircraft due to its close proximity to the airbase. It is also observed that noise baseline levels for NSR clusters 2 and 3 tends to higher on both weekdays and weekends across day, evening and night periods than NSR cluster 1. The higher baseline noise at NSR 2 and 3 are like due to its close proximity to major roads of Brickland Road and KJE. It is also located near the junction of Brickland Road and KJE where traffic tends to be heavier. If the difference between baseline noise level and maximum permissible noise level were less than 10 dBA, the maximum permissible noise levels are further adjusted according to EPM (Control of Noise at Construction Sites) Regulations, Third Schedule.

The noise baseline measurement results are summarised below:

8.3.4.1.1 N1 (Residential)

- During day time, L_{Aeq} 5 mins on weekdays (77.9 dBA) and on Sunday (58.9 dBA) comply with the respective maximum permissible noise levels for weekdays (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekday (63.5 dBA) and on Sunday (52.0 dBA) comply with the respective maximum permissible noise levels for weekdays (75 dBA) and Sunday (75 dBA).
- During evening time, L_{Aeq} 5 mins on weekdays (68.7 dBA) complies with the maximum permissible noise levels for weekdays (70 dBA) but L_{Aeq} 5 mins on Sunday (59.1 dBA) exceeds the maximum permissible noise levels for Sunday (55 dBA); L_{Aeq} 1 hour on weekdays (61.6 dBA) complies with the maximum permissible noise levels for weekdays (65.0 dBA).
- During night time, L_{Aeq} 5 mins on weekdays (72.9 dBA) and on Sunday (58.0 dBA) exceed the respective maximum permissible noise levels for weekdays (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekdays (62.5 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

8.3.4.1.2 N2 (Residential)

- During day time, L_{Aeq} 5 mins on weekdays (82.2 dBA) and on Sunday (62.1 dBA) comply with the respective maximum permissible noise levels for weekdays (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekdays (66.5 dBA) and on Sunday (57.6 dBA) comply with the respective maximum permissible noise levels for weekdays (75 dBA) and Sunday (75 dBA).
- During evening time, L_{Aeq} 5 mins on weekdays (68.0 dBA) complies with maximum permissible noise level for weekdays (70 dBA) but L_{Aeq} 5 mins on Sunday (59.4 dBA) exceeds the maximum permissible noise levels for Sunday (55 dBA); L_{Aeq} 1 hour on weekday (63.6 dBA) complies with the maximum permissible noise levels for weekdays (65 dBA).
- During night time, L_{Aeq} 5 mins on weekdays (69.5 dBA) and on Sunday (60.9 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekdays (62.4 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

8.3.4.1.3 N3 (School)

- During day time, L_{Aeq} 5 mins on weekdays (83.6 dBA) exceeds the maximum permissible noise level (75 dBA) but L_{Aeq} 5 mins on Sunday (62.3 dBA) complies with the respective maximum permissible noise levels for Sunday (75 dBA); L_{Aeq} 12 hours on weekdays (65.6 dBA) exceeds the maximum permissible noise levels for weekdays (60 dBA) but L_{Aeq} 12 hours on Sunday (57.1 dBA) complies with the respective maximum permissible noise levels for Sunday (60 dBA).
- During evening time, L_{Aeq} 5 mins on weekdays (74.9 dBA) and on Sunday (58.5 dBA) exceed the respective maximum permissible noise level for weekdays (55 dBA) and on Sunday (55 dBA); L_{Aeq} 12 hours on weekday (59.2 dBA) and on Sunday (54.7 dBA) exceed the respective maximum permissible noise level for weekdays (50 dBA) and on Sunday (50dBA).

- During night time, L_{Aeq} 5 mins on weekdays (61.5 dBA) and on Sunday (60.2 dBA) exceed the respective maximum permissible noise levels for weekdays (55 dBA) and Sunday (55 dBA); L_{Aeq} 12 hours on weekdays (59.2 dBA) and on Sunday (54.7 dBA) exceed the respective maximum permissible noise level for weekdays (50 dBA) and on Sunday (50dBA).

8.3.4.1.4 N3 (Residential)

- During day time, the monitored maximum L_{Aeq} 5 mins on weekdays (83.6 dBA) and on Sunday (62.3 dBA) comply with the respective maximum permissible noise levels for weekdays (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekdays (65.6 dBA) and on Sunday (57.1 dBA) comply with the respective maximum permissible noise levels for weekdays (75 dBA) and Sunday (75 dBA).
- During evening time, the monitored maximum L_{Aeq} 5 mins on weekdays (74.9 dBA) and on Sunday (58.5 dBA) exceed the respective maximum permissible noise levels for weekdays (70 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekdays (67.6 dBA) exceeds the maximum permissible noise levels for weekdays (65 dBA).
- During night time, the monitored maximum L_{Aeq} 5 mins on weekdays (61.5 dBA) and on Sunday (60.2 dBA) exceed the respective maximum permissible noise levels for weekdays (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekdays (59.9 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

Table 8-8: Noise Baseline Result for Affected Community

Sampling Point	Type of Affected Premises*	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA) [2]			Correction factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
N1	Residential	Weekday	L_{Aeq} 5 mins	77.9	68.7	72.9	90	70	55	0	3	0	90	73	72.9
			L_{Aeq} 1 hour	69.0	61.6	62.5	-	65	55	-	2	1	-	67	63.5
			L_{Aeq} 12 hours	63.5	54.0	54.0	75	-	-	0	-	-	75	-	-
		Sunday	L_{Aeq} 5 mins	58.9	59.1	58.0	75	55	55	0	1	2	75	60.1	60.0
			L_{Aeq} 1 hour	52.7	54.5	52.7	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	52.0	50.3	50.3	75	-	-	0	-	-	75	-	-
N2	Residential	Weekday	L_{Aeq} 5 mins	82.2	68.0	69.5	90	70	55	1	2	0	91	72	69.5
			L_{Aeq} 1 hour	74.9	63.6	62.4	-	65	55	-	3	0	-	68	62.4
			L_{Aeq} 12 hours	66.5	57.7	57.7	75	-	-	1	-	-	76	-	-
		Sunday	L_{Aeq} 5 mins	62.1	59.4	60.9	75	55	55	0	1	1	75	60.4	61.9
			L_{Aeq} 1 hour	59.1	57.7	59.6	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	57.6	56.9	56.9	75	-	-	0	-	-	75	-	-
N3	School	Weekday	L_{Aeq} 5 mins	83.6	74.9	61.5	75	55	55	1	0	1	84.6	74.9	62.5
			L_{Aeq} 1 hour	75.1	67.6	59.9	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	65.6	59.2	59.2	60	50	50	1	1	1	66.6	60.2	60.2

Sampling Point	Type of Affected Premises*	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA)[2]			Correction factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
		Sunday	L_{Aeq} 5 mins	62.3	**58.5**	**60.2**	75	55	55	0	2	1	75	60.5	61.2
			L_{Aeq} 1 hour	57.8	56.5	58.5	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	57.1	**54.7**	**54.7**	60	50	50	2	1	1	62	55.7	55.7
N3	Residential	Weekday	L_{Aeq} 5 mins	83.6	**74.9**	**61.5**	90	70	55	1	1	1	91	75.9	62.5
			L_{Aeq} 1 hour	75.1	**67.6**	**59.9**	-	65	55	-	2	1	-	69.6	60.9
			L_{Aeq} 12 hours	65.6	59.2	59.2	75	-	-	1	-	-		-	-
		Sunday	L_{Aeq} 5 mins	62.3	**58.5**	**60.2**	75	55	55	0	2	1	75	60.5	61.2
			L_{Aeq} 1 hour	57.8	56.5	58.5	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	57.1	54.7	54.7	75	-	-	0	-	-	75	-	-

Bold red: measured noise level exceeds the maximum permissible noise level stipulated by *EPM (Control of Noise at Construction Sites) Regulations*

[1] Maximum equivalent continuous noise level over specific period from noise baseline measurement [D = day time 7 am – 7 pm; E = evening time 7 pm -10 pm; N = night time 10 pm – 7 am).

[2] Based on *EPM (Control of Noise at Construction Sites) Regulations*, Second Schedule.

[3] Based on *EPM (Control of Noise at Construction Sites) Regulations*, Third Schedule.

8.3.4.2 Affected Fauna

The noise baseline sampling for fauna was conducted from 17 March to 4 April 2022. Noise baseline result and photographic logs are provided **Appendix 8B** and **Appendix 8C**, respectively and summary results are tabulated on **Table 8-9**.

The dominant frequency bands are also provided for an appreciation of the spectrum of noise at various frequencies which fauna on site will experience. However, due to limited information on the specific range each fauna hears at as explained in **Section 8.1.2**, it is omitted from the assessment. The noise baseline monitoring results are summarised below:

8.3.4.2.1 N4

- L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during day, evening and night time on weekdays were generally higher than Sunday.
- On weekday, during day time and evening time, the dominant frequency ranged from 63 Hz to 1,000 Hz (low and medium frequency). During night time, the dominant frequency ranges from 63 Hz to 125 Hz (low frequency).
- On Sunday, during day, evening, and night time the dominant frequency ranged from 63 Hz to 125 Hz (low frequency).
- The maximum L_{Aeq} 5 mins baseline noise levels observed during the day are 86.9 dBA, during the evening is 81.8 dBA and during the night is 73.3 dBA.
- The maximum L_{Aeq} 1 hour baseline noise levels observed during the day are 78.4 dBA, during the evening is 73.5 dBA and during the night is 72.9 dBA.
- The maximum L_{Aeq} 12 hours baseline noise levels observed during the day are 73.3 dBA, during the evening is 67.7dBA and during the night is 67.7 dBA.

8.3.4.2.2 N5

- The L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during day time, evening time and night time on weekdays were higher than Sunday.
- On weekday, during day and evening time the dominant frequency ranged from 63 to 500 Hz (low and medium frequency). During night time, the dominant frequency ranged from 63 to 125 Hz (low frequency).
- On Sunday, during day time the dominant frequency ranged from 63 Hz to 250 Hz (low frequency). During evening and night time, the dominant frequency was 63 Hz to 500 Hz (low and medium and high frequency).
- The maximum L_{Aeq} 5 mins baseline noise levels observed during the day are 88.9 dBA, during the evening is 87.8 dBA and during the night is 75.1 dBA.
- The maximum L_{Aeq} 1 hour baseline noise levels observed during the day are 80.9 dBA, during the evening is 80.5 dBA and during the night is 73.4 dBA.
- The maximum L_{Aeq} 12 hours baseline noise levels observed during the day are 74.7 dBA, during the evening is 72.0 dBA and during the night is 72.0 dBA.

8.3.4.2.3 N6

- L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during day time and evening time on weekdays were generally higher than Sunday.

- L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during night time on weekdays were lower than Sunday.
- On weekday, during day time and evening time, the dominant frequency ranged from 250 Hz to 8,000 Hz (low, medium and high frequency). During night time, the dominant frequency ranges from 1000 Hz to 8,000 Hz (high frequency).
- On Sunday, during day time the dominant frequency ranged from 500 Hz to 8,000 Hz (medium and high frequency). During evening time and night time, the dominant frequency was 2,000 Hz to 8,000 Hz (high frequency).
- The maximum L_{Aeq} 5 mins baseline noise levels observed during the day are 75.3 dBA, during the evening is 61.4 dBA and during the night is 60.7 dBA.
- The maximum L_{Aeq} 1 hour baseline noise levels observed during the day are 69.5 dBA, during the evening is 56.7 dBA and during the night is 56.4 dBA.
- The maximum L_{Aeq} 12 hours baseline noise levels observed during the day are 59.5 dBA, during the evening is 52.7 dBA and during the night is 52.7 dBA.

The noise levels at N6 are much lower than the baseline noise levels at N4 and N5. This is expected due to its distance away from the expressway which generates a large amount of sound as reflected in the louder noise at N4 and N5. The area between the roads and other noise sources (i.e., construction, aeroplanes) is also largely forested, which will further attenuate the sounds which reach N6. Fauna is generally well spread out on site, however, the nationally Critically Endangered Sunda pangolin (*Manis javanica*) and Nationally Extinct and Rediscovered forest hopper (*Astictopterus jama jama*) were only observed in the eastern part of the EIA Study Area, nearer to N6 as explained in **Section 6.2.4.3.6** and **Section 6.2.4.3.10**. Aside from the suitable habitat, lower noise levels could also be attributed to their presence as they are both noise-sensitive fauna. Over time, fauna adapt to noise levels either by moving away, behavioural or changing their vocal behaviour (Berger-Tal, et al., 2019). It is therefore a reasonable assumption that fauna have adapted to these maximum baseline noise levels at these respective areas.

Table 8-9: Noise Baseline Result for Affected Fauna

Monitoring Point	Period	Time	Maximum Baseline Noise Level (dBA)									
			Frequency (Hz) / Parameter	63	125	250	500	1k	2k	4k	8k	Total
N4	Weekday	Day 7 am – 7 pm	L_{Aeq} 5 mins	79.0	80.4	83.0	78.4	72.8	66.6	65.2	60.1	86.9
			L_{Aeq} 1 hour	71.9	71.9	73.9	69.2	64.2	62.0	60.5	55.4	78.4
			L_{Aeq} 12 hours	69.6	67.0	66.3	61.9	59.7	53.7	51.3	51.0	73.3
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	71.4	76.9	77.4	73.4	68.6	56.9	63.9	58.0	81.8
			L_{Aeq} 1 hour	68.3	67.3	66.8	63.2	59.8	52.8	62.1	57.4	73.5
			L_{Aeq} 12 hours	65.0	60.7	57.4	55.1	55.0	48.1	52.8	49.7	67.7
		Night 10 pm – 7 am	L_{Aeq} 5 mins	71.1	66.9	58.5	57.5	59.6	54.0	58.2	57.0	73.3
			L_{Aeq} 1 hour	71.1	65.5	57.3	57.1	59.6	53.5	58.2	55.1	72.9
			L_{Aeq} 12 hours	65.0	60.7	57.4	55.1	55.0	48.1	52.8	49.7	67.7
	Sunday	Day 7 am – 7 pm	L_{Aeq} 5 mins	67.2	62.4	54.8	55.5	56.5	55.5	55.6	52.3	69.5
			L_{Aeq} 1 hour	65.8	71.9	73.9	69.2	64.2	62.0	60.5	55.4	77.6
			L_{Aeq} 12 hours	64.3	67.0	66.3	61.9	59.7	53.7	50.8	49.6	71.8
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	66.0	61.8	53.8	55.1	57.0	51.7	61.3	50.2	69.1
			L_{Aeq} 1 hour	64.3	59.4	51.6	53.6	56.5	50.0	54.5	47.5	66.9
			L_{Aeq} 12 hours	63.5	58.1	50.9	52.1	55.0	49.8	49.8	45.2	65.7
		Night 10 pm – 7 am	L_{Aeq} 5 mins	70.7	65.0	56.3	57.0	60.3	60.7	59.5	54.5	72.8
			L_{Aeq} 1 hour	69.2	63.8	55.2	55.4	59.0	55.3	54.1	49.1	71.1
			L_{Aeq} 12 hours	63.5	58.1	50.9	52.1	55.0	49.8	49.8	45.2	65.7

Monitoring Point	Period	Time	Maximum Baseline Noise Level (dBA)									
			Frequency (Hz) / Parameter	63	125	250	500	1k	2k	4k	8k	Total
N5	Weekday	Day 7 am – 7 pm	L_{Aeq} 5 mins	83.2	82.4	84.1	80.3	70.9	70.2	67.4	61.3	88.9
			L_{Aeq} 1 hour	76.1	75.2	74.2	71.8	65.2	64.7	61.9	55.7	80.9
			L_{Aeq} 12 hours	71.8	67.5	65.7	64.0	62.0	57.9	54.8	51.4	74.7
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	82.5	82.3	82.5	78.3	69.8	59.0	59.8	47.8	87.8
			L_{Aeq} 1 hour	75.8	75.0	74.1	71.3	64.1	54.1	56.5	46.6	80.5
			L_{Aeq} 12 hours	68.5	65.7	63.7	61.7	58.8	50.3	53.4	45.4	72.0
		Night 10 pm – 7 am	L_{Aeq} 5 mins	72.8	67.8	57.8	60.8	62.8	54.1	65.2	50.0	75.1
			L_{Aeq} 1 hour	71.1	66.0	56.2	59.5	61.7	52.9	63.4	49.2	73.4
			L_{Aeq} 12 hours	68.5	65.7	63.7	61.7	58.8	50.3	53.4	45.4	72.0
	Sunday	Day 7 am – 7 pm	L_{Aeq} 5 mins	72.6	76.8	75.7	67.4	66.0	66.5	64.4	59.4	80.8
			L_{Aeq} 1 hour	68.7	69.9	68.6	61.7	61.1	60.5	58.3	53.5	74.7
			L_{Aeq} 12 hours	65.0	62.2	58.8	56.1	58.6	53.4	51.0	49.3	68.5
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	65.7	62.3	53.4	56.8	59.8	51.0	63.2	50.1	69.7
			L_{Aeq} 1 hour	64.4	60.7	51.9	54.7	59.0	49.9	59.6	45.8	67.9
			L_{Aeq} 12 hours	63.1	58.8	49.6	52.5	56.3	47.2	54.0	44.8	65.8
		Night 10 pm – 7 am	L_{Aeq} 5 mins	69.8	64.6	54.6	57.5	60.3	51.9	57.7	55.6	71.9
			L_{Aeq} 1 hour	68.1	63.0	53.4	56.4	59.2	50.5	56.4	47.5	70.2
			L_{Aeq} 12 hours	63.1	58.8	49.6	52.5	56.3	47.2	54.0	44.8	65.8

Monitoring Point	Period	Time	Maximum Baseline Noise Level (dBA)									
			Frequency (Hz) / Parameter	63	125	250	500	1k	2k	4k	8k	Total
N6	Weekday	Day 7 am – 7 pm	L_{Aeq} 5 mins	49.8	61.4	69.1	68.5	67.8	68.4	65.7	59.6	75.3
			L_{Aeq} 1 hour	44.0	54.4	62.5	62.2	62.1	63.2	60.6	54.3	69.5
			L_{Aeq} 12 hours	34.4	44.6	51.9	51.7	52.1	53.6	51.2	46.2	59.5
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	36.6	36.6	55.3	48.0	51.2	53.9	56.5	51.3	61.4
			L_{Aeq} 1 hour	31.7	31.7	48.0	41.3	46.4	46.3	53.0	50.0	56.7
			L_{Aeq} 12 hours	29.4	29.4	38.0	35.9	43.4	44.2	47.6	48.4	52.7
		Night 10 pm – 7 am	L_{Aeq} 5 mins	32.1	37.7	36.6	42.0	52.6	57.6	53.4	52.1	60.7
			L_{Aeq} 1 hour	30.9	34.6	33.4	39.7	50.5	51.1	48.9	50.3	56.4
			L_{Aeq} 12 hours	29.4	29.4	38.0	35.9	43.4	44.2	47.6	48.4	52.7
	Sunday	Day 7 am – 7 pm	L_{Aeq} 5 mins	39.5	54.3	59.5	60.1	60.9	63.6	61.3	55.0	68.7
			L_{Aeq} 1 hour	34.4	45.6	51.0	51.6	53.4	56.3	54.0	48.3	61.0
			L_{Aeq} 12 hours	30.3	37.2	41.6	43.5	46.5	50.0	47.1	44.3	54.2
		Evening 7 pm – 10 pm	L_{Aeq} 5 mins	30.3	30.3	31.9	37.5	47.6	56.4	49.6	50.4	58.5
			L_{Aeq} 1 hour	28.8	28.8	28.9	35.0	41.7	48.4	47.7	49.1	53.6
			L_{Aeq} 12 hours	28.2	28.2	28.3	35.0	42.3	43.3	50.1	47.3	53.0
		Night 10 pm – 7 am	L_{Aeq} 5 mins	34.1	38.9	34.5	41.1	48.8	49.8	63.0	51.0	63.7
			L_{Aeq} 1 hour	32.9	36.7	33.5	39.5	45.2	45.5	56.6	49.6	58.1
			L_{Aeq} 12 hours	28.2	28.2	28.3	35.0	42.3	43.3	50.1	47.3	53.0

8.4 Noise Emission Sources from the Proposed Construction Project

Noise is expected to be mainly generated from the following sources during construction:

- Operation of fuel burning equipment (e.g., generator) and handheld tools (e.g., electric drilling, nail gun, welding, grinder, gas cutter, chainsaw).
- Operation and movement of heavy vehicle/ machinery (e.g., excavators, piling machines, dozers, drilling machines, cranes, asphalt pavers, rollers, lorry cranes, transit mixers, and dump trucks).
- Demolition of existing paved and unpaved road.
- Dropping of construction material or waste from height.

Noise levels generated by construction equipment vary greatly depending on the construction stages (i.e., Stage 1 – Enabling Works, Stage 2 – Earthworks and Foundation, Stage 3 – Civil and Structural Works), type of construction activities, construction methodology, type of equipment, model and condition of equipment, quantity and duration of operation. The noise levels are also affected by distance, locations (either stationary or mobile sources), variations in the power of the equipment, and noise characteristics (e.g., continuous or intermittent noise, low frequency or high frequency noise) of the equipment.

At the time of this EIA report preparation, the construction methodology, technical details of the power mechanical equipment (PME) are only expected to be available at a later stage when the construction sub-contractor is on-board. Therefore, for this EIA, the construction methodology, type of equipment, quantity, and duration of operation that are likely to be used at each construction stage were estimated based on typical construction works and Jacobs' project experience on similar construction projects. **Table 8-10** summarises the list of emission sources from the PMEs and their respective sound power level (SWL). All SWL for emission sources were either reference *from SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites* or the *British Standards BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise as a general industrial common value* for this assessment. A more detailed description of the construction schedule and the equipment used in each phase is provided in **Appendix 8D**.

Table 8-10: Summary of the List of Emission Sources and Their Respective Sound Power Level (SWL)

Emission Sources	Sound Power Level SWL (dBA)	Source
Air compressor	114	SS 602-2014
Bar bender machine	90	BS 5228 Part 1
Bar cutter machine	90	BS 5228 Part 1
Boom lift	107	BS 5228 Part 1
Boring Rig	113	BS 5228 Part 1
Chain Saw	105	SS 602-2014
Concrete cutting saw	118	SS 602-2014
Concrete pump	102	SS 602-2014
Crane mounted auger	107	BS 5228 Part 1
Dozer	105	BS 5228 Part 1

Emission Sources	Sound Power Level SWL (dBA)	Source
Drill machine	96	BS 5228 Part 1
Dump Truck	102	SS 602-2014
Electric breakers	105	SS 602-2014
Electric drill	94	SS 602-2014
Excavator	100	SS 602-2014
Forklift	98	SS 602-2014
Generator	99	SS 602-2014
Hydraulic excavator breaker	110	BS 5228 Part 1
Lorry Crane	104	BS 5228 Part 1
Mobile crane	118	BS 5228 Part 1
Mobile/ crawler crane	102	SS 602-2014
Nail Gun	101	BS 5228 Part 1
Oxy cutter	94	SS 602-2014
Pre-boring Rig	112	BS 5228 Part 1
Roller	108	BS 5228 Part 1
Silent Piler	78	BS 5228 Part 1
1 Tonne roller	108	SS 602-2014
Trailer/ low bed truck	103	BS 5228 Part 1
Transit mixer	107	SS 602-2014
Vibrators	99	BS 5228 Part 1
Vibratory Roller	100	SS 602-2014
Vibratory tandem roller	108	SS 602-2014
Vibro-hammer	103	BS 5228 Part 1
Water pump	99	SS 602-2014
Welding	96	BS 5228 Part 1

8.5 Evaluation of Potential Noise Impacts from Construction Activities

The quantitative assessment of potential noise impacts distinguishes between those that are positive or negative nature; major, moderate or minor magnitude of changes; transboundary, national, or local extend; long or short term; direct or indirect pathway; reversible or irreversible; cumulative and non-cumulative. The noise impacts may affect NSRs with international, national or local value.

The prediction of the potential noise levels generated by the construction activities is simulated using noise modelling software CadnaA version 2020 (CadnaA), developed by DataKustik.

8.5.1 Noise Modelling Approach

As described in **Section 3** on the construction activities for the Project, the following are the model assumptions where duration of the construction activities are according to the EPM (Control of Noise at Construction Sites) Regulations:

- Construction activities are conducted within day time period of 7am – 7 pm over weekdays.
- Construction activities that involved bored piling, reinforced concrete works, segmental box girder installation and precast crosshead works may have night works that take place between the timing of 7pm – 11pm on weekdays.
- The construction site is divided into five zones as shown in in **Figure 8-2**.

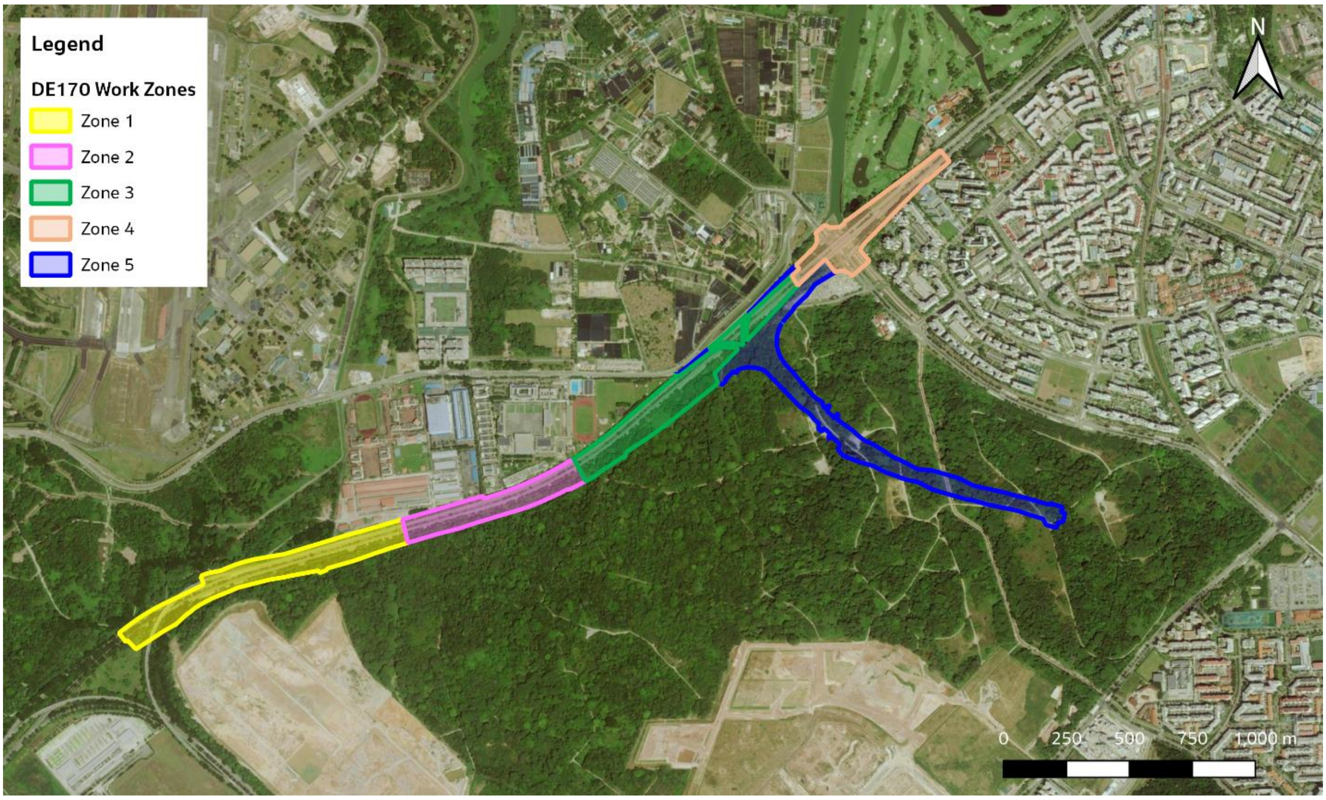


Figure 8-2: Project Zoning

For a more conservation approach in the noise modelling, the entire construction timeline is divided into four separate scenarios for construction activities in the day – Scenarios 1, 2, 3 and 4 (**Appendix 8E**). Construction activities in the day and their respective noise sources are categorised into four different scenarios base on the schedule of works. Construction activities that have their schedule fall within the respective time frame in each scenario will be considered in the modelling for the particular scenario. **Table 8-11** lists all the activities that will be modelled in each scenario. All the construction activities that fall in the particular scenario will be assumed to be taking place throughout the entire duration of the scenario considered.

