Environmental Impact Assessment for Tengah Heavy Vehicle Park

Final Report

JTC Corporation

Report

February 2025

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Final Report

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Waterlogged forest patch in Tengah

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Abbreviations

Abbreviation	Term
ABC	Active Beautiful Clean
ALAN	Artificial Lighting at Night
ASEAN	Association of Southeast Asian Nations
ASRs	Air Quality Sensitive Receptors
BCA	Building and Construction Authority
BIA	Biodiversity Impact Assessment
CCNR	Central Catchment Nature Reserve
CCTV	Closed-circuit television
CEMMP	Contract-specific Environmental Monitoring and Management Plan
COP-10	Tenth Meeting of the Conference of Parties
CR	Critically Endangered
DD	Data Deficient
DGPS	Differential Global Positioning System
DHI	DHI Water & Environment (S) Pte Ltd
EBS	Environmental Baseline Study
ECB	Erosion Control Blanket
ECM	Earth Control Measures
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EMMP	Environmental Management and Monitoring Plan
EN	Endangered
EPBC	Environment Protection and Biodiversity Conservation
EPE	Ecological Profiling Exercise
EPH	Environmental Public Health
EPHA	Environmental Public Health Act
EPR	Environmental Performance Report
EQO	Environmental Quality Objectives

Abbreviation	Term
ES	Environmental Scores
EX	Globally Extinct
FTA	Federal Transit Administration
GIIP	Good International Industry Practices
GLS	Government Land Sales
GPS	Global Positioning System
HAB	Harmful Algae Bloom
HDB	Housing and Development Board
HDV	Heavy Duty Vehicle
HVP	Heavy Vehicle Park
IA	Impact Assessment
IAIA	International Association for Impact Assessment
IAQM	Institute of Air Quality Management
IEA	Institute for Environmental Assessment UK
ILP	Institute of Lighting Professionals
ISA	International Society of Arboriculture
IUCN	International Union for Conservation of Nature
JID	Jurong Innovation District
JRL	Jurong Region Line
JTC	Jurong Town Corporation
KJE	Kranji Expressway
LAA	Land Acquisition Act
L_{eq}	Equivalent Continuous Sound Pressure Level
LKCNHM	Lee Kong Chian Natural History Museum
LTA	Land Transport Authority
MND	Ministry of National Development
MOM	Ministry of Manpower
MPA	Maritime and Port Authority
MSE	Ministry of Sustainability and the Environment
NBSAP	Singapore National Biodiversity Strategy and Action Plan

Abbreviation	Term
NCMP	Nature Conservation Master Plan
NEA	National Environment Agency
NEx	Presumed Nationally Extinct
NParks	National Parks Board
NSRs	Noise Sensitive Receptors
NUSLHMSG	NUS Libraries Historical Maps of Singapore
NW	Extinct in the Wild
PCO	Pest Control Officer
PCS	Pollution Control Study
PIE	Pan Island Expressway
PM_{10}, $PM_{2.5}$	Particulate Matter (with diameters of 10 or 2.5 micrometres or less, respectively)
PME	Power Mechanical Equipment
PPV	Peak Particle Velocity
PRO	Public Relations Officer
PUB	Public Utilities Board
PW	Portable Water
QECP	Qualified Erosion Control Professional
R&D	Research and Development
RIAM	Rapid Impact Assessment Matrix
SAAQT	NEA Singapore Ambient Air Quality Targets
SBG	Singapore Botanic Gardens
SDS	Safety Data Sheets
SECR	Site Environmental Control Report
SFA	Singapore Food Agency
SING	Singapore Botanic Gardens' Herbarium
SLA	Singapore Land Authority
SOP	Standard Operation Procedure
SRDB3	Species List (Red Data Book List), Third Edition
SWL	Sound Power Level
TDS	Total Dissolved Solids

Abbreviation	Term
TPZ	Tree Protection Zone
TSS	Total Suspended Solids
UHI	Urban Heat Island
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VSR	Vibration Sensitive Receptor
VU	Vulnerable
WCA	Western Catchment Area
WHO	World Health Organisation

Executive Summary

The Environmental Impact Assessment (EIA) for the development of Tengah Heavy Vehicle Park (HVP) identifies potential environmental pressures on physical and ecological receptors arising from the anticipated activities during both the construction and operational phases of the project. Significant environmental impacts were evaluated by assessing impact pathways and determining their potential consequences. The impact assessment was informed by an Environmental Baseline Study (EBS), which was conducted through primary field assessments in the Tengah HVP area and supplemented by secondary data consolidated from previous environmental studies. The proposed development may lead to a range of potential short-term impacts during the construction phase, as well as long-term impacts following its completion.

Short-term impacts during **construction phase** may be induced by the project footprint, vegetation clearance, physical and vehicular disturbances, changes in air quality, illumination, noise and vibration, landscape and visual aesthetics, water quality, soil and groundwater, management of waste and vector, and ecological connectivity. These pressures could affect terrestrial flora and fauna, habitats, surface hydrology, residential areas, and construction personnel.

Terrestrial Flora and Fauna

For **ecology and biodiversity**, an impact level of **Moderate Negative** has been predicted for both flora and fauna.

- Vegetation within the Tengah HVP footprint and site access areas will be cleared unless salvaged, while those within a 30-meter impact zone outside the project boundary may experience drastic environmental changes, such as increased light, temperature, wind exposure and decreased humidity. While the long-term permanence of the impact is acknowledged, secondary forest species adaptable to exposed conditions outside the development area are likely to survive despite habitat degradation and edge effects resulting from the project. Mitigating measures such as the implementation of Tree Protection Zones (TPZs), flora transplantation and potential propagation could reduce the extent of loss of conservation significant flora, bringing the residual impact level to **Minor Negative**.

- Despite implementing minimum fauna management controls, vegetation clearance and heavy machinery usage will lead to **Moderate Negative** impacts on herpetofauna and freshwater fauna as these groups are less mobile and more susceptible to construction-related injuries or mortality, while impacts on other groups are considered **Minor Negative** as they could be volant and are likely to respond and escape quickly. The long-term impacts are deemed irrecoverable due to full site clearance, with non-cumulative effects anticipated. Mitigation measures such as pre-felling fauna inspections, using only fully biodegradable Erosion Control Blankets (ECBs), and checking these ECBs and any pits daily could aid in protecting avian young and reduce the risk of fauna entrapments. Moreover, ecological buffer provision and translocation of freshwater fish could also contribute to the overall slight reduction in impacts, achieving a residual impact level ranging from **Moderate Negative** to **Slight Negative**.

- Human-wildlife conflict could be induced by the eviction of fauna species from their habitats. While the likelihood of attacks from species such as the Long-tailed Macaques and venomous snakes is considered relatively low, the potential for harm remains significant. The impacts of human-wildlife conflict are expected to be short-term, occurring primarily during the construction phase, with irrecoverable effects on individuals involved. Such impacts can be reduced upon the implementation of wildlife

awareness training, wildlife response and rescue protocol, and hoarding plan, bringing impact levels to **Minor to Slight Negative**.

Air Quality

Air Quality changes induced by construction activities are predicted to have impacts on terrestrial biodiversity and residential areas, ranging from **Minor Negative Impact** to **No Impact**. Adoption of measures such as the use of dust control techniques, physical screening, and site management practices can aid in minimising dust emissions and dispersion to the surrounding environment, reducing the impact on terrestrial fauna in Tengah Forest to **Slight Negative** Impact. **No impact** is anticipated for residential areas due to the present baseline conditions having dust generated from high traffic along the PIE and adjacent construction works ongoing.

Airborne Noise

Airborne Noise levels at the forest area is predicted to be 22 dBA to 33 dBA higher than the threshold noise limit of 60 dBA due to proximity to the work area. Even though the retained forests within Tengah Forest provide refuge for fauna to retreat away from noise sources/work areas, presence of construction and vehicular noise could potentially induce stress, behavioural changes, alterations in foraging patterns, and impaired auditory abilities in faunal species. Through the implementation of a comprehensive set of noise impact mitigation measures during the construction phase, the anticipated significance of noise impacts associated with various activities is expected to be **Minor Negative** for fauna.

Water Quality

Changes in **Water Quality** may impact freshwater stream and fauna, and residential receptors.

- Surface runoff carrying suspended sediments and pollutants into nearby freshwater streams during rainfall changes water quality, affecting aquatic fauna. The increased turbidity may clog the gills of aquatic species and reduce food availability, threatening Endangered species like the Crescent Betta and Three-spot Gourami. The overall impact on freshwater fauna is assessed as **Moderate Negative**. Additionally, spillage of fuels and chemicals stored on-site may occur, further degrading water quality and affecting freshwater fauna. While these impacts are likely temporary and recoverable, they could be cumulative over time, leading to **Minor Negative** impacts on freshwater biodiversity.

- For residents and public users of Jurong Lake, the runoff could affect recreational water quality and reduce the aesthetic value of the area. However, these impacts are considered **Minor Negative** and temporary.

- Residual impacts can be reduced by implementing water quality management plan and strict soil management and chemical storage protocols, to achieve an impact level of **Slight Negative**.

Ground Vibration

Construction activities using equipment like excavators, bulldozers, and compaction machines are expected to produce vibration levels of 1.5 mm/s, above the perceptible threshold for fauna. This would have a **Moderate Negative impact** on wildlife in Tengah Forest due to the potential disturbance and displacement of species. Mitigation measures, including engineering controls, are expected to reduce vibrations to less than 1 mm/s, lowering the residual impact to **Minor Negative**. Vibration levels from vibratory rollers could reach 3.5 mm/s, causing a **Moderate Negative impact** on local fauna. However, with mitigation, vibrations can be reduced to below 1 mm/s, reducing the overall impact to **Minor Negative**.

Illumination

The construction footprint is near a residential area, making residents the primary socio-economic receptor. While no night work is planned, auxiliary safety lighting may still cause light spill into homes, potentially disrupting residents' circadian rhythms and sleep patterns. However, as the nearby Jurong West residential area already experiences high light levels, the anticipated change is minor. This temporary impact can be mitigated through effective lighting management, such as using curtains or tinted windows. Overall, the light nuisance is classified as **Slight Negative**, with effects deemed non-permanent and recoverable.

Artificial lighting at night (ALAN) can disrupt ecosystems by affecting animal circadian rhythms and altering plant life cycles. It may increase predation risks for nocturnal animals, exhaust insects attracted to lights and disturb foraging and migratory patterns. The construction may introduce light spill into the southern part of Tengah Forest, impacting local fauna. However, given the urban context, these animals likely adapt to some nighttime lighting. Thus, the magnitude of change is minor, and impacts are expected to be temporary and manageable through the Environmental Management and Monitoring Plan (EMMP). Consequently, the significance of the impact on biodiversity is assessed as **Slight Negative**, with measures in place to minimize light spillage and ALAN.

Post-construction phase impacts may result from long-term changes in project footprint, vehicular traffic, illumination, microclimate, air quality, ecological connectivity, and landscape and visual aesthetics. These could affect receptors such as terrestrial flora and fauna, habitats, surface hydrology, and residential areas.

Terrestrial Flora and Fauna

For ecology and biodiversity, the predicted impact levels range from **Major Negative to Slight Negative**.

- The loss of habitat, particularly for native-dominated young secondary forests, is a significant concern, with approximately 93.1% of the 0.6 hectares being cleared, resulting in a **Moderate Negative** impact. These forests serve as refuges for native species and resemble Singapore's original ecosystem, making their removal detrimental. In contrast, 1.46 hectares of exotic-dominated young secondary forest will be cleared, leading to a **Minor Negative** impact. While these habitats regenerate more quickly, the changes will largely be irreversible.

- Waterbodies, including naturalized streams, will also face loss, with about 0.22 hectares affected, which will significantly impact downstream connectivity, resulting in a **Moderate Negative** impact. The abandoned plantation forest, covering 1.61 hectares, will see a **Slight Negative** impact due to its role in supporting native understorey species and ecosystem services. Scrubland will be similarly affected, with approximately 1.99 hectares cleared, leading to a **Slight Negative** impact.

- Habitat degradation and edge effects will impact areas within 30 meters of the worksite, leading to increased dust, noise, and urban runoff. These long-term and irreversible impacts will have cumulative effects on biodiversity, particularly affecting young secondary forests and abandoned plantation forests, which are ecologically distinct from urban environments.

- The development will significantly impact ecological connectivity, especially for non-volant mammals and herpetofauna, resulting in a **Minor Negative** impact due to increased distances between habitats. For birds, bats, butterflies, and odonates, a moderate loss of connectivity is anticipated, with permanent habitat clearance affecting movement patterns. However, ecological connectivity may be restored over time through targeted planting efforts.

- Freshwater fauna will experience substantial connectivity loss, leading to moderate negative impacts. Effective mitigation strategies, such as maintaining water quality and establishing ecological corridors, will be crucial to preserving connectivity for various animal groups and minimizing habitat degradation impacts.

Air Quality

Air Quality impacts post-construction is not anticipated to be significant, considering the present baseline conditions of the area has heavy traffic. Nevertheless, there will be impacts on receptors in the forest area. There should be implementation of regular vehicular maintenance, dust control measures, spill prevention practices, and policies to limit idling time for heavy vehicles. Additionally, green spaces and landscaping can be integrated into the site design to improve air quality.

Airborne Noise

Heightened **Airborne Noise** due to heavy vehicle traffic flow would cause disturbances to fauna, hence, good site practices and noise management (i.e., noise barriers, buffer planting) shall be adhered to, to reduce long-term noise impacts on wildlife receptors.

Construction of the HVP will involve significant earthworks and backfilling of streams, leading to the loss of habitats for species like the Crescent Betta and Three-spot Gourami. This is expected to have a **Major Negative** impact on freshwater biodiversity. Despite mitigation measures like erosion control and spill prevention, residual impacts on aquatic flora and fauna are still anticipated due to pollutants from vehicular exhaust and permanent hydrological changes. The residual impact is expected to reduce to **Moderate Negative** to **Slight Negative** in the post-construction phase.

Surface runoff from the HVP could carry pollutants into downstream waterbodies, potentially altering water quality and recreational use at Jurong Lake Gardens. However, with rigorous site management, including discharge monitoring and maintenance of control measures, **no residual impact** on residential receptors is expected during the post-construction phase.

Ground Vibration

During the operation phase, heavy vehicle traffic, including loaded and unloaded trucks, will generate less vibration than during construction. However, the impact will be long-term. Predicted vibration levels from trucks could reach 1.3 mm/s, and up to 1 mm/s for unloaded trucks at 50 km/h. Normal rubber-tired traffic vibrations are rarely perceptible, and overall, the vibration impact is assessed as **Minor Negative**. To minimize this impact, administrative measures such as speed restrictions and regular road maintenance are recommended. With proper management, the residual vibration impact is expected to be reduced to **Slight Negative**.

Illumination

During the operational phase, the proposed development will introduce permanent artificial lighting for commercial buildings and walkways, leading to increased light emissions. While this change is negative, its impact on nearby residents is expected to be slight, as lighting designs aim to minimize spill light, and residents already experience high light levels. Although the effects are permanent and non-cumulative, the overall significance is assessed as **Slight Negative**.

Fauna along the project's edge already experience light spill, and additional light pollution is likely to cause minor disturbances without significant behavioural changes. While these impacts are permanent and non-cumulative, the overall significance is considered **Minor Negative**. To mitigate light spill and ALAN impacts, the project could implement green building practices under the Green Mark Certification scheme, including eco-friendly lighting and landscaping to restore dark buffers. These measures are expected to reduce light impacts from minor to **Slight** or **Negligible** levels.

Air Temperatures

The conversion of forest cover to urban surfaces will raise ambient temperatures and lower humidity, particularly during night hours due to the urban heat island (UHI) effect. Residents of Jurong West Street 42 will be most affected, but given the area's history of forest clearance, discomfort is unlikely. While the HVP limits effective thermal management, incorporating nature-friendly landscaping can help mitigate UHI effects. Overall, impacts are permanent but recoverable and non-cumulative, resulting in a **Slight Negative** significance.

Clearing the secondary forest will create edge effects that disrupt microclimates, increasing risks of parasitism, predation, and elevated temperatures. These changes can heighten tree mortality and fire risks, particularly for sensitive species like herpetofauna that depend on stable conditions for foraging and mating. While much of Tengah Forest is already exposed to urban influences, existing fauna are likely adapted to these conditions. Mitigation measures, such as planting around the development, can help alleviate some impacts. Overall, these changes are permanent but recoverable and non-cumulative, leading to a **Slight Negative** significance. To further minimize impacts during the post-construction phase, design measures aligned with the BCA Green Mark Scheme will be implemented.

In conclusion, through the implementation of mitigation measures, regular inspections to ensure compliance, and effective feedback management, all potential environmental impacts arising from the project during pre-construction, construction, and post-construction phases can be minimized to acceptable levels. Therefore, from an environmental standpoint, the project is deemed feasible.

1 Introduction

1.1 Study Background

Jurong Innovation District (JID) is a 620ha next-generation industrial district planned and developed by JTC Corporation. Comprising five unique precincts - CleanTech Park, Bahar, Bulim, Tengah and Nanyang Technological University (NTU). JID is envisioned to be a vibrant, inclusive, sustainable and future-ready advanced manufacturing hub that powers innovation and drives economic growth as part of the Western Gateway of Singapore (Figure 1.1).

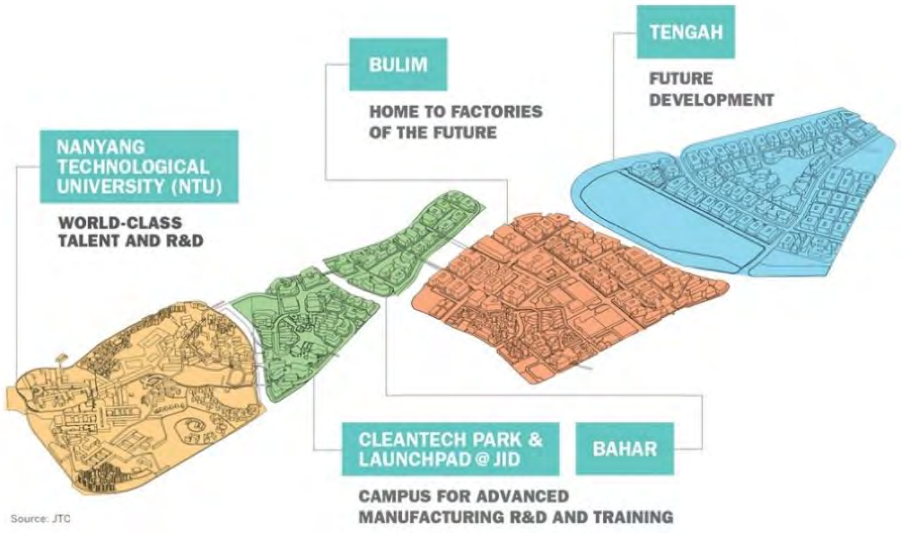

Figure 1.1 The five precincts located within JID, including Tengah, where the HVP will be built.

The Tengah Heavy Vehicle Park (HVP) is being proposed in view of the closure of the existing Bulim HVP. This relocation is necessary to facilitate the next phase of infrastructure works at Bulim. Tengah has been identified as the only suitable location to accommodate this new HVP (hereinafter referred to as Tengah HVP or the Project).

DHI Water & Environment (S) Pte Ltd (DHI) has been commissioned by JTC to conduct an Environmental Impact Assessment (EIA) for the development of Tengah HVP, given the biodiverse and ecologically sensitive habitats present within and around the planned Tengah HVP boundary. An overview of the project area is indicated in Figure 1.2.

This EIA Report is prepared according to the scope, approach and methodology approved earlier in the inception report. The EIA report documents the current baseline condition and ensures that any environmental impacts and their significance to the proposed development have been fully evaluated and assessed.

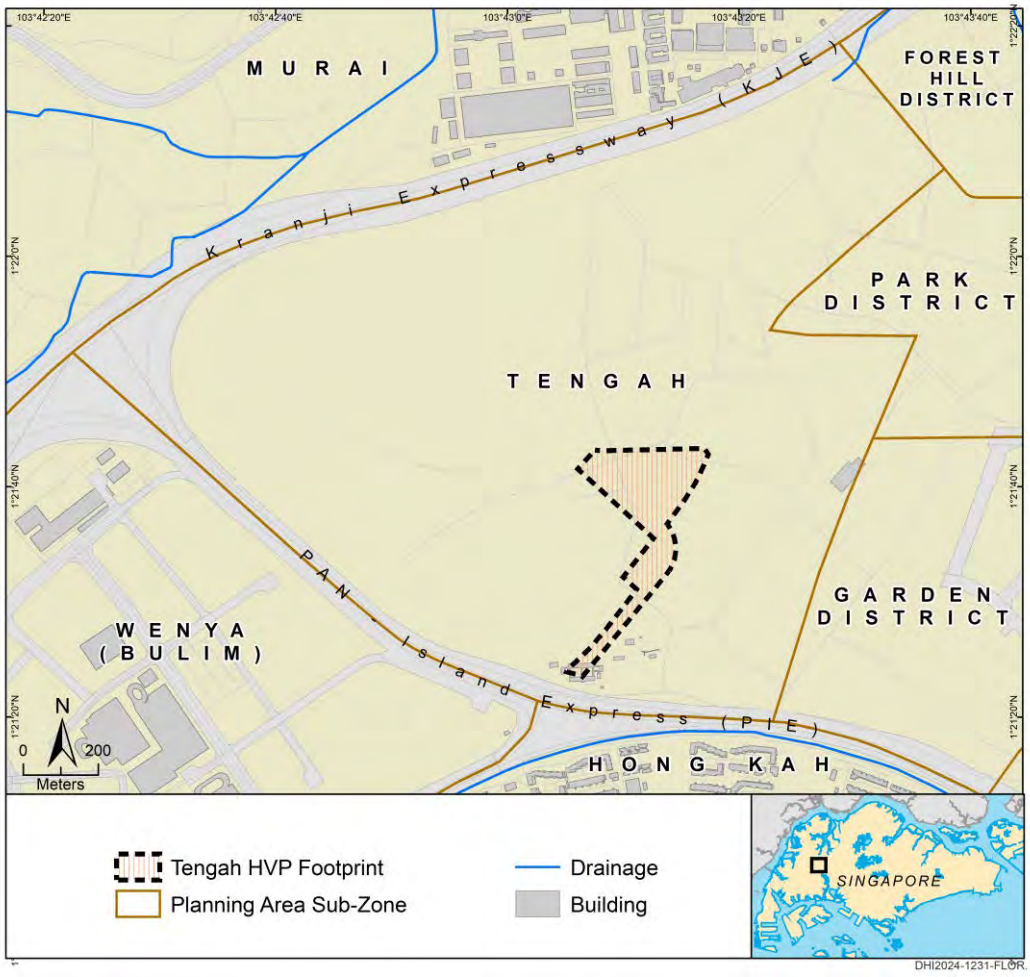

Figure 1.2 Proposed Tengah HVP at JID's Tengah Industrial Estate (Basemap source: OpenStreetMap).

1.2 Objectives

The objectives of this EIA are to:

- Evaluate the current environmental conditions in and around the project area.
- Analyse potential changes to the physical, chemical, ecological and biological environment.
- Assess the significance of the potential impacts on environmental and socio-economic receptors within the study area.
- Identify and evaluate the potential environmental impacts during construction and operation phase.
- Recommend management and mitigation measures to reduce environmental impact significance to reasonably acceptable levels.
- Propose an Environmental Monitoring and Management Plan (EMMP) to be put in place prior to, during, and for a limited period after development works are completed to ensure that the Project meets the Environmental Quality Objectives (EQOs) defined for the Project.

- The EIA will be conducted in accordance with Singapore's and Good International Industry Practices (GIIP) methodologies. The EIA also serves as a crucial step in obtaining development approvals, ensuring compliance with environment regulations, and incorporating recommendations from relevant authorities.

1.3 Scope of EIA study

The scope is to conduct an EIA and other detailed environmental studies in line with Biodiversity Impact Assessment (BIA) Guidelines published by NParks (2024a) and address all key potential environmental issues associated with the construction and operation phases of the Project as specified under Clause 3.2 of the Project Brief. A summary of the EIA scope includes:

- Conduct studies based on study boundary, approach, and methodology in consultation with relevant Technical Agencies.
- Revalidation of existing environmental baseline studies or detailed environmental reports such as EIA / BIA conducted by JTC and/or other agencies.
- Desktop studies, site reconnaissance surveys and investigations to obtain a thorough understanding of the environment.
- Detailed baseline and impact assessment of the flora, fauna, and habitats found in the study areas.
- Updated topography of the study area.
- Hydrology and water quality baseline survey and impact assessment
- Airborne noise and ground-borne vibration baseline survey and impact assessment
- Air quality baseline survey and impact assessment.
- Temperature and light baseline measurements and impact assessment.
- Recommend mitigation measures and best management practices.
- Develop an Environmental Management and Monitoring Plan (EMMP) framework.

This EIA report has been prepared based on information gathered through desktop study, information provided by Client and site visits conducted from August 2023 to March 2024. The EIA has been prepared based on the availability of information, in evaluating the Project's potential impact.

2 Project Description

Tengah HVP is located towards the south-west of JID's Tengah precinct, within the Tengah Planning Area of Singapore. The development area of Tengah HVP spans approximately 10.2 ha, which includes an access road and a 10 m construction buffer. To the west of Tengah HVP lies the JRL Depot site – currently cleared of vegetation and under construction by the Land Transport Authority (LTA), while the residential developments by private developers and Housing Development Board (HDB) lie to the east, with the development parcels that are already cleared of vegetation separated by at least 500m of secondary forest cover from Tengah HVP. Existing residential areas in Jurong West lie to the south of Tengah HVP across the Pan Island Expressway (see Figure 2.1).

At present, the land cover of Tengah HVP is predominantly secondary forest, between the Central Nature Reserves and Western Catchment Area. Historical baseline surveys carried out within Tengah Forest also revealed that it represented a hotspot for fauna species, particularly avifauna, for which 27 conservation significant species were documented (HDB, 2017). Freshwater habitats in the form of naturalised streams and pond(s) are also present in the study area.

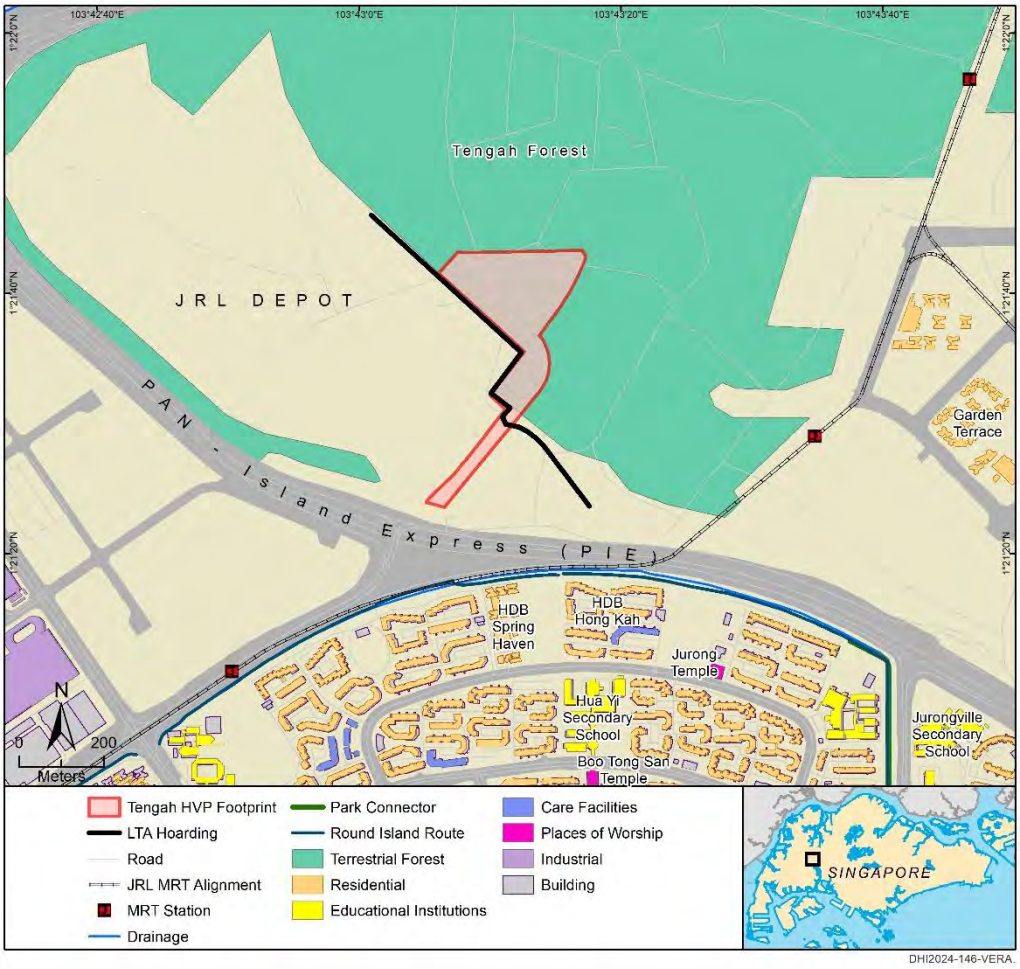

Figure 2.1 Development footprint of Tengah HVP and the land uses in the vicinity. (Basemap source: OpenStreetMap)

Tengah HVP will be developed as a temporary open air heavy vehicle surface parking facility.

According to the Master Plan 2019, the Tengah HVP site is designated for upcoming industrial purposes. The zoning for the site is categorized as 'Business 2', with designated smaller areas allocated for roads and utilities (Refer to Figure 2.2).

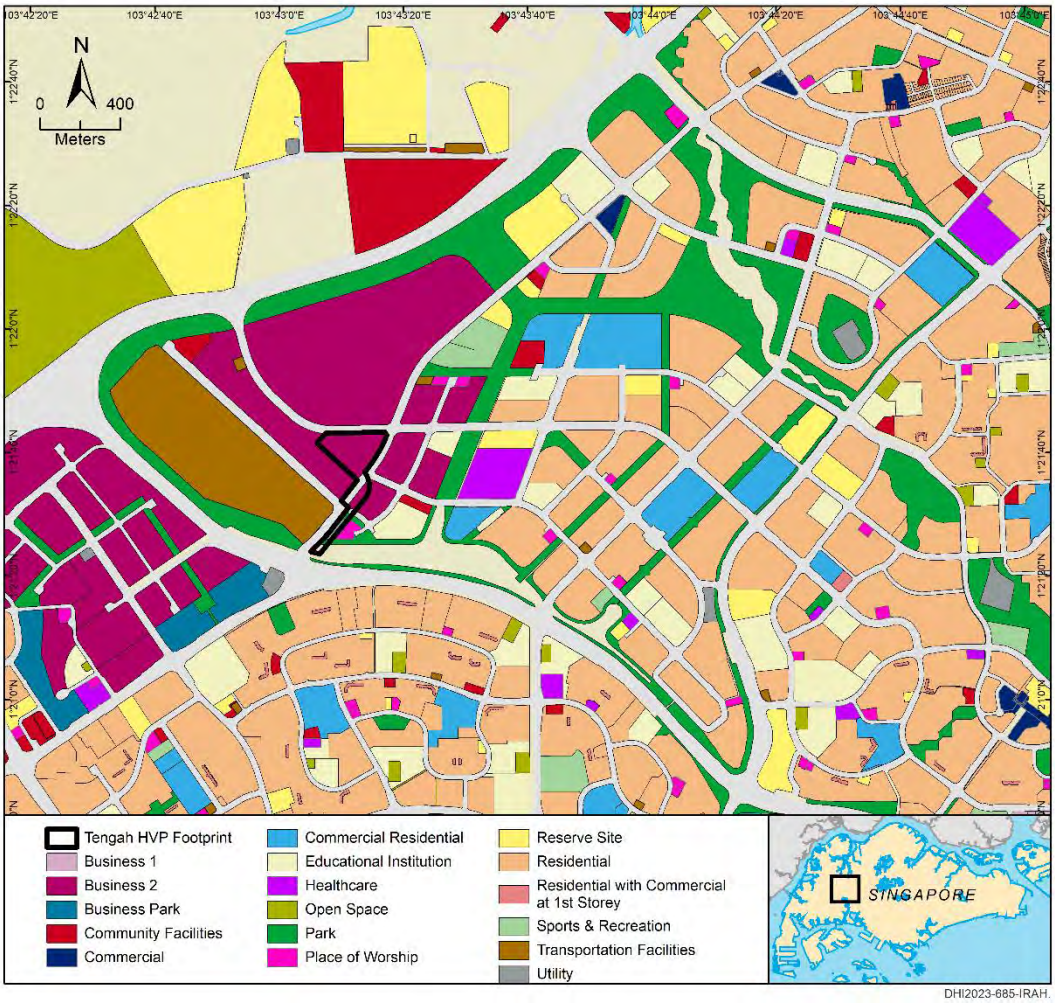

Figure 2.2 Master planning for the broader area surrounding Tengah HVP (Basemap source: URA Master Plan 2019)

2.1 Project Area

In view of the closure of the Bulim HVP, the proposed Tengah HVP will provide approximately 439 heavy vehicle parking lots and 200 motorcycle parking lots at Bulim Avenue (Figure 2.3). The Tengah HVP's development area covers approximately 10.2 hectares, incorporating a construction buffer of 10 meters.

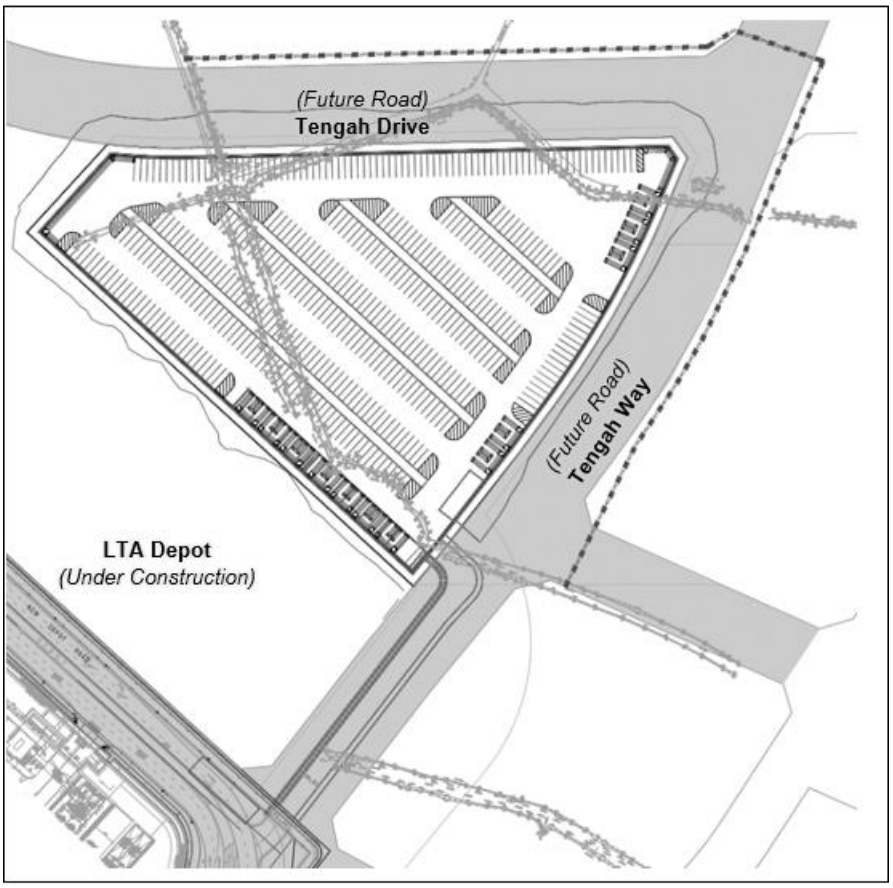

Figure 2.3 Site layout plan for Tengah HVP (Source: ABL/JTC).

2.1.1 Topography

Based on past reports and literature, the topographical characteristics of Tengah were known to be pre-dominantly low-lying in at the southern half of the area, as opposed to the northern half having a higher elevation. Tengah also has an extensive drainage system, with several waterways identified.

Due to ongoing and completed development projects within Tengah, there is a need to revalidate past topographical reports and provide updated data. As such, an updated topographical study was conducted as part of this EIA to validate past topographical data. A licensed topographic surveyor (YJP Surveyors Pte Ltd) was engaged to carry out the topographical survey, within the indicative survey area as shown in Figure 2.4. The survey area covered approximately 14 ha, excluding areas within the perimeter hoarding of the JRL Depot construction site.

The outcomes of the topographical study confirmed the findings of previous literature regarding the project site's low elevation. Additionally, it presented an updated layout of the waterbodies and drainage system, which can be referenced in Figure 2.4 and Appendix A.

The trees identified in the topography survey were cross-verified with those documented in the arboriculture surveys (refer to Section 5.3.2.4). This process offers species identification and serves as ground-truthing for tree girth and height.

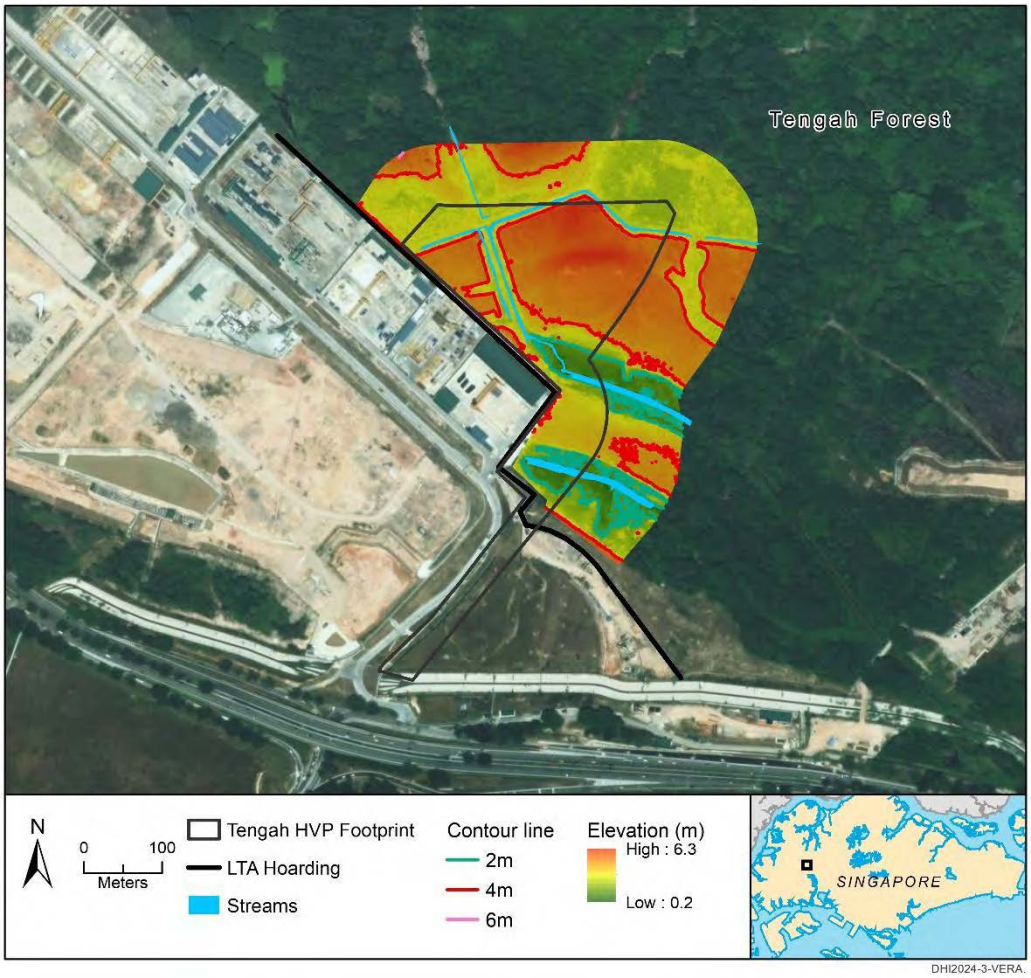

Figure 2.4 Topographical map of Tengah HVP (Basemap source: ArcMap World Imagery).

2.1.2 Land-use History

A chronological account of the changes in the land use of the Ecology Survey Area (refer to 4.2.1 and Figure 2.5) is detailed with inferences drawn from historical resources (maps, sea charts, and aerial photographs) contained within the NUS Libraries Historical Maps of Singapore (NUSLHMSG, 2024), unless otherwise mentioned.

The vegetation in the study area likely originally comprised of lowland mixed dipterocarp forest (Yee et al., 2011). However, the arrival of the British in 1819 have resulted in extensive deforestation of these dipterocarp forests for the cultivation of commercial crops (i.e. gambier, pepper, rubber, and pineapple) throughout the Singapore (Corlett, 1991; Pwee, 2021). The earliest available map of the area dates back to 1873 (Figure 2.5A). During this time, much of the Tengah area was converted to gambier and pepper plantations.

In 1945, the topography of West Bukit Timah (as depicted in Figure 2.5B), now situated on the eastern side of Tengah, was characterised by hills and streams. Streams in the north flowed towards Sungei Peng Siang, while those in the south drained towards Sungei Jurong. Due to the absence of a legend differentiating the natural and unnatural waterbodies, the typology of the two streams passing through the demarcated area is uncertain. However, the aforementioned streams are naturalised at present and categorised as natural forest streams (see Section 5.3.1.5).

In the Ecology Survey Area, all natural vegetation was removed for tree cultivation from the early 1940s until the early 1960s. By 1953, Rubber Tree plantations and other areas of minor cultivation were established in the area. Furthermore, the delineated region showed the existence of brush vegetation (Figure 2.5C).

As Singapore witnessed a sustained increase in prosperity through its role as a trans-shipment hub, the economic dependence on commercial agriculture diminished, leading to the transformation of these plantations into urban developments by the latter part of the 20th century (Tan, 2019). Consequently, a portion of the plantation within the demarcated area was cleared for resettlement as reflected in the 1966 historical map (Figure 2.5D). In 1993, a network of minor roads was established, and buildings were removed from the demarcated area, leaving some built-up areas on the eastern side of Tengah (Figure 2.5E). Referring to the 2010 map (Figure 2.5F), the developed areas within Tengah were entirely cleared, and the vegetation had regrown into abandoned plantation forest (previously labelled as 'sundry tree cultivation' in historical maps (Yee et al., 2016).

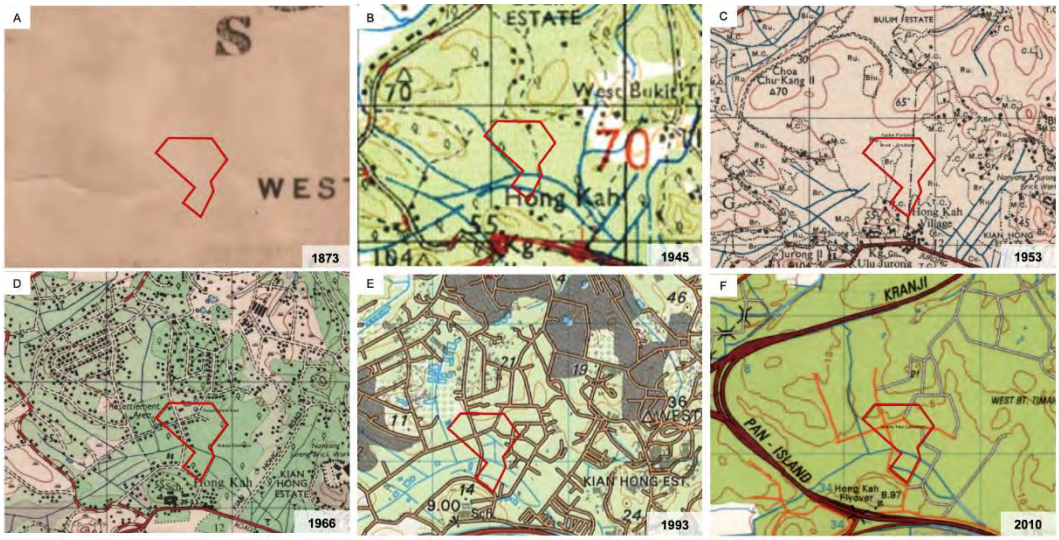

Figure 2.5 Historical maps of the Ecology Survey Area (in red outline). (A) In 1873, the demarcated area likely consisted of plantations. (B) In 1945, West Bukit Timah was hilly and streams of uncertain typologies were flowing through the demarcated area. (C) In 1953, minor cultivation and rubber tree plantations were established. (D) In 1966, roads and buildings were developed in the northwest. (E) In 1993, the buildings were vacated and removed from the demarcated area. (F) In 2010, buildings within the whole of Tengah were cleared and abandoned plantation forest re-established.

2.2 Project Works and Activities

The Project is at the planning and design stages, and actual details on construction activities, methodology, sequence and schedule will not be available for inclusion in this report.

Table 2.1 outlines the general infrastructure works that will be undertaken. JTC will review the actual construction activities with the appointed contractor at a later phase. For the purpose of this EIA, assumptions made are based on the typical activities anticipated for these construction works.

While the proposed locations for site office and storage areas are under review, these spaces will be located within the boundaries of the Project site. It is anticipated that all construction activities and material storage will also be confined within the boundaries of the Tengah HVP development site as depicted in Figure 1.2. The existing freshwater streams within the project would be affected by the proposed development and diversion

works would be necessary, subject to findings of the Environmental Baseline Study, particularly the ecological and topographical surveys. If stream diversions are deemed necessary, the development boundary outlined in Figure 1.2. will be adjusted accordingly, which will also necessitate modifications to the Ecology Survey Area (refer to Section 4.2.1 and Section 5).

Night work is currently not planned for this project in consideration of the ecological sensitivity of the area. However, we have considered the possibility of night work in this EIA in the event of unforeseen circumstances / emergency situations during the construction phase.

Table 2.1 Overview of Project activities during site preparation, pre-construction and post-construction phases

Project Activity	Description
Pre-Construction and Site Preparation Phase	
Prelim Site Works	• Topographical survey • Soil investigation involving drilling of boreholes • Service detection
Site Preparation	• Land clearance involving tree felling works
Land Preparation	• Excavation • Earthworks • Levelling of the site and slope regrading • Diversion of existing freshwater streams (where required) • Construction of temporary site office and storage areas • Mobilisation of equipment such as trucks, crawler cranes, mobile cranes, soil improvement rigs and excavators into project site
Construction Phase	
Infrastructure works	• Construction of roads, drains, sewer, utility services • Landscaping works • Construction of heavy vehicle parking lots
Post-construction Phase	
Operation works	• Interim provision of 439 heavy vehicle parking lots and 200 motorcycle parking lots

2.3 Project Timeline

The works for Tengah HVP development are expected to commence in 2025, subject to the clearance of the EIA report and obtainment of relevant authorities' approval prior to the commencement of works. Works are estimated to last for a period of 30 months. The tentative development timeline is shown in Table 2.2.

Table 2.2 Overview of Project timeline

Work progress	Timeline
Commence construction	2H 2025
Complete construction	2H 2027

3 Relevant Legislation, Standards and Guidelines

3.1 Applicable Legislation and Standards, and Guidelines

The environmental management framework for the Project adheres to the national environmental requirements outlined in various Acts, Regulations, and Guidelines as detailed in Table 3.1. Furthermore, specialised Codes of Practice guidelines have been established by pertinent agencies to address specific environmental considerations. The applicable local legislative and administrative requirements are comprehensively addressed in the relevant environmental or ecological sections.

Table 3.1 List of applicable laws, Standards and Guidelines relevant to the Project

Environmental Aspect	Applicable Acts, Regulations & Guidelines
General	• Planning Act, 1998 • Code of Practice for Pollution Control, 2013 • Code of Practice on Environmental Health, 2021 • Code of Practice for Environmental Control Officers for Construction Sites, 2020 • Environmental Public Health (Registration of Environmental Control Officers) Regulations, 2002 • NEA's Guidelines for Pollution Control Study (PCS), 2014 • Environmental Protection and Management Act, 2002
Surface Water Protection	• Sewerage and Drainage Act (Trade Effluent) Regulations, 2001 • Sewerage and Drainage Act (Surface Water Drainage) Regulations, 2008 • Environmental Protection and Management (Trade Effluent) Regulations, 2008 • Guidebook on Erosion and Sediment Control at Construction Sites (PUB, 2014) • Code of Practice on Surface Water Drainage, 7th Edition (PUB, 2018, with amendments under Addendum 1 in 2021) • Managing Urban Runoff - Drainage Handbook 1st Edition (PUB, 2013)
Air Quality Protection	• Environmental Protection and Management Act, 2002 • 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, 2012 • Environmental Protection & Management (Prohibition on the Use of Open Fires) Order 2008 • Singapore Air Quality Targets (NEA)

Environmental Aspect	Applicable Acts, Regulations & Guidelines
Noise	• Environmental Protection and Management Act, 2002 • Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 • Code of Practice for Noise Control on Construction and Demolition Sites, 2014 • Technical Guidelines for Noise Impact Assessment (NEA), 2016 • Technical Guideline for Land Traffic Noise Impact Assessment (NEA), 2016 • LTA's Noise Guidance: Developing a Noise Management Plan in LTA Projects, 2019
Wildlife Protection and Welfare	• Wildlife Act, 2000 • Singapore Red Data Book, Third Edition, 2024
Habitat Protection/ Conservation of Protected Areas	• Parks and Trees Act, 2006 • Parks and Trees Regulations, 2006 • Parks and Trees (Preservation of Trees) Order, revised 1998 • Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023) • Biodiversity Impact Assessment Guidelines (NParks, 2024a)
Waste and Hazardous Substances Management; General Waste Management	• Environmental Public Health Act, 2002 • Environmental Protection and Management (Hazardous Substances) Regulations, 2008 • Code of Practice for Licensed General Waste Collectors, 2019 • Code of Practice for Hazardous Waste Management, 2014 • Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Public Cleansing) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 • Sewerage and Drainage Act, 2001, Chapter 294 • Sewerage and Drainage (Trade Effluent) Regulations, 2008 • LTA's Guidebook for Best Environmental Practices – Construction Waste Management at LTA Sites, 2009
Vectors and Pesticides Management	• Control of Vectors and Pesticides Act, 2002 • NEA's Handbook of Scope of Works for Mosquito Control, 1995 • Code of Practice for Vector Control Operator, Technician and Worker, 2020 • Guidebook on Vector Control at LTA Sites, 2010

3.2 International Standards and Guidelines

3.2.1 International Best Practice Principles

The International Association for Impact Assessment (IAIA) has developed a set of International Best Practice Principles to guide the development and implementation of impact assessment (IA) processes (IAIA & IEA, 1999). These principles are intended to promote high-quality IA that is effective in identifying, predicting, and mitigating the potential impacts of projects and plans on the environment.

4 EIA Approach and Methodology

4.1 Overall Process

Singapore adopts a systematic framework to determine and mitigate the potential impact of any new development on the environment. Environmental considerations are an important part of the planning evaluation process, and planning approvals are granted to development proposals only when they have met the requirements imposed by the relevant regulatory agencies. If the impact on the environment could be significant, an environmental study will be required to assess in greater detail the full impact and develop more extensive mitigating measures.

This study was carried out according to the local EIA process as illustrated in Figure 4.1 and summarised in Table 3.1.

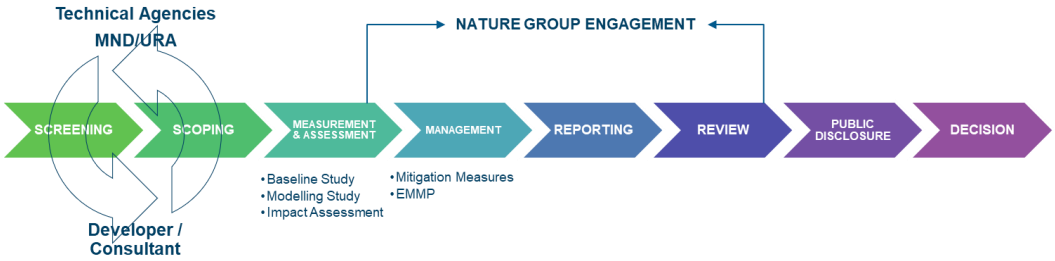

Figure 4.1 An illustration of EIA procedures in Singapore. Stakeholder engagement is project dependent, may take place at multiple stages of the study.

This EIA report documents the outcomes of the subsequent stages – Scoping, Measurement, Assessment and Management. DHI's approach to these tasks is illustrated in Figure 4.2 and outlined below. Following the Reporting stage, DHI will collaborate with the Client to engage Technical Agencies, stakeholder and the public before final decision-making process by URA and MND.

- **Scoping** – to propose and obtain consensus on the objectives, spatial and temporal scales and parameters of the EIA as well as all the assessment criteria and methodologies.
- **Measurement (Baseline Study)** – to study and fully describe the baseline for the assessment, either through field surveys or desktop literature searches, and predict potential changes in environmental parameters as a result of the Project, either qualitatively or quantitatively.
- **Assessment** – to classify the significance of the environmental pressures and their influence on sensitive environmental receptors, through the Rapid Impact Assessment Matrix (RIAM) methodology.
- **Management** – to identify measures to manage the impacts to a reasonably practicable level and outline a monitoring program to ensure that impacts are managed accordingly. Impact significance will be re-evaluated on the basis that mitigation measures are implemented, to derive the Residual Impact significance.

More details of these steps are discussed in the sub-sections to follow.

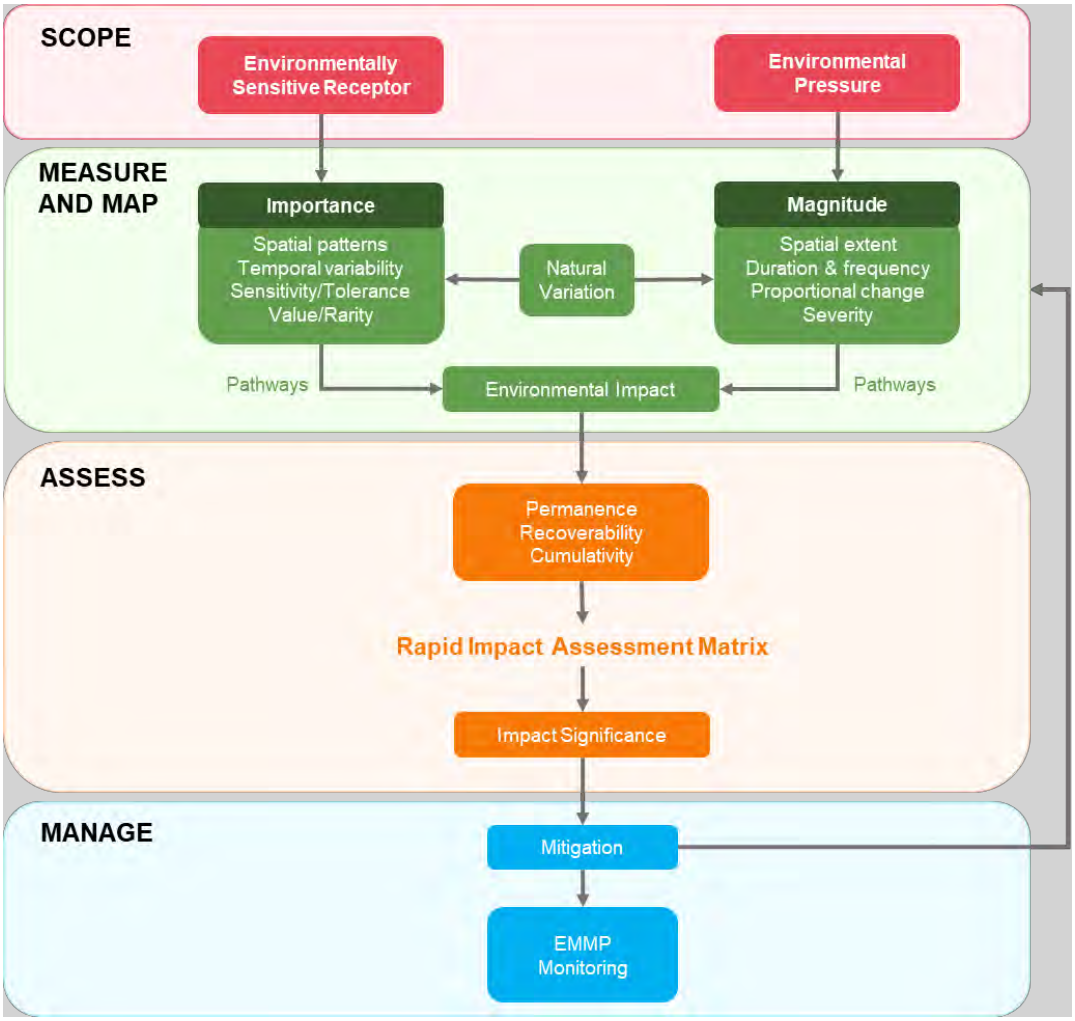

Figure 4.2 Overall workflow for the impact assessment process.

4.2 Scoping

Scoping is a critical step in the preparation of an EIA that defines the study area, to limit the spatial scope of the study, and components of study (surveys and assessment).

DHI identifies potential impacts from a proposed development through the development of a Scoping Matrix for the Project. This process requires a clear understanding of (i) potential changes, or pressures, that will arise from the proposed Project, (ii) presence of environmental sensitive features, or receptors, in its potential impact zone and (iii) impact processes, such as ecosystem processes and linkages.

An environmental pressure is defined as a change in environmental condition (such as currents, wave, water quality, etc.) resulting from a development project. A sensitive receptor is a social, economic or ecological feature that may be affected by a pressure or a group of pressures.

This scoping process requires a clear understanding of impact processes, such as ecosystem processes and linkages. An impact process is a description of how a specific receptor is affected by a specific type of impact: Pressure > Pathway > Receptor. All three elements are required for there to be an impact. For example, if there is no pathway from the source to the receptor, then no impact will eventuate; similarly, if there exist a source but no corresponding receptor, the impact will also not occur.

Outcomes of Scoping stage are documented in Section 4.2.5. The identified pressures and receptors are documented in a Scoping Matrix, which serves to outline their interactions. These interactions are examined and assessed in the EIA.

4.2.1 Identification of Study Area

The identification of the study area for each pressure involves defining and delineating the geographical scope or boundaries within which specific environmental pressures are observed or expected to occur from the Project. The spatial scope for analysis varies for each pressure. These distances have been determined in accordance with relevant local regulations, international guidelines or based on expert knowledge in the field of environmental impact assessment.

- Air Quality Impact Assessment (350m): The Institute of Air Quality Management (IAQM)'s Guidance on the Assessment of Dust from Demolition and Construction indicates that an air quality (dust) assessment is typically necessary where there is a human receptor within 350m of the boundary of the site (IAQM, 2016).
- Noise Impact assessment (150m): As per NEA's Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, the maximum permissible construction noise levels for buildings are set within 150 m of construction sites.
- Ecological Buffer (100m): The identification of ecological and biodiversity sensitive receptors includes a 100 m buffer in addition to the 10.2 ha Project development footprint – this combined area is hereinafter referred to as the "Ecology Survey Area" or "EIA Study Area" (Figure 4.3)

4.2.2 Identification of Sensitive Receptors

Using information gathered from literature review, DHI's internal expertise, and a desktop examination of publicly available data, key environmental receptors within the designed Study Areas have been identified and depicted in Figure 4.3 and detailed in Table 4.1.

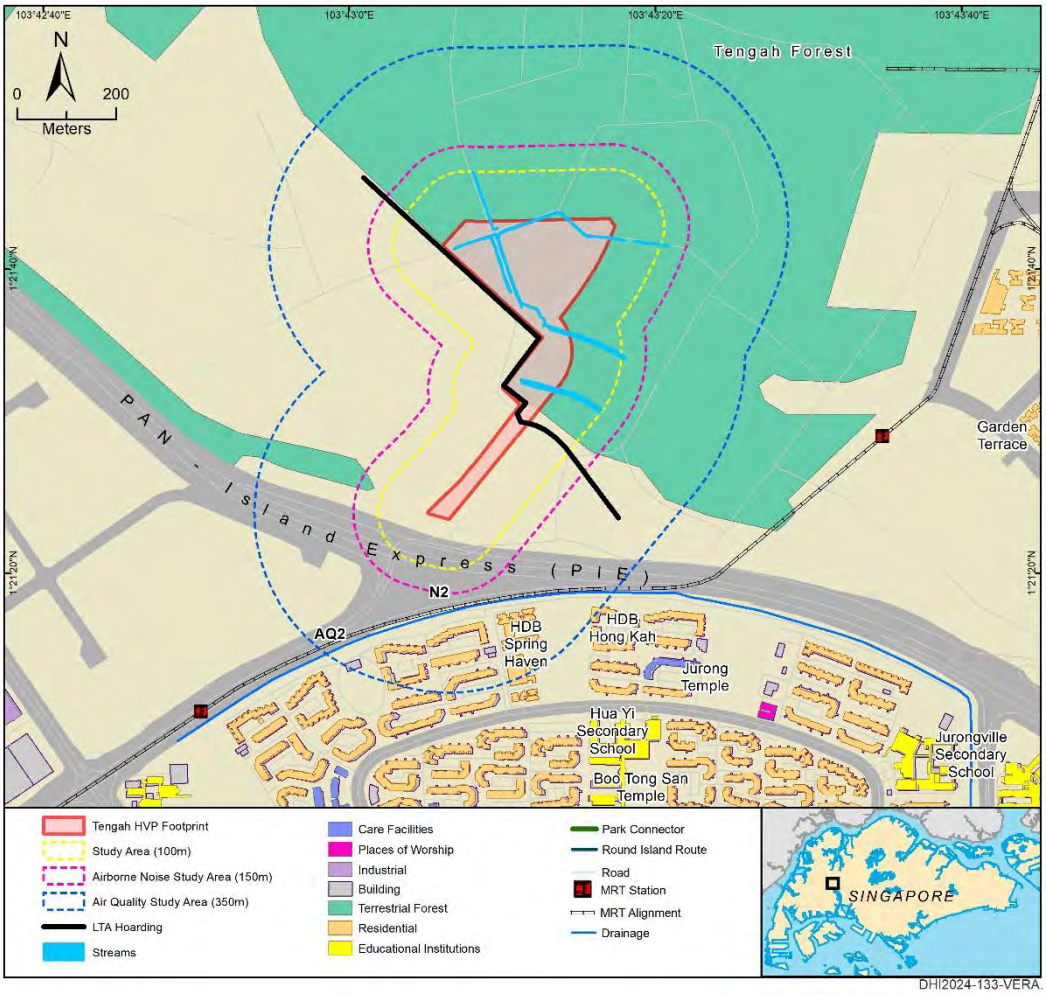

Figure 4.3 Overview of the identified sensitive receptors in relation to the Project development footprint, the buffer of 150 m and 350 m (representing the airborne noise and air quality study boundaries respectively), and Study Area of 100 m, which comprises the buffer area for ecological receptors. (Ecology Survey Area).

Table 4.1 Overview of key environmental sensitive receptors identified within the Study Area.

Sensitive Receptor	Description
Biodiversity and Ecological	
Project site and Tengah Forest	Tengah HVP is located within the broader Tengah Forest, which used to cover over 700 ha in area, forming the largest contiguous green cover on mainland Singapore outside of the Central Nature Reserves and Western Catchment area. Historical baseline surveys and reported sightings for Tengah Forest documented 44 conservation significant fauna species (Appendix B6). The dominant habitat type within Tengah Forest is exotic-dominated secondary forest, while naturalised freshwater streams also exist and harbour aquatic fauna species, including within the Tengah HVP site (HDB, 2017). The area is also crucial for facilitating ecological connectivity between Central Nature Reserves, Bukit Batok Nature Corridor, and Western Catchment area. The fauna receptors within the Tengah HVP site and adjacent Tengah Forest will be sensitive to air pollution, noise pollution, light pollution, ground vibration disturbances, changes

Sensitive Receptor	Description
	in microclimate, and reduction in surface water quality resulting from the Project's construction and operation.
Socio-Economic	
Residential Areas	The south of Project site is surrounded by residential developments along Jurong West Avenue 2 and PIE. The residential areas within the 350 m buffer zone are Block 553-559 Jurong West Street 42, Block 560A-561B Jurong West Street 42 and Block 407 Jurong West Street 42. Public amenities include Block 561 multi storey carpark and the residential park adjacent to Block 558. Residents of these areas would be susceptible to potential air quality (dust) impacts from the planned works.  Tengah residents who are moving in from 2024 may be susceptible to human-wildlife conflict during the construction of the HVP.
Construction personnel	Construction personnel can be directly and indirectly impacted by various environmental pressures associated with construction activities. This includes but is not limited to changes in air quality and noise levels, as well as potential human-wildlife conflict, during the construction stage.
Tengah HVP users	Users of the Tengah HVP would be susceptible to potential air quality impacts from the heavy vehicles during operation.

4.2.3 Identification of Potential Environmental Pressures

Drawing from the project details outlined in Section 2.2, Table 4.2 illustrates the environmental pressures anticipated on both the physical and biological environments as a consequence of the project activities.

Table 4.2 Overview of key environmental pressures identified during construction and post construction phase.

Construction Phase	Post-construction Phase
Project footprint	Project footprint/presence
Clearance of vegetation	Increased vehicular traffic
Presence of construction vehicles	Light emission from streetlights and vehicles
Physical disturbance due to pre-construction and construction activities	Changes in microclimate
Air (dust) emission from earthworks	Changes in air quality due to presence of heavy vehicles
Light emission from night works	Proximity of Tengah HVP to forested areas
Noise and vibration from potential piling works	Change in landscape and visual aesthetics
Landscape and visual aesthetics	
Pollution from improper site management (Waste, water quality, soil & groundwater quality)	
Proximity of project site to forested areas	

4.2.4 Planned Development in the Vicinity

During the construction phase of the Project, there would be other concurrent development projects within a similar timeframe. A brief description of the proposed projects within the vicinity of the Project is provided below and locations shown in Figure 4.4.

- **HDB – Brickland, Garden, Park and Plantation Districts:** Tengah Town will be comprised of five proposed districts providing thousands of new residential units. Construction and infrastructure/land preparatory works are ongoing and will continue in the near term.
- **HDB – Forest Hill District:** HDB will be carrying out earthworks and infrastructure works to support future development works in Tengah Forest Hill District from around 2028 onwards.
- **NParks, PUB – Tengah North (Project 1) (led by NParks):** Tengah North (Project 1) will feature an extensive green network comprising the “Forest Corridor”, “Central Park” and northern “Forest Fringe”. The project includes plans for ecological connectivity within and beyond Tengah and the naturalisation of the “Forest Stream”, integrating nature into the urban landscape.

- **HDB, NParks, PUB – Tengah Project 2 (led by HDB):** Tengah South (Project 2) includes the stormwater retention pond "Tengah Pond", the "Promenade Park", and part of the southern "Forest Fringe".
- **Jurong Region Line:** LTA has commenced construction of the new Jurong Region Line, which consists of 24 stations that serves existing and future developments in the Western part of Singapore, which includes Tengah and Jurong West. Construction is expected to be completed in phases from 2027**.**
- **Tengah Vehicular Interchange**: Construction of Tengah Vehicular Interchange at Kranji Expressway (KJE), including the widening of Lam San Flyover and re-alignment/widening of KJE to support the development of Tengah New Town by providing future residents with direct connectivity to the KJE. The development is expected to be completed by 2027.
- **PUB – Potable Water Pipelines from Nanyang Service Reservoir to Pan Island Expressway (PUB, 2021):** PUB – Potable Water Pipelines from Nanyang Service Reservoir to Pan Island Expressway: PUB has proposed a 1600/1200mm diameter Potable Water (PW) pipeline from the existing Nanyang Service Reservoir to PIE, located on the south of Tengah Forest. The project has commenced in 2022 and is expected to complete in 2031.

Figure 4.4 Known developments in the vicinity of Tengah HVP (respective developer as indicated).

4.2.5 Identification of Potential Environmental Impacts – Scoping Matrix

Potential impacts anticipated at the relevant environmental sensitive receptors in short-term (construction phase) and long-term (operation phase) are presented in Table 4.3 and Table 4.4 respectively. The identified environmental pressures/changes, and potential environmental impacts to the environmental sensitive receptors are tabulated in the Scoping Matrix in Table 4.5. This matrix forms the basis for the baseline study scope and impact assessment scope.

Table 4.3 Potential construction phase impacts of the proposed development

Type of receptor	Receptor	Potential Construction Phase Environmental Impact(s)
Biodiversity and ecology	Terrestrial fauna within and adjacent to Project footprint	• Displacement of fauna • Loss of flora and fauna (including conservation significant species) • Injury and mortality to fauna due to the construction activities and human-wildlife conflicts • Behavioural or physiological changes due to airborne noise, vibration, and air pollution (dust) from construction activities • Light pollution on fauna from unavoidable (emergency) night works
	Freshwater stream and fauna within Project footprint	• Improper management of construction site may lead to reduction in surface water quality (e.g., chemical and waste management, surface runoff) and impacting freshwater habitats and fauna
	Residents at upcoming Tengah residential developments Construction personnel within and around project site	• Human wildlife conflict from displacement of fauna from project footprint
Socio-economic	Residents at HDB at Jurong West Street 42	• Potential deterioration in air quality (e.g., dust) due to construction activities • Airborne noise, ground vibration causing adverse effects or nuisance on residents • Improper waste management within construction site may lead to vector-borne diseases
	Construction personnel	• Potential deterioration in air quality (e.g., dust) due to construction activities • Improper waste management within construction site may lead to vector-borne diseases • Construction activities generate high levels of noise, which can have adverse effects on hearing health of construction personnel. • Prolonged exposure to loud noises may lead to stress, fatigue, and long-term hearing impairment.

Table 4.4 Potential operational phase impacts of the proposed development

Type of Receptor	Receptor	Potential Operational Phase Environmental Impact(s)
Biodiversity and ecology	Terrestrial and freshwater flora and fauna within and adjacent Project footprint	• Loss of terrestrial and aquatic habitats • Loss of flora and fauna (including conservation significant species) • Loss of ecological connectivity between Central Catchment Nature Reserve, Bukit Batok Nature Corridor, and Western Catchment Area (cumulatively with adjacent developments within Tengah Forest) • Disturbances by vehicular noise • Light pollution from vehicles or fixtures. • Human-wildlife conflicts • Changes in microclimate due to vegetation clearance and exposure of flora and fauna to edge effects
	Users of Tengah HVP	• Human-wildlife conflicts arising from improper waste management and response to wildlife encounters
Surface hydrology	Freshwater stream(s) within Project footprint and its catchment area	• Changes in surface runoff and stream flowrate

Table 4.5 Scoping matrix.

