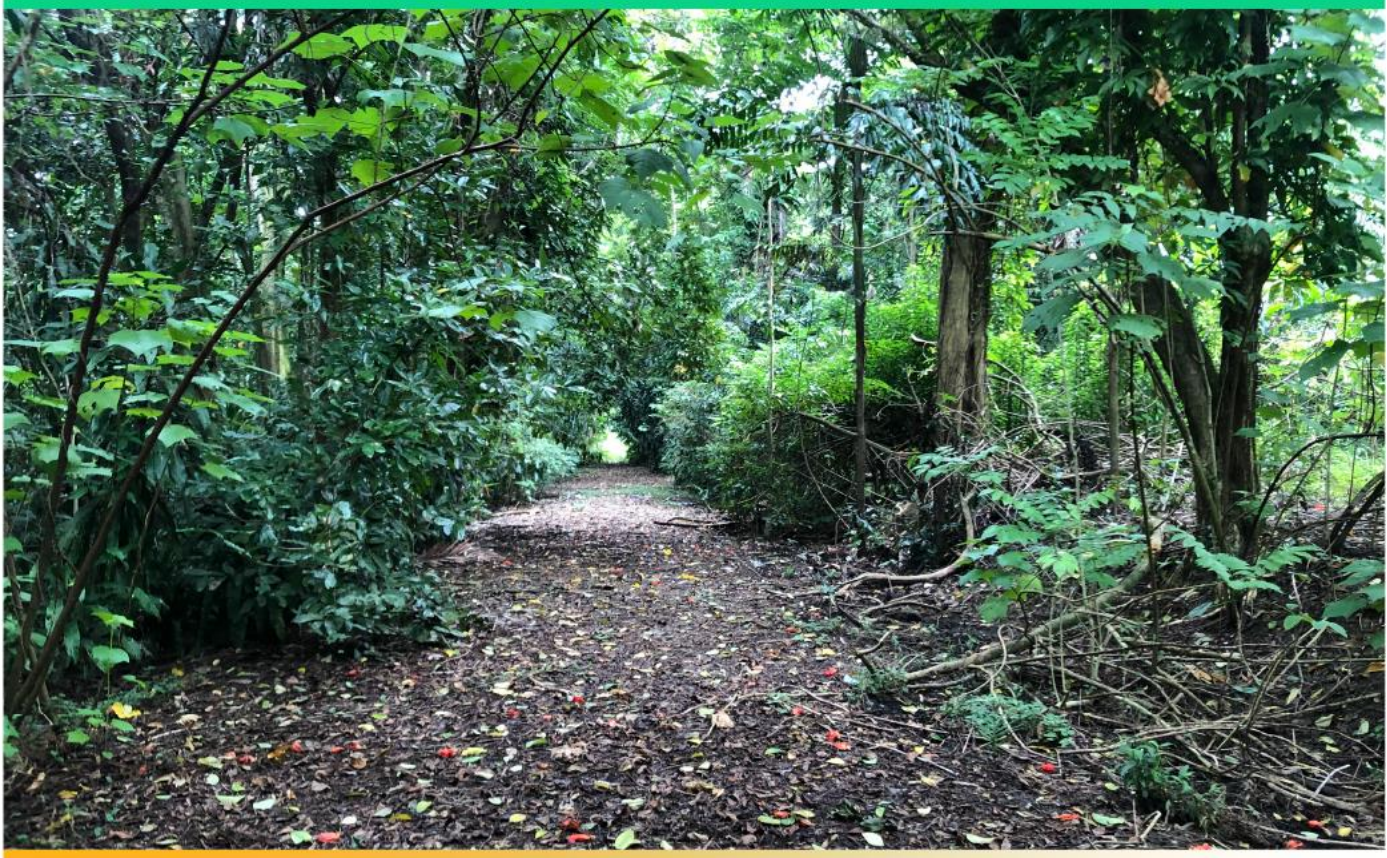


Specialist Consultancy Services for Environmental Impact Study at Tengah Town

Environmental Impact Study (EIS) Report

D3332600/F/4

3 November 2021

Housing and Development Board (HDB)



L/361/19

Specialist Consultancy Services for Environmental Impact Study at Tengah Town

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Acronyms and Abbreviations

$\mu g/m^3$	Microgram per Cubic Metre
1D	One Dimensional
2D	Two Dimensional
a.m.	Ante Meridiem
ABC	Active. Beautiful. Clean.
AECOM	AECOM Singapore Pte Ltd
ALARP	As Low As Reasonably Practicable
amsl	Metres above sea level
AOD	Above Ordnance Datum
APHA	American Public Health Association
APSN	Association for Persons with Special Needs
AQG	Air Quality Guidelines
ASR	Air Sensitive Receiver
AVA	Agri-Food and Veterinary Authority Aquaculture Technology Department
AVS	Animal and Veterinary Service
BOD	Biological Oxygen Demand
BOD_5	5-day Biological Oxygen Demand
C&D	Construction and Demolition
CCNR	Central Catchment Nature Reserve
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
COMET	Committee for Marine Projects
COP	Code of Practice
COVID-19	Coronavirus Disease 2019
CR	Critically Endangered
CS	Conservation Significance
CUGE	Centre for Urban Greenery and Ecology
dBA	A-weighted decibels
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DSTA	Defence Science and Technology Agency
EBS	Environmental Baseline Study
ECB	Erosion Control Blanket
ECM	Earth Control Measures

ECMO	Earth Control Measures Officer
ECO	Environmental Control Officer
ED	Earth Drain
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EMMP	Environmental Management and Monitoring Plan
EN	Endangered
EPA	Environmental Protection Agency
EPCC	Engineering and Procurement Consulting Consultant
EPHA	Environmental Public Health Act
EPM	Environmental Protection and Management
EPMA	Environmental Protection and Management Act
ES	Environmental Score
ESC	Erosion and Sediment Control
et al.	et alia
etc.	et cetera
EW	Extinct in the Wild
EX	Extinct
FEM	Federal Equivalent Method
FRM	Federal Reference Method
GIS	Geographic Information System
GN	Gomak Norite
GPS	Global Positioning System
HDB	Housing and Development Board
HEL	Highly Erodible Land
HK EPD	Hong Kong Environmental Protection Department
HSA	Health Science Authority
Hz	Hertz
i.e.	*id est*
ICM	Integrated Catchment Modelling
IDF	Intensity-duration Frequency
IDL	Insect Diversity Lab
ITE	Institute of Technical Education
IUCN	International Union for Conservation of Nature
JID	Jurong Innovation District
Jq	Queenstown Facies
JRL	Jurong Region MRT Line