Table 8-11: Estimated Period Covered by Each Scenario and List of Construction Activities in the Day that will be Modelled in each Scenario

Scenarios	Period	Construction Activities
Scenario 1	Nov 2023 to Mar 2024	• Advance works for all zones • Soil and geotechnical investigation at Zone 1 • Drainage and utilities diversion at Zone 1 • Work area set up at Zones 1 Stage 1, Zone 3, and Zone 5 • Site preparation at all zones • General earthworks at all zones • Demolition and hacking in Zones 1, 3, 4 and 5 • Bored piling in Zone 4 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • General works in Zone 5 • Drainage works in Zone 1 Stage 1 • RC works at Zone 4 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Segmental box girder installation at Zone 4 and Zone 5 Stage 2 (New vehicular bridge) • Precast crosshead at Zone 4 Stage 1 • General infrastructure works in Zones 4 and 5
Scenario 2	April 2024 to Nov 2025	• Drainage and utilities diversion at Zone 1 • Work area set up at Zone 1 Stages 2, 3 and 4, Zone 3 Stage 1,2, 3 and 4 • General earthworks at Zones 1, 3, 4 and 5 • Demolition and hacking in Zones 1, 3, 4 and 5 • Bored piling at Zone 3 Stages 1, 2 and 3, Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Road works at Zone 1 Stages 1, 2, 3 and 4, Zone 3 Stages 1, 2 and 3 and Zone 5 Stages 1, 2 and 3 • Drainage works at Zone 1 Stages 1, 2, 3 and 4, Zone 3 Stages 1, 2 and 3, Zone 5 Stages 2 and 3 and Zone 5- At grade Stages 1 and 2 • RC works at Zones 1 Stages 2 and 3, Zone 3 Stages 1 and 2, Zone 3 Stage 3 and Zone 4, Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Segmental box girder installation at Zone 3 Stages 1, 2, 3, Zone 4 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • General infrastructure works at Zones 1, 3 and 4 • Precast crosshead at Zone 4 Stages 1 and 2 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge)

Scenarios	Period	Construction Activities
Scenario 3	Dec 2025 to May 2026	• Work area set up at Zone 1 Stages 5 and 6, and Zone 3 Stage 4 • General earthworks in Zones 1 and 3 • Demolition and hacking in Zones 1, 3, 4 and 5 • Road works in Zone 1 Stages 4, 5 and 6, Zone 3 Stages 3 and 4 and Zone 5 Stage 3 • Drainage works in Zone 1 Stage 5, Zone 3 Stage 3, Zone 5 Stage 2, Zone 5- At grade Stage 2, Zone 5- At grade Stage 3, • General infrastructure works in Zones 1, 3 and 4 • Precast crosshead at Zone 4 Stages 1 and 2 • RC works at Zone 5 Stage 2 (New vehicular Bridge) • Segmental Box Girder Installation at Zone 5 Stage 2 (New Vehicular Bridge) • Precast crosshead at Zone 5 Stage 1 (Flyover) and Stage 2 (New vehicular Bridge)
Scenario 4	Jun 2026 to Aug 2027	• General infrastructure works at Zones 1 and 3 • Demolition and hacking in Zone 2 • Road Works in Zone 1 Stage 6 and Zone 3 Stage 4 • Drainage works at Zone 5- At grade Stage 4 and 5 • RC works at Zone 5 Stage 2 (New vehicular Bridge) • Precast crosshead at Zone 5 Stage 1 (Flyover) and Stage 2 (New vehicular Bridge)

Similarly, for night works, the timeline for entire night works is divided into four separate scenarios day – Scenarios 5A, 5B, 5C and 5D (**Appendix 8E**). Construction activities in the night works and their respective noise sources are categorised into four different scenarios base on the schedule of works. Construction activities that have their schedule fall within the respective time frame in each scenario will be considered in the modelling for the particular scenario. **Table 8-12** lists all the activities that will be modelled in each scenario. All the construction activities that fall in the particular scenario will be assumed to be taking place throughout the entire duration of the scenario considered.

Table 8-12: Estimated Period Covered by Each Scenario and List of Construction Activities during Night Works that will be Modelled in each Scenario

Scenarios	Period	Construction Activities
Scenario 5A	Nov 2023 to Oct 2024	• Bored piling in Zone 3 Stages 1 and 2 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • RC works at Zone 3 Stages 1 and 2 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Segmental box girder installation at Zone 3 Stages 1 and 2 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Precast crosshead at Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge)
Scenario 5B	Nov 2024 to Nov 2025	• Bored piling in Zone 3 Stage 3 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge)

Scenarios	Period	Construction Activities
		• RC works at Zone 3 Stage 2 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Segmental box girder installation at Zone 3 Stages 2 and 3 and Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge) • Precast crosshead at Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge)
Scenario 5C	Dec 2025 to Dec 2026	• RC works at Zone 5 Stage 2 (New vehicular bridge) • Segmental box girder installation at Zone 5 Stage 2 (New vehicular bridge) • Precast crosshead at Zone 5 Stages 1 (Flyover) and 2 (New vehicular bridge)
Scenario 5D	Jan 2027 to Aug 2027	• RC works at Zone 5 Stage 2 (New vehicular bridge)

8.5.2 Noise Modelling Assumption

The following assumptions were made in undertaking the noise modelling assessment:

- Only PME that will generate significant noise emission is considered in the noise modelling. The sound power levels are obtained from *SS 602: 2014* and *BS 5228-1: 2009*
- All equipment is modelled as point source in CadnaA.
- Ground absorption is set as 1 for forested areas and 0.5 for the residential areas around the contract boundary.
- Singapore's annual average ambient temperature and relative humidity of 28 ˚C and 84% RH is used in all the noise modelling scenarios.
- Community receptors of N1, N2 and N3 are compared with adjusted permissible noise limits according to the *EPM (Control of Noise at Construction Sites) Regulations*.
- Fauna receptors along construction site boundary in NSR cluster 4, 5 and 6 are compared with the maximum baseline levels obtained for N4, N5 and N6 respectively during the baseline monitoring with the assumption that they have since adapted to current baseline noise levels, even if these levels may be higher from what literature suggests as touched upon in **Section 8.1.2**.
- Noise level generated from construction activities to affected fauna are estimated by receiver points of 0.5 m high for ground-dwelling and understory fauna and by receiver points of 15 m high for arboreal fauna. The arboreal fauna receptor height of 15 m was chosen as the general height of trees around the Project. Arboreal fauna could include birds, bats and squirrels who may be more mobile and move away from the noisy activities, but also could build nest in roost in the trees and roost there which are less mobile. Both receiver points of 0.5m and 15m at NSR cluster 4, 5 and 6 are compared against the maximum baseline noise levels obtained for N4, N5 and N6 respectively.
- Only existing buildings within the EIA Study Area (i.e., 100 m from the Contract Boundary) that are potentially affected by the Project development are considered in the noise modelling (refer to **Table 8-5**). A reflection loss of 2 dBA is considered as the existing buildings are not of smooth façade.

- Noise level generated from construction activities to affected community are estimated along the building façade facing the construction site using building evaluation.
- Noise contour is estimated with 10 m x 10 m horizontal grid spacing and 1.5 m vertical grid spacing.
- Predicted noise levels at all NSRs (community and fauna) were determined by adding maximum background noise levels from the baseline monitoring to the maximum modelled noise as shown:
    - Predicted noise (dBA) = Maximum background noise (dBA) + Maximum modelled noise (dBA)

8.5.3 Noise Modelling Results for Day Works Scenarios

The summary of the predicted noise levels during construction stages in the day generated over period (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins), in the absence of any mitigation measures, are presented on **Table 8-13** and **Table 8-14** respectively. Modelled noise results are provided in **Appendix 8F.**

The predicted noise levels over 12 hours for day (L_{Aeq} 12 hours) presented on **Table 8-13** indicates that in the absence of noise mitigation measures at the construction area battery limit there will be no exceedance of the maximum adjusted permissible noise level at affected residential community receptors. However, there will be exceedances of up to 14.9 dBA (Scenario 2) at the affected school community receptor (Concord Primary School) and also exceedances at the affected fauna receptors (both ground dwelling and arboreal) from baseline noise level (in the range of 4.2 dBA to 23.5 dBA).

The predicted noise levels over 5 mins for day (L_{Aeq} 5 mins) presented on **Table 8-14** indicates that in the absence of noise mitigations at the construction area battery limit there will be no exceedance of the maximum adjusted permissible noise level at affected residential community receptors. However, there will be exceedances of up to 1.5 dBA (Scenario 2) at the affected school community receptor (Concord Primary School), and also exceedances at the affected fauna receptors (both ground dwelling and arboreal) from baseline noise level (in the range of 0.4 dBA to 11.3 dBA) at the for all modelled scenarios.

Table 8-13: Unmitigated Noise Levels for Day (L_{Aeq} 12 hours)

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [3](dBA)	Predicted Noise Level [4](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 1 (Nov 2023 to March 2024)							
N1	Residential (HTA)	63.5	64.7	67.2	75.0	75.0	Low
N2	Residential (Block 461)	66.5	68.1	70.4	75.0	76.0	Low
N2	Residential (Block 454)	66.5	70.1	71.7	75.0	76.0	Low
N2	Residential (Block 453)	66.5	71.3	72.5	75.0	76.0	Low
N2	Residential (Blocks 451 and 452)	66.5	71.3	72.5	75.0	76.0	Low
N3	School (Concord Primary School)	65.6	81.3	81.4	60.0	66.6	High
N3	Residential (Block 445)	65.6	69.7	71.1	75.0	76.0	Low
N4 (15m)	Arboreal Fauna	73.3	78.4	79.6	-	-	Medium
N5 (0.5m)	Ground-dwelling Fauna	74.7	77.6	79.4	-	-	Low
N5 (15m)	Arboreal Fauna	74.7	76.9	79.0	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	59.5	83.2	83.2	-	-	High
N6 (15m)	Arboreal Fauna	59.5	82.0	82.0	-	-	High

[3] Noise modelling output. Noise level is from construction activities only, without background noise

[4] Addition of background noise to modelling output

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [3](dBA)	Predicted Noise Level [4](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 2 (April 2024 to November 2025)							
N1	Residential (HTA)	63.5	61.6	65.7	75.0	75.0	Low
N2	Residential (Block 461)	66.5	69.2	71.1	75.0	76.0	Low
N2	Residential (Block 454)	66.5	70.9	72.2	75.0	76.0	Low
N2	Residential (Block 453)	66.5	72.1	73.2	75.0	76.0	Low
N2	Residential (Blocks 451 and 452)	66.5	72.1	73.2	75.0	76.0	Low
N3	School (Concord Primary School)	65.6	81.4	81.5	60.0	66.6	High
N3	Residential (Block 445)	65.6	70.2	71.5	75.0	76.0	Low
N4 (0.5m)	Ground-dwelling Fauna	73.3	82.8	83.3	-	-	Medium
N4 (15m)	Arboreal Fauna	73.3	83.0	83.4	-	-	High
N5 (0.5m)	Ground-dwelling Fauna	74.7	84.5	84.9	-	-	High
N5 (15m)	Arboreal Fauna	74.7	81.8	82.6	-	-	Medium
N6 (0.5m)	Ground-dwelling Fauna	59.5	84.3	84.3	-	-	High
N6 (15m)	Arboreal Fauna	59.5	82.7	82.7	-	-	High

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [3](dBA)	Predicted Noise Level [4](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 3 (Dec 2025 to May 2026)							
N1	Residential (HTA)	63.5	61.4	65.6	75.0	75.0	Low
N2	Residential (Block 461)	66.5	65.7	69.1	75.0	76.0	Low
N2	Residential (Block 454)	66.5	66.9	69.7	75.0	76.0	Low
N2	Residential (Block 453)	66.5	68.3	70.5	75.0	76.0	Low
N2	Residential (Blocks 451 and 452)	66.5	68.1	70.4	75.0	76.0	Low
N3	School (Concord Primary School)	65.6	70.1	71.4	60.0	66.6	Low
N3	Residential (Block 445)	65.6	65.1	68.4	75.0	76.0	Low
N4 (0.5m)	Ground-dwelling Fauna	73.3	83.0	83.4	-	-	High
N4 (15m)	Arboreal Fauna	73.3	83.1	83.5	-	-	High
N5 (0.5m)	Ground-dwelling Fauna	74.7	87.3	87.5	-	-	High
N5 (15m)	Arboreal Fauna	74.7	84.9	85.3	-	-	High
N6 (0.5m)	Ground-dwelling Fauna	59.5	85.3	85.3	-	-	High
N6 (15m)	Arboreal Fauna	59.5	83.0	83.0	-	-	High

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [3](dBA)	Predicted Noise Level [4](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 4 (June 2026 to Aug 2027)							
N1	Residential (HTA)	63.5	69.4	70.4	75.0	75.0	Low
N2	Residential (Block 461)	66.5	61.5	67.7	75.0	76.0	Low
N2	Residential (Block 454)	66.5	60.8	67.5	75.0	76.0	Low
N2	Residential (Block 453)	66.5	59.8	67.3	75.0	76.0	Low
N2	Residential (Blocks 451 and 452)	66.5	54.3	66.8	75.0	76.0	Low
N3	School (Concord Primary School)	65.6	59.8	66.6	60.0	66.6	Low
N3	Residential (Block 445)	65.6	53.4	65.9	75.0	76.0	Low
N4 (0.5m)	Ground-dwelling Fauna	73.3	87.5	87.7	-	-	High
N4 (15m)	Arboreal Fauna	73.3	83.0	83.4	-	-	High
N5 (0.5m)	Ground-dwelling Fauna	74.7	86.1	86.4	-	-	High
N5 (15m)	Arboreal Fauna	74.7	82.8	83.4	-	-	Medium
N6 (0.5m)	Ground-dwelling Fauna	59.5	82.3	82.3	-	-	High
N6 (15m)	Arboreal Fauna	59.5	81.4	81.4	-	-	High

Note: **Bold red** indicates exceedance to max adjusted permissible noise level (for N1, N 2 and N3) and exceedance to max baseline noise level (for N4, N5 and N6)

Table 8-14: Unmitigated Noise Levels for Day (L_{Aeq} 5 mins)

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 1 (Nov 2023 to March 2024)							
N1	Residential (HTA)	77.9	65.7	78.2	90.0	90.0	Low
N2	Residential (Block 461)	82.2	69.3	82.4	90.0	91.0	Low
N2	Residential (Block 454)	82.2	71.2	82.5	90.0	91.0	Low
N2	Residential (Block 453)	82.2	72.3	82.6	90.0	91.0	Low
N2	Residential (Blocks 451 and 452)	82.2	72.3	82.6	90.0	91.0	Low
N3	School (Concord Primary School)	83.6	82.3	86.0	75.0	84.6	Low
N3	Residential (Block 445)	83.6	70.7	83.8	90.0	91.0	Low
N4 (0.5m)	Ground-dwelling Fauna	86.9	81.0	87.9	-	-	Low
N4 (15m)	Arboreal Fauna	86.9	81.6	88.0	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	88.9	79.1	89.3	-	-	Low
N5 (15m)	Arboreal Fauna	88.9	78.4	89.3	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	75.3	84.7	85.2	-	-	Medium
N6 (15m)	Arboreal Fauna	75.3	83.0	83.7	-	-	Medium

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 2 (April 2024 to March 2025)							
N1	Residential (HTA)	77.9	62.9	78.0	90.0	90.0	Low
N2	Residential (Block 461)	82.2	70.3	82.5	90.0	91.0	Low
N2	Residential (Block 454)	82.2	72.0	82.6	90.0	91.0	Low
N2	Residential (Block 453)	82.2	73.5	82.7	90.0	91.0	Low
N2	Residential (Blocks 451 and 452)	82.2	73.2	82.7	90.0	91.0	Low
N3	School (Concord Primary School)	83.6	82.4	86.1	75.0	84.6	Low
N3	Residential (Block 445)	83.6	71.1	83.8	90.0	91.0	Low
N4 (0.5m)	Ground-dwelling Fauna	86.9	84.7	88.9	-	-	Low
N4 (15m)	Arboreal Fauna	86.9	84.5	88.9	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	88.9	83.2	89.9	-	-	Low
N5 (15m)	Arboreal Fauna	88.9	81.9	89.7	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	75.3	85.8	86.2	-	-	High
N6 (15m)	Arboreal Fauna	75.3	83.7	84.3	-	-	Medium

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 3 (Dec 2025 to May 2026)							
N1	Residential (HTA)	77.9	62.5	78.0	90.0	90.0	Low
N2	Residential (Block 461)	82.2	66.8	82.3	90.0	91.0	Low
N2	Residential (Block 454)	82.2	68.1	82.4	90.0	91.0	Low
N2	Residential (Block 453)	82.2	70.3	82.5	90.0	91.0	Low
N2	Residential (Blocks 451 and 452)	82.2	69.3	82.4	90.0	91.0	Low
N3	School (Concord Primary School)	83.6	71.1	83.8	75.0	84.6	Low
N3	Residential (Block 445)	83.6	66.0	83.7	90.0	91.0	Low
N4 (0.5m)	Ground-dwelling Fauna	86.9	84.1	88.7	-	-	Low
N4 (15m)	Arboreal Fauna	86.9	84.3	88.8	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	88.9	85.3	90.5	-	-	Low
N5 (15m)	Arboreal Fauna	88.9	84.1	90.1	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	75.3	86.3	86.6	-	-	High
N6 (15m)	Arboreal Fauna	75.3	84.0	84.6	-	-	Medium

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 4 (June 2026 to Aug 2027)							
N1	Residential (HTA)	77.9	70.5	78.6	90.0	90.0	Low
N2	Residential (Block 461)	82.2	62.6	82.2	90.0	91.0	No Change
N2	Residential (Block 454)	82.2	61.8	82.2	90.0	91.0	No Change
N2	Residential (Block 453)	82.2	60.8	82.2	90.0	91.0	No Change
N2	Residential (Blocks 451 and 452)	82.2	55.3	82.2	90.0	91.0	No Change
N3	School (Concord Primary School)	83.6	60.8	83.6	75.0	84.6	No Change
N3	Residential (Block 445)	83.6	54.5	83.6	90.0	91.0	No change
N4 (0.5m)	Ground-dwelling Fauna	86.9	89.0	91.1	-	-	Low
N4 (15m)	Arboreal Fauna	86.9	84.2	88.7	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	88.9	87.0	91.1	-	-	Low
N5 (15m)	Arboreal Fauna	88.9	83.7	90.0	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	75.3	83.3	83.9	-	-	Medium
N6 (15m)	Arboreal Fauna	75.3	82.4	83.2	-	-	Medium

Note: **Bold red** indicates exceedance to max adjusted permissible noise level (for N1, N 2 and N3) and exceedance to max baseline noise level (for N4, N5 and N6)

8.5.4 Noise Modelling Results for Night Works Scenarios

Summary results of unmitigated noise levels during night works generated over 1 hour (L_{Aeq} 1 hour) and 12 hours[5] (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins) are presented on **Table 8-15** and **Table 8-16** respectively. Modelled noise results are provided in **Appendix 8F**.

The predicted noise levels over 1 hour (L_{Aeq} 1 hour) and 12 hours (L_{Aeq} 12 hours) for night works presented on **Table 8-15** indicates that in the absence of any mitigation measures at the construction batter limit, there will be no exceedance of the maximum adjusted permissible noise level at affected residential community receptors. However, there will be exceedances of up to 0.4 dBA (Scenario 5A) at the affected school community (Concord Primary School), and also exceedances at the affected fauna receptors (both ground dwelling and arboreal) from baseline noise level (in the range of 0.6 dBA to 34.2 dBA).

The predicted noise levels over 5 mins for day (L_{Aeq} 5 mins) presented on **Table 8-16** indicates that in the absence of any mitigation measures at the construction battery limit, there will be no exceedance of the maximum adjusted permissible noise level at affected residential community receptors. However, there will be exceedances of up to 0.1 dBA (Scenario 5A) at the affected school community (Concord Primary School), and also exceedances at the affected fauna receptors (both ground dwelling and arboreal) from baseline noise level (in the range of 0.1 dBA to 30.4 dBA).

[5] Predicted noise levels over 12 hours (L_{Aeq} 12 hours) is only applicable for affected school community

Table 8-15: Unmitigated Noise Levels for Night Works (L_{Aeq} 1 hour and L_{Aeq} 12 hours)

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5A (Nov 2023 to Oct 2024)							
N1	Residential (HTA)	61.6	58.3	63.3	65.0	67.0	Low
N2	Residential (Block 461)	63.6	62.4	66.0	65.0	68.0	Low
N2	Residential (Block 454)	63.6	61.0	65.5	65.0	68.0	Low
N2	Residential (Block 453)	63.6	59.4	65.0	65.0	68.0	Low
N2	Residential (Blocks 451 and 452)	63.6	56.0	64.3	65.0	68.0	Low
N3	School (Concord Primary School)	60.2	49.6	60.6	50.0	60.2	Low
N3	Residential (Block 445)	67.6	52.8	67.8	65.0	69.6	Low
N4 (0.5m)	Ground-dwelling Fauna	73.5	80.6	81.4	-	-	Medium
N4 (15m)	Arboreal Fauna	73.5	81.4	82.0	-	-	Medium
N5 (0.5m)	Ground-dwelling Fauna	80.5	48.1	80.5	-	-	No Change
N5 (15m)	Arboreal Fauna	80.5	54.7	80.5	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	56.7	82.9	82.9	-	-	High
N6 (15m)	Arboreal Fauna	56.7	81.4	81.4	-	-	High

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5B (Nov 2024 to Nov 2025)							
N1	Residential (HTA)	61.6	58.2	63.2	65.0	67.0	Low
N2	Residential (Block 461)	63.6	62.0	65.9	65.0	68.0	Low
N2	Residential (Block 454)	63.6	60.5	65.3	65.0	68.0	Low
N2	Residential (Block 453)	63.6	58.9	64.9	65.0	68.0	Low
N2	Residential (Blocks 451 and 452)	63.6	55.2	64.2	65.0	68.0	Low
N3	School (Concord Primary School)	60.2	49.0	60.5	50.0	60.2	Low
N3	Residential (Block 445)	67.6	52.6	67.8	65.0	69.6	Low
N4 (0.5m)	Ground-dwelling Fauna	73.5	76.3	78.1	-	-	Low
N4 (15m)	Arboreal Fauna	73.5	78.6	79.8	-	-	Medium
N5 (0.5m)	Ground-dwelling Fauna	80.5	46.7	80.5	-	-	No Change
N5 (15m)	Arboreal Fauna	80.5	54.4	80.5	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	56.7	90.7	90.7	-	-	High
N6 (15m)	Arboreal Fauna	56.7	80.8	80.8	-	-	High

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5C (Dec 2025 to Dec 2026)							
N1	Residential (HTA)	61.6	45.4	68.7	65.0	67.0	Low
N2	Residential (Block 461)	63.6	55.1	64.2	65.0	68.0	Low
N2	Residential (Block 454)	63.6	51.1	63.8	65.0	68.0	Low
N2	Residential (Block 453)	63.6	49.8	63.8	65.0	68.0	Low
N2	Residential (Blocks 451 and 452)	63.6	52.5	63.9	65.0	68.0	Low
N3	School (Concord Primary School)	60.2	46.8	60.4	50.0	60.2	Low
N3	Residential (Block 445)	67.6	50.4	67.7	65.0	69.6	No Change
N4 (0.5m)	Ground-dwelling Fauna	73.5	65.1	74.1	-	-	Low
N4 (15m)	Arboreal Fauna	73.5	66.7	74.3	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	80.5	29.5	80.5	-	-	No Change
N5 (15m)	Arboreal Fauna	80.5	42.1	80.5	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	56.7	90.9	90.9	-	-	High
N6 (15m)	Arboreal Fauna	56.7	84.7	84.7	-	-	High

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5D (Jan 2027 to Aug 2027)							
N1	Residential (HTA)	61.6	42.1	61.7	65.0	67.0	Low
N2	Residential (Block 461)	63.6	51.8	63.9	65.0	68.0	Low
N2	Residential (Block 454)	63.6	47.0	63.7	65.0	68.0	Low
N2	Residential (Block 453)	63.6	49.8	63.8	65.0	68.0	Low
N2	Residential (Blocks 451 and 452)	63.6	50.4	63.8	65.0	68.0	Low
N3	School (Concord Primary School)	60.2	44.9	**60.3**	50.0	60.2	Low
N3	Residential (Block 445)	67.6	48.3	67.7	65.0	69.6	Low
N4 (0.5m)	Ground-dwelling Fauna	73.5	47.1	73.5	-	-	No Change
N4 (15m)	Arboreal Fauna	73.5	53.2	73.5	-	-	No Change
N5 (0.5m)	Ground-dwelling Fauna	80.5	20.4	80.5	-	-	No Change
N5 (15m)	Arboreal Fauna	80.5	32.9	80.5	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	56.7	87.3	**87.3**	-	-	High
N6 (15m)	Arboreal Fauna	56.7	82.1	**82.1**	-	-	High

Note: **Bold red** indicates exceedance to max adjusted permissible noise level (for N1, N 2 and N3) and exceedance to max baseline noise level (for N4, N5 and N6)

Table 8-16: Unmitigated Noise Levels for Night Works (L_{Aeq} 5 mins)

NSR Cluster	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5A (Nov 2023 to Oct 2024)							
N1	Residential (HTA)	68.7	59.4	69.2	70.0	73.0	Low
N2	Residential (Block 461)	68.0	63.7	69.4	70.0	72.0	Low
N2	Residential (Block 454)	68.0	62.2	69.0	70.0	72.0	Low
N2	Residential (Block 453)	68.0	60.6	68.7	70.0	72.0	Low
N2	Residential (Blocks 451 and 452)	68.0	57.2	68.3	70.0	72.0	Low
N3	School (Concord Primary School)	74.9	56.7	75.0	55.0	74.9	Low
N3	Residential (Block 445)	74.9	53.9	74.9	70.0	75.9	No Change
N4 (0.5m)	Ground-dwelling Fauna	81.8	82.0	84.9	-	-	Low
N4 (15m)	Arboreal Fauna	81.8	82.5	85.2	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	87.8	50.2	87.8	-	-	Low
N5 (15m)	Arboreal Fauna	87.8	55.7	87.8	-	-	Low
N6 (0.5m)	Ground-dwelling Fauna	61.5	84.7	84.7	-	-	High
N6 (15m)	Arboreal Fauna	61.5	81.7	81.7	-	-	High