Identified Sensitive Receptors	Pressures (Construction Phase)										Pressures (Operation Phase)						
	Project Footprint	Clearance of vegetation	Dust Emissions	Presence of Construction Vehicles	Construction Activities	Noise and Vibration	Landscape and Visual Aesthetics	Pollution from Improper Site Management	Proximity of Project Site to Forested Areas	Light Emission	Landscape and Visual Aesthetics	Project Footprint	Increased Vehicular Traffic	Light Emissions	Changes in Microclimate	Changes in Air Quality due to Heavy Vehicles	Proximity to Forested Areas
Terrestrial flora	L	L	S	S	S	-	-	S	-	S	-	L	-	-	L	L	-
Terrestrial fauna	L	L	S	S	S	S	-	S	S	S	-	L	L	L	L	L	L
Habitats	L	L	S	S	S	-	-	S	-	-	-	L	L	-	L	L	-
Surface Hydrology	L	L	-	-	S	-	-	S	S	-	-	L	-	-	-	-	L
Residential Areas	S	-	S	S	S	S	L	S	-	L	SL	L	L	L	L	L	-
Construction Personnel	S	S	S	S	S	S	-	S	S	S	-	-	-	-	-	-	-

Pressures = changes in environmental parameters as a result of the Project.

Receptors = social, economic or ecological features that may be affected by the pressure.

S = Short-term impacts

L = Long-term impacts

4.3 Baseline Study

The primary objectives of an Environmental Baseline Study are to understand the receptors, establish baseline conditions and collect data for subsequent impact assessments. The scope of this baseline study is designed based on the receptors identified (Table 4.7) and the relevant impacts (Table 4.3 and Table 4.4) that will be assessed in this EIA.

The baseline conditions have been established through a combination of a desktop study of and field surveys (primary data) and readily available information (secondary data). An overview of field surveys conducted for Tengah HVP is presented in Table 4.6.

Specifically, baseline ecological and environmental data collected from previous Environmental Impact Assessments (EIAs) and Biodiversity Impact Assessments (BIAs) conducted within and around the Project has been used to supplement the field baseline data collected.

Table 4.6 Summary of baseline surveys carried out for Tengah HVP.

Environmental Aspect	Location/Extent	Methods	Parameters	Frequency and Duration
Terrestrial Flora	Within the Project site, and 100 m from the Project site boundary. (Figure 4.3)	• Satellite data and ground truthing • Visual surveys • Mapping of habitat types • Vegetation sampling plots • Mapping and tagging of trees (including strangling *Ficus* sp.) with girth/spread ≥ 1.0 m • Mapping and tagging of conservation-significant plants with girth ≥ 0.3 m • Mapping of other plant specimens of value	• Map of habitats/vegetation types • Floral inventory checklists: identification to the lowest possible taxon, conservation status, species origin (i.e., native, exotic, etc.) • Map and shapefiles of trees with girth/spread ≥ 1.0 m and conservation-significant plants with girth ≥ 0.3 m; • Identification and girth measurement of woody and non-woody plant specimens ≥ 0.05 m girth within sampling plot	• Once off
Terrestrial Fauna	Within the Project site, and 100 m from the Project site boundary. (Figure 4.3)	• Visual and auditory transect surveys (diurnal and nocturnal) • Camera trapping • Bioacoustics surveys (bats) • Aquatic point counts • Push and scoop netting • Minnow trapping	• Fauna checklist: Identification to the lowest possible taxon, abundance, conservation status, noteworthy behaviour; and • Distribution maps of conservation-significant fauna species encountered • Taxon Sampling Curves evaluating sampling effort and coverage	• Transect surveys; 2 replicates per taxon, minimally separated by a week between each replicate; survey duration and timing will be specific to target fauna taxa (see Table 5.2) • For avifauna, 2 replicates during migratory season • Three replicates of bioacoustics surveys for bats

Environmental Aspect	Location/Extent	Methods	Parameters	Frequency and Duration
				• Camera traps: Continuous deployment for 60 days • Aquatic point counts: 20 minutes per point; two cycles per taxon group • Push and scoop netting: 2 replicates per event • Minnow trapping: One day one night; once per location
Air Quality	2 representative locations (Figure 6.1)	• Deployment of dust sensors for measurement of $PM_{2.5}$ and PM_{10} • Gas sampling and testing at accredited SINGLAS laboratory	• $PM_{2.5}$ and PM_{10} • Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), Sulphur Dioxide (SO_2)	• 7-day continuous measurement for dust
Airborne Noise	2 representative locations (Figure 7.1)	• Measurement with calibrated NEA approved Type 1 sound level meter	• Sound level (Leq A-weighted) measurements	• 7-day continuous monitoring of Leq 5mins, Leq 1hr and Leq 12-hour • Spot measurements of Leq 5mins at three (3) locations
Surface Water Quality and Hydrology	4 representative locations (Figure 8.2)	• Surface Water Quality • Measurement with calibrated Aqua TROLL 600 Multiparameter Sonde (In-situ) • Water quality samples sent to SAC-SINGLAS accredited laboratory (Ex-situ)	• 28 water quality parameters (5 in-situ and 23 ex-situ) includes chemical and biochemical parameters. •	• Dry and Wet weather

Environmental Aspect	Location/Extent	Methods	Parameters	Frequency and Duration
		• Hydrology • Cross-sectional profile and flow rate of the respective freshwater streams measured		
Ground Vibration	1 representative location (Figure 9.1)	• Measurement with vibration sensor	• Tri-axial movement measurement in peak particle velocity (ppv)	• 48-hour measurement
Ambient Light Levels	3 representative locations (Figure 10.2)	• Measurement of lux levels using micro-data loggers	• Mean daily mean, maximum, and minimum lux levels during night hours • Time-series lux level graphs for selected land use classes	• Continuous logging on a 5-minute interval for 2 weeks
Microclimate (Ambient Air Temperature)	9 representative locations across the forest-urban gradient (Figure 11.1)	• Measurement of ambient air temperature using micro-data loggers	• Mean daily mean temperature, maximum, and minimum temperatures for all locations.	• Continuous logging on a 5-minute interval for 2 weeks

4.4 Desktop Study

Where pertinent, both ecological and physico-environmental baseline data collected from the historical studies will be consulted and inferences drawn. The specific utilisation of secondary ecological data is further elaborated upon in Section 5. No references will be made to the physico-environmental baseline parameters of ambient light and microclimate, as these were not captured in any prior study. A concise summary of the objectives and scope of the relevant ecological and/or environmental surveys conducted in these four studies is presented in Appendix G.

4.5 Assessment Methodology

This section serves as the overarching framework for the impact assessment methodology. For each specialist discipline, the assessment will identify the likely significant environmental impacts. The criteria for determining significance are specific for each environmental aspect and will be defined in the relevant specialist sections.

DHI uses a tool called the Rapid Impact Assessment Matrix (RIAM) to quickly assess the potential environmental effects of development projects. This method, developed by Pastakia & Jensen in 1998, provides a clear and consistent way to summarise the overall impact of a development. RIAM helps pinpoint the most significant environmental concerns based on broad criteria outlined in Table 4.7. It also reduces bias in the assessment compared to other methods and considers how multiple impacts can accumulate over time.

The Biodiversity Impact Assessment (BIA) Guidelines of Singapore (National Parks Board, 2024) recommends the use of RIAM as one of three approved methods for assessing and summarising the overall significance of impacts.

Table 4.7 Overview of key environmental sensitive receptors identified within the Study Area.

Impact Significance	Broad Definition
No Impact	Changes are significantly below physical detection level and below the reliability of numerical models, so that no change to the quality or functionality of the receptor will occur.
Slight Impact	Changes can be resolved by numerical models and are detectable in the field, which may cause slight and localised nuisance or disruption of daily activities.
Minor Impact	Changes can be resolved by numerical models and are likely to be detected in the field, which may cause stress to a portion of the population at endurable levels, but at a spatial scale that is unlikely to have any secondary consequences.
Moderate Impact	Changes can be resolved by numerical models and are obviously detectable in the field, which may cause significant stress to a large portion of population and would likely disrupt the quality and functionality of the receptor.
Major Impact	Changes are highly detectable in the field and are likely to be related to significant habitat loss. Major impacts are likely to have secondary influences beyond the area of assessment.

RIAM translates qualitative standard definitions of evaluation criteria into semi-quantitative ordinal scores which are then used to calculate Environmental Scores (ES), vis the formula:

Environmental Score (ES) = I x M x (P + R + C)

The five evaluation criteria (variables) used in the formula are defined as:

(I) Importance: This defines the importance of the sensitive receptor identified, which is assessed against spatial or political boundaries, socio-economic value, intrinsic quality, or the degree of rarity.

(M) Magnitude: Impact Magnitude or Magnitude of change is based on the relationship between the analysed physio-chemical, biological, or socio-economic deviation from baseline conditions and the relevant environmental standards, benchmarks, guidelines, or tolerance limits. Importantly, the Magnitude value should reflect the magnitude of change experienced at a particular sensitive receptor. In this way, the impact pathway is considered, i.e., whether there is a spatial and/or temporal overlap between the environmental change and receptor. Positive or negative impacts are represented through positive or negative ordinal scores for Magnitude respectively.

(P) Permanence: This defines whether an impact is temporary or permanent, i.e. a measure of the temporal status of the loss / change. For example, slope stabilisation with gabion walls will be a permanent impact, while slope stabilization with sheet piles will be a temporary impact, given their eventual removal.

(R) Reversibility: The score expresses whether the receptor can recover from the impact, either unassisted or via mitigation measures. Reversibility is also a measure of the control over the effect of the condition. It is not equated with permanence. For example, the loss of streetscape trees is recoverable with replacement plantings, while the loss of an endemic species is irrecoverable.

(C) Cumulative Impact: This is a measure of whether the effect will have a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other conditions. For example, the loss of flora and fauna species is cumulative, given that it is also associated with other impacts such as the loss of ecosystem functioning and ecological connectivity.

The approach of RIAM is therefore to couple the potential impact Magnitude experienced at the sensitive receptor(s) of interest, with a concurrent assessment of receptor Importance, impact Permanence, Reversibility, and Cumulative potential.

The multiplication of *Importance (I)* and *Magnitude (M)* in the formula ensures that the weight of each evaluation criteria is expressed and is individually able to significantly influence the resultant environmental score. The summation of Permanence, Importance, and Cumulative ensures that these criteria are represented collectively, but do not have a large influence on the resultant environmental score individually.

The standard (generic) definitions of each evaluation criteria, and the associated ordinal scores used to calculate the environmental score, are shown in Table 4.8. To account for the wide variability and context-specificity of sensitive receptors and predicted environmental impacts (pressures), the generic definitions of *Importance* and *Magnitude* are shown in Table 4.8 will be customised and made specific for sensitive receptors and predicted environmental impacts respectively. The detailed evaluation framework, with justifications, is elaborated in each assessment in the proceeding sections.

Table 4.8 Evaluation criteria and the associated standard definitions and ordinal scores used in the calculation of Environmental Scores.

Evaluation Criteria	Standard Definitions	Ordinal Score
Importance	Important to national/international interests	5

Evaluation Criteria	Standard Definitions	Ordinal Score
	Important to regional/national interests	4
	Important to areas immediately outside the location condition	3
	Important to the local condition (within a large direct impact area)	2
	Important only to the local condition within a small direct impact area)	1
Magnitude*	Major positive benefit or change	+4
	Moderate positive benefit or change	+3
	Minor positive benefit or change	+2
	Slight positive benefit or change	+1
	No change/status quo	0
	Slight negative disadvantage or change	-1
	Minor negative disadvantage or change	-2
	Moderate negative disadvantage or change	-3
	Major negative disadvantage or change	-4
Permanence	Temporary or short-term change	2
	Permanent change or long-term value and/or function unlikely to return	3
Reversibility	Recoverable or controllable through EMMP	2
	Irrecoverable	3
Cumulativity	Impact can be defined as non-cumulative/single (no interaction with other impacts)	2
	Presence of obvious cumulative/cascading effect that will affect other developments or activities or trigger secondary impacts	3

*Definitions and scorings of Importance and Magnitude are customised for all identified sensitive receptors and environmental impacts respectively

For each identified environmental impact affecting a sensitive receptor, an environmental score will be computed. These scores will then be grouped into bands and ranked according to the ranges outlined in Table 4.9. Subsequently, these rankings will be converted into Impact Significance, serving as the outcome of the impact assessment process.

Table 4.9 Range bands of environmental scores and the associated Impact Significance used in RIAM.

Environmental Score (Range Bands)	Impact Significance
116 to 180	Major positive change/impact
81 to 115	Moderate positive change/impact
37 to 80	Minor positive change/impact
7 to 36	Slight positive change/impact
-6 to 6	No impact/Status quo/ Not applicable
-7 to -36	Slight negative change/impact
-37 to -80	Minor negative change/impact
-81 to -115	Moderate negative change/impact
-116 to -180	Major negative change/impact

4.6 Management of Environmental Impacts

Mitigation is typically required at least for identified environmental impacts predicted to be Moderate or Major. Mitigation measures are recommended and designed to reduce the impact down to an as-low-as-practicable level. Slight or Minor impacts may also require some type of mitigation, but it may also be enough to manage by having appropriate environmental procedures in place.

The term “mitigation measures” includes operational controls as well as management actions. These measures are often established through industry standards and may include:

- Changes to the design of the Project during the design process
- Engineering controls and other physical measures applied (e.g., noise barrier)
- Operational plans and procedures (e.g., noise pollution control management plan)
- Provision of like-for-like replacement, restoration, or compensation

The mitigation hierarchy concept is presented in Figure 4.5. In developing mitigation measures, the first focus is on measures that will avoid or minimise impacts through the design and management of the Project followed by those that restore or offset. Where impacts cannot be avoided, environmental mitigation measures will be incorporated into the final detailed construction design and specified for appropriate construction methodology.

It is important to note that not all impacts are inherently detrimental. There are opportunities to recommend actions that result in net positive gains. Avoidance, minimisation and/or restoration alone are generally not enough to achieve a net gain and some form of offset will be necessary.

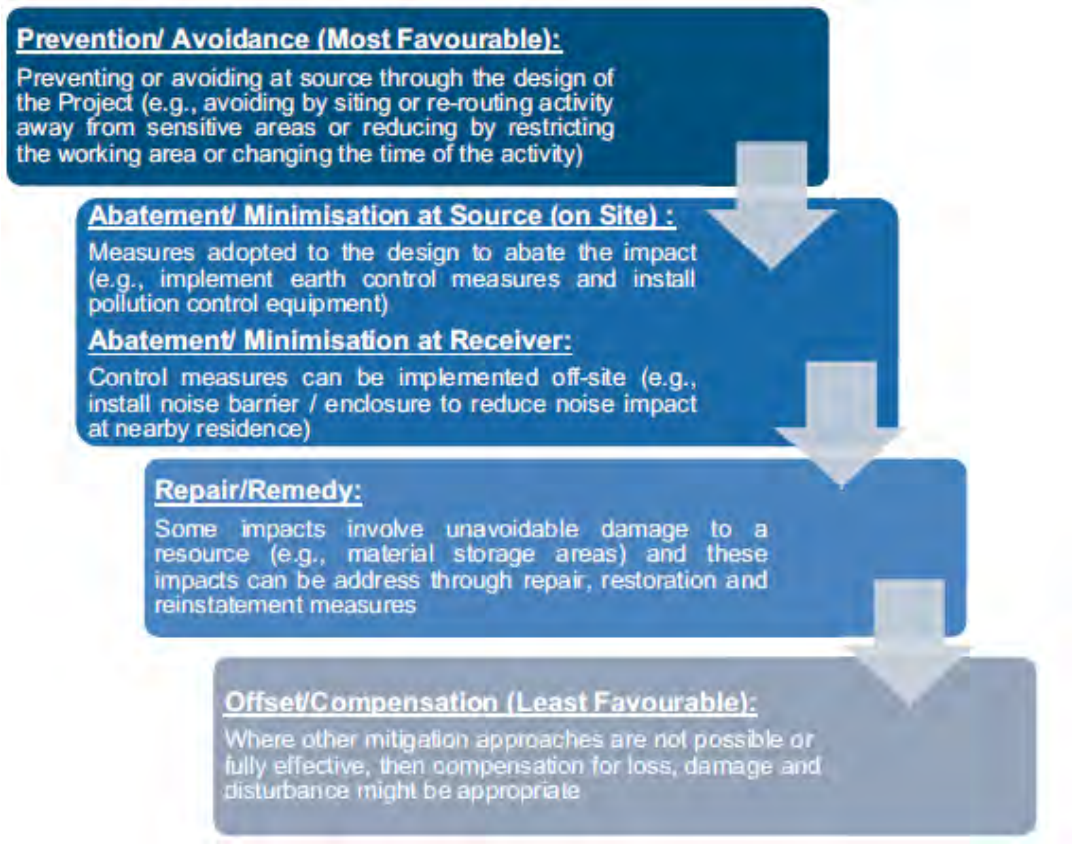

Figure 4.5 Hierarchy of mitigation strategy.

4.7 Reporting Flow

This report is structured according to the assessment process. It starts with documenting outcomes of Scoping Stage (Section 4.2.5). Chapters 5 – 11 cover individual environmental parameters, with the earlier sections in each chapter outlining the results of the baseline study, and the later sections covering the impact assessment and recommended mitigation measures, corresponding to the development stage of concern.

- Each of the impact assessment sections is carefully structured to illustrate the key components involved in analysing environmental impacts, namely:
- Evaluation framework for defining and scoring magnitude of environmental change
- Details the applicable environmental standards and guidelines used to assess environmental compliance. It then elaborates the specific criteria used to define the varying levels of Magnitude.
- Identification of relevant sensitive receptors and their importance scores
- Outlines key characteristics of all ecological sensitive receptors and elaborates the specific criteria used to define the varying levels of receptor Importance.
- Scoring for receptor Importance, Magnitude, Permanence, Reversibility, and Cumulative nature are then shown clearly, and the resultant Environmental Score and hence Impact Significance reported.
- Prediction of impact significance

- Outlines the predicted environmental stresses and pressures and their pathways or linkages with associated ecological sensitive receptors.
- Proposed mitigation measures
- Mitigation measures are recommended, following which Impact Significance is reevaluated to derive the Residual Impact Significance.
- Evaluation of residual impact significance
- Mitigation measures are expected to only affect the RIAM variable of Magnitude, hence only the change in Magnitude is shown for the evaluation of Residual Impact Significance

5 Ecology and Biodiversity

5.1 Applicable Legislation, Standards and Guidelines

National environmental management requirements that are applicable to the management and conservation of local biodiversity and ecology are found in several Acts, Regulations and Guidelines, as listed in Table 5.1.

Table 5.1 Applicable acts, regulation and guidelines for ecology and biodiversity receptors

Environmental Aspect	Applicable Acts, Regulations & Guidelines
Wildlife Protection and Welfare	• Wildlife Act, 2000 • Singapore Red Data Book, Third Edition, 2024 • NParks Species List (SRDB3)
Habitat Protection/ Conservation of Protected Areas	• Parks and Trees Act, 2006 • Parks and Trees Regulations, 2006 • Parks and Trees (Preservation of Trees) Order, revised 1998 • Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023a) • Biodiversity Impact Assessment Guidelines (NParks, 2024a)

National Biodiversity Strategy and Action Plan

The Singapore National Biodiversity Strategy and Action Plan (NBSAP) was developed and launched in 2009 by NParks as Singapore's blueprint for biodiversity conservation and to fulfil Singapore's commitment as a signatory to the Convention Biological Diversity (NParks, 2019a). The NBSAP provides a framework for conservation of biodiversity in Singapore and allows greater consideration of biodiversity issues in policy decisions. The NBSAP advocates the conduct of an EIA in the early stages of development projects to assess potential environmental impacts and to recommend mitigation measures to remediate these impacts.

Singapore's NBSAP was updated in 2019 with national targets developed with reference to the Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets established during the Tenth Meeting of the Conference of Parties to the Convention on Biological Diversity (COP-10) in 2010. The national targets were finetuned in the context of Singapore's unique circumstances as a highly urbanised city-state and one of the most densely populated countries in the world.

Nature Conservation Master Plan

In 2015, NParks launched a holistic Nature Conservation Master Plan (NCMP) that outlines the course of Singapore's biodiversity conservation plans for the next five years (NParks, 2019b). The NCMP comprises four aspects, namely:

1. The conservation of key habitats, including the safeguarding and strengthening of Singapore's core biodiversity areas by creating greenery nodes or buffer areas integrating with the urban landscape

2. Habitat enhancement, restoration, and species recovery

3. Applied research in conservation biology and planning, including comprehensive surveys and long-term monitoring of ecosystems and species.

4. Community stewardship and outreach in nature, which aims to encourage and build public interest and involvement in biodiversity conservation.

Aligned with the NCMP, the National Parks Board (NParks) initiated the Ecological Profiling Exercise (EPE) in February 2021 (URA, 2022). This exercise, conducted in consultation with the nature community and academic experts, aimed to comprehensively analyse the ecological profiles of green spaces within Singapore and to elucidate their role in strengthening island-wide ecological connectivity. Arising from this exercise, the Bukit Batok and Clementi Nature Corridors were conceptualized as essential components to bolster and maintain this critical connectivity network.

Tengah-Specific Nature Conservation Plans

The Tengah Forest Corridor and Bukit Batok Nature Corridor serve as crucial ecological corridors, bridging the gap between the Central Catchment Nature Reserve (CCNR) and Western Catchment Area (WCA) (NParks, 2023b). These vital arteries connect two of the island's largest forest fragments, forming a refuge for Singapore's diverse native biodiversity.

The forested areas within these corridors will facilitate wildlife dispersal, promoting gene flow across the Central Catchment and Western Catchment areas. The Bukit Batok Nature Corridor, specifically, encompass more than 125ha of nature parkland, complemented by an extensive 10km network of trails.

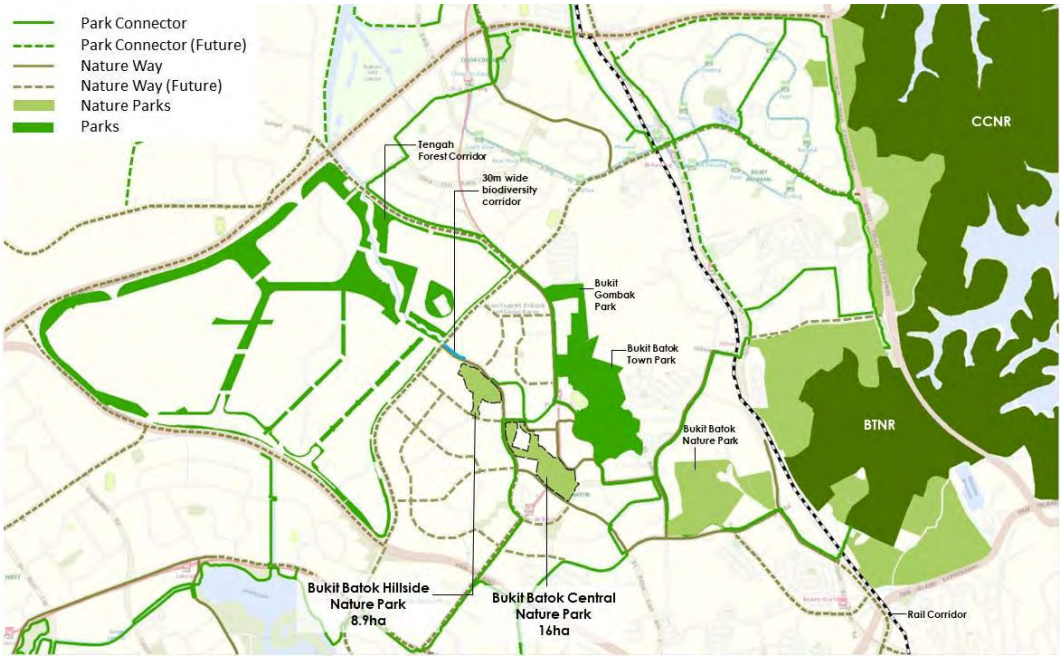

Figure 5.1 Ecological corridors (Tengah Forest Corridor and Bukit Batok Nature Corridor) proposed as part of NParks' Ecological Profiling Exercise to facilitate ecological connectivity between the Central Nature Reserves and Western Catchment Area. Source: NParks.

Singapore Green Plan 2030 and City in Nature

The Singapore Green Plan 2030 was launched in February 2021 as movement to advance Singapore's national agenda on sustainable development (MSE, 2024). It charts ambitious and concrete targets for the rest of this decade under five thematic pillars.

One such pillar, the "City in Nature" initiative is guided by four key strategies: extending the nature park network, intensifying nature in gardens and parks, restoring nature into the built environment, and strengthening connectivity between Singapore's green spaces. The initiative boasts ambitious targets, including the planting of 1 million trees under the "One Million Trees" movement and a more than 50% increase in total Nature Park land area by 2030 compared to the 2020 baseline.

Greenery Provisions for Development Projects and Handbook on Developing Sustainable Skyrise Gardens

NParks has guidelines that describe the statutory requirements on greenery provision, tree planting and conservation for development projects in Singapore, both within the premises at ground level (NParks, 2023a) or as skyrise greenery (NParks, 2017a). Planting specifications, flora species palette, applicable buffer and setback distances, and safety and maintenance regimes are provided in the guidelines for developers' consideration.

5.2 Methodology

Ecological baseline information was first collected using secondary data obtained through desktop study of established literature sources, including existing records, reports, and publications relevant to the ecology of the Study Area (Section 5.2.1). Field surveys were then carried out to verify and supplement the data as primary data (Section 5.2.2). Using both primary and secondary ecological data, important habitats and species of flora and fauna of conservation significance were identified.

5.2.1 Desktop Study

Primary data collected through ecological field surveys was supplemented with a desktop study of historical or secondary data, including but not limited to past EIA or environmental baseline reports, published literature and historical land-use information. Relevant historical studies were referenced.

The interpretation of secondary ecological data will primarily focus on spatial limitations within the Tengah HVP ecological Study Area, identifying habitats and/or significant conservation species. However, broader qualitative or non-geospatial inferences (e.g., ecological connectivity) may encompass the larger scope of the Tengah Forest. Geospatial data pertaining to species or habitats in these overlapping regions was extracted or manually referenced whenever accessible and included in the desktop study's findings.

Secondary ecological data that was collected more than 3 years ago has been included within the scope of this desktop study as well, as the data remains valuable as a retrospective point of reference, particularly concerning fauna. The unpredictable detectability of fauna, especially rarer species, demands a dataset with robust temporal coverage to accurately estimate actual species diversity and capture all crucial conservation species. It is important to note that some historical baseline habitat conditions documented in Tengah might not align with the current site conditions due to ongoing development activities. This potential disparity will be explicitly addressed in Section 5.2.2 when drawing inferences from historical data, subsequent to presenting the findings from primary data collection (field surveys).

5.2.2 Field Surveys

5.2.2.1 Site Reconnaissance Survey

Site reconnaissance surveys were conducted to obtain an initial understanding of the existing habitats and biodiversity. Field observations were used for planning and execution of the actual surveys. The objectives of the reconnaissance survey are as follows:

- Determine site accessibility and terrain
- Conduct a preliminary assessment to determine the dominant vegetation types
- Identify locations of existing natural permanent waterbodies, such as streams, ponds, and swampy areas (if any)
- Mark out survey sampling routes and points, and potential locations for camera trap

5.2.2.2 Flora

The field surveys conducted to obtain flora baseline data consist of habitat and vegetation mapping, general walking floristic surveys, and tree tagging and assessments, which are elaborated in subsequent sections. These were carried out between 26 October 2023 and 27 November 2023 in the Ecology Survey Area.

Habitat and Vegetation Mapping

A preliminary vegetation map was prepared based on visual interpretations of satellite images from Google Earth 9.168.0.1 (Google Inc. 2023). Preliminary classification of the vegetation types—for example, forests, grasslands, or managed vegetation— was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were 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 GPS receiver (Garmin GPSMap® 64s). Photographs of the vegetated areas were also taken. The boundaries of each vegetation type were tracked on the GPS receiver and mapped out on Google Earth 9.168.0.1. Adjustments was made to the preliminary maps according to actual observations during ground truthing. The classification of vegetation types referenced NParks (2020) and relevant publications such as Yee et al. (2016).

General Walking Floristic Surveys

All plants observed in the Ecology Survey 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 of plants observed followed that of NParks (2023c) for native plants, and Lindsay et al. (2022) for exotic plants, and other more recently published papers with updated information. The latter references were usually only used for one or a few individual species. Other information on the plant species was also cross referenced with online databases, namely, the National Parks Board Flora and Fauna Web (NParks, 2024b) and The Biodiversity of Singapore (LKCNHM, n.d.).

For plants that are not identified with certainty in the field, photographs and/or voucher specimens were taken. They were 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).

To identify extremely tall trees whose leaves were inaccessible for photography, dried leaf specimens matching these trees were meticulously collected from the forest floor and used as an aid to species identification.

Species of Conservation Significance

The assessment of whether flora species recorded were considered to be of conservation significance is elaborated in Section 5.2.4. For flora specimens of conservation significance, their geographic locations were marked using a Global Positioning System (GPS) receiver (Garmin GPSMap® 64s), which records locations with accuracy of ± 4 m, during floristic surveys. Where there were clusters of plants of conservation significance—i.e., more than one individual occurring within 5 m or less of another individual—the approximated 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, palm clusters, and strangling *Ficus* species of ≥ 3 m spread. Individuals were identified to species whenever possible. The girth (for trees) and spread (for palm clusters and strangling *Ficus* species) were measured and estimated, respectively. The height of all specimens was also estimated.

Other Plant Specimens of Value

Locations of other plant specimens that are of value but do not meet the minimum size requirement, as detailed above, were also recorded using the GPS receiver. Examples include bamboo clusters of < 3 m spread that may provide habitat for threatened bamboo bats, exotic Albizia trees (*Falcataria falcata*) with raptor nests, amongst others.

Tree Tagging and Assessment

All trees, single-stemmed palms (i.e., defined as having one obvious and erect stem), strangling *Ficus* species of ≥ 1.0 m girth or spread within the Project footprint were assessed during arboricultural surveys and tagged with a unique serial number. Other specimens that were considered of conservation significance with ≥ 0.3 m girth or spread were tagged. Geographic locations, girth/spread and height were also recorded.

Differential Global Positioning System (DGPS) that can achieve up to sub-meter accuracy was used to record geographic locations of the specimens using the SVY21 plane coordinate system. This local datum gives a more accurate representation of the areas of coverage in Singapore compared to a global datum and is used by the Singapore Land Authority (SLA) (Khoo, 2015).

Where specimens were inaccessible due to obstructions, (e.g., stream, nearby tree fall), these were not given a physical tag on site. However, the location of these specimens were still marked using the DGPS and they were still assessed by certified arborists.

Arboriculture assessment of the trees was conducted by certified arborists. Plant health and structural stability were assessed by observing for damages, decays, and/or canopy asymmetry, of which, if present, may compromise plant longevity and stability. Other characteristics that were recorded include presence of habitats and canopy linkages across roads for fauna.

There were more specimens assessed than tagged as some specimens occur in clusters, i.e., within 1–2 m of each other or are inaccessible during the tree mapping survey due to the terrain.

5.2.2.3 Fauna

Faunistic field surveys were carried out between 27 September 2023 and 7 December 2023 for the following taxa: (1) birds; (2) mammals (including bats) (3) herpetofauna (amphibians and reptiles); (4) butterflies (5) odonates (damselflies and dragonflies); (6) aculeates; and (7) freshwater fauna (fish, decapod crustaceans, and molluscs). Each survey was conducted twice with an interval of at least one month between the survey cycles, except for aquatic point counts A18, A25, A26, A30 and A31 (Figure 5.2), of which surveys were carried out with a two-week interval between cycles. This was because the waterbodies were found towards the later half of the survey period. All observations of species of conservation significance from the aforementioned taxa were recorded if seen outside the stated survey times. A checklist of all species of fauna observed from the surveys were compiled in Appendix B6. These checklists include fauna observed during dedicated taxonomic specific surveys, as well as opportunistic sightings at other times within this survey campaign.

Locations of aquatic sampling points, camera traps (HVP1 and HVP2) and terrestrial fauna transect are shown in Figure 5.2. Table 5.2 summarises all the surveys that were carried out for fauna, with the exception of roost emergence surveys as no bamboo clusters were identified. Each survey was performed by at least two surveyors. All fauna encountered were identified to species, or to the next lowest taxonomic level possible, and the location of each sighting was recorded using a handheld GPS (Garmin GPSMAP 64s). The number of individuals observed was also documented.

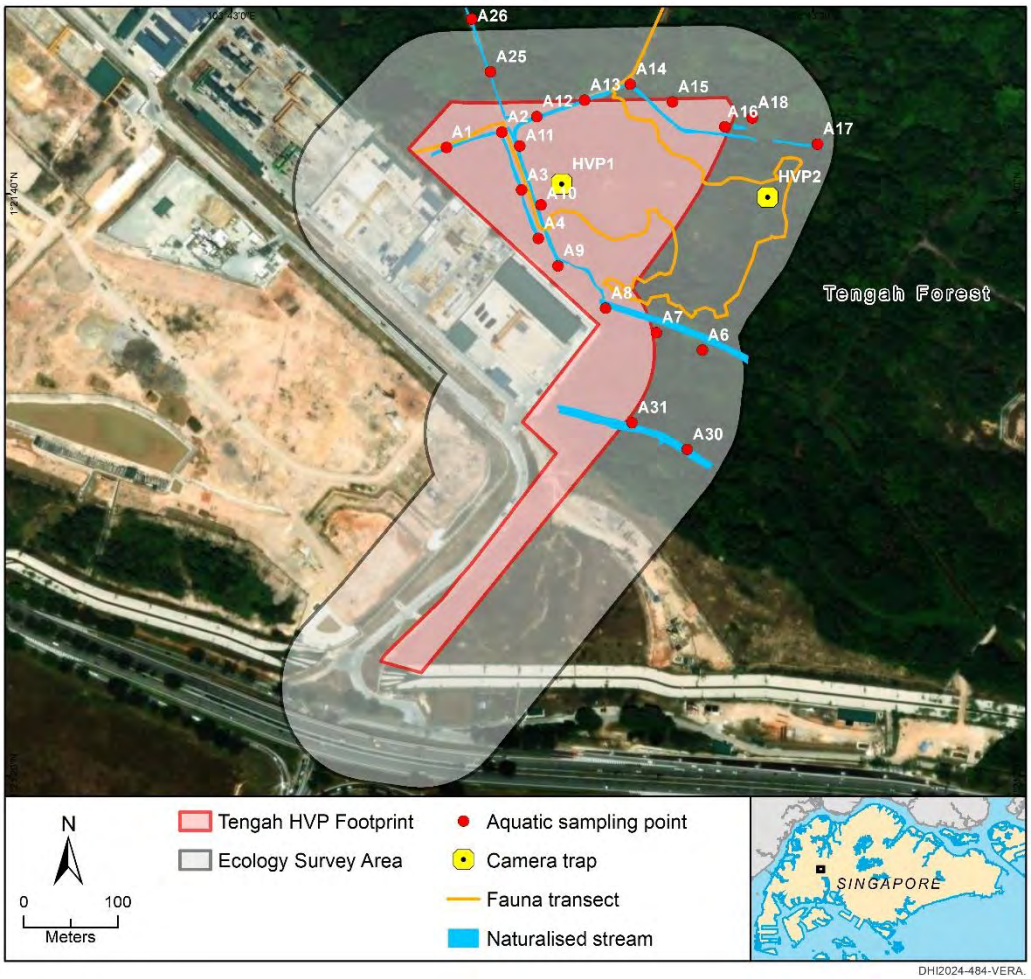

Figure 5.2 Locations of aquatic sampling points, camera traps (HVP1 and HVP2) and terrestrial fauna transect in the Ecology Survey Area of Tengah HVP.

Table 5.2 A summary of faunal survey methods across taxonomic groups.

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Diurnal transect surveys	Butterflies	0900-1600	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
	Odonates (damselflies and dragonflies)				
	Aculeates (bees and stinging wasps)				
Diurnal and nocturnal transect surveys	Herpetofauna (amphibians and reptiles)	0700–1000; 2000–2300	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
	Birds				
	Mammals (non-volant)				
Camera trapping	Mammals (non-volant)	24 h a day	60 days per camera trap (2 deployed)	24-h continuous period of recording on a camera trap	Infrared motion sensing
Bioacoustic surveys	Mammals (bats)	2000–2300	20–30 minutes per transect; three cycles	200-m continuous transects along a sampling route	Auditory only
Aquatic point counts	Odonates (damselflies and dragonflies)	0900–1600	20 minutes per point with; two cycles	Sampling points at waterbodies (at 50-m intervals for streams)	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
	Herpetofauna (amphibians and reptiles)	0900–1600; 2000–2300			
	Aquatic fauna (fish, decapod crustaceans, and molluscs)				
Push and scoop netting	Aquatic fauna (fish, decapod crustaceans, and molluscs)	0900–1600	20 minutes per netting event; two cycles	Sampling points at waterbodies (at 50-m intervals for streams)	–

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Minnow trapping	Aquatic fauna (fish and decapod crustaceans)	Overnight	One day one night; once per location	Traps inside waterbodies (at 50-m intervals along the lengths for streams where feasible)	Baited

Birds

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for birds along 200 m continuous transects on a sampling route. Birds were identified visually (with binoculars where necessary) and photographed. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising birds were also located or identified by call recognition, whenever possible. Surveys were carried out during the peak bird migratory season which is between September and February (Lim, 2009).

Non-volant Mammals

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

Non-volant mammals were also surveyed via camera trapping. Two camera traps were deployed across the Ecology Survey Area (Figure 5.2). Each terrestrial camera trap was set up approximately 20–30 cm above ground (Figure 5.3). They operated 24 hours a day and were programmed to record one 10-second footage per motion trigger with a 10-second quiet period following each trigger. Each camera trap was deployed for 60 days.

Figure 5.3 An example of a camera trap set-up.

Bats

Acoustic surveys were carried out for bats along 200 m continuous transects on a sampling route between 2000h and 2300h. The Song Meter Mini Bat (Wildlife Acoustics, Inc.) were used to record ultrasonic calls between 18 and 192 kHz at a sampling frequency of 384 kHz. Bamboo bat roost emergence surveys were not carried out as there were no bamboo clusters found within the Ecology Survey Area.

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 a sampling route. Twenty-minute point counts were conducted at aquatic sampling points (Figure 5.2) at 0900h in the morning. Each point count was carried out along a 10-m transect, where possible, considering limitations imposed by steep terrain and/or dense vegetation. As herpetofauna occupy a wide range of habitat types, both the diurnal and nocturnal surveys involved active searches for individuals on the ground, below rocks, logs, leaf litter and debris, in the water, and/or on vegetation. Rocks, logs, and other structures were returned to their original positions if moved during the searches. 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.

Butterflies

Diurnal transect surveys were carried out for adult butterflies along 200 m continuous transects on a sampling route between 0900h and 1600h. Butterfly caterpillars, pupae, eggs, and host plants were also be 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.

Odonates (Damselflies and Dragonflies)

Diurnal transect surveys were carried out for adult damselflies and dragonflies along 200 m continuous transects on a sampling route between 0900h and 1600h. Twenty-minute point counts were also conducted at aquatic sampling points (Figure 5.2) during the same survey window. Each point count was carried out along a 10-m transect, where possible, considering limitations imposed by steep terrain and/or dense vegetation. 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.

Aculeates (Bees and Stinging Wasps)

Surveys for aculeates were carried out subject to the availability of resources. Diurnal transect surveys were carried out for aculeates along 200 m continuous transects on a sampling route between 0900h and 1600h. Aculeates 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.

Freshwater Fauna (Fishes, Decapod Crustaceans, and Molluscs)

Diurnal and nocturnal twenty-minute point counts were conducted at aquatic sampling points in various waterbody types in the Ecology Survey Area between 0900h and 1600h, and 2000h and 2300h, namely naturalised streams, forest streams and unmanaged soft-bank ponds (Figure 5.9; Table 5.3).

Changes in the riparian vegetation were observed along the naturalised streams during our study period. However, these changes had no conclusive impacts to the overall baseline results for freshwater fauna and other taxa such as odonates and butterflies. All surveys continued as scheduled.

Table 5.3 List of aquatic sampling points at different waterbody types in the Ecology Survey Area of Tengah HVP.

Waterbody Type	Aquatic Sampling Point	Total
Naturalised stream	A1 - A4; A9 - A17; A25 & A26	15
Forest stream	A6 - A8; A30 & A31	5
Unmanaged soft-bank pond	A18	1
Total number of points surveyed		**21**

Each point count was carried out along a 10-m transect, where possible, considering limitations imposed by steep terrain and/or dense vegetation. 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 sampling points inside waterbodies during the day. Push netting was 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. Scoop netting was carried out, usually in shallower waters, using hand nets (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 deployed at 50-m intervals within the streams and ponds where feasible (e.g., sufficient water depth). Traps that were left overnight were checked and removed the following morning. All caught individuals were released immediately upon identification.

Analysis of Fauna Survey Data

Species Distribution Maps

The distribution of species of conservation significance were mapped using QGIS v.3.4 (QGIS, 2024).

Taxon Sampling Curves

Taxon sampling curves were only plotted for taxa with sufficient occurrences during targeted surveys, as large sample sizes are required for a robust estimation of sample coverage. The taxa are butterflies, odonates, aculeates, reptiles, birds, mammals (including bats), fish and molluscs. Incidence data was used to estimate sample coverage and species richness. The groups of taxa were analysed separately according to their survey sampling units. Species richness was plotted against sample coverage. Sample coverage refers to “the proportion of the total number of species in a community that belongs to the species represented in the sample”, i.e., how extensively the species in the community was sampled (Chao & Jost, 2012).

The taxon sampling curves were extrapolated to provide an estimation of species richness and sample coverage if the sample size was doubled. The associated standard error and 95% confidence interval were also computed. Standard error refers to the range of uncertainty of the estimate, while the 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 4.3.2 (R Core Team, 2023), using the “iNEXT” package 3.0.0 (Hsieh et al., 2020).

Camera Trapping

Camera trap location, species identity, and the number of individuals were recorded for each video with a positive capture of faunal species (i.e., with a faunal species recorded on the video). An independent detection constitutes video(s) of one (1) or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap.

To determine the adequacy of sampling effort, coverage-based rarefaction and extrapolation sampling curves were generated for non-volant mammals using the iNEXT Online software (Hsieh et al., 2020). The same method was adopted as per for all taxa stated above.

Acoustic Bat Sampling

All recorded bat calls were analysed using Kaleidoscope version 5.4.7 (Wildlife Acoustic Inc., 2021) to separate extraneous noise from bat echolocation calls. Identification of calls to species were visually processed based on the call shape, maximum frequency, minimum peak, call duration and pulse repetition rate (Pottie et al., 2005). Once these parameters were analysed, the results will be compared to relevant publications reporting echolocation signatures for bat species in Singapore (Pottie et al., 2005; Hughes et al., 2011; Collen, 2012). It should be noted that species identification may be hampered by the lack of publicly available echolocation recordings that can be used for comparison.

5.2.3 Nomenclature and Taxonomy

The nomenclature of flora and fauna species recorded from primary field surveys and desktop study were cross-referenced with relevant key references that include books, scientific publications, unpublished literature, and online databases.

Key data sources that were used in the biodiversity baseline characterisation and taxonomic group identification and nomenclature are:

- The Biodiversity of Singapore by the Lee Kong Chian Natural History Museum (LKCNHM, n.d.)
- Flora and Fauna Web by the National Parks Board (NParks, 2024b) and iNaturalist (n.d.)
- Species List (Red Data Book List) (NParks, 2024c),
- Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development (Ng et al., 2011)

Other key local and/or regional references for various taxonomic groups are listed in Table 5.4.

Table 5.4 Key references for the nomenclature and taxonomy for each taxonomic group

Taxon	Key References
Plants	Flora of Singapore: Checklist and bibliography (Lindsay et al., 2022)
Odonates	Ngiam & Ng, (2022)
Aculeata hymenopterans	• Ascher & Pickering (2018) • Ascher et al. (2022)
Spiders	Koh et al. (2022)
Herpetofauna (amphibians and reptiles)	Figueroa et al. (2023)
Birds	Gill et al. (2022)
Freshwater Molluscs	Tan et al. (2012)

5.2.4 Assessment of Conservation Significance

The assessment of whether certain species are of conservation significance is important for highlighting the need and priorities for conservation.

Threatened species of flora—i.e., listed in NParks (2023c) as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery) and defined in Lindsay et al. (2022) (Table 5.5) —were 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 was based on, but not limited to, information on the following: (1) land use history, (2) presence of large parent tree(s), (3) commercial availability, (4) data from previous environmental impact assessments, (5) reforestation efforts, (6) natural range, and (7) importance for associated fauna. Where the origin of a threatened species population is disputable or difficult to determine, the more conservative approach was adopted, i.e., they were considered of conservation significance, with or without corroborating findings from field surveys of fauna. In carrying out such assessments, conservation needs can then be prioritised, and resources gathered 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 (NParks, 2024c) (Table 5.5) for birds, mammals including bats, herpetofauna, butterflies, odonates, aculeates and freshwater fauna. The global conservation status references the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN, 2023).

Table 5.5 Criteria for conservation significance for flora and fauna under different classification systems

Conservation Status	Definition
Local (Flora) – Lindsay et al., 2022	
Vulnerable (VU)	Between 250 to 1000 mature individuals estimated in Singapore
Endangered (EN)	Between 50 and 250 mature individuals estimated to be in Singapore, with no evidence of decline or fragmentation of populations
Critically Endangered (CR)	Fewer than 50 mature individuals estimated to be in Singapore; or if more than 50 but fewer than 250 mature individuals, with evidence of rapid decline or decline and fragmentation of populations
Presumed Nationally Extinct (NEx)	Not recorded in Singapore within the last 30 years. Endemic species that are presumed nationally extinct will consequently also be presumed to be globally extinct
Globally Extinct (EX)	Globally extinct
Data Deficient (DD)	Not enough information available to assess the risk of extinction
Local (Fauna)– NParks, 2024c or Singapore Red Data Book, 2024 (latest available)	
Vulnerable (VU)	Species with <1,000 mature individuals and >250 total individuals
Endangered (EN)	Species with <250 mature individuals
Critically Endangered (CR)	Species with <50 mature individuals or <250 total individuals
Presumed Nationally Extinct (NE)	Flora and fauna not recorded within the last 30 and 50 years, respectively
Globally Extinct (EX)	Globally extinct, including in captivity or through cultivation
International/Global (Fauna)–- IUCN Red List	
Vulnerable (VU)	Species facing a high risk of extinction in the wild
Endangered (EN)	Species facing a very high risk of extinction in the wild
Critically Endangered (CR)	Species facing an extremely high risk of extinction in the wild
Extinct in the Wild (NW)	Species that only survives through cultivation, captivity or as a naturalized population(s) outside its natural range
Extinct (EX)	Globally extinct, including in captivity or through cultivation

5.3 Baseline Descriptions

This section presents the baseline findings compiled from primary data (field surveys) and secondary data (desktop study of historical data). The ecological field surveys were carried out from 29th August 2023 to 7th December 2023.

5.3.1 Terrestrial Habitats

Seven habitat types (four vegetated and three non-vegetated) were recorded within the Ecology Survey Area (Table 5.6, Figure 5.4). Nearly half of the area was taken up by built-up areas (13.0 ha, 45.1%), located in the southwest. Other areas were found to be mostly occupied by scattered patches of abandoned plantation forest (7.1 ha, 24.6%), scrubland (4.3 ha, 14.9%) and exotic-dominated secondary forest (2.9 ha, 10.2%). Two relatively small independent patches of native-dominated secondary forest (0.6 ha, 2.0%) were recorded. The remaining habitat consists of non-vegetated cleared area (0.3 ha, 1.2%) that only occupies a small portion of the overall area.

Table 5.6 Absolute and relative sizes of each habitat type in the Ecology Survey Area.

Category	Habitat type	Absolute size (ha)	Relative size (%)
Vegetated	Abandoned Plantation Forest	7.1	24.6
	Scrubland	4.3	14.9
	Exotic-dominated Secondary Forest	2.9	10.2
	Native-dominated Secondary Forest	0.6	2.0
Non-vegetated	Waterbodies	0.6	2.0
	Built-Up Area	13.0	45.1
	Cleared Area	0.3	1.2
	Total	**28.8**	**100**

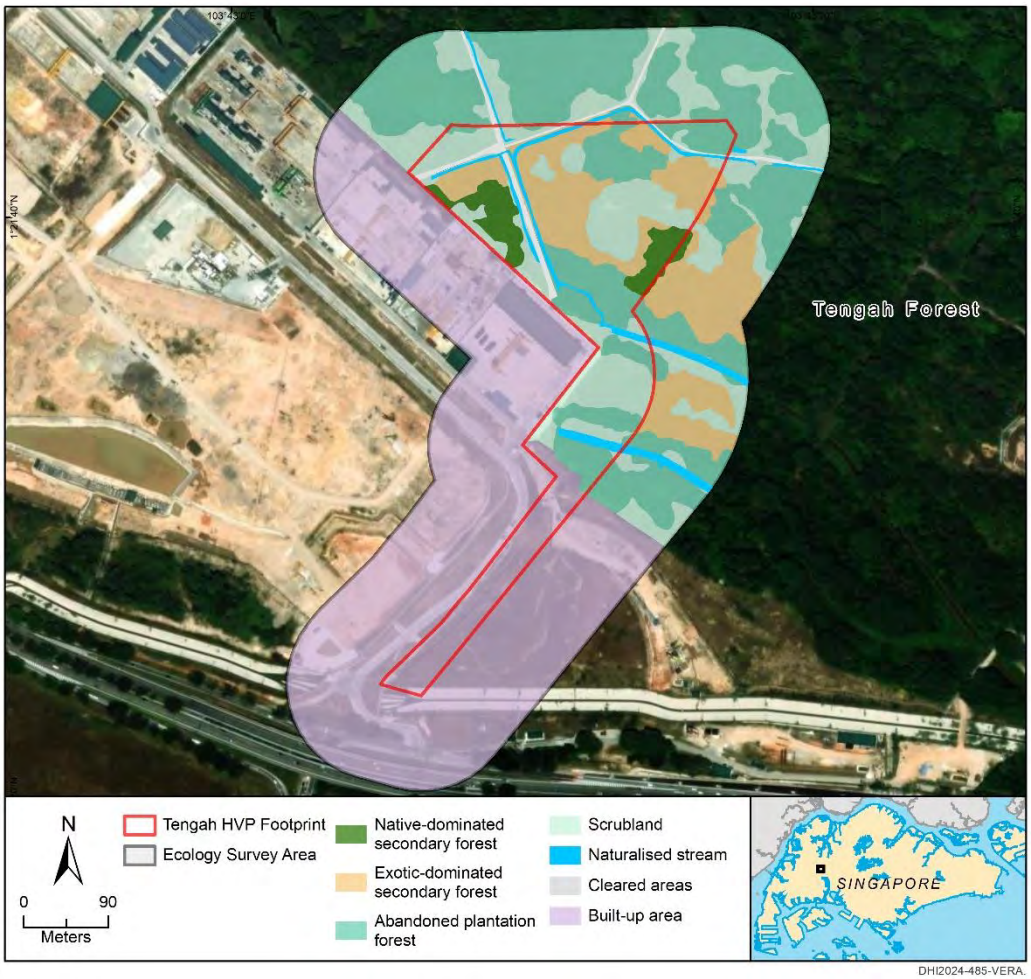

Figure 5.4 Habitat and vegetation map of Ecology Survey Area in Tengah HVP.

5.3.1.1 Abandoned Plantation Forest

Abandoned plantation forest (7.1 ha, 24.6%; Figure 5.4) is the largest vegetated habitat type in the Ecology Survey Area. Multiple large patches were found scattered across the Ecology Survey Area, with some located in waterlogged areas (Figure 5.5A) or intersected by small streams. Notable threatened species observed in this habitat type include the nationally Critically Endangered *Curculigo capitulata*, together with a few specimens of the nationally Vulnerable *Macaranga griffithiana* and *Goniophlebium percussum*.

Commonly encountered species within the understory of forest type include Simpoh Air (*Dillenia suffruticosa*), Wild Cinnamon (*Cinnamomum iners*; Figure 5.5B), Oil Palm (*Elaeis guineensis*; Figure 5.5C), and *Syzygium* spp. In the canopy stratum, different clusters were observed to be dominated either by Sea Almond (*Terminalia catappa*), Oil Palm, Rambutan (*Nephelium lappaceum*) and African Tulip (*Spathodea campanulata*). This could have been a result of past cultivation that has persisted to present day. Additionally, numerous large *Ficus microcarpa* trees were also recorded across the abandoned plantation forest.

Figure 5.5 Abandoned plantation forest in the Ecology Survey Area: (A) abandoned plantation forest occurring within a waterlogged area; (B) Wild Cinnamon (*Cinnamomum iners*); and (C) Oil Palm (*Elaeis guineensis*).

5.3.1.2 Scrubland

Scrubland occupies approximately 4.3 ha (14.9%; Figure 5.4) of the overall Ecology Survey Area as scattered patches. Two notable species that were found within the scrubland are the nationally Critically Endangered *Xyris complanata* and nationally Vulnerable *Scurrula ferruginea*.

In the waterlogged areas, species like *Neptunia plena* and *Mimosa pudica* were encountered frequently. In areas where it was relatively drier, clusters of Elephant Grass (*Cenchrus purpureus*; Figure 5.6A), *Urochloa mutica*, *Asystasia gangetica* subsp. *micrantha*, and *Ottochloa nodosa*; Figure 5.6B) were recorded.

In the large patch of scrubland in the central region of the Ecology Survey Area (Figure 5.6D), the scrubland here includes Resam Fern (*Dicranopteris linearis* var. *linearis*) and Clubmoss (*Palhinhaea cernua*), clusters of Slender Pitcher Plant (*Nepenthes gracilis*), and multiple saplings of Tembusu (*Cyrtophyllum fragrans*). In addition, Simpoh Air were observed stretching along the boundary of the scrubland and multiple clusters of the fern *Nephrolepis biserrata* (Figure 5.6C) were recorded in some open areas.

Figure 5.6 Scrubland in the Ecology Survey Area showing a variation of vegetation clusters: (A) *Cenchrus purpureus*; (B) spontaneous vegetation (including *Urochloa mutica, Asystasia gangetica* subsp. *micrantha*, and *Ottochloa nodosa*); (C) *Nephrolepis biserrata*; and (D) *Dicranopteris linearis* var. *linearis* and *Palhinhaea cernua*.

5.3.1.3 Exotic-dominated Secondary Forest

Exotic-dominated secondary forest (2.9 ha, 10.2%; Figure 5.4) patches are mainly situated in the central and southeastern regions of the Ecology Survey Area. Species of conservation significance that were found in other vegetation types—*Macaranga griffithiana*, *Melicope lunu-ankenda* and *Glochidion zeylanicum* var. *zeylanicum*— were also recorded in the exotic-dominated secondary forest patches. On the other hand, the nationally Endangered *Ficus caulocarpa* and Vulnerable *Litsea umbellata* were only present in this forest type in the entire Ecology Survey Area.

Exotic-dominated secondary forests typically regenerate on cleared areas or highly disturbed environments. As a result, the floristic composition is characterised by fast-growing exotic species, including Albizia (*Falcataria falcata*), *Leucaena leucocephala* subsp. *leucocephala*, *Acacia auriculiformis*, *Acacia mangium* and African Tulip trees. Another commonly observed species is *Vitex pinnata*. A majority of the understory was found to be dominated by Simpoh Air, except for some areas with sparse growth of Wild Cinnamon and *Gnetum gnemon* (Figure 5.7).

Figure 5.7 Exotic-dominated secondary forest in the Ecology Survey Area.

5.3.1.4 Native-dominated Young Secondary Forest

Native-dominated secondary forest (0.6 ha, 2.0%; Figure 5.4) was recorded within the central region of the Ecology Survey Area. This forest type occurs as two distinct patches, both of which display similar floristic compositions. The predominant species of the understory layer of this forest type is Simpoh Air (Figure 5.8A). Numerous trees of conservation significance with girths of more than 0.3 m were found concentrated within the native-dominated secondary forest and growing amongst the Simpoh Air. These species of conservation significance—*Macaranga griffithiana*, *Melicope lunu-ankenda* and *Glochidion zeylanicum* var. *zeylanicum*—were seen extending into the canopy layer (Figure 5.8B). The presence of fast-growing *Acacia auriculiformis* (Figure 5.8C) and Albizia trees, which occur throughout the Ecology Survey Area, were also found in this forest type.

Even though the forest patch is categorised as native-dominated young secondary forest, intrusive growth of fast-growing Albizia and *Acacia auriculiformis* trees, into the fringes of native forest from the surrounding exotic-dominated forest was observed. This is usually indicative of environmental disturbances or as a result of succession from a recently cleared area. As the site had not been recently cleared, it is highly likely that the Albizia and *Acacia auriculiformis* are recent successions as compared to the existing native forest. Moreover, the presence of these native trees of conservation significance with girths above 0.3 m suggests that the native-dominated young secondary forest had established for some time.

Figure 5.8 Native-dominated secondary forest in the Ecology Survey Area: (A) Understory layer with Simpoh Air (*Dillenia suffruticosa)*; (B) Canopy layer with *Melicope lunu-ankenda*; and (C) Presence of *Acacia auriculiformis* tree.

5.3.1.5 Waterbodies

Three main types of waterbodies were found present within the Ecology Survey Area (0.6 ha, 2.0%; Figure 5.4). Naturalised streams along the roads, that were likely dug out as drainage channels, were found bordering the forest patches (Figure 5.9A). Two forest streams were also found in the south of the Ecology Survey Area which had already been present during the 1940s (Figure 2.5B; Figure 5.9B). An unmanaged soft-bank pond was encountered in the northeast of the Ecology Survey Area that appears to be perennially inundated and covered in Duckweed (*Lemna aequinoctialis*) (Figure 5.9C).

Figure 5.9 Different types of water bodies occurring within the Ecology Survey Area of Tengah HVP: (A) Naturalised stream; (B) Forest stream; and (C) Unmanaged soft-bank pond.

5.3.1.6 Built-up Area

The built-up area (13.0 ha, 45.1%; Figure 5.4), belonging to the construction of the Jurong Region Line Integrated Rail & Bus Depot was found located in the southwest region of the Ecology Survey Area (Figure 5.4).The built-up area (13.0 ha, 45.3%; Figure 5.4), belonging to the construction of the Jurong Region Line Integrated Rail & Bus Depot was found located in the southwest region of the Ecology Survey Area (Figure 5.10).

Figure 5.10 Hoarded built-up area of the Jurong Region Line Integrated Rail & Bus Depot.

5.3.1.7 Cleared Area

The cleared area (0.3 ha, 1.2%; Figure 5.4) are roads with overgrown shrubs within the Ecology Survey Area that makes up a small portion of the overall area (Figure 5.11).

Figure 5.11 Cleared area in the Ecology Survey Area of Tengah HVP.

5.3.2 Terrestrial Flora

A total of 134 species and species groups belonging to 60 families were recorded from the Ecology Survey Area.

Of these, more than half comprise of native species (87 species, 64.9%). The remaining half includes exotic (42 species, 31.4%) and cryptogenic (5 species, 3.7%). The list of flora species is provided in Appendix B1. The numbers and percentages of the plant species belonging to each status category at each site are summarised in Table 5.7.

Native threatened species include species that have been accorded the following statuses: Vulnerable, Endangered, Critically Endangered and Presumed Extinct. For the overall findings, 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 Section 5.3.2.3.

Table 5.7 Number and percentage of plant species belonging to each status category in the Ecology Survey Area of Tengah HVP.

Origin	Status	Number of species	Percentage (%)
Native		**87**	**64.9**
Critically Endangered		6	4.5
Endangered		3	2.2
Vulnerable		7	5.2
Least Concern		70	52.2
Data Deficient		1	0.8
Exotic		**42**	**31.4**
Naturalised		24	18.0
Casual		11	8.2
Cultivated Only		7	5.2
Cryptogenic		**5**	**3.7**
Total		**134**	**100**

5.3.2.1 Species of Conservation Significance

Out of the 16 threatened native species, 11 are considered of conservation significance (Table 5.8; Figure 5.12), while 5 were likely to be persistent from cultivation. In sum, 199 specimens and/or clusters of specimens belonging to these species of conservation of significance were recorded and detailed in Appendix B2.

Table 5.8 Number of plant species of conservation significance in the Ecology Survey Area of Tengah HVP.

Status	Vulnerable	Endangered	Critically Endangered	Presumed Extinct	Total
Non-cultivated threatened Species	7	2	2	0	11
Cultivated threatened species	0	1	4	0	5
Total	**7**	**3**	**6**	**0**	**16**

Table 5.9 Breakdown of plant species of conservation significance in the Ecology Survey Area of Tengah HVP.

Habitat	Number of Individuals and Clusters					Number of Species				
	VU	EN	CR	EX	Total	VU	EN	CR	EX	Total
Native-dominated Secondary Forest	26	40	0	0	**66**	2	1	0	0	**3**
Abandoned Plantation Forest	58	4	1	0	**63**	5	1	1	0	**7**
Exotic-dominated Secondary Forest	34	14	0	0	**48**	5	2	0	0	**7**
Scrubland	15	1	1	0	**17**	4	1	1	0	**6**
Cleared Areas	3	0	0	0	**3**	2	0	0	0	**2**
Built-up areas	1	1	0	0	**2**	1	1	0	0	**2**

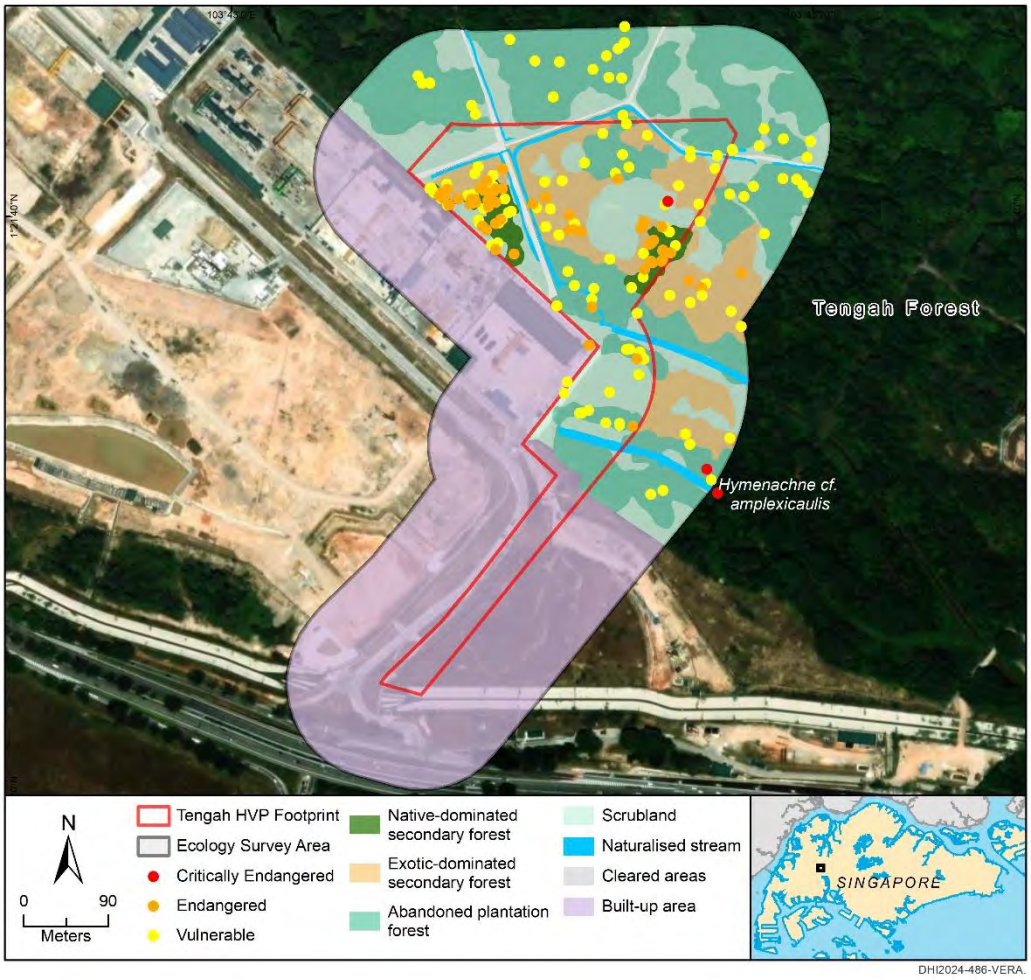

Figure 5.12 Location of plant species of conservation significance in the Ecology Survey Area of Tengah HVP, including *Hymenachne* cf. *amplexicaulis* that is at the 8 m away from the southeast boundary.

Majority of the species of conservation significance—mainly saplings of more than 0.3m girth—were found to be concentrated within the native-dominated secondary forest. Clusters of these species were also observed in other vegetation types such as abandoned plantation forest and exotic-dominated secondary forest, where they exhibit a girth range of less than 0.3 m.

Among all the native threatened species recorded, the most abundant species include the nationally Endangered *Melicope lunu-ankenda* (Figure 5.13A), nationally Vulnerable *Macaranga griffithiana* (Figure 5.13B), and *Glochidion zeylanicum* var. *zeylanicum* (Figure 5.13C). Populations of these three species have also been recorded in other areas across Tengah Forest (Camphora Pte. Ltd., unpublished data). Other notable native species recorded in the Ecology Survey Area include the nationally Endangered *Ficus caulocarpa* (Figure 5.13D), nationally Vulnerable *Goniophlebium percussum* (Figure 5.13E), *Cissus repens* (Figure 5.13F) and *Litsea umbellata*.

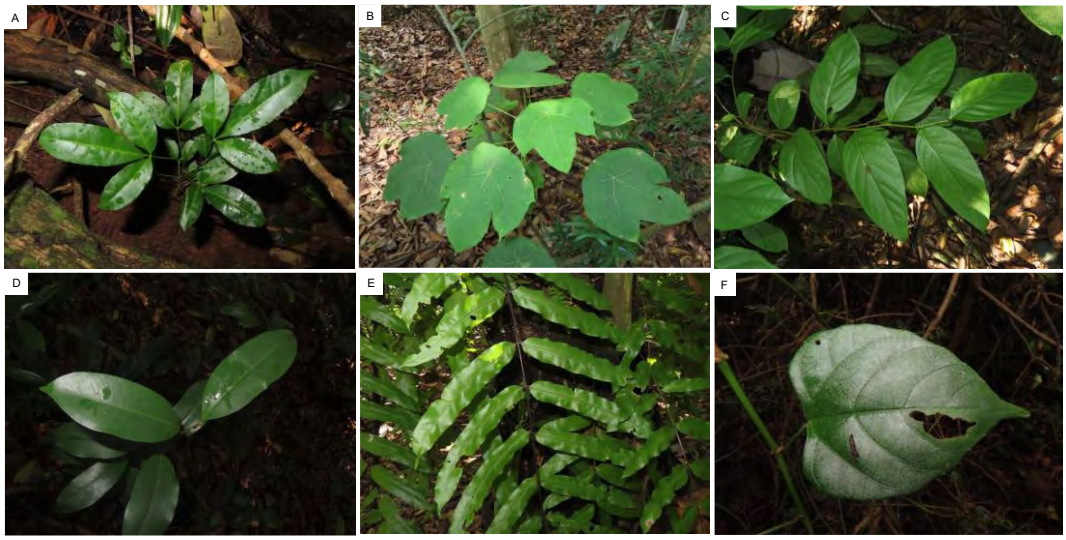

Figure 5.13 Plant species of conservation significance in Ecology Survey Area of Tengah HVP: (A) *Melicope lunu-ankenda*; (B) *Macaranga griffithiana*; (C) *Glochidion zeylanicum* var. *zeylanicum*; (D) *Ficus caulocarpa* (E) *Goniophlebium percussum*; and (F) *Cissus repens*.

Two clusters of the nationally Vulnerable *Selaginella willdenowii* (Figure 5.14A) were also recorded within the abandoned plantation forest in the southeastern region of the Ecology Survey Area. A small individual of *Curculigo capitulata* (Figure 5.14B) was also recorded. Limited information on the species' distribution and habitat in Singapore are available. To date, there are only three vouchered specimens in SING herbarium, all collected from Singapore Botanic Gardens (SBG). The population of this species elsewhere in Singapore is unknown, underscoring the significance of this finding.

The only nationally Critically Endangered species identified in the scrubland habitat is *Xyris complanata* (Figure 5.14C). The status of this species was previously listed as a 'weed of uncertain origin' in Chong et al. (2009) but was revised to Critically Endangered by Leong-Škorničková (2019). Vouchered specimens in the SING herbarium were last collected in 2008 from Tampines-Punggol area. However, Leong-Škorničková (2019) suggested that the population from Tampines may no longer exist owing to urban development. There are no known populations west of Punggol. Therefore, the findings in the Ecology Survey Area hold significance as a new locality record within Singapore, potentially shedding light on undetected populations in other locations. The habitat supporting *X. complanata* in this site aligns with the description in Leong-Škorničková (2019), which describes its preference for open wet sandy habitats. Other Vulnerable native species recorded in this habitat includes the mistletoe *Scurrula ferruginea*.

Also Critically Endangered, a notable record of a cluster of *Hymenachne* cf. *amplexicaulis* (Figure 5.14D) grass was recorded in the southeast of the Ecology Survey Area about 8m away from the boundary (Figure 5.12). This species inhabits vegetation near a water source and are found elsewhere in swamps, edges of ponds, and rivers with slow-flowing freshwater (Veldkamp et al., 2019).

Figure 5.14 Other plant species of conservation significance found in Ecology Survey Area of Tengah HVP: (A) *Selaginella willdenowii*; (B) *Curculigo capitulata*; (C) *Xyris complanata*; and (D) *Hymenachne* cf. *amplexicaulis*.