Jt	Tengah Facies
K	Soil Erodibility Factor
Ka	Alluvial Member
kHz	Kilohertz
KJE	Kranji Expressway
km	Kilometre
km/hr	Kilometre per Hour
L_{Aeq}	A-weighted equivalent continuous sound level
LCKNHM	Lee Kong Chian Natural History Museum
LCU	Landscape Character Unit
LiDAR	Light Detection and Ranging
LS	Combined Effects of Slope Length and Steepness
LTA	Land Transport Authority
LVIA	Landscape and Visual Impact Assessment
m	Metre
m/s	Metre per Second
mbgs	Metre below ground surface
Met	Meteorological
mg/L	Milligrams per Litre
MHMN	Mean High Water Neaps
MHWS	Mean High Water Springs
MINDEF	Ministry of Defence, Singapore
ML	Mean Level
MLS	Marchwood Laboratory Services (Singapore) Pte Ltd (MLS)
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MND	Ministry of National Development
MPA	Maritime and Port Authority
MRF	Materials Recovery Facility
MRT	Mass Rapid Transit
ms	Milliseconds
MUSLE	Modified Universal Soil Loss Equation
n	Roughness coefficient
N.A.	Not Applicable
NE	Presumed Nationally Extinct
NEA	National Environment Agency
NMDS	Non-metric Multidimensional Scaling

NMP	Noise Management Plan
NO_2	Nitrogen Dioxide
NO_3	Nitrate
NParks	National Parks Boards
NSR	Noise Sensitive Receiver
NTU	Nanyang Technological University
NUS	National University of Singapore
O_3	Ozone
OA	Old Alluvium
^oC	Degree Celsius
p.m.	Post Meridiem
PE	Potential Soil Erodibility
PERMANOVA	Permutational Multivariate Analysis of Variance
pH	Potential of Hydrogen
PIE	Pan-Island Expressway
PLD	Precise Levelling Datum
PM_{10}	Particulate Matter of Diameter 10 Micrometres or Less
$PM_{2.5}$	Particulate Matter of Diameter 2.5 Micrometres or Less
PME	Power Mechanical Equipment
PO_4	Phosphate
PRO	Public Relation Officer
PUB	Public Utilities Board
PVC	Polyvinyl chloride
PWC	Public Waste Collector
QECP	Qualified Erosion Control Professional
QP	Qualified Person
R	Rainfall Erosivity Factor
RAC	Recommended Area of Conservation
Rev	Revision
RIAM	Rapid Impact Assessment Matrix
SAAQT	Singapore Ambient Air Quality Target
SAC	Species Accumulation Curve
SDA	Sewerage and Drainage Act
sec	Second
SFA	Singapore Food Agency
SHD	Singapore Height Datum
SHE	Social, Health and Environment

SI	Soil Investigation
SING	Singapore Botanic Gardens' Herbarium
SLA	Singapore Land Authority
SO_2	Sulphur Dioxide
SRDB	Singapore Red Data Book
SS	Singapore Standard
SSMP	Site Specific Management Plans
SULE	Safe Useful Life Expectancy
SWL	Static Water Level
TA	Technical Agencies
Tc	Time of concentration
TDS	Total Dissolved Solids
TPZ	Tree Protection Zone
TSR	Tengah Service Reservoir
TSS	Total Suspended Solids
URA	Urban Redevelopment Authority
US	United States
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VSR	Visually Sensitive Receptor
VU	Vulnerable
WHO	World Health Organisation
WQ	Water Quality
WSP	Water Standpipe
WSQ	Workforce Skills Qualifications
WTE	Waste-to-Energy
ZVI	Zones of Visual Influence

1. Introduction

1.1 Study Background

On Dec 17, 2019, the Housing and Development Board (HDB) awarded the "Specialist Consultancy Services for Environmental Impact Study (EIS) at Tengah Town" (hereinafter referred to as "the EIS") to CH2M HILL Singapore Pte Ltd (a Jacobs' Company[1], hereinafter will be referred to as "CH2M HILL").

The EIS original contract term was 9-months with expected completion by Sept 17, 2020. As a result of the Coronavirus Disease 2019 (COVID-19) impact and the Revised Environmental Impact Assessment (EIA) Framework, the contract timeline for the EIS has been extended until January 2022.

1.2 Environmental Impact Study (EIS) Team

The EIS Team responsible for delivering this EIS Report consists of the following key team members:

Table 1.1: Team Composition for the EIS

S/N	Name of Professional	Position Assigned
1	Alicia Wong Yoon Lee	EIS Lead/Project Manager
2	Catherine Baldedara	Deputy Project Manager/Lead Consultant (Water Quality)/ Consultant (Geology and Groundwater)
3	Jaslyn Chan	Coordinator/Lead Consultant (Ecology and Biodiversity)
4	Ng Chin Boon	Lead Consultant (Surface Hydrology Modelling)
5	Malvin Manueli	Lead Consultant (Surface Hydrology, Geology and Groundwater)
6	Joan Julia	Lead Consultant (Air and Noise)
7	Hayden Burge	Lead Consultant (Landscape and Visual)
8	Joys Tan	Lead Consultant (Fauna)
9	Chloe Tan	Consultant (Fauna)
10	Boo Chih Min	Lead Consultant (Flora)
11	Siti Zaleha Abdullah	Consultant (Flora)
12	Derek Yap	Lead Consultant (Arboriculture)

1.3 EIS Report Structure

The structure of this EIS Report is shown as below with **Appendices** at the end.

Section	Title	Content
1.	Introduction	Overview of the study background, EIS Team Members, and report structure.
2.	EIS Requirement for the Project	Outline of the need for this EIS, with applicable environmental legislation, study objectives, scope of works, limitations, EIS Study Area and study components.

[1] CH2M HILL Singapore Pte Ltd was acquired by Jacobs Engineering Group Inc in 2017 with full integration done in July 2019.

Section	Title	Content
3.	Project Description	Description of the project background, location, historical land use, conceptual planning land use, committed developments, project activities, and implementation schedule.
4.	Geomorphology, Hydrogeology and Soil	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the geomorphology, hydrogeology and soil aspects.
5.	Surface Hydrology	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the surface hydrology aspect.
6.	Water Quality	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the surface water quality aspect.
7.	Ecology and Biodiversity	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the ecology and biodiversity aspects.
8.	Airborne Noise	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the airborne noise aspect.
9.	Ambient Air Quality	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the ambient air quality aspect.
10.	Visual and Landscape	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the visual and landscape aspect.
11.	Waste Management	Applicable legislation, assessment methodology, baseline results, evaluation of potential impacts (including cumulative impacts), recommendation of prevention and mitigation measures as well as residual impacts for the waste aspect.
12.	Environmental Management and Monitoring Plan	Outline of responsible parties with their respective roles and responsibilities in implementing, managing, performance monitoring and auditing of actions arising from recommended prevention and mitigation measures.
13.	Conclusion	Conclusion of the EIS.
14.	Reference	Reference material used for preparation of this EIS Report.