NSR Cluster	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5B (Nov 2024 to Nov 2025)							
N1	Residential (HTA)	68.7	58.2	69.1	70.0	73.0	Low
N2	Residential (Block 461)	68.0	62.0	69.0	70.0	72.0	Low
N2	Residential (Block 454)	68.0	60.5	68.7	70.0	72.0	Low
N2	Residential (Block 453)	68.0	58.9	68.5	70.0	72.0	Low
N2	Residential (Blocks 451 and 452)	68.0	55.2	68.2	70.0	72.0	Low
N3	School (Concord Primary School)	74.9	52.6	74.9	55.0	74.9	No Change
N3	Residential (Block 445)	74.9	55.0	74.9	70.0	75.9	No Change
N4 (0.5m)	Ground-dwelling Fauna	81.8	81.7	84.7	-	-	Low
N4 (15m)	Arboreal Fauna	81.8	81.8	84.8	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	87.8	50.0	87.8	-	-	No Change
N5 (15m)	Arboreal Fauna	87.8	55.7	87.8	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	61.5	91.7	91.7	-	-	High
N6 (15m)	Arboreal Fauna	61.5	83.2	83.2	-	-	High

NSR Cluster	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5C (Dec 2025 to Dec 2026)							
N1	Residential (HTA)	68.7	44.8	68.7	70.0	73.0	No Change
N2	Residential (Block 461)	68.0	54.3	68.2	70.0	72.0	Low
N2	Residential (Block 454)	68.0	50.8	68.1	70.0	72.0	Low
N2	Residential (Block 453)	68.0	49.1	68.1	70.0	72.0	Low
N2	Residential (Blocks 451 and 452)	68.0	51.2	68.1	70.0	72.0	Low
N3	School (Concord Primary School)	74.9	51.0	74.9	55.0	74.9	No Change
N3	Residential (Block 445)	74.9	49.0	74.9	70.0	75.9	No Change
N4 (0.5m)	Ground-dwelling Fauna	81.8	65.6	81.9	-	-	No Change
N4 (15m)	Arboreal Fauna	81.8	67.5	81.9	-	-	Low
N5 (0.5m)	Ground-dwelling Fauna	87.8	35.9	87.8	-	-	No Change
N5 (15m)	Arboreal Fauna	87.8	41.7	87.8	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	61.5	91.9	91.9	-	-	High
N6 (15m)	Arboreal Fauna	61.5	85.7	85.7	-	-	High

NSR Cluster	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)	Predicted Noise Level (dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 5D (Jan 2027 to Aug 2027)							
N1	Residential (HTA)	68.7	43.1	68.7	70.0	73.0	No Change
N2	Residential (Block 461)	68.0	48.0	68.0	70.0	72.0	No Change
N2	Residential (Block 454)	68.0	50.9	68.1	70.0	72.0	Low
N2	Residential (Block 453)	68.0	51.5	68.1	70.0	72.0	Low
N2	Residential (Blocks 451 and 452)	68.0	51.9	68.1	70.0	72.0	Low
N3	School (Concord Primary School)	74.9	52.9	74.9	55.0	74.9	No Change
N3	Residential (Block 445)	74.9	49.4	74.9	70.0	75.9	No Change
N4 (0.5m)	Ground-dwelling Fauna	81.8	48.1	81.8	-	-	No Change
N4 (15m)	Arboreal Fauna	81.8	54.1	81.8	-	-	No Change
N5 (0.5m)	Ground-dwelling Fauna	87.8	27.3	87.8	-	-	No Change
N5 (15m)	Arboreal Fauna	87.8	34.0	87.8	-	-	No Change
N6 (0.5m)	Ground-dwelling Fauna	61.5	88.3	**88.3**	-	-	High
N6 (15m)	Arboreal Fauna	61.5	83.1	**83.1**	-	-	High

Note: **Bold red** indicates exceedance to max adjusted permissible noise level (for N1, N 2 and N3) and exceedance to max baseline noise level (for N4, N5 and N6)

8.6 Noise Impact Assessment

8.6.1 Evaluation of Noise Disturbance from Construction Activities in the day to Identified NSRs (Affected Residential Community)

Affected community receptors are considered of local value. Potential noise impacts to affected community located near construction activities in the day are expected to be negative and direct. For residential community, the impact magnitude is expected to be low as the predicted noise are within the maximum adjusted permissible noise level while for school community (Concord Primary School), the impact magnitude is expected to range from low to high as the predicted noise ranges from less than 5 dBA to more than 10 dBA exceedance from the maximum adjusted permissible noise level. Duration is anticipated to be medium term as the construction activities are expected to last between 3 to 10 years and reversible as the impacts will cease upon completion of the construction activities. The geographical extent of noise impacts is considered to be outside local, within the EIS Study Area. Construction activities from other construction sites located within and in the vicinity of the Project development, may cause cumulative negative impacts, if constructions happen concurrently. Therefore, the overall impact severity of potential noise impacts from construction activities to affected community in the day is considered slight negative.

Impact significant for noise generated over specific period (L_{Aeq} 12 hours) in the day is presented on **Table 8-17**. Impact significant for noise generated over 5 mins (L_{Aeq} 5 mins) in the day is presented on **Table 8-18**. The detailed assessment of noise impact for each particular construction scenarios can be found in **Appendix 8G**.

Table 8-17: Impact Significance for Unmitigated Noise (L_{Aeq} 12 hours) in the Day to Affected Community for All Construction Scenarios

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 100 m buffer (area immediately outside Contract Boundary).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Low to High	Low for Residential community. All the predicted noise levels at residential communities are below the maximum adjusted permissible noise limits Low to High for School Community (Concord Primary School). The predicted noise is expected to range from less than 5 dBA to more than 10 dBA exceedances from the maximum adjusted permissible noise level.
A2.3: Impact Extent	2: Buffer Area	Noise impacts are anticipated to extend past the Project footprint (within 100m buffer outside EIA Study Area).
B1: Permanence	3: Medium-term	Noise impacts for entire construction period will be between 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B4: Cumulative	3: Cumulative	Noise generated from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES) for Residential Community	-44	
Environmental Score (ES) for School Community	-44 to -132	
Range Bands ES/ Impact Significance for Residential Community	Slight Negative Impact	All four construction scenarios for residential communities
Range Bands ES/ Impact Significance for School Community	Slight Negative Impact to Moderate Negative Impact	Slight Negative Impact for Scenarios 3 and 4, Moderate Negative Impact for Scenarios 1 and 2

Table 8-18: Impact Significance for Unmitigated Noise (L_{Aeq} 5 mins) in the Day to Affected Community for All Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 100 m buffer (area immediately outside he Contract Boundary).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	From No Change (0) to Low (1)	No Change to Low for Residential community. All the predicted noise levels at residential communities are below the maximum adjusted permissible noise limits. No Change to Low for School Community (Concord Primary School). The predicted noise levels ranges from below the maximum adjusted permissible noise limits to less than 5 dBA exceedance from maximum adjusted permissible noise level.
A2.3: Impact Extent	2: Buffer Area	Noise impacts are anticipated to extend past the Project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	3: Medium-term	Noise impacts for entire construction period will be between 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES) for Residential Community	0 to -44	
Environmental Score (ES) for School Community	0 to -44	
Range Bands ES/ Impact Significance for Residential Community	No Change to Slight Negative Impact	No Change for Scenario 4 (Except HTA), Slight Negative Impact for Scenarios 1, 2, 3 and 4 (Only HTA)
Range Bands ES/ Impact Significance for School Community	No Change to Slight Negative Impact	No Change for Scenario 4, Slight Negative Impact for Scenarios 1, 2 and 3

8.6.2 Evaluation of Noise Disturbance from Construction Activities during Night Works to Identified NSRs (Affected Residential Community)

Affected community receptors are considered of local value. Potential noise impacts to affected community located near construction activities during night works are expected to be negative and direct. For residential community, the impact magnitude is expected to be low as the predicted noise at are within the maximum adjusted permissible noise level. For school community (Concord Primary School), the impact magnitude is expected to be low as the predicted noise range from within the maximum adjusted permissible noise level to less than 5dBA exceedance from the maximum adjusted permissible noise level. Duration is anticipated to be temporary as nightworks are expected to be limited and only during emergency works for safety and technical reasons and reversible as the impacts will cease upon completion of the construction activities. The geographical extent of noise impacts is considered to be at buffer area. Construction activities from other construction sites located within and in the vicinity of the Project development, may cause cumulative negative impacts, if constructions happen concurrently. Therefore, the overall impact severity of potential noise impacts from construction activities to affected community during night works is considered slight negative.

Impact significant for noise generated over specific period (L_{Aeq} 12 hours) in the day is presented on **Table 8-19**. Impact significant for noise generated over 5 mins (L_{Aeq} 5 mins) in the day is presented on **Table 8-20**. The detailed assessment of noise impact for each particular construction scenario can be found in **Appendix 8G**.

Table 8-19: Impact Significance for Unmitigated Noise (L_{Aeq} 12 hours) during Night Works to Affected Community for All Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 100 m buffer (area immediately outside the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	From No Change (0) to Low (1)	No Change to Low for Residential community. All the predicted noise levels at residential communities are below the maximum adjusted permissible noise limits. Low for School Community (Concord Primary School). All the predicted noise are less than 5 dBA from the maximum adjusted permissible noise level.
A2.3: Impact Extent	2: Buffer Area	Noise impacts are anticipated to extend past the Project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	1: Temporary	Nightworks are expected to be limited and only during emergency works for safety and technical reasons.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES) for Residential Community	0 to -36	
Environmental Score (ES) for School Community	-36	
Range Bands ES/ Impact Significance for Residential Community	No Change to Slight Negative Impact	No Change for Scenario 5C for Block 445, Slight Negative Impact for Scenarios 5A, 5B, 5C (Except Block 445) and 5D
Range Bands ES/ Impact Significance for School Community	Slight Negative Impact	All four construction scenarios and all NSRs

Table 8-20: Impact Significance for Unmitigated Noise (L_{Aeq} 5 mins) in the Day to Affected Community for All Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 100 m buffer (area immediately outside the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	From zero (0) to Low (1)	No Change to Low for Residential community. All the predicted noise levels at residential communities are below the maximum adjusted permissible noise limits No Change to Low for School Community (Concord Primary School). All the predicted noise range from below the maximum adjusted permissible noise limits to less than 5 dBA exceedance from the maximum adjusted permissible noise level.
A2.3: Impact Extent	2: Buffer Area	Noise impacts are anticipated to extend past the Project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	1: Temporary	Nightworks are expected to be limited and only during emergency works for safety and technical reasons.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	0 to -36	
Environmental Score (ES)	0 to - 36	
Range Bands ES/ Impact Significance	No Change to Slight Negative Impact	No Change for all Scenarios for Block 445, Scenario 3 and 4 for HTA and scenario 4 for Block 461, Slight Negative Impact for Scenarios 1 (Except Block 445), 2 (Except Block 445), 3 (Except Blocks 445 and HTA) and 4 (Except Blocks 445, HTA and Block 461)
Range Bands ES/ Impact Significance	No Change to Slight Negative Impact	No Change for Scenarios 1, 2 and 3, Slight Negative Impact for Scenario 1

8.6.3 Evaluation of Noise Disturbance from Construction Activities in the day to Identified NSRs (Affected Fauna Community)

There are three categories of receivers with different noise-sensitivities and conservation priorities for the affected fauna at N4, N5 and N6 clusters. Noise impacts to fauna can range in severity and form. In the most severe of cases, fauna could experience damaged hearing from the exposure to sound above a certain threshold. Fauna may also have an increased psychological response of stress and fear which could lead to higher mortality and lower reproductive efficiency. Some may have behavioural responses, moving away from the noise into other patches of forests. This could possibly result in overcrowding in other forest patches and a competition of limited resources. For fauna which depend on vocalisation for communication, mating displays and navigation, the noise pollution may reduce their abilities to do so. This could result in greater energy expenditure as they adapt their vocalisation to the noise or the inability to successful find mates and or prey.

The noise impact assessment to affected fauna over various construction scenarios in the day is conducted in accordance the assessment methodology described in **Section 8.2**. The score rating for each assessment criteria under each construction stage is summarised on **Table 8-21** to **Table 8-22**. The detailed assessment of noise impact for each particular construction scenario can be found in **Appendix 8G**.

Table 8-21: Impact Significance for Unmitigated Noise (L_{Aeq} 12 hours) in the Day to Affected Fauna for All Construction Scenarios

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e., threatened species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles (lizards/ geckos/ skinks), and mammals).
	2: Priority/ Sensitivity - Medium	Fauna of non-conservation significance (i.e., common species) who are sensitive to sound (i.e,. Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles (lizards/ geckos/ skinks), and mammals).
	1: Priority/ Sensitivity - Low	Fauna who have lower sensitivity to sound (i.e., odonates, fish, and snakes).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna.
A2.2: Magnitude of Changes	From Low (1) to High (3)	High: Noise levels expected to increase, to more than 10 dBA above the baseline levels Medium: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels Low: Noise levels expected to increase, to no more than 5 dBA above the baseline levels
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B1: Permanence	3: Medium-term	Noise impacts for entire construction period will be between 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
	2: Reversible	Fauna that are not sensitive to noise are unlikely to have long-term impacts and can return to the site once the noise has ceased.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	-11 to -324	
Range Bands ES/ Impact Significance	Slight to Major Negative Impact	All four construction scenarios and all NSRs

Table 8-22: Impact Significance for Unmitigated Noise (L_{Aeq} 5 mins) in the Day to Affected Fauna for All Construction Scenarios

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e., threatened species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles (lizards/ geckos/ skinks), and mammals).
	2: Priority/ Sensitivity - Medium	Fauna of non-conservation significance (i.e., common species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles (lizards/ geckos/ skinks), and mammals).
	1: Priority/ Sensitivity - Low	Fauna who have lower sensitivity to sound (i.e. odonates, fish and snakes).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna
A2.2: Magnitude of Changes	From Low (1) to High (3)	High: Noise levels expected to increase, to more than 10 dBA above the baseline levels Medium: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels Low: Noise levels expected to increase, to no more than 5 dBA above the baseline levels
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests

Assessment Criterion	Score Rating	Rating Justification/ Definition
		outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.
B1: Permanence	3: Medium-term	Noise impacts for entire construction period will be between 3 to 10 years and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
	2: Reversible	Fauna that are not sensitive to noise are unlikely to have long-term impacts and can return to the site once the noise has ceased.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	-11 to -324	
Range Bands ES/ Impact Significance	Slight to Major Negative Impact	All four construction scenarios and all NSRs

8.6.4 Evaluation of Noise Disturbance from Construction Activities during Night Works to Identified NSRs (Affected Fauna Community)

The three categories of receivers with different noise-sensitivities and conservation priorities for the affected fauna at N4, N5 and N6 clusters will similarly experience the same negative noise impact mentioned in the above section. Noise at night may proportionally affect nocturnal animals more as they are used to navigating and functioning around lower noise levels. Fauna who are resting may also have greater energy expenditure if rest is disturbed from the noise disturbances.

The noise impact assessment to affected fauna over various construction scenarios during night works is conducted in accordance the assessment methodology described in **Section 8.2**. The score rating for each assessment criteria under each construction stage is summarised on **Table 8-23** to **Table 8-24** The detailed assessment of noise impact for each particular construction scenario can be found in **Appendix 8G**.

Table 8-23: Impact Significance for Unmitigated Noise (L_{Aeq} 1 hour) during Night Works to Affected Fauna for All Construction Scenarios

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e., threatened species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles lizards/ geckos/ skinks, and mammals).

Assessment Criterion	Score Rating	Rating Justification/ Definition
	2: Priority/ Sensitivity - Medium	Fauna of non-conservation significance (i.e., common species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles lizards/ geckos/ skinks, and mammals).
	1: Priority/ Sensitivity - Low	Fauna who have lower sensitivity to sound (i.e., odonates, fish and snakes).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna
A2.2: Magnitude of Changes	From Low (1) to High (3)	High: Noise levels expected to increase, to more than 10 dBA above the baseline levels Medium: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels Low: Noise levels expected to increase, to no more than 5 dBA above the baseline levels
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.
B1: Permanence	1: Temporary	Nightworks are expected to be limited and only during emergency works for safety and technical reasons.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
	2: Reversible	Fauna that are not sensitive to noise are unlikely to have long-term impacts and can return to the site once the noise has ceased.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	0 to 270	
Range Bands ES/ Impact Significance	No Change to Moderate Negative Impact	All four construction scenarios and all NSRs

Table 8-24: Impact Significance for Unmitigated Noise (L_{Aeq} 5 mins) in the Night to Affected Fauna for All Construction Scenarios

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e., threatened species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles (lizards/ geckos/ skinks), and mammals).
	2: Priority/ Sensitivity - Medium	Fauna of non-conservation significance (i.e., common species) who are sensitive to sound (i.e., Aculeate hymenopterans, lepidoptera, birds, amphibians, (reptiles lizards/ geckos/ skinks), and mammals).
	1: Priority/ Sensitivity - Low	Fauna who have lower sensitivity to sound (i.e. odonates, fish and snakes).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna
A2.2: Magnitude of Changes	From Minor (1) to Major (3)	Major: Noise levels expected to increase, to more than 10 dBA above the baseline levels Moderate: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels Minor: Noise levels expected to increase, to no more than 5 dBA above the baseline levels
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.
B1: Permanence	1: Temporary	Nightworks are expected to be limited and only during emergency works for safety and technical reasons.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
	2: Reversible	Fauna that are not sensitive to noise are unlikely to have long-term impacts and can return to the site once the noise has ceased.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.

Assessment Criterion	Score Rating	Rating Justification/ Definition
Environmental Score (ES)	0 to -270	
Range Bands ES/ Impact Significance	No Change to Moderate Negative Impact	All four construction scenarios and all NSRs

The Impact Significance of the construction noise to the affected fauna indicates that mitigation measures such as the use of noise barrier is recommended to reduce the Impact Significance.

8.6.5 Evaluation of Noise Disturbance from Operation Phase (Affected Residential Community)

Operational impacts within the EIA Study Area will potentially be from the use of the interchange and its periodic servicing or maintenance. Heavy construction vehicles are not anticipated to be used during such maintenance activities. As such, these operation phase activities will not generate significant level of noise.

Potential temporary impacts would possibly occur should there be major repairs, especially if heavy machineries are required. This would create potential sources of noise emissions. However, it is expected that such temporary impacts will only last for the duration of the maintenance works and would be limited in scope. Hence, any post-construction impact of maintenance works on the residential community is expected to be minimal.

8.6.6 Evaluation of Noise Disturbance from Operation Phase (Affected Fauna Community)

The post-construction impact of maintenance works on the fauna community is expected to be minimal as it would be temporary and of a similar or lower level than the operational noise from the road.

It is also likely that by the completion of the project, most fauna communities in the area would have adapted to higher noise levels. This can come about from noise-sensitive fauna moving away via the forest which runs adjacent to the project to less noisier sites (i.e., deeper into retained land or area where construction has been completed with lower operational noise) or adapting to navigating and or living with the higher noise levels. It is expected that the fauna threshold of noise sensitivity should increase overall as a result across the areas around DE170 and correspondingly the impact of noise on the fauna community.

8.7 Noise Mitigation Measure for Construction Activities

The assessment showed that the noise impact to the residential community receptors during the construction period are expecting to meet the EPM (Control of Noise at Construction Sites) Regulations, Second Schedule (**Table 8-1**) but not meeting for the school receptor: Concord Primary School. Additional mitigation measures would be required to reduce the noise impact to the Concord Primary School.

The construction noise is expected to negatively affect the fauna communities along the construction site boundary facing the forest area. NSR cluster 6 is more noise sensitive to fauna receptors than the other cluster area, primarily because this cluster is more inner to the forest area, where a low baseline noise level were observed during noise baseline monitoring. It is assumed that the fauna community there have not been adapted to the elevated noise level, hence, even the predicted noise level at N4, N5 and N6 are similar to each other, the potential negative impact to fauna at NSR 6 area is more severe than the other areas. The impact significances are summarised in **Table 8-25.**

Table 8-25: Summary of Evaluation of Residual Impacts to Community Receptors

Impact Register		Before Mitigation Measures		
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Impact Significance Evaluation
		Over Specified Period (L_{Aeq} 12 hours)		
N-I1	Noise Disturbance from Construction Activities in the Day to residential receptors	0 to -44	No Change to Slight Negative Impact	The direct impacts were assessed to be slight negative and meeting EPM regulations; therefore, no mitigation measure is proposed.
N-I2	Noise Disturbance from Construction Activities in the Day to school community receptor (Concord Primary School)	-132	Moderate Negative Impact	The direct impacts were assessed to be moderate negative and not meeting the EPM regulations; therefore, mitigation measure is proposed.
N-I3	Noise Disturbance from Construction Activities during Night Works to residential receptors	-36	Slight Negative Impact	The direct impacts were assessed to be slight negative and meeting EPM regulations; therefore, no mitigation measure is proposed.
N-I4	Noise Disturbance from Construction Activities during Night Works to community receptor (Concord Primary School)	-36	Slight Negative Impact	The direct impacts were assessed to be slight negative. However, it is not meeting EPM regulations as there is less than 5 dBA exceedances from the maximum adjusted permissible noise limits. Therefore, mitigation measure is proposed.
		Over 5 mins (L_{Aeq} 5 mins)		
N-I5	Noise Disturbance from Construction Activities in the Day to residential receptors	0 to -44	No Change to Slight Negative Impact	The direct impacts were assessed to be slight negative and meeting EPM regulations; therefore, no mitigation measure is proposed.
N-I6	Noise Disturbance from Construction Activities in the day to community receptor (Concord Primary School)	0 to -44	No Change to Slight Negative Impact	The direct impacts were assessed to be slight negative. However, it is not meeting EPM regulations as there is less than 5 dBA exceedances from the maximum adjusted permissible noise limits. Therefore, mitigation measure is proposed.
N-I7	Noise Disturbance from Construction Activities	0 to -36	No Change to Slight Negative Impact	The direct impacts were assessed to be slight negative and meeting

Impact Register		Before Mitigation Measures		
	during Night Works to residential receptors			EPM regulations; therefore, no mitigation measure is proposed.
N-I8	Noise Disturbance from Construction Activities during Night Works to community receptor (Concord Primary School)	0 to -36	No Change to Slight Negative Impact	The direct impacts were assessed to be slight negative. However, it is not meeting EPM regulations as there is less than 5 dBA exceedances from the maximum adjusted permissible noise limits. Therefore, mitigation measure is proposed.

To protect the fauna community from excessive exposure to the construction noise, further mitigation measures such as noise source controls, barriers to block noise propagating pathway are reviewed, tested and presented in this section for consideration and implementation during construction phase. The assumptions used in formulating mitigation measures and their practicality are based on the available information and assumptions at this current EIA stage.

8.7.1 Control Measures at Emission Source

The source emission control measures include quieter construction machines/equipment, enclosure, noise screen/ noise panel, portable noise barrier (**Figure 8-3**). During the construction, the contractor may use the PME with different sound power levels, different quantity and operating time from what was modelled. Enclosure at stationary PME such generator with sufficient height and width to accommodate for machinery/equipment housed within. The proposed enclosures may achieve noise level reduction of at least 15 dBA (Table F.3 of SS 602: 2014).

- Noise screen/ noise panel at moveable PME such excavator and crawler/ mobile crane and it should be of sufficient height and width to shield the noisy part. The proposed screening may achieve noise level reduction of at least 10 dBA (Table F.3 of SS 602: 2014).
- Portable noise barrier at construction activities e.g., soil investigation drilling activities, road and drainage work which are close to site boundary. The proposed portable noise barrier may achieve noise level reduction of at least 10 dBA (Section F.3.3.4 of SS 602: 2014).
- Quieter construction methodology such as the use of diamond wire saw cutter is able to achieve up to 30 dBA of noise reduction (based on LTA's Noise Guidance: Developing a Noise Management Plan).

Some of the mitigation measures at source are shown in **Figure 8-3**.

Generator with noise enclosure

Noise panel fitted on noise emission outlet of crane

Soundproof enclosure for crane

Portable noise barrier around work area that involves noisy equipment

Figure 8-3: Example of Noise Mitigation at Source

Source: LTA, 2019; and Eram Engineering Service, 2022

The best available low noise construction equipment that the contractor (CJC) may deploy for this Project is confirmed as listed in **Table 8-26**. The applicable engineering control measures at/near noise source that may further apply to reduce the noise and the estimated dBA reduction are also listed in **Table 8-26**.

Table 8-26: Resulting Sound Power Level of Equipment with Additional Engineering Control Measures

Equipment	Initial Sound Power Level (dBA)	CJC Equipment Sound Pressure Level	CJC Equipment Sound Power Level (dBA)	Type of Engineering Control Measures	Assumed Noise Reduction by Control Measures[1]	Reduced Sound Power Level at source (dBA)
Generator	99	53 dBA at 7 m	78	Noise enclosure [2]	15	78
Excavator	100	74 dBA at 7 m	99	Noise panel	10	90
Crawler Crane	102	78 dBA at 16 m	110	Noise enclosure	15	95
Mobile Crane	118	- [3]	-	Noise enclosure	15	103

Equipment	Initial Sound Power Level (dBA)	CJC Equipment Sound Pressure Level	CJC Equipment Sound Power Level (dBA)	Type of Engineering Control Measures	Assumed Noise Reduction by Control Measures[1]	Reduced Sound Power Level at source (dBA)
Lorry Crane	100			Noise screen/ Noise panel	10	90
Drilling Machine (A-frame)	105	-	-	Portable noise barrier	10	95
Air Compressor	114	71 dBA at 7 m	96	Portable noise barrier	10	86
Pump	96	-	-	Portable noise barrier	10	86
Pre-Boring Rig	112	85 dBA at 1.5 m	96	Portable noise barrier	10	86
Vibrator	99	-	-	Portable noise barrier	10	89
Boomlift	107	-	-	Portable noise barrier	10	97
Trailer	103	-	-	Portable noise barrier	10	93
Dump Truck	102			Portable noise barrier	10	92

Note:

[1] Assumed noise reduction by control measures obtained from SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites

[2] Assumed that 78dBA is the SWL of the generator with noise enclosure

[3] When best available low noise level equipment from CJC is not available at this phase, the SWL level listed in Section 8.4 applies.

8.7.2 Noise Barrier

Apart from the low noise and control measures at source, noise barrier is one of another most effective measure to reduce the noise level from construction activities. Noise Barriers include Permanent Noise Control Barriers (P.N.C.B), Temporary Noise Control Barriers (T.N.C.B), as well as Portable Noise Control Barriers and Noise Reduction Nets, also known as Sound Blankets.

A noise barrier should ideally be constructed such that it blocks the line of sight between receiver and the noise source (**Figure 8-4**). Lower floors of HDB building at the same height of the noise barrier and ground-dwelling/ understory fauna are expected to have more noise reduction from noise barrier than higher floors of HDB building and arboreal fauna.