5.3.2.2 Large Plant Specimens

A total of 37 large plant specimens were recorded in the Ecology Survey Area (Figure 5.15, Table 5.10, Appendix B3). Of these specimens, 16 (43.2%) are native and 21 are exotic (56.8%). Similarly, 17 specimens are stranglers (4.0–20.0 m girth spread) and 21 are large tree specimens (3.0–5.0 m girth). The most abundant large specimens that were encountered in the Ecology Survey Area are *Spathodea campanulata* (Figure 5.16A) and *Ficus microcarpa* (Figure 5.16B).

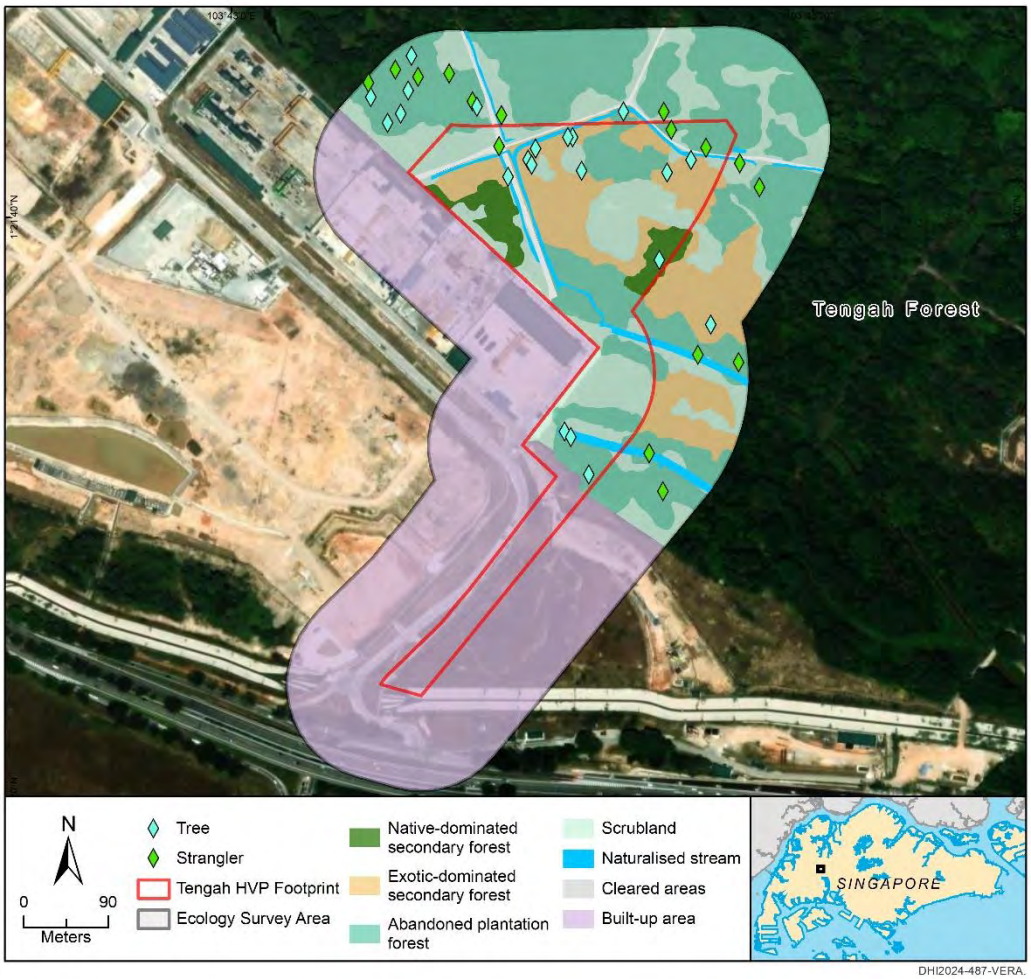

Figure 5.15 Location of large plant specimens in the Ecology Survey Area of Tengah HVP.

Table 5.10 Number of large plant specimens in the Ecology Survey Area of Tengah HVP.

Habit	Species	Origin	Status	No. of specimens
Tree	*Acacia auriculiformis*	Exotic	Naturalised	2
	Falcataria falcata	Exotic	Naturalised	6
	Hevea brasiliensis	Exotic	Naturalised	1
	Samanea saman	Exotic	Casual	2
	Spathodea campanulata	Exotic	Naturalised	10
Strangler	*Ficus microcarpa*	Native	Least Concern	16
			Total	37

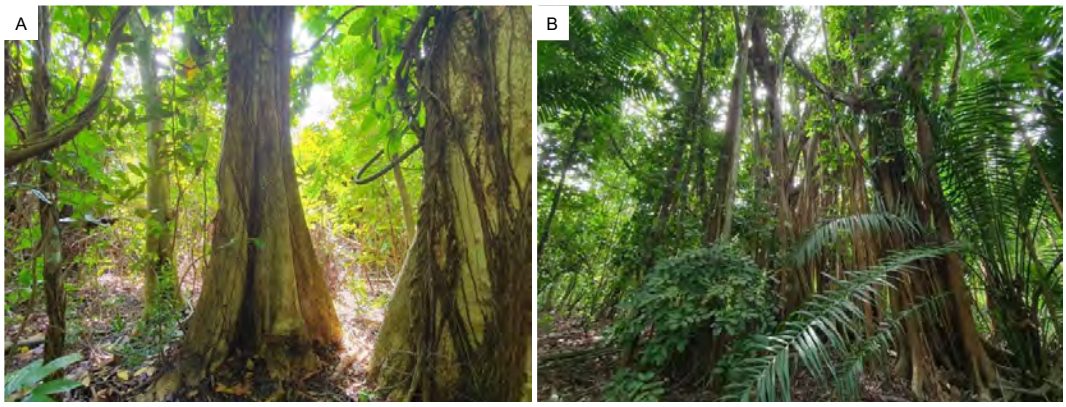

Figure 5.16 Large plant specimens in the Ecology Survey Area of Tengah HVP: (A) *Spathodea campanulata* and (B) *Ficus microcarpa*.

5.3.2.3 Other Plant Specimens of Value

A total of 12 specimens of value were recorded in the Ecology Survey Area (Figure 5.17; Table 5.11; Appendix B4). These specimens were only found in the abandoned plantation forest, with *Ardisia elliptica* (Figure 5.18A) as the most abundant species recorded, followed by *Ficus microcarpa* (Figure 5.18B) and *Ficus benjamina*.

Ardisia elliptica is a Least Concern native species. However, it has significance as a host plant to the threatened butterfly species, the Harlequin (*Taxila haquinus haquinus*) butterfly. Butterflies being typically host-specific, depend on specific plants for their life cycles. Even though there were no records of Harlequin butterfly found in this study, it had been recorded elsewhere within Tengah Forest (LTA, 2023) and is considered of probable occurrence within the Ecology Survey Area. *Ardisia elliptica* found in this area is likely dispersed from cultivated sources from urban areas.

Ficus species are commonly known as a keystone species in the tropics. This particularly refers to the monoecious figs such as *Ficus benjamina* and *Ficus microcarpa*—species that bear both male and female reproductive organs within the same individual. This unique characteristic enables monoecious figs to produce fruits all year round, especially during periods when alternative fruits are scarce (Lok et al., 2013). The interactions involving fig species emphasise their ecological importance in sustaining fauna populations within their ecosystems. Four *Ficus* specimens with a spread of < 3 m, that did not meet the criteria of large specimens, were considered as other plant specimens of value given their importance as keystone species.

Some other plants of note detected within the study area are *Caryota mitis*, *Leea indica* and *Dillenia suffruticosa*. They serve as sources of food for native biodiversity as well.

Table 5.11 Number of other plant specimens of value in the Ecology Survey Area of Tengah HVP.

Habit	Species	No. of specimens	Remarks
Shrub/Tree	*Ardisia elliptica*	8	Likely from cultivated source
Strangler	*Ficus microcarpa*	3	Least Concern
	Ficus benjamina	1	Cryptogenic

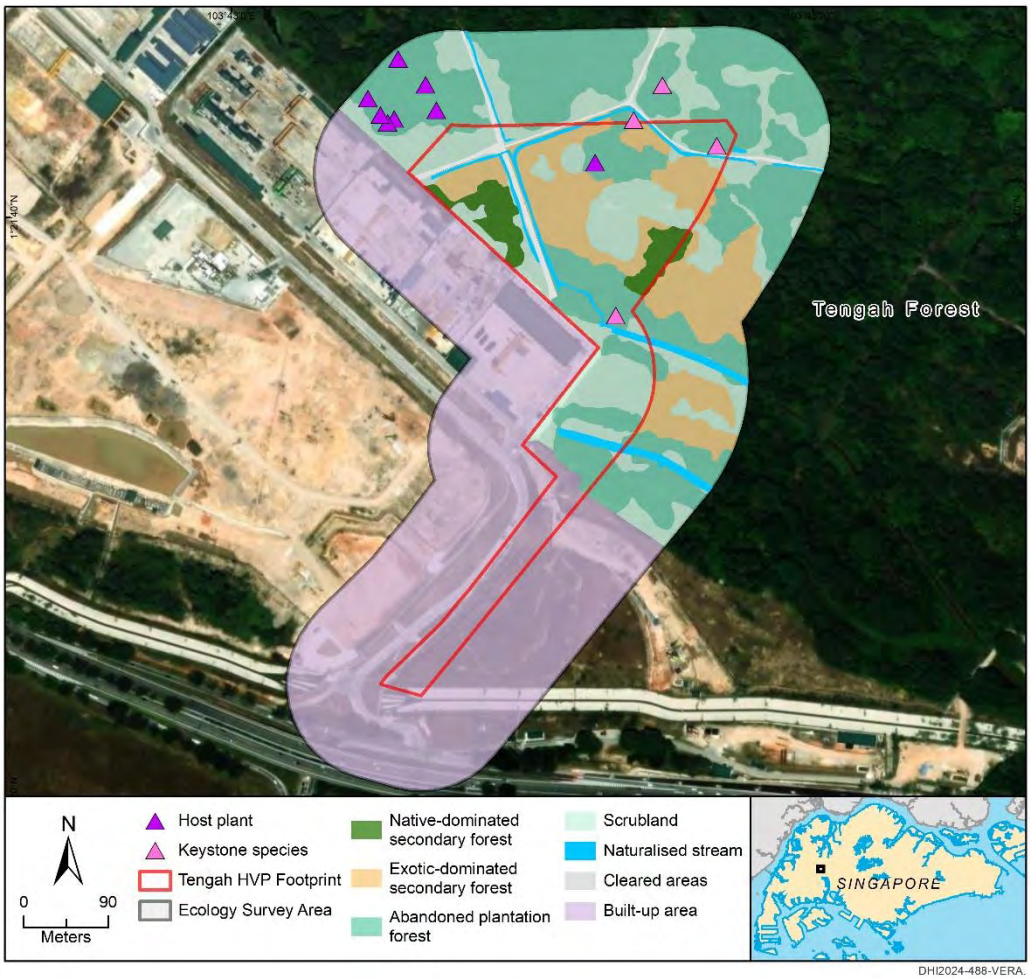

Figure 5.17 Location of other specimens of value in the Ecology Survey Area of Tengah HVP.

Figure 5.18 Other specimen of value in Ecology Survey Area of Tengah HVP: (A) *Ardisia elliptica* and (B) *Ficus microcarpa*.

5.3.2.4 Tree Mapping

A total of 310 trees and stranglers with girth/spread > 1 m were mapped in the Tengah HVP Footprint (Figure 5.19; Appendix B5). Of these, more than half are exotic species (188; 60.6%), 115 (37.1%) are native and seven are cryptogenic (2.2%). Four species make up more than 50% of the total number of trees mapped — *Spathodea campanulata* (76 specimens), *Melicope lunu-ankenda* (42 specimens), *Acacia auriculiformis* (39 specimens), and *Elaeis guineensis* (33 specimens), yielding a total of 190 individuals.

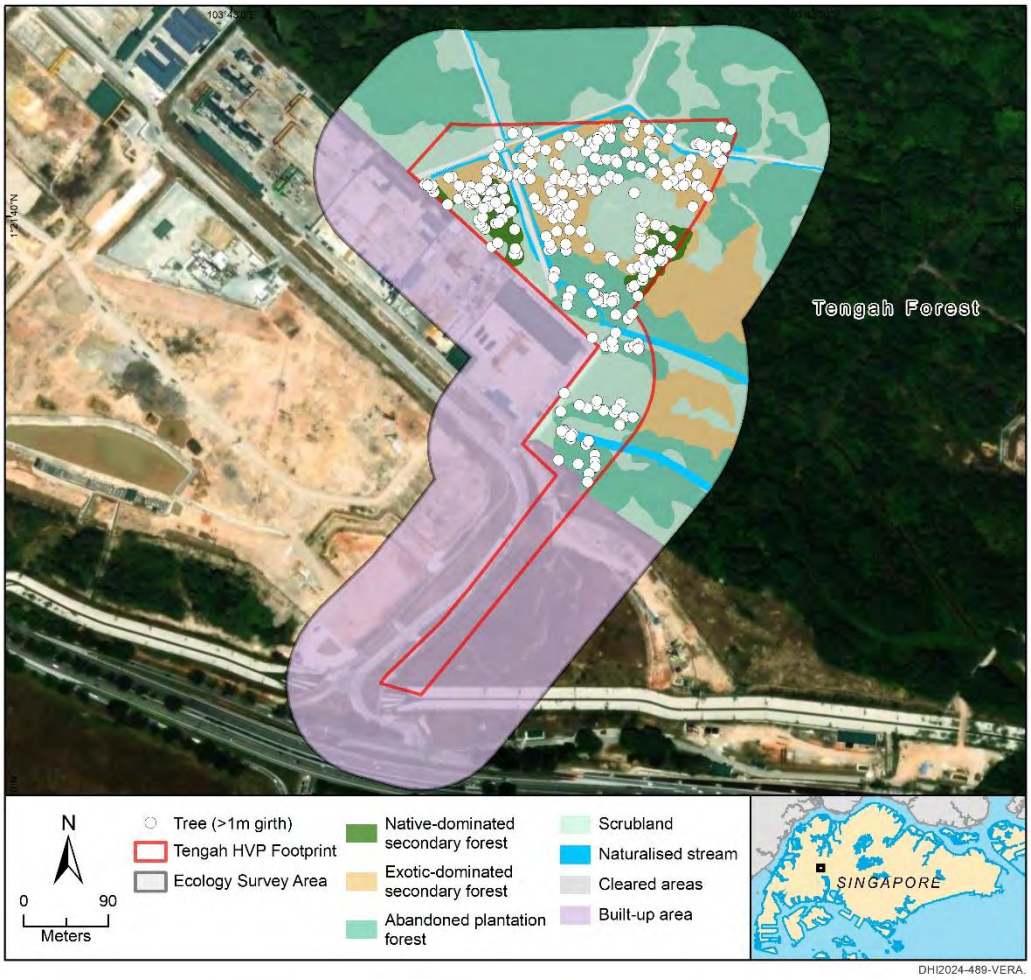

Figure 5.19 Location of trees mapped within the Tengah HVP Footprint.

5.3.3 Terrestrial Fauna

The field assessment recorded a total of 152 faunal species. In decreasing order of species richness, birds had the highest number of species recorded, followed by odonates, butterflies, herpetofauna, fish, aculeates, mammals, molluscs and decapod crustaceans (Table 5.12). Of these, 11 species are of conservation significance and further detailed in Section 5.3.3.9.

The list of recorded faunal species and probable species of conservation significance is available in Appendix B6.

Table 5.12 Summary of recorded faunal species and species of conservation significance in the Ecology Survey Area of Tengah HVP.

Faunal Group	Total no. of recorded species	
	All species	CS species
Birds	46	7
Mammals	9	1
Herpetofauna	18	0
Butterflies	22	0
Odonates	26	1
Aculeates	10	0
Fish	13	2
Decapod Crustaceans	1	0
Molluscs	7	0
Total	**152**	**11**

5.3.3.1 Taxon Sampling Curves

For transect surveys, sample coverage was generated for the following taxa: (1) odonates, (2) aculeate hymenopterans, (3) butterflies, (4) amphibians, (5) reptiles, (6) birds, (7) non-volant mammals, and (8) bats. For aquatic point counts, sample coverage was generated for the following taxa: (1) amphibians, (2) fish, (3) molluscs, (4) odonates and (5) reptiles. The analysis was not generated for decapod crustaceans as the number of species collected was too low. In addition, taxon sampling curves was not generated for camera trapping due to insufficient sampling units for the analysis. For transect surveys, all faunal groups show sample coverage of more than 80%, with the exception of butterfly, odonates and reptile. For aquatic surveys, the sample coverage was above 90% for all faunal groups, with the exception of reptiles. A summary of the taxon sampling analysis is shown in Table 5.13 and the sample coverage curves are shown in Figure 5.20.

Typically, sites with a high number of rare species and a few common species have a low inflection point (point where change in curvature is observed) on the sample-coverage axis and a 'long upward sloping line to the asymptote' (line where curve approaches) (Thompson & Withers, 2003). Although there were more species encountered for the observed richness during the aquatic surveys than transect surveys, all six unique species recorded during aquatic surveys recorded only one individual. These six reptile species were not rare species, but common species recorded in low abundance as illustrated by the lack of an inflection point in the sample completeness curve of aquatic surveys (Figure 5.20), where the species accumulation curve has not reached a point to provide an accurate estimate of species richness. While the sampling effort was sufficient as there were 21 aquatic points and two cycles each, the aquatic survey is a supplementary survey method for reptiles. In addition, the aquatic points were in forest streams (Figure 5.2; Table 5.3) that had varying depths and widths along their course, and for safety reasons, could only be accessed from the stream banks or edges at some points. Hence, common species such as the Red-eared Slider (*Trachemys scripta*) can be hard to spot/net from the murky waters.

Table 5.13 Result summary of the taxon sampling analysis.

Taxon	Sample coverage (%)	Observed Richness	Estimated Richness ± S.E.	95% Confidence Interval
Terrestrial Transect Surveys				
Aculeates	80.2	7	8 ± 2.2	7.2 – 19.5
Amphibian	100.0	7	7 ± 0.4	7.0 – 7.9
Bird	90.5	38	50 ± 8.5	41.2 – 79.9
Butterfly	74.9	19	25 ± 5.7	20.5 – 47.4
Mammal (bat)	100.0	3	3 ± 0.2	3.0 – 3.3
Mammal (non-bat)	100.0	4	4 ± 0.4	4.0 – 5.0
Odonata	72.1	15	54 ± 47.2	21.0 – 266.1
Reptile	69.1	3	4 ± 2.0	3.1 – 15.5
Aquatic Surveys				
Amphibian	100.0	8	8 ± 0.6	8.0 – 9.5
Fish	98.9	14	15 ± 1.3	14.1 – 21.7
Mollusc	100.0	6	6 ± 0.1	6.0 – 6.2
Odonata	93.6	19	31 ± 13.0	21.2 – 86.4
Reptile	0.5	6	21 ± 13.3	9.3 – 72.9

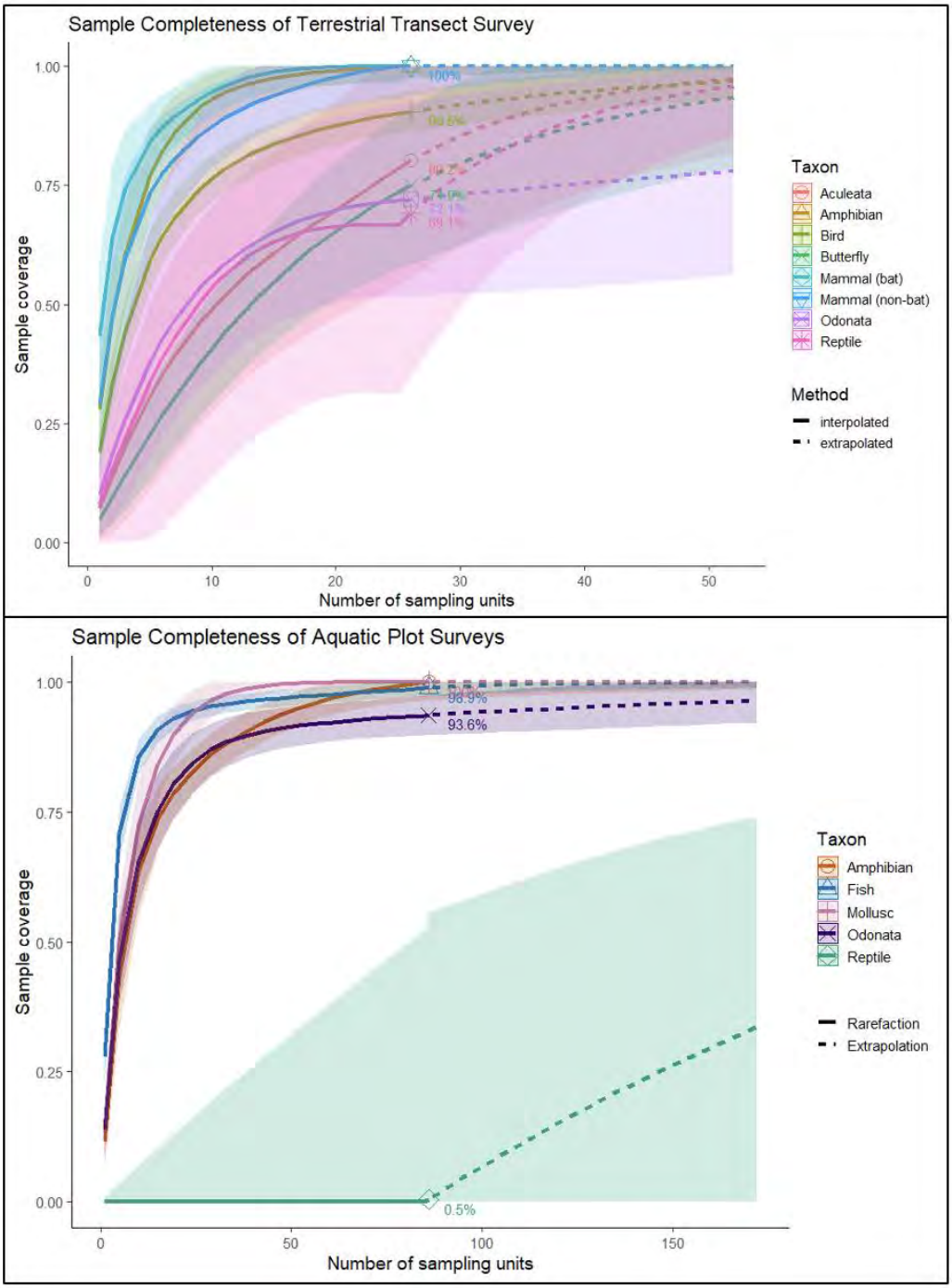

Figure 5.20 Taxon sampling curves for terrestrial transect and aquatic sampling points.

5.3.3.2 Birds

A total of 46 bird species were recorded from transect surveys and incidental findings, of which seven are species of conservation significance. The latter include the globally Critically Endangered Straw-headed Bulbul (*Pycnonotus zeylanicus*), the nationally Endangered Blue-eared Kingfisher (*Alcedo meninting*) and the nationally Vulnerable Large-billed Crow (*Corvus macrorhynchos*), Grey-headed Fish Eagle (*Icthyophaga ichthyaetus*), Changeable Hawk-eagle (*Nisaetus cirrhatus*), Swinhoe's White Eye (*Zosterops simplex*) and the globally Vulnerable Long-tailed Parakeet (*Psittacula longicauda*) (Figure 5.22).

The Straw-headed Bulbul was both heard and observed during the surveys. It is a frugivore that commonly occurs in forest and wooded habitats (Lim, 2019). A recent study by Chiok et al., 2020 revealed the importance of Singapore as a stronghold with local population estimates ranging from 22.9-57.3% of the species in Southeast Asia. In contrast with the global populations, local populations are less susceptible, but not completely unexposed to poaching pressures.

The Blue-eared Kingfisher is a forest piscivore and is highly dependent on streams and waterbodies for foraging. During the baseline study, the Blue-eared Kingfisher was recorded incidentally on two separate occasions, one of which was a sighting of an individual feeding on a small Common Snakehead (*Channa striata*) in the naturalised stream along the roads (Figure 5.21A).

Figure 5.21 Images of birds recorded at Ecology Survey Area: (A) Endangered Blue-eared Kingfisher (*Alcedo meninting*) feeding on a small Common Snakehead (*Channa striata*); (B) Vulnerable dark morph Changeable Hawk-eagle (*Nisaetus cirrhatus*); (C) Near Threatened and migrant Black-backed Dwarf Kingfisher (*Ceyx erithaca*).

The Large-billed Crow is an uncommon resident breeder that is less adapted to urban environments in comparison to the widespread and introduced House Crow (*Corvus splendens*) (Tan et al., 2020). Its decline is attributed to the competition by House Crows and a loss of secondary forest which the Large-billed Crows inhabit (Lim et al., 2003).

The Grey-headed Fish Eagle was recorded incidentally during an aquatic survey. It is known to forage in various large waterbodies in Singapore including reservoirs, quarry lakes, and canals (Bird Society of Singapore, 2023a). The small waterbodies within the Ecology Survey Area, however, are unlikely to support the foraging needs of the eagle, which was likely just passing through when spotted by the surveyors. Another raptor species, the Changeable Hawk-eagle (Figure 5.21B), was recorded incidentally and during the transect surveys. Being able to nest successfully in tall Albizia trees that are common in Singapore, the Changeable Hawk-eagle has adapted to tolerate less preferred habitats (Bird Society of Singapore, 2023b). Even though there were suitable trees present within the Ecology Survey Area, there were no records of raptor's nests.

Three Swinhoe's White-eyes were seen during the transect surveys. The national status of the Swinhoe's White-eye was recently raised to Vulnerable (NParks, 2023c) because the local population of the naturally-occurring native *erwini* subspecies appears to be confined to Pulau Ubin (Wu et al., 2023). On the main island of Singapore, the White-eye population is mostly composed of the non-native *simplex* or hybrid *simplex-erwini* gene pools believed to be established from escaped individuals from the pet trade. Although the individuals recorded in this assessment are most likely of introduced origin and unlikely to be of true conservation significance, there is still a possibility that they are of the native gene pool established from natural range expansion. Hence, it is still conservatively regarded as a species of conservation significance in this study.

Long-tailed Parakeets were recorded flying over the Ecology Survey Area in flocks of up to four individuals during the surveys. It is considered as a species of conservation significance due to habitat loss resulting from urbanisation as this species requires trees to nest in. Plausibly, the presence of other exotic and more adaptable parrots—such as the Red-breasted Parakeet (*Psittacula alexandri*) which were found in the Ecology Survey Area

in flocks of up to 12 individuals and occupying nest-holes—might outcompete and displace the native parrots (Neo, 2012).

Two winter visitors were recorded Black-backed Dwarf Kingfisher (*Ceyx erithaca*) and Barn Swallow (*Hirundo rustica*) (Table 5.14). The Barn Swallow is commonly sighted in Singapore (Bird Society of Singapore, 2023c) while the Black-backed Dwarf Kingfisher is an uncommon migrant. The latter was observed roosting on a tree in the mid-canopy during a nocturnal survey (Figure 5.21C).

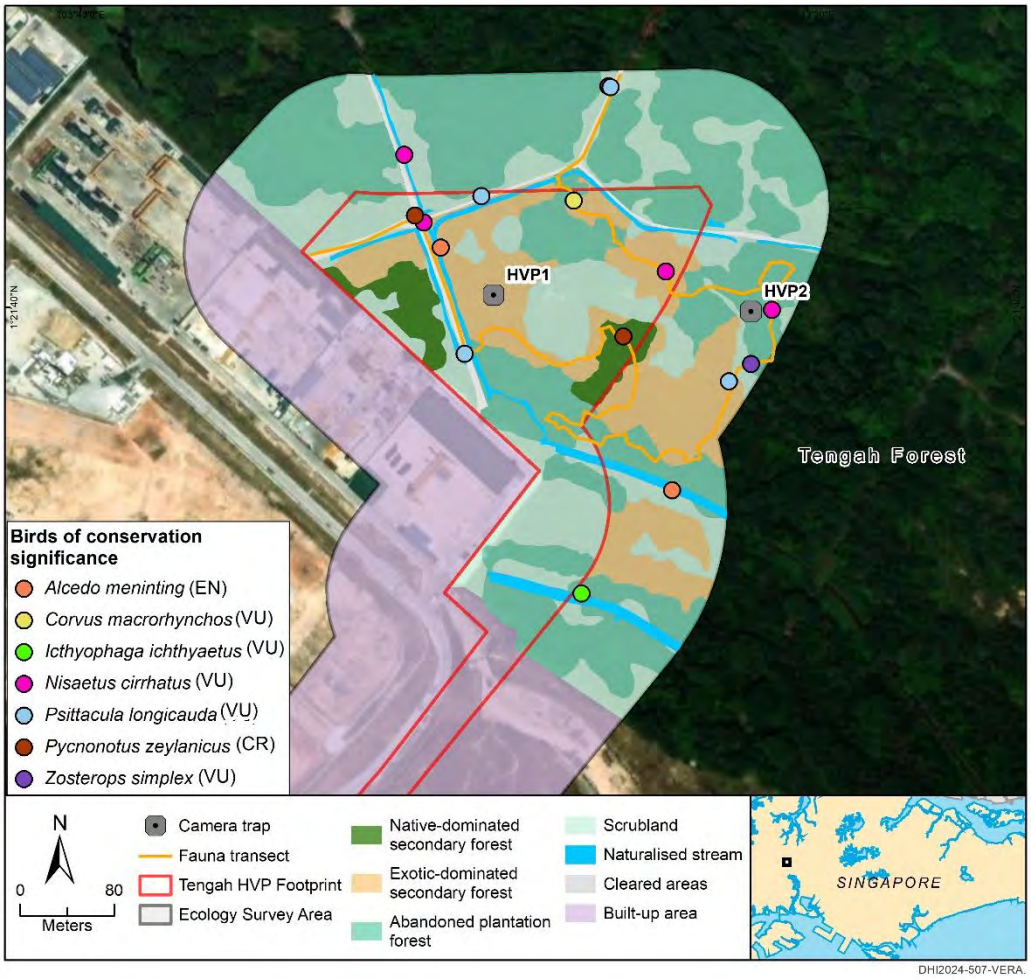

Figure 5.22 Birds of conservation significance noted along the faunal transect in the Ecology Survey Area of Tengah HVP.

Table 5.14 List of migratory bird species in Ecology Survey Area of Tengah HVP.

Scientific Name	Common Name	Global Status	National Status	Distribution and Rarity	Migrant Status
Ceyx erithaca	Black-backed Dwarf Kingfisher	Least Concern	Near Threatened	Uncommon	Winter visitor
Hirundo rustica	Barn Swallow	Least Concern	Near Threatened	Abundant	Winter visitor

5.3.3.3 Mammals

Non-volant Mammals

A total of five non-volant mammals were recorded from camera trap surveys, transect surveys and incidental findings, of which, the globally Endangered Long-tailed Macaque (*Macaca fascicularis*) is a species of conservation significance.

A single footage of a Long-tailed Macaque was recorded at camera trap station HVP2 which was deployed in the eastern section of the Ecology Survey Area (Figure 5.23). The core population of this species occurs in Western Catchment, Bukit Timah and Central Catchment Nature Reserves and Mandai (Sha et al., 2009; Riley et al., 2015). Although the Long-tailed Macaque is commonly associated with human-wildlife conflict, a census-wide survey in Singapore conducted by Riley et al. (2015) found no evidence of overpopulation. In addition, the native populations were more associated with wild populations than synanthropic populations, when compared to the same species occurring in Southeast Asia. Hence, the Long-tailed Macaques that are typically deemed as a nuisance are actually wild populations that require mitigation measures against human-wildlife conflict such as monkey guarding (Lew, 2019).

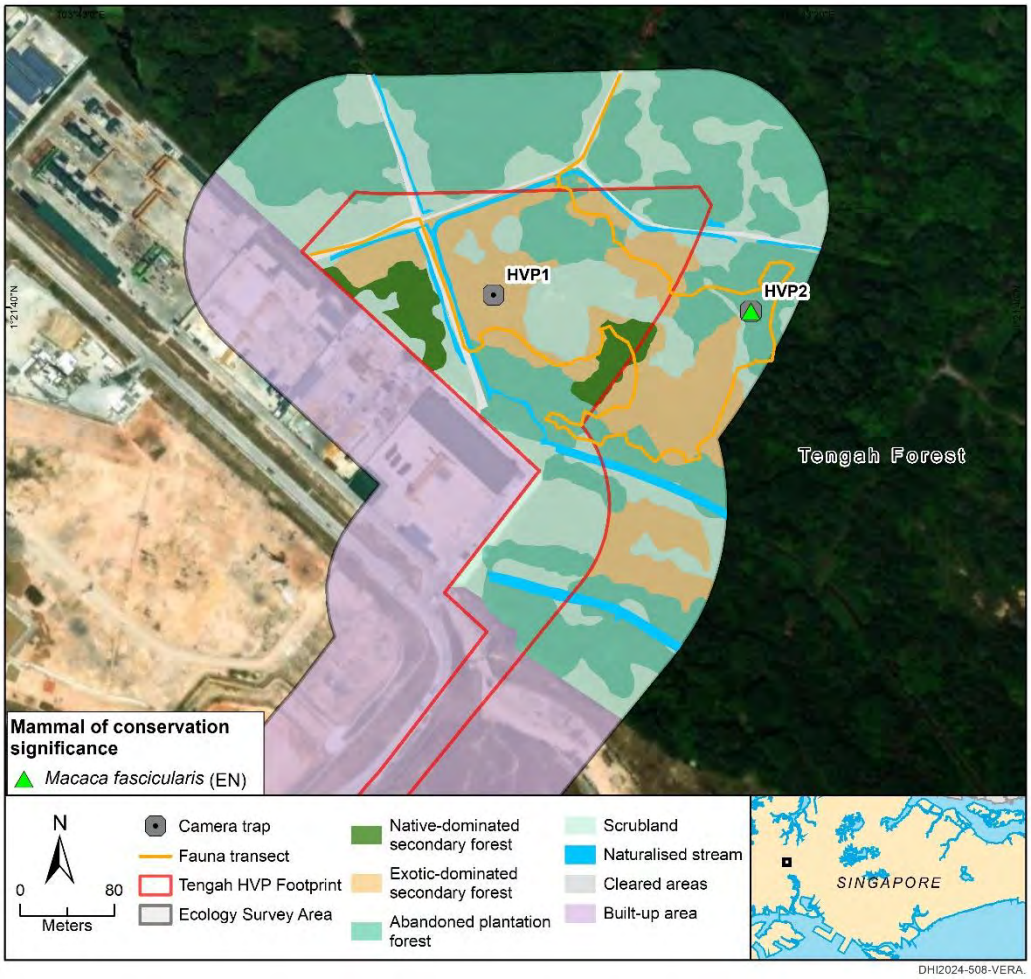

Figure 5.23 Mammals of conservation significance within the Ecological Survey Area of Tengah HVP.

Table 5.15 List of non-volant mammal species and respective camera trap stations observed.

Scientific Name	Common Name	Number of Independent Detections	Camera Trap Stations	
			HVP1	HVP2
Rattus tiomanicus	Malaysian Wood Rat	14	✓	
Tupaia glis	Common Treeshrew	11	✓	✓
Callosciurus notatus	Plantain Squirrel	8	✓	✓
Macaca fascicularis	Long-tailed Macaque	1		✓
Paradoxurus musangus	Sumatran Palm Civet	1	✓	

Bats

Visual and acoustic records from transect surveys yielded a total of four bat species with no species of conservation significance recorded. Bat species recorded in the Ecology Survey Area include Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis*), Lesser Asian House Bat (*Scotophilus kuhlii*), Black-bearded Tomb Bat (*Taphozous melanopogon*) and Pouch Tomb Bat (*Saccolaimus saccolaimus*) (Figure 5.24).

All of the recorded bat species are widespread and common except for the black-bearded tomb bat which is widespread but rare (Baker & Lim, 2012). In other parts of Southeast Asia where this species naturally occurs, roosts are often found in limestone and sea caves (Wei et al., 2008). Its wing morphology enables them to fly fast in uncluttered areas such as above-canopy and forest edges, but limits their manoeuvrability in cluttered spaces i.e., below-canopy (Wei et al., 2008).

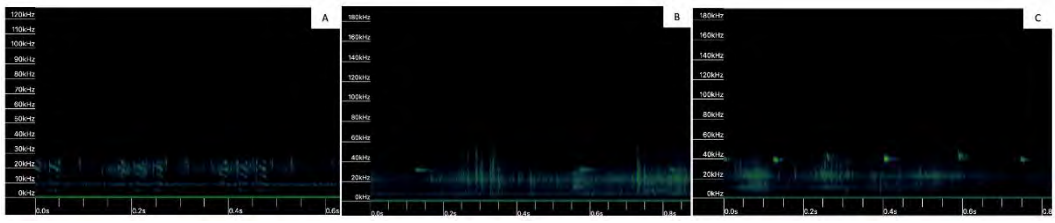

Figure 5.24 Spectrogram screengrabs of insectivorous bats recorded at Ecology Survey Area: (A) Pouch Tomb Bat (*Saccolaimus saccolaimus*); (B) Black-bearded Tomb Bat (*Taphozous melanopogon*); and (C) Lesser Asian House Bat (*Scotophilus kuhlii*).

5.3.3.4 Herpetofauna

Amphibians

A total of nine species of amphibians were recorded from transect surveys, aquatic surveys and incidental findings, with no records of species of conservation significance. Out of the eight amphibians, five are native and mostly widespread and common—Crab-eating Frog (*Fejervarya cancrivora*), Malayan Giant Frog (*Limnonectes blythii*), Painted Chorus Frog (*Microhyla butleri*), Dark-sided Chorus Frog (*Microhyla heymonsi*) and Four-lined Tree Frog (*Polypedates leucomystax*) (Figure 5.25). The Malayan Giant Frog had the highest number of visual records among the native frogs and was often observed leaping out of the waterbodies during aquatic sampling. However, the non-native species, namely Mukhlesur's Chorus Frog (*Microhyla mukhlesuri*) and Günther's Frog (*Sylvirana guentheri*) yielded the highest number of records and occurred throughout the site.

Figure 5.25 Images of amphibians recorded at the Ecology Survey Area: (A) native Painted Chorus Frog (*Microhyla butleri*) and (B) Crab-eating Frog (*Fejervarya cancrivora*).

Reptiles

A total of nine reptile species were recorded from the transect surveys, aquatic surveys and incidental findings, with no records of species of conservation significance. Out of the nine reptiles, seven are native and mostly widespread and common, such as Green Crested Lizard (*Bronchocela cristatella*), Striped Bronzeback (*Dendrelaphis caudolineatus*) (Figure 5.26A), Painted Bronzeback (*Dendrelaphis pictus*), Many-lined Sun Skink (*Eutropis multifasciata*), Reticulated Python (*Malayopython reticulatus*) (Figure 5.26B), Supple Skink (*Subdoluseps bowringii*) and Water Monitor (*Varanus salvator*).

Though non-native, the globally Critically Endangered Giant Asian Pond Turtle (*Heosemys grandis*; Figure 5.26C) was seen at aquatic sampling point A31 and an empty shell was found in the vicinity of camera trap HVP1. Native to Cambodia, Lao People's Democratic Republic, Malaysia, Myanmar, Thailand and Vietnam, the populations are threatened by habitat loss (mainly in Thailand) and harvested for food (Cota et al., 2021). Its status in Singapore was recently declared as 'established' due its widespread occurrence (e.g., Mandai, Kranji, Jurong Lake) and the presence of breeding evidence (Figueroa et al., 2023).

Figure 5.26 Images of reptiles recorded at Ecology Survey Area: (A) Native Striped Bronzeback (*Dendrelaphis caudolineatus*); (B) Reticulated Python (*Malayopython reticulatus*); and (C) non-native Giant Asian Pond Turtle (*Heosemys grandis*) at aquatic sampling point A31.

5.3.3.5 Butterflies

A total of 22 species of butterflies were recorded during transect surveys and incidental findings across the entire Ecology Survey Area (Figure 5.27). Although species of conservation significance were not recorded for this taxon, two species are nationally Near Threatened, the Malay Staff Sergeant (*Athyma reta moorei*) (Figure 5.27D) and Anderson's Grass Yellow (*Eurema andersonii andersonii*) (Figure 5.27E).

The Malay Staff Sergeant was recorded at the Ecology Survey Area on four separate occasions and the photographic record shows an individual, a female, resting on a leaf blade (Figure 5.27D). This very rare species is highly dependent on forested habitats for its survival and often sighted feeding on flowers and ripe fruits (Khew, 2015). To date, the Vulnerable tree species, *Glochidion zeylanicum* var. *zeylanicum*, present in the Ecology Survey Area (Section 4.3.2.1), is the only known larval host plant of this species (Tan, 2020).

Much like the Malay Staff Sergeant, the Anderson's Grass Yellow prefers forested habitats. During the faunal surveys, one individual was netted at aquatic sampling point A13 (Figure 5.27E). Although Near Threatened, this species is still considered moderately common (Khew, 2015).

Another noteworthy species is the non-threatened but moderately rare (Khew, 2015) Dark Tit (*Hypolycaena thecloides thecloides*) (Figure 5.27A). In the early stages of its life history, adult butterflies lay their eggs on its host plant *Flagellaria indica*, which is native climber species present in the Ecology Survey Area.

Figure 5.27 Images of butterflies recorded at the Ecology Survey Area: (A) Dark Tit (*Hypolycaena thecloides thecloides*); (B) Lesser Dart (*Potanthus omaha omaha*); (C) Burmese Bush Brown (*Mycalesis perseoides perseoides*); (D) Malay Staff Sergeant (*Athyma reta moorei*); and (E) Anderson's Grass Yellow (*Eurema andersonii andersonii*).

5.3.3.6 Odonates

A total of 26 species of odonates, 18 species of dragonflies and eight species of damselflies, were recorded during transect surveys, aquatic surveys and incidental findings across the entire Ecology Survey Area. The nationally Vulnerable Variable Featherlegs (*Copera vittata*) is the only species of conservation significance recorded once at the aquatic sampling point A31 (Figure 5.33). This species mainly inhabits swampy forest and slow-moving streams (Ngiam & Ng, 2022), which is characteristic of the habitat of the Ecology Survey Area. This species is considered nationally restricted and rare, with most records in the western part of Singapore, although it has been recorded in other areas such as Admiralty Park, Nee Soon Swamp Forest and Pulau Ubin (Ngiam & Ng, 2022). The rest of the odonates (examples of damselflies and dragonflies photographed in Figure 5.28) are mainly widespread and common species that are habitat generalists.

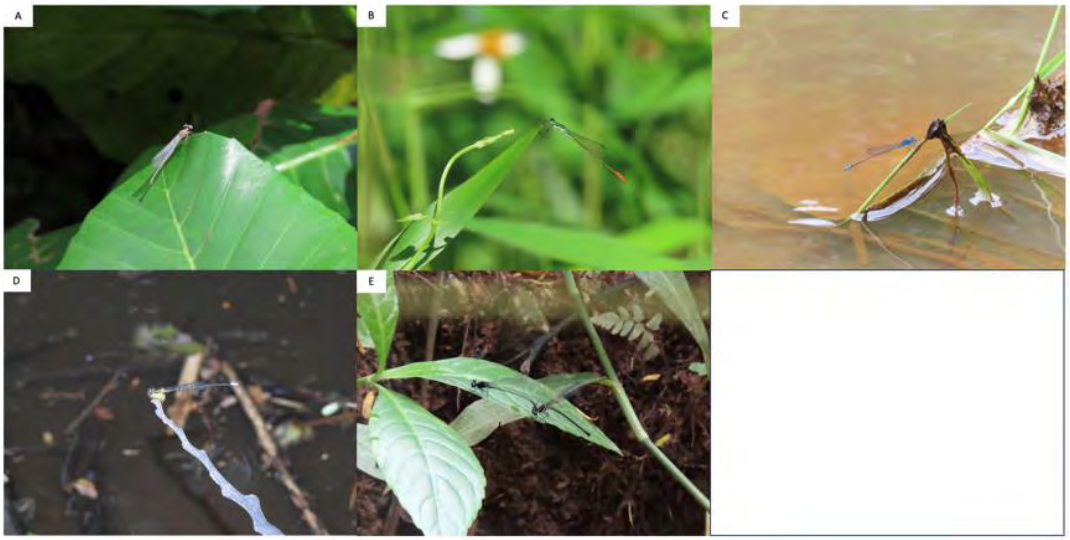

Figure 5.28 Images of damselflies at the Ecology Survey Area: (A) Vulnerable variable Featherlegs (*Copera vittata*); (B) Variable Wisp (*Agriocnemis femina*); (C) Blue Sprite (*Pseudagrion microcephalum*); (D) Yellow Featherlegs (*Copera marginipes*); (E) and a mating pair of Shorttail (*Onychargia atrocyana*).

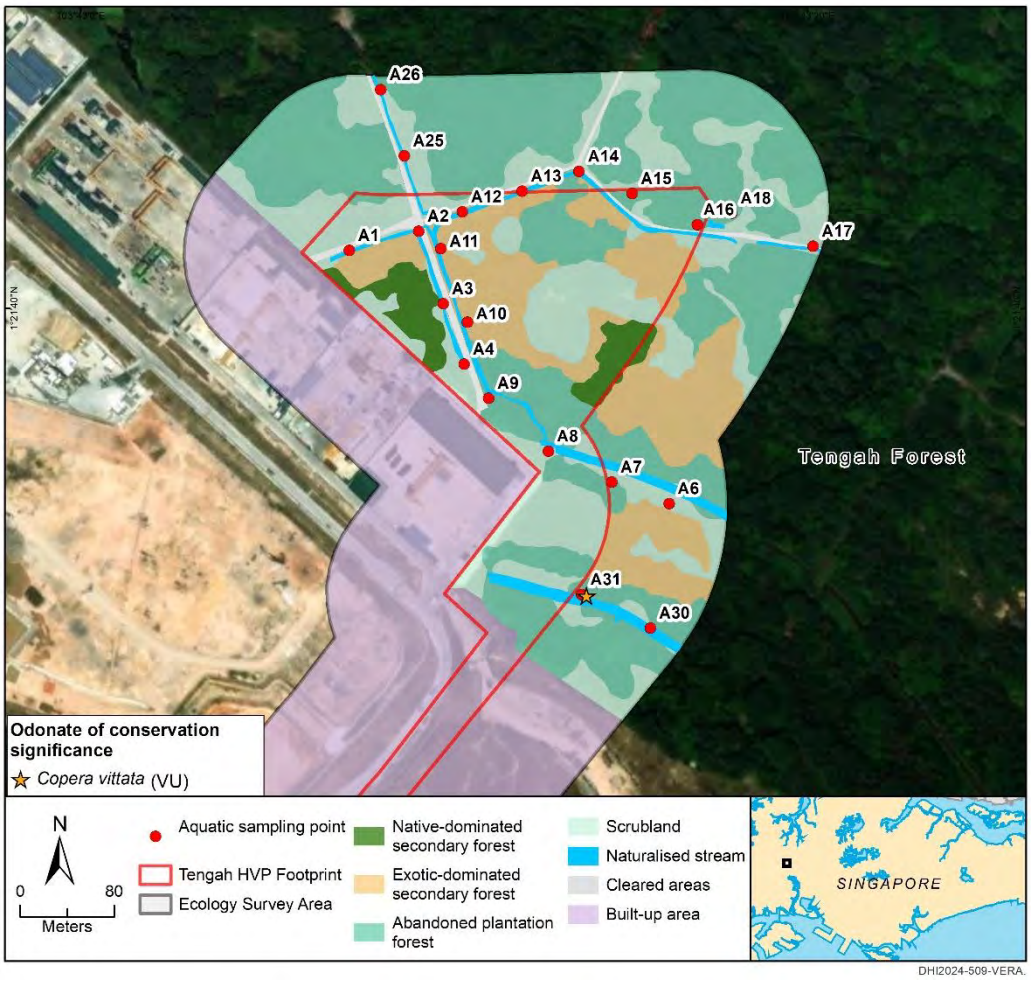

Figure 5.29 Odonates of conservation significance within the Ecological Survey Area of Tengah HVP.

5.3.3.7 Aculeates (Bees and Stinging Wasps)

Field assessments, including transect surveys and incidental findings, across the Ecology Survey Area yielded 10 species of aculeates, five species of bees and five stinging wasps. No species of conservation significance was recorded for this taxon. Dangling from a single attachment point of a petiole (Figure 5.30B), an open petiolate nest secured by saliva secretions of the wasp (Wenzel, 2020) was recorded south of the aquatic sampling point A31 during a reconnaissance survey. Additionally, the Lesser Paper Wasp is an uncommon species in Singapore that is often observed nesting in mangrove areas and in proximity to the open seas, but can also be found in inland secondary forest (Lee JXQ, pers. comm., 2024). A tree-hole that was opportunistically used as a nest by the Asian Honey Bees (*Apis cerana*) was found along the transect. Aside from the forest, Asian Honey Bees can also be commonly found in urban, parkland and coastal areas (Soh & Ascher, 2020).

Figure 5.30 Images of bees and wasps recorded at the Ecology Survey Area: (A) Asian Honey Bees (*Apis cerana*) nesting in a tree-hole and (B) a Lesser Paper Wasp's (*Parapolybia varia*) open petiolate nest dangling from a twig.

5.3.3.8 Freshwater Fauna (Fish, Decapod Crustaceans and Molluscs)

Aquatic surveys conducted in the naturalised streams yielded a total of 21 species of freshwater fauna, with 13 species of fish, seven species of molluscs and one species of freshwater shrimp. Among the freshwater fauna recorded, two species of fish were of conservation significance, namely the nationally Endangered Crescent Betta (*Betta imbellis*) and the nationally Vulnerable Three-spot Gourami (*Trichopodus trichopterus*).

The Crescent Betta was recorded in 3 out of 21 aquatic sampling points (Figure 5.32; A2, A13 & A14). Amongst other morphological characteristics of the Crescent Betta, the iridescent blue opercle scales and a bright red crescent on the distal edge of the caudal fin, distinguishes it from other species of the *B. splendens* group (Tan & Ng, 2005). In Singapore, this species is found in stagnant waterbodies with clear to brown water (Tan & Ng, 2005). Identification of the specimen photographed was identified to be a female Crescent Betta (Figure 5.31A; Kwan IWM, pers. comm., 2024) or a possible hybrid origin (Tan HH, pers. comm., 2024). Based on the historical account of land-use, activities of unclassified cultivation and nearby kampongs present, which might contribute to the uncertainty of its origin. However, natural forest streams may also have been present since the 1940s (Figure 2.5B). Since it is hard to differentiate the morphological features of hybrids and to accurately deduce its origin, the Crescent Bettas present in the Ecology Survey Area are considered to be species of conservation significance.

Three-spot Gourami was recorded in 11 out of 21 aquatic sampling points (Figure 5.31C; Figure 5.32). This species is capable of breathing atmospheric air from its labyrinth organ and thus able to thrive in anoxic waters (Low & Lim, 2012). The local populations of Three-spot Gourami have been observed in various waterbody types (rural and forest streams, ponds and reservoirs) of different qualities such as brackish, weedy and freshwater (Low & Lim, 2012). In the Ecology Survey Area, Three-spot Gourami were found present in naturalised streams (A3, A4, A16 & A17), forest streams (A7, A8, A9, A30 & A31) and unmanaged soft-bank pond (A18).

Other native fish species inhabit the fairly undisturbed waterbodies in Tengah which include the Oriental Climbing Perch (*Anabas testudineus*), Common Snakehead (*Channa striata*), Sunda Pygmy Halfbeak (*Dermogenys collettei*), Sunda Swamp Eel (*Monopterus javanensis*) and Striped Croaking Gourami (*Trichopsis vittata*). Meanwhile, non-native fishes common to Singapore, such as Indochinese Spotted Barb (*Barbodes rhombeus*), Pearl Danio (*Danio albolineatus*) and Guppy (*Poecilia reticulata*), were also found in most of the aquatic sampling points of the Ecology Survey Area.

Seven species of freshwater molluscs, the native *Melanoides tuberculata* as well as non-native Assassin Snail (*Anentome helena*), *Bithynia* sp., *Gyraulus* sp., *Physa acuta*, *Radix rubiginosa*, and *Sinotaia guangdungensis* were recorded. *Melanoides tuberculata*, present in both the forest streams and naturalised streams, is known to thrive in a wide range of habitats and is capable of tolerating disturbed and lower quality streams (Pointier et al., 1991). The most proliferative mollusc recorded is *Sinotaia guangdungensis* which was found nearly in every aquatic sampling point in large quantities; often too numerous to count. This introduced species has successfully established widely across Singapore in ponds, ditches, reservoirs and streams (Ng et al., 2014).

A single specimen of freshwater shrimp was photographed and identified to be Riceland Shrimp (*Macrobrachium lanchesteri*; Figure 5.31B) based on its rostral tooth morphology (Tan ZW, pers. comm., 2024). The Riceland Shrimp is a non-native species from the Palaemonidae family that are not known to have any harmful impacts on the native ecosystems to date (Yeo, 2010).

Figure 5.31 Images of freshwater fauna recorded at the Ecology Survey Area: (A) Endangered female Crescent Betta (*Betta imbellis*; photo by Ivan Kwan); (B) Riceland Shrimp (*Macrobrachium lanchesteri*); and Vulnerable Three-spot Gourami (*Trichopodus trichopterus*).

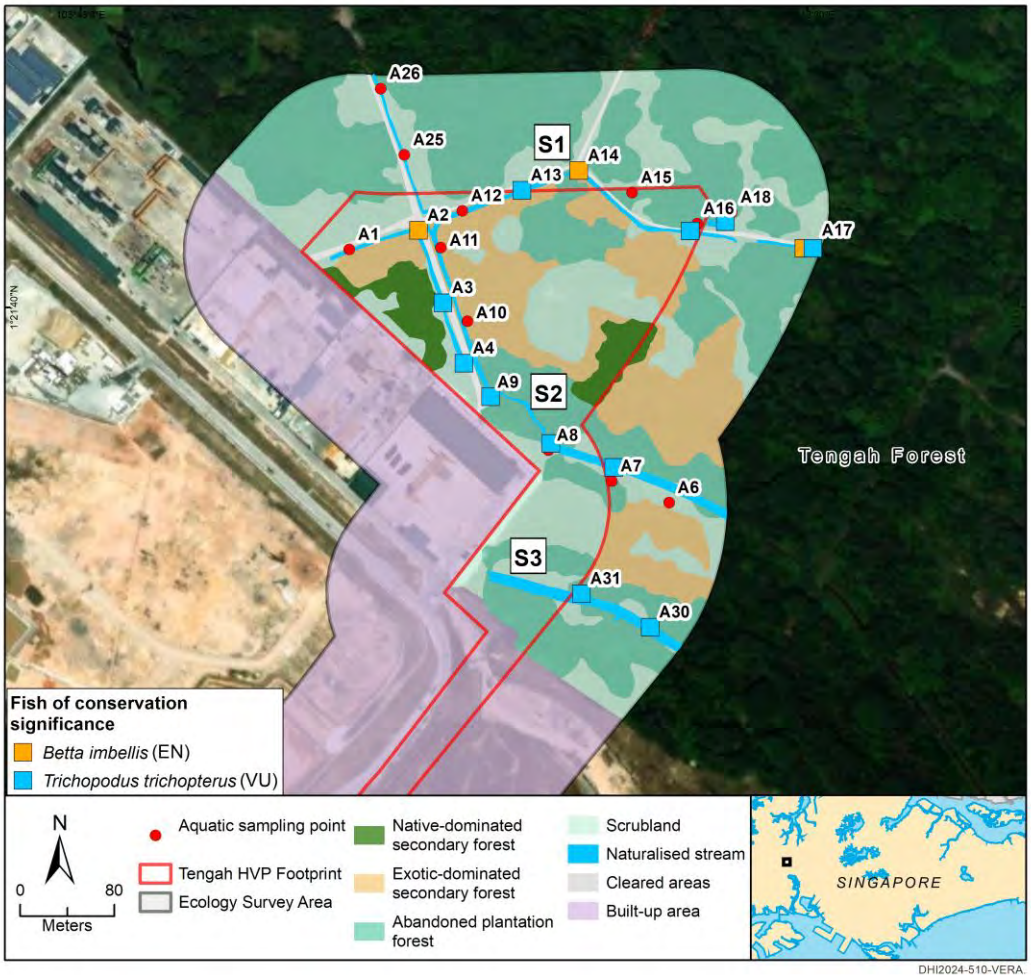

Figure 5.32 Fish of conservation significance within the Ecology Survey Area of Tengah HVP. S2, S2 and S3 denotes stream numbers.

5.3.3.9 Species of Conservation Significance

Desktop Study

Across the four studies that overlap with the current Ecology Survey Area of Tengah HVP (see **Appendix G** for summary of secondary data reviewed), a total of 20 species of conservation significance were identified. This comprised of 12 birds, 2 mammals, 3 herpetofauna, 1 butterfly and 2 freshwater fish. Table 5.16 presents a summary of the overall species of conservation significance identified across all historical studies.

Table 5.16 List of conservation significant fauna species that were historically recorded within the respective study areas that overlapped with the present Ecology Study Area.

Species Name	Common Name	IUCN	SRDB3*	Historical Study			
				Tengah Baseline Study (2017)	Tengah South EIS (2021b)	J1002 JRL EIA (2018)	Tengah Camera Trapping Study (2017)
Birds							
Alcedo meninting	Blue-eared Kingfisher	LC	EN	✓			
Chrysococcyx xanthorhynchus	Violet Cuckoo	LC	VU	✓			
Collocalia affinis	Plume-toed Swiftlet	LC	VU	✓	✓		
Copsychus malabaricus	White-rumped Shama	LC	EN	✓			
Copsychus saularis	Oriental Magpie-Robin	LC	VU	✓	✓		
Icthyophaga ichthyaetus	Grey-headed Fish Eagle	NT	VU	✓	✓	✓	
Ketupa ketupu	Buffy Fish Owl	LC	VU	✓	✓		
Nisaetus cirrhatus	Changeable Hawk Eagle	LC	VU	✓	✓	✓	✓
Nycticorax nycticorax	Black-crowned Night Heron	LC	EN	✓			
Psittacula longicauda	Long-tailed Parakeet	VU	NT	✓	✓	✓	
Psittinus cyanurus	Blue-rumped Parrot	NT	EN	✓			
Pycnonotus zeylanicus	Straw-headed Bulbul	CR	EN	✓	✓	✓	
Mammals							
Manis javanica	Sunda Pangolin	CR	CR		✓		✓
Tylonycteris malayana	Greater Bamboo Bat	NA	VU	✓			
Herpetofauna							
Amyda cartilaginea	Asian Softshell Turtle	VU	VU		✓		

Species Name	Common Name	IUCN	SRDB3*	Historical Study			
				Tengah Baseline Study (2017)	Tengah South EIS (2021b)	J1002 JRL EIA (2018)	Tengah Camera Trapping Study (2017)
Cuora couro	Malayan Box Turtle	NA	NT	✓	✓		
Homalopsis buccata	Puff-faced Water Snake	LC	VU	✓		✓	
Butterflies							
Euploea eyndhovii gardineri	Striped Black Crow	NA	EN	✓			
Freshwater Fish							
Trichopodus trichopterus	Three-spot Gourami	NA	VU	✓	✓	✓	
Betta imbellis	Crescent Betta	LC	EN			✓	

* Conservation status follows that of the Red Data Book Third Edition (NParks, 2024), which may differ from that at time of the historical survey. Species that were uplisted to be of conservation significance following the historical surveys are not shown here. CR: Critically Endangered; EN: Endangered; VU: Vulnerable.

Primary Surveys

Eleven species of conservation significance were recorded across the entire Ecology Survey Area. These include one odonate, two fish, seven birds and one non-volant mammal as illustrated in Figure 5.33 and listed in Table 5.17.

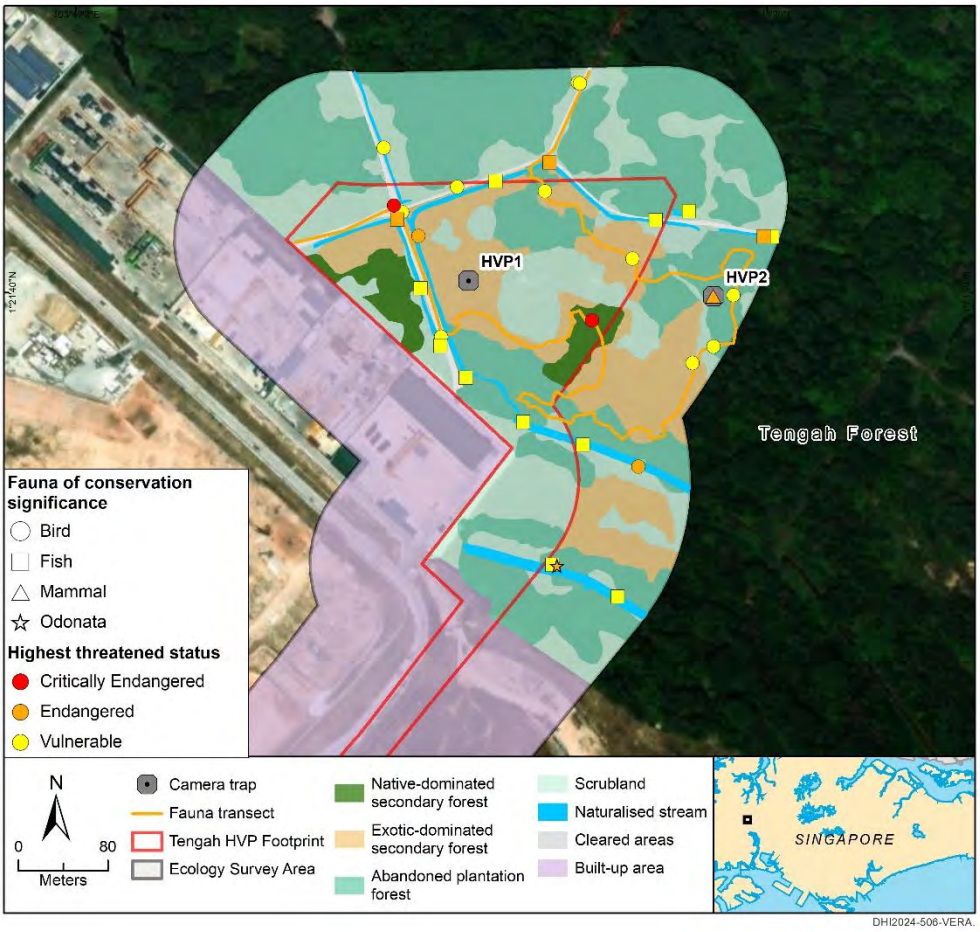

Figure 5.33 Location of faunal species of conservation significance recorded in Ecology Survey Area of Tengah HVP.

Table 5.17 Species of conservation significance observed in Ecology Survey Area of Tengah HVP.

No.	Taxon	Scientific Name	Common Name	Global Status	National Status
1	Odonate	*Copera vittata*	Variable Featherlegs	Least Concern	Vulnerable
2	Fish	*Betta imbellis*	Crescent Betta	Least Concern	Endangered
3	Fish	*Trichopodus trichopterus*	Three-spot Gourami	Least Concern	Vulnerable
4	Bird	*Alcedo meninting*	Blue-eared Kingfisher	Least Concern	Endangered
5	Bird	*Corvus macrorhynchos*	Large-billed Crow	Least Concern	Vulnerable
6	Bird	*Icthyophaga ichthyaetus*	Grey-headed Fish Eagle	Near Threatened	Vulnerable

No.	Taxon	Scientific Name	Common Name	Global Status	National Status
7	Bird	*Nisaetus cirrhatus*	Changeable Hawk-Eagle	Least Concern	Vulnerable
8	Bird	*Psittacula longicauda*	Long-tailed Parakeet	Vulnerable	Near Threatened
9	Bird	*Pycnonotus zeylanicus*	Straw-headed Bulbul	Critically Endangered	Endangered
10	Bird	*Zosterops simplex*	Swinhoe's White-eye	Least Concern	Vulnerable
11	Mammal	*Macaca fascicularis*	Long-tailed Macaque	Endangered	Least Concern

5.4 Impact Assessment

This subsection identifies, assesses, and predicts ecological and biodiversity impacts expected to occur as a result of the construction and post-construction (operational) phases of the Project, and predicts their significance prior to mitigation.

The significance of these environmental impacts will be scored in accordance with the framework delineated in Section 4.5.

5.4.1 Determining Importance and Magnitude

The generic criterion used to evaluate the Importance of ecological and biodiversity receptors, as stipulated in the BIA Guidelines (NParks, 2024a), is adapted Table 5.18 following a customisation that considers the context-specificity of Singapore's ecological landscape, and its constituent biodiversity, habitat types, and conservation values.

The evaluation of the Importance of identified receptors here utilised findings from the baseline surveys, the team's expert judgement, available scientific literature, and experience from similar developments within Singapore. The evaluation of Importance scores also considers the sensitivity or susceptibility of ecological receptors to the environmental pressure being assessed (e.g. airborne noise and air pollution).

Table 5.18 Criteria for Determining Receptor Importance.

Score	Specific Criteria	
	Habitat/Vegetation types	Fauna/Flora
5	• Nationally or internationally designated habitat/sites of biological and ecological importance, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Parks • Unrecognised habitat/sites of equivalent ecological value to designated and protected nature areas i.e. Primary forest, Freshwater swamp forests, Mangrove forests with distinct intertidal zonation • Natural freshwater streams within deep canopy cover • Highest ecological importance, near-inexistent potential for substitution, suis generis habitat nationally; many species with a highly restricted spatial distribution	• Contains native species that are deemed to be Critically Endangered based on local (SRDB3) and global (IUCN) conservation assessments • Critically Endangered species found onsite demonstrate high site fidelity and/or narrow habitat specificity • Proportion of conservation-significant taxa/species between 40-50% of all species, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with keystone ecological functions i.e. bamboo clusters where there are bamboo bats
4	• Nationally or regionally recognised sites of biological and ecological importance • Large, forested sites (≥20 ha) with closed canopy cover, outside of designated nature reserves, nature areas and other legally protected areas including Native-dominated, old secondary forest, Coastal forests and Mangrove relic forests	• Contains native species that are deemed to be Endangered based on local (SRDB3) and Critically Endangered based on global (IUCN) conservation assessments • Endangered species found onsite demonstrate high site fidelity and/or Critically Endangered species with lower site specificity • Proportion of conservation-significant taxa/species between

Score	Specific Criteria	
	Habitat/Vegetation types	Fauna/Flora
	• Natural freshwater streams, marshes or ponds within open canopy cover • High ecological importance with limited potential for substitution; core habitat nationally; many species with restricted spatial distribution	30-40%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with important ecological functions – Fig wasps for specific *Ficus* species
3	• Medium forested sites (5-20 ha) with closed canopy cover, outside of designated nature reserves, nature areas and other legally protected areas • Native-dominated, young secondary forest, Exotic-dominated secondary forest, and restored Mangrove forests • Naturalised streams, marshes or ponds with riparian vegetation • Moderate ecological importance with some potential for substitution, important habitat nationally; uncommon species with limited spatial distribution	• Contains native species that are deemed to be Vulnerable based on local (SRDB3) and Endangered based on global (IUCN) conservation assessments • Proportion of conservation-significant taxa/species between 20-30%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with defined ecological functions – most pollinators, food source for many species
2	• Smaller forested sites (1-5 ha), unmanaged vegetation under open canopy cover, such as Grassland or Scrubland habitats • Modified-urbanised streams with soft landscaping features, e.g. ABC projects • Modest ecological importance with the potential for substitution; important habitat locally, harbours common, non-urban species	• Contains native species that are deemed to be Least Concern based on local (SRDB3) and Vulnerable based on global (IUCN) conservation assessments • Proportion of conservation-significant taxa/species between 10-20%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above
1	• Non-forested sites with urban vegetation • Highly modified or fragmented habitats; managed turf, streetscapes • Low to non-existent ecological importance, highly substitutable	• Species of no national importance • Urban adapting or exploiting species

The Magnitude for injury or mortality to fauna and human-wildlife conflict on ecological receptors is assessed for the construction and operation of the Project using criteria presented in Table 5.19. for Magnitude for construction phase impacts resulting in injury or increased mortality of fauna, and increased probability of human wildlife conflict with regards to fauna receptors.

Table 5.19 Criteria for determining Magnitude for Fauna and Flora loss and Human-wildlife conflict during the construction phase.

Score*	Generic Criteria	Specific Criteria	
		Loss of Fauna/Flora	Human-wildlife conflict
-4	Major negative disadvantage or change	• Expected depletion of the population beyond 75% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is negligible or unlikely • Affects species without the ability to respond and relocate rapidly and further away from the source of potential injurious activities, and thus are likely to experience significant mortality and/or injuries consequential to fitness	• Increase to the rate of encounters with species that may result in severe injury or mortality in humans. • Species that are typically perceived as both nuisances and threats by construction personnel and others, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict.
-3	Moderate negative disadvantage or change	• Expected depletion of the population between 50 - 75% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible only in the long term, and/or up to 50% of current abundance or diversity • Affects species likely to respond quickly but lack the means to relocate rapidly and further away from the source of potential injurious activities. Species in this group are likely to be able to live amidst and evade deleterious activities/find alternative shelter (Urban adaptive mammals). Injuries/mortality likely to be occasional in nature.	• Increase to the rate of encounters with species that may result in injury in humans. • Species that are typically perceived as nuisances and possibly as threats by construction personnel and others, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict
-2	Minor negative disadvantage or change	• Expected depletion of the population between 25 - 50% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible in the long term, and/or up to 75% of current abundance or diversity • Affects species with a delayed response to disturbances, but with the means to relocate rapidly and further away from the source of potential injurious activities.	• Increase to the rate of encounters with species that may result in fear, revulsion, or concern in humans • Species that are possibly perceived as both nuisances and threats by construction personnel and others, less tolerant of human presence and urban environments

Score*	Generic Criteria	Specific Criteria	
		Loss of Fauna/Flora	Human-wildlife conflict
-1	Slight negative disadvantage or change	• Expected depletion of the population between < 25% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible in the long term, and/or up to 90% of current abundance or diversity • Affects species with the ability to respond and relocate rapidly and further away from the source of potential injurious activities, and thus are likely to experience limited to no mortality and/or mild injuries	• Increase to the rate of encounters with species that may result in annoyance in humans. • Species that may be perceived as a nuisance by construction personnel and others, face restricted to slight persecution in abundance, less tolerant of human presence and urban environments
0	No change	• No expected loss of flora and fauna • No increments to the expected rate of animal mortality and injury compared to the baseline level	• Increase to the rate of encounters with species likely to incite no negative responses in humans. • Species that are not perceived as nuisances or threats by construction personnel and others.