2. Environmental Impact Study (EIS) Requirement for the Project

2.1 EIS Requirement for Tengah and the Project

The EIS for the housing district development under the Phase 3 earthwork scheme in the EIS Study Area (hereinafter referred as "the Project") was requested by HDB (as the developing agency) via a Tender process in August 2019. This EIS is established to follow the study scopes required as per the Tender Specification.

2.2 Applicable Environmental Framework Legislation

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

In addition to the EPMA, the following Acts and their subsidiary regulations (**Table 2.1**) are also relevant to environmental protection in Singapore with implications to this EIS.

Table 2.1: Acts and Subsidiary Regulations

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Parks, Tree and Flora Protection	• Parks and Trees Act and its relevant Orders and Regulations	NParks
Animal/ Wildlife/ Fauna Protection[2]	• Wildlife Act •	Animal and Veterinary Service (AVS)[3]
Development and Redevelopment	• Planning Act	MND/URA
Reservoirs and Catchment Area Protection	• Public Utilities Act (Reservoirs and Catchment Areas) Regulations, 2006	Public Utilities Board (PUB)
Sewerage and Drainage Planning and Development	• Sewerage and Drainage Act and its subsidiary legislation	PUB
Noise at Construction Sites	• Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008	NEA
Air Pollution	• Environmental Protection and Management (Vehicular Emissions) Regulations 2008 • Environmental Protection and Management (Air Impurities) Regulations 2008 • Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2008 • Singapore Air Quality Targets	NEA

[2] Formerly administered and enforced by Agri-Food & Veterinary Authority of Singapore (AVA)
[3] AVS is a cluster within NParks, formed on 1 April 2019, https://www.nparks.gov.sg/avs/who-we-are/about-avs/who-we-are

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Water Pollution	• Environmental Protection and Management (Trade Effluent) Regulations 2008	NEA
Public Health and Environment	• Environmental Public Health Act (EPHA)	NEA
Waste	• Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, 2000	NEA
Vector Management	• Control of Vectors and Pesticides Act, 2002	NEA

2.3 EIS Objectives, Scope of Works and Limitations

The purpose of this EIS is to provide an assessment of the nature and extent of potential environmental impacts and cumulative impacts arising from the development of the Project within the EIS Study Area against the Tengah Master Plan 2019 gazetted by URA. This is assessed in association with the existing/ committed/ planned or known potential developments by other stakeholders/ agencies on environmental sensitive receptors, located within and in close proximity of the EIS Study Area.

The Scope of Works for this EIS include the following with its overview of deliverables at each stage given in **Figure 2.1**:

- Identify and describe the elements of the community and environment likely to be affected by the Project and other committed developments and/or likely to cause impacts on these projects, including both the natural and man-made environment and the associated environmental constraints to and by the projects.
- Describe the baseline conditions of the EIS Study Area and the environmental constraints.
- Identify, quantify and assess potential impacts and determine the significance of impacts on sensitive receptors.
- Recommend and justify effective prevention and mitigation measures (if any) to minimise potential environmental impacts (e.g. pollution, environmental disturbance and nuisance) during construction and operational phases.
- Identify, predict and evaluate the residual environmental impacts (i.e. after practicable mitigation) and the cumulative effects expected to arise during construction of the Project in relation to the sensitive receptors and potential affected uses.
- Identify, assess and specify methods, measures and standards, to be included during the construction of the Project which are necessary to mitigate the residual environmental impacts and cumulative effects associated with other development and reduce them to minimal levels.
- Investigate the extent of the secondary environmental impacts that may arise from the recommended mitigation measures and to identify constraints associated with the mitigation measures (if any) recommended in the EIS, as well as the provision of any necessary modifications.
- Propose an Environmental Management and Monitoring Plan (EMMP) to document specific monitoring and environmental impact management procedures for the Project.