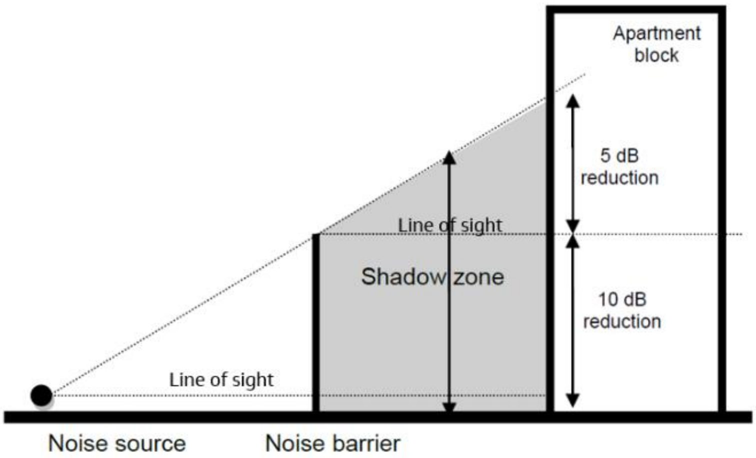


Figure 8-4: The Effectiveness of a Noise Barrier
Source: Figure F.6 of SS 602: 2014

The particular deployment of noise barriers will depend on specific construction site circumstances, which are unknown until construction site works commence. The detail specification and positioning of noise barrier would be best determined by the contractor in consultation with the provider of the noise barrier during the construction phases depending on the actual noise level emission and distance of the construction equipment from the affected NSRs.

Noise barriers should be with a minimum of Sound Transmission Class (STC) 18 to align with the clause 9.29 for the temporary noise barrier under LTA guidelines on Safety, Health and Environment Appendix B (August 2019 Edition). The location and the height of it are to be determined with the aid of the noise modelling exercise to achieve the required noise reduction objectives.

8.7.3 Evaluation of the Mitigation Measures

To determine the additional control measures that may be required to reduce the potential noise impact to the fauna and school community receptors. Modelling trials were conducted for the worst case scenario: Scenario 3 as its results has the highest exceedances at N6 fauna receptors as presented in **Appendix 8H**.

Noise modelling trials are carried out for specific period (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins) for fauna receptors at N4, N5 and N6 area. As a result of the modelling trials, the recommended options are

- Low Noise Powered Mechanical Equipment (PME) per **Table 8-26**.
- Noise barrier 1.4m at N6 area (**Figure 8-5**).

With the above mitigation measures, the following Worst-Case Scenarios are further modelled to understand the predicted noise level at various receptors post to the mitigation measures:

- Scenario 2 modelling (Worst case scenario for school community receptor for construction works in the day)
- Scenario 5A modelling (Worst case scenario for school community receptor for construction works in the night)
- Scenario 3 (Worst case scenario for fauna receptor for construction works in the day)
- Scenario 5C (Worst case scenario for fauna receptor for construction works in the Night)

The resulting predicted noise level for school and fauna community receptors (Day and Night Works) are summarized and compared in **Table 8-27 and Table 8-28** respectively. The resulting noise contours for the above-mentioned worst case scenarios for both community and fauna receptors are provided in **Appendix 8I.**

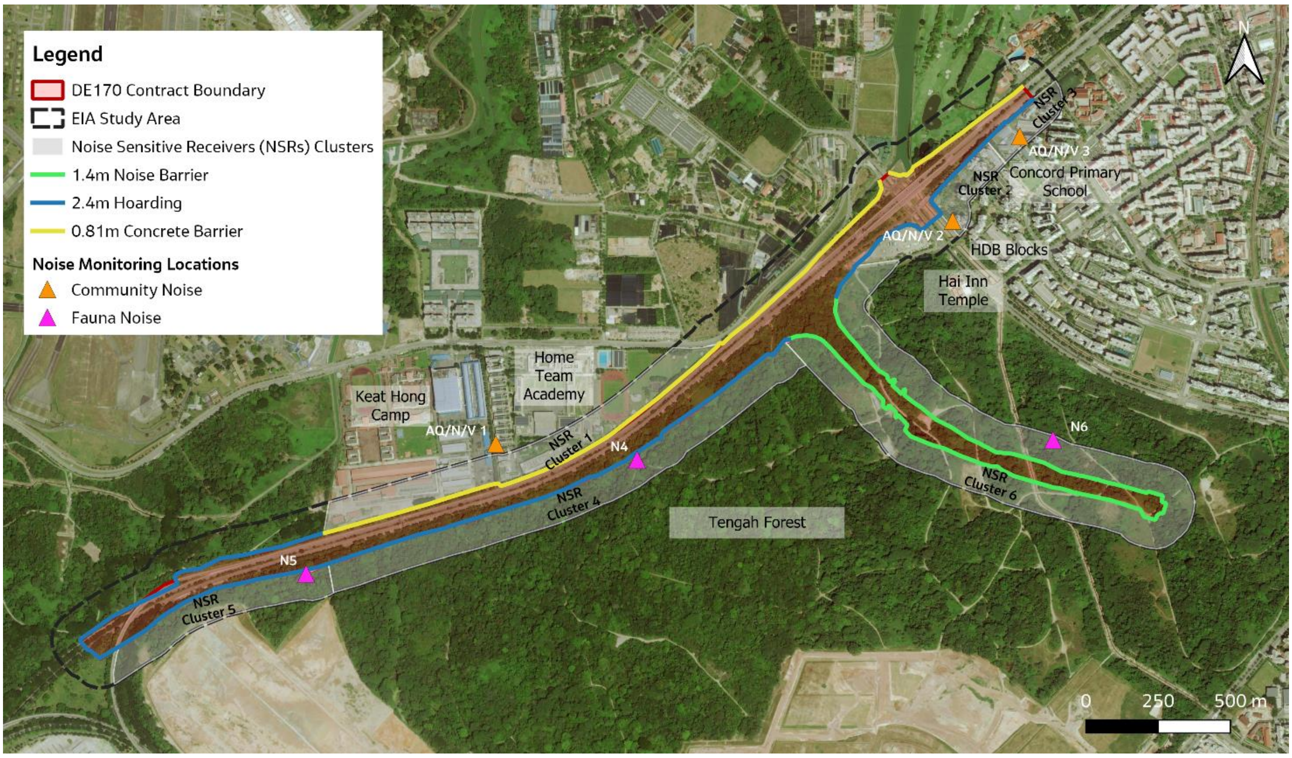


Figure 8-5: Recommended Location of Noise Barriers

Note: no noise barrier included at construction site boundary along width of existing roads. The 2.4m hoarding and 0.81m concrete barrier are not part of the mitigation measures

Table 8-27: Predicted Noise Level for Recommended Mitigation Option for School Community receptors (Day and Night Works)

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [6](dBA)	Predicted Noise Level [7](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Scenario 2 (April 2024 to March 2025) (LAeq12 hours)							
N1	Residential (HTA)	63.5	51.6	63.8	75.0	75.0	Low
N2	Residential (Block 461)	66.5	57.3	67.0	75.0	76.0	Low
N2	Residential (Block 454)	66.5	60.5	67.5	75.0	76.0	Low

[6] Noise modelling output. Noise level is from construction activities only, without background noise

[7] Addition of background noise to modelling output

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [6](dBA)	Predicted Noise Level [7](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
N2	Residential (Block 453)	66.5	63.0	68.1	75.0	76.0	Low
N2	Residential (Blocks 451 and 452)	66.5	61.2	67.6	75.0	76.0	Low
N3	School (Concord Primary School)	65.6	59.8	66.6	60.0	66.6	Low
N3	Residential (Block 445)	65.6	57.6	66.2	75.0	76.0	Low
Scenario 2 (April 2024 to March 2025) (LAeq 5 mins)							
N1	Residential (HTA)	77.9	52.7	77.9	90.0	90.0	No Change
N2	Residential (Block 461)	82.2	58.4	82.2	90.0	91.0	No Change
N2	Residential (Block 454)	82.2	61.7	82.2	90.0	91.0	No Change
N2	Residential (Block 453)	82.2	64.1	82.3	90.0	91.0	Low
N2	Residential (Blocks 451 and 452)	82.2	62.4	82.2	90.0	91.0	No Change
N3	School (Concord Primary School)	83.6	60.8	83.6	75.0	84.6	No Change
N3	Residential (Block 445)	83.6	58.6	83.6	90.0	91.0	No Change
Scenario 5A (Nov 2023 to Oct 2024) (LAeq1 hour)							
N1	Residential (HTA)	61.6	34.7	61.6	65.0	67.0	No Change
N2	Residential (Block 461)	63.6	43.8	63.6	65.0	68.0	No Change
N2	Residential (Block 454)	63.6	42.5	63.6	65.0	68.0	No Change
N2	Residential (Block 453)	63.6	41.4	63.6	65.0	68.0	No Change

NSR Cluster	Type of Affected Receptors	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities [6](dBA)	Predicted Noise Level [7](dBA)	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
N2	Residential (Blocks 451 and 452)	63.6	41.5	63.6	65.0	68.0	No Change
N3	School (Concord Primary School)	60.2	35.4	60.2	50.0	60.2	No Change
N3	Residential (Block 445)	67.6	39.7	67.6	65.0	69.6	No Change
Scenario 5A (Nov 2023 to Oct 2024) (LAeq 5 mins)							
N1	Residential (HTA)	68.7	35.9	68.7	70.0	73.0	No Change
N2	Residential (Block 461)	68.0	45.0	68.0	70.0	72.0	No Change
N2	Residential (Block 454)	68.0	43.6	68.0	70.0	72.0	No Change
N2	Residential (Block 453)	68.0	42.5	68.0	70.0	72.0	No Change
N2	Residential (Blocks 451 and 452)	68.0	42.7	68.0	70.0	72.0	No Change
N3	School (Concord Primary School)	74.9	42.6	74.9	55.0	74.9	No Change
N3	Residential (Block 445)	74.9	40.9	74.9	70.0	75.9	No Change

Table 8-27: Predicted Noise Level for Recommended Mitigation Option for Fauna Receptors (Day and Night Works)

Sampling Point	Type of Affected Premises*	Period	Parameter	Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)					
				Day Time	Baseline	Exceedance	Evening Time	Baseline	Exceedance
				(7am-7pm)	(7am-7pm)	(7am-7pm)	(7pm-10pm)	(7pm-10pm)	(7pm-10pm)
N4 (0.5m)	Fauna	Weekday	LAeq 5 mins	87.1	86.9	0.2	81.8	81.8	0.0
			LAeq 1 hour				73.5	73.5	0.0
			LAeq 12 hours	73.6	73.3	0.3			
N4 (15m)	Fauna	Weekday	LAeq 5 mins	87.1	86.9	0.2	81.8	81.8	0.0
			LAeq 1 hour				73.5	73.5	0.1
			LAeq 12 hours	74.2	73.3	0.9			
N5 (0.5m)	Fauna	Weekday	LAeq 5 mins	88.9	88.9	0.0	87.8	87.8	0.0
			LAeq 1 hour				80.5	80.5	0.0
			LAeq 12 hours	75.2	74.7	0.5			
N5 (15m)	Fauna	Weekday	LAeq 5 mins	88.9	88.9	0.0	87.8	87.8	0.0
			LAeq 1 hour				80.5	80.5	0.0
			LAeq 12 hours	75.2	74.7	0.5			
N6 (0.5m)	Fauna	Weekday	LAeq 5 mins	76.3	75.3	0.9	67.2	61.5	5.7
			LAeq 1 hour				65.4	56.7	8.7
			LAeq 12 hours	68.8	59.5	9.3			
N6 (15m)	Fauna	Weekday	LAeq 5 mins	76.8	75.3	1.5	**73.9**	61.5	12.4
			LAeq 1 hour				**72.5**	56.7	15.8
			LAeq 12 hours	**70.6**	59.5	11.0			

Note: Noise Modelling for Day and Night Works
Red: Exceedance of baseline levels
Bold Red: Exceedance of baseline levels of more than 10 dBA

The school community noise impact assessment in Scenario 2 (Worst case scenario for Day) and Scenario 5A (Worst case scenario for Night) using RIAM tool is further conducted for the recommended mitigation option and summarized in **Table 8-29**.

Table 8-29: Comparison of Noise Impact Assessment Ranking for Recommended Mitigation with Before Mitigation Measures

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Over Specific Period (L_{Aeq} 12 hours)				
N-I9	Noise Disturbance from Construction Activities in the Day to school community receptor (Concord Primary School)	-132	Moderate Negative Impact	-44	Slight negative impact
N-I10	Noise Disturbance from Construction Activities during Night Works to community receptor (Concord Primary)	-36	Slight Negative Impact	0	No Change
	Over L_{Aeq} 5 mins				
N-I11	Noise Disturbance from Construction Activities in the Day to community receptor (Concord Primary School)	-44	Slight Negative Impact	0	No Change
N-I12	Noise Disturbance from Construction Activities during Night Works to community receptor (Concord Primary School)	-36	Slight Negative Impact	0	No Change

The fauna noise impact assessment for Scenario 3 (Worst case scenario for Day) and Scenario 5C (Worst case scenario for Night) using RIAM tool is further conducted for the recommended mitigation option and summarized in the **Table 8-30**.

Table 8-30: Comparison of Noise Impact Assessment Ranking for Recommended Mitigation with Before Mitigation Measures

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Over Specific Period (Day- L_{Aeq} 12 hours)				
	Fauna at N4				
N-I13	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N4	-324	Major negative impact	-108	Minor negative impact
N-I14	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N4	-216	Moderate negative impact	-72	Minor negative impact
N-I15	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N4	-33	Slight negative impact	-11	Slight negative impact
N-I16	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N4	-324	Major negative impact	-108	Minor negative impact
N-I17	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N4	-216	Moderate negative impact	-72	Minor negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I18	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N4	-33	Slight negative impact	-11	Slight negative impact
	Fauna at N5				
N-I19	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N5	-324	Major negative impact	-108	Minor negative impact
N-I20	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N5	-216	Moderate negative impact	-72	Minor negative impact
N-I21	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N5	-33	Slight negative impact	-11	Slight negative impact
N-I22	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N5	-324	Major negative impact	-108	Minor negative impact
N-I23	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N5	-216	Moderate negative impact	-72	Minor negative impact
N-I24	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N5	-33	Slight negative impact	-11	Slight negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
	Fauna at N6				
N-I25	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N6	-324	Major negative impact	-216	Moderate negative impact
N-I26	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N6	-216	Moderate negative impact	-144	Moderate negative impact
N-I27	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N6	-33	Slight negative impact	-22	Slight negative impact
N-I28	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N6	-324	Major negative impact	-324	Major negative impact
N-I29	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N6	-216	Moderate negative impact	-216	Moderate negative impact
N-I30	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N6	-33	Slight negative impact	-33	Slight negative impact
	Over 5mins (Day- L_{Aeq} 5 mins)				
	Fauna at N4				
N-I31	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N4	-108	Minor negative impact	-108	Minor negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I32	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N4	-72	Minor negative impact	-72	Minor negative impact
N-I33	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N4	-11	Slight negative impact	-11	Slight negative impact
N-I34	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N4	-108	Minor negative impact	-108	Minor negative impact
N-I35	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N4	-72	Minor negative impact	-72	Minor negative impact
N-I36	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N4	-11	Slight negative impact	-11	Slight negative impact
	Fauna at N5				
N-I37	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N5	-108	Minor negative impact	-108	Minor negative impact
N-I38	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N5	-72	Minor negative impact	-72	Minor negative impact
N-I39	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N5	-11	Slight negative impact	-11	Slight negative impact
N-I40	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N5	-108	Minor negative impact	-108	Minor negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I41	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N5	-72	Minor negative impact	-72	Minor negative impact
N-I42	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N5	-11	Slight negative impact	-11	Slight negative impact
	Fauna at N6				
N-I43	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N6	-324	Major negative impact	-108	Minor negative impact
N-I44	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N6	-216	Moderate negative impact	-72	Minor negative impact
N-I45	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N6	-33	Slight negative impact	-11	Slight negative impact
N-I46	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N6	-216	Moderate negative impact	-108	Minor negative impact
N-I47	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N6	-144	Moderate negative impact	-72	Minor negative impact
N-I48	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N6	-22	Slight negative impact	-11	Slight negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
Over Specific Period (Night- LAeq 1 hour)					
Fauna at N4					
N-I49	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N4	-90	Minor negative impact	0	No change/ status quo
N-I50	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N4	-60	Minor negative impact	0	No change/ status quo
N-I51	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N4	-9	Slight negative impact	0	No change/ status quo
N-I52	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N4	-90	Minor negative impact	-90	Minor negative impact
N-I53	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N4	-60	Minor negative impact	-60	Minor negative impact
N-I54	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N4	-9	Slight negative impact	-9	Slight negative impact
Fauna at N5					
N-I55	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N5	0	No change/ status quo	0	No change/ status quo

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I56	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N5	0	No change/ status quo	0	No change/ status quo
N-I57	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N5	0	No change/ status quo	0	No change/ status quo
N-I58	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N5	0	No change/ status quo	0	No change/ status quo
N-I59	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N5	0	No change/ status quo	0	No change/ status quo
N-I60	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N5	0	No change/ status quo	0	No change/ status quo
Fauna at N6					
N-I61	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N6	-270	Moderate negative impact	-180	Moderate negative impact
N-I62	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N6	-180	Moderate negative impact	-120	Minor negative impact
N-I63	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N6	-27	Slight negative impact	-18	Slight negative impact
N-I64	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N6	-270	Moderate negative impact	-270	Moderate negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I65	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N6	-180	Moderate negative impact	-180	Moderate negative impact
N-I66	Noise emission from construction site toarboreal fauna of Priority/ Sensitivity Level - Low at N6	-27	Slight negative impact	-27	Slight negative impact
Over Specific Period (Night- L_{Aeq} 5 mins)					
Fauna at N4					
N-I67	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N4	-90	Minor negative impact	0	No change/ status quo
N-I68	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N4	-60	Minor negative impact	0	No change/ status quo
N-I69	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N4	-9	Slight negative impact	0	No change/ status quo
N-I70	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N4	-90	Minor negative impact	0	No change/ status quo
N-I71	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N4	-60	Minor negative impact	0	No change/ status quo
N-I72	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N4	-9	Slight negative impact	0	No change/ status quo

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
Fauna at N5					
N-I73	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N5	0	No change/ status quo	0	No change/ status quo
N-I74	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N5	0	No change/ status quo	0	No change/ status quo
N-I75	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N5	0	No change/ status quo	0	No change/ status quo
N-I76	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N5	0	No change/ status quo	0	No change/ status quo
N-I77	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N5	0	No change/ status quo	0	No change/ status quo
N-I78	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N5	0	No change/ status quo	0	No change/ status quo
Fauna at N6					
N-I79	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - High at N6	-270	Moderate negative impact	-180	Moderate negative impact
N-I80	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Medium at N6	-180	Moderate negative impact	-120	Minor negative impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures Recommended Mitigation Option Low Noise PME with barrier 1.4m at N6 area only (CJC input)	
N-I81	Noise emission from construction site to ground-dwelling fauna of Priority/ Sensitivity Level - Low at N6	-27	Slight negative impact	-18	Slight negative impact
N-I82	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High at N6	-270	Moderate negative impact	-270	Moderate negative impact
N-I83	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium at N6	-180	Moderate negative impact	-180	Moderate negative impact
N-I84	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Low at N6	-27	Slight negative impact	-27	Slight negative impact

8.7.4 Qualitative Residual Impact with Noise Barrier and other Mitigation Measures

Table 8-29 and **Table 8-30** showed that the noise source control measures noise barriers and are effective in reducing the noise impact magnitude to school and fauna communities (especially the impact to the ground-dwelling fauna). As the noise level of the construction equipment and activities may have been limited by the technology available, the contractor may consider mix of various method, e.g., combining quieter equipment and noise barrier to achieve the protection objective. However, it is also noted that it is challenging to provide full proof protection to the arboreal fauna as it is not realistic to elevate the noise barrier to as high as 15 meters.

However, with the additional control measures, the noise levels and corresponding impacts are expected to drop further than what is shown in the Residual Impact with Noise Barrier and the additional noise control measures at the source. It is worth noting that the assessment has conservatively placed the fauna receptor along the construction site boundary as they may be found right up to the hoarding and in the surrounding trees, after having been shepherded out of the Contract Boundary or if the area was part of their original home range. However, it is likely that with the noise and other disturbances (i.e., human vehicular presence), most fauna would move away from the Contract Boundary. The models have predicted that the louder noises are mostly experienced by the arboreal animals who are generally also more mobile and could move away from the noise source. However, the modelling results indicates that the construction noise would be reduced to the baseline condition at around 95 m away from the construction site boundary at N6 on elevation of 15 m high. Although it is possible that fauna will move away from loud noises, they may expend considerable energy to find other suitable habitats. This energy could otherwise be used for breeding, hunting or defences purposes. In addition, there remains some which are less mobile such as birds who have nested in nearby trees. This could lead to higher mortality rates and contribute to greater ecosystem pressures as fauna move towards more crowded habitats.

Hence, we would recommend the contractor to consider the installation of noise barrier of 1.4 m high at NSR 6 cluster area to protect the ground dwelling fauna community from exposing to excessive noise, i.e., net increase of sound pressure level <10 dBA during construction period. In the event that the contractor will be using different equipment, improved construction methods, more advance source control technology, instead of using a noise barrier, the contractor may review and verify using similar noise modelling approach and assessment criteria to validate the effectiveness that those control measures before carrying out the physical works on site.

8.8 Good Practice on Noise Control

Where applicable, the following good practice including administrative measure can be further reviewed and adopted by contractor to further reduce the potential construction noise impact to ALARP.

1. Contractor to prepare noise management plan (NMP) with the finalised construction method, schedule and equipment sound power levels to reconfirm the noise impact to community and fauna receptors are within acceptable range. The suggested NMP template is indicted in Annex H of SS 602: 2014.
2. Contractor to use engineering methodology to control noise at source (**Figure 8-3**), such as:
    - Noise enclosure to cover stationary PME such as generator
    - Noise screen/ noise panel to partially shield noise generated from noisy PME such as crane and excavator
    - Portable noise barrier for noisy construction activities e.g., soil investigation drilling activities and road and drainage work which are close to site boundary
    - Quieter construction methodology such as silent piler instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling

3. Contractor should plan the construction works to minimise noise sources on site through optimisation of construction sequence and methods such as optimising vehicular access to minimise reversing of vehicles and making use of existing structures such a silos or site offices as noise shield to reduce noise transmission from noisy static equipment to the noise receivers. (Based on LTA's Noise Guidance: Developing a Noise Management Plan)
4. Conduct continuous real time noise monitoring using Type 1 sound level meter with data logging at the affected NSRs. When noise level exceeds the maximum adjusted noise level, contractor should investigate and apply appropriate mitigation measures. Recommended monitoring locations:
    - For Affected fauna (NSR 4, NSR 5 and NSR 6) for entire construction period: noise meters to be located at site boundary adjacent to forested areas.
5. Implement industry best practices:
    - Only well-maintained PME should be operated on-site and should be serviced regularly during the construction.
    - The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the NSRs.
    - Use of alternative equipment with less noise emission such as use of rubber mallets instead of metal hammer.
    - Care shall be taken during loading or unloading, dismantling, or moving materials to reduce impact noise.
    - Silencers or mufflers on PME (e.g., generator sets) should be utilized and should be properly maintained during the construction.
    - Mobile PME, if any, should be sited as far from NSRs as possible.
    - PME (such as trucks and cranes) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum possible.
    - PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the nearby NSRs.
    - Noisy construction activities shall be avoided at nights and Sundays and public holidays when the noise limits are more stringent.
6. Consider limiting heavy construction working hours to 8 am to 6 pm where possible to avoid the timings when crepuscular species may be active. Toolbox meetings and winding down of work can be done outside of these hours.
7. Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense.
8. Where night works are conducted, the minimal amount of equipment should be used to reduce noise levels.
9. Where night works are conducted, workers should refrain from shouting or using loud hailers aside from emergency. Hand signals or walkie talkies can be employed instead.

9. Ground-Borne Noise and Vibration

This section describes the regulations and standards for ground-borne noise and vibration pollution control that are applicable to the Project development during the construction and operation phase activities and the methodology used for the ground-borne noise and vibration impact assessment. It also discusses the ground-borne noise and vibration baseline data obtained and assesses the potential ground-borne noise and vibration impacts associated with the construction and operation phase activities of the Project development. Appropriate mitigation measures are also provided.

9.1 Applicable Legislation Standards

There is no legislation and standard in Singapore presently that describe the methodology for ground-borne noise and vibration baseline assessment associated with human annoyance. Thus, in accordance with the Contract Specifications, we use the Transit Noise and Vibration Impact Assessment Manual published by U.S., Federal Transit Administration (FTA) adapted to Singapore situation as guidance on determination of baseline study area and identification of ground-borne noise (GBN) and vibration sensitive receivers (VSRs). The criteria for ground-borne noise and vibration causing human annoyance as provided in the FTA Transit Noise and Vibration Impact Assessment Manual is given on **Table 9-1**.

Table 9-1: Ground-Borne Noise and Vibration Criteria

Types of Affected Buildings	Ground Vibration Impact Levels			Ground-Borne Noise Impact Levels		
	Frequent Event	Occasional Event	Infrequent Event	Frequent Event	Occasional Event	Infrequent Event
Category 1	65 VdB	65 VdB	65 VdB	N/A	N/A	N/A
Category 2	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA
Special Buildings						
Concert hall	65 VdB	65 VdB	N/A	25 dBA	25 dBA	N/A
TV studio	65 VdB	65 VdB	N/A	25 dBA	25 dBA	N/A
Recording Studio	65 VdB	65 VdB	N/A	25 dBA	25 dBA	N/A
Auditorium	72 VdB	80 VdB	N/A	30 dBA	38 dBA	N/A
Theatre	72 VdB	80 VdB	N/A	35 dBA	43 dBA	N/A

Note:
1. Category 1 (High Sensitivity): This category covers vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations.
2. Category 2 (Residential): This category covers residential land uses and any buildings where people sleep, such as hotels and hospitals.
3. Category 3 (Institutional): This category includes institutional land uses with primarily daytime use e.g., schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference. It is not intended that buildings primarily for industrial use but has office space be included in this category.
4. “Frequent Events” is defined as more than 70 vibration events of the same source per day.
5. “Occasional Events” is defined as between 30 and 70 vibration events of the same source per day.
6. “Infrequent Events” is defined as less than 30 vibration events of the same source per day.
7. N/A means no specific criterion level has been stipulated in the FTA Transit Noise and Vibration Impact Assessment Manual. According to the manual, vibration-sensitive equipment is generally not sensitive to ground-borne noise.
8. VdB: Vibration velocity level in decibel

9.2 Methodology of Ground-Borne Noise and Vibration Assessment

9.2.1 Determination of Ground-Borne Noise and Vibration Sensitive Receivers

The criteria proposed for GBNs and VSRs are based on the Transit Noise and Vibration Impact Assessment Manual. The criteria are listed below:

- Category 1 (High Sensitivity): This category covers vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations.
- Category 2 (Residential): This category covers residential land uses and any buildings where people sleep, such as hotels and hospitals.
- Category 3 (Institutional): This category includes institutional land uses with primarily daytime use e.g., schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference. It is not intended that buildings primarily for industrial use but has office space be included in this category.
- Special Buildings: This category includes concert halls, TV studios, recording studios, auditoriums and theatres.

The representative GBNSRs and VSRs potentially affected by the Project development are identified through a combination of desktop study (i.e., review publicly available street directory and satellite map) and visual site survey.

9.2.2 Baseline Ground-Borne Noise and Vibration Monitoring and Ground-Borne Noise Calculation

The ground-borne vibration is monitored for a period of 24-hour for seven consecutive days using vibration monitoring instrument equipped with a Triaxial Geophone sensor with accuracy of +/- 5%. The meter is set in time interval of 5 minutes and the velocity-time domain minimum trigger level is set at 0.14 mm/s. The maximum ground-borne vibration is measured in peak particle velocity (PPV) based on the maximum values of the three components of the vibration – transverse, vertical and longitudinal direction and its corresponding frequency are recorded.