Similarly, the Magnitude for the loss of flora, fauna, habitat types and ecological connectivity are presented in Table 5.20.

Table 5.20 Criteria for determining Magnitude for Loss of habitat and ecological connectivity during the operation phase.

Score	Generic Criteria	Specific Criteria	
		Loss of habitat	Loss of ecological connectivity
-4	Major negative disadvantage or change	• Removal of beyond 75% of habitat type • Loss of habitat beyond point of recoverability • Habitat is likely to degrade into other habitats of lesser ecological value	• Developed site is connected to at least three or more other natural sites that are at least translocatable through short-distance flight, terrestrial or aquatic locomotion • Developed site is keystone position for connectivity across global or regional ecological landscape
-3	Moderate negative	• Removal of between 50 - 75% of habitat type	• Developed site is connected to at least or three or more natural sites through short-distance flight, or at least

Score	Generic Criteria	Specific Criteria	
		Loss of habitat	Loss of ecological connectivity
	disadvantage or change	• Loss of habitat to point of low recoverability • Habitat may only recover in the long-term	two adjacent sites through terrestrial or aquatic locomotion • Developed site is important place for connectivity across global or regional ecological landscape
-2	Minor negative disadvantage or change	• Removal of between 25 - 50% of habitat type • Loss of habitat to point of moderate potential recoverability • Habitat may only recover in the medium term	• Developed site is connected to two or more other natural sites that are translocatable only through short-distance flight or at least one adjacent site through terrestrial or aquatic locomotion • Developed site is important place for connectivity across global or regional ecological landscape
-1	Slight negative disadvantage or change	• Removal of < 25% of habitat type • Loss of habitat to point of moderate potential recoverability • Habitat may recover in the short term	• No nearby connected ecological sites that translocatable through terrestrial or aquatic forms of locomotion • At least one connected ecological site translocatable only through flight • Developed site is utilised for connectivity across global or regional ecological landscape
0	No change	• No loss of habitat	• No effects on ecological connectivity – developed site has no important habitats across local/regional/global ecological landscape

5.4.2 Construction Phase

In this section, the impacts associated with the construction of the Project on habitats and species within the Project are assessed.

5.4.2.1 Loss of Flora

For the direct impact of loss of flora, the flora receptor was assessed. There are 11 species of conservation significant flora (Appendix B2) with two nationally Critically Endangered species present. These species produce an Importance score of 4 (Table 5.18). The loss of flora will result in Moderate Negative impact owing to the clearance of the site and edge effects depending on the locations of the individuals, Individuals located within the Tengah HVP footprint and site access and boundary areas will be cleared if they cannot be salvaged, and those that are outside of the development footprint but within the 30-m

impact zone may experience a sudden large increase in light and temperature and lower humidity levels that may negatively impact their health and survival. Increased wind exposure is also likely.

Certain species (*Glochidion zeylanicum* var. *zeylanicum* and *Macaranga griffithiana*) are more affected by loss of flora as more than 50% of their individuals are located within 30m of the development footprint, justifying a Magnitude score of -3 (Table 5.19). However, since these are secondary forest species that are adapted to more exposed conditions and there are individuals located at the edges of the scrubland habitat, the remaining individuals outside of the project area will have a high likelihood of survival from the habitat degradation and edge effects brought on by the development (Section 5.4.3.2).

The Permanence of this impact is assessed to be long-term, Reversibility is irrecoverable and Cumulativity is cumulative as the site will be cleared, producing an Environmental Score of -108 (Table 4.8).

5.4.2.2 Faunal Injury or Mortality

Vegetation clearance and heavy machinery are expected to be involved in the site clearance and development construction. Assuming minimum controls are in place (e.g., pre-felling fauna inspection, wildlife response plan), the impact significance of faunal injury and mortality is expected to be Moderate Negative for herpetofauna and freshwater fauna, and Minor Negative for the other groups. These include conservation significant freshwater fauna, as well as primarily ground-dwelling species that are susceptible to collisions with vehicles and machinery or entrapments within the worksite (e.g., open pits). The recorded and probable occurrence of nationally Critically Endangered birds (Crested Serpent Eagle, *Spilornis cheela* and Ruddy Kingfisher, *Halcyon coromanda*), mammals (Leopard Cat, *Prionailurus bengalensis* and Sunda Pangolin, *Manis javanica*) and butterfly (Harlequin, *Taxila haquinus haquinus*) raise the Importance score of these faunal groups to 5, followed by nationally Endangered odonate (Blue-nosed Sprite, *Archibasis melanocyana*) and Crescent Betta (*Betta imbellis*), similarly raises the Importance score of these groups to 4. For herpetofauna and aculeates, these are given a score of 3 for Importance due to the presence of nationally Vulnerable species such as King Cobra (*Ophiophagus hannah*), Black-headed Collared Snake (*Sibynophis melanocephalus*), Red-tailed Pipe Snake (*Cylindrophis ruffus*), Asian Softshell Turtle (*Amyda cartilaginea*) and bee *Amegilla insularis*. (Table 5.18).

This impact is assessed to have the largest Magnitude on herpetofauna and freshwater fauna at -4 (Table 5.19), as these fauna have difficulty to respond quickly or relocate rapidly away from injurious construction activities, and thus likely to experience higher levels of injury or mortality. The other faunal groups are volant or are able to respond and relocate quickly, hence they are scored lower for Magnitude. The Permanence of this impact is assessed to be long-term, Reversibility is irrecoverable as full site clearance is assumed. The impacts are assumed to be non-cumulative (Table 4.8).

5.4.2.3 Human-Wildlife Conflict

The eviction of fauna species from their habitat within the area raises the possibility of human-wildlife conflict, as interactions between wildlife and humans utilising the adjacent commercial, industrial and residential infrastructure are likely to increase. The probability of human-wildlife interactions is especially elevated at the interfaces between the construction site and original habitat, particularly during the land clearance stage.

Without mitigation measures, Moderate Negative impacts due to human-wildlife conflict are expected for humans with an Importance score of 3 (Table 5.18) and Magnitude of -4 (Table 5.19) such as construction personnel as there are faunal species that typically perceived

as threats and nuisances recorded in the Ecology Study Area. These species include the Long-tailed Macaque (*Macaca fascicularis*), Smooth-coated Otter (*Lutrogale perspicillata*), King Cobra (*Ophiophagus hannah*), Reticulated Python (*Malayopython reticulatus*), and aculeate hymenopterans. Attacks from these animals may result in bites, scratches, stings or bruises. The Importance of mammals, herpetofauna and aculeates follows the scoring of the earlier section.

Despite the severe consequences of potential human-wildlife conflict, it is likely that the probability of such attacks is relatively low. Additionally, where the Long-tailed Macaque and Smooth-coated Otter are concerned, aggression usually arises in groups. Thus, this impact was given a Magnitude score for -2 for mammals (Table 5.19). For herpetofauna and humans, Magnitude was scored at -4 for (Table 5.19), particularly for snakes. The perception of snakes as an immediate threat to safety, along with the lack of general knowledge in differentiating between species, often results in a snake being captured and killed capriciously.

On the whole, the occurrence of human-wildlife conflict is likely to be transient and isolated, lasting for several years throughout the construction phase. However, instances of human-wildlife conflict will lead to non-reversible effects on the individuals involved. The impacts of human-wildlife conflict are not expected to be cumulative, primarily affecting only the individuals in question.

The Permanence of this impact is assessed to be short-term as the construction personnel will only be present during the construction phase, Reversibility is irrecoverable as there will be full site clearance and Cumulativity is non-cumulative (Table 4.8).

5.4.2.4 Human Disturbance

The impact of human disturbance on biodiversity is discussed in Section 6.4.2.2 for Air Quality, 7.4.2.1 for Airborne Noise, 9.4.3.2 for Ground Vibration, 10.4.3.2 for Illumination, and 11.4.3.1 for Ambient Air Temperature.

5.4.3 Post-construction Phase

5.4.3.1 Loss of Habitat

The Permanence of this impact is assessed to be long-term, Reversibility is irrecoverable as the site will be completely cleared for the HVP, and Cumulativity is cumulative on other biodiversity receptors (Table 4.8).

Native-dominated, Young Secondary Forest

Native-dominated, young secondary forest were given an Importance score of 3 (Table 5.18) and a Magnitude score of -4 (Table 5.20). The total area of this habitat type in the Study area is 0.6 ha and approximately 0.53 ha (93.1%) of this habitat is located within the worksite, which will be cleared.

The depletion of native-dominated, young secondary forests within the Study Area are not reversible. The course of natural succession in native-dominated, young secondary forests typically requires decades, and progresses through other faster growing habitat types, such as grasslands, scrublands, before slower growing, native tree species may be able to take hold. The total clearance of native-dominated, young secondary forests follows a continued trend in the reduction of an increasingly scarce habitat type within Singapore's ecological context. native-dominated, young secondary forests possess conditions that are most similar to Singapore's original ecoscape, serving as an important refuge for native flora and

fauna. Thus, their removal is likely to have cumulative effects in this regard. The final significance of this impact on native-dominated, young secondary forests is expected to be Moderate Negative.

Exotic-dominated, Young Secondary Forest

Exotic-dominated, young secondary forests were given an Importance score of 3 (Table 5.18) and a Magnitude score of -2 (Table 5.20). The total area of this habitat type in the Study area is 2.8 ha and approximately 1.46 ha (49.6%) of this habitat is located within the worksite, which will be cleared, resulting in a Minor Negative impact.

Whilst exotic-dominated, young secondary forests regenerate at a quicker rate than native-dominated secondary forests due to their composition of faster-growing exotic species, partial to full recovery of these habitats is still expected to take place in the order of years. Thus, the planned development is expected to result in largely irreversible changes.

Similarly, the impacts are deemed to be cumulative. Although exotic-dominated, young secondary forests may technically be considered an inferior habitat type compared to its native-dominated counterparts, the scarcity of forest habitat as a whole across Singapore exacerbates the consequences of further habitat loss.

Waterbodies

Of the 0.291ha of naturalised streams recorded within the study area, about 0.215 ha of these streams (~73.9%) are located within the development footprint. Given the vegetation cover of the streams, and the importance of the habitat for threatened species (refer to section 5.3.3.8) streams were given an Importance score of 4 (Table 5.18) and a Magnitude score of -4 (Table 5.20).

Currently, these watercourses running across and beyond the Tengah HVP footprint and are connected. If this part of the habitat is removed as part of the Project works, these will permanently affect downstream connections. There will be cascading impacts on ecological connectivity and aquatic fauna receptors primarily, as discussed in Section 5.4.3.3.

Abandoned Plantation Forest

Abandoned plantation forests were given an Importance score of 2 (Table 5.18) and a Magnitude score of -1 (Table 5.20). The total area of this habitat type in the Study Area is 7.1 ha and approximately 1.61 ha (22.7%) of this habitat is located within the worksite, which will be cleared, resulting in a Slight Negative impact.

Such forests while being completely cleared in the past for plantations, allow for native understorey species to reestablish as the former plantation crops form for a mature canopy layer to shade out sun-loving exotic species. Whilst former exotic and ornamental species persist, these habitats form an important seed-bank and sapling nursery for native species that require higher shade and humidity levels, and provide basic ecosystem services and connectivity for faunal species across the larger landscape.

Scrubland

Scrubland were given an Importance score of 2 (Table 5.18) and a Magnitude score of -2 (Table 5.20) as the total area of this habitat type in the Study area is 4.3 ha. Approximately 1.99 ha (47.8%) of this habitat is located within the worksite, which will be cleared, resulting in a Slight Negative impact.

The flora species that are dominant in scrubland are sun-loving, fast-growing species that can rapidly take over cleared land areas. Seed sources for such species which are wind-dispersed are similarly abundant across Singapore’s ecological landscape. Thus, the

regeneration of grasslands and scrublands is frequently observed at an early stage along the course of vegetation succession when cleared areas are left alone. Such areas also support lower numbers of faunal species as well as those that are more generalist and tolerant of disturbance.

5.4.3.2 Habitat Degradation and Edge Effects

Within 30 m of the worksite, 0.04 ha (100%) of native-dominated, young secondary forest, 0.46 ha (31.1%) of exotic-dominated, 0.05 ha (30.6%) of forest stream, young secondary forest, 1.21 ha (22.1%) of abandoned plantation forest and 0.71 ha (32.4%) of scrubland will experience habitat degradation and edge effects as the development involves the building of HVP with surfaces that absorb and retain heat, constantly produce dust, and noise disturbances.

The opening up of the forest to create more edges with urban elements such as impervious surfaces that increase the speed of runoff exiting from within the HVP while reducing water retention in the soil, exposed HVP site that results in a reduction of shade while increasing wind exposure and temperature and loss of humidity, as well as traffic that brings in noise and dust will have the largest effect on habitats specifically the young secondary forests and abandoned plantation forest. These edge effects are the greatest on these habitats as they are the most different to the urban environment, being able to retain water and slow runoff during rain events, high levels of shading resulting in lower ambient temperatures, light levels and higher humidity, as well as low levels of urban noise and dust.

The Permanence of this impact is assessed to be long-term, Reversibility is irrecoverable as the site will be present for the longer term with the effects continuing to be affect the receptor, and Cumulativity is cumulative on other biodiversity receptors (Table 4.8).

5.4.3.3 Loss of Ecological Connectivity

The notion of ecological connectivity describes the quality of the linkage between the site in question, amidst the broader network of other natural habitats as a whole. Thus, ecological connectivity is dependent on numerous metrics, beginning from the physical distances between the selected site and other natural areas, resource availability, microclimatic conditions and habitat suitability of connecting ecological corridors and may vary contextually at the level of differing taxonomic groups, insofar as forms of locomotion and territorial range may differ between them.

The loss of ecological connectivity may have complex consequences. For example, opting to develop a natural site with high innate ecological connectivity may avert the magnitude of deleterious consequences experienced by extant fauna present within the development footprint, as they may be able to relocate away from construction activities towards other connected suitable habitat. However, the loss of such sites may ultimately reduce the long-term survival of affected populations, which may have now become isolated into habitats with inadequate resources, where they could have previously moved between linked within the ecological network. In totality, evaluating the loss of ecological connectivity resultant from planned development remains an important consideration and helps to shed light on the long-term outlook with a cascade of consequences on affected fauna, flora and habitat.

The quantification of ecological connectivity in this impact assessment will be encompassed within Magnitude scoring. Accordingly, the magnitude of a loss in ecological connectivity will be scored higher should the ecological connectivity of the development site be of good quality, and the converse is similarly true.

On the whole, the nearest, distinctively separate patches of forest are those at the surrounding larger Tengah Forest area, Western Catchment through the cemetery

greenery along Jalan Bahar and former Bukit Batok Hillside Park, which are 1.5km and 2km away respectively. Furthermore, the Study Area remains separated from these natural sites by a dense matrix of urban development and ongoing construction at the southwest boundary and many parts of Tengah Forest and former Bukit Batok Hillside Park, including wide and heavily utilised roads at the south of the Study Area, as well as various residences, industrial facilities and other centres of human activity on the west and east of the Study Area. For these reasons, the hypothetical ecological corridors connecting the Study Area with these adjacent sites have generally been deemed to be of poor quality. Nevertheless, the Study Area is more easily accessible to and may serve as a stepping-stone habitat for volant species. Further taxa-specific assessments are described and in the relevant subsections below.

Non-volant Mammals and Herpetofauna

The development of the site is expected to result in a slight to negligible loss of ecological connectivity for both non-volant mammals and herpetofauna. Having to rely on terrestrial locomotion, the presence of construction sites, roads, mixture of urban development, along with the physical distance between suitable habitat patches would have translated to effectively impassable barriers to movement. Whilst the eventual development of the Study Area would contribute to an increase in the distance between the remaining habitat patches, with some intervention, these can be mitigated and new connections may be formed.

The loss of ecological connectivity as a result of the development of the Study Area is expected to have cumulative effects for non-volant mammals and herpetofauna, since the Study Area was a functional ecological corridor for these taxa in its pre-development condition.

Nevertheless, changes to the Study Area are expected to have permanent and reversible effects to ecological connectivity for these taxa. The creation of suitable ecological corridors would not only necessitate mitigative steps to be taken within the Study Area but will similarly require substantive changes to the extraneous urban matrix in the residences, industrial facilities and roads beyond the Study Area. This may be effected in the eventual HDB Tengah residential “forest town” (Section 4.2.4).

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of the loss of ecological connectivity on Non-Volant Mammals and Herpetofauna is expected to be a Minor Negative Impact.

Birds, Bats, Butterflies and Odonates

The development of the site is expected to result in a moderate loss of ecological connectivity for birds, bats, butterflies and odonates. These taxa rely on flight for locomotion and are thus less encumbered by the presence of construction sites and vehicular traffic compared to their terrestrial counterparts. Thus, some degree of ecological connectivity may be said to be pertinently provided by the Study Area to these taxa.

Nevertheless, various facets and urban structures still function as barriers to movement and dispersal for volant fauna. The presence of urban developments alters the suitability of habitat, resource availability and microclimatic conditions, alongside the threat of anthropogenic interference, thus hindering the free movement of volant fauna. Accordingly, an increase in the distance between suitable habitat as a result of the development of the Study Area, is likely to restrict the range of mobility in some species, as stopover sites with suitable climatic conditions, refuges and other resources are removed. Specifically, the loss of ecological connectivity relating to the Study Area may obstruct the dispersal of the aforementioned taxa from the larger Tengah Forest area, Western Catchment, former Bukit Batok Hillside Park and vice versa. At the regional level, the Study Area appears to be patronised by various migratory species, suggesting that it may play a role in sheltering

these species travelling along international migratory routes. Although the extent by which the Study Area is utilised is not specifically known, the development of the Study Area is expected to result in some degree of ecological connectivity loss for these species.

The loss of ecological connectivity is expected to have cumulative effects for Birds, Bats, Butterflies and Odonates, although it is expected to be permanent since the clearance of the habitat from the Study Area is currently believed to be total. However, the loss of ecological connectivity is expected to be reversible over time. Ecological connectivity may be restored through the retention of selected trees, as well as supplementary planting in an informed manner that provides suitable refuges for the range of volant fauna, as they reattempt to move between previously linked habitats. These measures will be further elaborated upon in Section 5.5.

Freshwater Fauna

The creation of the HVP at the Project site will likely entail the loss of connectivity between existing streams and waterbodies linking across ecological sites such as the larger Tengah Forest area, Western Catchment and former Bukit Batok Hillside Park, although no information on the extent and presence of aquatic connections are known. Freshwater and other aquatic-associated fauna will be most affected by the development assuming no actions are taken for maintaining connectivity across all adjacent sites and developments, particularly for upstream and downstream parts of forest and naturalised streams. Hence, more information on the status of hydrology and waterbodies in adjacent developments, as well as further future baseline surveys for areas around the current study area are pertinent for formulating an accurate assessment of waterbodies connectivity.

The loss of ecological connectivity is expected to have cumulative effects for freshwater fauna, although it is expected to be permanent and irreversible since the clearance of the habitat from the Study Area is currently believed to be total. The resulting impact is assessed to be Moderate Negative.

5.5 Mitigation Measures

5.5.1 Minimum Control Measures

This section lists biodiversity-specific minimum controls commonly implemented in Singapore for similar construction and post-construction activities. These are assumed to be implemented for the impact assessment. Minimum controls for each potential impact occurring from the construction and post-construction phases are listed on Table 5.21. These measures should be proposed in tandem with other environmental receptors (e.g., air and noise).

Table 5.21 Description of minimum controls implemented at construction and post-construction 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

Work Activities	Minimum Controls
	Daily checks by Environmental Checker / Environmental Control Officer / Earth Control Measures Officer on site, including but not limited to: • Visual checks for animal entrapments on-site, particularly within tree protection zones (TPZ), ECM sedimentation tanks, erosion control blankets (ECBs) and among construction materials and equipment • Gaps in hoarding 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 conflicts, in accordance to Section 10 of Wildlife Act No night works Adhere to regulations stipulated in the (1) Wildlife Act, (2) Parks and Trees Act, and (3) Animals and Birds Act
Vegetation clearance	Set up TPZs around trees or other plant specimens to be retained (if any). This should be executed by certified arborists and in accordance with NParks' guidelines 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 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 Tarpaulin mats should be on standby in adequate quantities on site during site clearance and excavation works, to ensure that exposed soil and stockpiles are covered and prevent overflow of silty discharge. Stockpiles should be covered within 5 minutes from the start of heavy rainfall. Ensure proper storage of materials likely to leach harmful chemicals and fuel-powered equipment. Store them away from waterbodies and/or sensitive habitats Implement dust control measures Ensure noise levels are within approved limits, and to implement noise barriers around project boundary
Post-Construction Phase	
General	Ensure noise levels are within approved limits Ensure dust levels are within approved limits 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. Adhere to regulations stipulated in the (1) Wildlife Act, (2) Parks and Trees Act, and (3) Animals and Birds Act

5.5.2 Design Phase Mitigation Measures

In this section, mitigation measures for the proposed Tengah HVP development are discussed. Mitigation measures should be considered in the order of the mitigation hierarchy: (1) Avoid, (2) Minimise, and (3) Rehabilitate/Restore. Avoidance of the impact is first attempted. If avoidance is not possible, the impacts will be minimised. Finally, if avoidance or minimisation are not possible, rehabilitation/ restoration of the remaining and/ or nearby habitats should be considered.

Most of the negative impacts that ecological receptors might experience during the post-construction phase can be mitigated through the design of the HVP. Although Moderate Negative impacts are expected during the post-construction phase, implementing the measures below would be a best practice and may compensate for some of the negative impacts during the construction phase as well.

Avoid

If Stream S1 can be retained with at least a 30 m buffer on each side where the existing vegetation and riparian edges are maintained on each side, this will reduce the magnitude of the impact of loss of habitat on the vegetated habitats and waterbodies and faunal injury or mortality to freshwater fauna such as the nationally Endangered Crescent Betta that is found in this stream (Figure 5.32). This channel should not serve to convey surface runoff, which could be contaminated by fuels and other chemicals from vehicles. This is contingent on a hydrology connectivity plan for the larger Tengah area, where Stream S1's connectivity external to the Project from source to end being kept, with sufficient water quality levels being maintained.

For the vegetated habitats, if the vegetation is maintained for the 30 m buffer on both sides of Stream S1, there will be between 0.7 to 1 ha of habitat retained for abandoned plantation forest, scrubland and exotic-dominated secondary forest. For the other receptors, there are no appropriate avoidance measures that can be implemented as the nature of the development is such that the entire Tengah HVP footprint would have to be cleared.

Minimise

The key mitigation measures to minimise biodiversity impacts through the design of the proposed development are summarised in Table 5.22 and detailed in the paragraphs below.

Table 5.22 Key recommended design measures to minimise biodiversity impacts.

Receptor	Impact Types	Mitigation Measures
Habitats	Loss of habitat Habitat degradation and edge effects Loss of ecological connectivity	Maintain stream connectivity and retain streams where possible
Flora	Loss of flora	Transplant suitable individuals of conservation significance Intensifying and/or expanding green buffer plantings within the development boundary

		Turfing of slopes and supplementing with suitable plants of various other habits
Fauna	Faunal injury or mortality Human-wildlife conflict Human disturbances	Incorporate wildlife-friendly lighting

Maintain stream connectivity

Waterbodies that are around and within the HVP should be part of a larger hydrology plan of the area. Where possible, the retention of naturalised streams and waterbodies should be explored. These retained streams should be minimally affected by the HVP during the operation stage, with considerations of HVP usage being balanced with streams that need to be connected across the Project footprint. Manmade structures such as culverts and road bridges within the HVP may be required to achieve this mitigation. If the project is unable to retain these naturalised streams, the proposed manmade structures such as culverts and other drains need to be constructed in a manner that takes into account the hydrology of the area, to ensure that overall hydrological flow continues to be maintained.

Transplantation of suitable plants

Conservation-significant flora can be identified and earmarked for transplantation prior to the commencement of construction activities. The selection of conservation-significant flora specimens should reflect a number of considerations, including conservation priority, cultivated or natural provenance, size, maturity, and accessibility of the plant, as well as the specimen's health, which may go some way into determining whether a specimen will successfully survive the transplantation process. If found not to be suitable for transplantation; harvesting of fruits, seeds, saplings, propagules, stem and leaf cuttings should be considered and conducted prior to the construction activity. Potential conservation significant species ideal for this site that were not especially large or have growth forms suitable for transplantation include the Critically Endangered *Curculigo capitulata*, *Xyris complanata,* Endangered *Melicope lunu-ankenda,* and some specimens of other Vulnerable finds such as *Goniophlebium percussum*, *Glochidion zeylanicum* var. *zeylanicum, Macaranga griffithiana* and *Selaginella wildenowii.* Additionally, where recorded individuals are too large for transplantation, there may be smaller individuals of the same species in the area that are more suited for transplantation. These larger individuals or climber species may also be available for propagation such as for provision of seeds or spores or stem cuttings.

Incorporate wildlife-friendly lighting
Wildlife-friendly lighting strategies can minimise the impact of light disturbances to fauna residing in the adjacent forest. Recommendations on suitable lighting strategies are further elaborated on in Section 10.5.2.

Rehabilitate/Restore

The key mitigation measures to rehabilitate/restore biodiversity through the design of the proposed development are summarised in Table 5.23 and detailed in the paragraphs below.

Table 5.23 Key recommended design measures to rehabilitate/ restore biodiversity.

Receptor	Impact Types	Mitigation Measures
Habitats	Loss of habitat Habitat degradation and edge effects Loss of ecological connectivity	Intensifying and/or expanding green buffer plantings within the development boundary Turfing of slopes and supplementing with suitable plants of various other habits

Intensification and expansion of buffer planting
Within the development boundary, green buffer planting should be maximised to minimise the likelihood of habitat degradation and edge effects through changes in microclimatic conditions such as increased temperature and wind exposure, and decreased humidity. Green buffer planting involves planting of native plants, particularly trees and shrubs to serve as a buffer between the development boundary and the eventual outlying roads. Where possible, peripheral planting verges comprised of native species of various other habits should also be planted (i.e., shrubs, ground cover), Ideally, the plants should be planted to emulate the framework of a rainforest (i.e., canopy, understorey, undergrowth).

5.5.3 Construction Phase Mitigation Measures

In addition to minimum controls in Section 5.5.1, the sections below provide a summary of the key recommended measures to avoid and minimise biodiversity impacts to habitats, flora and fauna species during the construction phase. The key mitigation measures to minimise biodiversity impacts during the construction phase are summarised in Table 5.24 and detailed in the proposed EMMP (Section 13).

Table 5.24 Key recommended measures to minimise biodiversity impacts during the construction phase.

Receptor	Impact Types	Mitigation Measures
Habitats	Loss of habitat Habitat degradation and edge effects Loss of ecological connectivity	Verify and review footprints for hoarding, worksite boundaries, and access roads Conduct regular site inspections to ensure contractor compliance to the EMMP Implement proper Earth Control Measures (ECM) plan prior to site clearance Implement dust control measures
Flora	Loss of flora	Verify and review footprints for hoarding, worksite boundaries, and access roads

		Proper flora management, including the implementation of appropriate TPZs for retained trees Conduct regular site inspections to ensure contractor compliance to the EMMP Conduct regular inspections to identify and monitor for forest edge effects and exotic fast-growing plants
Fauna	Faunal injury or mortality Human-wildlife conflict Human disturbances	Conduct regular site inspections to ensure contractor compliance to the EMMP Install hoarding properly to prevent wildlife entry Conduct biodiversity awareness trainings Ensure good housekeeping Conduct daily checks for roadkill and fauna entrapment within the worksite Use only fully biodegradable wildlife-friendly erosion control blankets Usage of glue traps to be prohibited Conduct directional site clearance Execute Wildlife Response Plan when a trapped/ injured/ dead/ dangerous animal is encountered Train site personnel that feeding of wildlife is strictly prohibited Aquatic fauna of conservation significance such as the Three-spot Gourami and Crescent Betta should be translocated to a suitable site with natural stream habitat. Restrict entry of site personnel beyond the worksite

Pre-felling fauna inspections

Trees selected for imminent felling should be adequately marked and physically tagged in a clear and distinct manner. Pre-felling inspections should be performed on such trees with the assistance of a trained ecologist, to check for the presence of arboreal fauna, fledging avifauna and other pre-existing or erected microhabitats, such as bird nests, bee hives and tree burrows. Appropriate actions should then be undertaken in response to the findings. For example, planned works should be postponed if active bird nests are found on trees marked for felling, until further verification attempts ascertain that the nests are no longer occupied or utilised.

Wildlife Management, Protection and Monitoring Plan (including Wildlife Response and Rescue Plan)

A suitable Wildlife Management, Protection and Monitoring Plan is to be prepared prior to the commencement of construction or clearance activity. This plan should identify and flag out potential species of interest, including conservation significant species, species likely to be able to move across established hoardings, and potentially injurious species. The plan should also encompass suitable Wildlife Response and Rescue protocols; these should dictate the procedures for the appropriate handling, trapping and relocation of errant wildlife, as well as contain relevant information for the employment of NParks Certified Animal Management Specialist to execute the aforementioned plan.

Planning and installation of hoarding

A suitable hoarding plan should be established prior to the commencement of construction or clearance activity. The placement of the hoarding should demarcate and define the planned construction area; and no modifications to the natural environment beyond the hoarding should be undertaken. The hoarding should be well-marked, with an installation depth of at least 300mm to prevent wild boars (*S. scrofa*) from entering or destabilising the hoarding structures through digging activity. Hoarding lines should be located at a distance away from the any retained trees to prevent damage to the major roots of trees during the installation process, which may destabilise trees and result to them falling accidentally. Once satisfactorily installed, the structural integrity of the hoarding should be subject to regular inspections, ensuring that no changes to the hoarding or earthen foundations occur throughout the construction phase, which may allow various fauna to enter the development area through gaps or by digging.

Flora Management

Clearance works should consider any vegetation immediately adjacent to the project site, particularly for slope levelling works. Working areas should be marked out by physical boundaries in order to prevent excess vegetation clearance. Should there be any trees identified for retention, as well as trees along the boundary of the Project, appropriate TPZs should be implemented. These TPZs are to be recommended by an ISA-certified Arborist and installed prior to any vegetation clearance. The integrity of TPZs are to be monitored regularly by the ISA-certified Arborist, who is to maintain records of tree health and TPZ integrity.

Prevention of fauna entrapment

Erosion Control Blankets (ECBs) can prove to be hazardous – becoming traps for ground-dwelling fauna such as snakes and lizards. To minimise the impact from fauna entrapment, the selection of ECBs should be limited to those made of fully biodegradable material. In addition, all ECBs and pits should be checked daily by on-site personnel, to minimise the likelihood of entrapping fauna, which can result in increased rates of injury or mortality over prolonged periods.

Biodiversity Awareness Training

The presence of the Long-tailed Macaques, Smooth-coated Otters and Reticulated Pythons may pose a threat to human health and safety. Conversely, aggressive animals and other fauna that generally repulse people may be subjected to persecution from people working on site. The implementation of Wildlife Awareness Training aims to provides an overview of the potentially injurious or distasteful species on site, an educated assessment of their potential threat and alternative solutions to violence for the management of such individuals. In addition, such training will also provide information on preventative measures intended to reduce the occurrence of negative human-wildlife encounters. For example, prevent wild animals from scavenging on construction site, areas for food consumption, storage, and waste disposal should be demarcated and managed. The personnel should also be briefed on what to do should they encounter specific wild animals.

Translocate Aquatic Fauna

The Three-spot Gourami and Crescent Betta can be captured at points at the streams it was encountered in and translocated to other suitable streams in the area that are not affected by works or other suitable streams as advised by NParks. This will minimise the impact of injury or mortality to these fishes, while allowing them to survive elsewhere.

5.5.4 Post-construction Phase Mitigation Measures

The section below provides a summary of the key recommended measures to avoid, minimise, rehabilitate/ restore biodiversity impacts to habitats, flora and fauna species during the post-construction phase.

Minimise

The key mitigation measures to minimise biodiversity impacts during the post-construction phase are summarised in Table 5.25 and detailed in the paragraphs below. The design measures that were proposed in Section 5.5.2 should be executed in this phase to achieve the intended mitigation as described.

Table 5.25 Key recommended measures to minimise biodiversity impacts during the post-construction phase.

Receptor	Impact Types	Mitigation Measures
Habitats	Loss of habitat Habitat degradation and edge effects Loss of ecological connectivity	Install fences or other suitable barriers between the Tengah HVP compound and adjacent forest to prevent human access into the forest Put up signages to deter members of the public from entering the forest or affecting waterways
Fauna	Faunal injury or mortality Human-wildlife conflict Human disturbances	Install barriers between the Tengah HVP compound and adjacent forest to prevent ground-dwelling fauna from entering the facility and human access into the forest Put up signages to educate members of the public on appropriate behaviours when encountering fauna or on interactions with waterbodies Incorporate wildlife-friendly lighting Ensure good housekeeping

Install barriers

Installing barriers between the Tengah HVP compound and adjacent forest can prevent ground-dwelling fauna from entering the facility and becoming susceptible to roadkills and human-wildlife conflict. Such barriers (fences, hoarding etc.) can also help to prevent members of the public from entering the forest, minimising the risk of habitat degradation, loss of ecological connectivity and human disturbances to the fauna inhabiting the forest, as well as further reducing the risk of human-wildlife conflict. Such wildlife-proof fences should be at least 1.8 m high, made of a hard, sturdy material (e.g., BRC fence), and embedded into the ground or installed on concrete surfaces to prevent animals from burrowing under the fence.

Put up signages

Signages are recommended to be put up around the Tengah HVP compound to educate users of the facility on appropriate behaviours when encountering fauna, reducing the likelihood of human-wildlife conflict. Signages that educate users on maintenance of cleanliness and proper behaviour around retained waterways in and around the HVP will also reduce the impact of habitat degradation and freshwater faunal injury or mortality. Signages to deter people from entering the forest can also help to minimise the risk of habitat degradation and maintain ecological connectivity.

Ensure Good Housekeeping

Good housekeeping related to waste management can minimise human-wildlife conflict. Food is an attractant to wildlife, and anthropogenic sources of food such as rubbish tend to be more easily accessible to fauna and higher in caloric yield than their natural food sources. Proper waste management measures such as the provision of wildlife-proof bins

and daily removal of waste from the facility would therefore reduce undesirable human-wildlife interactions.

Rehabilitate/Restore

The key mitigation measures to rehabilitate biodiversity impacts during the post-construction phase are summarised in Table 5.26 and detailed in the paragraphs below. The design measures that were proposed in Section 5.5.2 should be executed in this phase to achieve the intended mitigation as described.

Table 5.26 Key recommended measures to rehabilitate biodiversity impacts during the post-construction phase.

Receptor	Impact Types	Mitigation Measures
Habitats	Loss of habitat Habitat degradation and edge effects Loss of ecological connectivity	Intensifying and/or expanding green buffer plantings within the development boundary Turfing of slopes and supplementing with suitable plants of various other habits
Flora	Loss of flora	Intensifying and/or expanding green buffer plantings within the development boundary Turfing of slopes and supplementing with suitable plants of various other habits

Intensification and expansion of buffer planting
Please refer to Section 5.5.2 under Rehabilitate/Restore, Intensification and expansion of buffer planting.

5.6 Residual Impact

5.6.1 Construction Phase

5.6.1.1 Loss of Flora

With the implementation of mitigation measures, namely the implementation of TPZs and the transplantation of plant specimens particularly for smaller sized individuals or epiphytic or herbaceous species, the loss of flora conservation significant species can be reduced. For potential plants identified for transplantation, many of the conservation significant specimens here were suitable for transportation and transplantation. Others can potentially be available for propagation such as for provision of seeds or spores or stem cuttings. Thus, it might be concluded that relocation and transplantation efforts would be efficacious in the context of this development. However, the benefits of relocation and transplantation may ultimately be tempered by the ability of individual plants to adapt to their new environment. On average, relocation and transplantation measures are likely to dampen the extent of loss of conservation significant flora resultant from the eventual development of the Study Area.

5.6.1.2 Faunal Injury or Mortality

Birds and freshwater fauna are expected to be main beneficiaries of the implemented mitigation measures where injury and mortality are concerned. For example, the conduct of pre-felling fauna inspections is likely to protect fledging birds and eggs, where they might have otherwise been killed during the vegetation clearance process. Similarly, checking for roadkill and removing non-volant animals trapped under Erosion Control Blankets may provide a lease of life to these individuals. For freshwater fauna, if Stream S1 is retained, a 30m buffer with adequate construction controls and regular briefings to construction personnel on biodiversity awareness and waste control will be crucial to protecting freshwater fauna. The translocation of captured Crescent Betta and Three-spot Gourami from waterbodies affected by the development will also mitigate this impact on them. Nevertheless, individuals from the other animal groups are still expected to be directly injured or killed across a myriad of construction activities. On the whole, the residual impacts are likely to be slightly reduced with the implementation of the entire range of mitigation measures (Section 5.5).

5.6.1.3 Human-Wildlife Conflict

The impacts of human-wildlife conflict for both affected individuals and affected species may be ameliorated through the combined implementation of Wildlife Awareness Training, Wildlife Response and Rescue Protocol and Hoarding Plan. The former two measures will provide informed, alternative pathways of recourse where undesirable species of fauna come into close proximity with people. Meanwhile, the latter is expected to reduce the frequency of human-wildlife interactions as a whole. Together, these measures intend to reduce the rate by which violence is utilised on undesirable species, and by which human-initiated antagonism can in turn result in reprisals such as scratches, bites and envenomation. The successful implementation of mitigation measures and EMMP will benefit humans on-site the most as they will be prepared to handle whichever fauna in various situations should they be found in or close to the Project.

However, a successful reduction of human-wildlife conflict impacts is ultimately dependent on the voluntary uptake of the suggested protocols. Accordingly, some species will inadvertently invoke repulsion in some individuals, which may result in injury and death to the animal in question. This behavioural diversity in individual conduct is likely to result in a more modest reduction of impacts than if responses were purely rational.

5.6.2 Post-construction Phase

5.6.2.1 Loss of Habitat

If Stream S1 with a 30m buffer on each side is retained and unobstructed flow of water beyond the Tengah HVP footprint is ensured, this waterbody will be able to remain as available habitat. The area of waterbodies that is affected will reduce to 0.45 ha. This is also dependent upon the protection and maintenance of waterbodies and streams upstream and downstream from Stream S1 across other surrounding sites. The vegetated habitats will also have between 7 to 24% of the total habitat retained as buffer.

5.6.2.2 Habitat Degradation and Edge Effects

With the implementation of mitigation measures such as planting along forest and riparian edges as well as retention of habitat for Stream S1, the impact of habitat degradation will be reduced, resulting in a reduction of impact across most habitats except abandoned plantation forest. For waterbodies, if the habitats are maintained with pre-construction

water quality that can support the baseline freshwater fauna, the effect of degradation will be mitigated.

5.6.2.3 Loss of Ecological Connectivity

For volant fauna, the creation of new ecological corridors and connections across new urban landscapes and remnant patches of greenery and parks may be required to allow the movement of such fauna across the sites. This would depend on planned / future corridors in adjacent areas to the HVP.

For freshwater fauna, ecological connectivity can be somewhat maintained for Stream S1 if the waterbodies and streams from surrounding sites are preserved, and the streams are either maintained with at least a 30m buffer on each side while ensuring that the water quality is kept to a sufficient standard for freshwater fauna to survive. For all other animal groups, as some vegetated habitat is retained as buffer to Stream S1, this remaining habitat can serve as an ecological connection along the stream.

5.7 RIAM Summary

5.7.1 Construction Phase

Table 5.27 Summary of impact assessment for ecological impacts for the construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of flora	Flora	4	-3	3	3	3	-108	Moderate negative	-2	-72	Minor negative
Faunal Injury or Mortality	Birds	5	-2	3	3	2	-80	Minor negative	-1	-40	Minor negative
	Mammals	5	-2	3	3	2	-80	Minor negative	-1	-40	Minor negative
	Herpetofauna	3	-4	3	3	2	-96	Moderate negative	-3	-72	Minor negative
	Butterflies	5	-2	3	3	2	-80	Minor negative	-1	-40	Minor negative
	Odonates	4	-2	3	3	2	-64	Minor negative	-1	-32	Slight negative
	Aculeates	3	-2	3	3	2	-48	Minor negative	-1	-24	Slight negative
	Freshwater fauna	4	-4	3	3	2	-128	Major negative	-3	-96	Moderate negative
Human-wildlife conflict	Mammals	5	-2	2	3	2	-70	Minor negative	-1	-35	Slight negative
	Herpetofauna	3	-4	2	3	2	-84	Moderate negative	-3	-63	Minor negative
	Aculeates	3	-3	2	3	2	-63	Minor negative	-2	-42	Minor negative
	Humans	3	-4	2	3	2	-84	Moderate negative	-2	-42	Minor negative

5.7.2 Post-construction Phase

Table 5.28 Summary of impact assessment for ecological impacts for the post-construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of habitat	Native-dominated, young secondary forest	3	-4	3	3	3	-108	Moderate negative	-3	-81	Moderate negative
	Exotic-dominated secondary forest	3	-2	3	3	3	-54	Minor negative	-1	-27	Slight negative
	Waterbodies	4	-4	3	3	3	-144	Major negative	-3	-108	Moderate negative
	Abandoned plantation forest	2	-1	3	3	3	-18	Slight negative	-1	-18	Slight negative
	Scrubland	2	-2	3	3	3	-36	Slight negative	-1	-18	Slight negative
Habitat Degradation and Edge Effects	Native-dominated, young secondary forest	3	-4	3	3	3	-108	Moderate negative	-2	-54	Minor negative
	Exotic-dominated secondary forest	3	-2	3	3	3	-54	Minor negative	-1	-27	Slight negative
	Waterbodies	3	-2	3	3	3	-54	Minor negative	-2	-54	Minor negative
	Abandoned plantation forest	2	-1	3	3	3	-18	Slight negative	-1	-18	Slight negative
	Scrubland	2	-2	3	3	3	-36	Slight negative	-1	-18	Slight negative
Loss of ecological connectivity	Non-volant mammals and herpetofauna	5	-2	3	2	3	-80	Minor negative	-1	-40	Minor negative
	Birds, Bats, Butterflies and Odonates	5	-2	3	2	3	-80	Minor negative	-1	-40	Minor negative
	Freshwater fauna	4	-3	3	3	3	-108	Moderate negative	-2	-72	Minor negative

6 Air Quality

Within the current Project area, the main sources of air pollution are from motor vehicles along the Pan Island Expressway, as well as emission from adjacent ongoing construction. Construction activities from the Project will likely further impact air quality, particularly through the increase in particulate matter and heavy vehicle exhaust emissions. The use of the site as a Heavy Vehicle Park will also contribute to post-construction air quality impacts.

This section includes the applicable legislation and standards of air quality management and baseline study of the Project. Development impact from the construction and post-construction phase will be assessed and evaluated and suitable mitigation measures will be proposed.

Site surveys were conducted to measure the Project's baseline condition for general air pollutants (PM_{10}, $PM_{2.5}$, NO_2, CO, O_3, SO_2). The findings were utilised to set the baseline conditions, acting as a standard for evaluating the Project's potential impact on the air quality concerning identified sensitive receptors and the overall ambient air quality due to the activities associated with both construction and post-construction phases of the Project.

6.1 Applicable Legislation and Standards

Air quality in Singapore is governed by NEA Singapore Ambient Air Quality Targets (SAAQT) shown in Table 6.1 below. Baseline results will be assessed based on SAAQT.

Table 6.1 NEA Singapore Ambient Air Quality Targets (Long Term Targets)

Pollutant	Averaging period	Singapore Ambient Air Quality Targets *
Particulate Matter (PM_{10})	24 hours	50 µg/m^3
	1 year	20 µg/m^3
Particulate Matter ($PM_{2.5}$)	24 hours	25 µg/m^3
	1 year	10 µg/m^3
Sulphur Dioxide ($SO_{2)}$	24 hours	20 µg/m^3
Nitrogen Dioxide (NO_2)	1-hour	200 µg/m^3
	1 year	40 µg/m^3
Carbon Monoxide (CO)	8 hours	10 mg/m^3
	1 hours	30 mg/m^3
Ozone (O_3)	8 hours	100 µg/m^3

** Long term targets adopted for SO_2 and $PM_{2.5}$*

Other than the SAAQT, below are the list of Applicable Acts, Regulations & Guidelines for air quality protection that will be referenced to for the analysis of the air quality impact assessment in this study.

- 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, 2012
- Environmental Protection & Management (Prohibition on the Use of Open Fires) Order 2008
- Technical Memorandum Annex 12: Guidelines for Air Quality Assessment published by HK EPD
- Energy Conservation Act, 2014
- Guidance on the assessment of dust from demolition and construction, Institute of Air Quality Management (IAQM), 2016

The Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 in Singapore focuses on controlling and reducing emissions from vehicles. It sets standards for vehicle exhaust emissions to mitigate air pollution, promoting environmental sustainability. The regulations aim to enhance air quality and public health by enforcing emission standards for vehicles operating in Singapore.

Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012 regulates all off-road diesel engines (e.g., cranes, excavators, power generators, etc) imported into Singapore must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards. This regulation is in place to ensure that exhaust emissions are controlled at source to meet air quality standards and do not contribute additional pollutants to the environment.

Guidance on the assessment of dust from demolition and construction by IAQM is an essential tool for evaluating the dust impact arising from various scales of demolition and construction activities. In the absence of construction and development plans at the time of writing, this guideline serves as a valuable resource for estimating dust impact and conducting air quality assessments.

6.2 Methodology

The potential effects on air quality resulting from dust and gaseous emissions related to construction can pose health risks to humans and may also disrupt specific manufacturing procedures that are sensitive to elevated dust concentrations. A baseline study was conducted to evaluate the current ambient air quality and establish the existing environmental conditions.

This section will encompass the methodology used for collecting primary data and reviewing secondary data. Additionally, it will outline the findings derived from both primary data collection and the analysis of secondary data sources.

6.2.1 Desktop Study

The desktop study, which utilises secondary data from previous EIAs conducted around the Project (see Section 4.3), satellite imagery, existing land use, and development activities, assists in identifying the baseline air monitoring location and provides comparison data for the primary data collected.

Secondary data provides an overview of the progressive air quality condition over the years considering with the on-going construction of housing, transportation and water pipelines and other future developments planned within the Tengah area.

Previous studies of air quality within Tengah listed below have been reviewed.

Tengah South Environmental Impact Study (HDB, 2021b)

J1002 Jurong Region Line Mainline and Depot Environmental Impact Assessment (LTA, 2018)

6.2.2 Field survey

Air quality measurements were conducted at two (2) locations (AQ1 and AQ2) that are representative of sensitive receptors in the project vicinity are depicted in Figure 6.1. Air quality monitoring details are reflected in Table 6.2 below.

Ambient air quality measurements were conducted using the Kunak AIR Pro Air Quality Monitoring Station (Non-USEPA). This station employs two distinct measurement methods:

- **Particle size (PM_{10}, $PM_{2.5}$):** Measured by laser scattering method, which utilises laser light to analyse the size and distribution of airborne particles.
- **NO_2 and CO, O_3, SO_2:** measured by electrochemical method, which involves the use of electrochemical sensors to detect the presence and concentration of these gases.

Data logging was at 10- minute intervals for particulate matter and 5-minute for the 4 gas pollutants. The hourly and 24-hour daily averages were computed based on the averaging data obtained and the results were compared against the Singapore Ambient Air Quality Targets 2020.

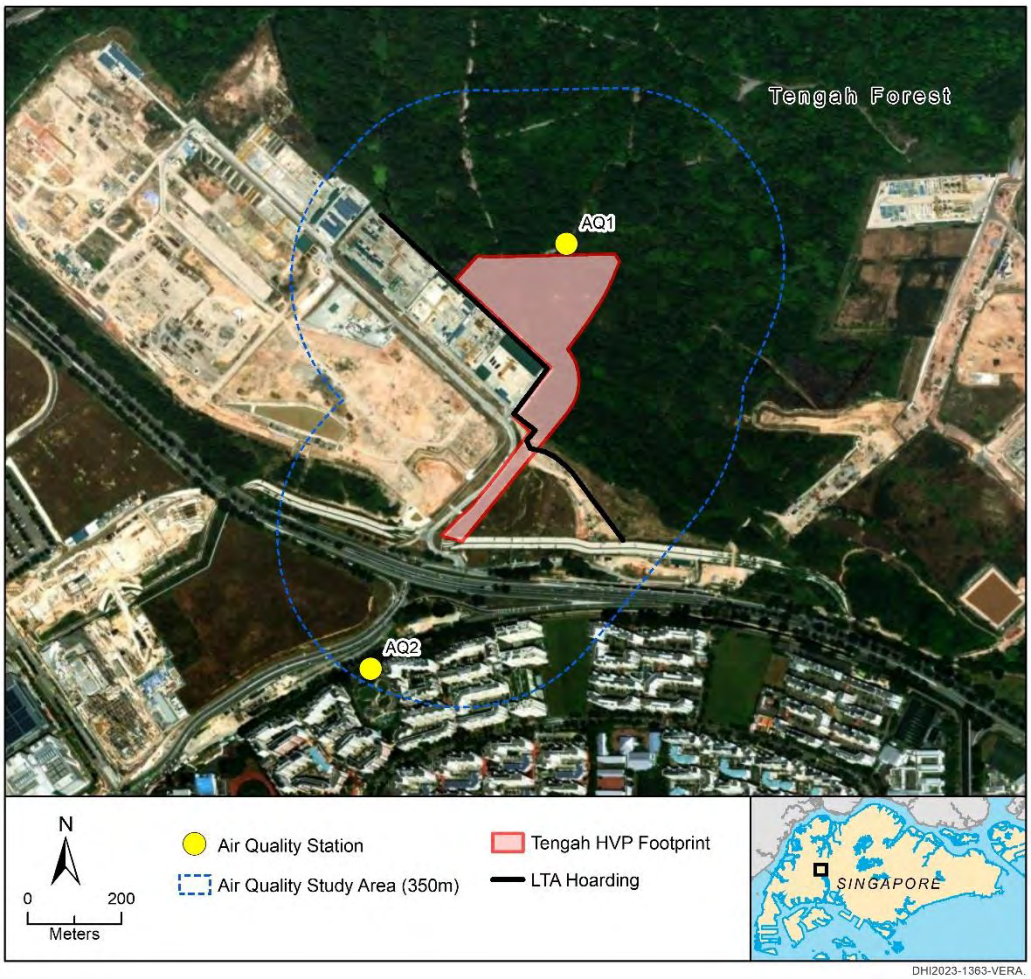

Figure 6.1 Location of air quality monitoring station. (Basemap source: ArcMap World Imagery)

Table 6.2 Air quality monitoring period

Station	Location	Type of receptor	Monitoring Period	Pollutants Measured
AQ1	Tengah forest	Fauna within secondary forest	12 to 18 Sep 2023	• PM_{10} • $PM_{2.5}$ • CO • SO_2 • NO_2 • O_3
AQ2	Along HDB at Jurong West Street 42	Residential Area	20 to 26 Sep 2023	

6.3 Baseline Descriptions

6.3.1 Desktop Study

6.3.1.1 Past EIA studies

Average air quality was collected and reported in the following past EIA studies:

- LTA Jurong Region Line (2018)
- Tengah South EIS (2021)

These studies revealed that ambient air quality parameters consistently met SAAQT limits for all residential receptors identified. No exceedances were reported.

6.3.1.2 NEA Long Term Ambient Air Quality Monitoring

Table 6.3 presents the general ambient air monitoring findings by NEA in Singapore spanning from 2018 to 2022, juxtaposed with the Singapore Long Term Ambient Air Quality Targets. Analysis of Table 6.3 indicates that, with the exception of carbon monoxide (CO) and Nitrogen Dioxide (NO_2), all parameters consistently surpassed the Singapore Long Term Air Quality Targets during the specified period. The escalated concentrations of PM_{10}, $PM_{2.5}$, and O_3 in Singapore are partially linked to intermittent haze occurrences stemming from forest fires in neighbouring countries, although domestic emissions from industries, shipping, and motor vehicles may also significantly contribute to the background levels.

Table 6.3 NEA Long term ambient air quality monitoring

	PM_{10} (24-hr)	$PM_{2.5}$ (24-hr)	SO_2 (24-hr)	NO_2 (1-hr)	O3 (8-hr)	CO (8-hr)	CO (1-hr)
SAAQT	**50**	**25**	**20**	**200**	**100**	**10**	**30**
2022	**51**	**26**	**37**	128	**124**	1.7	2.1
2021	**51**	**28**	**89**	123	**176**	1.2	1.3
2020	43	24	**30**	118	**145**	1.2	1.3
2019	**90**	**62**	**57**	156	**125**	1.7	2.3
2018	**59**	**32**	**65**	147	**150**	2.0	2.5

Note: Limit exceedance has been reported in bold

6.3.2 Field survey

Air quality monitoring was conducted from 12 to 26 Sep 2023, the results of which are presented below in Table 6.4. The baseline measurements reflect the 99th percentile as per the WHO global air quality guidelines (2021). The full dataset for air quality readings can be referred to in Appendix C.

A1 was located within Tengah Forest, while A2 was located within an HDB estate. As noted in Table 6.4, ambient air quality monitoring has shown compliance with national targets (SAAQT) and WHO global air quality guidelines, as detailed in Section 6.1, with the exception of SO_2, which exceeded SAAQT (Long-term) targets at both A1 and A2.

Table 6.4 Baseline measurements of PM_{10}, $PM_{2.5}$, NO_2 and CO (99^{th} percentile)

Measurement Location / Limit		Results ($\mu g/m^3$)				Results (mg/m^3)	
	PM_{10} (24-hr) a	**$PM_{2.5}$ (24-hr) a**	**SO2 (24-hr)**	**NO_2 (1-hr)**	**O3 (8-hr) a**	**CO (8-hr)**	**CO (1-hr)**
SAAQT [a]	**50**	**25**	**20**	**200**	**100**	**10**	**30**
A1 (Tengah Forest)	21.21	16.47	**26.66**	29.00	44.36	0.41	0.6
A2 (HDB Jurong West St 42)	21.15	17.22	**87.95**	66.40	63.37	0.79	0.92

Note: Limit exceedance has been reported in bold

[a] based on the 99th percentile of air quality data, which corresponds to roughly 3-4 exceedance days per year, as per the WHO global air quality guidelines (pictured below). The SAAQT (Site Specific Air Quality Targets) have been established based on this percentile.

Although the summarised data indicates an exceedance of the average SO_2 (24-hr) levels in A1, readings ranged from 1.41 to 27.19 $\mu g/m^3$, with an exceedance on only one of the seven days. While the specific source of the SO_2 exceedance could not be identified, this may be attributed to a one-off periodic event.

For A2, SO_2 (24-hr) readings ranged from 24.22 to 89.32 $\mu g/m^3$, with readings on all seven days exceeding the SAAQT (Long-term) targets. The relatively high levels of SO_2 may be attributed to high vehicular traffic in the area, particularly the Pan Island Expressway (PIE) which is a major highway in Singapore.

6.4 Impact Assessment

To assess the potential impacts of construction dust emission, a semi-quantitative approach is adopted based on the UK Institute of Air Quality Management (IAQM)'s Guidance on the Assessment of Dust from Demolition and Construction, and further interrupted with RIAM (see evaluation framework in Section 4.5).

The emissions of pollutant such as nitrogen dioxide and hydrocarbons into the airshed can stem from the movement of heavy vehicles and powered machinery within the construction site. However, these contributions are anticipated to be regulated under the Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012. As of 1 July 2012, all off-road diesel engines (e.g., cranes, excavators, power generators, etc) imported into Singapore must adhere to the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards. Given these regulations, the potential impacts from these pollutants are expected to be addressed adequately and are therefore not further considered in the following assessment.

6.4.1 Determining Importance and Magnitude

Air quality impacts anticipated from the construction and post-construction phase of the development were evaluated in-line with the UK Institute of Air Quality Management's Guidance on the Assessment of Dust from Demolition and Construction (2016).

The assessments of risk of dust impacts from Project construction activities are guided by the IAQM framework. This framework categorises the Magnitude and sensitivity of receptors into various categories:

- Magnitude: Negligible, Small, Medium and Large
- Sensitivity of receptors: Low, Medium and High

The DHI's RIAM framework offers greater detail, necessitating certain receptor-specific adaptations of the IAQM method as outlined below.

Table 6.5 Criteria for Determining Air Quality Sensitive Receptor Importance

Score	Generic Definition	Customised Definition
5	Important to national/ international interests	Social-economic receptors affected are specifically protected by national or international policies or legislation and are of significance at the regional or national scale.
4	Important to regional/national interests	Social-economic receptors where more sensitive members of the public are exposed for eight hours or more in a day, e.g., hospital and care facilities
3	Important to areas immediately outside the local condition	Social-economic receptors where members of the public are exposed for eight hours or more in a day, for example, residential properties and schools
2	Important only to the local condition (within a large direct impact area)	Social-economic receptors where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office and shop workers
1	Important only to the local condition (within a small direct impact area)	Social-economic receptors with transient exposure, e.g., recreational users of playgrounds, visitors to place of worship, etc.

According to IAQM's Guidance on the Assessment of Dust from Demolition and Construction, activities on construction sites that will potentially result in dust impact include demolition, earthworks, construction and trackout. Table 6.6 summarises the referenced definition of dust emission magnitude in relation to the estimated scale of construction activities.

Table 6.6 IAQM's Definition of Potential Dust Emission Magnitude

Type of Activity	Dust Emission Magnitude Classification Reference		
	Large	**Medium**	**Small**
Demolition	• Total building volume >50,000 m^3 • Potentially dusty construction material (e.g. concrete) • On-site crushing and screening[1] • Demolition activities >20 m above ground level	• Total building volume 20,000 m^3 - 50,000 m^3 • Potentially dusty construction material • Demolition activities 10-20 m above ground level	• Total building volume <20,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber) • Demolition activities <10 m above ground • Demolition during wetter months
Earthworks	• Total site area >10,000 m^2 • Potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size) • >10 heavy earth moving vehicles active at any one time • Formation of bunds >8 m in height • Total material moved >100,000 tonnes	• Total site area 2,500 m^2 - 10,000 m^2 • Moderately dusty soil type (e.g. silt) • 5-10 heavy earth moving vehicles active at any one time • Formation of bunds 4 m - 8 m in height • Total material moved 20,000 tonnes - 100,000 tonnes	• Total site area <2 ,500 m^2 • Soil type with large grain size (e.g. sand) • <5 heavy earth moving vehicles active at any one time • Formation of bunds <4 m in height • Total material moved <20,000 tonnes • Earthworks during wetter months
Construction	• Total building volume >100,000 m^3 • On site concrete batching[1] • Sandblasting	• Total building volume 25,000 m^3 - 100,000 m^3 • Potentially dusty construction material (e.g. concrete) • On site concrete batching[1]	• Total building volume <25,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber)
Trackout	• >50 Heavy Duty Vehicle (HDV) (>3.5 tonnes) outward movements[2] in any one day[3] • Potentially dusty surface material (e.g. high clay content) • Unpaved road length >100 m	• 10-50 HDV outward movements2 in any one day [3] • Moderately dusty surface material (e.g. high clay content) • Unpaved road length 50 m - 100 m	• <10 HDV outward movements[2] in any one day[3] • Surface material with low potential for dust release • Unpaved road length <50 m

[1] Mobile crushing equipment and concrete batching plants can be significant sources of dust. Professional judgement will be required to determine how the use of crushing and screening equipment or on site concrete batching will affect the dust emission magnitude.

[2] A vehicle movement is a one-way journey, i.e. from A to B, and excludes the return journey.

[3] HDV movements during a construction project vary over its lifetime, and the number of movements is the maximum not the average

In the RIAM framework, Magnitude has been adapted with the risk of impacts assigned a score of 0 to -4. The air quality Magnitude evaluation framework for this EIA is presented in Table 6.7

Table 6.7 Criteria for Magnitude in Air Quality

Score	IAQM Risk of Impacts Classification	Generic Definition	Customised Definition
-4	Large	Major negative disadvantage or change	• Severe effects on air quality which are likely to be long lasting, typically widespread in nature and requiring significant intervention to return to baseline • Air quality is likely to routinely exceed national / international standards, guidelines or target levels
-3		Moderate negative disadvantage or change	• Potential effects on air quality which are likely to be long lasting, typically widespread in nature and requiring moderate intervention to return to baseline • Air quality is likely to approach or in danger of exceeding national / international standards, guidelines or target levels
-2	Medium	Minor negative disadvantage or change	• Short-term localised effects on air quality which are likely to return to equilibrium conditions within a short timeframe (hours or days at most) • Air quality is likely to be within national / international standards, guidelines or target levels
-1	Low	Slight negative disadvantage or change	• Short-term localised effects on air quality but likely to be highly transitory (lasting hours) and well within natural fluctuations • Air quality is likely to be well within national / international standards, guidelines or target levels
0	Negligible	No change	• Status quo

6.4.1.1 Identified Sensitive Receptor and Importance

Air quality sensitive receptors (ASRs) that would be susceptible to potential impacts from the planned works that are located within the 350m radius of the Project boundary are identified and shown in Figure 6.2 below. Description of the receptors are shown in Table 6.8.

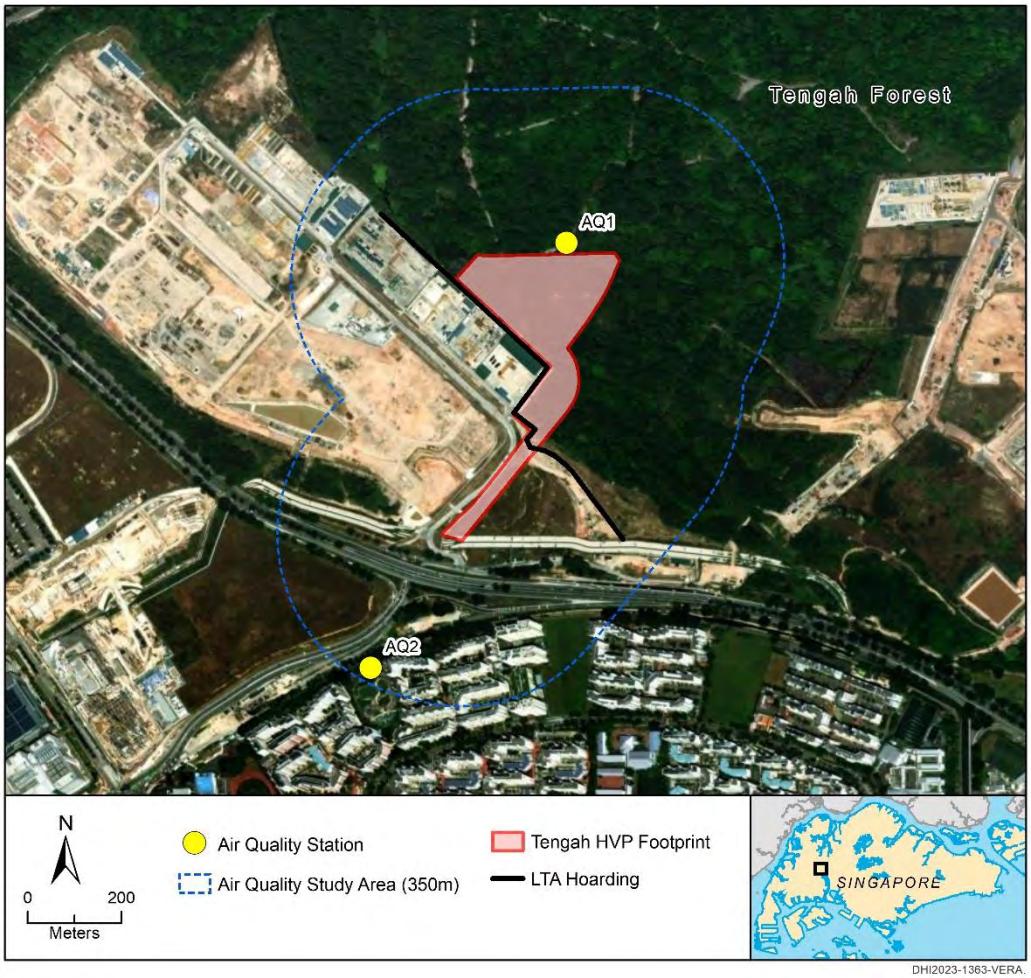

Figure 6.2 Air quality sensitive receptor identified within 350 m radius of Project boundary.

Table 6.8 Identified air quality sensitive receptor and their Importance.

Type of receptor	Description	Sensitivity	Importance Score
Residential areas	• HDB residences along Jurong West Street 42	Residents at these locations are expected to be exposed to the air emissions from Project site at least 8 hours a day.	3
Terrestrial fauna	• Fauna within Tengah Forest	Fauna at these locations is expected to be exposed to the air emissions from Project site at least 8 hours a day.	3

6.4.2 Construction Phase

The construction activities and timeline for the Project can be referred to in Section 2.2 and 2.3. A detailed construction programme is not available at this stage of assessment, given the existing land condition and terrain of the project site, it is expected that site clearance and land preparation would be the main works.

6.4.2.1 Dust Emission from Construction Activities

For construction phase, dust emissions from construction activities, equipment, suspended particles due to movement, and wind erosion from exposed surfaces typically outweigh the emissions of gaseous pollutants such as NO_2 and CO, provided that the on-site engines are well-maintained and adhere to NEA regulations. Table 6.9 outlines the primary sources of dust emission during the construction phase.

Construction phase involves land clearance, site levelling, land preparation and infrastructure works.

With reference to IAQM assessment guideline, the construction activities are generally classified into demolition (minimal in current project), earthworks (site formation and levelling and excavation), construction (foundation and superstructure), and trackout (transportation of dusty materials). Based on the scale of the proposed development, the potential dust impacts from these works are evaluated and the Magnitude as classified using IAQM guideline is presented Table 6.10 and the subsequent subsections.

Table 6.9 Air pollutants source anticipated during the construction phase.

Air Pollutant	Source of Emission
PM2.5, PM10	• Construction processes which involve disturbance of earth materials, such as site clearance, excavation, stockpiling, handling/transportation of materials • Movement of construction vehicles and equipment causing suspension of dust from exposed surface within construction site • Fugitive dust due to wind action on open / exposed earth materials and stockpiles, and combustion of fuel

Table 6.10 Anticipated IAQM Magnitude for the construction activities.

Activities	IAQM Magnitude	Description of expected scale of works
Earthwork	Large	• Total site area significantly >10,000 m^2, potentially dusty soil type • >10 heavy earth moving vehicles active at any one time • Total material moved significantly >100,000 tonnes
Construction	Small	• Total building volume <25,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber)
Trackout	Medium	• 10-50 HDV outward movements in any one day • Moderately dusty surface material (e.g. high clay content) • Unpaved road length 50 m - 100 m

The Project's indicative activities (Table 2.1) have been categorised into the following:

- Earthworks
  - Earthworks anticipated for the Project include the processes of soil-stripping, ground-levelling, excavation, stockpiling, and landscaping.

- Given the current site condition and hilly terrain (refer to Figure 2.4), significant volume of earth disturbing works due to site clearance and levelling for establishing the land will take place. Removal of existing vegetation and ground levelling will be the main activities. Subsequently, excavators are employed to loosen and remove the broken rocks, which is expected to generate dust.
- Following the IAQM's definition of earthworks, potential dust emission magnitude from the Project site clearance and excavation works is classified as "Large".

- Construction
  - The Project is slated as a HVP, therefore, only roads, parking lots, drains/culverts, a substation and an underground stormwater detention tank will be constructed. It is estimated that the total building volume will be minimal with low potential for dust release.
  - Following the IAQM's definition of construction, a classification of "Small" dust emission magnitude is assigned.
- Trackout
  - Dust and dirt from the construction site, if unmanaged, will be transported onto the public road network, where it may accumulate and then re-suspended by vehicles using the network. Heavy duty vehicles (HDVs) when leaving the construction site may carry dusty materials with them and may then disperse onto the road.
  - The inventory list of anticipated construction vehicles and the number of trips is not available at the time of writing. There are construction projects surrounding the Project and paved roads have been established. A conservative approach for the Project has been considered with less than 50 HDV outward movements in a day along an unpaved road length more than 100 m.
  - Following the IAQM's definition of impact from trackout activities, a classification of "Medium" dust emission magnitude is assigned

6.4.2.2 Air Quality Impact on Sensitive Receptors

Biodiversity in Tengah Forest / within Project site

The Project site encompasses the Tengah Forest, characterized by a dense terrestrial forest. The fauna residing in these habitats may face potential impacts from the dust generated by activities on the Project site.

The fauna within the edge of Tengah Forest is already exposed to emissions from vehicles along the Pan Island Expressway (PIE), located 100m south of the Project, and surrounding construction projects. This suggests that these species may adapted to these environmental conditions.

Earthworks

The total earthwork area and volume is estimated to be approximately 82,000 m^2 and 318,000 m^3 respectively. It is anticipated that land clearing and within the Project site will start progressively from south to north in phases. Given the extensive work area and the earthworks activities could spent for months, the dust emission from the earthworks is expected to be significant and would impose ***Minor negative impact*** on the biodiversity in Tengah Forest.

Construction

Construction activities such as excavation, grading, and earthmoving can generate significant amounts of dust. This dust can settle on vegetation and disturb the habitats of various plant and animal species. Additionally, inhalation of dust particles can affect the respiratory systems of animals.