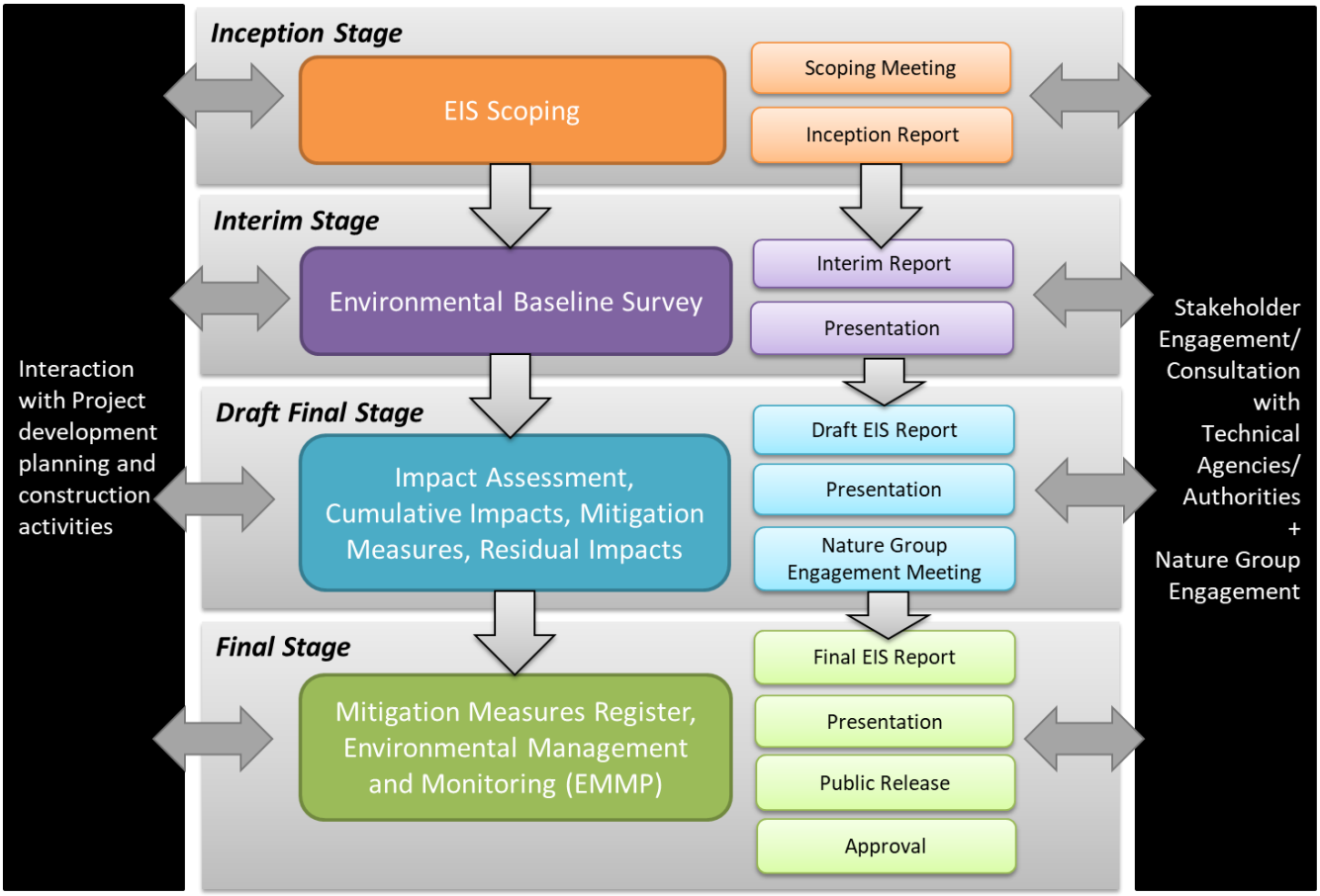


Figure 2.1: Scope of Works and Submission Process Flows of this EIS

2.4 EIS Limitation

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

2.5 EIS Study Area

With reference to the EIS Study Area Boundary defined in **Section 2.3** of the Tender Specifications for the EIS Study Area with ~150 ha as well as Geographic Information System (GIS) study boundary files given by HDB upon Project Award, we have proposed, defined and justified the EIS Study Area as presented in **Figure 2.2**. The EIS Study Area has an area of 166 hectares (ha) following the HDB provided GIS study boundary files. On top of the EIS Study Area, we have added a 150 metre (m) buffer area from the EIS Study Area to capture potential human sensitive receptors in relation to airborne noise (i.e. Noise Sensitive Receiver (NSR)) and ambient air quality impacts (i.e. Air Sensitive Receiver (ASR)) from the development works. The 150 m buffer is derived from the *Environmental Protection and Management (EPM) (Control of Noise at Construction Sites) Regulations*. A 500 m buffer from the EIS Study Area to the north and south was added to capture potential visually sensitive receptors in the community. The 500 m buffer was derived from a visual site analysis. Peng Siang river and Kranji Reservoir were identified as water sensitive receivers (WSRs) being connected to the water network in the EIS Study Area.

This EIS Study Area, located at the northeast tip of the overall Tengah Town development, was presented via the EIS Inception Report and approved to be used for this EIS by HDB and the relevant TAs/ stakeholders (i.e. URA, MND, NEA, PUB, NParks and LTA).



Figure 2.2: EIS Study Area and the Proposed Buffer Area for Air, Noise, Visual and Water Sensitive Receivers

Base Map: ESRI

2.6 EIS Baseline Components

The EIS baseline components (environmental aspects/ resources/ receptors) as listed below are in accordance with the Specifications of the Tender Document and the endorsed Inception Report.

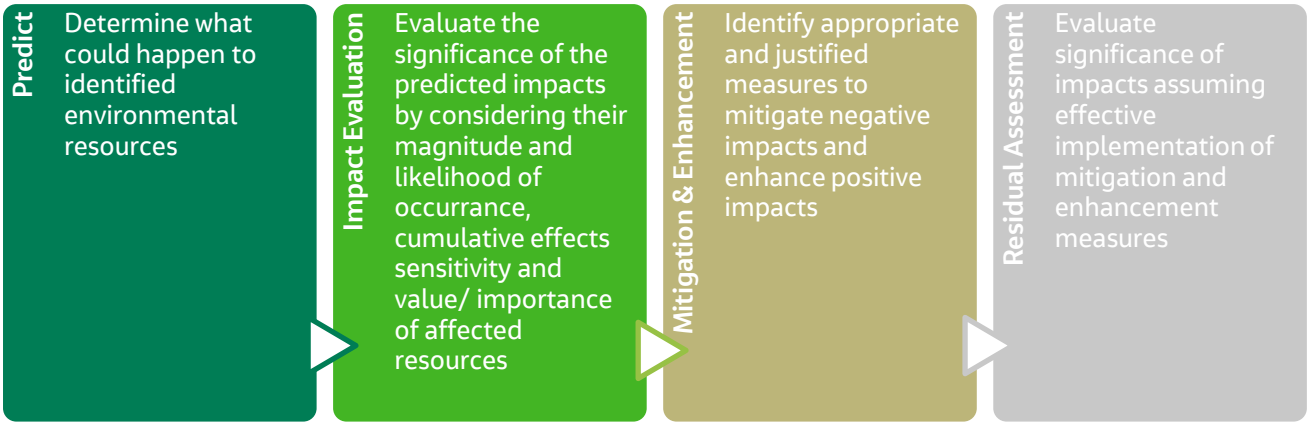
Physical Environment	Biological Environment	Human Environment
• Geomorphology, topography, hydrogeology and soils • Surface hydrology • Water quality • Airborne noise levels • Ambient air quality	• Flora and vegetation • Trees • Ecosystems and the species of flora and fauna, focusing specifically on species and taxonomic groups that are rare and threatened, have significant ecological or keystone functions, or are otherwise of public interest	• Visual and landscape • Waste

The current conditions of the identified environmental aspects/ resources/ receptors were documented via a combination of desktop study of existing available information and gathering primary data through site visits and field surveys that were conducted between February and October 2020. The assembling and evaluation of

the baseline data on the physical environment, biological and human environment was restricted within the defined EIS Study Area, the 150 m buffer (for airborne noise and ambient air quality) and the 500 m buffer from the EIS Study Area to the north and south (for potential visually sensitive receptors in the community). The environmental parameters were collected, measured and presented in ways which are consistent with applicable environmental standards, norms and requirements both national and international. Secondary data from the desktop assessment was used to comprehend primary baseline collection precisely of the EIS Study Area.

2.7 Impact Assessment

The impact assessment approach and methodology for the EIS is given below:



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

2.7.1 Assessment Criterion

The criteria that will be used for the assessment fall into two groups, Group A and Group B, with their respective factors of assessing indicated in **Figure 2.3**.