The ground-borne vibration readings in terms of vibration velocity level in decibel (VdB) and the ground borne noise readings in term of dBA are calculated from the peak particle velocity (PPV) data obtained following the guidance provided in the FTA Transit Noise and Vibration Impact Assessment Manual.

9.3 Pre-construction Baseline

9.3.1 Determination of Ground-Borne Noise and Vibration Sensitive Receiver

Based on the mentioned criteria on **Section 9.2.1** and the site reconnaissance carried out on 26 January 2022, the list of GBN/VSR within the EIA Study Area (i.e. 100 m from the DE170 Contract Boundary) that are potentially affected by the Project development is listed on **Table 9-2** and illustrated in **Figure 9-1**.

Table 9-2: Identified Ground-Borne Noise and Vibration Sensitive Receiver (GBN/VSR) for the Project

GBNSR/VSR Cluster	Cluster Description	Type of Receiver	Number of Storeys	Location and Distance of Cluster to the EIA Study Area
GBN/VSR Cluster 1	Home Team Academy, 501 Old Choa Chu Kang Road Keat Hong Camp, 611 Old Choa Chu Kang Road	Recreational, Residential	4	Within the central portion of the EIA Study Area, 100 m from DE170 Contract boundary
GBN/VSR Cluster 2	Block 450A Choa Chu Kang Avenue 4	Residential	16	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 451 Choa Chu Kang Avenue 4		16	
	Block 452 Choa Chu Kang Avenue 4		16	
	Block 453 Choa Chu Kang Avenue 4		16	
	Block 454 Choa Chu Kang Avenue 4		16	
	Block 455 Choa Chu Kang Avenue 4		16	
	Block 456 Choa Chu Kang Avenue 4		12	
	Block 459 Choa Chu Kang Avenue 4		12	
	Block 460 Choa Chu Kang Avenue 4		16	
	Block 461 Choa Chu Kang Avenue 4		16	
	Hai Inn Temple, 33 Brickland Road	Cultural	4	
GBN/VSR Cluster 3	Concord Primary School, 3 Choa Chu Kang Avenue 4	School	4	Within the eastern portion of the EIA Study Area, 100 m from DE170 Contract Boundary
	Block 443 Choa Chu Kang Avenue 4	Residential	15	
	Block 444 Choa Chu Kang Avenue 4		15	
	Block 445 Choa Chu Kang Avenue 4		8	
	Block 446 Choa Chu Kang Avenue 4		15	

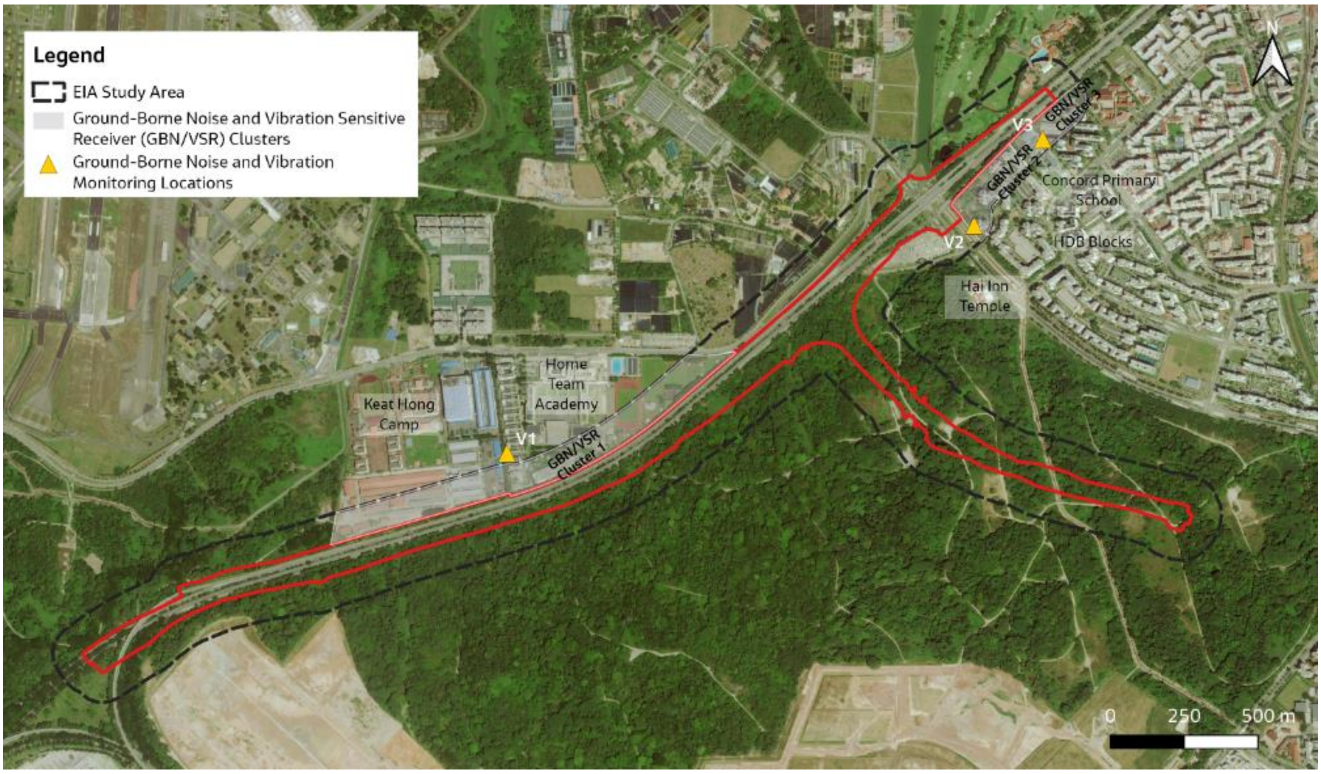


Figure 9-1: Ground-Borne Noise and Vibration Sensitive Receiver Cluster and Monitoring Locations

9.3.2 Ground-Borne Noise and Vibration Baseline Monitoring

Three (3) ground-borne noise and vibration measurement station are selected. The locations of the noise baseline monitoring are shown in **Figure 9-1** and described on **Table 9-3**.

Table 9-3: Location of Ground-Borne Noise and Vibration Monitoring Station

Ground-Borne Noise and Vibration Measurement Station	Description
V1	Home Team Academy
V2	At an open space between Block 461 and Block 460 Choa Chu Kang Avenue 4
V3	At an open space between Concorde Primary School and multistorey carpark Block 446

Ground-borne noise and vibration level is measured over 24 hours and for seven consecutive days. Monitoring is time interval of 5 minutes, and the velocity time domain minimum trigger level is set at 0.14 mm/s. The maximum peak particle velocity (PPV) in transverse, vertical and longitudinal direction and its corresponding frequency are recorded.

9.3.3 Results and Discussion

The ground-borne noise and vibration baseline monitoring was conducted by ENSSCOM and supervised by our environmental engineers from 5 April to 29 April 2022. The results of the ground-borne noise and vibration baseline sampling were used to established pre-construction ambient vibration levels and benchmarked against the criteria for ground-borne noise and vibration causing human annoyance as provided in the FTA Transit Noise and Vibration Impact Assessment Manual.

The ground-borne noise and vibration baseline monitoring reports and photographic logs are provided in **Appendix 9A** and **Appendix 9B**, respectively, and summary results are tabulated on **Table 9-4**. The ground-borne vibration readings in terms of VdB and the ground borne noise readings in terms of dBA are calculated from the PPV data obtained following the guidance provided in the FTA Transit Noise and Vibration Impact Assessment Manual as shown on **Table 9-5**.

Table 9-4: Ground-borne Noise and Vibration Baseline Monitoring Results

Description	V1	V2	V3	Remarks
Peak Particle Velocity, PPV (mm/s)	0.762	1.778	3.556	Value from ground vibration measurement report
Vibration Amplitude, Lv, rms (mm/s)	0.1905	0.4445	0.889	Lv, rms = PPV / Crest Factor, Crest Factor = 4
Vibration Velocity Level, Lv (VdB) (a)	78	85	91	Lv = 20 x log (Lv,rms / Lref), Lref = 1 x 10-6 inch/second
Conversion Factors from Floor Vibration to Noise Levels Cnoise (b)	-26	-26	-26	Lp – Lv = -10logh + 10log RT -20, h = 2.2 & RT = 0.5 for typical residential room
Conversion from Vibration Level (VdB) to A-weighted Noise (dBA) (c)	-20	-20	-20	Low frequency (<30 Hz): -50 dB; Typical frequency (peak 30 to 60 Hz): - 35 dB; High frequency (60 to 100 Hz): -20 dB
Ground-borne Noise Level (dBA)	31	38	44	a) + b) + c)

Ground-borne noise and vibration data were compared with criteria for ground-borne noise and vibration causing human annoyance as provided in the FTA Transit Noise and Vibration Impact Assessment Manual.

Table 9-5. Ground Vibration and Ground-borne Noise Results Compared with Assessment Criteria

Ground-Borne Noise and Vibration Measurement Station	Category	Vibration Velocity Level, Lv (VdB)		Ground-borne Noise Level (dBA)	
		Result	Criteria	Result	Criteria
V1	2	78	75	31	38
V2	2	85	75	38	38
V3	2	91	75	44	38
V3	3	91	78	44	43

Note:

(1) Figures in **bold red:** Vibration Velocity Level, Lv (VdB) or Ground-borne Noise Level (dBA) exceeded the assessment criteria for ground-borne noise and vibration causing human annoyance as provided in the FTA Transit Noise and Vibration Impact Assessment Manual: Category 1 (High Sensitivity): Vibration-sensitive research and manufacturing, hospitals with vibration-sensitive equipment, and university research operations; Category 2 (Residential): Residential land uses and any buildings where people sleep, such as hotels and hospitals; and Category 3 (Institutional): Institutional land uses with primarily daytime use e.g., schools, churches, other institutions, and quiet offices that do not have vibration-sensitive equipment, but still have the potential for activity interference. It is not intended that buildings primarily for industrial use but has office space be included in this category.

(2) If more than one category is present, the more stringent limit will be applied

Analysis of the result shows that with the exception of ground-borne noise level at V1, all calculated vibration velocity and ground-borne noise levels are above the respective assessment criteria as provided by the FTA Transit Noise and Vibration Impact Assessment Manual.

The exceedances might be due to the monitoring locations located in close proximity to roads and pedestrian ways.

9.4 Impact Assessment Before Mitigation Measures

9.4.1 Evaluation of Construction Phase Impact

Vibration is expected to be mainly generated from the following sources during construction:

- Construction of access road that involve the use of excavator and roller
- SI works that involve the use of drilling rig, air compressor and diaphragm pump
- Bored piling works including the use of vibro hammer
- Concreting works using concrete vibrator machine

According to the FTA Transit Noise and Vibration Impact Assessment Manual, in case where prolonged annoyance or damage from construction vibrations are not expected, a qualitative assessment is appropriate. Hence, potential ground-borne noise and vibration impacts for affected community was conducted using the modified RIAM as indicated in Section 2 and is discussed in the following sections. The full assessment with the scoring results using RIAM with value sensitivity characteristic and magnitude changes definition is given in **Appendix 9C**.

The qualitative assessment of potential ground-borne noise and vibration impacts distinguishes between those that are positive or negative nature; major, moderate or minor magnitude of changes; transboundary, national, or local extend; long, medium or short term; direct or indirect pathway; reversible or irreversible; and cumulative or non-cumulative. The ambient air quality impacts may affect GBN/VSRs with international, national or local value.

A summary of the potential ground-borne noise and vibration impacts at the GBN/VSRs is presented on **Table 9-6** and **Table 9-7** and discussed in detail below.

9.4.1.1 Ground-borne noise and vibration emissions from construction activities

Ground-borne noise and vibration levels generated by construction equipment will vary depending on the type of equipment, model and condition of equipment and duration of operation. The ground-borne noise and vibration levels will also be affected by distance, locations (either stationary or mobile sources), variations in the power of the equipment, and vibration characteristics (either continuous or intermittent vibration) of the equipment.

Potential impact assessment of potential ground-borne noise and vibration at affected community (GBN/VSR 1) are presented on **Table 9-6** while potential impact assessment of potential ground-borne noise and vibration at affected community (GBN/VSR 2, GBN/VSR 3) during construction phase is presented on **Table 9-7**.

Table 9-6: Impact Significance for Ground-Borne Noise and Vibration during Construction Phase for GBN/VSR1

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Ground-borne noise and vibration impacts are expected to be within the EIA Study Area (area immediately outside the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Construction equipment/ machinery (e.g., piling equipment, compactor, hydraulic breaker and pipe jacking machine) emits significant ground-borne noise and vibration levels.
A2.2: Magnitude of Changes	2. Medium	Vibration velocity levels and ground-borne noise levels at GBNSR/VSR 1 are expected to be more than 5 dBA but less than10 dBA of the assessment criteria limits for GBN/VSR 1.
A2.3: Impact Extent	2: Buffer Area	Ground-borne noise and vibration impacts are anticipated to extend beyond project footprint (within 100 m buffer outside the Contract Boundary).
B1: Permanence	3: Medium-term	The use of construction equipment/ machinery that causes ground-borne noise and vibration will persist for a period of 3 to 10 years and will cease when construction works stops
B2: Impact Pathway	3: Direct	Ground-borne noise and vibration from the operation of construction equipment/ machinery has a direct impact on affected community (GBNSR/VSR 1)
B3: Reversibility	2: Reversible	Ground-borne noise and vibration is reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Ground-borne noise and vibration from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the affected community (GBNSR/VSR 1) when happen concurrently.
Environmental Score (ES)	(-8) x 11 = -88	
Range Bands ES/ Impact Significance	Minor Negative Impact	

Table 9-7: Impact Significance for Ground-Borne Noise and Vibration during Construction Phase for GBN/VSR 2 and GBN/VSR 3

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Outside Local	Ground-borne noise and Vibration impacts are expected to be within the EIA Study Area (area immediately outside the Contract Boundary).
A2.1: Impact Nature	-1: Negative	Construction equipment/ machinery (e.g., piling equipment, compactor, hydraulic breaker and pipe jacking machine) emits significant ground-borne noise and vibration levels.
A2.2: Magnitude of Changes	3: High	Vibration velocity levels and ground-borne noise levels at GBNSR/VSR 2 and GBNSR/VSR 3 are expected to be more than than10 dBA of the assessment criteria limits for GBN/VSR 2 and 3 during construction activities. This is based on the higher baseline vibration velocity levels and ground-borne noise levels at GBN/VSR 2 and 3. (Conservative approach)
A2.3: Impact Extent	2: Buffer Area	Ground-borne noise and vibration impacts are anticipated to extend beyond project footprint (within 100m buffer outside the Contract Boundary).
B1: Permanence	3: Medium Term	The use of construction equipment/ machinery that causes ground-borne noise and vibration will persist for a period of 3 to 10 years and will cease when construction works stops
B2: Impact Pathway	3: Direct	Ground-borne noise and vibration from the operation of construction equipment/ machinery has a direct impact on affected community (GBNSR/VSR 2 and GBNSR/VSR 3).
B3: Reversibility	2: Reversible	Ground-borne noise and vibration is reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Ground-borne noise and vibration from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the affected community (GBNSR/VSR 2 and GBNSR/VSR 3) when happen concurrently.
Environmental Score (ES)	(-12) x 11 = -132	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

9.4.2 Evaluation of Operation Impacts

Operational impacts within the EIA Study Area will potentially be from the use of the interchange and its periodic servicing or maintenance. Heavy construction vehicles are not anticipated to be used during such maintenance activities. As such, these operation phase activities will not generate significant level of ground-borne noise and vibration.

Potential short-term operation phase impacts would possibly occur should there be major repairs, especially if heavy machineries are required. This would create potential sources of ground-borne noise and vibration emissions. However, it is expected that such short-term operation impacts will only last for the duration of the maintenance works and would be limited in scope. Potential impact assessment of potential ground-borne noise and vibration during operation phase for affected community are presented on **Table 9-8**.

Table 9-8: Impact Significance for Ground-borne Noise and Vibration from Operation Activities to GBN/VSRs

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Ground-borne noise and Vibration impacts are expected to be within project footprint.
A2.1: Impact Nature	-1: Negative	Construction equipment/ machinery (e.g., piling equipment, compactor, hydraulic breaker and pipe jacking machine) emits significant ground-borne noise and vibration levels.
A2.2: Magnitude of Changes	1: Low	Vibration velocity levels and ground-borne noise levels at the affected community (all GBNSR/VSRs) are expected to be low and close to baseline levels as there will be unlikely be the use of heavy construction vehicles.
A2.3: Impact Extent	1: Local	Ground-borne noise and vibration impacts are anticipated to be within the project footprint.
B1: Permanence	1: Temporary	The use of construction equipment/ machinery that causes ground-borne noise and vibration during major repair works will be temporary as it will only last for the duration of the repair works.
B2: Impact Pathway	3: Direct	Ground-borne noise and vibration from the operation of construction equipment/ machinery has a direct impact on affected community.
B3: Reversibility	2: Reversible	Ground-borne noise and vibration is reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Ground-borne noise and vibration from other construction projects (such as ongoing Contract J102 by LTA which is located at the central part of EIA Study Area) are expected to cause cumulative impacts to the affected community when happen concurrently.
Environmental Score (ES)	(-1) x 9 = -9	
Range Bands ES/ Impact Significance	Slight Negative Impact	

9.5 Recommendation of Prevention and Mitigation Measures

9.5.1 Construction Phase Mitigation Measures

A number of mitigation measures may be adopted to eliminate, minimise or reduce the potential ground-borne noise and vibration impacts during construction activities of the Project development. The overall approach will involve the following approaches:

- **Mitigation at Planning and Management Stage**: The objective is to reduce or eliminate specific ground-borne noise and vibration sources form the activities that generate airborne noise at planning stage.
- **Mitigation at Ground-Borne Noise Source**: The objective is to control at ground-borne noise and vibration noise source.
- **Monitoring at Ground-Borne Noise and Vibration Receiver:** The objective is to become aware of the vibration level being generated from the construction activities and equipment with the implementation of mitigation measures.

Mitigation at Planning and Management Stage

- ECO should prepare and implement site environmental control plan and programme specific to the construction works undertaken in the Project.
- Operate equipment (e.g., piling equipment, compactor, hydraulic breaker and pipe jacking machine) that emit significant ground-borne noise and vibration levels, as far away from GBN/VSRs as possible.
- Construction works to be done in phases e.g., demolition, earthmoving and ground impacting operations so as not to occur in the same time period at the same area, if possible, to minimize cumulative impact.
- Contractor should avoid night-time construction activities near residential areas and notify nearby GBN/VSRs in advance of the construction activities.

Mitigation at Ground-Borne Noise Source

- Avoid impact pile driving where possible in areas with GBN/VSRs. Drilled piles or the use of a sonic or vibratory pile driver causes lower ground-borne noise and vibration levels where the geological location permits their use. Alternatively, use jetting, pre-drilling, auger cast piles, non-displacement piles, using pile cushioning between the driving hammer and the pile, non-impact pile drivers with a vibratory pile driver, or resonance-free vibrator.
- Minimize driving track mounted equipment over paved surfaces with steel cleats. Use rubber pads where possible to reduce vibrations or use rubber-tired vehicles in place of tracked vehicles.
- Avoid using hydraulic breakers and select rock coring/breaking methods not involving or have reduced vibration impact, where possible. For example, using polycrystalline diamond compact (PDC) bit to reduce vibration when drilling rock formations.
- Fill in potholes and eliminate pavement discontinuities, keep haul roads smooth by periodic grading; pave existing roads to provide a smooth traveling surface, reduce speed of vehicles and weight of vehicle loads, as far as practicable.

Monitoring at Ground-Borne Noise and Vibration Receiver

- Conduct real time vibration monitoring using vibration meter with data logging at the affected GBN/VSRs when involving activities that create a vibration impact, (e.g., pilling and ground impacting operations). When vibration level exceeds the trigger level, contractor should investigate if the source of vibration is due to construction works and apply mitigation.

9.5.2 Operation Phase Mitigation Measures

The direct impacts were assessed to be slight negative; therefore, no mitigation measure is proposed. Should major repairs be undertaken during the operation phase, mitigation measures proposed for the construction phase will apply.

9.6 Residual Impacts

The adoption of the mitigation measures recommended above will assist to mitigate and further reduce the ground-borne noise and vibration impacts during construction of the Project. After implementation of these suggested mitigation measures, the residual significance of ground-borne noise and vibration impacts is anticipated to be slight to minor negative impact. A summary of the ground-borne noise and vibration impact significance pre- and post- mitigation is presented on **Table 9-9**.

Table 9-9: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Impact Significance)	
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Environmental Score (ES)	Range Band of ES / Impact Significance
V-I1	Ground-borne noise and vibration from construction activities to GBN/VSR 1	-88	Minor Negative Impact	-44	Slight Negative Impact
V-I2	Ground-borne noise and vibration from construction activities to GBN/VSR 2 and GBN/VSR 3	-132	Moderate Negative Impact	-88	Minor Negative Impact
V-I3	Ground-borne noise and vibration from operation activities to GBN/VSRs	-9	Slight Negative Impact	The direct impacts were assessed to be slight negative; therefore, no mitigation measure is proposed	

10. Assessment of Waste Impacts

This section assesses the impact relating to the management of wastes associated with the proposed pre-construction and construction activities of the Project. It includes a description of the applicable legislation and standards, methodology, and criteria used for the assessment. It also recommends measures for the mitigation of the impacts.

10.1 Applicable Legislation and Standards

EPHA contains specific provisions relating to industrial waste and its disposal. The Commissioner for Public Health may require the owner or occupier of any workplace to furnish information on the amount, type, and nature of any industrial waste found on his premises. The owner or occupier may also be required to treat the industrial waste at his own expense before disposal. EPH (Toxic Industrial Waste) Regulations specifies wastes which are classified as toxic industrial wastes (TIW) and regulates their handling, transport, and disposal.

The Code of Practice (COP) on Pollution Control provides recommended control measures for industries and trade premises in handling, transport, and disposal of TIW. Factories are required to install in-house treatment facilities to recycle and reuse their TIW or to treat their TIW for safe disposal. However, factories may apply for clearance from the Pollution Control Department (PCD) to engage licensed TIW collectors to collect their wastes for recycling or treatment for safe disposal.

The EPH (General Waste Collection) Regulations govern the collection and disposal of general waste. All waste collectors must be licensed and listed by the NEA. Wastes are classified into three types (bulky wastes, putrefiable waste, and sludge) and disposed of differently in particular vehicles, e.g., sludge and latrine waste from portable toilets must be transported in tanker trucks. All wastes must be disposed of only at disposal facilities or incineration plants. The collector must keep proper records including the place and frequency of collection, place of disposal, type, and tonnage of waste collected and disposed, and the vehicle used. Collectors must ensure that the refuse or waste is not dropped, scattered or spilled into any public place.

The COP for Environmental Control Officers (ECO) spells out the role of occupiers of construction sites and of the ECO, and their responsibilities pertaining to waste management at construction sites.

10.2 Methodology of Waste Impact Assessment

There is currently no legislation in Singapore that guides waste management impact assessments. The assessment methodology taken in this section include:

- Identification of wastes streams and management method
- Assessment of environmental impacts
- Development of appropriate mitigation measures

10.2.1 Identification of Waste Streams and Management Method

The different types of waste streams arising from the baseline conditions, pre-construction and construction, and post-construction activities are identified by combination of visual observation field survey and desktop assessment with reference to client-held data and publicly available sources as listed below. The current waste management methods for each waste stream including disposal, handling, storage, and recycling facilities are also classified, thereafter.

- National Environment Agency (NEA). (7 July 2021). *Waste Management*. National Environment Agency. https://www.nea.gov.sg/our-services/waste-management/overview
- Land Transport Authority (LTA). (16 August 2021). *Construction Waste Management at LTA Sites, 2009*. https://www.lta.gov.sg/content/dam/ltagov/industry_innovations/industry_matters/safety_health_environment/pdf/Construction_Waste_Guidebook.pdf
- Building Construction Authority (BCA). (22 January 2020). *Guidelines for Pre-Demolition Audit, Sequential Demolition and Site Waste Management Plan*. https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/sc_demoprotocol.pdf

Wastes in Singapore can be classified as general waste and toxic industrial waste. General wastes/ Non-hazardous wastes consist mainly of waste from households, trade, commercial, and industrial premises. Toxic industrial/ hazardous wastes are waste which by their nature and quality may be potentially detrimental to human health and/ or the environment and which require special management, treatment, and disposal. In 2021, about 6.94 million tonnes of solid waste was generated, of which 3.83 million tonnes were recycled.

10.2.1.1 Non-hazardous Waste

According to *Code of Practice for Licensed General Waste Collectors*, non-hazardous waste, also called general waste, is waste that falls into three main categories as given on **Table 10-1**.

Table 10-1: Waste Classification

Categories	Types of Waste
Type A	• Waste such as unwanted furniture, electrical appliances, construction, and renovation debris, and cut tree trunks and branches • Bulky waste • Non-putrefiable waste • Recyclable waste (excluding food waste) • Digested sludge that has been dewatered from water reclamation plants
Type B	• Domestic refuse, food waste (excluding used cooking oil), and market waste • Waste with a high organic content and which is putrefiable • Used cooking oil (Type B.1)
Type C	• Sludge and other waste from grease interceptors • Sewage, sludge, and other waste from water-seal latrines, sewage treatment plants (other than water reclamation plants), septic tanks, or other types of sewerage systems • Waste from sanitary conveniences not part of a sewerage system, including waste from sanitary conveniences which are mobile or on ships or aircraft

All general wastes are collected and transported for disposal by collectors with valid General Waste Collector's Licences issued by NEA according to the waste categories as given above. General waste is separated for recycling and disposal often at source point. Recyclables are sent to the Materials Recovery Facilities (MRFs) to be sorted into the categories of paper, plastic, metal, and glass. These recyclables are then compacted into bales to be sent to specialised recycling facilities locally and abroad for processing into new materials. General waste for disposal falls into two categories, incinerable and non-incinerable waste. Incinerable waste are sent to waste-to-energy (WTE) plants, of which there are currently four in Singapore:

- TuasOne Waste-to-Energy Plant (TWTE)

- Keppel Seghers Tuas Waste-to-Energy Plant (KSTP)
- Tuas South Incineration Plant (TSIP)
- Senoko Waste-to-Energy Plant (SWTE)

The incineration process reduces the volume of waste by 90% and produces steam which runs turbine-generators and generates electricity. The WTE plants are also equipped with an efficient flue gas cleaning system which remove dust and pollutants from the flue gas to allow the emissions meet the air quality standards in the EPMA. Non-incinerable general waste include a range of items such as bulky waste, carbon fibres, fire retardants, electronic waste and construction waste amongst others listed in the as listed in *Appendix 1 of the Code of Practice for Licensed General Waste Collectors*. These wastes must be broken down to fit incineration size requirements, treated before incineration, or will be landfilled as-is. Incinerated ash alongside any non-incinerable wastes are then sent to the Tuas Marine Transfer Station where it is collected and transported to Semakau Landfill.

10.2.1.2 Hazardous Waste

Hazardous wastes are often termed as toxic industrial waste and include a range of waste such as chemicals, lead-tainted products, polyvinyl chloride (PVC), used oil and pathogenic waste amongst others listed in the *Environmental Public Health (Toxic Industrial Waste) Regulations*. Hazardous waste is collected and treated by NEA licensed toxic industrial waste collectors who have specialised approved storage, process, treatment, and disposal facilities related to the specific hazardous waste. The residues will have to comply with stringent standards before they can be incinerated and or disposed at the landfill.