Given that the project involves building a HVP, the process of heating and applying asphalt can emit volatile organic compounds (VOCs) and other fumes into the atmosphere. Extended exposure to these emissions may adversely affect the health of nearby wildlife, particularly small mammals, birds, and insects. However, the exposure is anticipated to be short term (<6 months). ***Slight negative impact*** of dust is expected from the construction activities.

Trackout

Trackout dust, stems from transporting earthwork and construction materials using HDV. The impact of trackout dust is expected to be minimal as the access road will be less than 50 HDV outward movements in a day along an unpaved road length more than 100 m. ***Slight negative impact*** on the biodiversity in Tengah Forest due to trackout.

Residential Areas

Within the 350-meter assessment buffer from the Project site, as outlined in residential areas have been identified.

Given their proximity to the Project boundary (i.e.>300m), residents of HDB likely to experience minimal to no impacts from the development activities of the Project. It is to be noted that the current state of the residential area are already exposed to dust generated from high vehicular traffic along the PIE as well as current construction activities located adjacent to the Project. Therefore, ***No impact*** to residential receptors is anticipated during Earthworks, Construction and Trackout.

6.4.3 Post-Construction Phase

The post-construction phase air quality impacts of a heavy vehicle park can include:

Vehicle Emissions: Heavy vehicles parked in the facility can emit pollutants such as nitrogen oxides (NOx), particulate matter (PM), volatile organic compounds (VOCs), and carbon monoxide (CO) from their exhaust systems. These emissions contribute to poor air quality in the surrounding area, potentially affecting human health and nearby ecosystems.

Dust Resuspension: The movement of heavy vehicles within the park can resuspend dust particles settled on the ground. This can lead to increased levels of particulate matter in the air, which may exacerbate respiratory issues and degrade air quality.

Traffic-related Pollution: Increased traffic flow associated with the operation of the heavy vehicle park can result in elevated levels of pollutants emitted from vehicles on surrounding roads. This includes pollutants from both diesel and gasoline-powered vehicles, contributing to overall air pollution levels in the vicinity.

Overall, the post-construction phase air quality impacts of a heavy vehicle park are not anticipated to be significant, taking into account the current on-site conditions of the area where the area is partially bounded by main roads with heavy traffic and other projects undergoing development. Some impacts might be felt on the remaining forested area. The effects of which will be assessed qualitatively, based on the characteristics of the emissions and distance from relevant receptors.

Table 6.11 Air pollutants emitted by the development within the Project site

Air Pollutant	Source of Emission
Nitrogen oxides, NO_x	Emissions from industrial process (if any), typically related to the use of fuel
PM2.5, PM10	Emissions from induced vehicular traffic in the area

6.5 Mitigation Measures

6.5.1 Construction Phase

To address the air quality impact stemming from construction activities, a set of mitigation measures is proposed at source to minimise emission from the construction. General good site management practices shall be implemented, incorporating effective earth control measures throughout all stages of construction. General and activities specific measures are proposed below, and these collective strategies aim to significantly reduce airborne dust during construction, promoting a healthier air quality environment for both on-site workers and the surrounding community. Regular monitoring and adjustment of these measures will be integral to ensuring their continued effectiveness throughout the construction phase.

General measures:

- Comply with relevant environmental regulations, including the Environmental Protection and Management Act and any other regulations and guidelines come into effect when the time of construction works commencement.
- Minimise the duration of bare earth exposure through careful planning of work sequence and schedule.
- If exposure of bare earth and stockpile of earth materials is needed on site, Erosion Control Blankets shall be used to cover the exposed surfaces to prevent wind erosion and wash off by rain.

- Plants and machineries used on site shall be properly and regularly inspected and maintained to control dust and air pollutants emission.
- Minimise dust emission from dusty activities, e.g. excavation and demolition of existing paved roads, by water spraying and / or physical screening.
- To schedule activities with the potential for higher dust emissions, such as earthworks during periods of lower wind speeds to reduce the dispersion of airborne particles
- Wheel washing bay shall be provided, and all trucks / vehicles shall be washed before leaving the construction site.
- Minimize traffic delays caused by movement of construction vehicles by planning transport route and transport period that avoid congested areas and peak hours of road use.
- Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeters recommended to reduce dust deposition.
- Avoid burning of waste or other materials.

Earthworks:

- Prompt removal of excavated soil from the construction site to prevent prolonged exposure.
- To limit the height of stockpiles to control airborne dust.
- Earthworks to be conducted in stages.
- To cover any exposed earth areas not in immediate use with erosion control blankets.
- To compact or pave any exposed earth areas not in immediate use.

Construction:

- Installation of physical barriers to contain ground-level pollutants.
- To prioritize the use of low volatile organic compound (VOC) construction materials for paints, adhesives, and sealants.
- To utilize emission-reducing construction equipment.
- Regular inspection and maintenance of construction equipment to control emissions.
- If concrete batching is carried out on site, the batching plant shall be placed away from the sensitive receptors.
- Use enclosed chutes and conveyors and covered skips wherever possible.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.

Trackout:

- Installation of trackout control mats at exit points complemented by wheel wash stations.
- Designing site exit points paved or stabilized surfaces to minimize the disturbance of loose soil.
- Enforcing lower speed limits within the construction site to ensure vehicles move within the site and exit gradually.

- Equipping all haul trucks transporting materials with covers to reduce dust emissions during transit.
- Regular maintenance and cleaning of road within site to promptly remove accumulated dust and debris minimizing the generation of dust.

6.5.2 Post-Construction Phase

The Project's operation will involve a significant flow of heavy vehicle traffic. Currently, the extent of this traffic remains uncertain. Implementing measures such as regular maintenance of vehicles to reduce emissions, dust control measures, and spill prevention practices can help mitigate these impacts and improve air quality in the surrounding environment. Policies to limit idling time for heavy vehicles may be implemented

Green spaces and landscaping can be integrated into the site design which can contribute to air quality improvement. As the future operation of the Project is not expected to result in significant change in air quality in the area, no specific mitigation measures are recommended.

6.6 Residual Impact

6.6.1 Construction Phase

Through the implementation of a comprehensive set of air quality impact mitigation measures during the construction phase, the anticipated significance of air quality impacts associated with various activities is expected to be significantly reduced to minor or negligible levels. These measures, ranging from the use of dust control techniques, physical screening, and site management practices, are strategically designed to minimize dust emissions and dispersion to the surrounding environment. The residual impact after implementing these mitigation strategies is outlined in Section 6.7.

6.6.2 Post-Construction Phase

The residual impact is anticipated to remain unchanged.

6.7 RIAM Summary

6.7.1 Construction Phase

Table 6.12 Summary of impact assessment for Air Quality impacts for the construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Earthworks	Terrestrial fauna (Tengah Forest)	3	-3	2	2	2	-54	Minor negative impact	-2	-36	Slight negative impact
	Residential areas	3	0	2	2	2	0	No impact	-	-	No impact
Construction activities	Terrestrial fauna (Tengah Forest)	3	-1	2	2	2	-18	Slight negative impact	-1	-18	Slight negative impact
	Residential areas	3	0	2	2	2	0	No impact	-	-	No impact
Trackout	Terrestrial fauna (Tengah Forest)	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Residential areas	3	0	2	2	2	0	No impact	-	-	No impact

6.7.2 Post-Construction Phase

Table 6.13 Summary of impact assessment for Air Quality impacts for the post construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Emission from HVP operation	Terrestrial fauna (Tengah Forest)	3	-1	3	3	2	-24	Slight negative impact	-1	-24	Slight negative impact
	Residential areas	3	0	3	3	2	0	No impact	-	-	No impact

7 Airborne Noise

The main sources of anthropogenic noise around the Project area are from motor vehicles along the Pan Island Expressway, as well as construction activities from adjacent ongoing construction. Construction activities from the Project such as land clearance, earthworks, and infrastructure works will further increase airborne noise levels. The use of the site as a Heavy Vehicle Park will also contribute to post-construction noise impacts on sensitive receptors.

This section presents the applicable legislation and standards of airborne noise and the baseline study of the Project. Development impact from the construction and post-construction phase will be assessed and evaluated and suitable mitigation measures will be proposed in the final EIA document.

Site surveys measured the baseline condition, establishing initial conditions that serve as a benchmark for assessing potential impacts on sensitive receptors and airborne noise from the project's construction and post-construction activities.

7.1 Applicable Legislation and Standards

The noise assessment criteria for this Project adhere to the Singapore Construction Noise Regulations. Table 7.1 below. Details the permissible construction noise limits for worksites from Monday to Sunday.

Table 7.1 Maximum Permissible Noise Levels for Construction Site – Monday to Sunday

Monitoring Station	Worksite Operational Period			Parameter
	Day (07:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 07:00)	
(a) Hospitals, schools, institutions of higher learning, homes for the aged sick etc.	60	50		$L_{eq-12hr,}$ dB(A)
	75	55		$L_{eq-5min,}$ dB(A)
(b) Residential buildings located less than 150 m from the construction site where the noise is being Emitted	75	-	-	$L_{eq-12hr,}$ dB(A)
	-	65	55	$L_{eq-1hr,}$ dB(A)
	90	70	55	$L_{eq-5min,}$ dB(A)(1)
	75	55		$L_{eq-5min,}$ dB(IA)(2)
(c) Building (other than those in paragraphs (a) and (b))	75	65		$L_{eq-12hr,}$ dB(A)
	90	70		$L_{eq-5min,}$ dB(A)

Notes:
(1) Applicable maximum permissible noise levels where noise is being emitted on Mondays to Saturdays.
(2) Applicable maximum permissible noise levels where noise is being emitted on Sundays and public holidays.
Source: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2011

According to NEA's directive, the maximum permissible noise levels for construction sites shall be adjusted by the addition of a correction factor to the higher of either the permissible noise level or the measured background noise level, to account for the existing background noise levels in the area. The correction factors correspond to the difference between the applicable permissible level, and the background noise level, and are presented in Table 7.2 below.

It should be noted the correction factor is not to be used during the design and prediction phase. Instead, the intent of the correction factor is for use during assessment to account for background ambient noise levels.

Table 7.2 Correction factor

Difference between Permissible and Background Noise Levels dB(A)	Correction Factor dB(A)
Below 2	3
2 to less than 4	2

Difference between Permissible and Background Noise Levels dB(A)	Correction Factor dB(A)
4 to less than 10	1
10 and above	0

**Source: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2011*

7.2 Methodology

Construction noise from the project site will be a source of environmental pollution, impacting both residents and wildlife. Prolonged exposure can elevate stress levels in humans and disrupt or disorient animals in the nearby forest. Establishing a baseline for current noise levels will be crucial to assess the project's impact and implement effective mitigation measures.

Methodology and findings of primary data collection and review of secondary data will be presented in this section.

7.2.1 Desktop Study

Secondary data such as previous EIA report, satellite imagery, existing land use, and development activities assist in identifying the baseline air monitoring location and provide comparison data for the primary data collected. Secondary data provides an overview of the progressive airborne noise condition over the years where applicable considering with the planned development within the area (see Section 4.2.4 for details).

7.2.2 Field Survey

To establish the baseline airborne noise at the noise sensitive receivers (NSRs) as tabulated in Table 7.3 within the study area, airborne noise measurements were conducted at two (2) representative locations. The monitoring locations are shown in Figure 7.1 with a description of the monitoring locations provided in Table 7.4.

Continuous monitoring for five (5) successive days, encompassing both weekdays and weekends was conducted at each monitoring station. The instruments were positioned away from primary roads or any other probable external sources that could affect the readings.

NEA- approved Type 1 sound level meters were used for the noise measurements. The noise loggers were installed at a height of 1.5 m above the ground and placed at a distance from any building façade or reflective surface. Additionally, the chosen locations for baseline noise monitoring were situated away from local noise sources such as mechanical equipment, pumps, or routine community activities.

Table 7.3 Noise monitoring locations.

Station	Location	Type of receptor
N1	Tengah Forest	Fauna within secondary forest
N2	Block 558 HDB Jurong West	Residential areas

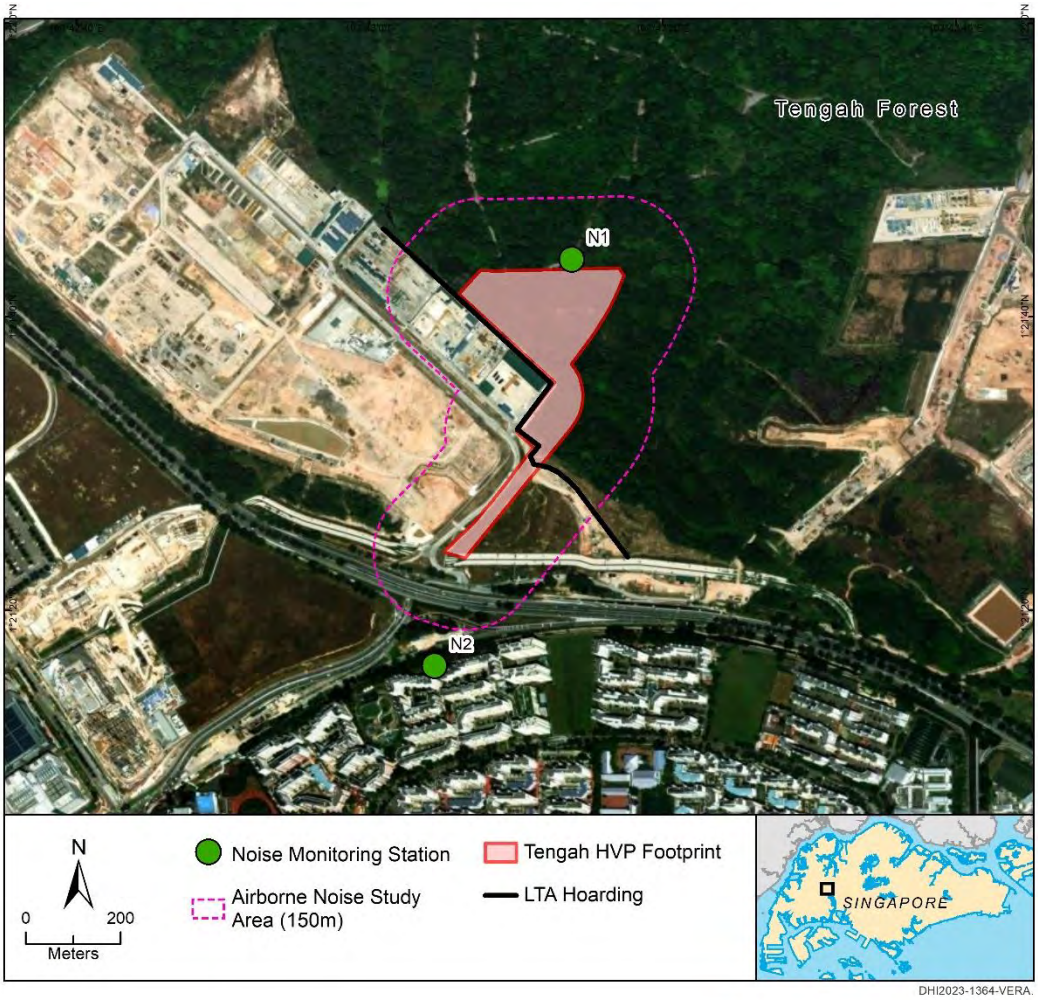

Figure 7.1 Noise Monitoring stations (Basemap source: ArcMap World Imagery).

Table 7.4 Description and photos of baseline noise measurement locations.

N1 – Tengah Forest	N2 – Block 558 HDB Jurong West
At the forest edge adjacent to track	~100 m from expressway
	

7.3 Baseline Descriptions

7.3.1 Desktop Study

A summary of noise levels in $L_{eq\ 5\ mins}$ were reported for past EIA studies:

- LTA Jurong Region Line (2018)
- Tengah South EIS (2021)

A review of past EIA studies reflected elevated ambient noise exceeding NEA limits for $L_{eq\ 5mins}$ the monitoring locations situated throughout Jurong West residential blocks. This occurs primarily during evenings and nights. Traffic within the HDB blocks and the adjacent PIE, located within 100 meters, had been identified as the main contributors for the exceedances.

7.3.2 Field Survey

A summary of L_{10} of $L_{eq\text{-}5\ mins}$, $L_{eq\text{-}1hr}$ and $L_{eq\text{-}12hr}$ values measured from 7 to 12 September 2023 at the two (2) locations are presented in Table 7.5 and Table 7.6. L_{10} represents the noise level exceeded for 10% of time, which means noise levels fall below this level 90% of the time. The L_{10} values filter out the higher 10% of noise levels recorded which may probably be due to sporadic or intermittent events. Plots of $L_{eq\text{-}5mins}$ timeseries at each location are presented in Figure 7.2 and Figure 7.3. The full dataset for noise readings can be referred to in Appendix D.

N1 was located within Tengah Forest and the continuous measurement of $L_{eq\text{-}5mins}$ is compared against NEA's permissible construction noise limits for premises other than residential and school / health care centre premises. The L_{10} of $L_{eq\text{-}5\ mins}$, $L_{eq\text{-}1\ hr}$ and $L_{eq\text{-}12\ hr}$ of N1 measurements were below the respective criteria throughout the baseline survey period of five (5) days on both weekdays and weekends.

N2 was located within an HDB estate, and the continuous measurement of $L_{eq\text{-}5\ mins}$ is compared against NEA's permissible construction noise limits for residential premises. Elevated ambient noise, particularly in the evening and night hours, was observed to be above the NEA limits (10pm – 7am on weekday and 7pm – 7am on weekend). The elevated ambient noise, especially in the evenings and nights, could be attributed to N2's proximity to a highway located within 100m. Additionally, other potential sources like traffic and recreational activities within the HDB estate could be contributing factors.

Table 7.5 L_{10} of $L_{eq\text{-}5\ mins}$ (dBA) during different periods.

Station	Measured Noise Level, Weekdays (dBA)			Measured Noise Level, Sunday (dBA)	
	7am - 7pm	7pm - 10pm	10pm - 7am	7pm - 7am	
N1	58 (90)	70 (70)	66 (70)	54 (90)	57 (70)
N2	64 (90)	60 (70)	**56 (55)**	58 (75)	**59 (55)**

Notes:

Values in bracket indicate the NEA's criteria for the type of NSR at corresponding time period.

Exceedance values are indicated in bold.

Table 7.6 L_{10} of $L_{eq\ 12\ hrs}$ (or $L_{eq\ 1\ hr}$ where specified) (dBA) during different periods.

Station	Measured Noise Level, Weekdays (dBA)			Measured Noise Level, Sunday (dBA)	
	7am - 7pm	7pm - 10pm	10pm - 7am	7pm - 7am	
N1	62 (75)	65 (65)		53 (75)	57 (65)
N2	64 (75)	63 (65) *	**56 (55)** *	57 (75)	55 (-)

Notes:

* Leq 1hr value is presented instead of $L_{eq\ 12hr}$ for comparison with corresponding criteria

Values in bracket indicate the NEA's criteria for the type of NSR at corresponding time period.

Exceedance values are indicated in bold.

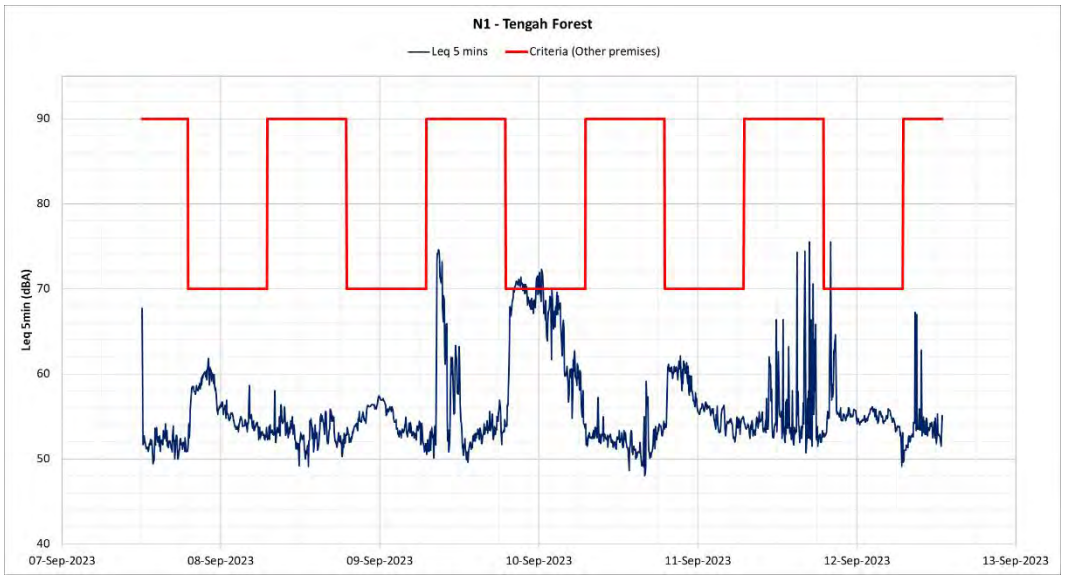

Figure 7.2 $L_{eq\ 5\ mins}$ data recorded at N1 (Tengah Forest), from 7 – 12 September 2023

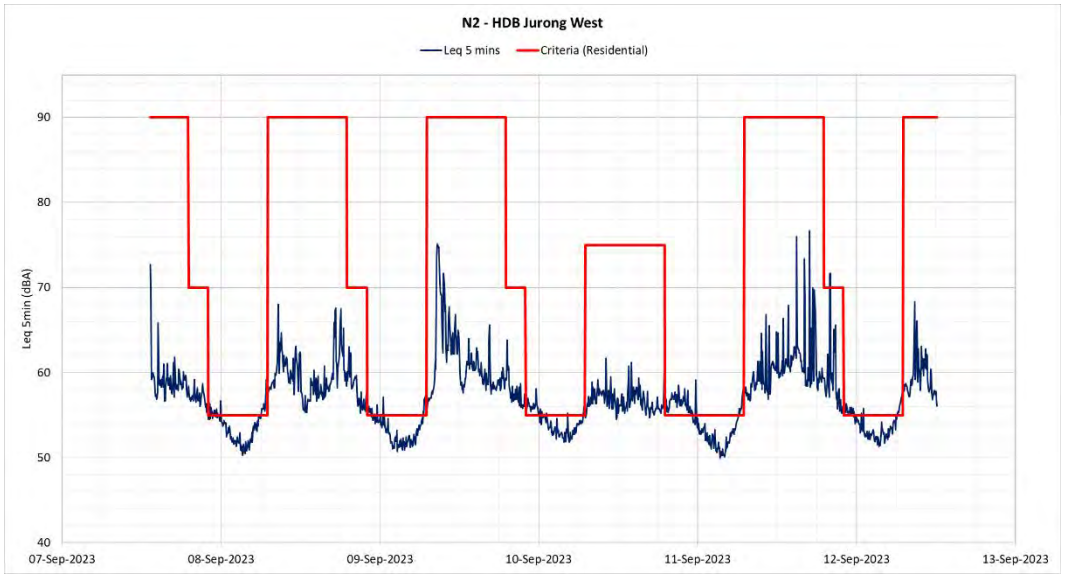

Figure 7.3 $L_{eq\ 5\ mins}$ data recorded at N2 (residential), from 7 – 12 September 2023

7.4 Impact Assessment

7.4.1 Determining Importance and Magnitude

The type and sensitivity of noise sensitive receptors (NSRs) would be similar to ASRs. The assessment can be referred to Section 5.4.1.

To assess the magnitude of noise impact to the NSRs (human receptors), the predicted noise levels are compared with the NEA's guideline on construction noise limits stated in Table 7.1. The resulting exceedance is interpreted and categorised into different significance levels as described in Table 7.7. The thresholds presented takes guidance from the Fundamentals of Acoustics adopted by WHO which indicate a change in sound pressure level of 3 dB is just perceptible to the human ear and that of 5 dB is clearly noticeable (Hansen, 1951).

For terrestrial and freshwater fauna receptors, there are no specific guidelines or thresholds stipulated globally or in Singapore, partly because the effects of noise on most fauna species are poorly understood (Larkin *et al.* 1996; Brown 2001), hence guidance is taken from relevant organisations, literature, and expert judgement. For example, The Nature Conservancy (2015) recommends noise levels to be ideally as low as 55 dB within 100 m from source to protect sensitive animal species. Other studies have suggested that higher noise levels of around 68 dB may reduce birds' foraging ability and eventually lead them to avoid and abandon the habitat (Ortega, 2012). For acoustic pollution impacts specific to aquatic fauna and habitats, a noise level above 60 dB is accepted to induce behavioural changes in freshwater fauna and temporary changes in population patterns (Kunc et al., 2016). Given that different species have varied tolerance to anthropogenic noise and noise levels (Parris and Schneider, 2008), and taking into account the concentration of anthropogenic noise sources (expressway traffic, construction sites) that characterise this Study Area, a noise level of 60 dB is taken as the threshold for fauna receptors in this Study, above which detectable changes are predicted.

The evaluation of Magnitude for airborne noise-sensitive human and fauna receptors are presented in Table 7.7.

Table 7.7 Evaluation Framework for Magnitude in noise level for human and fauna receptors. Where multiple criteria result in multiple possible scores, the more conservative score (higher Magnitude) is adopted in evaluating the Magnitude.

Score	Generic Criteria	Specific Criteria	
		Human Receptors	Fauna Receptors
-4	Major negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by more than 10 dBA	• Predicted noise level exceeded 85 dBA, likely resulting in death or injury of fauna receptors
-3	Moderate negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 5 to 10 dBA • Or predicted noise level at NSR cause an increase of greater than 10 dBA as compared to baseline level	• Predicted noise level cause an increase of greater than 10 dBA as compared to baseline level • Or predicted noise level of 75-85 dBA, resulting in evident physiological and anatomical changes, and low survivability and biological fitness of fauna populations

Score	Generic Criteria	Specific Criteria	
		Human Receptors	Fauna Receptors
-2	Minor negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 3 to 5 dBA • Or predicted noise level at NSR cause an increase of up to 10 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 10 dBA as compared to baseline level • Or predicted noise level of 65-75 dBA, resulting in significant behavioural changes in fauna (change in feeding patterns, predator-prey interactions, reduced ability to maintain territories and increased aggression between individuals)
-1	Slight negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 1 to 3 dBA • Or predicted noise level at NSR cause an increase of up to 5 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 5 dBA as compared to baseline level • Or predicted noise level of 60-65 dBA, resulting in temporary/recoverable shifts in fauna behaviour (e.g., change in vocalisation pattern or avoidance of areas with acoustic pollution), which are not expected cause a substantial change in species population
0	No change	• Predicted noise level at NSR exceeded the limit by up to 1 dBA • Predicted noise level at NSR cause an increase of up to 3 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 3 dBA as compared to baseline level • Or predicted noise level below 60 dBA, with no changes in fauna behaviour or populations expected

7.4.1.1 Importance Rating of Sensitive Receptors

Identified Sensitive Receptors

The NSR and their importance within the 150m survey corridor of the Project can be referred to in Table 6.8.

The noise sensitive receivers are also illustrated in Figure 7.4.

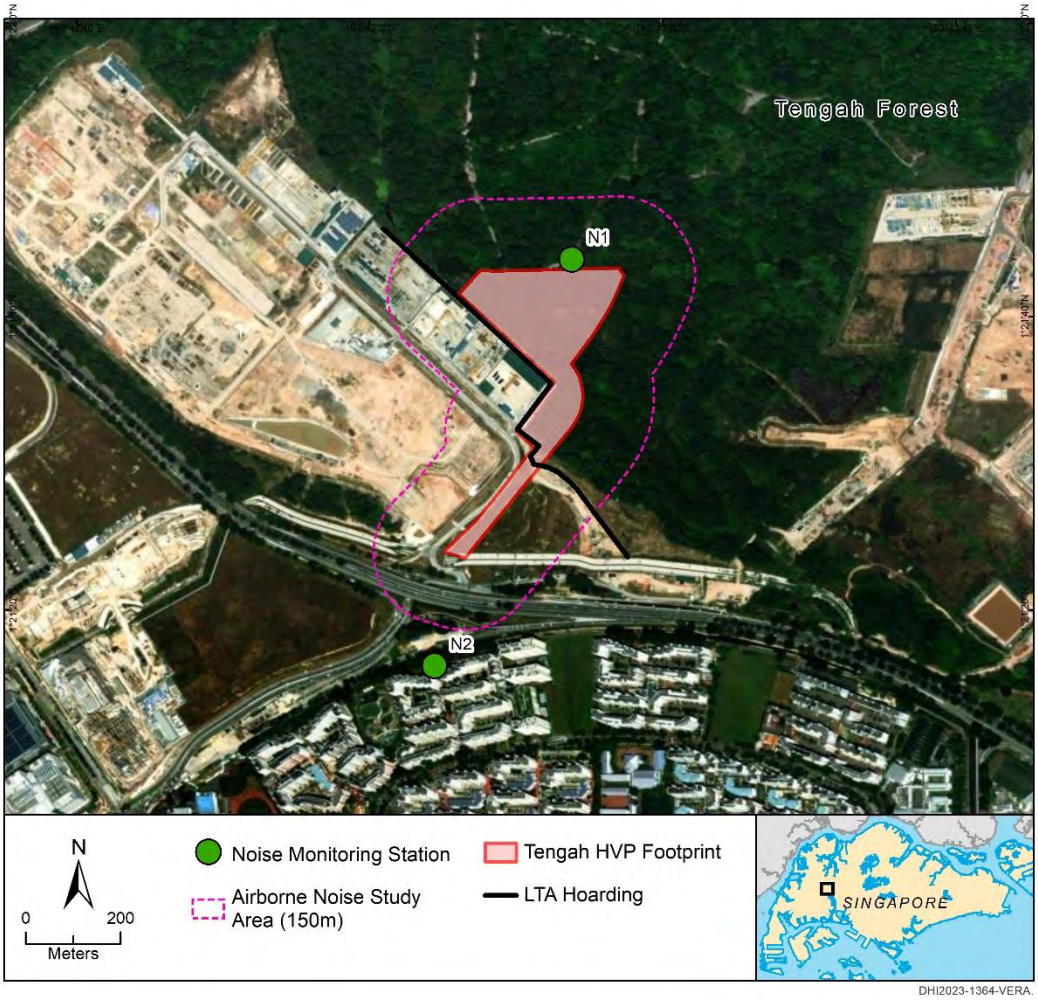

Figure 7.4 Location of Noise Sensitive Receptors

Table 7.8 Identified air quality sensitive receptor and their Importance.

Type of receptor	Description	Sensitivity	Importance Score
Terrestrial fauna (N1)	Fauna within Tengah Forest	Fauna at these locations is expected to be exposed to the noise from Project site at least 8 hours a day.	3
Residential areas (N2)	HDB residences along Jurong West Street 42	Residents at these locations are expected to be exposed to the noise from Project site at least 8 hours a day.	3

7.4.2 Construction Phase

At the time of this EIA report preparation, the construction methodology and technical details are expected to be available at a later stage when the construction sub-contractors are on-board.

Noise level generated by construction equipment will vary greatly depending on the type of equipment, model and condition of equipment, and duration of operation. The airborne noise levels will be affected by distance, locations (either stationary or mobile sources) and variations in the power of the equipment. The airborne noise levels will also be affected by noise characteristics (continuous or intermittent) of the equipment. It is assumed that the majority of noise-emitting work will be undertaken during the daytime and that night works would only be required under exceptional circumstances. For this EIA, type of equipment used during construction have been anticipated. Table 7.9. summarises the list of emission sources from the anticipated power mechanical equipment (PME) and their respective sound power level (SWL). All SWL for emission sources were reference from British Standards BS 5228 -1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1.For this EIA, type of equipment, quantity, and duration of operation likely to be used have been anticipated based on typical construction work has been tabulated in Table 7.9.

The following activities are identified as potential sources of noise during the construction phase is expected to be mainly generated from the following sources during construction:

- Operation of fuel burning equipment such as generator
- Operation and movement of heavy vehicle/machinery
- Demolition of existing paved and unpaved road
- Dropping of construction material from height

In general, the machineries during construction are predicted to have relatively localised influence zone upon assessment.

Table 7.9 Anticipated construction equipment and its sound power level for each phase and stage of works

Activity	Anticipated Construction Equipment	Sound power level per equipment (From BS 5228) – Based on SPL@10m	Predicted dB(A) at N1 (25m)	Predicted dB(A) at N2 (250m)
Construction activities for project	Bore Piling Rig	93.4 dB(A)	65.4 dB(A)	45.4 dB(A)
	Track crane	82.9 dB(A)	54.9 dB(A)	34.9 dB(A)
	Excavator	86.0 dB(A)	58.0 dB(A)	38.0 dB(A)
	Concrete mixer	83.6 dB(A)	55.6 dB(A)	35.6 dB(A)
	Grader	92.4 dB(A)	64.4 dBA)	44.4 dB(A)
	Dump truck	94.6 dB(A)	66.4 dB(A)	46.6 dB(A)
	Road roller	89.7 dB(A)	61.7 dB(A)	41.7 dB(A)

7.4.2.1 Impact to Fauna within Tengah Forest

Without mitigation measures, predicted noise levels at the forested area (10m from works boundary) is 22 dBA to 33 dBA higher than the threshold noise limit of 60 dBA due to the proximity of the forested area to the work area. The forested area facing the works are expected to experience significant change in noise level perception during construction. However, the availability of retained forests within the Tengah Forest provide a refuge for fauna species to retreat away from noise sources/work area.

The potential ramifications of noise on terrestrial wildlife encompass physical harm to hearing organs, increased energy expenditure, or physical injury while reacting to noise disruption of regular animal behaviours, as well as hindered communication. Persistent effects may lead to habitat loss due to avoidance behaviours, diminished reproductive success, and heightened mortality rates. Some species experience stress due to noise, affecting their foraging or breeding habits, or prompting them to vacate an area, while others appear unaffected or adapt gradually to noise over time. Certain species have adjusted to urban environments through phenotypic plasticity, altering the frequency of their vocalizations to avoid being masked by noise, and thrive in urban settings. However, not all species can adapt behaviourally, with most being adversely affected by human-generated noise and actively avoiding noisy sources.

For instance, reduced species diversity and breeding densities of birds are observed along roads and highways, a phenomenon frequently attributed to traffic volume. When evaluating impacts on wildlife, the characteristics of noise, such as pitch (high or low) and duration (sudden or continuous), must be taken into account, alongside its intensity, measured in dB(A). Many bird species exhibit greater sensitivity to sudden loud noises compared to continuous or gradually fading noise.

Construction activities are bound to impact the neighbouring wildlife in adjacent forested areas. According to Table 7.9 without mitigation measures, construction noise levels could reach up to 66 dB(A) at the ecological receptor taken at 25m distance. These activities are likely to deter most animals from the construction zone, although the actual distance between fauna and construction works may vary. Installation of hoarding along the works' boundary will serve as a physical barrier, partially screening noise and aiding in attenuating construction-related noise.

A score of -3 for Magnitude has been assigned attributing to terrestrial fauna due to exposure of the wild fauna to noise levels up to 75 dBA.

Permanence and reversibility are scored at 2 given the short-term nature of construction noise and the ability of fauna populations to adapt and recover from any impacts, albeit highly minimal.

While noise thresholds for various fauna remain inadequately researched, stress-induced behavioural changes, alterations in foraging patterns, and impaired auditory abilities have been observed. Noise impacts on birds have received relatively more attention, with a threshold of 60 dB(A) adopted in this study.

7.4.2.2 Residents

Residents could potentially experience construction-related noise, which may impact their health and overall well-being. Generally, noise diminishes as distance from the source increases, owing to the dispersion of sound energy through the atmosphere. It is worth noting that the residential receptor is positioned over 200 meters from the nearest project boundary. Taking into account sound propagation principles over distance and the typical noise levels generated by construction equipment, as well as the presence of the PIE (Pan Island Expressway) between the project site and residential area, it is expected that noise emanating from the construction site will not affect the residents.

7.4.3 Post-Construction Phase

The Project's operation will involve a significant flow of heavy vehicle traffic, which may cause disturbance to sensitive ecological receptors in the surrounding forested areas.

The potential noise impacts from the project on the site are deemed to be **Minor negative**.

7.5 Mitigation Measures

7.5.1 Construction Phase

The noise impact from the construction activities should be mitigated at source, if possible, in order to meet the construction noise limits specified by NEA. Good site practices and noise management can be expected to considerably reduce the pre-construction and construction noise impact. The following recommendations present best practice measures for the control of noise for the identified noise generated impacts from equipment identified:

- Prior to commencement of construction works, install hoarding and noise barriers along project boundary
- Select equipment with low noise emissions
- Inspect and maintain vehicles and mechanical plants in good effective working order and operate in a manner to minimise noise emissions
- Keep compressor, generator and engine compartment doors close and plant turned off when not in use.
- Machines in intermittent use will be shut down or throttled down to a minimum during periods between works
- Use precaution and care when unloading vehicles / equipment to minimise noise emissions.
- Limit the timing of the use of heavy machineries (e.g. cranes, excavators, generators) to minimise noise emission, in particular early morning and evening hours when animals are more active. Where alternatives are available, only equipment and vehicles that emit lower noise levels are to be used.
- Where necessary, retrofitting silencer or enclosure on machine engines and exhaust to reduce noise emission.
- Use material stockpiles and suitable work locations to screen work locations and maximise the distance between work activities and the nearest noise sensitive receptors
- Apply a speed limit (typically 20km/h) to all vehicles entering the site which drivers will be required to adhere to
- Manage project vehicles to not wait or queue up with engines running at the entrance to the site access
- Inspect vehicles regularly identifying maintenance issues which generate excessive noise and carry out maintenance as required
- Use adjustable or directional audible vehicle-reversing alarms or use alternative warning systems. Careful management of site layout to minimise the need to perform reversing manoeuvres
- Avoid unnecessary revving of engines, reducing speed of vehicle movement and maintaining the condition of the road surface to avoid body slap from empty lorries, designing and maintaining access routes to minimise vehicle noise
- Explain and train drivers the methods to help minimise vehicular noise impacts.

- Construction personnel to be trained to adopt noise-reduction techniques in construction activities such as reducing the drop height of materials.
- Daily toolbox briefing should include reminders on the need to implement noise-reduction techniques in construction activities, proper operation and restricted timing of heavy equipment to avoid excessive noise, turning off machines when not in use.
- All construction personnel should be educated about sensitive ecological nature of work areas before commencing the work

7.5.2 Post- Construction Phase

The noise impact from the post-construction activities should be mitigated at source, if possible. Good site practices and noise management can be expected to considerably reduce the impact of operational noise to the sensitive receptors within the surrounding forested areas. The following are recommendations for the reduction of noise impacts from the operation of the HVP:

- Regular maintenance of vehicles to ensure exhaust systems are maintained to prevent noise from leaks or failures, proper inflation and regular maintenance of tires to prevent noise due to tire wear and tear.
- Planting trees and shrubs to act as natural sound barriers and/or installing noise barriers to block transmission of noise to surrounding areas, particularly areas facing the remaining forested areas
- Retaining a permanent noise barrier along the edges of the HVP facing the forested areas.

7.6 Residual Impact

Through the implementation of a comprehensive set of noise impact mitigation measures during the construction phase, the anticipated significance of noise impacts associated with various activities is expected to be reduced, although they will still remain within the band of **Minor Negative** for fauna, and **No Impact** for residents. These measures, ranging from the use of control measures at emission source techniques, implementation of noise barriers, and site management practices, are strategically designed to minimize noise to the surrounding environment. The residual impact after implementing these mitigation strategies is outlined in Section 7.7.

7.7 RIAM Summary

7.7.1 Construction Phase

Table 7.10 Summary of impact assessment for Noise impacts for the construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Noise from Operating Heavy Vehicles	Terrestrial fauna (Tengah Forest) (N1)	3	-3	2	2	3	-63	Minor negative impact	-2	-42	Minor negative impact
	Residential areas (N2)	3	0	2	2	3	0	No impact	0	0	No impact

7.7.2 Post-Construction Phase

Table 7.11 Summary of impact assessment for Noise impacts for the post-construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Noise from Operating Heavy Vehicles	Terrestrial fauna (Tengah Forest) (N1)	3	-3	3	2	3	-72	Minor negative impact	-1	-24	Slight negative impact
	Residential areas (N2)	3	0	3	2	3	0	No impact	0	0	No impact

8 Surface Water Quality and Hydrology

This section includes the applicable legislation and standards of surface water quality management and baseline conditions of water quality and stream hydrology of the Project.

A significant portion of Tengah Forest and its immediate vicinity are part of the Jurong Lake Catchment area, as seen in Figure 8.1 Stormwater is an important contributor to Singapore's water needs and is popularly known as the country's first national tap. Within the southern portion of Tengah Forest, stormwater is naturally collected and channelled through a network of natural earth streams into Jurong Canal/River, and eventually flows into Jurong Lake, which is connected to the larger Pandan Reservoir and Catchment Area as well.

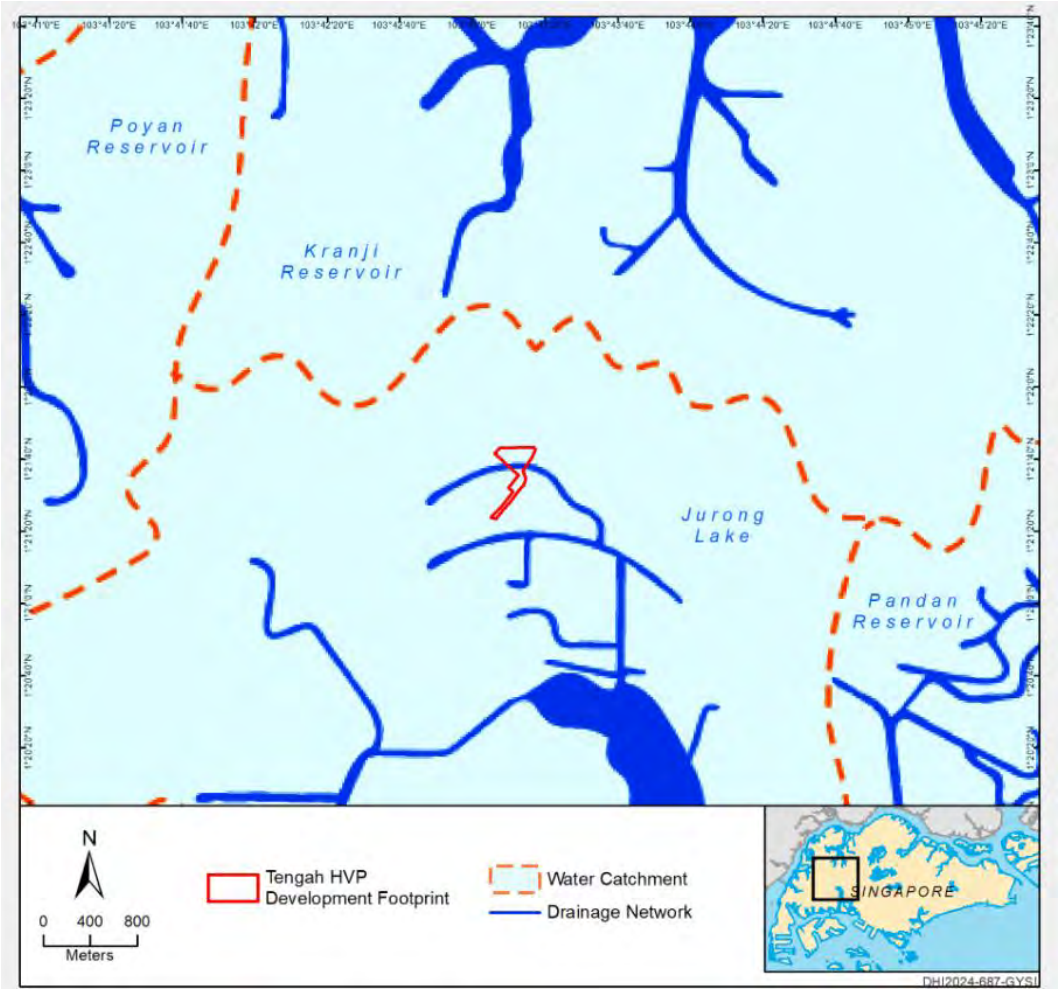

Figure 8.1 Water catchment network in relation to the Project footprint.

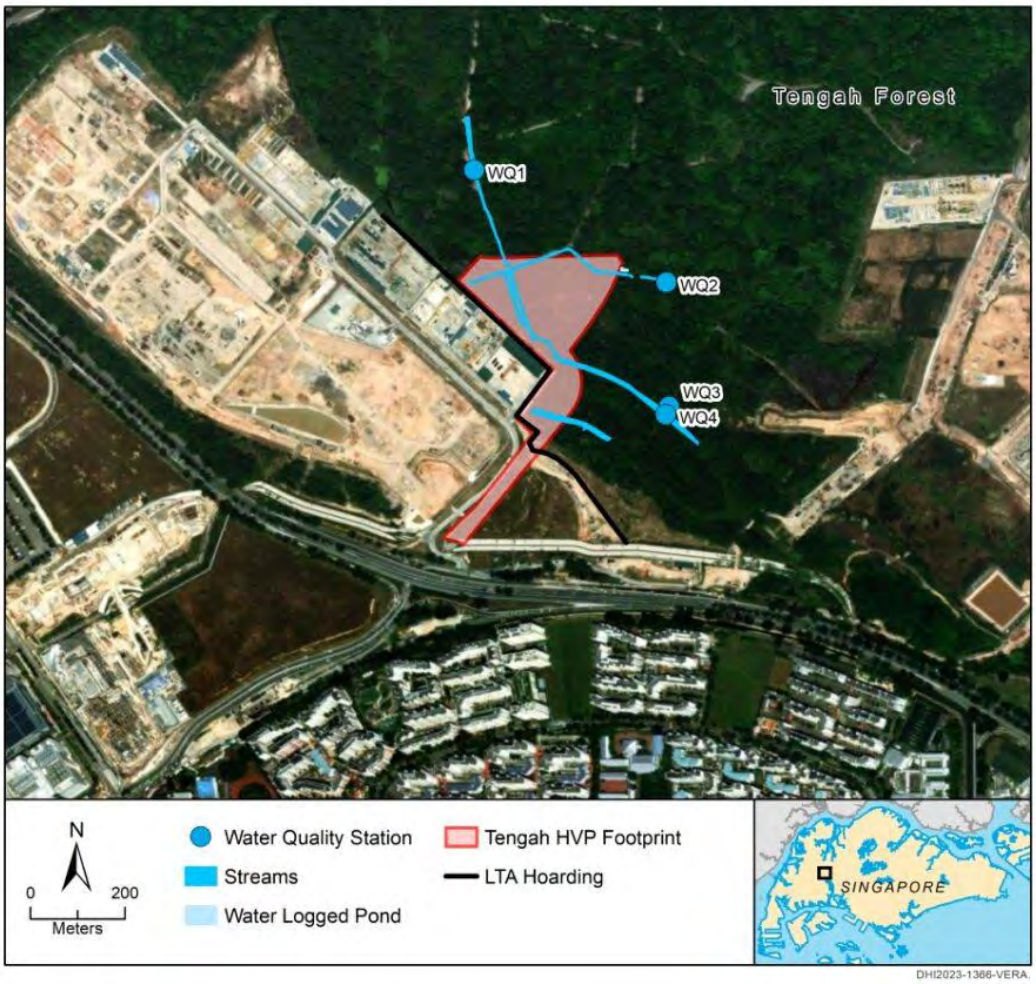

Figure 8.2 Monitoring locations for surface water quality and stream hydrology. WQ1 is upstream of the Project footprint; WQ3 and WQ4 are downstream of the Project footprint. WQ2 is presumed to be downstream of the Project footprint. (Basemap source: ArcMap World Imagery)

8.1 Applicable Legislation and Standards

The water quality survey locations for this study cover a freshwater environment. Presently, there are no established guidelines for freshwater streams in Singapore. Although local EIAs typically contrast baseline water quality survey findings with NEA's 'Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse', these limits apply to discharged water, rather than a receiving body of water. Consequently, the baseline water quality data collected in this EIA will not be compared against these specific limits.

8.2 Methodology

Effluent from the Project may potentially be a source of water pollution, impacting both residents and wildlife downstream. Polluted water may affect catchment areas and disrupt aquatic ecosystems in the nearby forest. Establishing a baseline for current water quality levels will be crucial to assess the project's impact and implement effective mitigation measures. Methodology and findings of primary data collection and review of secondary data are presented in this section.

8.2.1 Desktop Study

To enhance the surface water quality and hydrology dataset, information from previous studies is commonly incorporated. Nevertheless, the majority of the associated projects lacked overlapping or nearby sampling points. One sampling point from the Tengah South EIS Report (HDB, 2021b) loosely overlaps with the Project's study area, as the sampling point is located downstream of a natural earth stream that runs through the Project footprint.

Applicable water quality information which stems from the J1002 project were conducted more than 5 years ago. Additionally, the water quality sampling point closest to the study area has since undergone development. As such, the relevance of the data is limited.

For stream hydrology, past studies were consulted to determine if there were any discernible changes in the hydrology of the areas that overlap with the Project footprint, as well as upstream and downstream. The studies reviewed included those listed in the environmental scoping Section 4.4, as well as other studies and reports pertinent to the Tengah area.

8.2.2 Field Survey

8.2.2.1 Baseline Surveys

Surface Water Quality

Baseline surface water quality was established at four (4) sampling points – Situated along two adjacent branches of tributary waterways leading toward Jurong River, ultimately draining into Jurong Lake. While WQ1, WQ2 and WQ3 were pre-determined points for sampling, WQ4 is an additional point that was selected to bolster the primary dataset. These points are located upstream and downstream of the Project area, in order to provide baseline water quality data against which potential impacts to water quality and changes in sediment load can be assessed.

Although water quality sampling was only required to be conducted for one dry event (no rain event in the preceding 48 hours) and one wet event (within 2 hours following a rain event), some additional data was also collected for one dry and one wet weather event, in order to bolster the primary surface water quality dataset. All water sampling events have been detailed in Table 8.1.

In-situ water quality measurements were taken using a calibrated Aqua TROLL 600 Multiparameter Sonde, while ex-situ sampling was conducted by collecting water quality samples and sending them for analysis to a SAC-SINGLAS accredited laboratory. A total of 28 water quality parameters (5 in-situ and 23 ex-situ) were assessed. A range of chemical and biochemical parameters were covered, including total suspended solids, dissolved heavy metals, waterborne organic contaminants and chlorophyll-a. The analytical test methods used for ex-situ water quality sampling are also shown in Table 8.2 to Table 8.5. All water quality sampling events have been detailed in Table 8.1.

Stream Hydrology

At the same four sampling points, the cross-sectional profile and flow rate of the respective freshwater streams were measured, where possible (Figure 8.13). While water quality samples and stream hydrology measurements were initially planned to be collected simultaneously for all four sampling points during both dry and wet weather events, WQ3 was excluded during wet weather sampling and WQ4 was excluded during both dry and wet weather sampling initially due to site inaccessibility and flooding, which caused the stream to be hidden and prevented entry due to safety concerns. Site access was arranged for WQ3 and WQ4 separately during subsequent dry and wet weather events. All stream hydrology surveys have been detailed in Table 7.1. However, only hydrological data

collected on 7 Feb 2024 (dry weather event) and 4 Mar 2024 (wet weather event) will be presented in this report.

In accordance with the BIA guidelines (NParks, 2024a), at each sampling point, the wetted width was measured, and the stream channel divided into three parts. Stream depth was also measured and averaged for each part. The cross-section area of the stream was determined by multiplying the averaged depth with the wetted width. Stream velocity was measured using a Hach® FH950 Portable Velocity Meter. Stream flow rate was then obtained by the following equation:

$$Flow\ rate\ (m^3/s)\ =\ Cross\ section\ (m^2)\ \times\ Average\ Velocity\ (m/s)$$

Figure 8.3 Calculation of cross-sectional area from the wetted width and averaged depth across the left, centre, and right stream portions.

Table 8.1 Summary of water quality and hydrology primary survey data obtained, according to sampling locations.

Location	Event	Date	Surface Water Quality		Hydrological Measurements
			In-situ	Ex-situ	
WQ1	Dry	27 Sep 2023	✓	✓	✓
	Wet	21 Nov 2023	✓	✓	✗
	Dry	7 Feb 2024	✓	✗	✓
	Wet	4 Mar 2024	✓	✗	✓
WQ2	Dry	27 Sep 2023	✓	✓	✓
	Wet	21 Nov 2023	✓	✓	✗
	Dry	7 Feb 2024	✓	✗	✓
	Wet	4 Mar 2024	✓	✗	✓
WQ3	Dry	27 Sep 2023	✓	✓	✓
	Wet	21 Nov 2023	✗	✗	✗
	Dry	7 Feb 2024	✓	✗	✓
	Wet	4 Mar 2024	✓	✓	✓
WQ4	Dry	27 Sep 2023	✗	✗	✗
	Wet	21 Nov 2023	✗	✗	✗

Location	Event	Date	Surface Water Quality		Hydrological Measurements
			In-situ	Ex-situ	
	Dry	7 Feb 2024	✓	✗	✓
	Wet	4 Mar 2024	✓	✓	✓

8.2.2.2 Supplementary Stream Characterisation Surveys

Due to the discovery of conservation-significant aquatic fauna within the streams running through and adjacent to the Project footprint, an additional round of hydrological surveys was deemed necessary, in order to ascertain stream flow conditions, connectivity between streams, and upstream stream sources. The supplementary stream characterisation surveys were conducted on 12 July 2024. The points surveyed largely overlapped with the aquatic sampling points used in the ecological baseline surveys for freshwater fauna, with some additional points being added to the dataset to further bolster understanding of the hydrology of the area (Figure 8.4).

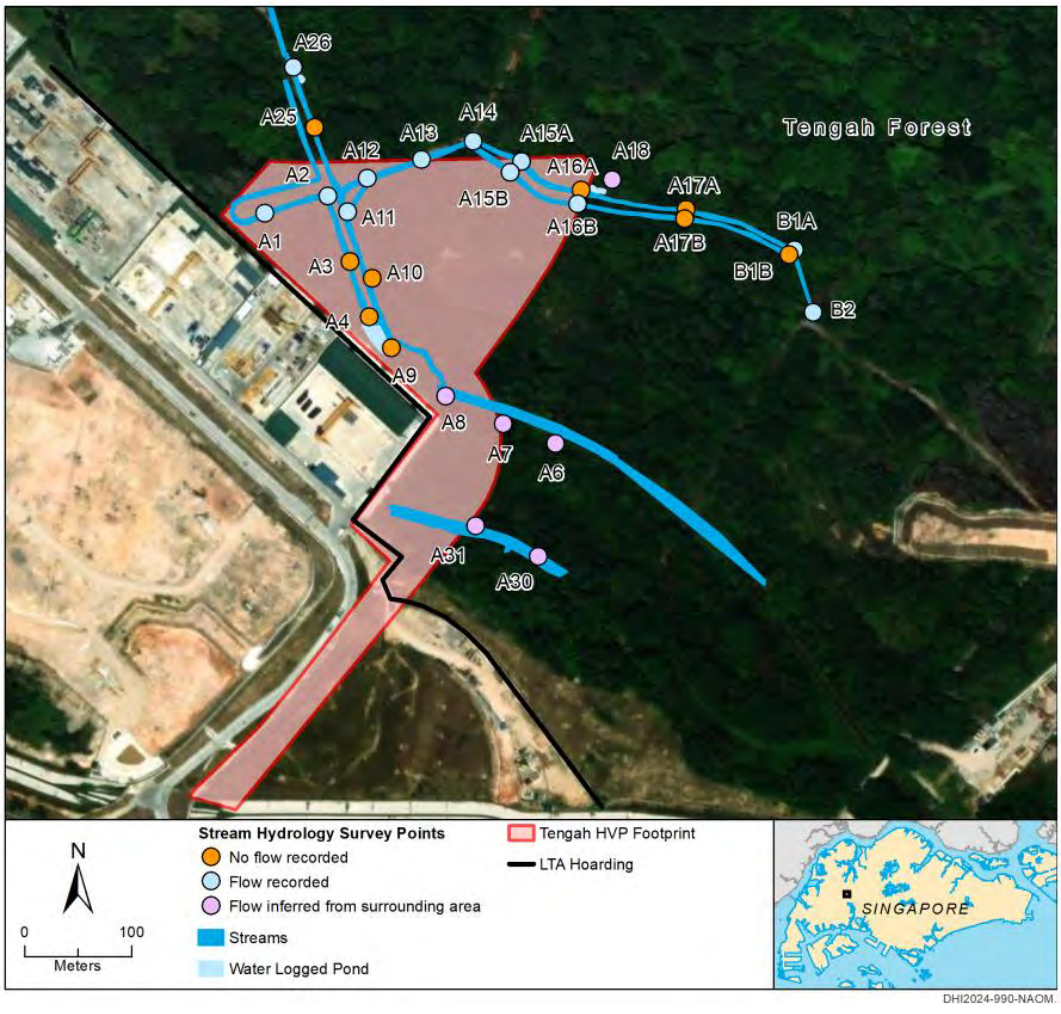

Figure 8.4 Locations of secondary hydrological sampling points relative to Project footprint.

Identical hydrological parameters (with the exception of water quality) were measured and reported, as described in detail in Section 8.2.2.1. Additionally, the direction of flow and upstream sources of each stream flowing through the project footprint were identified where possible.

8.3 Baseline Descriptions

8.3.1 Desktop Study

Surface Water Quality

Secondary data from the Tengah South EIS Report (HDB, 2021b) revealed that the large earth stream associated with sampling point WQ4 previously recorded multiple exceedances when compared to NEA's criteria for Trade Effluent Discharge to Controlled Watercourses for the following parameters – Total Suspended Solids (mg/L) and pH. Values for Total Nitrogen (mg/L), Total Phosphorus (mg/L), Ammoniacal Nitrogen (mg/L), Dissolved Oxygen (mg/L), Turbidity (NTU) and Total Suspended Solids (mg/L) were also found to have exceeded various international aquatic life criteria. The various exceedances were potentially attributed to surface runoff and effluent from nearby construction sites.

Hydrology

Past studies reveal that the primary flow of water runs through the Project footprint from a northwest-southeast direction and drains directly into Jurong River, which then subsequently flows into Jurong Lake, which is a catchment area. The Project area is also considered to be a low-lying area, in relation to the northern half of Tengah, which is higher in elevation (Figure 2.4).

With reference to the historical maps, the streams that traverse across the Project site appear to be both natural-occurring, man-made and subsequently naturalised due to disuse, with diversions occurring throughout the years due to development within the Tengah area. In 1945, the streams that feed into Jurong River (overlapping with the Project area) were already present (Figure 8.5). The latter streams were referred to as 'D5' and 'D6' in the HDB Tengah Environmental Baseline Study (HDB, 2017) and 'WB1-3' in the J1002 EIA Report (LTA, 2018; Figure 8.10). In the current study, the corresponding streams are S1 & S2 respectively (Figure 8.23). The stream and waterbody network were largely maintained across the years and up till present (refer to maps of Tengah from 1966 – 2010; Figure 8.6 to Figure 8.9).

For the areas that overlap with the Project footprint, no significant stream diversions or other changes were observed, apart from the J1002 diversion (Figure 8.10). At the time of writing, the J1002 LTA project is understood to be underway, with land clearance and the diversion of the stream completed (Figure 8.11), which is reflected in the satellite map of the Project area shown in Figure 8.2 above. Apart from the latter diversion, stream S1 (upstream) and downstream of stream S2 appear to be intact.

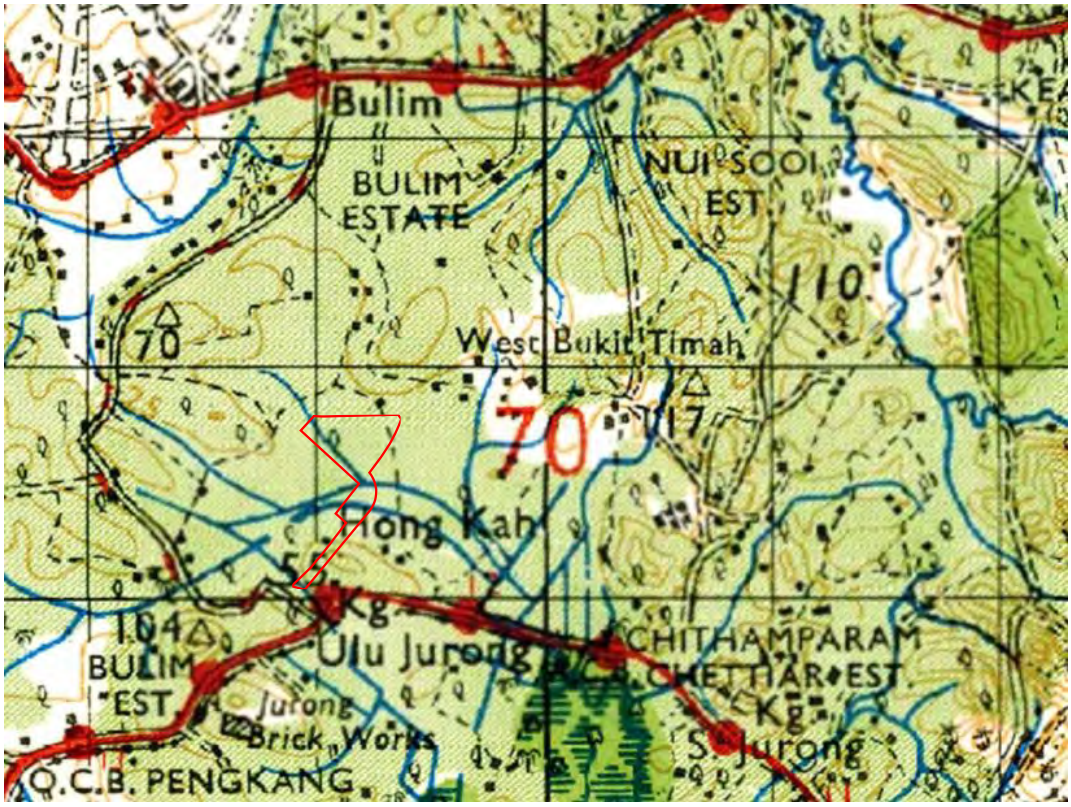

Figure 8.5 Map of Tengah in 1945. Approximate location of Project area outlined in red. Source: National Archives Singapore.

Figure 8.6 Map of Tengah in 1966. Approximate location of Project area outlined in red. Source: National Archives Singapore.

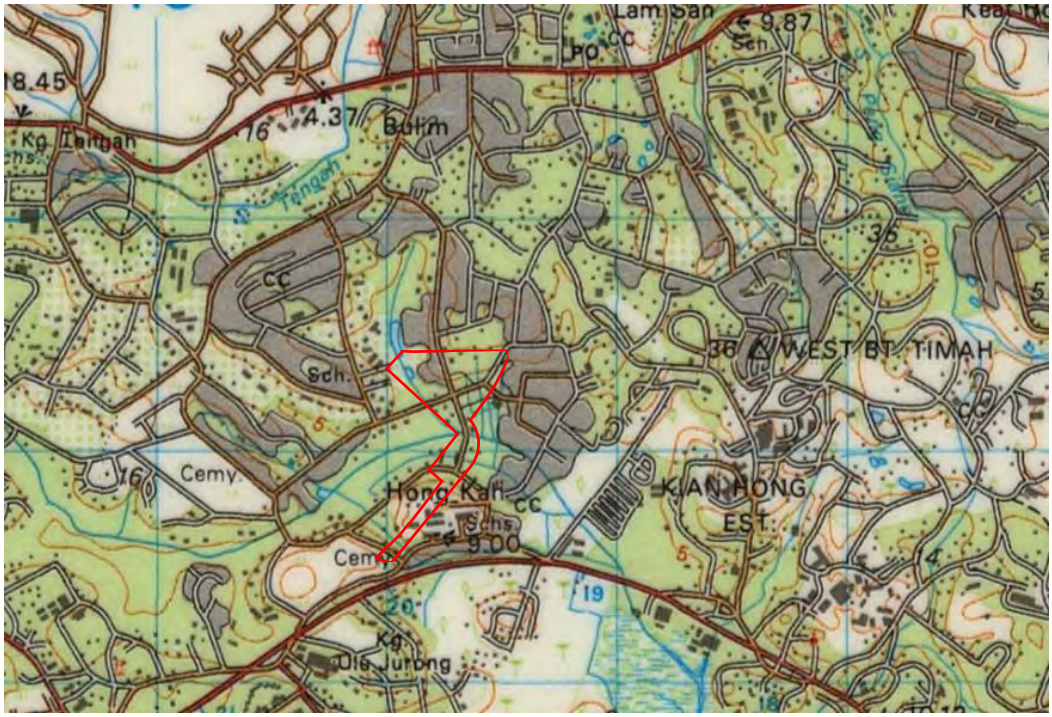

Figure 8.7 Map of Tengah in 1978. Approximate location of Project area outlined in red. Source: National Archives Singapore.

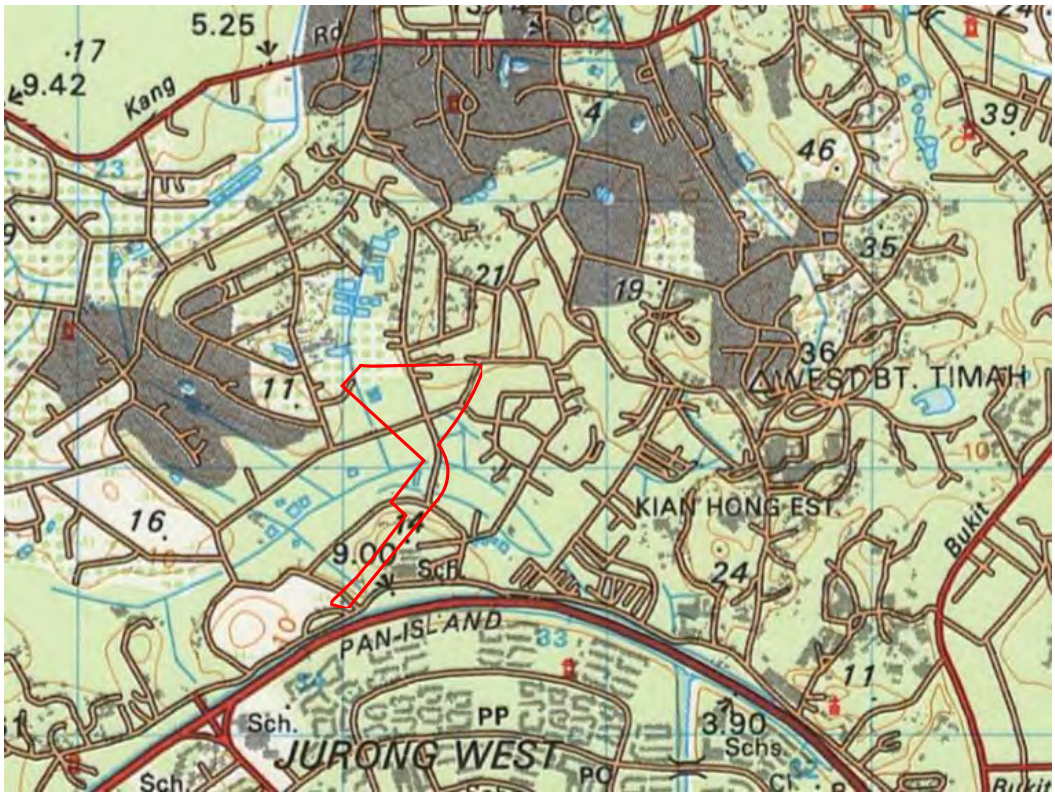

Figure 8.8 Map of Tengah in 1993. Approximate location of Project area outlined in red. Source: National Archives Singapore.

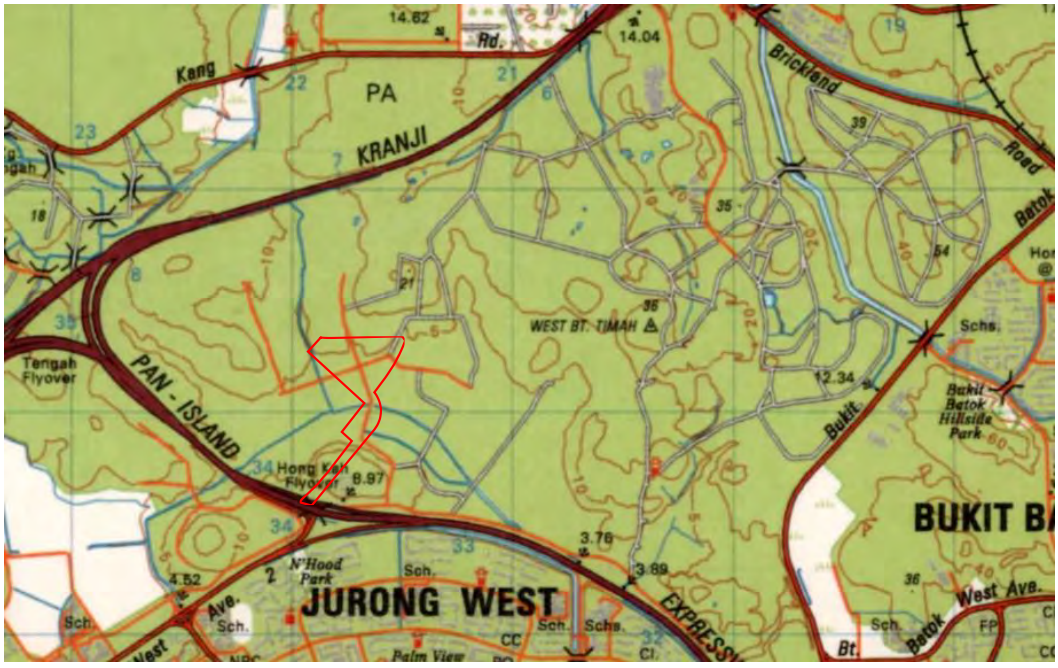

Figure 8.9 Map of Tengah in 2010. Approximate location of Project area outlined in red. Source: National Archives Singapore.