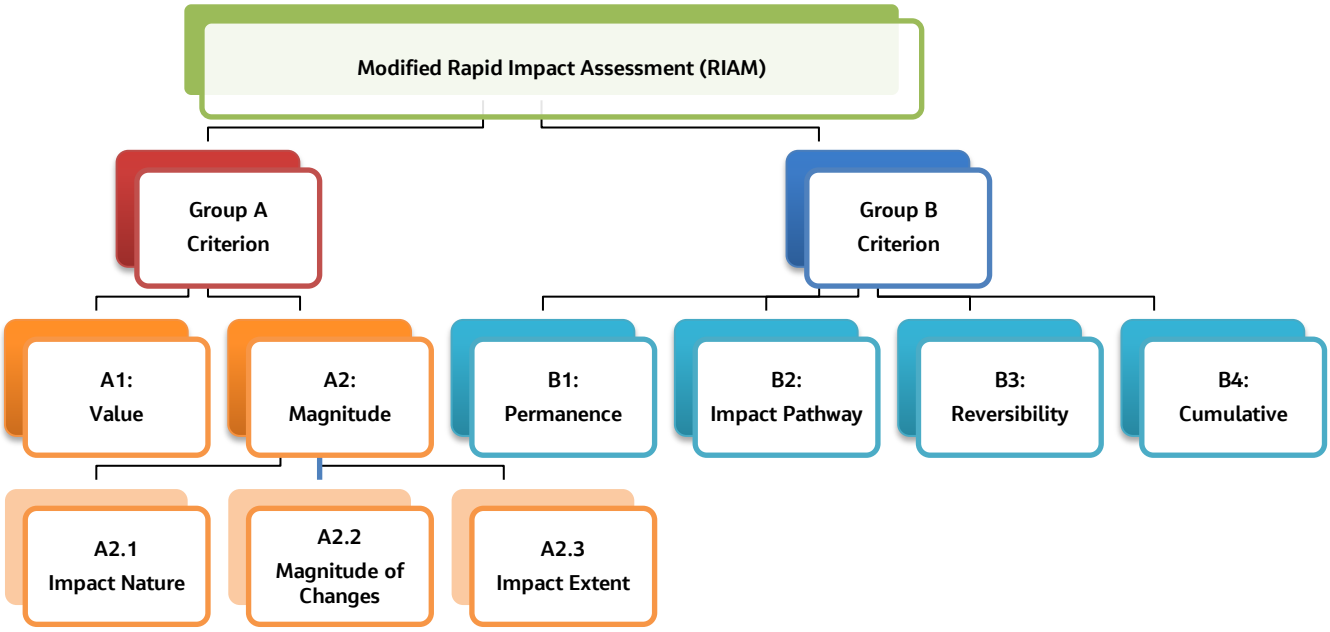


Figure 2.3: Assessment Criteria for Impact Significance following the RIAM Method

2.7.1.1 Group A Criterion

Group A Criterion is the measure of importance of the existing sensitive receiver characteristic with value level (A1) against the magnitude (scale) of the changes whether the impact nature is a beneficial or dis-beneficial impact (A2). Score for Group A will be calculated using multiplication, i.e. (A1) x (A2.1) x (A2.2) x (A2.3) = AT, where (A1) to (A2.3) are the individual criteria scores in Group A and (AT) is the result of multiplication of all Group A scores. The definition and score general criteria considered for Group A is given in **Table 2.2**.

Table 2.2: Definition and Score Criteria for Group A Criterion

Group A Criterion	Score/ General Criteria Considered
A1 – Value Sensitive Receiver Characteristic	**4:** Important to international interest (beyond Singapore) **3:** Important to national/ regional interest (within Singapore context) **2:** Importance to area immediately outside local condition including buffers (i.e. 150 m buffer for NSR/ ASR and 500 m buffer for VSR) (Tengah) **1:** Importance to local condition (EIS Study Area) **0:** No importance, i.e. value does not carry important role in local interest
A2 – Magnitude Measure of the scale of benefit/dis-benefit (impact nature) of an impact or a condition	**A2.1 – Impact Nature (Benefit or Dis-benefit)** **+1:** Positive impact **-1:** Negative impact **0:** Negligible impact/ no change/ status quo

Group A Criterion	Score/ General Criteria Considered
A2 – Magnitude Measure of the scale of benefit/dis-benefit (impact nature) of an impact or a condition	**A2.2 – Magnitude of Changes***
	3: High impact/ changes **2:** Medium impact/ changes **1:** Low impact/ changes **0:** No change/ status quo/ negligible
	A2.3 – Impact Extent (Geographical Extent of the Induced Change)
	4: Transboundary (Impact extend beyond Singapore boundary) **3:** Impact extend up to National boundary **2:** Impact extend beyond local context, i.e. extend up to NSR/ ASR/ VSR/ WSR **1:** Impact within local area, i.e. within the Project footprint **0:** No change/ status quo

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

2.7.1.2 Group B Criterion

Group B Criterion is the measure of value to the situation, but individually should not be capable of changing the score obtained. The criteria factors definition with their individual scope in this group is shown in **Table 2.3**.

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

Table 2.3: Definition and Score Criteria for Group B Criterion

Group B Criterion	Scores/ Definition
B1 – Permanence Whether a condition is temporary or permanent, and should be seen only as a measure of the temporal status of the condition. The time period over which a resource/ receptor is affected	4: Long term effects, i.e. > 10 years (over the lifetime of the Project)
	3: Medium term, i.e. ≥ 3 years ≤ 10 years
	2: Short term, i.e. less than 3 years
	1: Temporary, i.e. less than one month
B2 – Impact Pathway Whether the receivers are directly or indirectly impacted	3: Direct impact
	2: Indirect impact
	1: No change/ not applicable
B3 – Reversibility Whether a condition can be changed and is a measure of the control over the effect of the conditions	3: Irreversible
	2: Reversible
	1: No change/ not applicable

Group B Criterion	Scores/ Definition
B4 – Cumulative Whether the effect will have a single direct impact or whether there will be a cumulative effect over time or synergistic effect with other conditions	3: Cumulative/ synergistic
	2: Non-cumulative/ single
	1: No change/ not applicable

2.7.2 Impact Severity/ Significance

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

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

The severity of impact for each of the evaluated potential impact identified has been categorised using a qualitative scale of severity with range bands as indicated in **Table 2.4**.