10.2.2 Assessment of Environmental Impacts

The semi-qualitative assessment of potential waste impacts takes into account the pre-construction, construction, and post-construction activities of the Project development, and distinguishes between those that are positive or negative. The negative impacts associated with mismanagement of onsite generation of non-hazardous and hazardous wastes include:

- **Odour,** when waste is not collected regularly
- **Water quality,** when leachate from waste enters waterbodies located in the vicinity of the construction site
- **Visual,** when uncollected waste is unsightly to the community
- **Health,** when uncollected waste attracts disease vectors and scavenging animals, and may result in human-wildlife conflict

Impacts that are direct or indirect and whether they are long- or short-term, cumulative, or irreversible are also identified. The potential environmental impacts of the waste identified are also assessed to determine the significance of these impacts in terms of minor, moderate, and major based on the volume of the waste generated and the severity of the environmental impacts. The volume of waste that may be generated are qualitatively identified or estimated in terms of low, medium, and high based on available literature review for further evaluation in the Draft EIA considering several factors.

- **Low:** Minimal and barely noticeable volume; less than 50 tonnes/month
- **Medium:** Moderate and noticeable volume; 50-500 tonnes/month
- **High:** Large and very noticeable volume; more than 500 tonnes/month

10.3 Pre-construction Baseline Conditions

10.3.1 National Waste Generation Statistics

NEA has overseen the setting up of several recycling facilities for concrete waste, general construction waste, and demolition waste to support recycling of construction waste. These recycling facilities convert construction waste into secondary aggregates for further processing into non-structural concrete products for use in new building or as materials for temporary road access in construction sites.

NEA also promotes the use of recycled materials in the construction industry to ensure long-term success of construction waste recycling. NEA encourages collaboration among recycling and construction companies and research institutions to explore the innovative use of recycled materials as substitutes for conventional construction materials and to examine the performance of recycled building materials and products.

In 2021, about 1,013,000 tonnes of construction and demolition debris had been generated in Singapore and 99% of this construction waste was recycled while the remaining one percent was disposed of at the offshore landfill (NEA, 2022). Semakau Landfill is the only landfill left in Singapore (MEWR, 2016). The high percentage of recycling however does not imply the end of the construction waste disposal problem for the construction industry. There remains a sizable volume of construction waste sent for land filling, about 2,000 tonnes in 2021. However, this number has decreased since 2020 in which 3,000 tonnes was sent for landfilling.

Waste that is not segregated at source, cannot be used, or be recycled is then collected and sent to the waste-to-energy plants for incineration. Incineration reduces the volume of solid waste by about 90% and energy is recovered to generate electricity. The ash residues from the incineration process are sent to the Tuas Marine Transfer Station (TMTS) for disposal at the offshore Semakau Landfill (NEA, 2022).

10.3.2 DE170 EIA Study Area Waste Generation

The EIA Study Area also contains remnant waste from its previous land uses as a village and plantation grounds where housings and temples were present. Baseline surveys have been carried out to observe the site conditions within the Project development. Dumping of sundry wastes (broken glass, rubber, bricks, metal and plastic pipes, corrugated zinc sheets) have been observed.

The following waste streams have been identified to be currently present within the EIA Study Area:

- General waste such as food and packaging littered by trespassers known to hike in the area.
- Remnant general waste from previous land uses such as plastic, bricks, and glass.

10.4 Identification of Waste Streams for the Project

10.4.1 Volume Quantification of Waste Streams for the Project

In order to quantify the volume of waste streams in this Project, certain assumptions were made in order to reasonably estimate the volumes that would be expected and hence the impacts and management methods that would follow. The following key assumptions on **Table 10-2** were taken to estimate and quantify the amount of waste that would be produced by this project:

Table 10-2: Key Unit Volume Estimation & Assumptions

Type of Waste	Unit Volume Assumption
Wood (Deforestation)	209.4 tonnes/ ha[1]
Construction & Demolition	5280 tonnes/ ha[2]
Hazardous	5 % of C&D Waste[3]
Municipal	0.024 tonnes/ person/ month[4]
Sewage	6.9 tonnes/ person/ month[5]
Number of Persons	**Number of Persons**
Workers on-site (Daily)	Approximately 830[6]
Sources: [1] Ngo et al., 2013 [2] Arpitha, Sanjeet, & Vinutha, 2020; Lu, Yuan, & Xue, 2021; [3] Llatas, 2011; [4] MEWR & NEA, 2019; [5] COP on Sewerage and Sanitary Works; [6] BCA, 2021 (Project Productivity)	

The estimation of wood waste volume assumes that the forested area (~20 ha) follows the aboveground biomass (AGB) of a Singaporean secondary forest.

10.4.2 Waste Streams from Construction Phase

The construction activities (i.e., land clearance, earthworks, and bridge construction) take place over the span of approximately five years, producing different waste streams of varying amounts. The following activities have been proposed in relation to the waste context:

- **Enabling Works/ Preliminary Construction Works:** The DE170 Contract Boundary consists of a mix of vegetated areas and existing infrastructure. Works may potentially produce waste from the erections of the temporary and permanent structures, vegetation clearance and machinery maintenance. It will also include remnant waste removal. The vegetation present includes a distribution of exotic-dominated secondary forest, abandoned plantations woodlands and scrublands.
- **Earthworks and Foundations:** Bored piling works, ERSS, pile cap construction as well as earthworks including excavation, backfilling will be done. Works may potentially produce demolition and soil waste.
- **Civil and Structural Works:** Concrete casting, installation of precast RC structures and installation and erection of the necessary structures. It will also include the pavement of the carriageway and slip roads and the constructions of drains and box culverts.

The following waste streams and their volumes have been identified to be potentially present during construction activities in the following volumes:

Table 10-3: Waste Stream from Construction Activities of the Project

Type of Waste	Source	Anticipated Volume
Horticulture Waste (i.e., Tree Trunks and Branches) (Type A Waste)	Produced during tree felling/ vegetation clearance including grass shrubs and tree trunks/ branches which are not retained. Wastes in the form of cleared trees, pruning from trees and dried leaves will continue to be produced in subsequent phases for maintenance of the vegetation related to safety.	230 Tonnes/ Month **Medium**: the volume produced is expected to be medium as a large part of the working area is currently existing roads with only the fringes where expansion will take place being forested. A

Type of Waste	Source	Anticipated Volume
		segment of the forest will be felled for the flyover and road into Tengah.
Construction and Demolition (C&D) Debris (Type A Waste)	Produced throughout the construction phase from the demolition of existing structures including concrete and metal frames. It also includes damaged/ surplus construction materials, equipment wrapping, and packaging produced from the construction works.	490 Tonnes/ Month Medium: the volume produced is expected to be moderate and bulky in correspondence with the construction scale and large area to be development.
Hazardous/ Toxic Industrial Waste	Produced throughout the construction phase from the use of machineries within the construction site including used engine oils, hydraulic fluids, waste fuel, contaminated soil and spent chemicals from machinery and equipment maintenance activities. Toxic waste could also include materials contaminated by chemicals such as containers and packaging materials used to hold the chemicals.	25 Tonnes/ Month Low: the volume produced is expected to be minor and produced as and when it is used for the various machineries.
Domestic Refuse and Food Waste (Type B Waste)	Produced throughout the construction phase from canteen, site office, worker's dormitories.	20 Tonnes/ Month Low: the volume produced is expected to be due to the nature of municipal waste
Recyclable Waste (Type A Waste)	Cardboard, paper packaging, papers, e-waste, plastics products, glass products produced from site office/ workers' dormitories.	
Sewage (Type C Waste)	Produced throughout the construction phase from mobile toilet facilities including wastewater and excrements.	5,700 Tonnes/ Month High: The volume produced is expected to be high due to the nature of sewage which has a high liquid content.

10.4.3 Waste Streams from Operation Phase

There is no waste expected from the operation phase except from the general maintenance of the project which is likely to be minimal. With the routine waste management system in Singapore, there is negligible impact from waste generated in the operation phase.

10.5 Impact Assessment

Impacts of the waste can arise when waste is insufficiently managed, which can easily happen when large volumes are produced without a waste management system to support. These impacts have a range of minor to major impacts on the waste generation site and the surrounding areas.

10.5.1 Impact Assessment of Construction Activities Waste Generation

10.5.1.1 Wood (i.e., Tree Trunks/ Branches)

The felling of trees and vegetation results in large amounts of felled trees and vegetation could be visually unpleasant prior to its removal. Felled wood also produces sawdust which could contaminate waterbodies and irritate human and wildlife in the vicinity. Dried wood is also a potential fire hazard.

Table 10-4: Impact Significance for Generation of Wood Waste (Direct)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The environmental sensitive receiver includes waterbodies connected to the national network of water channels, surrounding community and fauna receptors, of which wood dust/ shavings can be spread to via the wind.
A2.1: Impact Nature	-1: Negative	A reduction of water and air quality is expected.
A2.2: Magnitude of Changes	2: Medium	A moderate amount of wood is produced but is planned for removal from the construction site to off-site recycling and disposal facilities. The wood residues and dust from the tree felling, decomposition process during temporary stockpiling activities prior to disposal are expected be of medium magnitude.
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary due to wind and water movement.
B1: Permanence	2: Short Term	Felling of trees is expected to take place during the enabling works/ preliminary construction stage, will take place within a period of less than 3 years.
B2: Impact Pathway	3: Direct	There is a direct impact on the air and water quality
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling.
Environmental Score (ES)	(-12) x (10) = -120	
Range Bands ES/ Impact Significance	Minor Negative Impact	

The felling of trees and removal of vegetation also results in the release of the carbon that was originally stored within. The carbon is released into the atmosphere as carbon dioxide or methane immediately when burnt and slowly if it undergoes the process of decomposition (Houghton, 2005). Carbon dioxide and methane are both greenhouse gases which contribute towards global warming as they trap heat within the atmosphere. It is expected that most of the horticultural waste products will be removed from construction site and recycled into compost or burnt as biofuel, processes which produce greenhouse gases. A small portion may be recycled as wood chips mixed with binders into new wood products.

Greenhouse gases have transboundary impacts and contributes to global climate changes. It is not easy to remove such gases from the atmosphere once it has been released. The amount of carbon that will be released from the clearance of the vegetation in the EIA Study Area depends on the amount of biomass, which relates to their carbon content, that is removed. As the current area is largely vegetated with a small portion set aside for conservation, a significantly major amount of forest material is slated to be removed. As a gauge, it was reported that pristine forest in Malaysia and Indonesia could release between 316 to 474 tonnes CO_2-eq per hectare of wood removal (Croezen & van Valkengoed, 2009). Pristine forest are noted to have a higher biomass and carbon content than regenerated forest like those in Tengah forest. Aside from climate impacts, the sight of large amounts of felled trees and vegetation could also be visually unpleasant. Horticultural waste is also a fire hazard.

Table 10-5: Impact Significance for Generation of Wood Waste (Indirect)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	4: International	The environmental sensitive receiver includes the environmental and community globally who area affected by climate change.
A2.1: Impact Nature	-1: Negative	Climate change has negative impacts of changing weather patterns such as more frequent heatwaves, severe storms, and droughts.
A2.2: Magnitude of Changes	2: Medium	A moderate amount of wood is produced and will be removed from construction site for recycling and disposal facilities. Carbon emissions from their felling is expected to similarly be of medium magnitude.
A2.3: Impact Extent	2: Transboundary	Greenhouse gases enter the atmosphere and undergoes global circulation.
B1: Permanence	4: Long Term	Climate change has long term impacts such as a decrease in sea ice further exacerbating further climate changes and increased weather pressures.
B2: Impact Pathway	2: Indirect	Contributes to climate change, which indirectly affected the environment and community.
B3: Reversibility	3: Irreversible	Carbon sequestration from the atmosphere is not economical with current day technology.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling.
Environmental Score (ES)	(-32) x (12) = -384	
Range Bands ES/ Impact Significance	Major Negative Impact	

10.5.1.2 Construction and Demolition (C&D) Debris

C&D waste is non-hazardous in nature but the dust and debris that is produced from it could potentially cause health hazards for the wildlife and humans who breathe it in. The dust and debris could also settle into the natural open streams and water canal resulting in contamination of the water sources. C&D waste could be a fire hazard as it includes flammable materials such as plastic wrappings. Damaged or surplus construction materials could, depending on the size and shape, be choking or trapping hazards to wildlife. It is also visually unpleasant to look at.

Table 10-6: Impact Significance for Generation of C&D Waste

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The environmental sensitive receiver includes waterbodies connected to the national network of water channels, surrounding community and fauna receptors, of which silica dust / fugitive dust can be spread to via the wind.
A2.1: Impact Nature	-1: Negative	A reduction of water and air quality is expected.
A2.2: Magnitude of Changes	2: Medium	A moderate amount of C&D waste is produced from construction works, with a large proportion to be sorted and sent off-site for re-use and recovery of materials The volume of dust and debris from the sorting, storage, transportation process are expected to be of medium magnitude
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary due to wind and water movement.
B1: Permanence	2: Medium Term	Construction and demolition works will take place within a period of less than 10 years.
B2: Impact Pathway	3: Direct	There is a direct impact on the air and water quality
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction.
Environmental Score (ES)	(-12) x (11) = -132	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

10.5.1.3 Hazardous/ Toxic Industrial Waste

There is a range of possible toxic waste that could be discharged during construction activities, each having their own forms of specific impacts. In general, most chemical waste are fire hazards and could cause fire to start especially if other flammable wastes are present on construction site. Toxic waste could also infiltrate into the ground soil causing ecological shifts in the soil, resulting in issues with vegetation growth and soil erosion (Ashraf et al., 2014). Chemicals could also seep into water sources directly or through contaminated soil, polluting the groundwater. Exposure to wildlife and humans could also prove to be harmful, via corrosive means during direct contact or poisoning leading to associated health issues (NRC (US) Committee on Environmental Epidemiology, 1991).

Table 10-7: Impact Significance for Generation of Hazardous/ toxic Industrial waste

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The environmental sensitive receiver includes waterbodies connected to the national network of water channels and seepage into the soil. It also includes community and fauna who work or reside nearby respectively.
A2.1: Impact Nature	-1: Negative	A reduction of water and soil quality is expected. Human and animal health is also of concern.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.2: Magnitude of Changes	1: Low	Toxic waste produced is expected to be in small amount and collected and treated by NEA licensed toxic industrial waste collectors. The remnant of waste that could be arising from accidentally leakage during the management process would potentially result in a low magnitude
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary due to water movement.
B1: Permanence	2: Medium Term	Construction and demolition works will take place within a period of less than 10 years.
B2: Impact Pathway	3: Direct	There is a direct impact on the water and soil quality
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time although it may require specialised removal to due to the chemical nature.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction.
Environmental Score (ES)	(-6) x (11) = -66	
Range Bands ES/ Impact Significance	Minor Negative Impact	

10.5.1.4 Domestic Refuse, Food Waste, and Recyclable Waste

Domestic waste is non-hazardous in nature but could pose choking hazards to wildlife, may be visually unpleasant, and produce unpleasant odours. As the construction is done in an area in close proximity to untouched forested areas known to be inhabited by wildlife, such waste especially those of food origin could attract wildlife and pests if not disposed correctly. This would then result in human-wildlife conflicts and pest-related health concerns for those onsite.

Table 10-8: Impact Significance for Generation of Domestic Waste

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	The environmental sensitive receiver are largely limited to the environment, humans, and fauna on and in proximity to the Contract Boundary.
A2.1: Impact Nature	-1: Negative	The unpleasant visual and odours as well a human-wildlife conflict are negative in nature.
A2.2: Magnitude of Changes	1: Low	The waste generated is expected to be low while and collected/ transported out for treatment/ disposal according to applicable COP. The remnant of waste due to improper management on-site is expected to therefore be low.
A2.3: Impact Extent	2: Buffer Area	Impacts may extend to fauna in close proximity to the EIA Study Area.
B1: Permanence	2: Medium Term	Construction and demolition works will take place within a period of less than 10 years.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B2: Impact Pathway	3: Direct	There is a direct impact on the water and soil quality.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction with worker presence all across.
Environmental Score (ES)	(-2) x (11) = -22	
Range Bands ES/ Impact Significance	Slight Negative Impact	

10.5.1.5 Sewage

Sewage is biohazardous as it may contain bacteria and diseases that can cause environmental and health issues if exposed into the environment. As the construction is done in an area with natural open streams and connection to the water canal system, there is a potential water contamination issue. However, sewage can be generally well-managed in a construction site following COP with proper toilets equipped with sewage disposal and management system. The high volume expected to be produced alongside the contamination risks would result in only a moderate significance of the associated hazards.

Table 10-9: Impact Significance for Generation of Sewage

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The environmental sensitive receiver includes waterbodies connected to the national network of water channels.
A2.1: Impact Nature	-1: Negative	A reduction of water quality is expected.
A2.2: Magnitude of Changes	1: Medium	A high volume is expected to be produced but with only a medium magnitude expected from leakage/ insufficient capacity.
A2.3: Impact Extent	2: Buffer Area	Impact can extend outside the Contract Boundary due to water movement.
B1: Permanence	2: Medium Term	Construction and demolition works will take place within a period of less than 10 years.
B2: Impact Pathway	3: Direct	There is a direct impact on the water and soil quality
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction with worker presence all across.
Environmental Score (ES)	(-12) x (11) = -132	
Range Bands ES/ Impact Significance	Moderate Negative Impact	

10.6 Recommendation of Management, Prevention and Mitigation Measures

The following recommendations are made in alignment to Singapore's waste management strategies for sustainable waste and resource management. It follows a hierarchy of management decisions designed to reduce the amount of waste that is produced and disposed to the landfill.

Due to the largely natural landscape of the environment, several impacts have been heightened to be of greater significance. Mitigation methods therefore have to take into consideration, the proximity to the forest reserves and the forest features within.

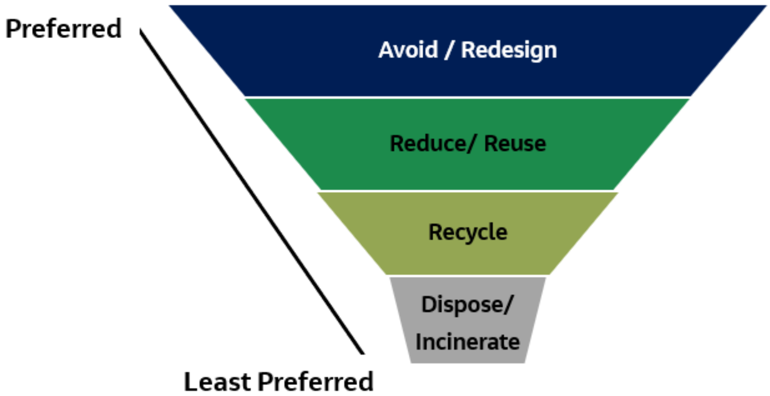


Figure 10-1: Hierarchy of Waste Management

10.6.1 Construction Activities Waste Prevention and Mitigation Measures

The following management measures have been identified to be applied to during different stages of the Project development, i.e., project planning and throughout construction stage:

a) Project Planning/ Pre-construction

- Conduct an analysis of the project waste profile to develop a waste management strategy to focus on waste elimination and to identify and communicate responsibilities for waste minimisation between developer; designer; project manager; contractors and suppliers.
- Make arrangements for on-site separation and collection of materials.
- Establish a waste management and monitoring procedures and system for the Project to include waste stream and source identification, handling, storage, disposal tracking and monitoring, progress modification, evaluation as well as compliance audits.
- Careful planning in material estimation and procurement process to minimize wastes generation.
- A routine schedule and recycling plan can be set up for horticultural waste based on the various volume produced at different construction stages.
- A review and reporting protocol for waste generated during construction should be developed that of which includes the amount of recycling and disposal done. Recycling targets should be set aligned to match or be better than Singapore's current recycling rate for C&D, ferrous metal, paper/cardboard, plastics, food, wood and horticultural. This report should be reviewed monthly to examine areas of improvement in waste reduction and management.

b) Construction Stage

Applying waste minimisation techniques and good practices on site following waste management hierarchy, i.e., source reduction, waste exchange, recycling, reuse, and waste segregation, for example:

- Horticultural waste should be transported to specialised horticultural recycling facilities where they can be grinded into wood chips which can be turned into mulch or compost. Wood chips can also be used to make new wood products by mixing it with binders. Horticultural waste which is not suitable to be recycled should be used as fuel in biomass power plants.
- Biodigesters or composting stations could be introduced onsite to deal with food waste generated by workers, converting it into grey water or compost which can then be reused onsite. These stations are usually well sealed which also reduces the hazard of wildlife being attracted to the area.
- Ensure that toilets are adequately placed across the construction site and sufficiently bunded to ensure that there is no spillage and contamination of soil and waterways.
- Wildlife proof bins should be used to reduce the hazard of wildlife being attracted to the area and accessing the food waste. This will reduce human wildlife conflict.
- Construction waste should be properly segregated and have set storage locations to extract recoverable and recyclable materials which can then be reused or recycled. Recycling bins should be provided alongside every trash bin with well-labelled signs and examples of common recyclables items to help workers sort their waste.
- Implement waste handling, storage, collection, and disposal good practices following applicable legislations as indicated in **Section 10.1**.

10.7 Residual Impact

The adoption of the regulatory and mitigation measures proposed above will assist to reduce the magnitude of the waste impact by reducing the amount of waste being produced and ensuring that the waste is properly segregated, treated and or managed. This will allow minimal leakage out of the system. It also seeks upcycling opportunities for wood waste to extract maximum value.

Table 10-10: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Impact Significance)	
ID	Impacts	Environmental Score (ES)	Range Band of ES / Impact Significance	Environmental Score (ES)	Range Band of ES / Impact Significance
W-I1	Impact of generation of wood waste (Direct	-120	Minor Negative Impact	-60	Minor Negative Impact
W-I2	Impact of generation of wood waste (Indirect)	-384	Major Negative Impact	-192	Moderate Negative Impact
W-I3	Impact of generation of C&D waste	-132	Moderate Negative Impact	-66	Minor Negative Impact

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Impact Significance)	
W-I4	Impact of generation of hazardous/ toxic Industrial waste	-66	Minor Negative Impact	-33	Slight Negative Impact
W-I5	Impact of generation of municipal waste	-22	Slight Negative Impact	-11	Slight Negative Impact
W-I6	Impact of generation of sewage	-132	Moderate Negative Impact	-66	Minor Negative Impact

11. Environmental Management and Monitoring Plan

This Section outlines an Environmental Management and Monitoring Plan (EMMP) specification and its structure which consist of requirement of policy statement, organisational structure with assigned roles and responsibilities, reporting and communication plans, management and monitoring measures, and training programme that will be put in place during construction phase of the Project for implementation of all the recommended prevention and mitigation measures in the preceding sections.

11.1 Purpose of EMMP

An EMMP for project-specific implementation during construction phase has the following purposes for:

- Commitment of compliance with mitigation and enhancement measures identified in this EIA as well as the relevant environmental legislation by responsible parties during the various stages of construction phase
- Basis of guidance to the appointed Project Consultant and Main Contractor in developing an EMMP for implementing appropriate environmental controls and monitoring procedures
- Basis of guidance to the Project Developing Agency (LTA) in establishing impact registers and management protocols to safeguard identified environmental impacts during construction phase
- Performance monitoring and auditing of the actual environmental impacts of the Project during different stages of construction.

11.2 Change Management and Review Process

The EIA has been prepared based on information available at the design stage of the Project, the EMMP may be updated once the detailed design is approved for the construction works. In particular, the recommended mitigation measures in this EIA may be revised in detail in parallel with the approved design for the Project.

For each of the issues identified as impacts in the preceding sections, suitable mitigation measures have been proposed to reduce the significance of each impact or to avoid the impact occurring at all. In tandem with the assessment and mitigation steps, the expected impacts and their associated mitigation must be monitored to determine the effectiveness of mitigation and to revise, amend relevant mitigation measures shown by monitoring to be inadequate or unsuccessful.

As EMMP serves as a “live document”, the plan will be reviewed and updated as additional project information become available and in the light of further consultation with technical agencies. The change management review process comprises:

- Verification if the EMMP is achieving the objectives
- Environmental impact register evaluation
- Mitigation measures enhancement, where necessary
- Upcoming or new environmental impacts due to change in construction methodology

11.3 Contract-Specific EMMP Structure

A Contract Specific EMMP is required to be developed by the appointed Project Consultant and Contractors (this shall be referred to by all contractors for various stages of construction phase). The Contract-Specific EMMP shall include but not be limited to the following scopes where their respective specifications are described in the following subsections.

- Project description
- Project environmental policy and objectives
- EMMP organization structure
- EMMP roles and responsibilities
- Reporting and communication plans
- Training programme
- Environmental impact register with identified sensitive receivers from the EIA's findings (key aspect of concerns), potential impacts with their respective mitigation and/or enhancement measures to be implemented including wildlife shepherding plan for wildlife migration out from project construction boundary
- Environmental performance inspection and monitoring regime for aspect such as air, noise, water quality and biodiversity to be conducted during construction period
- Environmental audit programme
- Contingency plan
- Stakeholder engagement and management

11.3.1 Project Description

The Contractor is required to include a description of the Project with the following key content:

- Overall site utilisation and layout plan
- Construction method statements
- Utilities and services plan
- Access (e.g., vehicular entrances and vehicle movement to the Project development)
- Construction material and chemical storages, soil stockpile area, etc.
- Hoarding and tree felling plan
- Construction sequence
- Waste handling and management

11.3.2 Project Environmental Policy and Objectives

The Contractor is required to establish a project-specific environmental policy that affirms their commitment to EMMP implementation. The project specific environmental policy should cover the following:

- Commitment from the company's management on environmental safeguarding for the Project
- Compliance with all applicable environmental legislation and relevant requirements including mitigation measures from this EIA and industry best practices
- Commitment to prevent pollution
- Commitment to continually improve environmental performance by setting and reviewing environmental objectives and targets
- Communication and education plans with all associated persons/ affected communities/ stakeholder to achieve environmental goals

11.3.3 EMMP Organization Structure

The Developing Agency, LTA, will oversee the implementation of the EMMP by the Contractor and its subcontractors, or any third party during the construction period of the Project. The Technical Agencies and relevant authorities and stakeholders (i.e., URA, NParks, NEA, and PUB) will be responsible for providing guidance for requirements and sharing with LTA for issues related to interfacing works where cumulative impacts are identified. A recommended organization structure for EMMP implementation during construction phase is presented in **Figure 11-1**.