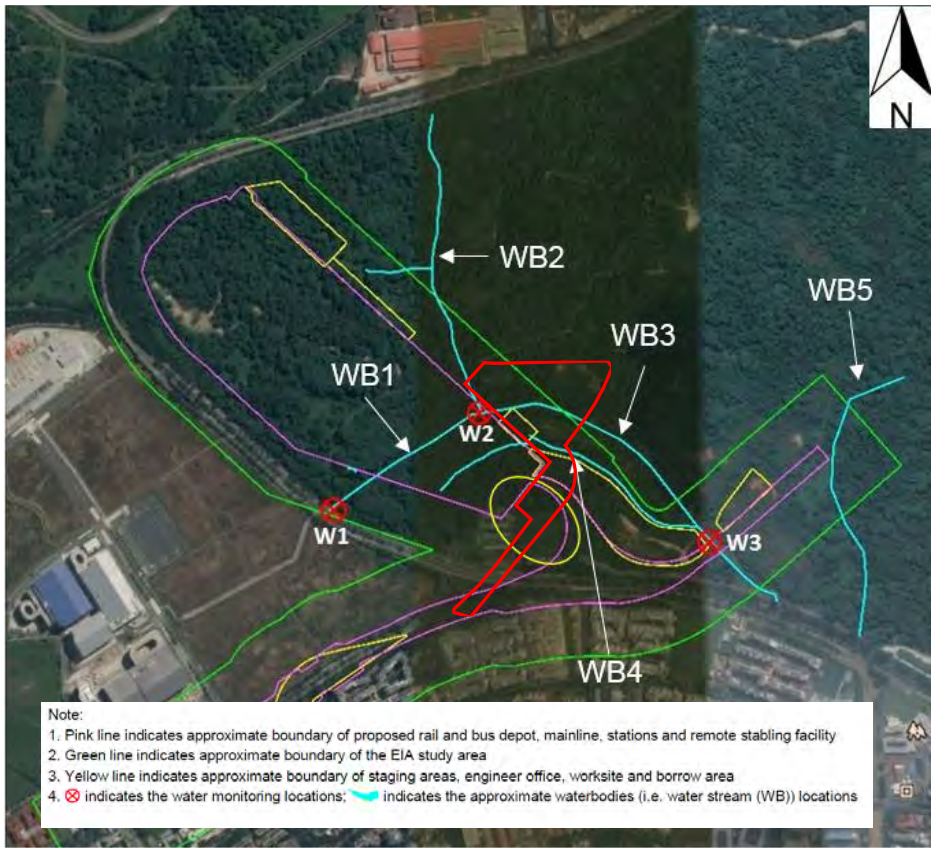

Figure 8.10 Locations of watercourse in the J1002 EIA Study Area. The area outlined in red shows the approximate location of the Project area. Source: J1002 EIA Report (LTA, 2018).

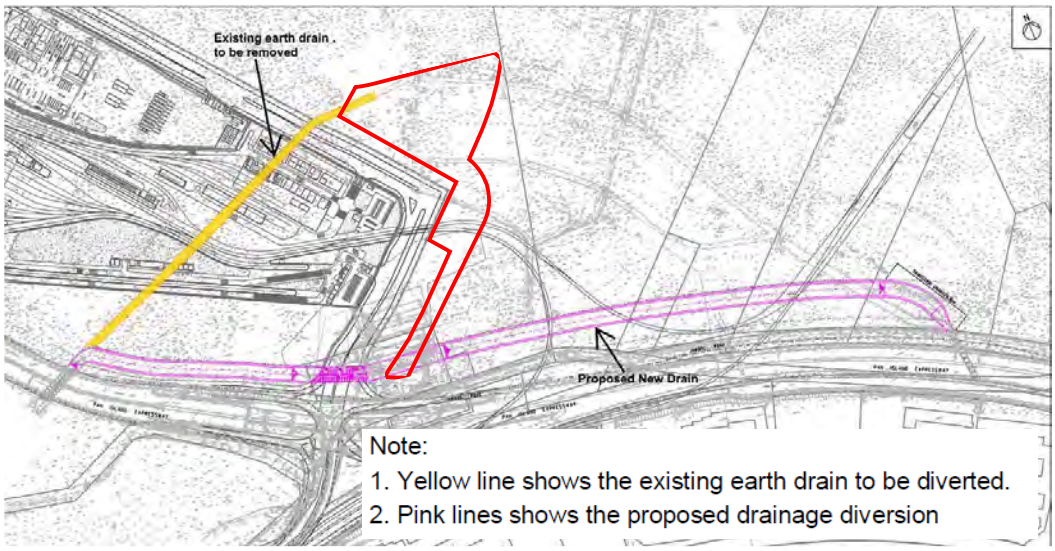

Figure 8.11 Proposed drainage diversion for the J1002 Project. The area outlined in red shows the approximate location of the Project area. Source: J1002 EIA Report (LTA, 2018).

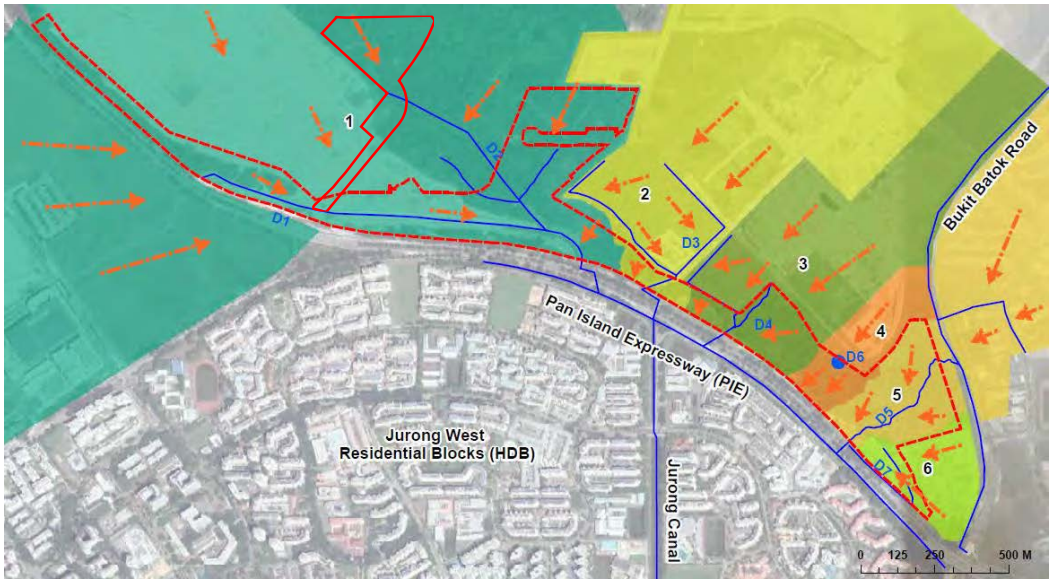

Figure 8.12 Catchment map with identified watercourses in Tengah south. The area outlined in red shows the approximate location of the Project area. Source: Tengah South EIS Report (HDB, 2021b).

8.3.2 Field Survey

8.3.2.1 Baseline Surveys

Surface Water Quality

In-situ and ex-situ baseline water quality measurements results are displayed according to each sampling point, starting from Table 8.2 for WQ1 and ending at Table 8.5 for WQ4. The baseline water quality results generally show that WQ1, WQ2 and WQ4 contain mildly acidic water during both dry and wet weather events. WQ3, however, contains slightly alkaline water instead, which increased in pH from 7.03 to 7.67 between the dry and wet weather events on 7 Feb 2024 and 4 Mar 2024, becoming more alkaline. Arsenic levels

recorded at WQ2 are much higher than those at WQ1, WQ3 and WQ4, indicating a potential source of heavy metal/metalloid contamination that drains directly into WQ2. Simultaneously, WQ2 also displayed the highest amounts of TSS during the dry weather event, which further reinforces the potential presence of a nearby source of contamination, in the form of effluent or industrial leachates. TSS levels across the sampling locations were higher during the wet weather event as compared to the dry weather event, which is not unexpected as increased levels of precipitation are commonly associated with surface runoff and erosion. These increased levels of turbidity are also visible when comparing the sites visually on-site during each weather event, as can be seen in Figure 8.13 and Figure 8.14. Lastly, WQ3 registered significantly higher levels of faecal coliform and *E. coli* bacteria during the wet weather event, strongly suggesting a potential source of human or animal waste mixing with the stream draining towards WQ3. Ex-situ surface water quality test reports for all dry and wet weather events may be found in Appendix E1.

Table 8.2 Results of baseline surface water quality sampling performed at WQ1.

Sampling Point: WQ1						
Surface Water Quality Parameter	**Unit**	**Test method**	**Dry Event (27 Sep 2023)**	**Dry Event (7 Feb 2024)**	**Wet Event (21 Nov 2023)**	**Wet Event (4 Mar 2024)**
pH	-	-	6.69	6.31	6.3	6.51
Temperature	°C	-	26.42	26.78	26.08	27.22
Salinity	PSU	-	0.11	0.05	0.03	0.05
Dissolved Oxygen (DO)	mg/L	-	NA*	4.67	5.14	4.60
Turbidity	NTU	-	19.71	7.98	122.01	78.58
Total Suspended Solids (TSS)	mg/L	APHA 2540D	8.40	NA	122.00	NA
Total Dissolved Solids (TDS)	mg/L	APHA 2540C	121.00	NA	45.00	NA
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	1.3100	NA	1.3700	NA
Total Organic Carbon (TOC)	mg/L	APHA 5210B	2.9460	NA	6.0290	NA
Nitrate (NO_3-N)	mg/L	APHA 4500-NO3 (I)	0.06	NA	0.28	NA
Nitrite (NO2-N)	mg/L	APHA 4500-NO3 (I)	ND	NA	0.02	NA
Ammonia (NH3-N)	mg/L	APHA 4500-NH3 (H)	0.41	NA	0.06	NA
Phosphate (PO4-P)	mg/L	APHA 4500-P (G)	0.03	NA	0.03	NA
Total Nitrogen (TN)	mg/L	APHA 4500-P (J)	0.6449	NA	2.0017	NA
Total Phosphate (TP)	mg/L	APHA 4500-P (J)	0.0344	NA	0.1935	NA
Dissolved Arsenic (As)	µg/L	APHA 3125B	1.0210	NA	2.0820	NA
Dissolved Cadmium (Cd)	µg/L	APHA 3125B	ND	NA	ND	NA
Dissolved Chromium (Cr)	µg/L	APHA 3125B	ND	NA	0.2650	NA
Dissolved Copper (Cu)	µg/L	APHA 3125B	0	NA	4	NA
Dissolved Nickel (Ni)	µg/L	APHA 3125B	ND	NA	ND	NA
Dissolved Zinc (Zn)	µg/L	APHA 3125B	4	NA	2	NA
Dissolved Lead (Pb)	µg/L	APHA 3125B	ND	NA	0	NA
Dissolved Mercury (Hg)	µg/L	APHA 3125B	ND	NA	ND	NA
Chlorophyll-a	µg/L	APHA 10150C	1	NA	8	NA
Oil and Grease	mg/L	Accredited In-house Method MLS-SOP-WQ-033 Rev 0 (adapted from APHA 5520C)	ND	NA	0.2831	NA
Faecal Coliform	cfu/100mL	APHA 9222D	230	NA	1,600	NA
E. coli	cfu/100mL	APHA 9222H	130	NA	500	NA
Enterococci	cfu/100mL	APHA 9230C	330	NA	10,000	NA

** DO measurement not available due to sensor fault*

Table 8.3 Results of baseline surface water quality sampling performed at WQ2.

Sampling Point: WQ2						
Surface Water Quality Parameter	**Unit**	**Test method**	**Dry Event (27 Sep 2023)**	**Dry Event (7 Feb 2024)**	**Wet Event (21 Nov 2023)**	**Wet Event (4 Mar 2024)**
pH	-	-	6.30	6.96	6.4	6.68
Temperature	°C	-	26.38	28.31	26.48	27.96
Salinity	PSU	-	0.07	0.12	0.04	0.07
Dissolved Oxygen (DO)	mg/L	-	0.90	3.68	5.39	4.54
Turbidity	NTU	-	17.16	48.32	75.27	69.61
Total Suspended Solids (TSS)	mg/L	APHA 2540D	64.00	NA	47.33	NA
Total Dissolved Solids (TDS)	mg/L	APHA 2540C	168.00	NA	43.00	NA
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	3.1500	NA	1.4100	NA
Total Organic Carbon (TOC)	mg/L	APHA 5210B	13.7870	NA	8.7150	NA
Nitrate (NO_3-N)	mg/L	APHA 4500-NO3 (I)	0.05	NA	0.78	NA
Nitrite (NO2-N)	mg/L	APHA 4500-NO3 (I)	0.02	NA	0.02	NA
Ammonia (NH3-N)	mg/L	APHA 4500-NH3 (H)	0.22	NA	0.17	NA
Phosphate (PO4-P)	mg/L	APHA 4500-P (G)	0.17	NA	0.03	NA
Total Nitrogen (TN)	mg/L	APHA 4500-P (J)	1.2560	NA	1.9454	NA
Total Phosphate (TP)	mg/L	APHA 4500-P (J)	0.4010	NA	0.0649	NA
Dissolved Arsenic (As)	µg/L	APHA 3125B	13.7740	NA	6.1110	NA
Dissolved Cadmium (Cd)	µg/L	APHA 3125B	ND	NA	ND	NA
Dissolved Chromium (Cr)	µg/L	APHA 3125B	0.3870	NA	0.2400	NA
Dissolved Copper (Cu)	µg/L	APHA 3125B	0.7600	NA	4.8140	NA
Dissolved Nickel (Ni)	µg/L	APHA 3125B	ND	NA	ND	NA
Dissolved Zinc (Zn)	µg/L	APHA 3125B	ND	NA	10.8400	NA
Dissolved Lead (Pb)	µg/L	APHA 3125B	ND	NA	ND	NA
Dissolved Mercury (Hg)	µg/L	APHA 3125B	ND	NA	ND	NA
Chlorophyll-a	µg/L	APHA 10150C	50.6763	NA	1.8669	NA
Oil and Grease	mg/L	Accredited In-house Method MLS-SOP-WQ-033 Rev 0 (adapted from APHA 5520C)	ND	NA	ND	NA
Faecal Coliform	cfu/100mL	APHA 9222D	500	NA	1,700	NA
E. coli	cfu/100mL	APHA 9222H	320	NA	100	NA
Enterococci	cfu/100mL	APHA 9230C	480	NA	11,000	NA

Table 8.4 Results of baseline surface water quality sampling performed at WQ3.

Sampling Point: WQ3						
Surface Water Quality Parameter	**Unit**	**Test method**	**Dry Event (27 Sep 2023)**	**Dry Event (7 Feb 2024)**	**Wet Event (21 Nov 2023)**	**Wet Event (4 Mar 2024)**
pH	-	-	7.08	7.03	NA	7.67
Temperature	°C	-	27.59	26.07	NA	28.13
Salinity	PSU	-	0.13	0.11	NA	0.11
Dissolved Oxygen (DO)	mg/L	-	1.81	2.08	NA	4.99
Turbidity	NTU	-	9.77	9.60	NA	478.74
Total Suspended Solids (TSS)	mg/L	APHA 2540D	3.00	NA	NA	344.00
Total Dissolved Solids (TDS)	mg/L	APHA 2540C	181.00	NA	NA	169.00
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	0.6867	NA	NA	1.72
Total Organic Carbon (TOC)	mg/L	APHA 5210B	9.5000	NA	NA	8.00
Nitrate (NO_3-N)	mg/L	APHA 4500-NO3 (I)	0.03	NA	NA	0.095
Nitrite (NO2-N)	mg/L	APHA 4500-NO3 (I)	ND	NA	NA	0.013
Ammonia (NH3-N)	mg/L	APHA 4500-NH3 (H)	0.09	NA	NA	0.019
Phosphate (PO4-P)	mg/L	APHA 4500-P (G)	0.07	NA	NA	0.066
Total Nitrogen (TN)	mg/L	APHA 4500-P (J)	0.6127	NA	NA	0.83
Total Phosphate (TP)	mg/L	APHA 4500-P (J)	0.0899	NA	NA	0.068
Dissolved Arsenic (As)	µg/L	APHA 3125B	5.2490	NA	NA	8.49
Dissolved Cadmium (Cd)	µg/L	APHA 3125B	ND	NA	NA	ND
Dissolved Chromium (Cr)	µg/L	APHA 3125B	0.1800	NA	NA	0.69
Dissolved Copper (Cu)	µg/L	APHA 3125B	1	NA	NA	2.75
Dissolved Nickel (Ni)	µg/L	APHA 3125B	ND	NA	NA	ND
Dissolved Zinc (Zn)	µg/L	APHA 3125B	ND	NA	NA	ND
Dissolved Lead (Pb)	µg/L	APHA 3125B	ND	NA	NA	ND
Dissolved Mercury (Hg)	µg/L	APHA 3125B	ND	NA	NA	ND
Chlorophyll-a	µg/L	APHA 10150C	1	NA	NA	2.05
Oil and Grease	mg/L	Accredited In-house Method MLS-SOP-WQ-033 Rev 0 (adapted from APHA 5520C)	ND	NA	NA	0.40
Faecal Coliform	cfu/100mL	APHA 9222D	120	NA	NA	22,000
E. coli	cfu/100mL	APHA 9222H	70	NA	NA	21,000
Enterococci	cfu/100mL	APHA 9230C	310	NA	NA	6,000

Table 8.5 Results of baseline surface water quality sampling performed at WQ4.

Sampling Point: WQ4						
Surface Water Quality Parameter	**Unit**	**Test method**	**Dry Event (27 Sep 2023)**	**Dry Event (7 Feb 2024)**	**Wet Event (21 Nov 2023)**	**Wet Event (4 Mar 2024)**
pH	-	-	6.71	6.71	NA	6.78
Temperature	°C	-	26.87	26.80	NA	27.6
Salinity	PSU	-	0.13	0.10	NA	0.10
Dissolved Oxygen (DO)	mg/L	-	1.64	1.94	NA	3.61
Turbidity	NTU	-	33.04	16.91	NA	25.09
Total Suspended Solids (TSS)	mg/L	APHA 2540D	NA	NA	NA	11.80
Total Dissolved Solids (TDS)	mg/L	APHA 2540C	NA	NA	NA	144.00
Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210B	NA	NA	NA	1.19
Total Organic Carbon (TOC)	mg/L	APHA 5210B	NA	NA	NA	5.94
Nitrate (NO_3-N)	mg/L	APHA 4500-NO3 (I)	NA	NA	NA	0.12
Nitrite (NO2-N)	mg/L	APHA 4500-NO3 (I)	NA	NA	NA	0.014
Ammonia (NH3-N)	mg/L	APHA 4500-NH3 (H)	NA	NA	NA	0.12
Phosphate (PO4-P)	mg/L	APHA 4500-P (G)	NA	NA	NA	0.055
Total Nitrogen (TN)	mg/L	APHA 4500-P (J)	NA	NA	NA	0.72
Total Phosphate (TP)	mg/L	APHA 4500-P (J)	NA	NA	NA	0.056
Dissolved Arsenic (As)	µg/L	APHA 3125B	NA	NA	NA	3.25
Dissolved Cadmium (Cd)	µg/L	APHA 3125B	NA	NA	NA	ND
Dissolved Chromium (Cr)	µg/L	APHA 3125B	NA	NA	NA	0.23
Dissolved Copper (Cu)	µg/L	APHA 3125B	NA	NA	NA	2.05
Dissolved Nickel (Ni)	µg/L	APHA 3125B	NA	NA	NA	ND
Dissolved Zinc (Zn)	µg/L	APHA 3125B	NA	NA	NA	8.09
Dissolved Lead (Pb)	µg/L	APHA 3125B	NA	NA	NA	ND
Dissolved Mercury (Hg)	µg/L	APHA 3125B	NA	NA	NA	ND
Chlorophyll-a	µg/L	APHA 10150C	NA	NA	NA	4.32
Oil and Grease	mg/L	Accredited In-house Method MLS-SOP-WQ-033 Rev 0 (adapted from APHA 5520C)	NA	NA	NA	ND
Faecal Coliform	cfu/100mL	APHA 9222D	NA	NA	NA	2,000
E. coli	cfu/100mL	APHA 9222H	NA	NA	NA	2,000
Enterococci	cfu/100mL	APHA 9230C	NA	NA	NA	4,900

Stream Hydrology

Table 8.6 Baseline surface hydrological information recorded during the dry weather event.

Sampling Location (Dry)	Wetted Width (m)	Average Depth (m)	Velocity (m/s)	Cross-section area (m^2)	Flow Rate (m^3/s)
WQ1	0.85	0.1	0.05	0.085	0.00425
WQ2	1.1	0.16	No flow	0.176	No flow
WQ3	0.23	0.13	0.22	0.030	0.0066
WQ4	6.0	1.16	No flow	6.96	No flow

Table 8.7 Baseline surface hydrological information recorded during the wet weather event.

Sampling Location (Wet)	Wetted Width (m)	Average Depth (m)	Velocity (m/s)	Cross-section area (m^2)	Flow Rate (m^3/s)
WQ1	1.05	0.12	0.23	0.126	0.029
WQ2	1.6	0.11	No flow	0.176	No flow
WQ3	0.65	0.17	0.53	0.111	0.059
WQ4	6.0	1.79	0.04	10.74	0.430

Figure 8.13 Water quality and stream hydrology sampling points within the study area during dry weather event.

All four water quality sampling points were slow-moving to stagnant forest streams with vegetated banks (Figure 8.13). WQ1 and WQ3 were relatively shaded, while WQ2 had full solar exposure. WQ3 is a tributary to WQ4, which is the largest of the streams surveyed and drains directly into the Jurong river downstream. The baseline surface hydrological survey confirmed that the average depth of all the streams surveyed is relatively shallow, ranging from 10cm to 13cm, with the exception of WQ4 which has an average depth of 1.16m (Table 8.6). The overall trend showed a generally gentle flow rate, with WQ4 exhibiting the largest increased in flow rate during the wet weather event (Table 8.7). The turbidity of the streams visibly increased during the wet weather event, indicating significant levels of erosion taking place during rainy weather (Figure 8.14).

Figure 8.14 Water quality and stream hydrology sampling points within the study area during wet weather event.

8.3.2.2 Supplementary Stream Characterisation Surveys

Selected photographs taken during the supplementary stream characterisation surveys are shown in Figure 8.15 to Figure 8.20. The supplementary stream characterisation surveys revealed that most of the streams passing through the Project footprint are interconnected (sometimes in multiple ways, see Figure 8.15, Figure 8.16, Figure 8.21), either by surface flow during ponding or flooding events (Figure 8.17, Figure 8.18, Figure 8.19), or old subsurface culverts and drains that run beneath road junctions (Figure 8.20). The hydrological parameters recorded at each sampling point, and the observed direction of stream flow at each sampling point may be found in Table 8.8 and Figure 8.21 below. Photographs of all sampling points where stream flow was measured may be found in Appendix E2.

Figure 8.15 Stream flowing from the junction (top left) and A12 (top right) towards A11 (bottom right).

Figure 8.16 Stream flowing from A12 towards the junction.

Figure 8.17 Example of a stream at sampling point A4 flowing into an adjacent stream connecting to sampling point A9 via surface runoff, likely caused by ponding.

Figure 8.18 Heavy ponding between A16A, A17A and A18 as stream drains into unmanaged soft-bank pond at sampling point A16A.

Figure 8.19 Example of water seepage from north of A14 flowing towards A14.

Figure 8.20 Example of a subsurface culvert channelling stream flow from sampling point A2 to the junction where A2, A11 and A12 intersect (Figure 8.21) .

Table 8.8 Baseline surface hydrological information recorded during the secondary hydrological baseline surveys.

Sampling Location (Dry)	Wetted Width (m)	Average Depth (m)	Velocity (m/s)	Cross-section area (m^2)	Flow Rate (m^3/s)
A2	0.86	0.23	0.12	0.198	0.0237
A3	1.95	0.26	No flow	0.501	No flow
A4	2.5	0.28	No flow	0.708	No flow
A9	3.2	0.45	No flow	1.44	No flow
A10	2.5	0.51	No flow	1.28	No flow
A11	2.5	0.23	0.05	0.583	0.0292
A12	2.4	0.09	0.06	0.216	0.0130
A13	1.2	0.17	0.08	0.208	0.0166
A14	1.8	0.13	0.055	0.234	0.0129
A15A	1.9	0.08	0.035	0.146	0.005
A15B	2.05	0.19	0.08	0.390	0.0312
A16A	2.6	0.15	No flow	0.400	No flow
A16B	2	0.05	0.01	0.107	0.00107
A17A	2.3	0.12	No flow	0.284	No flow
A17B	0.9	0.03	No flow	0.027	No flow
A1	1.35	0.14	0.05	0.189	0.00945
A25	1.1	0.05	No flow	0.055	No flow
A26	1.8	0.18	0.02	0.324	0.00648
B1A	0.55	0.17	0.08	0.0935	0.00748
B1B	0.47	0.51	No flow	0.241	No flow
B2	1.45	0.13	0.08	0.189	0.0151

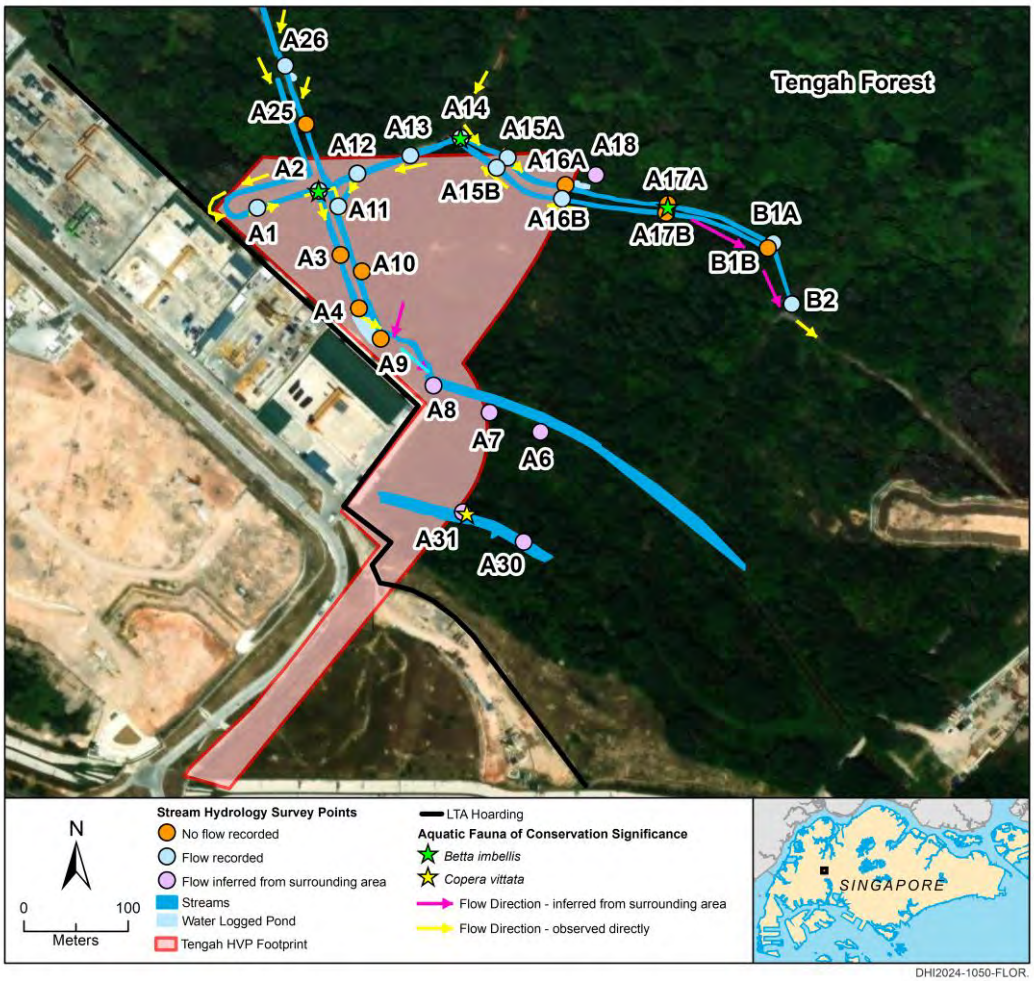

Figure 8.21 Directions of stream flow observed at secondary hydrological sampling points.

At sampling point A16A, it was noted that the stream flow was being partially channelled into an unmanaged soft-bank pond at point A18 (Figure 8.22). The presence of this pond and the waterlogged area around it may be altering the general flow of streams in the area, potentially contributing to the opposite directions of flow observed at points A15A to B1A, as opposed to points A15B to B1B.

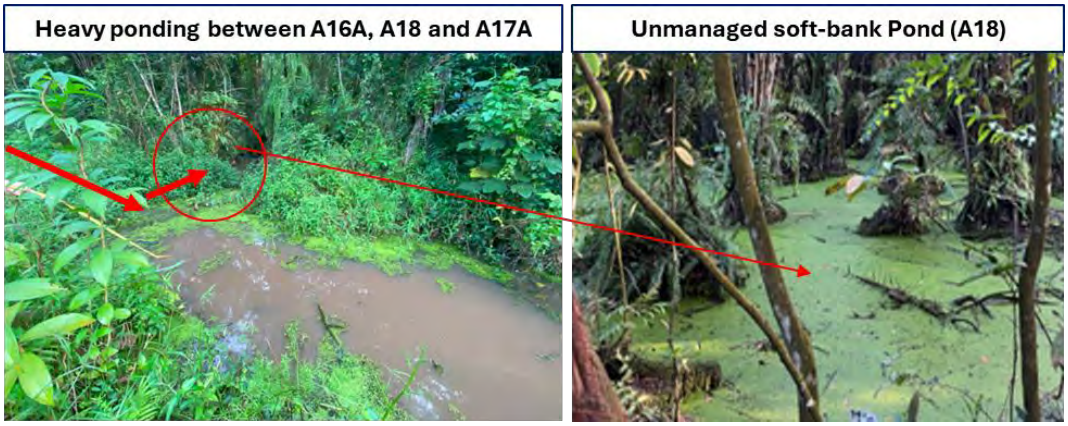

Figure 8.22 Stream flow being channelled from A16A to the unmanaged soft-bank pond at A18.

8.4 Impact Assessment

This subsection identifies, assesses and predicts water quality and hydrology impacts expected to occur as a result of the construction and post-construction (operational) phases of the Project, and predicts their significance prior to mitigation.

The significance of these environmental impacts will be scored in accordance with the framework delineated in Section 4.5.

8.4.1 Determining Importance and Magnitude

Being an island nation, the importance of surface water quality and hydrology is confined to the national geographic boundaries of the country, and the catchment area assessed is likewise within Singapore only. The potential impact related to surface water quality and hydrology for waterbodies running within and through the Project site is expected to affect the environment itself. Thus, the receptors considered for this assessment are the Project site and its immediate surrounding, catchment areas downstream, ecological receptors such as aquatic fauna that depend on the waterbodies in and around the Project site, as well as human and socioeconomic receptors that depend on the aforementioned catchment processes for the national water supply as well as recreational uses downstream. The general framework for the evaluation of importance of receptors and the associated scores are presented in Table 8.9 for Surface Water Quality, and Table 8.10 for Hydrology.

Table 8.9 Criteria for Determining Receptor Importance (Surface Water Quality).

Score	Generic Definition	Customised Definition
5	Important to national/international interests	The surface water receptor lies within an unmodified habitat, is nationally rare with high socioeconomic or ecological value or quality, and is generally irreplicable via engineering means (e.g., forest streams, freshwater swamps and marshes, quarry lakes, hot springs). The surface water receptor is wholly relied upon locally and is important at a national catchment level for provisioning services and contribution to dependent ecosystems (e.g., reservoirs within a protected catchment area).
4	Important to regional/national interests	The surface water receptor is wholly relied upon locally, with no suitable technically or economically feasible alternatives, and is important at a local catchment level for provisioning, regulating, or cultural/aesthetic services (e.g. reservoirs outside of a protected catchment, naturalised ponds, stormwater retention ponds, landmark Active Beautiful Clean (ABC) projects such as Bishan-Ang Mo Kio Park, stormwater diversion canals, downstream segments of major rivers and canals leading to reservoirs.
3	Important to areas immediately outside the local condition	The surface water receptor is important at a local catchment level for provisioning or regulating services, with limited technically or economically feasible alternatives of comparable quality or function (e.g., large monsoon drains, PUB rain garden features)
2	Important only to the local condition (within	The surface water receptor is important at a local catchment level for provisioning or regulating services, but there is sufficient capacity or opportunity for alternative sources of

Score	Generic Definition	Customised Definition
	a large direct impact area)	comparable quality or function (e.g., small drains that are controlled watercourses)
1	Important only to the local condition (within a small direct impact area)	The surface water resource has low value, and little or no role in provisioning of services to the local community or ecosystem (e.g., uncontrolled watercourse, drains discharging to the sea, small concrete-lined ponds)

Table 8.10 Criteria for Determining Receptor Importance (Hydrology).

Score	Generic Definition	Customised Definition
5	Important to national/international interests	Receptors specifically protected by national or international policies or legislation and are of significance at the regional or national scale, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Park
4	Important to regional/national interests	Receptor locations where human or wildlife populations are readily exposed to surface water and are dependent on the surface water resources for economical or biological support to sustain the population
3	Important to areas immediately outside the local condition	Receptor locations where the surface water resource is an important water supply, and is currently used, but there is capacity and/or adequate opportunity for alternative sources of comparable quality.
2	Important only to the local condition (within a large direct impact area)	Receptor locations accessible by general public where exposure is transient, for example public footpath, playing fields, parks.
1	Important only to the local condition (within a small direct impact area)	Receptor locations with limited access and where exposure is transient, for example private premises.

The magnitude of change used for surface water quality and hydrology are presented in Table 8.11 and Table 8.12 respectively.

Table 8.11 Criteria for Determining Magnitude of Change in Surface Water Quality

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	• Severe effects on water quality which are likely to be long lasting (months or more) and give rise to indirect ecological and/or socio-economic impacts • Water quality is likely to routinely exceed baseline criteria levels or allowable criteria • Likely to involve significant alterations to existing drainage regimes and patterns
-3	Moderate negative disadvantage or change	• Potential localised effects on water quality which are likely to be long lasting (weeks or months) and give rise to indirect ecological and/or socio-economic impacts • Water quality is likely to occasionally exceed baseline criteria levels or allowable criteria

Score	Generic Criteria	Specific Criteria
		• Likely to involve moderate alterations to existing drainage regimes and patterns
-2	Minor negative disadvantage or change	• Short term localised effects on surface water quality but which are likely to return to equilibrium conditions within a short timeframe (hours or days at most) • Water quality is likely to be within baseline criteria levels or allowable criteria • Likely to be some alteration to existing drainage regimes and characteristics, although the frequency and magnitude of flooding upstream or downstream is not expected to be materially affected
-1	Slight negative disadvantage or change	• Short term localised effects on surface water quality but likely to be highly transitory (lasting hours) and well within natural fluctuations • Water quality is likely to be within baseline criteria levels or allowable criteria • Likely to be some alteration to existing drainage regimes and characteristics, although the frequency and magnitude of flooding upstream or downstream is not expected to be materially affected
0	No change	• Water quality is likely to be well within baseline criteria levels or allowable criteria • No alterations to existing drainage regimes and characteristics and thus negligible or no impact on upstream or downstream flood flows

Table 8.12 Criteria for Determining Magnitude of Change in Hydrology.

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	• Severe effects on surface water hydrology affecting an extensive area and may give rise to indirect ecological and/or socio-economic impacts • Likely to involve significant alterations to existing drainage regimes and patterns • Alterations to hydrology expected to cause potentially severe effects on catchment processes which are likely to be long lasting (years or permanent)
-3	Moderate negative disadvantage or change	• Localised effects on surface water hydrology which happen regularly and may give rise to indirect ecological and/or socio-economic impacts • Likely to involve significant alterations to existing drainage regimes and patterns • Alterations to hydrology expected to cause potential localised effects on catchment processes which is likely to be long lasting
-2	Minor negative disadvantage or change	• Localised effects on surface water hydrology which happens occasionally, but can be remediated in time during construction

Score	Generic Criteria	Specific Criteria
		• Likely to be some alteration to existing drainage regimes and characteristics, although the frequency and magnitude of flooding upstream or downstream is not expected to be materially affected
-1	Slight negative disadvantage or change	• Localised effects on surface water hydrology but the incident rarely happens • No alterations to existing drainage regimes and characteristics and thus negligible or no impact on upstream or downstream flood flows • Short term localised effects on surface water hydrology but likely to be highly transitory (lasting hours) and well within natural fluctuations
0	No change	• Status quo

8.4.2 Importance Rating of Sensitive Receptors

The identified sensitive receptors were further post stratified into two main receptors, namely aquatic fauna (biodiversity) and humans (socio-economic). The receptors were then accorded their respective importance scores based on Table 10.4 and Table 8.10 above, with justifications described in Table 8.13 below.

The sensitive receptors were identified based on the planned development, as well as the areas downstream and adjacent to the Project site.

Table 8.13 Relevant Sensitive Receptors for Surface Water Quality and Hydrology

Category	Sensitive Receptor	Importance Score	Justification
Fauna	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	4	• Aquatic fauna are highly sensitive to changes in water quality and hydrology. Water pollution and stream backfilling or realignment will therefore exert negative impacts on them. • There are conservation significant aquatic fauna (e.g., *Betta imbellis*) within the streams in Tengah forest.
Socio-economic	Residents of private and HDB estates, as well as members of public downstream of the Project Site, e.g., Jurong Lake District	3	• Residents and public downstream of the Project site will be able to visually detect any pollution in the Jurong River and Jurong Lake Gardens, as well as changes to hydrology if the flow of water is interrupted. • Jurong Lake Gardens is an important catchment area, as it serves the Pandan Reservoir catchment, and is also recreationally important alongside having multiple ABC water design features. The public utilise Jurong Lake for recreational activities such as

Category	Sensitive Receptor	Importance Score	Justification
			kayaking, and may be exposed to polluted water. • The planned Tengah Pond is situated downstream of the Project site, and any backfilling of earth streams running through the Project site may adversely affect water supply to the pond.

8.4.3 Construction Phase

In this section, the impacts associated with the construction of the Project on surface water quality and hydrology within and downstream of the Project are assessed. For the assessment of surface water hydrology, the key waterbodies that are taken into consideration within the Project site are labelled in Figure 8.23 below.

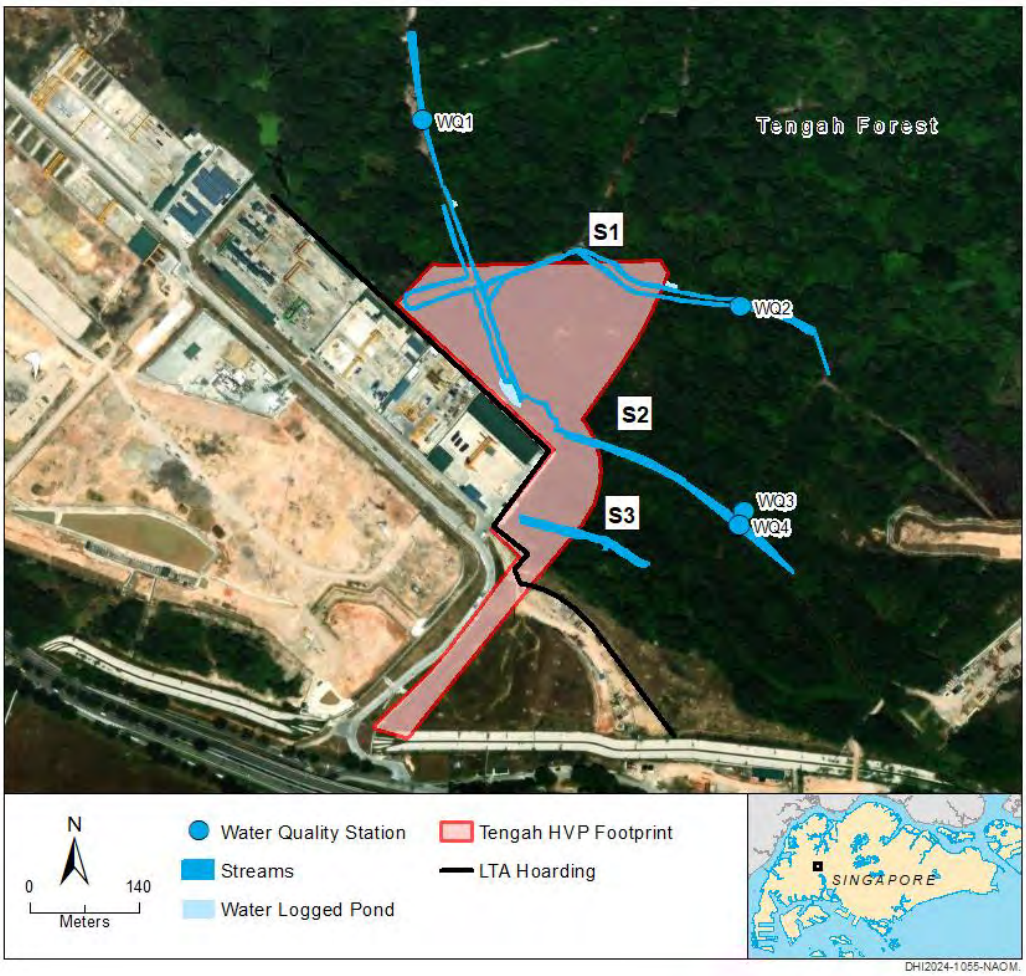

Figure 8.23 Streams passing through Project footprint. Streams 1, 2 and 3 are labelled as S1, S2 and S3 respectively.

Erosion, Surface Runoff and Sediment Plume

The construction phase would involve large amounts of vegetation clearance throughout the project footprint, including the creation of large tracts of exposed earth and spoil materials due to the levelling of the site which currently experiences undulations in elevation of about 4.5m. During wet weather events, high amounts of rainfall would cause surface runoff to carry away exposed soil and any other loose construction material and debris. Given that there are currently two major earth streams as well as multiple minor natural tributary streams running through the project site, without suitable mitigation, the surface runoff from rainfall events would contain elevated levels of suspended sediments, thereby raising the turbidity of receiving waterbodies, which would be the natural streams in the vicinity. The surface runoff may also contain debris, refuse, oil and grease along with other construction-related leachates and effluents, which will impact surface water quality in the receiving waterbodies. The sediment plume may eventually make its way downstream via rainfall enhanced stream flow, ultimately entering Jurong River and Jurong Lake.

Freshwater Stream and Fauna

Given Singapore's history of land use change, the slightly acidic freshwater earth streams S1, S2 and S3 present within the Project site represent a somewhat rare habitat within Singapore's context. The impacts of surface runoff directly affect freshwater fauna on multiple trophic levels. Any increase in turbidity is likely to impede respiratory processes of fauna that depend on dissolved oxygen to breathe, as fine sediment particles may clog the gills of aquatic fauna. Heightened levels of sediment in the water would also impede the vision of fauna that rely on optical detection of their surroundings. When food availability is lowered on multiple trophic levels, mass death of fauna may occur as well, in tandem with HAB events mentioned above.

Lastly, stream S1 is host to conservation-significant aquatic fauna, both the Crescent Betta (*Betta imbellis*) and the Three-spot Gourami (*Trichopoda trichopterus*), which are locally Endangered and Vulnerable in the Singapore Red Data Book (3rd Edition). Therefore, the freshwater stream and its associated fauna have been allocated an Importance score of 4. With reference to Table 8.11 and Table 8.12, the Magnitude of change for surface water quality is scored at -3.

Residents and Members of Public

Residents living in the vicinity of Jurong Lake District and members of the public who utilise the recreational facilities available in Jurong Lake Gardens may be exposed to polluted water if they enter the lake to perform water sports such as kayaking. Any visible change in turbidity due to surface runoff from the Project site will also reduce the aesthetic value of the park, thereby warranting an Importance score of 3. With reference to Table 8.11 and Table 8.12, the Magnitude of change for surface water quality is scored at -2.

However, since construction works are temporary and any negative impacts are controllable with proper site management, cumulative effects are not expected. Therefore, the impacts are deemed to be non-permanent, recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

8.4.3.1 Water Pollution Due to Fuel and Chemical Spillage

The construction of the HVP may require on-site storage and handling of chemicals including cement, fuels, and lubricants. If these are not contained carefully, these might flow into streams, thus affecting their water quality, leading to the impacts to fauna relying on these habitats.

These impacts are likely to be temporary, recoverable, but potentially cumulative, the impact to freshwater biodiversity is considered minor negative.

8.4.4 Post-construction Phase

In this section, the impacts associated with the operation of the Project on surface water quality and hydrology within and downstream of the Project are assessed.

8.4.4.1 Changes to Hydrology

The construction of the HVP involves significant earthworks due to the slightly undulating elevation across the Project footprint and backfilling of the streams cutting through the Project site will likely be required as part of the overall design of the development.

Freshwater Stream and Fauna

Should streams be completely backfilled, all aquatic flora and fauna that currently rely on them will perish, which include the conservation significant Crescent Betta as well as the Three-spot Gourami which are nationally Endangered and Vulnerable species. As such, to Table 8.11 and Table 8.12, the Magnitude of change for hydrology is scored at -4.

Since any backfilling of the stream will lead to a permanent loss of the stream habitats, the overall significance of this impact to freshwater biodiversity is considered to be Major negative.

Residents and Members of Public

As there are currently no residents or members of public living directly around the Project footprint, any changes to the hydrology of the area due to the backfilling of streams will not affect them, both directly and indirectly. As such, the Magnitude of change for hydrology is scored at 0.

Vehicle-related particulate matter and discharge may be carried by surface runoff during wet weather events and enter waterbodies adjacent to the Project site. In significant quantities, this may result in water pollution, which would decrease the aesthetic value of receiving waterbodies, affecting socioeconomic receptors downstream and endanger any flora and fauna present in them.

Factors associated with vehicular discharge that may contribute to waterbody pollution include the following:

- Wear-and-tear: Particulate matter generated from tyre and road surface erosion
- Engine and brake discharge: Engine/brake oil and heavy metals discharged or leaked from vehicles
- Exhaust: Water-soluble polluting gases and particulate matter such as soot emitted by vehicle exhausts

Furthermore, residents living in the vicinity of the HVP during the post-construction phase and members of the public who utilise the recreational facilities available in Jurong Lake Gardens downstream may be exposed to polluted water if they enter the lake to perform water sports such as kayaking. Any visible change in water quality due to runoff from the HVP will also reduce the aesthetic value of the park, thereby warranting an Importance score of 3. With reference to Table 8.11 and Table 8.12, the Magnitude of change for surface water quality is scored at -2.

However, such negative impacts are deemed to be controllable with proper site management, and cumulative effects are not expected. Therefore, the impacts are deemed

to be non-permanent, recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

Should the streams be backfilled as a result of the development, fundamental changes to Tengah's hydrology and ecology are expected (see Section 8.4.4.1). However, no further impact to the hydrology of the area is expected to occur during the post-construction phase, as the vehicular traffic is contained within the project footprint and is not expected to exert further changes that affect the hydrology of the surrounding area, as opposed to the construction phase.

8.5 Mitigation Measures

8.5.1 Construction Phase

8.5.1.1 Surface Water Quality and Hydrology

Slight negative impacts are anticipated on the surface water quality within and around the Project site during the construction phase. Mitigation measures have been recommended to safeguard against issues such as surface runoff and the accidental release of chemicals. Details of these measures can be found in Table 8.14.

Table 8.14 Proposed Surface Water Quality Impact Mitigation Measures by Hierarchy Type

Hierarchy	Mitigation Measures
Avoidance	• Engage a Qualified Erosion Control Professional (QECP) to formulate and implement an Earth Control Measures (ECM) plan in accordance with PUB requirements • Avoid siting work areas within 30 m from the nearest waterbody, i.e. work areas should not be sited within 30 m from the freshwater streams running through the Project footprint. • Only store minimal quantity of chemicals, oil and fuels on site. • Suitable containers shall be used to hold the chemical wastes to avoid leakage or spillage during storage, handling, and transport • Additional containments to store chemicals, oil/fuels shall be implemented to contain the leak/ spillage etc. • All slurry preparation activities are to be conducted within designated areas away from streams, with adequate containment measures • Chemical waste containers shall be labelled with appropriate warning signs and symbols to avoid accidents. There shall also be clear instructions showing what action to take in the event of an accident. • No vehicle fuelling and maintenance to be allowed within the project area • Appropriate concrete washout areas should be provided and should not be performed in or near any of the watercourses. Concrete debris and water used for dust control should not be allowed to cause contamination within the work area or to run offsite. • Water in the washout areas shall not be discharged to any watercourses. • No sullage/used water shall be discharged to any watercourses.

Hierarchy	Mitigation Measures
Minimization	• Construction works are to be conducted in accordance with the Environmental Protection and Management (Trade Effluent) Regulations • Clearance of surface vegetation should be done in stages to reduce the amount of surface runoff and erosion • Hoarding should be in place to clearly demarcate work area, hence limiting the spatial extent of soil and slope works • Silt curtains should be installed along the boundaries of work areas to minimize sediment runoff into waterways. At areas of the construction zone closest to the freshwater stream, double layers of silt curtains can be installed to greatly reduce the risk of stream sedimentation • 100% Biodegradable Erosion Control Blankets should be installed wherever bare earth is exposed • Soil and material stockpiles should be covered with tarpaulin when not in use • Proper erosion and sediment control measures should be implemented by engaging a Qualified Erosion Control Professional (QECP) to design and implement an Earth Control Measures (ECM) plan • Turf cover should be established during reinstatement of the work site to minimize soil erosion • After rain events, earth control measures in the Area are to be inspected and maintained over the course of construction • Tarpaulins mats (in adequate quantities) should be on standby during site clearance and excavation works, to ensure that exposed soil and stockpiles are covered and prevent overflow of silty discharge • Any construction equipment which causes pollution to the water system due to leakage of oil or fuel shall be removed off-site immediately. • Spillage or leakage of chemical waste to be controlled using suitable absorbent materials • Chemicals will always be stored on drip trays or in bunded areas where the volume is 110% of the stored volume. • Proper records of Safety Data Sheet (SDS) for all chemical, fuel, solvents stored on site is required • Proper storage and provision of Spill Kits and training of staff on how to use the Spill Kit • Any contractor generating waste oil or other chemicals as a result of his activities should register as a chemical waste producer. Disposal of the waste oil should be done through a licensed toxic industrial waste collector. • A full containment bund wall should be provided for bulk storage oil tanks, including skid tanks. A collection sump should be provided to collect any spillage. All leaks and spillages in the storage area or construction site shall be collected and sent to a licensed toxic waste collector for proper disposal. • Good housekeeping practices should be implemented to minimize careless spillage and to keep the storage and the workspace in a tidy and clean condition. • Appropriate training including safety codes and relevant manuals should be given to the personnel who regularly handle the chemicals on site.

Hierarchy	Mitigation Measures
	• A temporary cut-off drainage channel and associated facilities should be provided to collect the runoff generated and prevent concrete-contaminated water from entering watercourses • Engage a Qualified Erosion Control Professional (QECP) to formulate and implement an Earth Control Measures (ECM) plan in accordance with PUB requirements
Restoration	Nil
Offsets	Nil

8.5.2 Post-Construction Phase

8.5.2.1 Surface Water Quality

During the post-construction phase, implementing proactive and diligent mitigation measures is crucial to safeguard surface water quality. Regular monitoring and inspection of these conditions are essential to promptly identify any issues.

To prevent soil erosion from surface runoff entering the streams, ongoing maintenance of soil erosion control practices, such as maintaining vegetation cover along the streams, is imperative.

A perimeter drain should also be installed along the perimeter of the HVP to prevent oil and fuel-based runoff from heavy vehicles from entering the streams.

Moreover, ensuring the implementation of adequate measures as vehicle maintenance, dust control and spill prevention practices contributes significantly to maintaining good surface water quality in the area.

With the proper post-construction phase management measures described above, the impacts to receiving waterbodies during the post-construction phase are expected to be mitigated, to maintain and improve water quality in the surrounding environment.

8.5.2.2 Surface Hydrology

Adverse impacts long term are anticipated on surface hydrology within and downstream of the Project site, particularly if backfilling of streams is required. Mitigation measures have been recommended to address these impacts. Details of these measures can be found in Table 8.15 below.

Table 8.15 Proposed Surface Hydrology Impact Mitigation Measures by Hierarchy Type.

Hierarchy	Mitigation Measures
Avoidance	• Avoid the backfilling of the streams, running through the Project footprint, in order to maintain hydrological connectivity with the source of the streams upstream of the Project site, as well as downstream. This is most applicable to stream S1 which has conservation significant freshwater fauna such as Crescent Betta.

Hierarchy	Mitigation Measures
Minimization	• If the streams cannot be retained, they should be diverted and realigned instead, while retaining the overall hydrological flow of the area upstream and downstream. Stream S1's upstream connectivity must be maintained, as the flow of surface water in the area travels in a southeasterly direction from the northwest boundary of the site towards the southeast boundary. • Any watercourse diversion design must be in line with PUB's Code of Practice on Surface Water Drainage. This is to ensure the preservation of flow capacity during the construction phase. • Within the development areas, guidelines will be put in place stipulating maximum areas of hard paved areas allowed, requiring much of the ground to be green or porous, to minimise surface runoff and maximise groundwater percolation to avoid flooding streams.
Restoration	• Nil
Offsets	• Nil

8.6 Residual Impact

8.6.1 Construction Phase

8.6.1.1 Surface Water Quality

By employing a range of mitigation measures during construction phase, the expected significance of residual surface water quality impacts is anticipated to be considerably minimized. These measures, including a detailed water quality management plan and strict soil management and chemical storage protocols, aim to effectively address and mitigate potential risks. No residual impact is anticipated with proper implementation of mitigation measures.

8.6.2 Post-Construction Phase

Through the implementation of proactive management measures during operation, the anticipated residual impact on surface water quality and hydrology is expected to be at a negligible level for socioeconomic receptors. Rigorous monitoring and inspection protocols, especially regarding potential vehicular discharge from future heavy vehicle traffic in the HVP are necessary. Ongoing maintenance of soil erosion control and spill prevention and management practices ensures the aesthetic quality and health of watercourses for socioeconomic use. Thus, no residual impact is expected to socioeconomic receptors during the post-construction phase, with adequate mitigation measures in place.

However, for aquatic flora and fauna present in the watercourses near to the HVP site, there is still some impact anticipated even with the implementation of adequate mitigation measures. Some changes to water quality are expected from the presence of water-soluble polluting gases released by vehicle exhausts. Additionally, permanent changes to hydrology are expected, leading to a potential loss or degradation of stream habitats. The residual impact to aquatic biodiversity is expected to change from Moderate negative to Slight negative in the post-construction phase.

8.7 RIAM Summary

Table 8.16 Summary of impact assessment for Surface Water Quality and Hydrology impacts for the construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Impact to water quality due to sediment runoff and siltation	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	4	-3	2	2	2	-72	Minor negative	-1	-24	Slight negative
	Immediate community downstream of the Project site	3	-2	2	2	2	-36	Slight negative	-1	-18	Slight negative
Water pollution due to fuel and chemical spillage	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	4	-2	2	2	3	-56	Minor negative	-1	28	Slight negative
Degradation of stream habitat due to soil erosion	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	4	-2	2	2	3	-56	Minor negative	-1	-28	Slight negative

Table 8.17 Summary of impact assessment for Surface Water Quality and Hydrology impacts for the post-construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of stream habitats	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	4	-4	3	3	3	-144	Major negative	-3	-108	Moderate negative
Contamination of receiving waterbodies due to	Aquatic fauna dependent on forest streams within, downstream	4	-2	2	2	2	-48	Minor negative	-1	-24	Slight negative

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
vehicular discharge	and adjacent to Project site										
	Immediate community downstream of the Project site	3	-2	2	2	2	-36	Slight negative	0	0	No impact

9 Ground Vibration

Given the forested nature of the Project site, baseline vibration levels are currently relatively low. Construction activities from the Project such as land clearance, earthworks, potential piling will increase ground vibration levels. The use of the site as a Heavy Vehicle Park may also contribute to post-construction vibration impacts on sensitive receptors, due to the movement of heavy vehicles.

This section includes the applicable legislation and standards of ground vibration management and baseline study of the Project area. Development impact from the construction and post-construction phase will be assessed and evaluated and suitable mitigation measures will be proposed.

Site surveys were conducted from 29 Sep 2023 to 01 Oct 2023 to measure the baseline condition and the results were used to establish the initial conditions that serve as a benchmark for evaluating any impact that may occur to the sensitive receptors and ambient ground vibration as a result of the construction and post-construction activities associated with the Project.

9.1 Applicable Legislation and Standards

Singapore does not have any national criteria that relates to ground vibration.

It is common for the LTA to require the vibration to be assessed against relevant international standards. The British Standards have been used for many projects and are summarised:

- BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting
- BS 5228-2 2009: Code of practice for noise and vibration control on construction and open sites – vibration
- BS 5228-3-1997: Noise and vibration control on construction and open sites
- BS 5228-4 1992: Code of practice for noise and vibration control on construction and open sites – noise and vibration control of piling

9.2 Methodology

9.2.1 Desktop Study

Secondary data such as previous EIA report, satellite imagery, existing land use, and development activities assist in identifying the baseline vibration monitoring location and provide comparison data for the primary data collected. Secondary data provides an overview of the progressive ground vibration condition over the years considering with the on-going construction and other future developments planned within the Tengah area.

J1002 Jurong Region Line Mainline and Depot Environmental Impact Assessment (LTA, 2018) study of ground vibration within Tengah was reviewed.

9.2.2 Field Survey

The baseline ground vibration monitoring comprised of one (1) vibration monitoring station for continuous measurements over a 48-hour period of vibration. Monitoring location shown in Figure 9.1 was selected to represent ecological sensitive receptors located in close proximity to the Project site. The measurement was conducted using a tri-axial vibration sensor (INSTANTEL INC) which records particle movement in three dimensions with 0.3 mm/s trigger level. A peak particle velocity (PPV) level of 0.3 mm/s is classified under the impact category described as “Vibration might just be perceptible in residential environments” in British Standard BS 5228-2. Data was collected every 5 seconds and the PPV in millimetres per second (mm/sec) recorded for plotting to a chart.

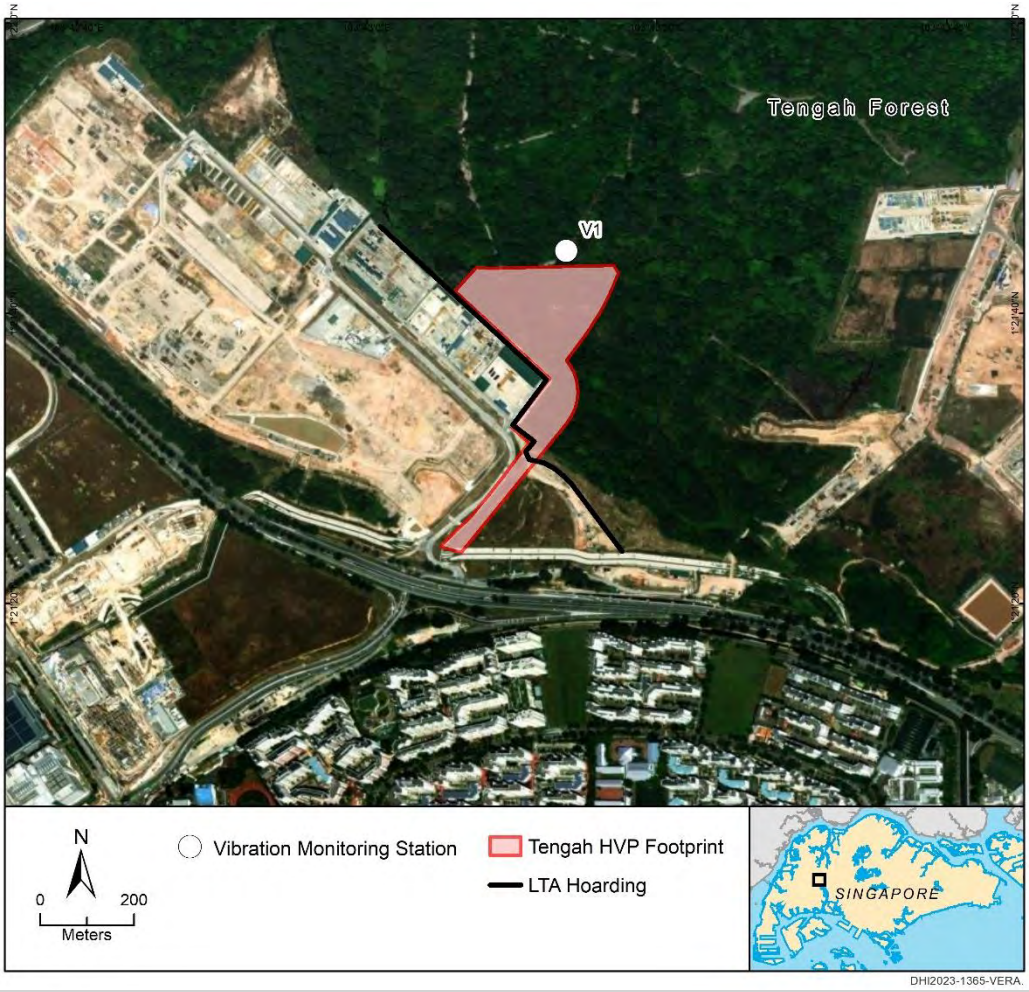

Figure 9.1 Monitoring locations for ground vibration.

9.3 Baseline Description

Vibrations generated from heavy equipment and machinery used during construction can have adverse effects on the surrounding environment and human health. Ground vibrations are a form of environmental pollution that can cause structural damage to buildings and sensitive infrastructures, and also disrupt the ecosystem. The establishment of a baseline condition helps to determine the current levels of ground vibrations in the surrounding environment before the development activities commence.

Methodology and findings of primary data collection and review of secondary data will be presented in this section.

9.3.1.1 Desktop Study

In view of the expected construction activities listed in Section 2.3, ground vibration could be generated from the heavy machinery operation during site clearance and excavation to level the land to designed level, mobilisation of equipment such as trucks, crawler crane, mobile cranes, soil improvement rigs and excavators into Project site and infrastructure works such as construction of roads, drains, and landscaping works. However, in view of the relatively small scale of development without significant land intrusive works, vibration is expected to be localised within the Project site and immediate surroundings.

Review of previous studies

Vibration measurements from previous studies within the vicinity of Project Site will be referenced and compared with current primary data collected for airborne noise baseline study.

A ground-borne vibration monitoring was monitored for a period of 24-hour from 02 Aug 2016 to 03 Aug 2016. Two (2) locations were selected, V1 at Block 407 Jurong West Street 42 and V2 at Jurong Junior College. These locations are out of the study area of this Project, hence not relevant for this study.

9.3.1.2 Field Study

PPV can be defined as the instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position. The vibration chart recorded at Tengah Forest is presented in Appendix F.

The timeseries of the measurements showed that the measured PPV were below the minimum trigger level of 0.3 mm/s for most of the time, with a few elevated readings recorded on 29 September 2023 10:53am to 11:30am. Table shows the 95% percentile of the peak component measurements to show the upper limit of the vibration levels with the outliers filtered. The elevated readings were possibly due to interference from sources such as vehicles, wildlife or rainfall. The baseline study results showed that the existing ambient vibration levels are hardly perceptible (below 0.3 mm/s).

Table 9.1 Results of baseline measurements of ground vibration level at 95th percentile

Monitoring Station	PPV (mm/s)
V1	0.063 mm/s

9.4 Impact Assessment

9.4.1 Determining Importance and Magnitude

Vibration criteria for human comfort have been based on the guidance of British Standards BS 5228-2 (2009).

BS 5228-2 (2009) provides simple criteria in terms of the overall peak particle velocity (PPV). PPV is a parameter that only considers the overall level of the vibration source. The proposed impact criteria for vibration (PPV) are outlined in Table 9.2 below.

From our experience on construction vibration loggers, majority of vibration equipment available in the market are in PPV. PPV may be used to set the trigger level on the vibration monitoring loggers during construction.

Table 9.2 Proposed Impact Criteria for Human Comfort Vibration (PPV)

Vibration Level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

Table 9.3 Evaluation Framework for Magnitude in Vibration Level for Human and Fauna Receptors.

Score	Generic Criteria	Specific Criteria	
		Human Receptors	Fauna Receptors
-4	Major negative disadvantage or change	> 10 mm/s PPV	Affects entire population or a significant part of it causing a substantial decline in abundance or change in and recovery of the population (or another dependent on it) is not possible either at all or within several generations due to natural recruitment
-3	Moderate negative disadvantage or change	1 to 10 mm/s PPV	Effect causes a substantial change in abundance or reduction in distribution of a population over one or more generations but does not threaten the long-term viability or function of that population, or any population dependent on it
-2	Minor negative disadvantage or change	0.3 to 1 mm/s PPV	Effect does not cause a substantial change in the population of the species, or other species dependent on it
-1	Slight negative disadvantage or change	0.14 to 0.3 mm/s PPV	Effect is within the normal range of natural variation accustomed to by the population of the species
0	No change	< 0.14 mm/s PPV	Status quo

9.4.2 Identified Vibration Sensitive Receptors

As described in Section 4.2.2, the nearest identified vibration sensitive receptor (VSR) is the fauna in the Tengah Forest to the immediate north of the project site, assumed to be located 10 m away from the planned construction for the purpose of the assessment.

The nearest human receptors are the residents in the residential area at the south of the construction site. However, they are considered insensitive as the construction activities are more than 200 m from the planned construction. The distance of 200 m would cause the attenuation of the vibration from the impactful equipment to an imperceptible level. Therefore, human receptors have been excluded from the vibration prediction of this study.

Table 9.4 List of Vibration Sensitive Receptors.

S/N	Receptor	Distance nearest to Construction (m)
1	Fauna in Tengah forested areas	10

9.4.3 Construction Phase

Assessment of potential vibration impact is evaluated with reference to the FTA Transit Noise and Vibration Impact Assessment Manual (FTA, 2018).

FTA's guidelines provide a list of standard vibration level of construction equipment / activity measured at 25 ft / 7.6 m from the source. The vibration levels from the equipment involved for the HVP construction works are referenced to the similar type of machines / construction activities in FTA's guideline and applied with distance attenuation using below standard formula to deduce the vibration influence zone.

$$PPV_{Receiver} = PPV_{Ref} \times \left(\frac{d_{ref}}{d}\right)^{1.5}$$

Where $PPV_{Receiver}$ = peak particle velocity at the receiver in mm/s
$PPV_{Equipment\ Ref}$ = peak particle velocity of the source, measured at the reference distance (7.6 m)
d_{ref} = reference distance for the vibration source (7.6 m)
d = horizontal distance from the source to the receiver (m)

The details of the vibration-generating equipment are not available at the time of the EIA. Assumptions have been made based on the anticipated activities during each stage and the typical mechanical equipment adopted for these activities. The assumed equipment and the standard vibration level are tabulated in Table 9.5:

Table 9.5 Anticipated construction activities, equipment and reference vibration emission level.

Construction Activity	Equipment	Reference PPV at 7.6 m from source (mm/s)
Clearance of vegetation	Excavator	2.3
	Bulldozer	2.3
Construction of roads	Hydraulic breaker	2.3
	Milling machine	0.4
	Compaction machine	2.3
	Vibratory roller	5.3
Building of drains/ buildings/ detention pond	Loaded trucks	1.9
	Rotary bored piling	1.0*

**The reference distance is at 7 m for rotary bored piling*

9.4.3.1 Vibration Impact Zone

The impact zone of vibration impact of more than 0.3 mm/s is up to 30 m from operating excavator, bulldozer, hydraulic breaker and compaction machine, and up to 26 m from

loaded trucks. The impact zone of vibration impact of more than 1.0 mm/s is up to 13 m from excavator, bulldozer, and hydraulic breaker, and up to 12 m from loaded trucks. At 10 m away from the abovementioned equipment, the predicted vibration impact level is up to 1.5 mm/s in PPV. The typical impact zone from one operating equipment at the works boundary is illustrated in Figure 9.2. The centre of the contour with the highest vibration impact level is where the vibration source is located. The vibration source is placed at the boundary of the work area.

Of the assumed list of construction equipment in Table 9.5, vibratory roller which might be used as an alternative to compaction machine has the greatest vibration level at source. Its impact zone of more than 0.3 mm/s is up to 52 m from source, of more than 1.0 mm/s is up to 23 m from the source. At approximately 10 m away from the source, the predicted vibration level reaches up to 3.5 mm/s in PPV. The impact zone from vibratory roller is illustrated in Figure 9.3.

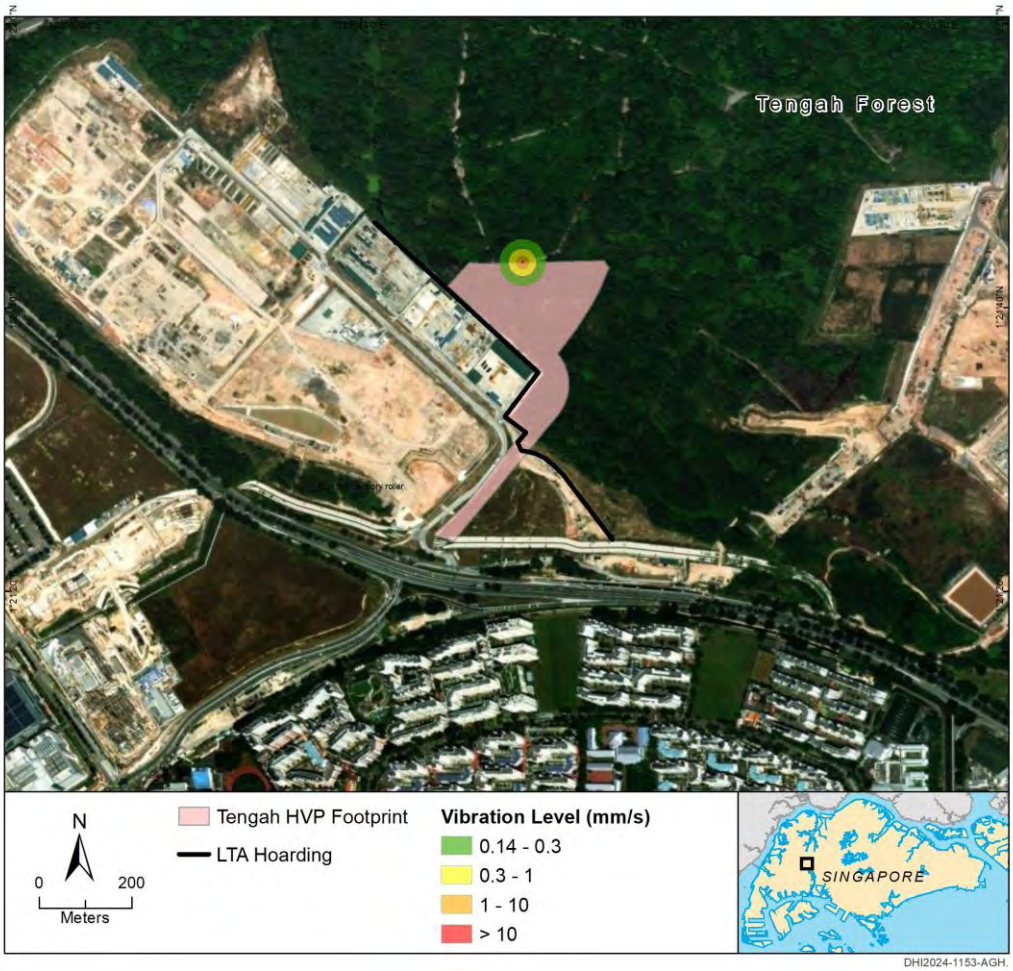

Figure 9.2 Impact zone from excavator/ bulldozer/ hydraulic breaker/ compaction machine.