Table 2.4: Range bands of Environmental Score (ES) and the corresponding level of Impact Significance

Environmental Score (ES)	Impact Severity/ Significance	Definition
416 to 624	**Extreme Positive Effect**	Impact which causes great improvement or benefit to the existing environment
234 to 415	**Major Positive Effect**	Impact which causes major improvement or benefit to the existing environment
103 to 233	**Moderate Positive Impact**	Impact which causes noticeable improvement or benefit to the existing environment
13 to 102	**Minor Positive Impact**	Impact which causes minor improvement or benefit to the existing environment
4 to 12	**Slight Positive Impact**	Impact which causes slight improvement or benefit to the existing environment
-3 to 3	**No Change/ Status Quo**	No discernible deterioration or improvement to the existing environment
-4 to -12	**Slight Negative Impact**	Impact which causes slight deterioration or dis-benefit to the existing environment
-13 to -102	**Minor Negative Impact**	Impact which causes minor deterioration or dis-benefit to the existing environment
-103 to -233	**Moderate Negative Impact**	Impact which causes a noticeable deterioration or dis-benefit to the existing environment
-234 to -415	**Major Negative Impact**	Impact which causes major deterioration or dis-benefit to the existing environment
-416 to -624	**Critically Negative Impact**	Impact which causes critical deterioration or dis-benefit to the existing environment

2.7.3 Identification and Recommendation Applicable Presentation/Mitigation/ Enhancement Measures

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



Figure 2.4: Mitigation Hierarchy

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

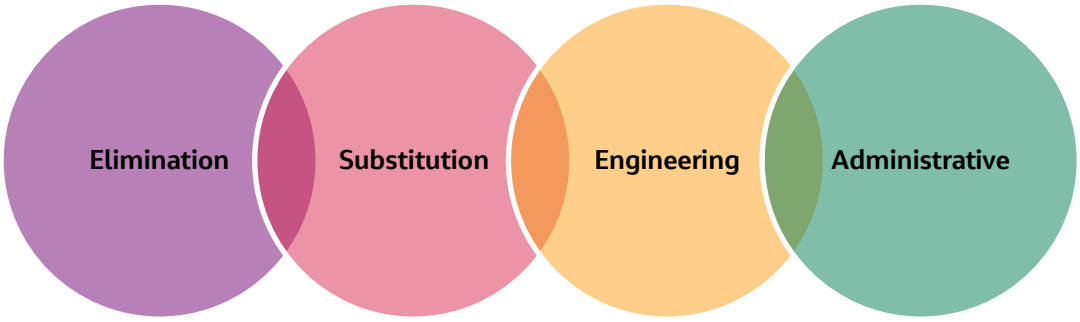


Figure 2.5: Control Method

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

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

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

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

2.8 Development of Specification for Environmental Management and Monitoring Plan

An environmental management and monitoring plan (EMMP) specification for the construction phase of the Project that incorporates the recommended mitigation and enhancement measures will be formulated to address the following:

- Roles and responsibilities of entire workflow and duration of the environmental monitoring phase
- Reporting and communication plans
- Development of a Wildlife Management Plan (with consultation with NParks and PUB) for implementation prior to or as part of the advance works
- Indicators to be monitored (e.g. ecology/ biodiversity and water quality)
- Recommendation of mitigation measures for construction activities
- Monitoring plan with specific monitoring procedures for construction
- Inspection/ monitoring and auditing regimes
- Contingency plans stating clearly the actions to be taken by the responsible parties
- Establishment of a system of reporting and submission of monitoring results and data to allow appropriate quality checks for the recommended mitigation measurements

3. Project Description

3.1 Project Overview

Tengah Town is a new township development in Tengah bounded by the Kranji Expressway (KJE), Pan-Island Expressway (PIE), Brickland Road and Bukit Batok Road in the Western Region of Singapore. The overall Tengah Town development area has a size of 700 ha. It is estimated that, when fully developed, Tengah Town will provide about 42,000 new homes and workplaces in the Western Region of Singapore, and complement other developments in Tengah, Jurong Innovation District and Jurong Lake District (HDB Press Release, 2018).

The concept development of Tengah Town is guided by six key ideas/ features revolving around nature and community (HDB Press Release and Media Factsheet, 2016 and 2018) (**Figure 3.1**):

- Creating five unique housing districts
- Creating a lush evergreen town under the Biophilic Town Framework
- Provision for walking and cycling everywhere
- Provisions for moving around with ease to support Singapore's movement towards a car-lite and people-friendly environment
- Enabling close-knit communities
- Creating a smart and sustainable town



Figure 3.1: Greenery Structure Concept of the Tengah Town Development

Source: https://www.todayonline.com/singapore/peek-tengah-next-new-hdb-town-size-bishan

Tengah Town is planned to be integrated with the area's surrounding greenery and biodiversity. One major attraction will be the creation of an approximately 100 m wide and 5 kilometres (km) long Forest Corridor, in collaboration with NParks, is envisioned to form part of the larger network of greenery that connects the Western Water Catchment Area and the Central Catchment Nature Reserve (CCNR). This Forest Corridor will be planted with rainforest tree species to transform it into a rich forest habitat (HDB Press Release, 2016; HDB Media Factsheet, 2018; and HDB Media Factsheet, 2019).

Tengah Town will also feature the first car-free town centre with lush parks and vehicles plying underneath the town centre. It will offer a greener, car-lite, people-friendly and pedestrian-friendly environment. All the roads in Tengah Town will come with dedicated walking and cycling paths on both sides of the road, to enable residents to enjoy seamless and safe connections for walking and cycling (HDB Press Release, 2016; HDB Media Factsheet, 2018; and HDB Media Factsheet, 2019).

The development of Tengah Town will be guided by the Smart HDB Town Framework, introduced in 2014, where it covers four key dimensions, i.e. smart planning, smart environment, smart estate and smart living. The township will be planned with smart technologies that have features such as smart lighting and the Urban Water Harvesting System (HDB Press Release, 2016; HDB Media Factsheet, 2018; and HDB Media Factsheet, 2019).

Five unique housing districts will be developed in Tengah Town progressively, they are the Plantation, Park, Garden, Brickland and Forest Hill Districts (see **Figure 3.2**). Each of these housing districts will be designed with nature in mind following the development's key ideas. Of the five housing districts, Plantation District, with an area of about 90 ha, was the first district launched by HDB in November 2018. This housing district, when fully constructed, will create 10,000 new homes. Following Plantation District, the next district launched was the Garden District in May 2019, which occupies an area of 80 ha and is estimated to provide up to 6,500 new homes when fully completed (HDB Press Release, 2016; HDB Media Factsheet, 2018; and HDB Media Factsheet, 2019).