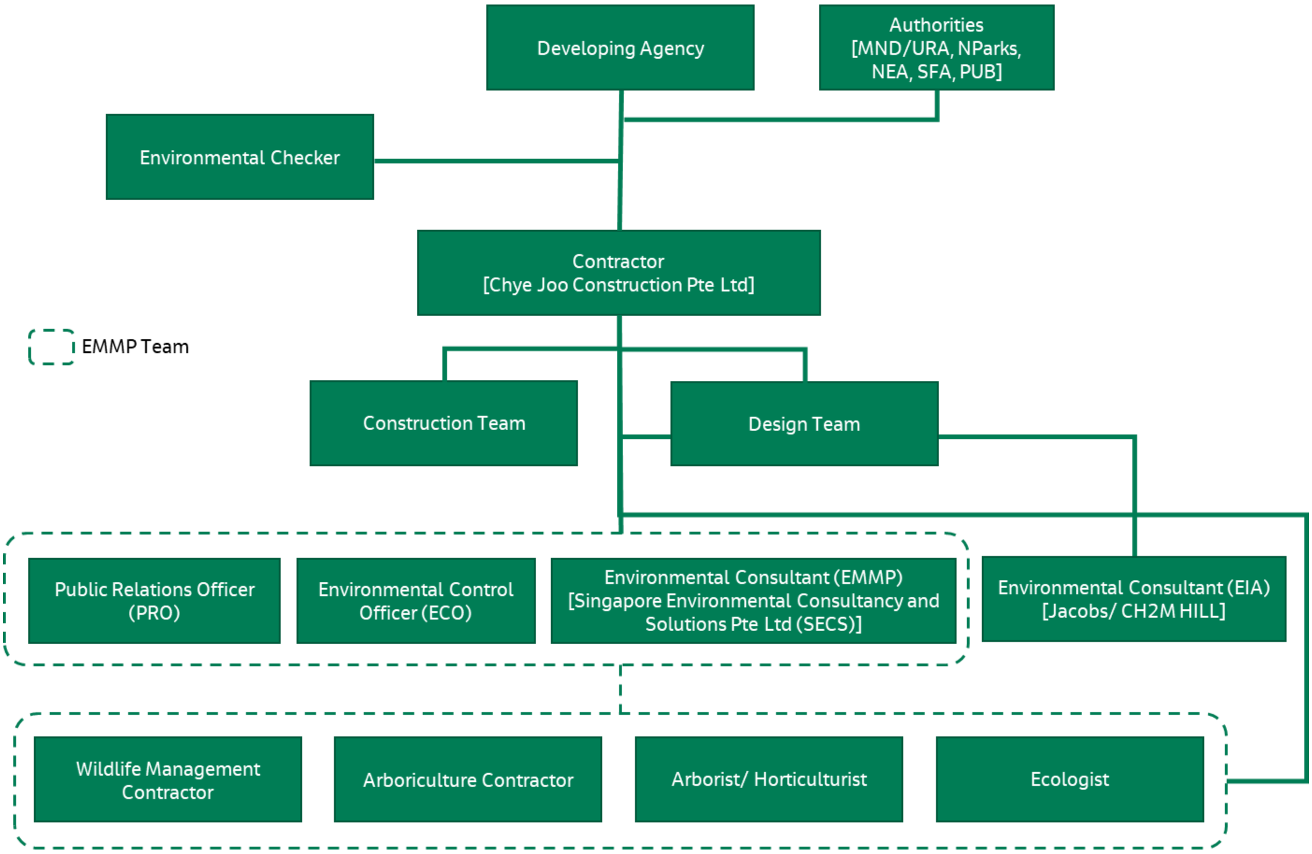


Figure 11-1: Recommended Organisation Chart for EMMP Implementation

11.3.4 EMMP Roles and Responsibilities

The roles and responsibilities for each key party in the recommended EMMP Organization Structure during construction phase is given on **Table 11-1**.

Table 11-1: Roles and Responsibilities of Key Parties in Recommended EMMP Organization Structure

Role	Party	Key Responsibilities
Project Management and Construction Supervision	Developing Agency / QP (Supervision) Team /	• Responsible for the overall management of the project development with full commitment to environmental policy and EMMP implementation.

Role	Party	Key Responsibilities
	Environmental Checker	• Review internal and external audit reports relating to environmental management for the respective developments. • Communicate requirements from agencies/EIA to the Contractors. • Supervise and oversee construction works undertaken by Contractor according to contracts requirement, engineering, construction and EMMP specifications set by Developing Agency/ Authorities. • Monitor compliance of the implementation of the EMMP against the Contract specification and relevant environmental legislation requirement. • Audit the environmental performance monitoring. • Activate relevant response plans in the event of any exceedances or incidents. • Carry out complaint investigations, where applicable.
Contractor	CJC	• Responsible to execute the contract in compliance to applicable environmental legislation, environmental policy, mitigation/ enhancement measures recommended in the EIA, etc., set by relevant authorities and the Developing Agency. • Employ and appoint an Environmental Monitoring and Management team consisting of the Consultant, adequately supported by specialist teams including but not limited to the scopes of water, noise, air quality, wildlife shepherding, flora and fauna monitoring. • Appoint a Public Relation Officer (PRO) to support the Developing Agencies in carrying out complaint investigation. • Establish method statements according to recommended mitigation measures, provide relevant information to Contract Specific EMMP Team on potential activities that create adverse environmental conditions. • Participate in the site audits undertaken by the third party independent Environmental Performance Auditor and undertake corrective actions instructed by the Environmental Performance Auditor. • Submit proposal for mitigation measures should there be an exceedances or incidents. • Implement approved mitigation measures to reduce the potential impacts from exceedances or incidents. • Submit periodic environmental performance monitoring reports to Developing Agencies for review.
Environmental Consultant	Jacobs	• Recommend environmental parameters to be managed and monitored in the EMMP.

Role	Party	Key Responsibilities
(EIA)		• Recommend environmental performance monitoring and auditing scheme to be transform as part of Contract specification requirement.
Environmental Consultant (EMMP)	SECS	• Prepare and develop a contract specific Environmental Monitoring and Management Plan (CEMMP) based on his detailed construction method and the EMMP developed during the EIA • Submit to all relevant Authorities, including but not limited to HDB, URA, NEA, NParks and the Developing Agencies for approval prior to the commencement of the works. • Monitor the implementation of EMMP and submit Monthly EMMP report.

11.3.5 Reporting and Communication Plan

All documentation throughout the construction contract period should exist in a written format and be filed in a traceable and systematically manner. The Contractor is to establish templates for reporting for approval by the Developing Agency prior to commencement of contract works. All documentation templates/ formats should be clearly communicated to potential users (i.e., Project Management Team, Project Consultants and Contract Specific EMMP Team). The documents shall include the following at a minimum:

- Minutes of records and attendance records for all meetings and trainings related to the environment
- Special management plan and/ or technical records
- Method statement for construction
- Environmental inspection reports
- Environmental performance monitoring reports
- Environmental audit reports
- Non-compliance and remedial action plans

11.3.6 Specific Management and Monitoring Plans

The Environmental Impact Register outlined in **Section 12** is recommended as a management and monitoring tool. Continuous Compliance Monitoring is recommended throughout the Project development by the Developing Agency, QP (Supervision) Team and Contractor.

11.3.7 Training Programme

The appointed Contractors are responsible for induction and appropriate trainings related to environment topics of all workers employed on the construction site. The main purposes are to translate/ communicate EMMP requirements, to promote environmental awareness on responsibilities and to build capacity in mitigation measures implementation. The recommended training programmes are listed but not limited to:

- Tree protection management plan
- Wildlife awareness and response procedures
- Water quality management plan and procedures

- Earth control measures management plan
- Air quality management plan
- Noise and vibration management plan
- Environmental incident response and reporting procedures

The SO will conduct periodic reviews and update training programme requirement to align with any project information changes.

11.3.8 Environmental Audit Regime

The purpose of environmental auditing is to provide an independent check that appropriate environmental management is taking place in accordance with statutory requirements and the EMMP. The environmental audit will also review the results of monitoring undertaken during the construction phase to identify the need for any additional environmental management or mitigation measures to be implemented.

The scope of the Environmental Audit Regime shall cover all the environmental issues relating to construction that are addressed in this EIA report and by the EMMP. The Environmental Audit shall be undertaken by the Developing Agency's appointed Environmental Checker. The activities to be undertaken as part of an environmental audit include:

- Examination of the environmental incidents and complaints log
- Examination of the environmental register, including results of monitoring
- Interviews with the Contractor's Project Manager, Contract Specific EMMP representative(s) and ECO and other site staff as required
- Consultation with relevant statutory authorities, where appropriate
- Visual examination of the construction site, to examine working practices, environmental effects, mitigation measures and monitoring activities

For this Project, it is recommended that the environmental auditing to be carried out on biannual (i.e., twice a year) basis throughout the construction phase.

11.3.9 Contingency Plan

In order to safeguard the environment and workers health and safety, the construction contract specification should include the requirement for Contractors to develop an Emergency Preparedness and Response Plan for any emergency/ incidents/ accidents happen during construction according to the regulations/ guidelines (e.g. Environmental Protection and Management Act, Environmental Public Health Act, Building Control Act, Control of Vectors and Pesticides Act, Code of Practice on Surface Water Drainage, National Heritage Board Act, Parks and Trees Act and Sewerage and Drainage Act).

The plan should include environmental related emergency/ incidents (i.e., spillage, wildlife incident) which should cover the following recommended specifications:

- Emergency contact personnel and contact detail (internal and external contact)
- Emergency contact organisation, include first and second point of contact
- Incident response notification procedures and action flow chart
- Response reporting timeframe

- Reporting requirement (date, time, location, incident encounter, reporting person and witness) and reporting timeframe (i.e., within 24 hours of an incident happen)
- Reporting flow, i.e., report should be prepared by Contractor's appointed Ecologist/ EMMP Team and ultimately reporting to Developing Agency

11.3.10 Stakeholder Engagement and Communication Plan

A specific Stakeholder Engagement Plan and Grievance Mechanism procedures should be established as part of the Contract Specific EMMP with the following specifications:

- Stakeholder identifications and analysis, i.e., nature groups (NG) engaged during the EIA stage
- Information disclosure. The type of information should be on environmental impacts and public safety concerns
- Stakeholder consultation requirement
- Communication channel where project information can be shared and communicated to affected communities and public to provide greater transparency and help in allaying uncertainty or misconceptions about the project.
- A grievance mechanism/ procedure to handle feedback and complaints to incorporate input from various stakeholders and public
- Organization chart with roles and responsibilities for stakeholder engagement and grievance mechanism
- Documentation and investigation procedures
- Performance monitoring and evaluation of effectiveness of plan

12. Environmental Impact Register

Sections 4 to 10 outlines the potential environmental impacts associated with the construction activities of the Project development as identified in the EIA. It also identifies the mitigation measures proposed for each impact.

The environmental impact register (**Table 12-1**) outlines the minimum procedures that are recommended to ensure proper management of the various environmental aspects associated with the construction as well as the responsibilities for action and monitoring the effectiveness of the mitigation measures. This register forms the basis for the EMMP for the Employer and Contractor to follow.

Table 12-1. Environmental Impact Register for the Project

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Geomorphology, Soil, and Groundwater Quality	Soil at Buffer Area	Outside Local/ Medium	Changes to Soil Infiltration Capacity	Slight Negative Impact	• Develop and undertake a programmatic Excavation, Cut and Fill and Earthmoving plan. • Engagement of a Qualified Person (QP)/Professional Engineer (PE) to conduct slope stability and soil compaction studies within and adjacent to the areas of concern prior to any clearing and earthworks. • Stockpile stripped topsoil in a designated area strategically placed within the Contract Boundary and cover the area as necessary to reduce or prevent soil loss from secondary erosion from wind or runoff. • Placement of Erosion and Sediment Control (ESC) structures (i.e., biodegradable Erosion Control Blanket (ECB)) at open areas where applicable. • Rehabilitate temporary construction areas such as staging and stockpiling zones as close as practicable to its pre-construction conditions that can be revegetated. • Placement of piezometers and monitoring wells adjacent to work areas where groundwater hydrostatic pressure is expected to become potentially high that these may also affect the subsurface-related construction activities.	Slight Negative Impact	• Groundwater levels at locations where groundwater hydrostatic pressure is expected to become potentially high – to be determined by QP • Daily Environmental Inspection	• Contractor Project Manager (PM) • QP / PE • Environmental Checker • ECO	
	Soil at Buffer Area	Outside Local/ Medium	Soil Loss and Erodibility	Slight Negative Impact		Slight Negative Impact			
	Groundwater at Buffer Area	Outside Local/ Medium	Changes in Hydrogeology	Slight Negative Impact		Slight Negative Impact			
	Soil and Groundwater at Buffer Area	Outside Local/ Medium	Land contamination due to pollutive substances leaks or spills	Slight Negative Impact	• Prepare spoil (soil and concrete debris) management and disposal plan. • Maintain records of all spoil removed from construction site. • Avoid mixing different types of spoil unless they are to be disposed of at the same location within the same facility. • Only licensed and approved waste haulers should be used to collect and transport any contaminated material to an appropriate disposal site. • Store chemical materials and wastes in a locked area with secondary containment. The risks associated with the storage and handling of chemicals can be further minimised by: o Provision of an appropriate, well ventilated storage area o Careful handling of waste fuel and oil residues o Storage of wastes remote from sensitive receivers o Training of workers on the concepts of site cleanliness and appropriate chemical handling procedures • Workers handling soil should wear appropriate Personal Protective Equipment (PPE) such as boots, overalls, rubber gloves, goggles and implement good personal hygiene practices to minimise accidental ingestions, direct contact, and inhalation of contaminants, if identified. • *Prepare and implement a dewatering management plan of removed groundwater from the excavation*. The management plan shall have protocol of no direct discharge of groundwater from dewatering process into any public sewer line. Pumped water (groundwater) should undergo analytical test based on baseline condition from the result of soil and groundwater study to determine the method of treatment or disposal.	Slight Negative Impact	• Soil disposal records • Hazardous or toxic industrial wastes disposal records • Daily Environmental Inspection	• Contractor PM • QP / PE • Environmental Checker • ECO	
	Soil and Groundwater at Buffer Area	Outside Local/ Medium	Land contamination due to hazardous or toxic industrial wastes	Slight Negative Impact		Slight Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Water and Waterbodies	Sungei Peng Siang, which is a tributary of Kranji Reservoir	National/ High	Water quality deterioration due to soil erosion and surface runoff from construction site	Moderate Negative Impact	• Install site boundary hoarding with embedded silt fence at the bottom hoarding to enclosed construction working space. This will contain silty water generated from construction phase activities including any bentonite slurry overflow from bored piling works. • All exposed earth created should be covered with fully biodegradable ECB. • Before work commences, submit the Earth Control Measures (ECM) proposal duly endorsed by his Qualified Erosion Control Professional (QECP) to PUB and copied to the Developing Agency indicating: o Exposed surfaces will be minimised according to the construction activities. o Effective sediment control facilities (including storage and treatment facilities) will be implemented. o A system of ECM will be in place before work commences. o Clearance Certificate to commence earthworks is obtained. o During construction, ECM will be revised/updated and put in place to control silty discharge, as the need arises. • Spill containment shall be provided at all discharge point. ECM design, included trade effluent treatment system shall recommend the type of spill containment in the event of non-complying discharges. • Cleared vegetation in particular at sloped areas, will be covered with ECB to control erosion of exposed soil. Re-vegetate exposed ground as soon as possible to stabilise surfaces and minimise erosion of soil to watercourses.	Minor Negative Impact	• Real-time monitoring of total suspended solids (TSS) at ECM discharge points • Daily monitoring/ inspection of pH level by ECO at ECM discharge points • Monthly surface water sampling at ECM discharge points for parameters listed on Table 5-1 • Daily environmental Inspection • Daily inspection of implementation of actions and monitoring as prescribed within the ECM Plan • Daily site inspections to confirm provision of spill kits and secondary containment trays	• Contractor PM • Environmental Checker • ECO	
	Sungei Peng Siang, which is a tributary of Kranji Reservoir	National/ High	Water quality deterioration due to use, storage and handling of diesel, oil and other pollutive substances spill	Moderate Negative Impact	• Put in place a response plan to cater for accidental spillages into any watercourse. This plan shall be communicated to all personnel. Training shall be provided for all staff in spill response measures. • All spill containment facilities and spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • All spills must be cleaned within the same day or immediately for under wet weather conditions. • Safety Data Sheet (SDS) for all hazardous materials shall be compiled and stored on site and available for viewing. • Spill management kits shall be provided at worksites (in accordance with the type of hazardous materials to be used, include but not limited to rags, sands, eyewash, protective gloves, etc.) at where hazardous materials, equipment and machinery will be stored and used. • Hazardous materials shall be stored in bunded and covered areas in accordance with the manufacturer's safety requirements. Storage of hazardous materials on-site should be limited to the minimum necessary to reduce the impact of any spillage or mitigation failure.	Minor Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Water and Waterbodies	Sungei Peng Siang, which is a tributary of Kranji Reservoir	National/ High	Water quality deterioration due to discharge of trade effluent discharge	Moderate Negative Impact	• Trade effluent generated shall be collected and disposed off-site. No discharge to watercourse unless the treated trade effluent comply to Trade Effluent Regulations (TER) limits as stipulated in the EPMA. • Appropriate concrete washout water containers should be provided and stored away from any streams for offsite disposal through licensed waste treatment contractors. • Bentonite slurry in intermediate bulk container (IBC) tanks used in Soil Investigation (SI) works should be stored away from any streams or drains and disposed offsite through licensed waste treatment contractors. • Wheel wash wastewater to be diverted into ECM facilities for reuse as wheel washing.	Minor Negative Impact			
	Sungei Peng Siang, which is a tributary of Kranji Reservoir	National/ High	Water quality deterioration due to sedimentation from loss/ disturbance of topsoil	Minor Negative Impact	• Stream diversion works (i.e., ground preparation, vegetation clearing, topsoil removal, excavation and concreting) should be done in phased manner to minimise the area disturbed at any given time. If the stream to be diverted is long, the alignment may be subdivided into segments for which drain construction works can be scheduled and completed before moving on to the next segment. • Topsoil removed should be harvested and stockpiled in a designated area and covered to prevent soil loss. Soil conserved can be used for backfilling and planting of riparian vegetation for WQ4 diversion, in consultation with a biodiversity specialist.	Slight Negative Impact			
	Catchment in Buffer Area	Outside Local/ Medium	Change in Hydrology during Construction Phase	Slight Negative Impact	• Develop comprehensive and sound Excavation, Cut and Fill and Earthmoving Plan. The execution of construction work should be done accordingly in stages and programmed segments to avoid formation of uneven slopes or terrain that can influence surface flows into the existing as well as diverted or improved drains. This will also avoid the unnecessary increase in surface water flow rate on temporary or permanent water features or drains. • Minimize the disturbance area affected by excavation and earthworks to what is only necessary and defined in accordance with the Site Construction Plan. • Strategically designate temporary diversion channels within construction work areas to manage and direct surface flows and avoid surface water ponding that may cause temporary flooding. • The Site Construction Plan is recommended to consider allocation of some of the available land resource, where possible, that can naturally accommodate excess surface runoff and thereby reduce the surface water flow rates entering drains and waterways and reducing the need for auxiliary equipment e.g., pumps, during peak rainfall regimes.	Slight Negative Impact	Visual inspection for onsite flooding	• Contractor PM • Environmental Checker • ECO	
	Catchment in Buffer Area	Outside Local/ Medium	Change in Hydrology during Operation Phase	Minor Negative Impact		Slight Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ecology	Abandoned-land Forest	High	Loss of Vegetation/ Habitat	Major Negative Impact	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite. • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible. • Conduct regular inspections to ensure contractor compliance to the EMMP, with oversight by the Developing Agency • Ensure minimum control measures stated in Section 6.2.7 are properly implemented. This includes soil erosion measures, dust control measures, installation of tree protection zones, pre-felling fauna inspection and wildlife response plan. • Ensure silt fences and other silt control measures along the worksite hoarding are installed and maintained properly to prevent siltation into conserved waterbodies. • Retain ground cover for as long as possible before removal. When ground cover is removed, ECM is to be in place. • Ensure no encroachment into forest adjacent to DE170 Contract Boundary. • Conduct monitoring to identify any impacts to habitats within forest adjacent to DE170 Contract Boundary. This may include: o Visual inspection of terrestrial and aquatic habits o Visual inspection for forest edge effects	Major Negative Impact	• Daily Environmental Inspection • Visual inspection of terrestrial and aquatic habits • Visual inspection for forest edge effects	• Contractor PM • Environmental Checker • ECO • Qualified Ecologist or Fauna Specialist • Qualified arborist of horticulturist	
	Exotic-dominated Secondary Forest	Medium	Loss of Vegetation/ Habitat	Moderate Negative Impact		Moderate Negative Impact			
	Scrubland	Low	Loss of Vegetation/ Habitat	Minor Negative Impact		Minor Negative Impact			
	Urban Vegetation	Low	Loss of Vegetation/ Habitat	Minor Negative Impact		Minor Negative Impact			
	Closed-canopy streams	Medium	Loss of Vegetation/ Habitat	Moderate Negative Impact		Moderate Negative Impact			
	Open-country stream	Medium	Loss of Vegetation/ Habitat	Moderate Negative Impact		Moderate Negative Impact			
	Closed-canopy & semi open-country ponds	Medium	Loss of Vegetation/ Habitat	Moderate Negative Impact		Moderate Negative Impact			
	Open-country pond	Low	Loss of Vegetation/ Habitat	No change		No change			
	Canal with naturalised sections	Low	Loss of Vegetation/ Habitat	No change		No change			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ecology	Abandoned-land Forest	High	Habitat Degradation	Slight Negative Impact	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, and associated works, outside of worksite. • Ensure that minimum control measures as well as engineering controls are in place to prevent contamination and siltation into the sensitive habitats and waterways. • Ensure any associated slope stabilisation and grading works will not impact topography of areas outside worksite and, water quality and hydrology of the conserved waterbodies within the EIA Study Area. • Conduct regular inspections to ensure contractor compliance to the EMMP, with oversight by the Developing Agency • Ensure minimum control measures stated in Section 6.2.7 are properly implemented. This includes soil erosion measures, dust control measures, installation of tree protection zones, pre-felling fauna inspection and wildlife response plan. • Ensure silt fences and other silt control measures along the worksite hoarding are installed and maintained properly to prevent siltation into conserved waterbodies. • Retain ground cover for as long as possible before removal. When ground cover is removed, ECM is to be in place. • Ensure no encroachment into forest adjacent to DE170 Contract Boundary • Conduct monitoring to identify any impacts to habitats within forest adjacent to DE170 Contract Boundary. This may include: o Visual inspection of terrestrial and aquatic habits o Visual inspection for forest edge effects	Slight Negative Impact	• Daily Environmental Inspection • Visual inspection of terrestrial and aquatic habits • Visual inspection for forest edge effects	• Contractor PM • Environmental Checker • ECO • Qualified Ecologist or Fauna Specialist • Qualified arborist of horticulturist	
	Exotic-dominated Secondary Forest	Medium	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Scrubland	Low	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Urban Vegetation	Low	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Closed-canopy streams	Medium	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Open-country stream	Medium	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Closed-canopy & semi open-country ponds	Medium	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			
	Open-country pond	Low	Habitat Degradation	No Change		No Change			
	Canal with naturalised sections	Low	Habitat Degradation	Slight Negative Impact		Slight Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ecology	Abandoned-land Forest	High	Changes in Species Composition	Moderate Negative Impact	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, and associated works, outside of worksite. • Ensure that minimum control measures as well as engineering controls are in place to prevent contamination and siltation into the sensitive habitats and waterways. • Ensure any associated slope stabilisation and grading works will not impact topography of areas outside worksite and, water quality and hydrology of the conserved waterbodies within the EIA Study Area. • Conduct regular inspections to ensure contractor compliance to the EMMP, with oversight by the Developing Agency. • Ensure minimum control measures stated in Section 6.2.7 are properly implemented. This includes soil erosion measures, dust control measures, installation of tree protection zones, pre-felling fauna inspection and wildlife response plan. • Ensure silt fences and other silt control measures along the worksite hoarding are installed and maintained properly to prevent siltation into conserved waterbodies. • Retain ground cover for as long as possible before removal. When ground cover is removed, ECM is to be in place. • Ensure no encroachment into forest adjacent to DE170 Contract Boundary • Conduct monitoring to identify any impacts to habitats within forest adjacent to DE170 Contract Boundary. This may include: ○ Visual inspection of terrestrial and aquatic habits • Visual inspection for forest edge effects	Moderate Negative Impact	• Daily Environmental Inspection • Visual inspection of terrestrial and aquatic habits • Visual inspection for forest edge effects	• Contractor PM • Environmental Checker • ECO • Qualified Ecologist or Fauna Specialist • Qualified arborist of horticulturist	
	Exotic-dominated Secondary Forest	Medium	Changes in Species Composition	Moderate Negative Impact		Moderate Negative Impact			
	Scrubland	Low	Changes in Species Composition	Minor Negative Impact		Minor Negative Impact			
	Urban Vegetation	Low	Changes in Species Composition	Minor Negative Impact		Minor Negative Impact			
	Closed-canopy streams	Medium	Changes in Species Composition	Moderate Negative Impact		Moderate Negative Impact			
	Open-country stream	Medium	Changes in Species Composition	Moderate Negative Impact		Moderate Negative Impact			
	Closed-canopy & semi open-country ponds	Medium	Changes in Species Composition	Moderate Negative Impact		Moderate Negative Impact			
	Open-country pond	Low	Changes in Species Composition	No Change		No Change			
	Canal with naturalised sections	Low	Changes in Species Composition	Minor Negative Impact		Minor Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ecology	Fauna	High	Light disturbances	Minor to Moderate Negative Impact	• Restrict working hours to 0800H–1800H • Implement lighting plan for night works • Minimise night-time works particularly during bird migratory season (September to February) • Where night-time works are unavoidable, adopt the following measures: o Review construction method statements and site lighting plan with the EMMP Specialist and Ecologist before the commencement of night works and where necessary o Reduce light spillage into adjacent areas by adopting the following measures: o Worksite hoarding to be opaque and dark-coloured where possible o Increase the height of worksite hoarding, especially in areas adjacent to natural areas o Ensure that no light sources are directly visible from the forest edge as much as possible o Ensure that lighting is only used where really necessary; remainder of worksite to remain dark as much as possible o Lighting to be directed downwards to reduce light spillage upwards, as it may impact migratory birds o To establish a wildlife response plan to be executed when fauna (e.g., disoriented birds) is found on-site during night-time works • For lighting equipment, consider: o Using warm lighting where possible during construction works after 6 pm (i.e., soft white and warm white light bulbs, preferably at < 2,700 K) • Avoid using high UV and broad-spectrum lights (except for safety reasons)	Minor to Moderate Negative Impact	Daily Environmental Inspection	• Contractor PM • Environmental Checker • ECO	
	Fauna	High	Loss of/ reduction in habitats and food sources	Minor to Major Negative Impact	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite. • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible. • Additional planting of cultivated *Ardisia elliptica* as host plants for the harlequin butterfly	Minor to Moderate Negative Impact	• Daily Environmental Inspection • Monthly Tree and Flora Inspections • Monitor for potential unauthorised vegetation clearance to planting area of *Ardisia elliptica*, and monitor for the presence of harlequin butterfly	• Contractor PM • Environmental Checker • ECO • Qualified arborist and/or horticulturalist	