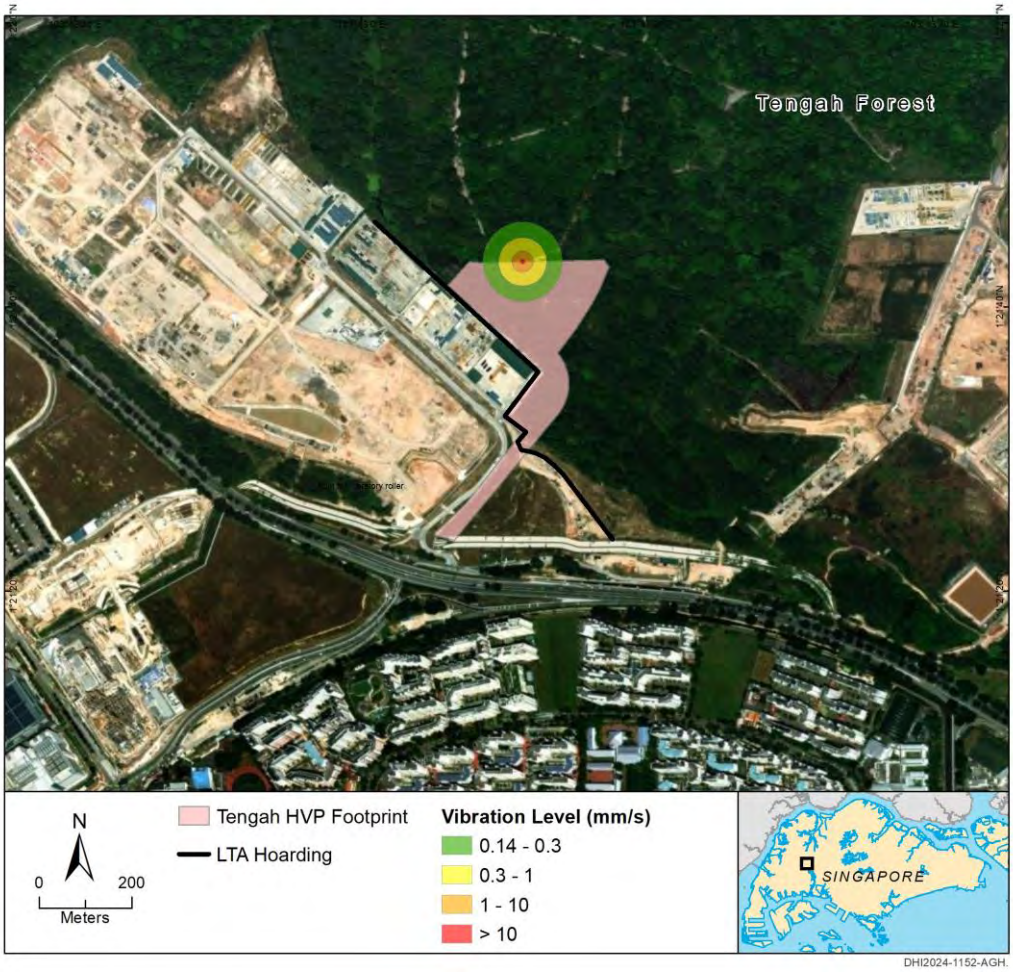

Figure 9.3 Impact zone from vibratory roller.

9.4.3.2 Impact to Fauna within Tengah Forest (common construction equipment)

Without mitigation, due to the proximity of the fauna in Tengah Forest to the construction site, the fauna receptor is assessed to experience higher than perceptible level (i.e., 0.14 to 0.3 mm/s) of vibration impact from the typical construction equipment. The predicted vibration level from excavator, bulldozer, hydraulic breaker and compaction machine at the nearest fauna receptor is 1.5 mm/s which will cause moderate negative disadvantages on the population.

A score of 3 for Importance was attributed to terrestrial fauna in the Tengah due to the presence of species of conservation significance in the vicinity. A score of -3 for Magnitude was attributed to terrestrial fauna due to transient exposure of the wild fauna to vibration of 1.5 mm/s from the construction. Permanence and reversibility are scored at 2 given the temporary nature of construction vibration and the ability of fauna populations to vacant and reinhabit the area after construction. A score of 3 for Cumulative Impact was attributed to terrestrial fauna given the possible cascade effect of the wildlife driven by the development towards the nearby habitats outside the influence zone which might in turn induce stress to the local fauna populations.

The magnitude of vibration impact from the typical construction equipment to the fauna within the secondary forest is classified to be **Minor Negative** Impact.

9.4.3.3 Impact to Fauna within Tengah Forest (vibratory roller)

Without mitigation, due to the proximity of the fauna in Tengah Forest to the construction site, the fauna receptor is assessed to experience higher than perceptible level (i.e., 0.14 to 0.3 mm/s) of vibration impact from most of the powerful equipment. The predicted vibration level from the vibratory roller at the nearest fauna receptor is 3.5 mm/s which will cause moderate negative disadvantages on the population.

A score of 3 for Importance was attributed to terrestrial fauna in the Tengah due to the presence of species of conservation significance in the vicinity. A score of -3 for Magnitude was attributed to terrestrial fauna due to transient exposure of the wild fauna to vibration of 3.5 mm/s from the construction. Permanence and reversibility are scored at 2 given the temporary nature of construction vibration and the ability of fauna populations to vacant and reinhabit the area after construction. A score of 3 for Cumulative Impact was attributed to terrestrial fauna given the possible cascade effect of the wildlife driven by the development towards the nearby habitats outside the influence zone which might in turn induce stress to the local fauna populations.

The magnitude of vibration impact from the vibratory roller to the fauna within the secondary forest is classified to be **Minor Negative** Impact.

9.4.4 Post-Construction Phase

The Project's operation will involve a significant flow of heavy vehicle traffic including the loaded and unloaded trucks. With the absence of the powerful equipment for construction, the vibration impact level will be significantly less than during the construction stage. However, the impact will be long-term.

The predicted vibration impact from the trucks at the nearby fauna and human receptors is up to 1.3 mm/s. The predicted impact from unloaded heavy vehicle is up to 1 mm/s at a speed of 50 km/hr. The vibration from normal rubber-tired traffic is rarely perceptible. The potential vibration impacts from the project on the site are deemed to be **Minor Negative**.

9.5 Mitigation Measures

9.5.1 Construction Phase

Low vibration construction techniques are recommended to be implemented in the construction contracts. Low-power machinery of the same type should be considered to reduce the vibration strength at source. For compaction of road surface, compaction machines which cause much less vibration than vibratory roller is recommended.

To further reduce the significance of the impact, a minimum distance of 15 m between heavy vibration-generating equipment and the Tengah Forest edge is recommended.

It is also recommended that the Best Practicable Means in line with the British Standard BS5228-2:2009 be implemented during the construction stage. This will include the following as appropriate:

The Contractor shall propose and justify effective, feasible and site-specific mitigation measures and conditions to minimise vibration and comply with the criteria. Mitigation measures shall be in the order of the following hierarchy of controls:

- Elimination
- Substitution

- Engineering control
- Administrative control
- Photographs, drawings and specifications for all mitigation measures shall be provided, where applicable.
- All equipment used on site shall be regularly maintained and shall be operated in a manner that minimises vibration as far as is practicable.
- Damaged equipment shall not be used.
- Equipment not in use shall be shut down to reduce the amount of vibration generated by idling motors.

9.5.2 Post-Construction Phase

To reduce the vibration impact of the moving heavy vehicles at the operation phase of the HVP, administrative measures including restricting the speed of the incoming and outgoing vehicles, regular maintenance to control the roughness of the surface of the HVP are recommended.

9.6 Residual Impact

9.6.1 Construction Phase

With the substitution and engineering controls, the score of Magnitude was reduced to -2 due to transient exposure of the wild fauna to vibration of less than 1 mm/s from any of the construction activity and equipment. The administrative control might potentially further reduce the impact from some equipment such as excavator and loaded trucks to less than 0.3 mm/s.

The magnitude of vibration impact to the fauna within the secondary forest remains as a **Minor Negative** Impact.

9.6.2 Post-Construction Phase

With sufficient management, it is anticipated that the significance of vibration impact will be reduced from **Minor Negative** to **Slight Negative** Impact.

9.7 RIAM Summary

9.7.1 Construction Phase

A summary of the predicted vibration impact assessment for the various sensitive receptors is provided in Table 9.6.

Table 9.6 Summary of impact assessment for Vibration impacts for the construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Vibration from Construction Equipment	Fauna in Tengah Forest	3	-3	2	2	3	-63	Minor negative impact	-2	-42	Minor negative impact

9.7.2 Post-Construction Phase

Table 9.7 Summary of impact assessment for Vibration impacts for the post-construction phase. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Vibration from Operating Heavy Vehicles	Fauna in Tengah Forest	3	-3	3	2	3	-72	Minor negative impact	-1	-24	Slight negative impact

10 Illumination

Light pollution generally refers to the encroachment of artificial light into unlit areas, which include residential districts and in particular nature areas, where nocturnal and crepuscular wildlife may be impacted. While the project site is currently forested, sources of light pollution include streetlights, vehicular lighting, and construction lights from the adjacent project site. Construction activities, particularly if they take place at night, will increase light pollution to the surrounding sensitive receptors. During the post-construction phase of the project, the removal of the forest in the Project area, as well as the presence of heavy vehicles, may lead to increased light levels in the surrounding forest.

While there are no applicable legislations in Singapore focused on light pollution impacts, this section here presents the applicable standards. It then describes baseline ambient light levels, assesses and predicts the significance of light pollution impacts generated during the Project's operation phase, and proposes suitable mitigation measures.

10.1 Applicable Legislation and Standards

There are currently no legislations or regulations for light pollution in Singapore that pertain to ecological receptors and impacts. Nonetheless, international organisations such as the Institution of Lighting Professionals (ILP, 2013) and Buglife: The Invertebrate Trust (Bruce-White and Shardlow, 2011) advocate considering the potential for light pollution impacts on wildlife as part of the scoping process for EIAs. While the assessment of light pollution impacts on fauna and human receptors is gradually gaining traction in EIAs conducted in Singapore, the quantification of baseline ambient light levels was rarely conducted in these EIAs. Moreover, among the few studies where baseline ambient light levels were

quantified, they were typically limited to readings taken from a single timepoint instead of time-series data logged over weeks. Therefore, the baseline ambient light study conducted in this EIA can be viewed as contributing to knowledge gaps, and upon which applicable legislation may be developed in the future.

10.1.1 Local Guidelines

The Land Transport Authority (LTA) of Singapore regulates illuminance levels for public street lighting via a set of guidelines (LTA, 2019). The LTA guidelines are presented in Table 10.1.

Table 10.1 LTA Guidelines for public street lighting.

Road Lighting Levels		
Type of Roads	**Minimum Average Illuminance (at floor level)**	
Expressway and Major Road	20 lux	
Expressway and Major Road conflict area	1.5x (e.g. 30 lux)	
Minor and Residential Road	10 lux	
Minor and Residential Road conflict area	1.5x (e.g. 15 lux)	
Footpath Lighting Levels		
Alongside with public streetlights (without dedicated footpath lightings)	5 lux	NA
Footpath (with dedicated footpath lightings)	10 lux	0.25

While not entirely related to light spill, NParks in 2022 released 'Bird-Safe Building Guidelines' which include proposed mitigation measures for reducing light spill, preventing bird strikes and entrapment within illumination zones; particularly for nocturnal birds and night-flying migratory birds (NParks, 2022). Some of the proposed mitigation measures include:

- Lighting design that minimizes light spill (I.e., shielded and downward pointing lighting)

10.1.2 Guidelines in Other Countries

Australia

Guidelines pertaining to light pollution for wildlife are present in other countries. For instance, the Australian government in 2020 developed the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Department of the Environment and Energy Australia, 2020). The latter was subsequently updated in May 2023 (Department of the Environment and Energy Australia, 2023). In particular, the Guidelines provide a framework that includes best practises for lighting design that accounts for wildlife and nature areas. Some of the recommendations are as follows:

- Always using Best Practice Lighting Design to reduce light pollution and minimise the effect on wildlife.

- Undertaking an Environmental Impact Assessment for effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.
- Checklist for Artificial Light Management.

These Guidelines provide technical information to inform the management of artificial light for Australia's *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act).

United Kingdom

In the United Kingdom, applicable guidelines on lighting impacts on wildlife are developed by various non-governmental organisations, with notable examples being the Bat Conservation Trust and Buglife: The Invertebrate Conservation Trust. The *Interim Guidance: Recommendations to help minimise the impact artificial lighting* (Bat Conservation Trust, 2014) provides recommendations to help minimise the impact of artificial lighting on wildlife, including:

- Usage of narrow spectrum light sources to lower the range of species affected by lighting
- Usage of light sources that emit minimal ultra-violet light
- Avoid white and blue wavelengths of the light spectrum to reduce insect attraction and where white light sources are necessary, they should be of a warm / neutral colour temperature <4,200 kelvin in order to manage the blue short wave length content
- Lights used should peak higher than 550 nm

These recommendations are also concurred by the guidelines published by Buglife (2011), which has further details and recommendations that are more specific to invertebrates, which form the base of terrestrial food webs and hence have knock-on effects across the trophic levels.

A UK professional engineering institution – the Institution of Lighting Professionals, has published a guidance note on the evaluation of lighting impacts, including on wildlife, in Environmental Impact Assessments (ILP, 2013).

10.2 Methodology

To date, there have not been historical ambient light studies nor data relevant to the Project site. To establish baseline data, a baseline light survey with three ambient light monitoring locations was conducted. Each survey location was chosen to represent sensitive receptors across various categories, as well as the possibility of experiencing altered lighting conditions during the operational phase.

Measurements of ambient light intensity (lux levels) was continuously logged on a 5-minute interval over a 14-day period covering both weekdays and weekends, from 6-19 January 2023, using HOBO Pendant Temperature/Light Data Logger MX2202 (ONSET, Bourne, MA, USA) (Figure 10.1). The light sensors on the loggers were oriented on the horizontal plane facing upwards for standardisation. Lux level data is then summarised and presented in tabular and temporal (time-series) graphical form.

Baseline lux level measurements was processed to obtain the mean daily values, and the mean daily maximum and minimum values, and mean nocturnal (defined as the time period from 2000h to 0600h) values to facilitate the evaluation of existing light pollution levels.

Figure 10.1 HOBO Pendant MX2202 Temperature and Light Data Logger deployed during the baseline study.

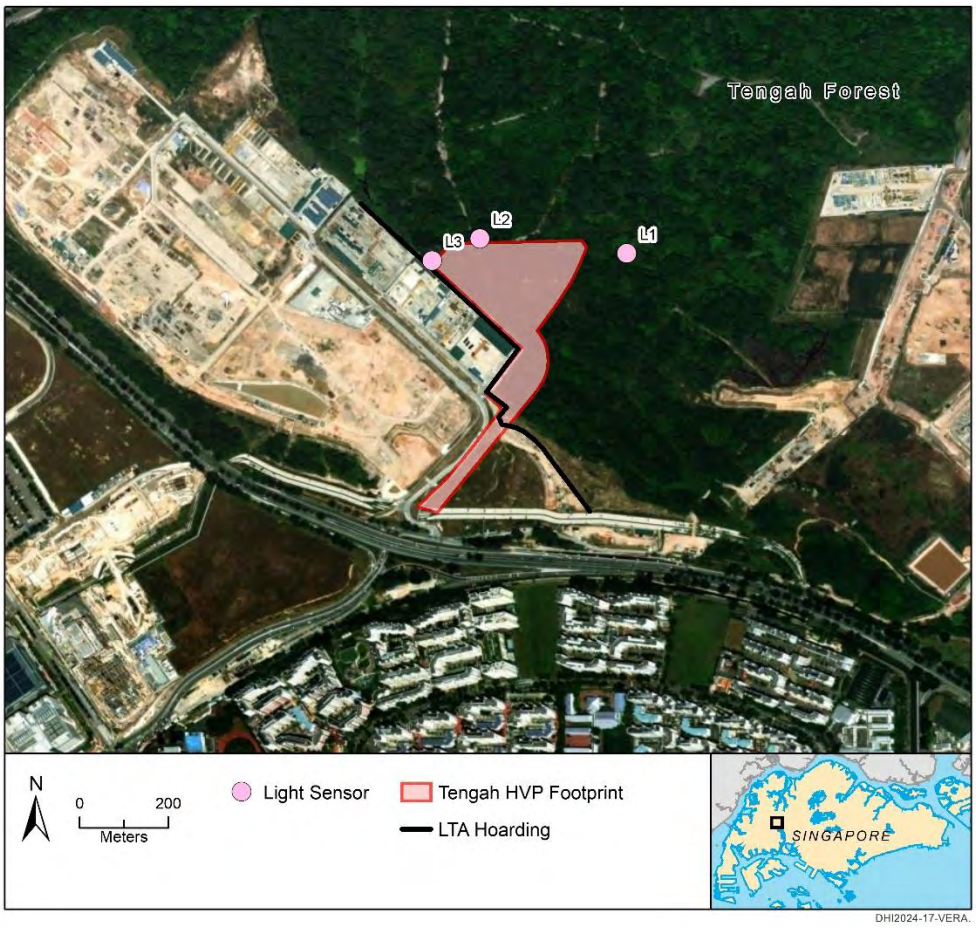

Figure 10.2 Deployment locations of micro-loggers (HOBO MX2202) for ambient light baseline.

Based on the three sensitive receptors identified, the Project footprint and buffer zones of 150m (Figure 10.2), three dataloggers were deployed (Table 10.2).

Table 10.2 Receptors sensitive to changes in ambient light at each baseline ambient light measurement location.

Baseline ambient light location ID	Sensitive Receptors
L1	Forest interior (>300m from forest edge)
L2	Near forest edge (≈100m from forest edge)
L3	At forest edge

10.3 Baseline Description

To obtain an understanding of the ambient light levels at the Project site prior to the construction phase, baseline data are required. This section details the data collection methods and findings from the baseline study.

During the day, L2 recorded the highest daily maximum and mean light levels, followed by L3 and L1 (Table 10.3; Figure 10.4). The micro-loggers that were deployed at locations L1 was in the forest interior, whereas L2 and L3 were in more open areas that were relatively lesser canopy and vegetation cover (Figure 10.3). While L2 was deployed in a location near (but not at) the forest edge and had denser vegetation cover, it appeared to have relatively less canopy cover as compared to L3 (Figure 10.3). The contrasting daytime ambient light levels across the three sites generally reflects the availability of shade cast by adjacent structures or vegetation cover.

Ambient light levels during the night exhibited a general absence of light pollution (Table 10.3). Graphical illustrations for day and night light levels are shown in Figure 10.4 & Figure 10.5. The mean nocturnal ambient light levels recorded across all stations were negligible (Table 10.3), indicating little to no light pollution, reflecting the rapid decay of nocturnal ambient light levels with distance from artificial light sources.

Table 10.3 Ambient Light Levels Recorded at Light-Sensitive Receptors.

Light Level Statistics (Mean)	Mean (Lux 3.s.f.)		
	L1 (Forest Interior)	L2 (Near Forest Edge)	L3 (Forest Edge)
Daily maximum light level	31100	73900	58500
Daily mean light level	1610	8470	5410
Nocturnal* light level	0.00	0.00	0.00
Daily minimum light level	0.00	0.00	0.00

** Nocturnal hours from 2000h-0600h*

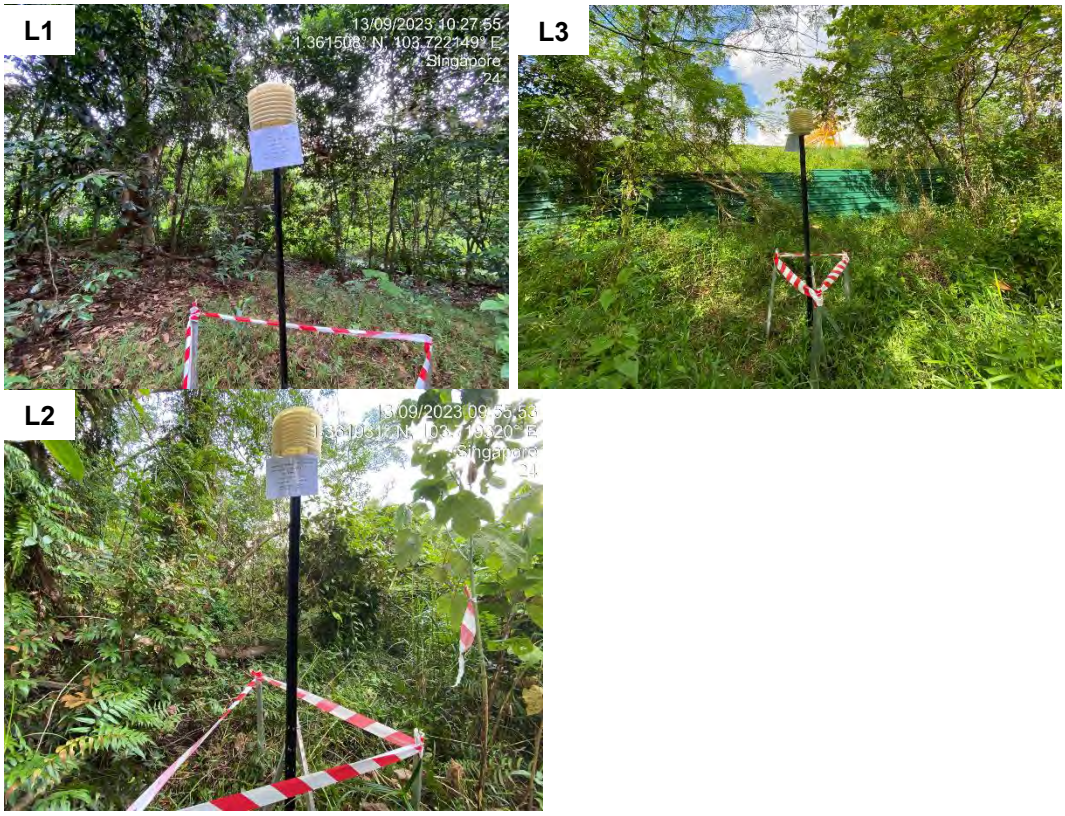

Figure 10.3 Site conditions at the time of light sensor deployment.

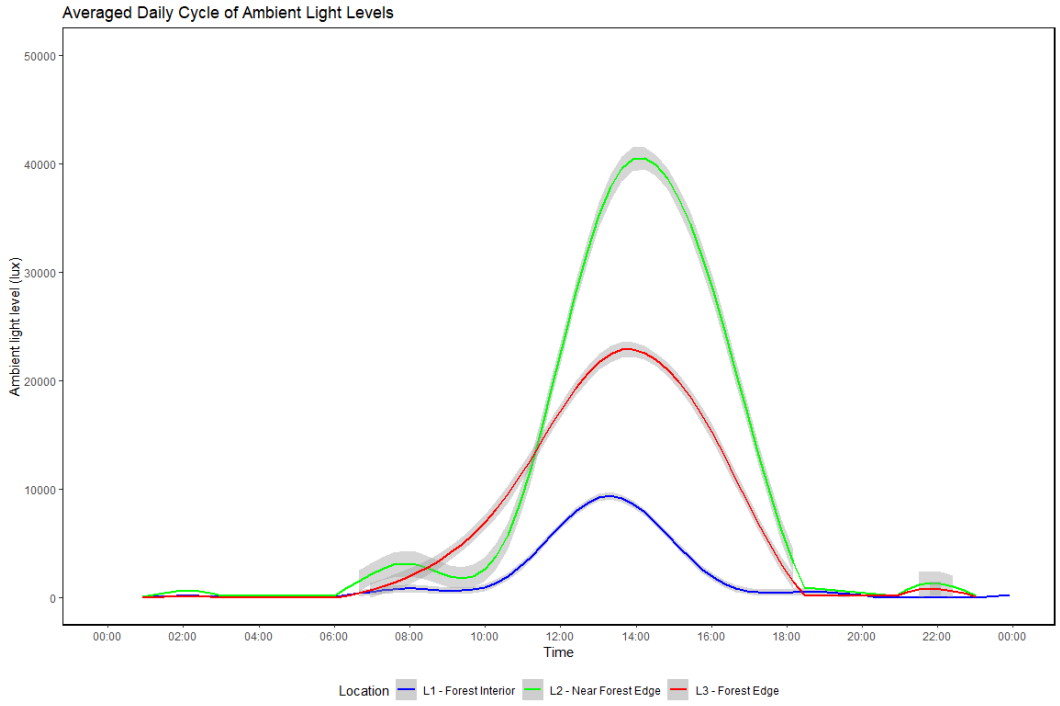

Figure 10.4 Averaged daily diurnal cycle of ambient light level.

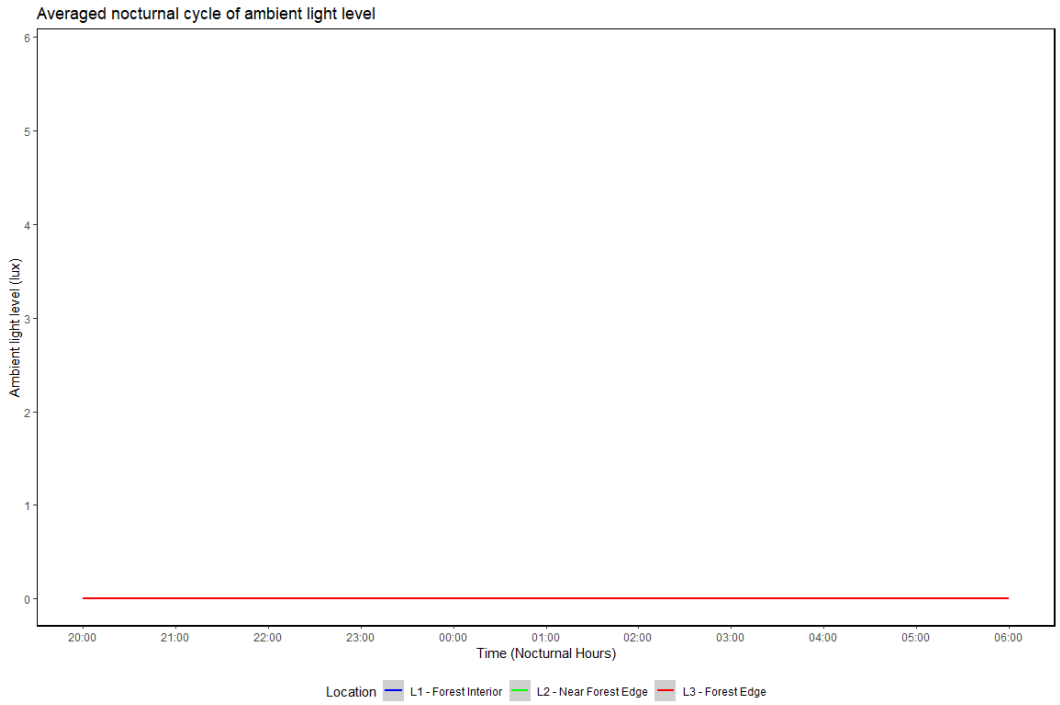

Figure 10.5 Averaged nocturnal cycle of ambient light level.

10.4 Impact Assessment

10.4.1 Determining Importance and Magnitude

The evaluation framework for importance of sensitive receptors and Magnitude defined for the lighting impact assessment is presented in Table 10.4.

Table 10.4 Evaluation Framework for Importance of Light-Sensitive Receptors

Score	Socio-economic	Ecological
5	Locations where light-sensitive activities such as sleep are of high importance by the more sensitive members of the public, e.g., hospitals and polyclinics Locations with existing very low ambient light levels	Locations where the receptors affected are specifically protected by national or international policies or legislation and are of high importance at the regional or national scale, e.g., fauna (nocturnal and crepuscular fauna) in Nature Reserves, Nature Areas, ASEAN Heritage Park Populations mainly residing deep within forests, not urban-adapted and highly susceptible to ALAN
4	Locations where more sensitive members of the public are exposed for eight hours or more in a day, e.g., residential care homes Locations with existing low ambient light levels	Locations where the receptors affected are of moderate importance at the regional or national scale, e.g., fauna in forested sites outside of designated nature reserves and nature areas Populations mainly residing within forests and not urban-adapted
3	Locations where light-sensitive activities such as sleep are of moderate importance by the members of the public, e.g., private residential, and dormitories Locations with existing moderate ambient light levels Locations where members of the public are exposed for eight hours or more in a day, e.g., residential properties and schools	Locations where the receptors affected are important for the functioning and integrity of adjacent habitats, e.g., green corridors, biodiversity buffer area Fauna accustomed to existing urban night lighting, but minor impacts are expected Locations where the receptors affected contain specific species or taxa that are sensitive to ambient light levels
2	Locations where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office, industrial and shop workers Locations with existing moderate-to-high ambient light levels	Locations where the receptors affected are with limited biodiversity and ecological value, e.g., grasslands and shrubland Fauna populations accustomed to existing night lighting, but slight disturbances are still expected
1	Receptors with transient exposure, for example recreational users of parks and playgrounds	Locations where the receptors affected are with little to no biodiversity value, e.g., managed turf

Table 10.5 Evaluation Framework for Magnitude of Change in Lighting

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	**Biodiversity** • Populations are irretrievably compromised due to ALAN • High likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents are severely disturbed by visible lights • Excessive lights directly visible inside any room in the house leading to sleep disorder and other related health issues • High likelihood that residents will regularly lodge complaints to Authorities about excessive light trespass
-3	Moderate negative disadvantage or change	**General** • Predicted night lighting levels to be significantly higher than existing levels for a long duration throughout the night **Biodiversity** • Populations are moderately disturbed due to ALAN • Moderate likelihood of behavioural changes within populations, and their extirpation from the current habitat • Discernible and fundamental changes to existing light levels, that would disturb populations **Socio-economic** • Residents are notably disturbed by visible lights and are likely to file complaints with the local authorities • Obtrusive light trespass and glare are present inside any room within the house, thereby affecting their quality of life • Sleep quality may be affected without window coverings
-2	Minor negative disadvantage or change	**General** • Predicted night lighting levels to be slightly higher than existing levels for a long duration throughout the night **Biodiversity** • Populations experience minor disturbance due to ALAN, but not to the extent that the overall condition of the populations are impaired in the long term • Low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents are mildly disturbed by the visibility of lights within their homes, and may experience discomfort
-1	Slight negative disadvantage or change	**General** • Predicted night lighting levels to be slightly higher than existing levels for a short duration throughout the night **Biodiversity**

Score	Generic Criteria	Specific Criteria
		• Populations experience slight disturbances due to ALAN • Very low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents may notice the visibility of lights within their homes, but is unlikely to cause discomfort
0	No change	**General** • Little to no perceptible change to the night lighting conditions assessed as compared to the existing levels **Biodiversity** • Little to no disturbances on populations • Negligible likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents not affected nor disturbed by visibility of lights

10.4.2 Importance Rating of Sensitive Receptors

The identified sensitive receptors were further post stratified into two main receptors, namely fauna (biodiversity) and humans (socio-economic) and. The receptors were then accorded their respective importance scores based on Table 10.4 above, with justifications described in Table 10.6 below.

The sensitive receptors were identified based on the planned development, which excludes the existing area within the Project site.

Table 10.6 Relevant Light-Sensitive Receptors.

Category	Ambient light sensitive receptor	Importance Score	Justification
Fauna	Terrestrial fauna within forest patches adjacent to Project site	4	• Wildlife is known to be sensitive to light levels, especially nocturnal species. Light pollution and excessive artificial light at night (ALAN) can therefore exert negative impacts on them. • The presence of bats (pollinators), owls (nocturnal predators) and non-volant mammals like civets (seed dispersers) within the Project site would therefore be affected by ambient levels.
Socio-economic	Residents of Jurong West HDB Workers living in dormitories in worksite adjacent to Project	3	• Workers living in the dormitories will spend a significant amount of time in their rooms, especially after work hours. • HDB residents are likely to be residing within their premises for eight hours or more in a day, making them susceptible to excessive light pollution.

Category	Ambient light sensitive receptor	Importance Score	Justification
			• However, the HDB estate is >150m away from the Project footprint, and there is existing lighting within the premises and adjacent to it (lighting along PCN). • Nonetheless, light pollution and excessive ALAN from the Project can still exert negative impacts on the receptors.

10.4.3 Construction Phase

10.4.3.1 Light Nuisance from Construction Site during Night-Time Works to Residents

The Project footprint is situated in area adjacent to a sizeable residential housing district, which serve as the main socio-economic receptor. The construction lighting from the Project may therefore affect the residents.

For this Project, although no night works have been planned thus far, auxiliary lighting for safety and industry purposes may still be required, further exacerbating the impacts of light spill into the nearby residential areas. This may have a negative impact to the circadian clock of residents', which is a 24-hour day/night cycle that has an influence on physiological activities. Difficulties adjusting the circadian clock can result in affects to people who rotate shifts or work at night, and delayed sleep–phase syndrome, in which people fall asleep late at night and struggle to wake up in time for work, school, or social engagements.

With reference to Table 10.5, the magnitude of the change is expected to be minor as the majority of the residents from the Jurong West HDB are already exposed to relatively high light levels, and changes to these levels due to Project activities are expected to be minimal. Overall, the duration of the impact is expected to be temporary in nature during the construction phase and is mitigable with proper lighting management, such as curtains, blinds and tinted windows, which are often already installed in households throughout Singapore.

The impact severity due to light nuisance from construction activities of the proposed Project to the nearby residents is therefore considered to be non-permanent, recoverable, non-cumulative and thus, the overall significance of this impact is considered to be slight negative.

10.4.3.2 Biodiversity

Artificial lighting at night (ALAN) can have adverse impacts on the ecosystem. The heightened presence of ALAN disrupts the circadian rhythms of animals and alters the day-night cycle for plants. This disruption may result in increased predation by diurnal carnivores on nocturnal animals, exhaustion for insects drawn to artificial light, disorientation and disturbance in foraging patterns for birds, as well as changes to the disturbance in foraging, communication, reproduction, and migratory patterns of various animals (Longcore & Rich, 2004; Eisenbeis et al., 2006; Falcón et al. 2020).

Exposure to ALAN can disorient birds and increase their exposure risks to predation (McLaren et al., 2018). It can also repel wildlife from passageways and corridors (Bliss-Ketchum et al. 2016), as well as light-adverse bats from their usual feeding grounds and travel pathways, thereby affecting their vital ecological role as seed dispersers and pollinators (Lewanzik & Voigt, 2014; Pauwels et al. 2019). These cumulative changes may lead to downstream impacts on ecosystem functions.

The planned construction works would expose the southern part of Tengah Forest to potential light spill, thereby affecting the fauna residing within it. However, given the urban nature of the areas surrounding the forest and the existing developments adjacent to the Project, the fauna residing within Tengah Forest are likely to be accustomed to some level of night lighting levels, particularly near the edge of the forest.

Thus, with reference to Table 10.5, the magnitude of the change is expected to be minor. The duration of the impact is expected to be temporary in nature during the construction phase and is controllable with proper lighting management through EMMP.

Therefore, the impacts are deemed to be non-permanent, recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

10.4.4 Post-Construction Phase

10.4.4.1 Light Nuisance from Future Building Operation

Residents

During the operational stage, source of light impacts will be derived from the operation of the proposed development where installation of artificial lightings is required to illuminate the associated ancillary and related facilities. There will therefore be an increased light source emission from the operation of the commercial buildings, new covered linkways, walkways, pedestrian overhead bridge, etc., and these fixtures would be permanent.

Considering an increase of light source emission from the pre-development ambient lighting conditions, the nature of impact from the proposed development is anticipated to be negative. In reference to Table 10.5, the magnitude of the change from the anticipated increased illuminance however is not expected to cause any significant impacts to nearby residential premises or care facilities is expected to be slight as the illuminance from commercial developments are typically designed to be localised to reduce spill light impacts on the nearby residential premises. Moreover, the existing public street lighting, residential lighting, commercial lighting and construction lighting from the adjacent active work site are light sources that residents are likely accustomed to. The overall potential light impacts are deemed to be permanent, irrecoverable, non-cumulative, but the overall significance of this impact is considered slight negative.

Biodiversity

The nature of light impacts on the terrestrial fauna in Tengah Forest is anticipated to be negative in the long term given that the illuminance of the surrounding area is increased with the proposed development.

Fauna around the periphery of the Project site is already exposed to light spill emanating from existing lighting fixtures along the public roads and residential buildings in the vicinity, therefore the incremental light pollution would result in minor disturbances to fauna, but have a very low likelihood of behavioural changes to populations. Further, it is likely that

fauna receptors in the vicinity have developed some level of acclimatisation to their disturbed surroundings.

With reference to Table 10.5, the magnitude of the change is expected to be slight due to localised illuminance at the proposed development, and fauna utilizing the forest edges are typically expected to have adapted to urban lightings. The potential light impacts are deemed to be permanent, irrecoverable, non-cumulative, and therefore the overall significance of this impact is considered minor negative.

10.5 Proposed Mitigation Measures

10.5.1 Construction Phase

Table 10.7 Mitigation measures to ameliorate impacts of light pollution.

Hierarchy	Mitigation Measures
Avoidance	• Avoiding use of lighting that is not needed • Avoid construction works during night hours as much as practicable • Illumination with a high UV component should be avoided to reduce impacts on insects
Minimisation	• Erect hoarding around construction site • Checklist for Artificial Light Management / Night Works Management Plan • Lights should be pointed downwards and towards the interior of the site instead of resulting in spillage beyond the site boundary and into adjacent retained forest area. Shields can be installed for light fixtures near the site boundary to minimise light spillage into adjacent forest habitats • If needed outside operating hours, low lux level lighting with light shields shall be used along pathways, paved areas and in areas where public access cannot be prevented. Limiting light intensity to the minimum possible levels while not compromising on safety requirements (Figure 10.7) • If needed outside daylight hours, to illuminate only sections of the work site required for work and access • Where possible and safe, use motion sensor to activate lighting for less frequently accessed areas • Where possible and safe, have light sources be lower than the perimeter hoarding height • Lights operating at night should be of low wavelengths and narrow spectrum (Figure 10.6) • Managing the direction of light emissions, i.e. light should be shielded, directed downwards and away from forested areas (Figure 10.6) • Ensure all unnecessary lights are turned off at the end of any night works • When directing light sources, be aware of reflective surfaces that could reflect the directed light to sensitive areas

Hierarchy	Mitigation Measures
	• Site lighting locations should be reviewed regularly to ensure minimal impacts to surrounding terrestrial fauna receptors
Restoration Offsets	• N.A.

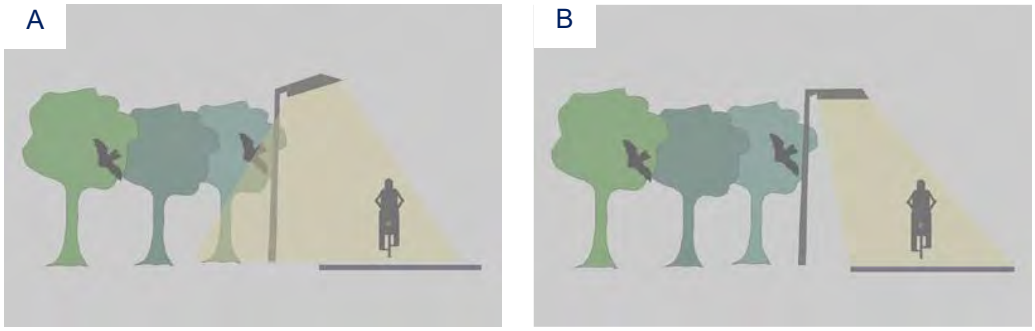

Figure 10.6 Best lighting practices to minimise/avoid light trespass. (A) Conventional design that results in light spillage towards adjacent forest habitat. (B) Shielded and angled lighting that focuses the light cone only on the area where is it needed (Adapted from Voigt et al., 2018).

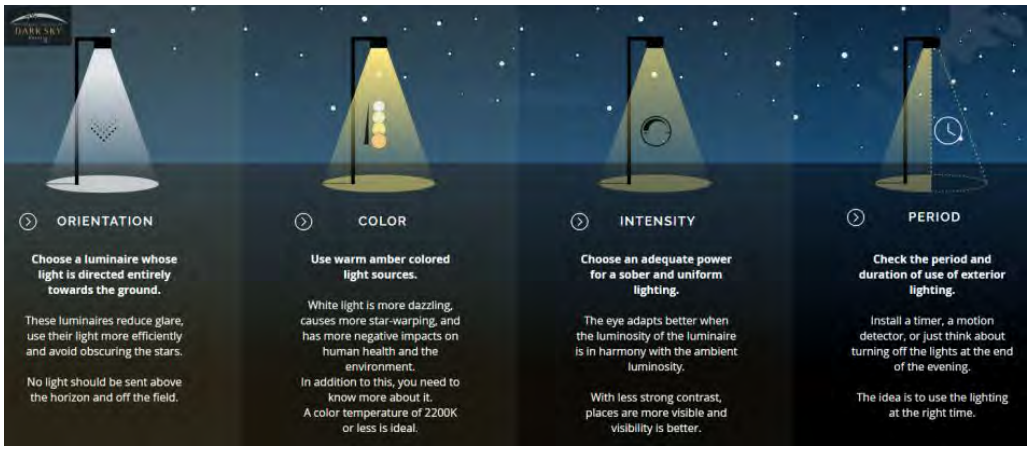

Figure 10.7 Best lighting practices (Adapted from Mont-Mégantic International Dark Sky Reserve).

Should nightworks be required, a Light Management Plan should be developed as part of the Construction EMMP prior to the commencement of works. This should detail the implementation plan for mitigation measures set out in Table 10.7, including layouts and designs of lights used, durations and activities which require night lighting, and roles and responsibilities pertaining to lighting management.

10.5.2 Post-Construction Phase

Table 10.8 Mitigation measures to ameliorate impacts of light pollution.

Hierarchy	Mitigation Measures
Avoidance	Same proposed measures as in Table 10.7
Minimisation	Same proposed measures as in Table 10.7
	• Additionally, lighting should adhere to MOM's minimum safety requirements for works to be performed at night: - SS 531 – 2: 2008: Code of Practice for Lighting of Work Places - SS 531 – 3: 2008: Lighting Requirements for Safety and Security of Outdoor Work Places
Restoration	**BCA Green Mark Certification Scheme** The Resilience section of the Green Mark certification programme recommends for the restoration of natural habitats, and native planting palette to be weaved into overall design plan, taking into account abovementioned pointers relating to lighting (e.g., setting of dark buffers) which can be considered as offsets for the increased light outputs from the overall development
Offsets	

10.6 Residual Impact

10.6.1 Construction Phase

Through the implementation of a night works management plan during the construction phase, the anticipated significance of light spillage and ALAN impacts associated with the various construction activities is expected to be reduced to slight or negligible levels. These measures, ranging from the use of light shields, low wavelength and narrow spectrum lights to the incorporation of wildlife-friendly lighting designs, are strategically designed to minimize light spill and ALAN. The cumulative effect of employing these mitigation strategies is outlined in Section 10.7.

10.6.2 Post-Construction Phase

Through the implementation of green building design via the Green Mark Certification scheme, which includes (but is not limited to) eco-friendly lighting technologies, efficient and sustainable energy usage, as well as biodiversity restoration and offsets (via landscaping and planting to restore dark buffers), the anticipated significance of light spill and ALAN impacts is anticipated to be minimized from minor to slight or negligible levels. The cumulative effect of employing these mitigation strategies is outlined in Section 10.7.

10.7 RIAM Summary

A summary of the predicted light impact assessment for the various sensitive receptors during the construction and post-construction phase is provided in Table 10.9 and Table 10.10.

10.7.1 Construction Phase

Table 10.9 Summary of impact assessment for ecological impacts for the construction phases. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Light nuisance from construction night works (short term)	Residents	3	-1	2	2	2	-18	Slight negative	-	-	No impact
	Fauna	4	-2	2	2	2	-48	Minor negative	-1	-24	Slight negative

10.7.2 Post-Construction Phase

Table 10.10 Summary of impact assessment for ecological impacts for the post-construction phases. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Light nuisance from future building HVP operation (long term)	Residents	3	-1	3	2	2	-21	Slight negative	-	-	No impact
	Fauna	4	-2	3	2	2	-56	Minor negative	-1	-28	Slight negative

11 Ambient Air Temperature

The occurrence of a distinct variation between heat levels (temperature) of an urban area, compared to non-urbanised places is known as the Urban Heat Island (UHI) effect (Voogt, 2004). Urban areas such as cities tend to trap heat more effectively than rural, less built-up areas, within pockets of elevated temperatures in structures, known as heat islands. These heat islands range from buildings to paved surfaces, and in the evening, as they release their contained heat stored over the day from solar exposure, these areas become hotter than their surroundings. The end result is a climate where large cities experience significantly higher evening temperatures than their rural counterparts. A temperature difference of up to 7°C has been observed between urban and suburban areas in Singapore after sunset, and this has formed the basis for local government agencies to develop mitigation measures (SG101, 2022).

The UHI effect causes impacts to both socioeconomic and ecological receptors, such as public health, biodiversity, tourism and hydrological processes, to name a few. A rise in temperatures from the UHI effect tends to lead to heightened energy usage from air conditioners to maintain the same cooling temperatures, ultimately resulting in a vicious cycle of warming air temperatures. Cities experience this effect disproportionately, as the effects of UHIs are far more pronounced in built up areas, especially in the tropics. In extreme cases, rises in temperature lead to heat wave events, which are known to directly cause human mortality.

The UHI effect is also known to influence the microclimatic environments within ecosystems, particularly in the form of edge-effects in forested areas. Forest edges of 50-100m have been documented to experience more significant fluctuations in light, temperature and humidity levels during the day (Pohlman et al., 2009), making them more susceptible to tree mortality, gaps in the canopy, and a greater chance for early successional non-native flora to proliferate due to the drier and hotter conditions.

Therefore, given the potential impacts of the UHI effect and microclimatic fluctuations on the environment, it is pertinent that ambient air temperature be taken into consideration for environmental impact assessments.

11.1 Applicable Legislation and Standards

There are currently no legislations/regulations for the potential of developments to alter microclimatic conditions, in particular ambient air temperature, pertaining to ecological receptors.

11.2 Methodology

Microclimate represented by ambient air temperature was measured to obtain a representative baseline against which the magnitude of change in ambient air temperature during the Project's operation phase can be evaluated. It is known that vegetation and forest within urban area can reduce the UHI effect, via cooling capacity from transpiration, trapping moisture, and providing shade. The baseline ambient air temperature was measured across a forest-urban gradient – within the forest interior (300m from forest edge), close to the forest edge (100m from forest edge), and at the boundary between the forest edge and urban areas (Figure 11.1).

Ambient air temperature was recorded using micro-data loggers with temperature accuracy of <±0.5°C – HOBO MX2202 (ONSET, Bourne, MA, USA). Each iButton logger was

enclosed within a white PVC housing designed to shield against direct solar radiation but permit airflow, hence enhancing the reliability of temperature measurements. Each iButton logger was positioned at a standardised height of 1.5 m above the ground level (Figure 11.2). Temperature readings were taken at intervals of 5 minutes.

Nine (9) MX2202 loggers were deployed over a 14-day period (20 December 2023 to 3 January 2024) to capture the spatial and temporal heterogeneities of ambient temperature. The locations were chosen to maximise the coverage across the three different cover classes, i.e. forest edge habitat, 100m from the forest edge, and 300m from the forest edge. (Figure 11.1), with three (3) sensors deployed per cover class. This broad coverage across cover classes provided sufficient data points for predicting future ambient air temperatures during the Project's operation stage.

Baseline microclimatic measurements of ambient temperature were processed to obtain the mean daily values, and the mean daily maximum and minimum values, to facilitate the evaluation of the urban heat island effect. Data is presented in tabular and temporal (time-series) graphical form. The point data obtained was also interpolated to create heat maps of existing temperatures for ease of visualisation.

Table 11.1 Relevant Sensitive Receptors and the respective cover class represented by each set of temperature loggers deployed.

Temperature Logger	Land Cover Class
T1.1, 1.2, 1.3	Forest interior (>300m from forest edge)
T2.1, 2.2, 2.3	Near forest edge (≈100m from forest edge)
T3.1, 3.2, 3.3	At forest edge

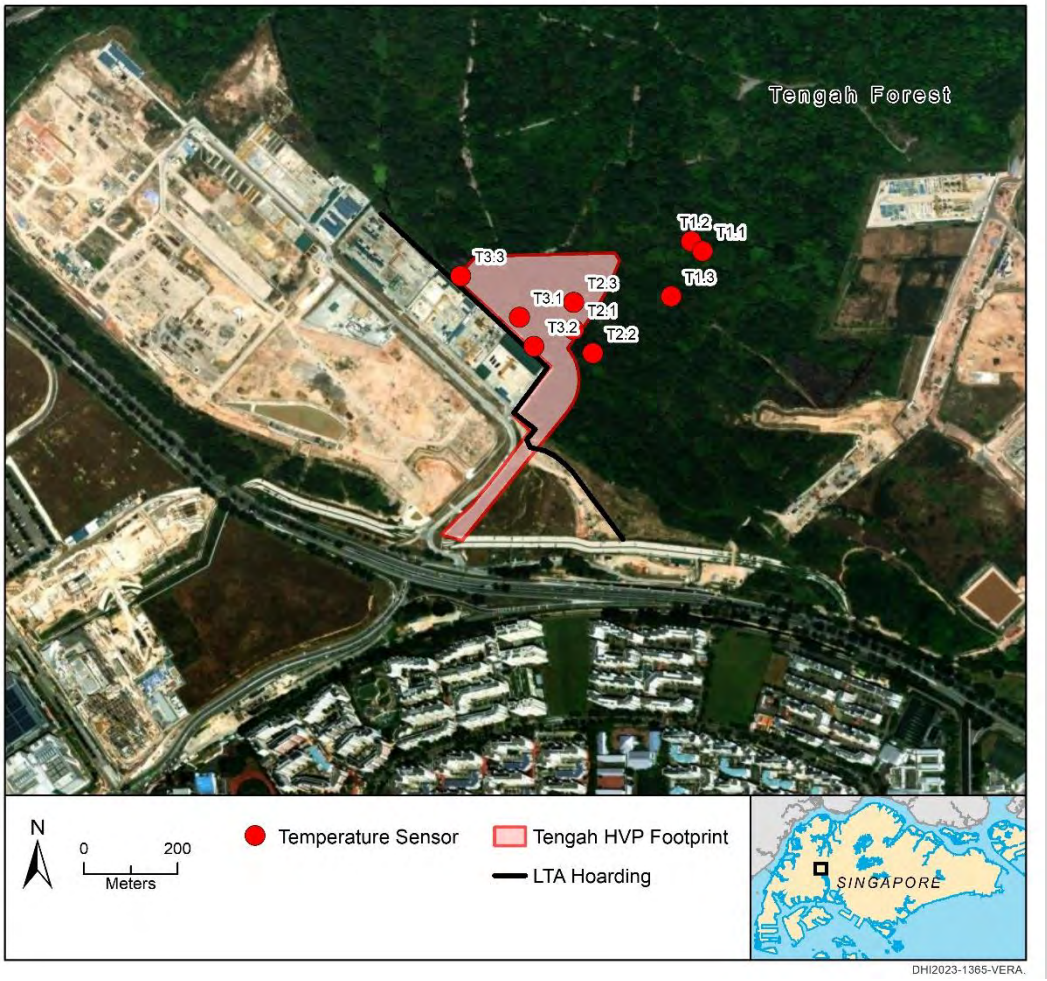

Figure 11.1 Deployment locations of temperature loggers, distributed to cover the various ground cover classes (forest interior, close to forest edge, at forest edge).

Figure 11.2 Dataloggers deployed at Project site, from a forest to urban gradient (From left to right: T1.1 – Forest interior, T2.1 – Close to forest edge & T3.2 – at forest edge).

11.3 Baseline Description

As historical data/studies on microclimate and ambient air temperature for the Project site were lacking, a 2-week baseline monitoring regime was implemented here, from 20 December 2023 to 3 January 2024.

The temperature data exhibited a clear pattern across the forest-urban gradient, with the greatest divergence across survey locations observed in daily maximum temperatures, followed by daily mean temperatures (Table 11.2, Figure 11.3).

Areas with sparse or no shade resulted in highest daily maximum temperatures, reflecting the strong impact of solar exposure time on the land and thereby air temperature. This was most evident at locations T3.1 and T3.2, which were open areas devoid of any canopy cover. In contrast, locations within forest interior conditions (T1.1 and T1.2) recorded the lowest daily maximum temperatures, reflecting both the shading effect provided by the canopy cover and cooling due to evapotranspiration from the surrounding vegetation.

Unexpectedly, there were no significant differences observed in mean nocturnal temperatures across all three land-cover classes, marking a potential absence of the UHI effect at night. However, the relatively cooler night-time temperatures could possibly be attribute to the year-end Northeast monsoon, which brings heavy rainfall on a nearly daily basis, causing overall temperatures to fall and stabilise after sunset.

Table 11.2 Mean temperatures of dataloggers deployed across Project site.

Land-cover Category	Location	Mean Temperature (°C)			
		Daily Minimum	Daily Mean	Daily Maximum	Nocturnal*
Forest interior	T1.1	24.60	25.97	28.62	25.29
	T1.2	24.61	25.95	28.58	25.29
	T1.3	24.49	25.95	28.87	25.18
Near to forest edge	T2.1	24.45	25.98	28.80	25.23
	T2.2	24.52	26.02	29.03	25.24
	T2.3	24.33	26.14	29.75	25.12
At forest edge (Urban area)	T3.1	24.60	26.83	32.52	25.34
	T3.2	24.51	26.68	32.37	25.28
	T3.3	24.39	26.50	31.55	25.14

** Nocturnal hours from 2000h-0600h*

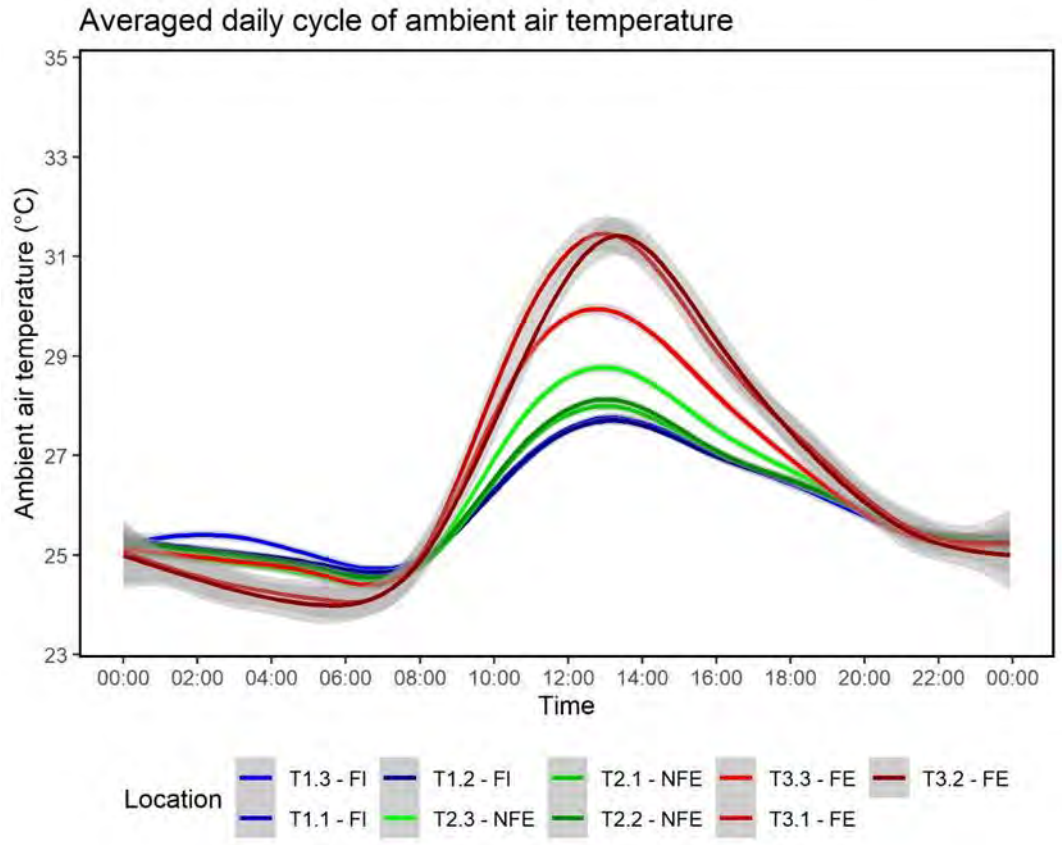

Figure 11.3 Graph of averaged daily cycle of ambient air temperature, for dataloggers T1.1, 1.2, 1.3, 2.1, 2.2, 2.3, 3.1, 3.2, and 3.3. FI — Forest Interior, NFE — Near Forest Edge, and FE — Forest Edge.

For a better overall illustration of the ambient temperatures across the Project site, a heat map showing the distribution of temperature levels is shown in Figure 11.4 below. A divergence of > 0.8°C in daily mean temperatures was observed.

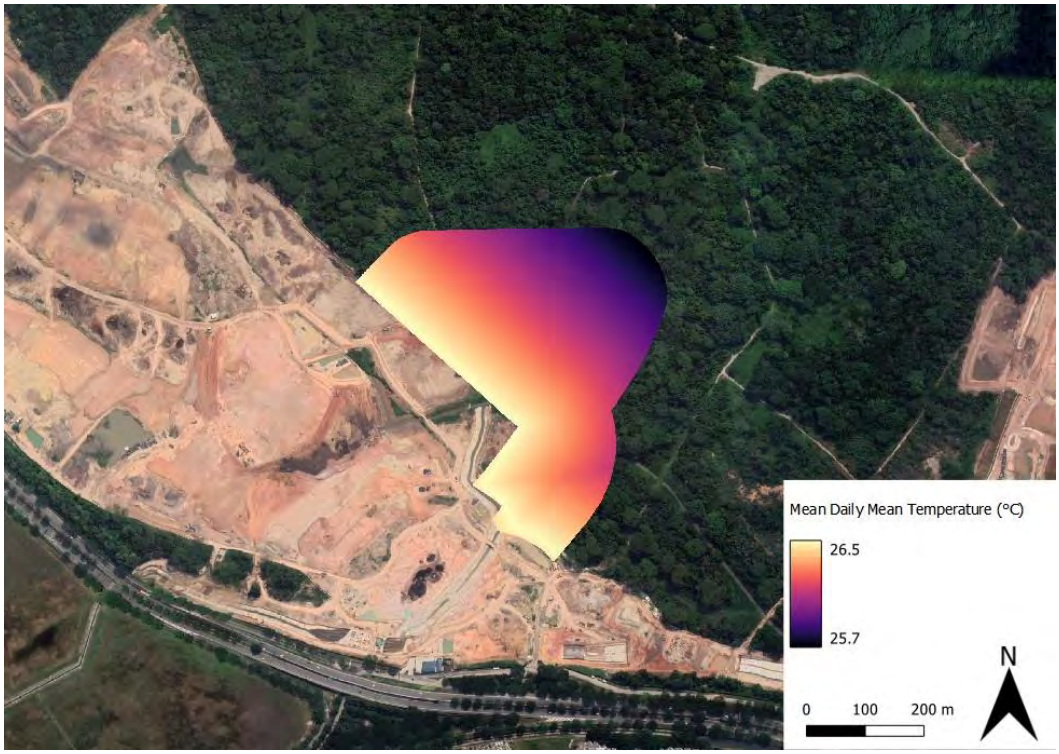

Figure 11.4 Heat map of mean daily temperatures across a subset of the Study Area.

For changes in ambient air temperatures, urbanised sites at the forest edge exhibited markedly higher changes in daily mean and daily maximum temperatures (Table 11.3), where a divergence of ≈3.94°C was recorded in the mean daily maximum temperatures. These findings corroborate the earlier data (in Table 11.2) where the UHI effect was observed at. However, it is once again worth noting that the data collection period was within the Northeast Monsoon period which brings cooler weather, which may have caused the UHI effect to be underestimated.

Table 11.3 Δ Mean temperature across Project site.

Land-cover Category	Location	Δ Mean Temperature (°C) ^			
		Δ Daily Minimum	Δ Daily Mean	Δ Daily Maximum	Δ Nocturnal*
Forest interior	T1.1	0.27	0.02	0.04	0.17
	T1.2	0.28	-	-	0.17
	T1.3	0.16	-	0.29	0.06
Near to forest edge	T2.1	0.12	0.03	0.22	0.11
	T2.2	0.19	0.07	0.45	0.12
	T2.3	-	0.19	1.17	-
At forest edge (Urban area)	T3.1	0.27	0.88	3.94	0.22
	T3.2	0.18	0.73	3.79	0.16
	T3.3	0.06	0.55	2.97	0.02

** Nocturnal hours from 2000h-0600h*

^ The dashes (-) refer to the lower bound value from which Δ is calculated

11.4 Impact Assessment

11.4.1 Determining Importance and Magnitude

The evaluation framework for importance of sensitive receptors and magnitude of change defined for the ambient air temperature impact assessment is presented in Table 11.4.

Table 11.4 Evaluation Framework for Importance of Temperature-Sensitive Receptors

Score	Socio-economic	Ecological
5	• Locations where temperature-sensitive activities are of high importance by the more sensitive members of the public, e.g., hospital/polyclinics • Locations where residents are highly susceptible to potential heatwaves and heat strokes that entail may be fatal • Locations with existing very low ambient temperature levels and very high green coverage – which would experience significant changes in ambient temperature levels if development were to occur	• Locations where the receptors affected are specifically protected by national or international policies or legislation and are of high importance at the regional or national scale, e.g., fauna (such as sea turtles & migratory birds) in Nature Reserves, Nature Areas, ASEAN Heritage Park • Locations where the microclimate impacts of edge effects and/or habitat loss would be highly detrimental to the threatened flora and fauna that reside within and/or adjacent to it
4	• Locations where more sensitive members of the public are exposed for eight hours or more in a day, e.g., residential care homes • Locations where residents are susceptible to potential heatwaves and heat strokes that entail may be fatal • Locations with existing low ambient temperature levels and high green coverage	• Locations where the receptors affected are of moderate importance at the regional or national scale, e.g., fauna in forested sites outside of designated nature reserves and nature areas • Locations where the microclimate impacts of edge effects and/or habitat loss would be highly detrimental to the threatened flora and fauna that reside within and/or adjacent to it
3	• Locations where temperature-sensitive activities are of moderate importance by the members of the public, e.g., private residential, and dormitories • Locations with existing moderate ambient temperature levels that correspond with daily meteorological service readings • Locations where members of the public are exposed for eight hours or more in a day, e.g., residential properties and schools	• Locations where the receptors affected are important for the functioning and integrity of adjacent habitats, e.g., green corridors, biodiversity buffer areas • Locations where the receptors affected contain specific species or taxa that are sensitive to ambient temperature levels, but are able to withstand and/or adapt to changes
2	• Locations where the people exposed are workers and they may be exposed for eight hours or more in a	• Locations where the receptors affected are with limited biodiversity

Score	Socio-economic	Ecological
	day, for example, office, industrial and shop workers	and ecological value, e.g., grasslands and shrubland
1	• Receptors with transient exposure, for example recreational users of parks and playgrounds	• Locations where the receptors affected are with little to no biodiversity value, e.g., managed turf

As there have been no established frameworks for assessing ambient air temperature impacts for EIA purposes (as described in Section 11.1), DHI developed a qualitative assessment matrix based on the RIAM approach, via a combination of desktop studies and literature review, with the Project's site characteristics taken into consideration.

Table 11.5 Evaluation Framework for Magnitude of Change in Ambient Air Temperature

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	**Biodiversity** • Populations are irretrievably compromised due to significant changes in ambient air temperatures • High likelihood of behavioural changes within populations, and their extirpation from current habitat **Socio-economic** • Residents are severely disturbed by changes in ambient air temperatures • Significant changes ambient air temperatures inside any room in the house leading to sleep disorder and other related health issues
-3	Moderate negative disadvantage or change	**Biodiversity** • Populations are moderately disturbed due to changes ambient air temperature levels • Moderate likelihood of behavioural changes within populations, and their extirpation from the current habitat • Discernible and fundamental changes to ambient air temperature levels, that would disturb populations **Socio-economic** • Residents are notably disturbed by changes in ambient air temperature levels • Sleep quality may be affected
-2	Minor negative disadvantage or change	**Biodiversity** • Populations experience minor disturbance due to changes in ambient air temperature levels, but not to the extent that the overall condition of the populations are impaired in the long term • Low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic**

Score	Generic Criteria	Specific Criteria
		• Residents are mildly disturbed by changes in ambient air temperature levels within their homes, and may experience discomfort
-1	Slight negative disadvantage or change	**Biodiversity** • Populations experience slight disturbances due to changes in ambient air temperature levels • Very low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents may notice the changes in ambient air temperatures within their homes, but is unlikely to cause discomfort
0	No change	**Biodiversity** • Little to no disturbances on populations • Negligible likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents not affected nor disturbed by ambient air temperatures within their homes

11.4.2 Importance Rating of Sensitive Receptors

The identified sensitive receptors were post-stratified into two main categories, namely fauna (biodiversity) and human (socio-economic) receptors. Based on the ratings described in Table 11.4 above, the importance scores for each receptor and the justifications are presented in Table 11.6 below.

The sensitive receptors were identified based on the planned development, which excludes areas that have already been subjected to clearance and/or development within the Project site.

Table 11.6 Sensitive receptors and their assigned importance score.

Category	Ambient air temperature sensitive receptor	Importance Score	Justification
Fauna	Terrestrial fauna in Tengah Forest	3	• Wildlife is known to be sensitive to ambient air temperature levels, especially nocturnal species. Changes in temperatures can therefore exert negative impacts on them. • The presence of herpetofauna within the Project site would therefore expose them to potential impacts due to changes in ambient air temperature levels.

Category	Ambient air temperature sensitive receptor	Importance Score	Justification
Human	HDB Residents living along Jurong West Street 42 Workers living in dormitories in worksite adjacent to Project	2	• The majority of HDB residents can be expected to be residing within their premises for eight hours or more in a day, especially after work hours. This makes them susceptible to excessively high ambient air temperatures. • Much of the southern portion of Tengah Forest has already been cleared, and is currently under development as revealed by satellite imagery. As such, it is unlikely that the current planned development will contribute significantly to changes in ambient air temperature. • Workers living in the dormitories will spend a significant amount of time in their rooms, especially after work hours.

11.4.3 Overall Impacts throughout the Project and Operational Phase

11.4.3.1 Long term changes in Ambient Air Temperatures from HVP Operation

Residents

We can expect the conversion of forest cover to buildings and urbanised surfaces to raise the ambient temperatures and lower humidity, given the reduction in evapotranspiration and the associated cooling capacity. The elevated ambient temperatures will be most pronounced during night hours, when trapped heat is slowly released from urban structures, leading to an urban heat island effect.

Existing residents at Jurong West Street 42 will be most vulnerable to elevated ambient temperatures and the UHI effect, given their proximity to the loss of forest cover and the presence of new buildings. However, the overall Project area has already been subject to significant amounts of forest clearance and development, due to concurrent projects occurring within the vicinity. Changes to ambient air temperatures levels are therefore expected in the long term, but residents are unlikely to be experience discomfort.

Although the UHI effect can be mitigated through the adoption of design guidelines to maximise thermal comfort, this is difficult to achieve for the planned development, as it is a HVP with few to no low-rise or high-rise structures present. As such, thermal heat gain on the façade is hard to mitigate, and vertical greenery cannot be harnessed to mitigate any heat gain on vertical structures. Nature-friendly landscaping, however, can still be interspersed throughout the development footprint, to ameliorate the UHI effect. The lack of vertical structures also reduces the amount of heat accumulated during daylight hours and accordingly decreases the amount of trapped heat released at night.

Ergo, the impacts are deemed to be permanent, but recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

Biodiversity

Clearance of the secondary forest will introduce edge effects that perturbs habitat microclimate, resulting in heightened risks of parasitism or disease, predation risks, elevated temperatures, reduced humidity, increased wind speeds, and increased light availability. Increased wind speeds at the newly exposed forest edge will likely increase the susceptibility of trees to wind-induced damage and treefalls, and consequently elevated tree mortality. Adverse microclimatic conditions would also result in higher risks of drying out and subsequent fire risk. Studies on forest fragmentation have reported increased tree mortalities up to 300 m deep from a forest edge, and reduced humidity up to 100 m deep (Laurance et al., 2018).

Alterations in microclimatic conditions, and in turn forest structure dynamics, can have substantial and long-term impacts on the faunal communities that inhabit the forests, as many of the species have adapted to specific microclimates that exist within the forest structures. For instance, herpetofauna are known to be sensitive and susceptible to changes in temperature and humidity levels. Reptiles and amphibians are ectothermic organisms, being unable to regulate their own body temperatures and are therefore susceptible to the prevailing microclimatic conditions. Moreover, critical activities such as foraging and mating are closely tied to suitable temperature and moisture regimes. Altered microclimates may thus result in reproductive failure and mortality (Olson & Saenz, 2013).