Figure 3.2: The Five Housing Districts of Tengah Town development

Source: Press Release Tengah dated Sept 8, 2016. Received from HDB Feb 5, 2020

As shown in **Figure 3.3**, according to the URA gazetted Tengah Master Plan 2019 (Last Revised Date: 27 Nov 2019), the proposed Tengah Town is zoned mainly for residential, commercial and business with land use categories consisting of "Residential", "Commercial & Residential", "Business 2", "Transport Facilities", "Park", "Reserve Site", "Health & Medical Care" and "Education Institution". The new township will be supported by necessary facilities and utilities, i.e. road, Mass Rapid Transit (MRT) lines and stations, power supplies and water supplies.

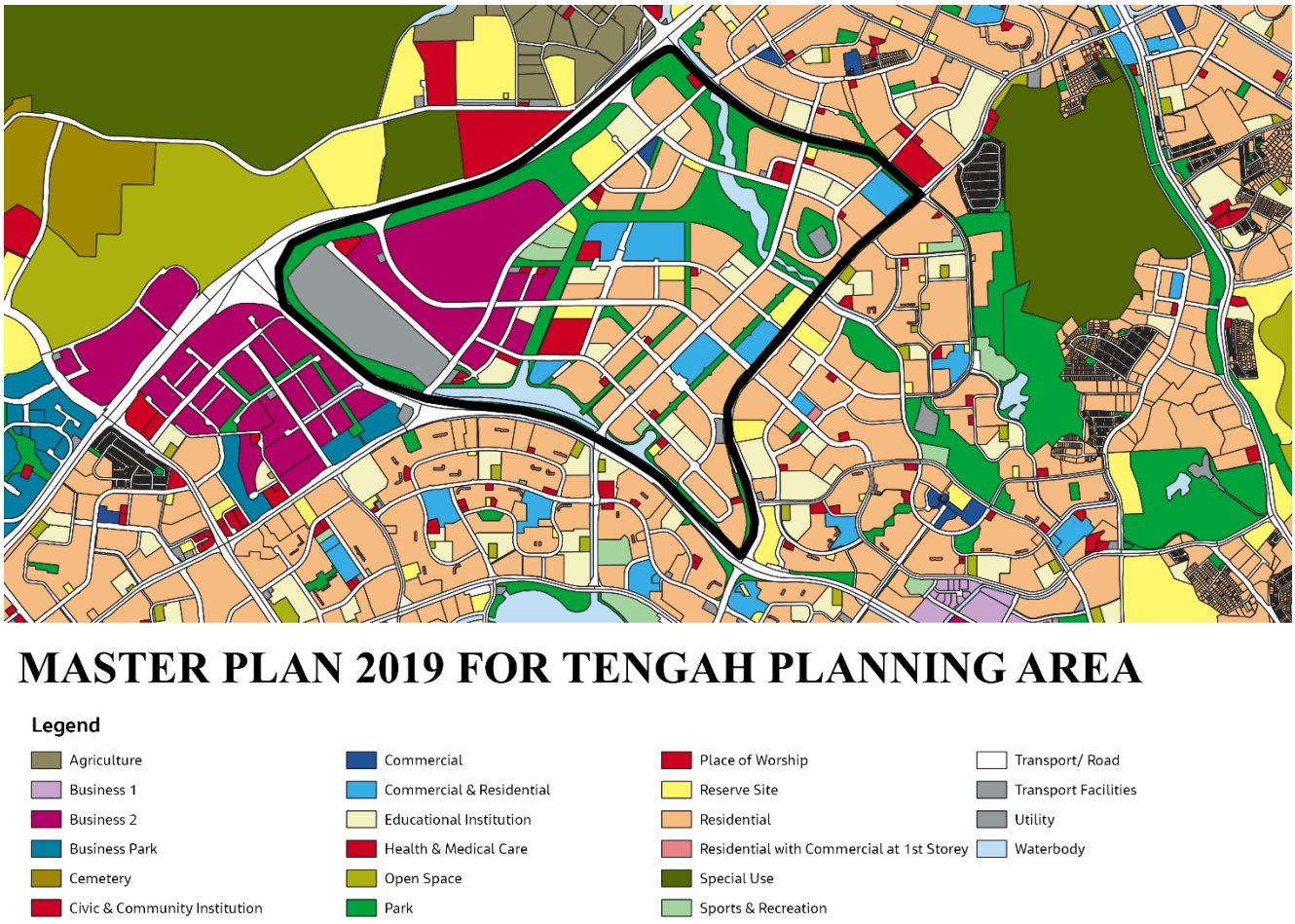


Figure 3.3: The URA Master Plan 2019 for Tengah Planning Area (Indicated in Black Outlined)

Source: adopted from URA Master Plan 2019 (https://www.ura.gov.sg/maps/?service=MP)

3.2 Description of the EIS Study Area

3.2.1 Location

The EIS Study Area encompasses the northeast portion of the overall Tengah Town development area is currently located at Tengah bounded by Brickland Road at the north, Bukit Batok Road at the east and Tengah forested area at south and west (see **Figure 3.4**).



Figure 3.4: Location of the EIS Study Area is indicated by the red outline, while the additional 150 m buffer for noise- and air-sensitive receivers is indicated by the yellow outline and the visually sensitive receivers indicated by the purple buffer. Also shown is the location of the water sensitive receivers, Peng Siang River and Kranji Reservoir. Key plan shows the location of the EIS Study Area within Singapore.

Base Map: ESRI

3.2.2 Historical Land Use

3.2.2.1 Etymology of Tengah

Tengah's etymology is believed to come from its historical ownership, and not of a language origin although Tengah does means "Central" in Malay. In 1853, a man named Teng Ah Ting (variations spelt Teng Ah Tong, Ten Ah Tong) was given concession to farm the land now known as Tengah. Due to its proximity to the Kranji River, it was hence established as a "chu kang", which referred to farming land established by the riverside. Early Chinese settlers had a practice of naming riverside villages by the family clan which controlled the village, which led to the area being called Teng Chu Kang. Teng Ah Ting, the head of the farm, was also colloquially known as Teng Ah, which resulted in his farm occasionally being recorded as "Teng Ah Kang" and the tributary river beside his farm being called Teng-ah river. Over time, the name "Teng-ah" came to replace most references to the area (Tann, 2017).

3.2.2.2 Historical Land Use

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

In Tengah, as plantations grew less lucrative, villages, small scale farms, brickwork factories and coconut plantations moved in to replace the abandoned land before it was eventually drafted as military land where it has remained as until the plans to develop it into a town estate were announced. A brief time summary of major developments within Tengah where the EIS Study Area is located can be found in **Table 3.1** is based on a mix of historical maps, photographs and research. A series of historical maps can also be found in **Figure 3.5**.