<table>
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<tr><th rowspan="2">Environmental Aspect</th><th colspan="2">Description of Receptor</th><th colspan="2">Description of Potential Impact</th><th rowspan="2">Recommended Mitigation Measures</th><th rowspan="2">Residual Impact Significance</th><th rowspan="2">Description of Monitoring Required</th><th rowspan="2">Resources and Responsible Party</th><th rowspan="2">Close-up Actions</th></tr>
<tr><th>Sensitive Receiver</th><th>Value/ Sensitivity</th><th>Impact</th><th>Overall Impact Significance</th></tr>
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<tbody>
<tr><td rowspan="4">Ecology</td><td>Fauna</td><td>High</td><td>Loss/ reduction of ecological connectivity for faunal movement</td><td>Minor to Moderate Negative Impact</td><td rowspan="4">• Implement passive wildlife shepherding through directional site clearance
• Establish a Wildlife Response Plan in consultation with NParks Animal Management Centre, to be executed during encounters with trapped, injured or dead wildlife, as well as incidents of human-wildlife conflict
• Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes
• Adopt road calming measures such as speed bumps and speed limits to minimise roadkill accidents
o During construction phase, vehicular traffic is expected to increase from the development. Speed limits (15–20 km/h) should be adhered to strictly.
o In addition, speed bumps could be integrated on key access routes within the construction site to prevent speeding.
• Ensure integrity of hoarding
o To minimise entry of fauna into the DE170 Contract Boundary, the integrity of hoarding must be maintained at all times. Gaps in hoarding facilitates entry of fauna into the construction site.
o Regular inspections should be conducted to ensure there are no gaps in hoarding at all times.
o The hoarding must not have any gaps between the panels and are to extend at least 300mm into the ground.
o o The access gates, when shut, must not have any gaps between the panels and must be flush as close to the ground as possible.
• Train site personnel on biodiversity awareness and actions to take when encountering wildlife
• Ensure good housekeeping controls such as provision of wildlife-proof bins and indoor eating areas
• Conduct regular inspections to ensure contractor compliance to the EMMP and identify potential faunal entrapments
• Establish a temporary wildlife crossing to allow faunal movement between adjacent forest at night when there are no works. (No entry of site personnel to vegetated areas outside of the agreed working space, including adjacent forest areas and other parts of Tengah Forest.
• Replant cultivated Ardisia elliptica, host plant for the harlequin butterfly to restore connectivity within Tengah Forest.</td><td>Minor Negative Impact</td><td rowspan="4">• Daily Environmental Inspection
• Fauna Inspection
• Check camera traps to ensure that the temporary wildlife crossings were operational during designated hours</td><td rowspan="4">• Contractor PM
• Environmental Checker
• ECO
• Qualified Ecologist or Fauna Specialist</td><td rowspan="4"></td></tr>
<tr><td>Fauna</td><td>High</td><td>Accidental injury or mortality</td><td>Minor to Moderate Negative Impact</td><td>Minor Negative Impact</td></tr>
<tr><td>Fauna</td><td>High</td><td>Human disturbances</td><td>No Change to Minor Negative Impact</td><td>Slight to Minor Negative Impact</td></tr>
<tr><td>Fauna</td><td>High</td><td>Human wildlife conflict</td><td>Minor Negative Impact</td><td>Minor Negative Impact</td></tr>
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Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ecology	Flora	High	Mortality	No Change to Major Negative Impact	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite. • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible. • Transplant or harvest or propagate trees/ saplings of conservation significance if they are to be cleared • Engage flora specialist to monitor health of transplanted individuals • Engage with a certified arborist if pruning is needed for any tree specimens • Conduct regular inspections to ensure contractor compliance to the EMMP	No Change to Minor Negative Impact	• Daily Environmental Inspection • Monthly Tree and Flora Inspections	• Contractor PM • Environmental Checker • ECO • Qualified arborist and/or horticulturalist	
	Flora	High	Impediment to seedling recruitment	No Change to Minor Negative Impact	• Transplant or harvest or propagate trees/ saplings of conservation significance if they are to be cleared • Engage flora specialist to monitor health of transplanted individuals • Engage with a certified arborist if pruning is needed for any tree specimens • Conduct regular arboricultural inspections to monitor the health of the retained specimens, if any. • Conduct regular inspections to ensure contractor compliance to the EMMP • Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible.	No Change to Minor Negative Impact	Tree and Flora Inspections	Qualified arborist and/or horticulturalist	
	Flora	High	Competition from exotic species	No Change to Minor Negative Impact		No Change to Minor Negative Impact			
	Flora	High	Decline in plant health and survival	No Change to Moderate Negative Impact		No Change to Moderate Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Air Quality	ASR 1, ASR 2, ASR 3	Outside Local/ Medium	Air quality deterioration due to fugitive dust emissions during construction phase	Moderate Negative Impact	Dust Control • Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeters are recommended to reduce dust deposition at adjacent areas construction site. • Construction works including vegetation clearance and tree felling should be done in phases/ segments to minimise the area disturbed at any given time. • Extent of excavation and soil exposure areas recommended to be kept to minimum required for construction. • Maintain access roads in the construction site damp (e.g., using sprinkler) with the misting frequency increased during dry periods. • Exposed earth should be properly treated by compaction, turfing, vegetation planting or sealing with bituminous materials, concrete, or other suitable materials as soon as practicable after construction activities have been completed. • For areas with ongoing earth works, cover exposed earth with impermeable sheeting for short periods (1 to 2 days) or with fully biodegradable ECB in longer periods. • Construction site perimeters and adjacent roads or lands should be regularly inspected to check for and if necessary, remove dust deposition. • Vehicle on-site speed restrictions should be imposed by contractor to prevent dust being whipped up by vehicle movements. • Vehicle washing facilities with high pressure water jets should be provided at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point should be paved with concrete or tarred with bituminous materials by contractor. Stockpile Management • Stockpiles of soil and dusty materials should be located as far as possible from ASRs, considering prevailing wind directions and seasonal variations. • Any soil or stockpiles of dusty material should be properly stored, covered entirely with impervious sheeting. • Stockpiles and excavations should be removed, backfilled, or reinstated (as appropriate) as soon as practicable following excavation or unloading. • Any soil and dusty materials remaining after removal of a stockpile should be wetted with water and cleared from surfaces of work areas or roads with the misting frequency increased during dry periods. • Stockpiles of soil and dusty materials should not extend beyond pedestrian barriers or fencing.	Minor Negative Impact	Conduct ambient air quality monitoring for SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ during the different construction scenarios: • Scenario 1: Nov 2023 to Mar 2024 • Scenario 2: April 2024 to Nov 2025 • Scenario 3: Dec 2025 to May 2026 • Scenario 4: Jun 2026 to Aug 2027 Monitoring at AQ1 over a sampling period on one week should be conducted during the southwest monsoon for scenarios 2, 3 and 4 where the upwind receptors are likely to be impacted. Monitoring at AQ2 and AQ3 over a sampling period of one week should be conducted during the northeast monsoon period for scenarios 1, 2, 3 and 4 where the downwind receptors are likely to be impacted	• Contractor PM • Environmental Checker • ECO	

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Air Quality	ASR 1, ASR 2, ASR 3	Outside Local/ Medium	Air quality deterioration due to exhaust emissions from construction fuel-burning machinery and transport vehicles during construction phase	Minor Negative Impact	• All fuel-burning machinery or transport vehicles should be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke. • Construction works should be done in phases/ segments to limit the number of fuel-burning machinery at the construction site at any given time. • Vehicle and equipment exhaust should be controlled by good practice procedures, such as turning off equipment when not in use. • Vehicle speed restrictions on construction site areas or access roads should be imposed, especially on unpaved roads. • For areas requiring traffic diversion at public roads Traffic Control Plan in accordance with COP for Traffic Control at Work Zone (2019) should be implemented to minimise traffic congestion and vehicular waiting time at traffic diversion sites and contribute to reduction in vehicle exhaust emissions. • Load of dusty materials on a vehicle leaving a construction site should be covered entirely with impervious sheeting by contractor. Vehicle should not be overloaded and should be cleaned prior to leaving the site. • Proper cover for vehicle (e.g., tipper lorry) to avoid falling of soil debris. Any skip hoist used to transport dusty materials should be completely enclosed by impervious sheeting. • Vehicle washing facilities with high pressure water jets should be provided by contractor at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point should be paved. • If roadways are contaminated with dusty materials from construction site, clean-up should be conducted without delay. • Vehicle on-site speed restrictions should be imposed by contractor to prevent dust being whipped up by vehicle movements. • All fuel-burning machinery or transport vehicles should be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke.	Slight Negative Impact	Conduct ambient air quality monitoring for SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ during the different construction scenarios: • Scenario 1: Nov 2023 to Mar 2024 • Scenario 2: April 2024 to Nov 2025 • Scenario 3: Dec 2025 to May 2026 • Scenario 4: Jun 2026 to Aug 2027 Monitoring at AQ1 over a sampling period on one week should be conducted during the southwest monsoon for scenarios 2, 3 and 4 where the upwind receptors are likely to be impacted. Monitoring at AQ2 and AQ3 over a sampling period of one week should be conducted during the northeast monsoon period for scenarios 1, 2, 3 and 4 where the downwind receptors are likely to be impacted	• Contractor PM • Environmental Checker • ECO	

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Airborne Noise	Community NSRs (NSR 1, NSR 2, NSR 3)	Outside Local/ Medium	Noise from Construction Activities to Residential community (L_{Aeq} 12 hours) in the Day	Slight Negative impact	• Additional engineering control measures enclosure, noise screen/ noise panel o Enclosure at stationary PME such generator with sufficient height and width to accommodate for machinery/equipment housed within. The proposed enclosures may achieve noise level reduction of at least 15 dBA (Table F.3 of SS 602: 2014). o Noise screen/ noise panel at moveable PME such excavator and crawler/ mobile crane and it should be of sufficient height and width to shield the noisy part. The proposed screening may achieve noise level reduction of at least 10 dBA (Table F.3 of SS 602: 2014). o Portable noise barrier at construction activities e.g., soil investigation drilling activities, road and drainage work which are close to site boundary. The proposed portable noise barrier may achieve noise level reduction of at least 10 dBA (Section F.3.3.4 of SS 602: 2014). • Quieter construction methodology such as the use of diamond wire saw cutter is able to achieve up to 30 dBA of noise reduction (based on LTA's Noise Guidance: Developing a Noise Management Plan). • Contractor to prepare noise management plan (NMP) with the finalised construction method, schedule and equipment sound power levels to reconfirm the noise impact to community and fauna receptors are within acceptable range. The suggested NMP template is indicted in Annex H of SS 602: 2014. • Contractor to use engineering methodology to control noise at source, such as: o Noise enclosure to cover stationary PME such as generator. o Noise screen/ noise panel to partially shield noise generated from noisy PME such as crane and excavator o Portable noise barrier for noisy construction activities e.g., soil investigation drilling activities and road and drainage work which are close to site boundary • Quieter construction methodology such as silent piler instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling	Slight Negative impact	Conduct continuous real time noise monitoring using Type 1 sound level meter with data logging at the affected NSRs. When noise level exceeds the maximum adjusted noise level, contractor should investigate and apply appropriate mitigation measures.	• Contractor PM • Environmental Checker • ECO	
		Outside Local/ Medium	Noise from Construction Activities to School community (L_{Aeq} 12 hours) in the Day	Moderate Negative impact		Slight Negative impact			
		Outside Local/ Medium	Noise from Construction Activities to Residential Community i(L_{Aeq} 5mins) in the day	Slight Negative impact		Slight Negative impact			
		Outside Local/ Medium	Noise from Construction Activities to School community (L_{Aeq} 5 mins) in the in the day	Slight Negative impact		Slight Negative impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
		Outside Local/ Medium	Noise from Construction Activities to Residential community (L_{Aeq} 1 hour) in the Night	Slight Negative impact	• Contractor should plan the construction works to minimise noise sources on site through optimisation of construction sequence and methods such as optimising vehicular access to minimise reversing of vehicles and making use of existing structures such a silos or site offices as noise shield to reduce noise transmission from noisy static equipment to the noise receivers. • Implement industry best practices: o Only well-maintained PME should be operated on-site and should be serviced regularly during the construction. o The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the NSRs. o Use of alternative equipment with less noise emission such as use of rubber mallets instead of metal hammer. o Care shall be taken during loading or unloading, dismantling, or moving materials to reduce impact noise. o Silencers or mufflers on PME (e.g., generator sets) should be utilized and should be properly maintained during the construction. o Mobile PME, if any, should be sited as far from NSRs as possible. o PME (such as trucks and cranes) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum possible. o PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the nearby NSRs. o Noisy construction activities shall be avoided at nights and Sundays and public holidays when the noise limits are more stringent. • Consider limiting heavy construction working hours to 8 a.m. to 6 p.m. where possible to avoid the timings when crepuscular species may be active. Toolbox meetings and winding down of work can be done outside of these hours. • Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense. • Where night works are conducted, the minimal amount of equipment should be used to reduce noise levels. • Where night works are conducted, workers should refrain from shouting or using loud hailers aside from emergency. Hand signals or walkie talkies can be employed instead.	Slight Negative impact			
		Outside Local/ Medium	Noise from Construction Activities to School community (L_{Aeq} 12 hours) in the Night	Slight Negative impact		Slight Negative impact			
		Outside Local/ Medium	Noise from Construction Activities to Residential Community (L_{Aeq} 5 mins) in the Night	Slight Negative impact		Slight Negative impact			
		Outside Local/ Medium	Noise from Construction Activities to School community (L_{Aeq} 5 mins) in the Night	Slight Negative impact		Slight Negative impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					

Airborne Noise	Fauna NSRs (NSR 4, NSR 5, NSR 6)	Low to High	Noise from Construction Activities (L_{Aeq} 12 hours) in the Day	Slight to Major Negative Impact	• Noise barriers, 1.4 m high, are recommended to be erected along NSR cluster 6
					• Noise barriers should be with a minimum of Sound Transmission Class (STC) 18, to be effective to reduce noise level for ground-dwelling fauna and affected community at lower floors.
					• Additional engineering control measures enclosure, noise screen/ noise panel
					  o Enclosure at stationary PME such generator with sufficient height and width to accommodate for machinery/equipment housed within. The proposed enclosures may achieve noise level reduction of at least 15 dBA (Table F.3 of SS 602: 2014).
					  o Noise screen/ noise panel at moveable PME such excavator and crawler/ mobile crane and it should be of sufficient height and width to shield the noisy part. The proposed screening may achieve noise level reduction of at least 10 dBA (Table F.3 of SS 602: 2014).
					  o Portable noise barrier at construction activities e.g., soil investigation drilling activities, road and drainage work which are close to site boundary. The proposed portable noise barrier may achieve noise level reduction of at least 10 dBA (Section F.3.3.4 of SS 602: 2014).
					• Quieter construction methodology such as the use of diamond wire saw cutter is able to achieve up to 30 dBA of noise reduction (based on LTA's Noise Guidance: Developing a Noise Management Plan).
					• Contractor to prepare noise management plan (NMP) with the finalised construction method, schedule and equipment sound power levels to reconfirm the noise impact to community and fauna receptors are within acceptable range. The suggested NMP template is indicted in Annex H of SS 602: 2014.
					• Contractor to use engineering methodology to control noise at source, such as:
					  o Noise enclosure to cover stationary PME such as generator.
					  o Noise screen/ noise panel to partially shield noise generated from noisy PME such as crane and excavator
					  o Portable noise barrier for noisy construction activities e.g., soil investigation drilling activities and road and drainage work which are close to site boundary
					• Quieter construction methodology such as silent piler instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling
					• Contractor should plan the construction works to minimise noise sources on site through optimisation of construction sequence and methods such as optimising vehicular access to minimise reversing of vehicles and making use of existing structures such a silos or site offices as noise shield to reduce noise transmission from noisy static equipment to the noise receivers.
					• Implement industry best practices:
					  o Only well-maintained PME should be operated on-site and should be serviced regularly during the construction.
					  o The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the NSRs.
						Slight to Major Negative Impact	Conduct continuous real time noise monitoring using Type 1 sound level meter with data logging at the affected NSRs. When noise level exceeds the maximum adjusted noise level, contractor should investigate and apply appropriate mitigation measures.
							Recommended monitoring locations:
							For Affected fauna (NSR 4, NSR 5 and NSR 6) for entire construction period: noise meters to be located at site boundary adjacent to forested areas.
							Conduct weekly inspection for bird's nest within the EIA study area (100 m from DE170 Contract Boundary)
								• Contractor PM
								• Environmental Checker
								• ECO
								• Bird Specialist	

	Fauna NSRs (NSR 4, NSR 5, NSR 6)	Low to High	Noise from Construction Activities (L_{Aeq} 5 mins) in the Day	Slight to Major Negative Impact		Slight to Minor Negative Impact			
	NSR 4, NSR 5, NSR 6	Low to High	Noise from Construction Activities (L_{Aeq} 1 hour) in the Night	Slight to Moderate Negative Impact		No change/ Status Quo to Moderate Negative Impact			
	NSR 4, NSR 5, NSR 6	Low to High	Noise from Construction Activities (L_{Aeq} 5 mins) in the Night	Slight to Moderate Negative Impact		No change/ Status Quo to Moderate Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
					o Use of alternative equipment with less noise emission such as use of rubber mallets instead of metal hammer. o Care shall be taken during loading or unloading, dismantling, or moving materials to reduce impact noise. o Silencers or mufflers on PME (e.g., generator sets) should be utilized and should be properly maintained during the construction. o Mobile PME, if any, should be sited as far from NSRs as possible. o PME (such as trucks and cranes) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum possible. o PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the nearby NSRs. o Noisy construction activities shall be avoided at nights and Sundays and public holidays when the noise limits are more stringent. • Consider limiting heavy construction working hours to 8 a.m. to 6 p.m. where possible to avoid the timings when crepuscular species may be active. Toolbox meetings and winding down of work can be done outside of these hours. • Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense. • Where night works are conducted, the minimal amount of equipment should be used to reduce noise levels. • Where night works are conducted, workers should refrain from shouting or using loud hailers aside from emergency. Hand signals or walkie talkies can be employed instead.				

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Ground-borne Noise and Vibration	GBN/VSR 1	Outside Local/ Medium	Ground-borne-noise and vibration disturbance from proposed construction activities	Minor Negative Impact	• ECO should prepare and implement site environmental control plan and programme specific to the construction works undertaken in the Project. • Operate equipment (e.g., piling equipment, compactor, hydraulic breaker, and pipe jacking machine) that emit significant ground-borne noise and vibration levels, as far away from GBN/VSRs as possible. • Construction works to be done in phases e.g., demolition, earthmoving, and ground impacting operations so as not to occur in the same time period at the same area, if possible, to minimize cumulative impact. • Contractor should avoid night-time construction activities near residential areas and notify nearby GBN/VSRs in advance of the construction activities. • Avoid impact pile driving where possible in areas with GBN/VSRs. Drilled piles or the use of a sonic or vibratory pile driver causes lower ground-borne noise and vibration levels where the geological location permits their use. Alternatively, use jetting, pre-drilling, auger cast piles, non-displacement piles, using pile cushioning between the driving hammer and the pile, non-impact pile drivers with a vibratory pile driver, or resonance-free vibrator. • Minimize driving track mounted equipment over paved surfaces with steel cleats. Use rubber pads where possible to reduce vibrations or use rubber-tired vehicles in place of tracked vehicles. • Avoid using hydraulic breakers and select rock coring/breaking methods not involving or have reduced vibration impact, where possible. For example, using polycrystalline diamond compact (PDC) bit to reduce vibration when drilling rock formations. • Fill in potholes and eliminate pavement discontinuities, keep haul roads smooth by periodic grading; pave existing roads to provide a smooth traveling surface, reduce speed of vehicles and weight of vehicle loads, as far as practicable.	Slight Negative Impact	Conduct real time vibration monitoring using vibration meter with data logging at the affected GBN/VSRs when piling activities are ongoing	• Contractor PM • Environmental Checker • ECO	
	GBN/VSR 2, GBN/VSR 3	Outside Local/ Medium	Ground-borne noise and vibration disturbance from proposed construction activities	Moderate Negative Impact		Minor Negative Impact			

Environmental Aspect	Description of Receptor		Description of Potential Impact		Recommended Mitigation Measures	Residual Impact Significance	Description of Monitoring Required	Resources and Responsible Party	Close-up Actions
	Sensitive Receiver	Value/ Sensitivity	Impact	Overall Impact Significance					
Waste	Community, fauna and waterbodies.	National/ High	Wood Waste Generation (Direct Impact)	Minor Negative Impact	• Conduct an analysis of the project waste profile to develop a waste management strategy to focus on waste elimination and to identify and communicate responsibilities for waste minimisation between developer; designer; project manager; contractors and suppliers. • Plan for on-site separation and collection of materials. • Establish a waste management and monitoring procedures and system for the Project to include waste stream and source identification, handling, storage, disposal tracking and monitoring, progress modification, evaluation as well as compliance audits. • Careful planning in material estimation and procurement process to minimize wastes generation. • A routine schedule and recycling plan can be set up for horticultural waste based on the various volume produced at different construction stages. • A review and reporting protocol for waste generated during construction should be developed that of which includes the amount of recycling and disposal done. Recycling targets should be set aligned to match or be better than Singapore's current recycling rate for C&D, ferrous metal, paper/cardboard, plastics, food, wood and horticultural. This report should be reviewed monthly to examine areas of improvement in waste reduction and management. • Horticultural waste should be transported to specialised horticultural recycling facilities where they can be grinded into wood chips which can be turned into mulch or compost. Wood chips can also be used to make new wood products by mixing it with binders. Horticultural waste which is not suitable to be recycled should be used as fuel in biomass power plants. • Biodigesters or composting stations could be introduced onsite to deal with food waste generated by workers, converting it into grey water or compost which can then be reused onsite. These stations are usually well sealed which also reduces the hazard of wildlife being attracted to the area. • Ensure that toilets are adequately placed across the construction site and sufficiently bunded to ensure that there is no spillage and contamination of soil and waterways. • Under no circumstances shall sewage be discharged into any receiving watercourse and must be treated separately from the surface runoff • Wildlife proof bins should be used to reduce the hazard of wildlife being attracted to the area and accessing the food waste. This will reduce human wildlife conflict. • Construction waste should be properly segregated and have set storage locations to extract recoverable and recyclable materials which can then be reused or recycled. Recycling bins should be provided alongside every trash bin with well-labelled signs and examples of common recyclables items to help workers sort their waste. • Implement waste handling, storage, collection and disposal good practices following applicable legislations as indicated in Section 10.1.	Minor Negative Impact	• General disposal records • Hazardous or toxic industrial wastes disposal records • Daily Environmental Inspection	• Contractor PM • Environmental Checker • ECO	
	Community	Inter-national/ Very High	Wood Waste Generation (Indirect Impact)	Major Negative Impact		Moderate Negative Impact			
	Community, fauna and waterbodies.	National/ High	Construction and Demolition (C&D) Debris	Moderate Negative Impact		Minor Negative Impact			
	Community, fauna waterbodies and soil	National/ High	Hazardous/ Toxic Industrial Waste	Minor Negative Impact		Slight Negative Impact			
	Community and Fauna	Local/ Low	Domestic Refuse, Food Waste and Recyclable Waste	Slight Negative Impact		Slight Negative Impact			
	Waterbodies	National/ High	Sewage	Moderate Negative Impact		Minor Negative Impact			

13. Conclusion

The Developing Agency proposes a new road interchange across KJE with connecting vehicular road and bridge called Forest Drive, leading into Tengah New Town. In future, the flyover will sit above the Forest Corridor running through Tengah Town that is envisioned to form part of the larger network of greenery that connects the Western Water Catchment Area (WWCA) and the Central Catchment Nature Reserve (CCNR), allowing connectivity to remain underneath. The Project also involves the widening and modification of Lam Sam Flyover and vehicular bridge widening along KJE. At the western section, a culvert will be built to provide fauna connectivity from the Forest Corridor into WWCA. Given that the affected work area of the Project is within Tengah Forest, an EIA is conducted. A range of potential environmental impacts is identified from the EIA, and the following assessments and conclusions are made for their respective environmental receptors.

Geomorphology and Hydrogeology:	Construction activities potential geomorphology impacts include change in soil infiltration capacity, soil loss and erodibility, changes in hydrogeology, while soil and groundwater impacts include potential land contamination from pollutive substances leaks or spills and hazardous or toxic industrial wastes disposal. Residual impacts in the affected area include permanent reduction of land area with soil cover and permanent change in hydrogeological dynamics. With the adoption of mitigation measures, including the engagement of QP/PE to conduct slope stability study, the impact significance to geomorphology, soil and groundwater caused by construction activities is assessed as slight negative.
Water Quality and Waterbodies:	Six (6) cluster of streams have been observed in the EIA Study Area. Water quality monitoring in two (2) dry weather events and one (1) wet weather event has been carried out for the streams. Potential impacts to the water quality would potentially come from surface runoff, potential pollutive substances spill, trade effluent discharge, sedimentation from loss/disturbance of topsoil and changes in hydrology. It is expected that with the adoption of appropriate mitigation measures, the impact significance to water quality and waterbodies ranges from slight negative to minor negative.
Ecology:	Four key terrestrial habitats are present within the EIA Study Area, which include abandoned-land forest, scrubland, urban vegetation and exotic-dominated secondary forest. Waterbodies, including streams and ponds, are also present. A total of 217 flora species and one species group was recorded, of which 21 are considered of conservation significance. A total of 295 fauna species were recorded, of which 22 are of conservation significance. During the construction phase, impacts are expected to be concentrated within the contract boundary and within 30-m of the boundary. Ecological impacts such as loss of vegetation, habitat degradation, and change of species composition are expected to habitats. For flora species, they may be impacted in terms of mortality, impediment of seedling recruitment and competition to exotic species and decline in plant health and survival. For faunal species, loss of/ reduction in habitats and food sources, light disturbances, accidental injury or mortality, loss/reduction of ecological connectivity for faunal movement, human disturbances are expected. These impacts range from slight negative to major negative. By various mitigation measures such as reinforcement of Wildlife Response Plan and biodiversity awareness training, provision of temporary wildlife crossing to provide faunal

	connectivity, transplantation of species of conservation significance, several of these impacts can be reduced in significance. There are, however, impacts that will not be mitigated significantly such as light disturbances and loss of vegetation. Minor positive impact is expected from the construction of the KJE culvert.
Ambient Air	A screening of potential Air Sensitive Receivers (ASRs) has been carried out and three (3) locations within the EIA Study Area have been identified. The types of ASRs identified are recreational, residential, school, and cultural. Potential air quality impacts towards these ASRs may occur during the construction phase. These impacts are mainly from fugitive dust emission and exhaust emissions from fuel burning equipment/ machinery/ vehicle. It is expected that with the adoption of appropriate mitigation measures, the impact significance to air quality ranges from slight negative to minor negative.
Airborne Noise:	A screening of potential Noise Sensitive Receivers (NSRs) was carried out and six (6) locations within the EIA Study Area have been considered. The types of NSRs identified are community (recreational, residential, school, and cultural) and fauna. Noise levels generated by construction equipment vary greatly depending on the construction stages, type of construction activities, construction methodology, type of equipment, model, and condition of equipment, quantity, and duration of operation. The noise levels are also affected by distance, locations (either stationary or mobile sources), variations in the power of the equipment, and noise characteristics (e.g., continuous, or intermittent noise, low frequency, or high frequency noise) of the equipment. It is expected that with the adoption of noise barrier recommended will assist to reduce the noise impacts to the fauna receptors at N6 during construction phase of the Project. After implementation of these recommended mitigation measures, the residual significance for affected community is slight negative while that for affected fauna is anticipated to be mitigated to mostly slight negative impacts with a smaller number of receptors still facing minor negative to major negative impacts.
Ground-borne Noise and Vibration:	A screening of potential ground-borne noise and vibration sensitive receivers (GBN/VSRs) has been carried out and three (3) locations within the EIA Study Area have been identified. The types of GBN/VSRs identified are residential and institutional. Potential ground-borne noise and vibration impacts towards these GBN/VSRs may occur during the construction phase. These impacts are mainly from pilling and ground impacting operations. It is expected that with the adoption of appropriate mitigation measures, the impact significance to ground-borne noise and vibration ranges from slight negative to minor negative.
Waste:	Construction wastes generated due to the Project development include horticulture waste, construction and demolition debris, hazardous/ toxic industrial waste, domestic refuse, food and recyclable wastes, and sewage. Impacts of the waste can arise when waste is insufficiently managed, which may happen when large volumes are produced without a waste management system to support. Applying waste minimization techniques and good practices on waste management hierarchy will assist to reduce the impact significance to slight negative to moderate negative impact.

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