Notwithstanding the potential impacts of edge effects mentioned above, much of Tengah Forest will be exposed to the Project development and future HVP operations, along with other planned projects within the area. However, given that the southern parts of Tengah Forest have already been exposed to site clearance and building works, existing edge effects are likely to be present. The fauna within Tengah Forest are also likely to be urban-adapted and acclimatised to the surroundings. That said, the loss of habitat from the Project development and future HVP operation therefore exerts long term impacts, but will be mitigatable via the implementation of some mitigation measures including planting within and around the development.

Therefore, the impacts are deemed to be permanent, but recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

11.5 Mitigation Measures

Table 11.7 Mitigation measures to ameliorate impacts of changes to ambient air temperatures.

Hierarchy	Mitigation Measures
Avoidance	N.A.
Minimisation Restoration	**BCA Green Mark Certification Scheme** • Although the development footprint is not expected to contain any buildings, relevant pointers may still be adapted from the BCA Green Mark Certification Scheme, in order to mitigate impacts resulting from a rise in ambient air temperature. • Practicable mitigation measures to ameliorate the UHI effect should also be identified and implemented

Hierarchy	Mitigation Measures
Offsets	• This can be achieved via appropriate material selection, fine-tuning the landscape (both hardscape, softscape) and appropriately designing building surfaces • 'RE1.2b Urban Heat Island Mitigation' involves the adoption and implementation of UHI mitigation measures which can include: • Provision of unshaded hardscape areas with SRI > 39 (this includes unshaded carparks, internal roads, plazas, and pedestrian walkways) • A combination of the aforementioned strategies to mitigate ambient air temperature is recommended. • In particular, a mix of natural landscaping (i.e., nature-based/natural climate solutions), with innovative green building design for outdoor spaces would serve to regulate, and possibly lower outdoor ambient air temperatures • Benefits apply to both biodiversity and humans

11.6 Residual Impact

11.6.1 Overall Project duration and Post-Construction Phase

Through the implementation of a comprehensive set of design mitigation measures during the post-construction phase recommended by the BCA Green Mark Scheme, particularly relating to efficient and sustainable energy usage, the anticipated significance of ambient air temperature impacts may be minimised slightly, with residual impacts being slight. The cumulative effect of employing these mitigation strategies is outlined in Section 11.7.

11.7 RIAM Summary

Summary RIAM table below for the overall Project during and post-construction phase, after mitigation measures (Table 11.8).

11.7.1 Construction Phase

Table 11.8 Summary of impact assessment for temperature impacts for the construction phase of the Project. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Ambient temperature increase from construction works (short term)	Residents	2	-1	2	2	2	-12	Slight negative	-	-	No impact
	Fauna	3	-2	2	2	2	-36	Minor negative	-1	-18	Slight negative

11.7.2 Post-Construction Phase

Table 11.9 Summary of impact assessment for temperature impacts for the post-construction phase of the Project. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Overall ambient temperature increase from future HVP operation (long term)	Residents	2	-1	3	3	2	-16	Slight negative	-	-	No impact
	Fauna	3	-1	3	2	2	-21	Slight negative	-1	-21	Slight negative

12 Construction Waste & Vector Proliferation

The inappropriate management, storage and disposal of construction wastes generated during the construction process has the potential to result in various forms of environmental contamination, with downstream effects such as degradation of soil quality, shifts in flora and fauna composition towards pest or nuisance species. Poorly managed construction wastes may also have adverse effects on people in proximity, causing acute illnesses/injury and in severe circumstances, resulting in chronic conditions.

12.1 Applicable Legislation and Standards

National environmental management requirements that are applicable to the management and control of environmental pollution and vector proliferation are found in several Acts, Regulations and Guidelines, as listed in Table 12.1.

Table 12.1 Applicable acts, regulation and guidelines for environmental pollution and vector control

Environmental Aspect	Applicable Acts, Regulations & Guidelines
Waste management and environmental pollution	• Environmental Public Health Act (2002) • General Waste Collection Regulations (2000) • Toxic Industrial Wastes Regulations (2000) • Specified Construction Sites Order (2021)
Vector control	Control of Vectors and Pesticides Act (2002)

Environmental Public Health Act

The Environmental Public Health Act (EPHA) enacted in 2002 embodies the parent regulatory framework that governs the management of waste produced through commercial, industrial and personal activity. Several regulations under this parent act are of relevance to the range of waste expected to be produced during the construction process.

The General Waste Collection Regulations pertains to the management of most forms of non-hazardous waste, including the obligations for both the producers and collectors of such waste products.

The Toxic Industrial Waste Regulations, in turn, stipulates the bounds by which hazardous or toxic wastes may be generated, managed and disposed. A catalogue of wastes classified as “Toxic Industrial Wastes” similarly falls within the purview of these regulations, and may include a variety of sludges, chemicals and solvents. Specific requirements necessitate the appointment of licensed toxic industrial waste companies for the management, treatment and disposal of such wastes.

The Specified Construction Sites Order represents a more recent obligation for site occupiers to manage potential environmental damage through the appointment of a licensed Environmental Control Officer, who is legally required to monitor, assess and mitigate the extent of environmental damage.

Control of Vectors and Pesticides Act

The Control of Vectors and Pesticides Act functions as the governing set of guidelines for the for the control of vectors; and through this prevent the proliferation of vector-propagated diseases, such as Dengue Fever, the Zika Virus and Murine Typhus, amongst a whole range of other infectious diseases. The Act regulates the formal licensing of official NEA approved Vector Control Operators and workers and controls the legal availability of toxicants and repellents intended for use in vector control.

12.2 Impact Assessment

12.2.1 Determining Importance and Magnitude

The evaluation of waste and vector control criteria is outline below.

Table 12.2 Criteria for Determining Waste and Vector Sensitive Receptor Importance

Score	Generic Definition	Customised Definition
-4	Important to national/international interests	Receptors specifically protected by national or international policies or legislation and are of significance at the regional or national scale, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Park
-3	Important to regional/national interests	Receptor locations where human or wildlife populations are readily exposed to the construction environment and are dependent on the soil and groundwater resources for economical or biological support to sustain the population
-2	Important to areas immediately outside the local condition	Receptor locations where the construction environment is utilised in distant, but not within the immediate proximity. Adequate opportunities are available for the utilization of alternative sources of comparable quality.
-1	Important only to the local condition (within a large direct impact area)	Receptor locations accessible by general public where exposure is transient, for example public footpath, playing fields, parks.
0	Important only to the local condition (within a small direct impact area)	Receptor locations with limited access and where exposure is transient, for example private premises.

Construction waste

The pollutive effects of construction waste during the construction phase are expected to influence all the environment as a whole in and around the vicinity of the Project Site. Downstream receptors from this process may broadly include the construction personnel, and the various flora and fauna identified within the Study Area. An assessment of the impacts associated with environmental pollution and construction activities to flora and fauna have been discussed in Section 5. Thus, this section will focus on their effects on construction personnel.

Since construction personnel are typically equipped with suitable personal protective equipment, have undergone safety training and are managed in accordance to established protocols and practices, their susceptibility to the effects of construction waste and pollution is expected to be minimal. Thus, construction personnel will be given an importance score of 1.

Vector Proliferation

The proliferation of vectors and associated spreading of diseases would be similarly expected to mainly affect the construction personnel operating within the project area. Whilst the effects of construction waste are often warded off by suitable preventative measures, additional opportunities are available to affect construction workers, particularly during their personal and rest time, during which, personnel are often left in proximity to the site, but to their own devices. In these respects, the importance score of construction personnel is raised to 3.

An additional receptor has been identified with respect to the proliferation of vectors. Residents living in adjacent homes, and workers working in the various commercial and industrial facilities surrounding the Study Area are likely recipients of such impacts. Relevant vectors, such as mosquitoes, flies and rats are likely able to successfully escape the construction bounds of the Study Area and move into these aforementioned adjacent areas. Thus, an importance score of 3 has been similarly attributed to these individuals.

Evaluation framework for environmental pollution Magnitude is presented below.

Table 12.3 Evaluation Framework for Magnitude in Environmental Pollution

Score	Generic Definition	Customised Definition
-4	Major negative disadvantage or change	• Production and retention of waste material that is of at least intermediate toxicity, resulting in potentially chronic or substantive impacts on health and quality of environmental receptors i.e., release of asbestos, heavy metals, and radioactive material • Effects of environmental pollution are essentially permanent; pollutive effects may be mitigated but not resolved, resulting in the disequilibrium of affected environmental receptors
-3	Moderate negative disadvantage or change	• Production and retention of waste material that is of mild toxicity, resulting in potentially acute impacts on health and quality of environmental receptors • Effects of environmental pollution necessitate dedicated removal, resulting in the disequilibrium of affected environmental receptors if left without intervention
-2	Minor negative disadvantage or change	• Production and retention of waste material that is of indiscernible toxicity, but may be associated with reduced quality of environmental receptors, and long-lasting irritation or discomfort in human receptors i.e., microplastic release, loose ashes, oils and sludges • Effects of environmental pollution benefit from intentional removal, to reduce the duration and extent of pollutive effects
-1	Slight negative disadvantage or change	• Production and retention of waste material that may produce temporary mild irritation, discomfort, or

Score	Generic Definition	Customised Definition
		annoyance in human receptors i.e., accidental spillage of organic waste • Effects of environmental pollution are temporary, and self-resolving
0	No change	• Status quo

12.3 Prediction and Assessment of Impacts

12.3.1 Construction Phase

An assortment of natural and artificial wastes are expected to be produced as a consequence of the construction process. Whilst the production of wastes is generally unavoidable, the management of waste has traditionally been unproblematic within the context of Singapore's developments. Thus, the magnitude of impacts associated with waste-based environmental pollution is generally classed as Minor.

Similarly, conditions created by the construction process that may be conducive to the proliferation of various pests and vectors are generally also adequately controlled and managed by standard practices utilised in Singapore. Accordingly, the magnitude of impacts associated with the presences and diseases spread by vectors have been deemed to be Minor.

Both the generation of wastes and propagation of vectors is expected to be limited to the duration and scale of the construction process. Thus, waste-linked environmental pollution and vector-linked impacts have been deemed to be both temporary and reversible.

The subsections below briefly describe categories of waste, vectors and their associated impacts.

Cut and Felled Vegetation

A large quantity of vegetation is expected to be removed and felled during the clearance of habitat from the Study Area. Improperly managed stockpiles of rotting vegetation may be a source of fouling, function as refuges for pests and zoonotic vectors and may pose a fire hazard, especially under dry and hot conditions.

Excavated Earth and Substrata

The levelling of the Study Area through excavation works is expected to result in large volumes of loose substrata and earth. Improperly managed excavated earth may result in significant off gassing, and excessive sedimentation of both adjacent roads and drainage cisterns as a result of surface runoff.

Miscellaneous Waste

Miscellaneous waste include scrap food, litter and debris associated with human activities in and about the construction site. The improper management and disposal of these miscellaneous wastes may become a significant source of odour, windblown litter, soil and water fouling, as well as sustenance for various vectors and pests.

Construction Waste

Extraneous waste is expected to be generated through inefficiencies in the construction process. This may consist of broken concrete, scrap metal, wood such as planks, boards and pallets, as well as various plastic material such as packaging, wrapping and sheets. The degradation of these materials has the potential to release various toxicants, irritants and dusts into the surrounding environment. For example, various plastic products may be broken down into microplastics, whose effects on the soil and water quality, as well as animal and human health remain unknown. Similarly, the corrosion of metal-based products may suffuse the environment with excessive concentrations of heavy metal ions, which may then have a myriad of downstream effects on environmental acidification, nutrient balance, beyond generally being inherently toxic.

Hazardous Waste

Hazardous waste is likely to arise as a result of chemical usage during the construction process. Broad categories of such hazardous waste include various lubricants, solvents, colouring agents and contaminated water, amongst other synthetic or artificial chemical agents.

The inherent toxicity in these chemical agents are expected to pose a range of downstream effects on both environmental and human health, potentially shifting the equilibrium of ecosystems past points of functionality and afflicting human receptors with a host of acute and chronic ailments. Various hazardous wastes may also be highly flammable, such as those that may be classed as hydrocarbons.

Mosquito Breeding

Stagnant water pools suitable for mosquito breeding are a frequent consequence of construction related activities. These pools may form as a result of ditches, holes and other recessed areas that fill up during periods of heavy rainfall, or can be formed through improper storage of equipment and machinery in a manner that allows for the retention of water. The potential proliferation of mosquitoes may preliminarily function as an annoyance but can also secondarily result in the dissemination of serious diseases amongst construction workers operating within the development area. These diseases include Dengue, Chikungunya, Zika and Encephalitis, all of which have been recorded in Singapore.

Vector Proliferation

The accumulation of food waste material, if poorly managed, can provide other vector species, such as rodents, flies and cockroaches, with easy access to food and shelter. The breeding of these other vectors generally results in a sense of unease and the spread of food-borne diseases.

12.3.2 Post-Construction Phase

During the post-construction phase of the project, the site will be used by heavy vehicle operators. Expected waste generated includes general waste from the users of the future heavy vehicular park, particularly food and food packaging waste. Some sewage waste may also be generated.

If not managed properly, food waste in particular will likely be a factor in potential human-wildlife conflicts, as food waste is deemed as a food source by animals. Further, with the Tengah district dubbed as the “forest town”, it is crucial for operational food waste impacts to be considered and mitigated.

12.4 Proposed Mitigation Measures

12.4.1 Construction Phase

Construction-related Waste

The management of construction waste broadly falls into three categories: Reduction, Reuse and Disposal. The order of these options is aligned with a hierarchy of priorities; impacts should be and would be most effectively mitigated through a reduction in the generation of construction wastes as a whole, before considering reusing suitable material. Finally, the proper disposal of unusable construction wastes through licensed waste collection and disposal contractors remains the last choice of recourse. These options should be encapsulated within a waste management plan appropriately devised during the pre-construction phase, stipulating the procedures for the management, recycling and disposal of waste in an environmentally friendly and sustainable manner.

Table 12.4 Aspects and mitigation measures employed for proper waste management.

Aspect	Details
Reduction	• Accurate pre-construction planning for logistical and material requirements, with an emphasis of having reasonable, but not excessive margins. • Earth Control Measures such as the deployment of Erosion Control Blankets of should be employed to prevent sources of environmental pollution from escaping into adjacent waterways, reservoirs and substrata.
Reuse	• Timber/wood from cut vegetation can be recovered for use in the wood industry as far as possible. • Surplus excavated material and inert wastes (soil, broken rock etc.) shall be reused within project site as backfill, landscaping, erosion control and restoration features wherever practicable. • Scrap metals (e.g., welding rods, end caps, off-cuts etc.) can be recovered and sent for recycling as scrap.
Dispose	• Chemical toilet facilities/ septic tank system with collection of accumulated waste for off-site disposal by a licensed general waste collector. • Other inert general waste will be collected and disposed through licensed waste collector. • General refuse generated on-site must be stored in enclosed bins separate from construction and hazardous wastes. A licensed general waste collector shall be employed by the Contractor to remove general refuse, on a daily or every second day basis to minimise odour, pest, and litter impacts. • All non-hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (General Waste Collection) Regulations. • Any hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (Toxic Industrial Wastes) Regulations.

Vector Control & Mosquito Breeding

Mitigative measures intended to impede the proliferation of vectors begin with the implementation of an appropriate vector control plan during the pre-construction and construction phases. The design and implementation of such a plan typically falls within the purview of the environmental consultant and NEA approved vector control operator. The standard aspects and relevant responsibilities of a vector management plan and team are detailed in Table 12.5 and Table 12.6.

Table 12.5 Aspects and mitigation measures employed to prevent mosquito breeding.

Aspect	Details
Prevention	• Orderliness and organisation should be maintained within the construction site; debris, litter and waste should be removed promptly • Air-handling units are to be situated under shelter, and equipped with an overflow pipe to allow for the draining of rainwater • Construction material and equipment to be stored at an elevated position to prevent the accumulation of stagnant water • Potential receptacles for water storage, including various pails, containers, corrugated plastic/metal sheets, are to be kept indoors and away from accidental exposure to rainfall • Puddles should be drained or emptied promptly • Holes and ditches should be filled, covered, or levelled to prevent the accidental accumulation of water
Monitoring	• Daily checks should be conducted for mosquito breeding, including aforementioned receptacles, alongside the presence of larvae • Weekly checks of NEA's dengue cluster map should be performed to reassess this risk to construction workers • Noticeable increases in the number of vectors should be reported to the NEA for investigation
Mitigation*	• Repellents and insecticides are to be applied into stagnant water weekly

**Thermal fogging cannot be carried out within 100m of Tengah Forest*

Proliferation of Other Vectors

Table 12.6 Aspects and mitigation measures employed to prevent the proliferation of other vectors such as rodents and cockroaches.

Aspect	Details
Prevention	• Proper sanitation and cleanliness should be maintained at all times, particularly around the living quarters of construction personnel • Food and sanitary waste should be disposed of in covered bins, and regularly cleared out from the site to proper waste disposal facilities • Edibles shall be adequately stored within rodent-proof storage such as sealed containments and elevated at least 60cm above ground
Monitoring	• Daily site inspections should be conducted to check for the presence of rodent burrows on a weekly basis • Noticeable increases in the number of vectors should be reported to the NEA for investigation
Mitigation	• Identified active burrows should be treated with rodenticides for at least three consecutive days or until all rats are dead, and sealed with compacted earth

12.4.2 Post-Construction Phase

As the intended Project development is a heavy vehicle park, there is still likely to be some waste generated during the post-construction phase (as described in Section 12.3.2). Table 12.7 below presents proposed mitigation measures relating to the operational waste impacts of the development.

Table 12.7 Aspects and mitigation measures employed to ensure proper waste disposal and prevent the proliferation of vectors.

Aspect	Details
Prevention	• Provision of sufficient refuse bins to prevent improper waste disposal • Provision of enclosed and wildlife-proof refuse bins to prevent human-wildlife conflict • Waste should be regularly cleared out from the site to proper waste disposal facilities
Mitigation	Educational signages (e.g., advocating for proper waste disposal and no feeding of wildlife) to be placed at appropriate locations within site

12.5 Residual Impact

The residual impacts were evaluated using the RIAM method (Table 12.8 and Table 12.9) with due consideration that the recommended mitigation measures are implemented by the Contractor. The residual impacts are likely to be in the band of slight negative to no impact and considered acceptable.

12.6 RIAM Summary

12.6.1 Construction Phase

Table 12.8 Summary of impact assessment for waste and vector impacts for the construction phase of the Project. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Pollution from construction waste	Fauna	4	-2	2	2	2	-48	Minor negative impact	-1	-24	Slight negative impact
Vector Proliferation	Residents	3	-1	2	2	2	-18	Slight negative impact	-	-	No impact
	Construction workers	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact

12.6.2 Post-Construction Phase

Table 12.9 Summary of impact assessment for waste and vector impacts for the post-construction phase of the Project. The change in Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score).

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Pollution from waste generated by heavy vehicle operators	Fauna	4	-2	3	2	2	-56	Minor negative impact	-1	-28	Slight negative impact
Vector Proliferation	Heavy vehicle park users	3	-2	3	2	2	-42	Minor negative impact	-1	-21	Slight negative impact

13 Environmental Management and Monitoring Plan

This section outlines the monitoring and management measures that are recommended for the development.

13.1 Objectives

The Environmental Management and Monitoring Plan (EMMP) constitutes a methodical strategy aimed at reducing environmental impacts and overseeing the execution of these alleviation measures. Its purpose is to ensure that the Project is implemented without causing unacceptable adverse effects on the site and its surrounding environment. Additionally, the EMMP serves as a valuable tool for evaluating the effectiveness of implemented mitigation measures in minimizing and maintaining potential project-related impacts at acceptable levels throughout the construction phase.

13.2 EMMP Roles and Responsibilities

For the implementation and sustained success of the EMMP, there are many different parties that must commit to ensure that the impacts to ecology and environment of the Project's construction activities will be mitigated to the lowest practicable level, with on-going monitoring designed to maintain this optimum level of mitigation for the duration of the proposed Developments.

13.2.1 Employer

It will be the responsibility of the Employer to ensure implementation of the EMMP by the Contractors or any third party during the construction periods of the Project. References within the EMMP to the "Employer" are to JTC as the proposed Developing Agency. References to the "Contractor" are to the main contractors for the construction phase and also include any sub-contractors under their purview.

13.2.2 Employer's Environmental Team

13.2.2.1 EMMP Consultant

JTC will engage an EMMP Consultant independently from Contractor construction contracts. The EMMP consultant shall formulate an EMMP that covers all proposed construction activities during the Development. This EMMP shall consider construction methodologies and activities and shall serve as a plan to implement the mitigation measures covered in this EIA.

The EMMP Consultant is responsible for conducting regular inspections of the site to monitor Contractor's implementation of EMMP measures, and audit of environmental monitoring data provided by the Contractor. Where audit findings highlight a nonconformance, there will be an investigation and appropriate corrective action taken. All environmental audits will be clearly documented and filed internally. The EMMP Consultant is responsible for the overall quality and effectiveness of the EMMP, organising the EMMP audits and provision of comment clarifications and presentations when required with stakeholders and authorities.

Biodiversity Specialists (Ecologist and Arborist)

The EMMP Consultant's team shall include a sufficiently experienced Ecologist to conduct a pre-clearance wildlife inspection and prepare wildlife management protocols as and when required by the relevant Authorities. The Ecologist is responsible for ensuring wildlife encountered during pre-clearance inspections are reported to the EMMP consultant and advising the EMMP consultant on further actions to mitigate fauna injury or mortality.

The EMMP consultant's team shall also include shall also a sufficiently experienced ISA-certified Arborist to conduct pre-felling inspection of trees and ensure that appropriate tree protection measures are implemented for retained trees directly adjacent to the Project footprint.

The EMMP Consultant will be responsible for developing and training the Contractor and any sub-contractors in compliance with the EMMP, and incidents of human-wildlife conflicts.

13.2.3 Contractor

The Contractor shall be responsible for establishing an Environmental Team that comprises different environmental specialists to work with the regulatory authorities in Singapore to comply with regulations, policies and guidelines related to environmental affairs. The Contractor shall coordinate with EMMP Consultant (independently engaged by employer) and comply with the EMMP developed by the EMMP consultant. The Contractor shall ensure that all staff are familiar with the relevant parts of the EMMP.

While the EMMP sets out the requirements for environmental management during the construction phase, and the responsibilities for meeting them, the details of the actions to be taken in order to implement each aspect of the EMMP will need to be developed and specified by the Contractor in method statements. These method statements demonstrate how compliance with the requirements of the EMMP is to be achieved. These method statements need to be submitted to the EMMP Consultant and Employer for approval and distribution to relevant regulatory authorities as appropriate.

The Contractor will also be responsible for the provision and installation of all monitoring instruments required under the EMMP specifications, together with the necessities to ensure smooth operation and accurate data and results, such as power supply, mounting, protective or weather-proof casing. The data from the monitoring instruments shall be shared with the EMMP Consultant for EMMP monitoring requirements.

The Contractor will be responsible for developing and training staff in Emergency Management Procedures that cover potential incidents such as spills and leaks.

13.2.4 Contractor's Environmental Team

Environmental Control Officer

The Contractor shall engage at least one full-time Environmental Control Officer (ECO) for the construction phase of the development. The ECO shall be registered with the Commissioner of Public Health and discharge the duties set out in the Code of Practice for ECO. The ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control.

At least three weeks before construction works commencement, the ECO will submit an Environmental Control Program. After works commence a Site Environmental Control Report (SECR) should be submitted every 2 weeks to the Contractor. The report shall be made available for inspection on demand by the Director-General of Public Health or any Public Health Officer. The Environmental Control Program SECR shall contain the information required by the Singapore Code of Practice for Environmental Control Officers.

Environmental Specialists

The Contractor will also be responsible where applicable to appoint Qualified Erosion Control Professional (QECP) (as required by PUB), Earth Control Measures Officer (ECMO), NEA-licensed Pest Control Officer (PCO), NParks Certified Animal Management Specialist, Tree Felling Contractor with ISA-certified Arborist, Landscape/Horticultural Contractor (if required), SINGLAS accredited laboratory, and licence waste collectors to implement the EMMP requirements.

Any environmental specialist or company engaged by the Contractor to undertake the works under the CEMMP, must be adequately experienced. Equipment or instruments used must be maintained and calibrated at manufacturer recommended frequencies. All the certifications, accreditation and quality assurance records must be gathered and documented if and when required by the Contractor.

NParks Certified Animal Management Specialist

The Contractor shall engage an NParks Certified Animal Management Specialist that can be mobilised immediately when the EMMP consultants advise that relocation of fauna is necessary and feasible during the earthworks stage of the construction to capture and relocate wildlife of concern encountered during the pre-felling investigation by the Ecologist. The Animal Management Specialist must be a third-party contractor that has been given approval from the Director-General of Wildlife Management to conduct specific activities that are restricted by the Wildlife Act. The EMMP consultants will advise the Contractor as and when relocation is necessary and feasible.

13.3 Impact Mitigation and Monitoring

This section presents some key impact management measures and the monitoring regime recommended for the pre-construction and construction phase of the Development. Subsections below listed out the brief description of the key EMMP measures.

Additionally, post-construction stage monitoring will solely aim to restore the site to its pre-construction condition as closely as possible. It will not involve monitoring the impact from the operations.

13.3.1 Environmental Impacts Register

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
Ecology and Biodiversity	Flora	High	Loss of Flora	Moderate negative	• Transplantation of suitable individuals of conservation significance • Intensifying and/or expanding green buffer plantings within the development boundary • Turfing of slopes and supplementing with suitable plants of various other habits • Verify and review footprints for hoarding, worksite boundaries, and access roads • Proper flora management, including the implementation of appropriate TPZs for retained trees • Conduct regular site inspections to ensure contractor compliance to the EMMP • Conduct regular inspections to identify and monitor for forest edge effects and exotic fast-growing plants	• ISA-certified Arborist • EMMP Consultant • Contractor • Trained Ecologist • Landscape/Horticultural Contractor (if required)	Minor Negative	• EMMP consultant's team shall also include a sufficiently experienced ISA-certified Arborist to conduct pre-felling inspection of trees, and ensure that appropriate tree protection measures are implemented for retained trees directly adjacent to the Project footprint • EMMP Consultant should conduct monthly site visits to monitor the implementation of the CEMMP, as well as coordinate with the relevant Environmental Specialists on the status of CEMMP implementation • Monthly inspections of Tree Protection Zones (TPZs) of retained trees by the flora specialist/arborist • Monthly inspections of forest edge to ensure that it is intact and not adversely impacted by works by flora specialist/arborist • Monthly inspection of retained streams for visual impacts such as loss of vegetation, erosion, or siltation by assigned ecologist • EMMP Consultant shall carry out monthly inspection to ensure proper implementation of EMMP measures and its effectiveness. The consultant shall also inspect the perimeter of permanent hoarding around the site to ensure there are no gaps or defects where ground	• Contract-specific EMMP (CEMMP) • Environmental Performance Report

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
								dwelling wildlife can enter the cleared site area where extensive construction work would have begun	
	Birds	High	Faunal Injury or Mortality	Minor Negative	• Incorporate wildlife-friendly lighting • Reinstate/ realign naturalised stream • Conduct regular site inspections to ensure contractor compliance to the EMMP • Install hoarding properly to prevent wildlife entry • Conduct biodiversity awareness trainings • Ensure good housekeeping • Conduct daily checks for roadkill and fauna entrapment within the worksite • Use only fully biodegradable wildlife-friendly erosion control blankets • Conduct directional site clearance • Execute Wildlife Response Plan when a trapped/ injured/ dead/ dangerous animal is encountered • Train site personnel that feeding of wildlife is strictly prohibited • Divert naturalised stream to ensure unobstructed flow of water to/ from the forest streams and naturalised streams beyond the Tengah HVP footprint • Restrict entry of site personnel beyond the worksite • Install fences between the Tengah HVP compound and adjacent forest to prevent ground-dwelling fauna from entering the facility and human access into the forest • Put up signages to educate members of the public on appropriate behaviours when encountering fauna or on interactions with waterbodies	• EMMP Consultant • Trained Ecologist • Contractor • NParks Certified Animal Management Specialist	Minor Negative	• EMMP Consultant's team shall include a sufficiently experienced Ecologist to conduct a pre-clearance wildlife inspection and prepare wildlife management protocols as and when required by the relevant Authorities. • EMMP Consultant will be responsible for developing and training the Contractor and any sub-contractors in compliance with the EMMP, and incidents of human-wildlife conflicts. • Contractor shall engage an NParks Certified Animal Management Specialist that can be mobilised immediately when the EMMP consultants advise that relocation of fauna is necessary and feasible during the earthworks stage of the construction to capture and relocate wildlife of concern encountered during the pre-felling investigation by the Ecologist • The ECO shall conduct daily checks to ensure that no fauna is trapped in ECM blankets and pits. • Monthly inspections of the hoarding surrounding the project site by assigned ecologist to ensure that there are no gaps • Monthly verification that ECM blankets are 100% biodegradable and adequately used by assigned ecologist	• Contract-specific EMMP (CEMMP) • Wildlife Management Plan • Environmental Performance Report
	Mammals	High		Minor Negative			Minor Negative		
	Herpetofauna	Moderate		Moderate Negative			Minor Negative		
	Butterflies	High		Minor Negative			Minor Negative		
	Odonates	High		Minor Negative			Slight Negative		
	Aculeates	Moderate		Minor Negative			Slight Negative		
	Freshwater Fauna	High		Moderate Negative			Minor Negative		
	Mammals	High	Human Wildlife Conflict	Minor Negative			Slight Negative		
	Herpetofauna	Moderate		Minor Negative			Minor Negative		
	Aculeates	Moderate		Minor Negative			Minor Negative		
	Humans	Moderate		Moderate Negative			Minor Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
								• Review of any wildlife incidents that had taken place during the month by assigned ecologist	
	Native-dominated, young secondary forest	Moderate	Loss of Habitat	Moderate Negative	• Identify mature trees of functional importance for retention • Maintain stream connectivity and build lots around waterways that are to be retained • Intensifying and/or expanding green buffer plantings within the development boundary • Turfing of slopes and supplementing with suitable plants of various other habits • Reinstate/realign naturalised stream • Verify and review footprints for hoarding, worksite boundaries, and access roads • Conduct regular site inspections to ensure contractor compliance to the EMMP • Implement proper Earth Control Measures (ECM) plan prior to site clearance • Implement dust control measures • Install fences between the Tengah HVP compound and adjacent forest to prevent human access into the forest • Put up signages to deter members of the public from entering the forest or affecting waterways	• EMMP Consultant • Trained Ecologist • Contractor • Environmental Control Officer • Qualified Erosion Control Professional (QECP)	Moderate Negative	• EMMP Consultant's team shall include a sufficiently experienced Ecologist to conduct a pre-clearance wildlife inspection and prepare wildlife management protocols as and when required by the relevant Authorities.	• Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Exotic-dominated secondary forest	Moderate		Minor Negative			Slight Negative		
	Waterbodies	Moderate		Moderate Negative			Slight Negative		
	Abandoned plantation forest	Low		Slight Negative			Slight Negative		
	Scrubland	Low		Slight Negative			Slight Negative		
	Native-dominated, young secondary forest	Moderate	Habitat Degradation and Edge Effects	Moderate Negative			Minor Negative		
	Exotic-dominated secondary forest	Moderate		Minor Negative			Slight Negative		
	Waterbodies	Moderate		Minor Negative			Minor Negative		
	Abandoned plantation forest	Low		Slight Negative			Slight Negative		
	Scrubland	Low		Slight Negative			Slight Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
	Non-volant mammals and herpetofauna	High	Loss of ecological connectivity	Minor Negative			Minor Negative		
	Birds, Bats, Butterflies and Odonates	High		Minor Negative			Slight Negative		
	Freshwater fauna	High		Minor Negative			Slight Negative		
Air Quality	Terrestrial Fauna (Tengah Forest)	Moderate	Earthworks	Minor Negative	• Prompt removal of excavated soil from the construction site to prevent prolonged exposure. • To limit the height of stockpiles to control airborne dust. • Earthworks to be conducted in stages. • To cover any exposed earth areas not in immediate use with erosion control blankets. • To compact or pave any exposed earth areas not in immediate use.	• EMMP Consultant • Contractor • Environmental Control Officer (ECO)	Slight Negative	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control. Continuous (24 hrs a day) monitoring of particulate matter, averaged over 1-day period. • PM2.5 • PM10 **Location:** • At the edge of the retained section of Tengah forest	• Site Environmental Control Report (SECR) • Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Residential Areas	Moderate		No Impact			No Impact		
	Terrestrial Fauna (Tengah Forest)	Moderate	Construction Activities	Slight Negative	• Installation of physical barriers to contain ground-level pollutants. • Employing local exhaust ventilation systems. • To prioritize the use of low volatile organic compound (VOC) construction materials for paints, adhesives, and sealants. • To utilize emission-reducing construction equipment. • Regular inspection and maintenance of construction equipment to control emissions. • If concrete batching is carried out on site, the batching plant shall be placed away from the sensitive receptors. • Use enclosed chutes and conveyors and covered skips wherever possible. • Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.		Slight Negative		
	Residential areas	Moderate		No Impact			No Impact		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
	Terrestrial fauna (Tengah Forest)	Moderate	Trackout	Slight Negative	• Installation of trackout control mats at exit points complemented by wheel wash stations. • Designing site exit points paved or stabilized surfaces to minimize the disturbance of loose soil. • Enforcing lower speed limits within the construction site to ensure vehicles move within the site and exit gradually. • Equipping all haul trucks transporting materials with covers to reduce dust emissions during transit. • Regular maintenance and cleaning of road within site to promptly remove accumulated dust and debris minimizing the generation of dust.		Slight Negative		
	Residential areas	Moderate		No Impact			No Impact		
	Terrestrial fauna (Tengah Forest)	Moderate	Emissions from HVP operation	Slight Negative	• Regular maintenance of vehicles to reduce emissions, dust control measures, • Spill prevention practices • Green spaces and landscaping can be integrated into the site design which can contribute to air quality improvement.		Slight Negative		
	Residential areas	Moderate		No Impact			No Impact		
Airborne Noise	Terrestrial Fauna (Tengah Forest) (N1)	Moderate	Noise from Operating Heavy Vehicles (Construction Phase)	Minor Negative	• Prior to commencement of construction works, install noise barriers along project boundary facing Tengah forest • Select equipment with low noise emissions • Inspect and maintain vehicles and mechanical plants in good effective working order and operate in a manner to minimise noise emissions • Keep compressor, generator and engine compartment doors close and plant turned off when not in use. • Machines in intermittent use will be shut down or throttled down to a minimum during periods between works • Use precaution and care when unloading vehicles to avoid un-necessary noise. • Limit the timing of the use of particularly noise plant. Where alternatives are available, only equipment and vehicles that emit lower noise levels are to be used (i.e. late morning to late afternoon)	• EMMP Consultant • Contractor • Environmental Control Officer (ECO)	Minor Negative	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control. Continuous (24 hrs a day) monitoring of noise levels • L_{eq} 12 hrs • L_{eq} 1 hr • L_{eq} 5 mins	• Site Environmental Control Report (SECR) • Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Residential Areas (N2)	Moderate		No Impact			No Impact		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					• Where necessary, fit more effective exhaust equipment to earth moving equipment (5 to 10dB(A) reduction) • Use site terrain, material stockpiles and suitable work locations to screen work locations and maximise the distance between work activities and the nearest noise sensitive receptors • Apply a speed limit (typically 20km/h) to the access track and around the site which drivers will be required to adhere to • Manage project vehicles to not wait or queue up with engines running at the entrance to the site access • Inspect vehicles regularly identifying maintenance issues which generate excessive noise and carry out maintenance as required • Use adjustable or directional audible vehicle-reversing alarms or use alternative warning systems. Careful management of site layout to minimise the need to perform reversing manoeuvres • Avoid unnecessary revving of engines, reducing speed of vehicle movement and maintaining the condition of the road surface to avoid body slap from empty lorries, designing and maintaining access routes to minimise vehicle noise • Explain and train drivers the methods to help minimise vehicular noise impacts. • Construction personnel to be trained in noise-reduction behaviours such as reducing the drop height of materials. • Daily tool box briefing should include reminders on the need to implement noise-reduction behaviours • All construction personnel should be educated about sensitive ecological nature of work areas before commencing the work			**Location:** • At the edge of the retained section of Tengah forest	
	Terrestrial Fauna (Tengah Forest) (N1)	Moderate	Noise from Operating Heavy Vehicles (Post-	Minor Negative	• Regular maintenance of vehicles to prevent noise from failures.		Slight Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
	Residential Areas (N2)	Moderate	Construction Phase)	No Impact	• Proper inflation and regular maintenance of tires to prevent noise due to tire wear and tear. • Planting trees and shrubs to act as natural sound barriers and/or installing noise barriers to block transmission of noise to surrounding areas		No Impact		
Surface Water Quality and Hydrology	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	High	Impact to water quality due to sediment runoff and siltation	Minor Negative	**Surface Water Quality; Avoidance** • Engage a Qualified Erosion Control Professional (QECP) to formulate and implement an Earth Control Measures (ECM) plan in accordance with PUB requirements • Avoid siting work areas within 30 m from the nearest waterbody, i.e. work areas should not be sited within 30 m from the freshwater streams running through the Project footprint. • Avoid storing excessive quantity of chemicals on site. • Suitable containers shall be used to hold the chemical wastes to avoid leakage or spillage during storage, handling, and transport • All slurry preparation activities are to be conducted within designated areas away from streams, with adequate containment measures • Chemical waste containers shall be labelled with appropriate warning signs and symbols to avoid accidents. There shall also be clear instructions showing what action to take in the event of an accident. • No vehicle fuelling and maintenance to be allowed within the project area • Appropriate concrete washout areas should be provided and should not be performed in or near any of the watercourses. Concrete debris and water used for dust control should not be allowed to cause contamination within the work area or to run offsite. • Construction works are to be conducted in accordance with the Environmental Protection and Management (Trade Effluent) Regulations	• EMMP Consultant • Contractor • Environmental Control Officer (ECO) • Qualified Erosion Control Professional (QECP) • Earth Control Measures Officer (ECMO)	Slight Negative	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control. Monthly in-situ and ex-situ monitoring **In-situ measurement** of temperature, pH, conductivity, turbidity, total dissolved solids (TDS), and dissolved oxygen. **Ex-situ measurement** of total suspended solids (TSS), biological oxygen demand (BOD5), chemical oxygen demand (COD), total nitrogen (TN), nitrate (NO3-N), ammoniacal nitrogen (NH4-N), total phosphorus (TP), orthophosphate (PO4-P), total organic carbon (TOC), total alkalinity, oil & grease [Total], oil & grease [hydrocarbon], lead (Pb), zinc (Zn), mercury (Hg) and Enterococcus. **Location**:	• Site Environmental Control Report (SECR) • Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Immediate community downstream of the Project site	Moderate		Slight Negative			No Impact		
	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	High	Degradation of stream habitat due to soil erosion	Minor Negative			Slight Negative		
	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	High	Impact to stream habitat due to backfilling of stream	Major Negative			Moderate Negative		
	Aquatic fauna dependent on forest streams within, downstream and adjacent to Project site	High	Contamination of receiving waterbodies due to vehicular discharge	Slight Negative			Slight Negative		
	Immediate community downstream	-		No Impact			No Impact		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
	of the Project site				• Clearance of surface vegetation should be done in stages to reduce the amount of surface runoff and erosion • Hoarding should be in place to clearly demarcate work area, hence limiting the spatial extent of soil and slope works • Silt curtains should be installed along the boundaries of work areas to minimize sediment runoff into waterways. At areas of the construction zone closest to the freshwater stream, double layers of silt curtains can be installed to greatly reduce the risk of stream sedimentation • 100% Biodegradable Erosion Control Blankets should be installed wherever bare earth is exposed • Soil and material stockpiles should be covered with tarpaulin when not in use • Proper erosion and sediment control measures should be implemented by engaging a Qualified Erosion Control Professional (QECP) to design and implement an Earth Control Measures (ECM) plan • Turf cover should be established during reinstatement of the work site to minimize soil erosion • After rain events, earth control measures in the Area are to be inspected and maintained over the course of construction • Tarpaulins mats (in adequate quantities) should be on standby during site clearance and excavation works, to ensure that exposed soil and stockpiles are covered and prevent overflow of silty discharge • Any construction equipment which causes pollution to the water system due to leakage of oil or fuel shall be removed off-site immediately. • Spillage or leakage of chemical waste to be controlled using suitable absorbent materials. Any spillage/leakage waste shall be removed off-site immediately and disposed properly with NEA licensed waste collector.			At least one point directly downstream of all streams crossing the project site Implementation of TSS monitor and CCTV • Total Suspended Solids (TSS) **Location**: Every discharge point	

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					• Chemicals will always be stored on drip trays or in bunded areas where the tray/bund capacity is 110% of the stored chemical volume. • Proper records of Safety Data Sheet (SDS) for all chemical, fuel, solvents stored on site is required • Proper storage and provision of Spill Kits and training of staff on how to use the Spill Kit • Any contractor generating waste oil or other chemicals as a result of his activities should register as a chemical waste producer. Disposal of the waste oil should be done through a licensed toxic industrial waste collector. • A full containment bund wall should be provided for bulk storage oil tanks, including skid tanks. A collection sump should be provided to collect any spillage. All leaks and spillages in the storage area or construction site shall be collected and sent to a licensed toxic waste collector for proper disposal. • Good housekeeping practices should be implemented to minimize careless spillage and to keep the storage and the workspace in a tidy and clean condition. • Appropriate training including safety codes and relevant manuals should be given to the personnel who regularly handle the chemicals on site. • A temporary cut-off drainage channel and associated facilities should be provided to collect the runoff generated and prevent concrete-contaminated water from entering watercourses • Engage a Qualified Erosion Control Professional (QECP) to formulate and implement an Earth Control Measures (ECM) plan in accordance with PUB requirements				

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
Ground Vibration	Fauna in Tengah Forest	Moderate	Vibration from Construction Equipment	Moderate Negative	**Construction Phase** • Low vibration construction techniques are recommended to be implemented in the construction contracts. • Low-power machinery of the same type should be considered to reduce the vibration strength at source. • Compaction machines which cause much less vibration than vibratory roller is recommended. • Rotary bored piling machine shall be used to minimise the impact comparing to impact pile driver. • Minimum distance of 15 m between heavy vibration-generating equipment and the Tengah forest edge is recommended. • British Standard BS5228-2:2009 be implemented during the construction stage. This will include the following as appropriate: • The Contractor shall propose and justify effective, feasible and site-specific mitigation measures and conditions to minimise vibration and comply with the criteria. Mitigation measures shall be in the order of the following hierarchy of controls: • Elimination • Substitution • Engineering control • Administrative control • Photographs, drawings and specifications for all mitigation measures shall be provided, where applicable. • All equipment used on site shall be regularly maintained and shall be operated in a manner that minimises vibration as far as is practicable. • Damaged equipment shall not be used.	• EMMP Consultant • Contractor • Environmental Control Officer (ECO)	Minor Negative	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control. Continuous monitoring of ground-borne vibration levels • PPV (mm/s) **Location** At the edge of the retained section of Tengah Forest	• Site Environmental Control Report (SECR) • Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Fauna in Tengah Forest	Moderate	Vibration from Operating Heavy Vehicles	Minor Negative			Slight Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					• Equipment not in use shall be shut down to reduce the amount of vibration generated by idling motor **Post-Construction Phase.** • Restricting the speed of the incoming and outgoing vehicles • regular maintenance to control the roughness of the surface of the HVP				
Illumination	Residents	Moderate	Light nuisance from construction night works (short term)	Slight Negative	**Avoidance** • Avoiding use of lighting that is not needed • Avoid construction works during night hours as much as practicable • Illumination with a high UV component should be avoided to reduce impacts on insects **Minimisation** • Erect hoarding around construction site • Checklist for Artificial Light Management / Night Works Management Plan • Lights should be pointed downwards and towards the interior of the site instead of resulting in spillage beyond the site boundary and into adjacent retained forest area. Shields can be installed for light fixtures near the site boundary to minimise light spillage into adjacent forest habitats • If needed outside operating hours, low lux level lighting with light shields shall be used along pathways, paved areas and in areas where public access cannot be prevented. Limiting light intensity to the minimum possible levels while not compromising on safety requirements (Figure 10.7) • Where possible and safe, use motion sensor to activate lighting for less frequently accessed areas • Where possible and safe, have light sources be lower than the perimeter hoarding height • Lights operating at night should be of low wavelengths and narrow spectrum (Figure 10.6)	• EMMP Consultant • Contractor • Environmental Control Officer (ECO)	No Impact	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control.	• Contract-specific EMMP (CEMMP) • Light Management Plan • Site Environmental Control Report (SECR) • Environmental Control Program • Environmental Performance Report
	Fauna	High		Minor Negative			Slight Negative		
	Residents	Moderate	Light nuisance from future building operation (long term)	Slight Negative			No Impact		
	Fauna	High		Minor Negative			Slight Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					• Managing the direction of light emissions, i.e. light should be shielded, directed downwards and away from forested areas (Figure 10.6) • Ensure all unnecessary lights are turned off at the end of any night works • When directing light sources, be aware of reflective surfaces that could reflect the directed light to sensitive areas **Post-construction Phase; Minimisation** **BCA Green Mark Certification Scheme** • The Project site is part of the Tengah New Town district, a government land sales (GLS) site (URA, 2023) o As part of the 2nd Green Building Masterplan, Green Mark certification (either Platinum or GoldPLUS rating) is necessitated for any new development that fall under GLS programmes (BCA, 2023) o Prescribed Green Mark ratings have to be obtained before TOP/CSC can be granted • Additionally, lighting should adhere to MOM's minimum safety requirements for works to be performed at night: • SS 531 – 2: 2008: Code of Practice for Lighting of Work Places • SS 531 – 3: 2008: Lighting Requirements for Safety and Security of Outdoor Work Places **Post-construction Phase; Restoration & Offsets** **BCA Green Mark Certification Scheme** The Resilience section of the Green Mark certification programme recommends for the restoration of natural habitats, and native planting palette to be weaved into overall design plan, taking into account above mentioned pointers relating to lighting (e.g., setting of dark buffers) which can be considered as offsets for the increased light outputs from the overall development				

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
Ambient Air Temperature	Residents	Low	Ambient temperature increase from construction works (short term)	Slight Negative	**BCA Green Mark Certification Scheme** • Practicable mitigation measures to ameliorate the UHI effect should also be identified and implemented • This can be achieved via appropriate material selection, fine-tuning the landscape (both hardscape, softscape) and appropriately designing building surfaces • 'RE1.2b Urban Heat Island Mitigation' involves the adoption and implementation of UHI mitigation measures which can include: • Provision of unshaded hardscape areas with SRI > 39 (this includes unshaded carparks, internal roads, plazas, and pedestrian walkways) • A combination of the aforementioned strategies to mitigate ambient air temperature is recommended. • In particular, a mix of natural landscaping (i.e., nature-based/natural climate solutions), with innovative green building design for outdoor spaces would serve to regulate, and possibly lower outdoor ambient air temperatures • Benefits apply to both biodiversity and humans	• EMMP Consultant • Contractor • Environmental Control Officer (ECO)	No Impact	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control.	• Contract-specific EMMP (CEMMP) • Site Environmental Control Report (SECR) • Environmental Control Program • Environmental Performance Report
	Fauna	Moderate		Minor Negative			No Impact		
	Residents	Low	Overall ambient temperature increase from future HVP operation (long term)	Slight Negative			No Impact		
	Fauna	Moderate		Slight Negative			No Impact		
Construction Waste & Vector Proliferation	Fauna	High	Pollution from construction waste	Minor Negative	**<u>Construction Phase</u>** **Construction-related waste** • Accurate pre-construction planning for logistical and material requirements, with an emphasis of having reasonable, but not excessive margins. • Earth Control Measures such as the deployment of Erosion Control Blankets of should be employed to prevent sources of environmental pollution from escaping into adjacent waterways, reservoirs and substrata. • Timber/wood from cut vegetation can be recovered for use in the wood industry as far as possible. • Surplus excavated material and inert wastes (soil, broken rock etc.) shall be reused within project site as backfill, landscaping, erosion control and	• EMMP Consultant • Contractor • Environmental Control Officer (ECO) • NEA-licensed Pest Control Officer (PCO)	Slight Negative	• Contractor's ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control.	• Site Environmental Control Report (SECR) • Contract-specific EMMP (CEMMP) • Environmental Control Program • Environmental Performance Report
	Residents	Moderate	Vector Proliferation	Slight Negative			No Impact		
	Construction Workers	Moderate		Slight Negative			Slight Negative		
	Fauna	High	Pollution from waste generated by heavy vehicle operators	Minor Negative			Slight Negative		
	Heavy Vehicle Park Users	Moderate	Vector Proliferation	Minor Negative			Slight Negative		

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					restoration features wherever practicable. • Scrap metals (e.g., welding rods, end caps, off-cuts etc.) can be recovered and sent for recycling as scrap. • Chemical toilet facilities/ septic tank system with collection of accumulated waste for off-site disposal by a licensed general waste collector. • Other inert general waste will be collected and disposed through licensed waste collector. • General refuse generated on-site must be stored in enclosed bins separate from construction and hazardous wastes. A licensed general waste collector shall be employed by the Contractor to remove general refuse, on a daily or every second day basis to minimise odour, pest, and litter impacts. • All non-hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (General Waste Collection) Regulations. • Any hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (Toxic Industrial Wastes) Regulations. **Vector Control & Mosquito Breeding** • Orderliness and organisation should be maintained within the construction site; debris, litter and waste should be removed promptly • Air-handling units are to be situated under shelter, and equipped with an overflow pipe to allow for the draining of rainwater • Construction material and equipment to be stored at an elevated position to prevent the accumulation of stagnant water • Potential receptacles for water storage, including various pails, containers, corrugated plastic/metal sheets, are to				

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					be kept indoors and away from accidental exposure to rainfall • Puddles should be drained or emptied promptly • Holes and ditches should be filled, covered, or levelled to prevent the accidental accumulation of water • Daily checks should be conducted for mosquito breeding, including aforementioned receptacles, alongside the presence of larvae • Weekly checks of NEA's dengue cluster map should be performed to reassess this risk to construction workers • Noticeable increases in the number of vectors should be reported to the NEA for investigation • Repellents and insecticides are to be applied into stagnant water weekly **Proliferation of Other Vectors** • Proper sanitation and cleanliness should be maintained at all times, particularly around the living quarters of construction personnel • Food and sanitary waste should be disposed of in covered bins, and regularly cleared out from the site to proper waste disposal facilities • Edibles shall be adequately stored within rodent-proof storage such as sealed containments and elevated at least 60cm above ground • Daily site inspections should be conducted to check for the presence of rodent burrows on a weekly basis • Noticeable increases in the number of vectors should be reported to the NEA for investigation • Identified active burrows should be treated with rodenticides for at least three consecutive days or until all rats are dead, and sealed with compacted earth **<u>Post-Construction Phase</u>** • Provision of sufficient refuse bins to prevent improper waste disposal				

Environmental Aspect	Description of Receptor		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receptor	Importance	Impact	Impact Significance					
					• Provision of enclosed and wildlife-proof refuse bins to prevent human-wildlife conflict • Waste should be regularly cleared out from the site to proper waste disposal facilities • Educational signages (e.g., advocating for proper waste disposal and no feeding of wildlife) to be placed at appropriate locations within site				

13.3.2 Contract-Specific EMMP

Prior to commencement of construction works, the Contractor shall work with the appointed EMMP Consultant to formulate a Contract-specific EMMP (CEMMP) based on their planned construction works details. The CEMMP shall make reference to the mitigations and monitoring as recommended in this EIA.

The following components shall be covered in Contract-Specific EMMP:

- Project Description
- Project Team
- Environmental Objectives
- Environmental Management and Mitigation Measures
- Environmental Monitoring
- Biodiversity Monitoring
- Health and Safety
- EMMP Documents and Reporting
- Change Management and Review

The CEMMP document will contain the following management and monitoring plans to achieve the environmental objectives of the EMMP:

- Flora and Arboriculture Management and Monitoring Plan
- Wildlife Management Plan (including Wildlife Response and Rescue Plan)
- Water Pollution Control and Monitoring Plan
- Noise Management and Monitoring Plan
- Air Pollution Control and Monitoring Plan
- Waste Management and Monitoring Plan
- Ground-borne Vibration Management and Monitoring Plan
- Earth Control Measures Plan
- Light Management and Monitoring Plan
- Vector Control Plan

13.3.3 Pre-construction Phase

Flora

The proposed development involves clearance of vegetation within the project site. Flora along the development boundary may be impacted as well. An ISA certified Arborist and/or flora specialist should be engaged to execute tree protection and assessment works.

A tree felling plan shall be devised to confirm the trees to be felled, retained or salvaged. Tree protection zones shall be established to protect retained trees as well as trees along the project boundary, and hoardings should be erected around the project site to prevent excessive clearance or vegetation damage outside the project area.

Plant Salvaging

JTC will consult NParks on salvaging of plants of conservation and concern, as well as the retention of mature trees (if any) prior to construction works. These include Critically Endangered species such as *Curculigo capitulata* and *Xyris complanata,* and Endangered species such as *Ficus caulocarpa* and *Melicope lunu-ankenda* (Appendix B1). The locations of conservation-significant flora species recorded during the baseline survey should be verified by a certified arborist / flora specialist, and individuals suitable for transplanting or sapling salvaging should be identified and clearly tagged. Additionally, mature trees potentially earmarked for retention as part of the urban ecoscape shall be assessed for tree health, vigour, structural stability, alongside a qualitative evaluation of its

contribution to ecological function before final decisions regarding retention are undertaken. For conservation-significant flora species not suitable for transplanting, harvesting of fruits, seeds, saplings, propagules or stem and leaf cuttings can be carried out.

Tree Protection Zones

A tree protection zone (TPZ) refers to a specified area that protects the entire tree including the roots system, trunk, and crown, and should be maintained to protect the trees throughout the period of construction.

Before the commencement of clearance works, a certified arborist shall conduct an assessment to identify suitable trees for retention along the boundary of the worksite. Selected trees should have a Tree Protection Zone (TPZ) recommended based on site utilisation plans and developed in accordance with the Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023). The TPZ aims to minimise the impact of construction activities on trees, including but not limited to mechanical injury to roots, trunks and branches due to contact with equipment, materials, debris or other activities. It also aims to minimise soil compaction, which results in poor functioning of roots, and changes in soil levels that can cut off or suffocate roots.

Figure 13.1the general protection radius required based on the respective girth of retained trees. However, the TPZ size may still vary depending on both the crown and root spread which may render the need for larger tree protection zones, particularly for trees with a girth exceeding 2m.

Minimum Protection Zone from the Centre of a Tree

Girth (m)	Minimum Protection Zone
≤1.0m	2.0m
>1.0m but ≤1.5m	3.0m
>1.5m but ≤2.0m	4.0m
>2.0m	5.0m

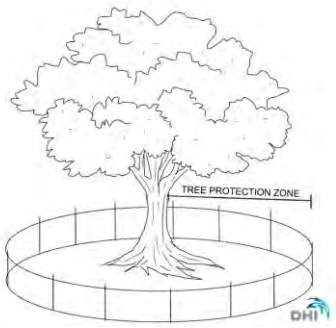

Figure 13.1 General guideline for minimum protection zone (radius) (NParks, 2023) and depiction of TPZ set up.

The following specifications extracted from NParks (2023) shall be adhered to for construction work carried out within and outside of the TPZ.

Inside TPZ:

- There must be no excavation, raising or lowering of soil level, compaction or any form of construction activities including temporary works within the hoarded area.
- Dumping of debris, excavated materials and/or storage of construction materials and equipment are not allowed within the TPZ.
- The demolition of drains, structures within the TPZ should be carried out manually and backfilled with Approved Soil Mixture (ASM) immediately.
- Trees are to be watered regularly if rainfall is inadequate.

- Trees are to be fertilised if soil tests or deficiency symptoms indicate they are nutrient stressed.

Outside TPZ:

- If major roots are encountered during excavation, the applicant may like to seek advice from a certified arborist, as cutting of major roots may affect the stability of the tree. Where possible, alternative proposals should be explored to avoid the need to cut the roots.
- In cases where the trees are managed by NParks (e.g. trees within the roadside verge) or are required by NParks to be conserved (e.g. trees with girth >1.0m within TCA or vacant land), approval from NParks must be obtained before the major root can be cut.
- If approval is granted by NParks to cut the roots, this must be done with a clean cut using a chainsaw.
- All building debris and chemical wastes should not be burned or buried within green verges on the site.

The TPZs should be set up at the start of the construction phase and should not be encroached upon in the course of any works. The certified arborist shall provide monthly checks on the integrity and conditions of the TPZs and report any findings to the appointed environmental control officer (ECO) for rectification and follow-up, which will be documented in the monthly Environmental Performance Report.

Fauna

A Wildlife Management Plan shall be devised by the assigned ecologist and/or EMMP consultant, dictating the appropriate handling, trapping and translocation protocols to be undertaken in line with NParks regulations, should errant wildlife be spotted within active developmental areas. The plan shall also include relevant contacts of NParks Certified Animal Management Specialists who may be utilised in the execution of any wildlife rescue and relocation processes.

Biodiversity Awareness Training

Prior to the start of any construction activities, all construction personnel are to attend a biodiversity awareness training by the assigned ecologist and/or CEMMP consultant. The purpose of the training is to inform on the ecological importance of the site, and the importance of minimising impacts to the natural environment. Construction personnel should also be trained on the common fauna species found within and around the site, and the key aspects of the Wildlife Response and Rescue Protocol. After the initial training, refresher training and toolbox briefings are to be conducted on a regular basis.

Biodiversity Management – Staged and Directional Clearance

The Project site comprises primarily of vegetated area. Prior to any vegetation clearance, embedded perimeter hoardings are to be installed along the works boundary for fully enclose the Project area, so as to prevent animals running onto the roads which may cause injury and casualty of wildlife, as well as human-wildlife conflict. Vegetation will be cleared in stages, starting from the southern area , towards the northern area bounded by Tengah Forest. This is to allow avifauna to move towards the Tengah Forest in the north.

Directional site clearance shall be carried out to funnel wildlife towards planned points (Figure 13.2). For areas where there is no connectivity to Tengah forest, if any, they will be captured and released in other suitable habitats in consultation with NParks. For more effective animal management, vegetation clearance, wildlife trapping, and translocation exercises will take place sequentially in smaller subsections of the Project area. These subsections will be demarcated by temporary hoarding, to prevent animals from moving

into the larger forested area. The Contractor shall propose the corresponding hoarding plan, including temporary hoardings for wildlife trapping. A registered Wildlife Management Company shall be engaged for the trapping and relocation of animals within the Project site.

For wild boar found within the project site during the pre-construction or construction stage, NParks is to be notified as soon as possible at nparks_wildlife_management@nparks.gov.sg for advice and subsequent action. An approved Animal Management Specialist must also be engaged to trap and remove individuals, the process of which may take about 4 to 6 weeks.

Figure 13.2 Proposed directional clearance during construction phase.

Pre-felling Wildlife Inspection

Pre-felling wildlife inspections shall be conducted by the appointed Ecologist before the clearance of each area. The Ecologist will conduct surveys to identify fauna species,

focusing particularly on arboreal fauna, fledgling avifauna, and any pre-existing or constructed microhabitats, such as bird nests, bee hives, and tree burrows. Should active bird nests are found, the Ecologist is to report the findings to the Contractor. Felling of the tree can only be conducted upon fledging of the chick. Other observances are to be reported to the Contractor and Consultant to plan for specific management approaches prior to clearance.

Before initiating any vegetation clearance, camera traps will be deployed in each zone for a period of five days to observe the presence of wildlife on site. This process will enable the Animal Management Specialist to develop appropriate trapping methods for the animals identified within the site.

For streams and waterbodies that are not retained and known to be habitats to the Three-spot Gourami and Crescent Betta, these freshwater fauna will be trapped at different points of the waterbody and translocated to identified and authorised recipient sites. This should be conducted prior to any works affecting these streams.

Wildlife Response and Rescue Protocol
Even after completing pre-felling fauna inspections and directional clearance, there remains a significant likelihood that animals could enter the site and become trapped, especially those that burrow or climb. For this reason, the EMMP Consultant, informed by their ecologist, should develop a Wildlife Response and Rescue Protocol. If any fauna are found within the working areas, all construction activities must cease immediately, and the Wildlife Response and Rescue Plan should be implemented.

Environmental Monitoring

Prior to the start of construction works, it is recommended that the Contractor conducts one round of baseline surveys for the re-establishment of baseline conditions. The parameters, duration, and location of these surveys can be found in Table 13.1.

Table 13.1 Baseline monitoring of environmental parameters.

Environmental Aspect	Parameters and Duration	Location
Airborne Noise	A noise baseline monitoring of at least seven (7) days (1 week) • Leq 12 hrs • Leq 1 hr • Leq 5 mins	• At the edge of the retained section of Tengah forest
Air Quality	Continuous monitoring of for at least seven (7) days (1 week) averaged over 1-day period. • PM2.5 • PM10	• At the edge of the retained section of Tengah forest
Water Quality	One time monitoring **In-situ measurement** of temperature, pH, conductivity, turbidity, total dissolved solids (TDS), and dissolved oxygen. **Ex-situ measurement** of total suspended solids (TSS), biological oxygen demand (BOD5), chemical oxygen demand (COD), total nitrogen (TN), nitrate (NO3-N), ammoniacal nitrogen (NH4-N), total phosphorus (TP), orthophosphate (PO4-P), total organic carbon (TOC), total alkalinity, oil & grease [Total], oil & grease [hydrocarbon],	• At least one point upstream and one point downstream of each stream crossing the project site.

Environmental Aspect	Parameters and Duration	Location
	lead (Pb), zinc (Zn), mercury (Hg) and Enterococcus.	
	Total Suspended Solids (TSS)	• At final discharge point
Ground-borne Vibration	One-time continuous vibration monitoring will be conducted for at least seven (7) days (1-week) period • PPV (mm/s)	• At the edge of the retained section of Tengah forest

13.3.4 Construction Phase

Construction stage monitoring entails regular inspection to register excessive environmental impact and allow prompt follow up actions in case of environmental non-conformance. Monitoring by means of instrumental data collection and visual inspections, shall be employed by the Contractor's ECO to ensure environmental management and mitigation measures are effectively implemented on-site.

In the event where works need to be carried out during nighttime (after 7 pm), a Light Management Plan which includes the specifications and locations of proposed artificial night lighting shall be prepared by the Contractor, , This is to prevent excessive light spill towards Tengah Forest and the residential areas surrounding the Project site.

The EMMP Consultant shall carry out monthly inspection to ensure proper implementation of EMMP measures and its effectiveness. The consultant shall also inspect the perimeter of permanent hoarding around the site to ensure there are no gaps or defects where ground dwelling wildlife can enter the cleared site area where extensive construction work would have begun. Recommendations shall be made if any of the mitigation or management measures are found inadequate. In the circumstances where any trees are to be retained within the site or adjacent to it, an Arborist shall be engaged to carry out monthly monitoring and assess the health of the retained trees.

Flora Monitoring

Monthly site visits by the flora specialist/arborist should be conducted to ensure that mitigation measures in the CEMMP have been implemented and are effective in reducing any impacts to retained trees within and around the site, and forested area surrounding the site. These include:

- Monthly inspections of Tree Protection Zones (TPZs) of retained trees
- Monthly inspections of forest edge to ensure that it is intact and not adversely impacted by works

Fauna Monitoring

The ECO shall conduct daily checks to ensure that no fauna is trapped in ECM blankets and pits.

Monthly site visits by the assigned ecologist should ensure that the mitigation measures in the CEMMP have been implemented and are effective in reducing any impacts to fauna species around the site. These include:

- Monthly inspections of the hoarding surrounding the project site to ensure that there are no gaps

- Monthly verification that ECM blankets are 100% biodegradable and adequately used.
- Monthly inspection of retained streams for visual impacts such as loss of vegetation, erosion, or siltation.
- Review of any wildlife incidents that had taken place during the month.

Environmental Monitoring

During the construction phase, it is the responsibility of the contractor to conduct regular environmental monitoring. The parameters, duration, and location of these surveys can be found in Table 13.2

Table 13.2 Construction phase monitoring of environmental parameters.

Environmental Aspect	Parameters and Duration	Location	Standards/Criteria
Airborne Noise	Continuous (24 hrs a day) monitoring of noise levels • Leq 12 hrs • Leq 1 hr • Leq 5 mins	• At the edge of the retained section of Tengah forest	• Environmental Protection and Management (Control of Noise at Construction Sites) 2008
Air Quality	Continuous (24 hrs a day) monitoring of particulate matter averaged over 1-day period. • PM2.5 • PM10	• At the edge of the retained section of Tengah forest	• Approved Air Pollution Control Plan by ECO
Water Quality	Monthly in-situ and ex-situ monitoring **In-situ measurement** of temperature, pH, conductivity, turbidity, total dissolved solids (TDS), and dissolved oxygen. **Ex-situ measurement** of total suspended solids (TSS), biological oxygen demand (BOD5), chemical oxygen demand (COD), total nitrogen (TN), nitrate (NO3-N), ammoniacal nitrogen (NH4-N), total phosphorus (TP), orthophosphate (PO4-P), total organic carbon (TOC), total alkalinity, oil & grease [Total], oil & grease [hydrocarbon], lead (Pb), zinc (Zn), mercury (Hg) and Enterococcus.	• At least one point directly downstream of all streams crossing the project site • Ex-situ measurements for water quality, and flow rates, at the same points as baseline survey for S1	• To maintain baseline conditions
	Implementation of TSS monitor and CCTV • Total Suspended Solids (TSS)	• Every discharge point	• Sewerage and Drainage (Surface Water Drainage) Regulation 2007
Ground-borne Vibration	Continuous monitoring of ground-borne vibration levels • PPV (mm/s)	• At the edge of the retained section of Tengah forest	• 3.0mm/s at the edge of the retained section of Tengah Forest

13.4 EMMP Reporting

Fortnightly Site Environmental Control Report

Prior to the start of works, the ECO shall prepare the Site Environmental Control Programme. During the construction stage, the ECO must submit fortnightly Site Environmental Control Reports (SECR) to the Project Manager, which includes an assessment of the environmental efforts undertaken and a review of their effectiveness.

The ECO is responsible for regularly inspecting construction activities to ensure that environmental protection and pollution control measures are implemented properly and on time, based on the CEMMP's recommendations. All observations and actions taken by the ECO should be recorded and included in the SECR. Findings documented within the SECR are to be included in the EPR, as described in the next section.

Monthly Environmental Performance Report

The EMMP Consultant shall prepare a Monthly Environmental Performance Report. This report should be submitted to the project management team, JTC, and any relevant technical agencies. The monthly environmental performance report will include the following:

- Description of project activities conducted on site during the month
- Status of CEMMP implementation
- Monitoring records for the following:
    - Flora and Fauna monitoring report
    - ECM discharge monitoring report
    - Water quality monitoring
    - Noise monitoring report
    - Air quality monitoring report
- Environmental objectives (i.e., compliance, potential non-compliance and mitigating actions)
- Environmental non-compliance (i.e., warnings, fines, stop-work orders etc.)
- Wildlife encounters, injuries, and mortality record
- Environmental inspection records
- Environmental incident reports
- ECO site environmental control report
- Environmental training records
- Minutes of environmental meetings
- Grievance records

13.5 Non-Compliance and Remedial Action

In the event of non-compliance of the Contractor with the requirements of the EMMP, the following process is recommended:

- The Employer to issue a notice of non-compliance to the Contractor, stating the nature and magnitude of the contravention.
- The Contractor to provide the Employer with a written statement describing remedial actions to be taken to rectify the non-compliance and expected results of the actions.

- The Contractor to correct the non-compliance within a period that is stipulated by the Employer, to provide the Employer with documented evidence of the completed remedial actions and obtain the Employer's approval for closure of the non-compliance notice.

If the Contractor fails to remedy the non-compliance within the predetermined timeframe or if the non-compliance gives rise to physical environmental damage, the Employer may take action (e.g. impose a penalty, require specific remedial action to be undertaken or stop work) based on the conditions of contract.

13.6 Feedback Management

The Contractor will establish a feedback management process to ensure that any complaints or feedback received from stakeholders are appropriately recorded, investigated, and resolved where required throughout the Developments. The main components of the feedback process will include:

- Prompt acknowledgement and response to stakeholder complaints, keeping them informed of the progress and outcomes
- Accurate records of complaints, investigations and outcomes are maintained
- Resolution within a specified timeframe (proposed four weeks)
- An escalation mechanism in the event that complaint cannot be resolved by the Developer(s) within the specified timeframe
- Assign responsibility and accountability to individual(s) such as Public Relations Officer (PRO) within the Developer(s) for administering the feedback procedure
- Government Agencies to be kept informed of complaints, where required.

13.7 Management of Change

Deviations from the scope of work might occur during execution of the Developments. Change is an inevitable part of the development, so managing and reviewing change during the execution phase is an important factor in success of the Developments. The overall aim of the EMMP is to ensure that environmental management is implemented, and its performance monitored. This means there must be scope for corrective action to be taken if required. It may be necessary to make modifications to the EMMP over the course of the Developments when:

- Unanticipated environmental impacts are identified that require additional mitigation
- When mitigation proposed proves ineffective or unable to be implemented
- When the Developments change in a way that is substantially different to that described in the EIA (e.g. internal changes initiated by the project team, external changes initiated by the Developer; or external changes that are a result of third-party stakeholders)

The overall responsibility for the management of change to the EMMP during construction and operation phase rests with the Employer in consultation with the relevant specialists and/or technical agencies where required. The steps for managing change to the EMMP are as follows:

- Identify and describe unanticipated impacts, ineffective mitigation or changes in the Developments construction or operation that require updates to the EMMP

- Suggest mitigation to manage the identified issues
- Concerns/issues could, for example, be highlighted in site inspection reports or progress calls with the Developer(s) on an ongoing basis
- Review and update the EMMP in consultation with the relevant specialists and/or technical agencies
- Record recommended corrective action in a Minutes of Meeting.

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