Table 3.1: Timeline Summary of Major Development at the EIS Study Area

Year	Major Development
1853	Established as part of a riverside farm with gambir and pepper plantations.
1900s	Transition from gambier and pepper plantations towards rubber plantations.
1945	The area is largely devoted to rubber plantations, with a small segment of forested area and a couple of housing estates scattered within the EIS Study Area.
1966	The extent of the rubber plantation has been reduced, with a portion of land marked out as sundry[4]. Brickwork factories have been built around Tengah but none in the EIS Study site. A large portion of land has transitioned to grassland. A much larger number of inhabitants resided in the area.
1975	Rubber plantations are much more limited in the area, with mostly minor cultivation or sundry as well as a small coconut plantation.
1980s	Villagers in Tengah were progressively relocated under Singapore's government resettlement plans, demolishing much of the Kampongs which resided there.

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

Year	Major Development
1993	Land is no longer used for plantations and vegetation mainly consisted of sundry trees. A couple of Chinese temples are noted to be within the area. The upper reaches of Sungei (River) Peng Siang which runs through the central of Study Area has been straightened and concretized into a water canal. Bukit Batok Road which borders the southeast of the EIS Study Area has been built.
1998	The western side of Tengah has been restricted for military training purpose, settlements have mostly shifted out and the area allowed to revegetate.
2005	The Tengah site including the EIS Study Area is completely closed off to the public and restricted for military use.
2008	Brickland Road, which borders the northeast of the EIS Study Area, has been built.

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

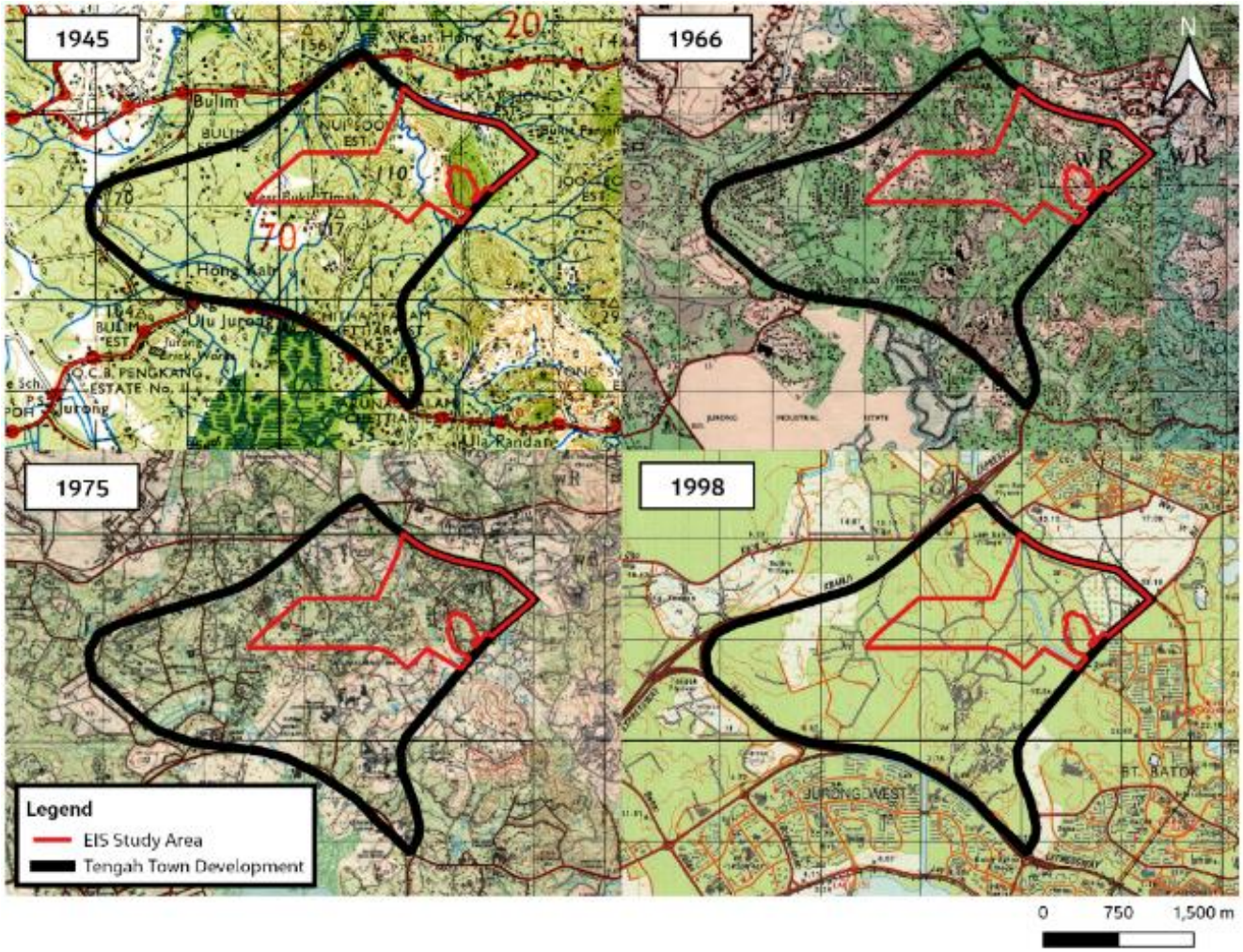


Figure 3.5: Topographic Map of Tengah (outlined in black) and the EIS Study Area (outlined in red) (1945-1998)

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

3.2.3 Current Land Use

The EIS Study Area is presently used as a military training ground by the Ministry of Defence, Singapore (MINDEF). The major land cover of the EIS Study Area are secondary forest habitats with a smaller portion of shrubland and grasslands. Non-vegetated areas represent a very small fraction of the EIS Study Area, and consist of a monsoon canal at the centre, freshwater streams, ponds and dirt tracks. The EIS Study Area also serves as an ecological corridor linking the two largest contiguous forest areas in Singapore – Western Water Catchment Area to the West and the CCNR via Bukit Batok to the East.



Figure 3.6: Aerial Map of Tengah EIS Study Area in 2020

Base Map: ESRI and Orthophoto from LiDAR survey (June 2020)

3.2.4 Future Land Use

The future land use development planning for Tengah Town is earmarked in the URA's Tengah Master Plan 2019 as indicated in **Figure 3.7**.

Development of the overall Tengah Town is by stages, planned over three broad terms as shown in **Figure 3.8**.

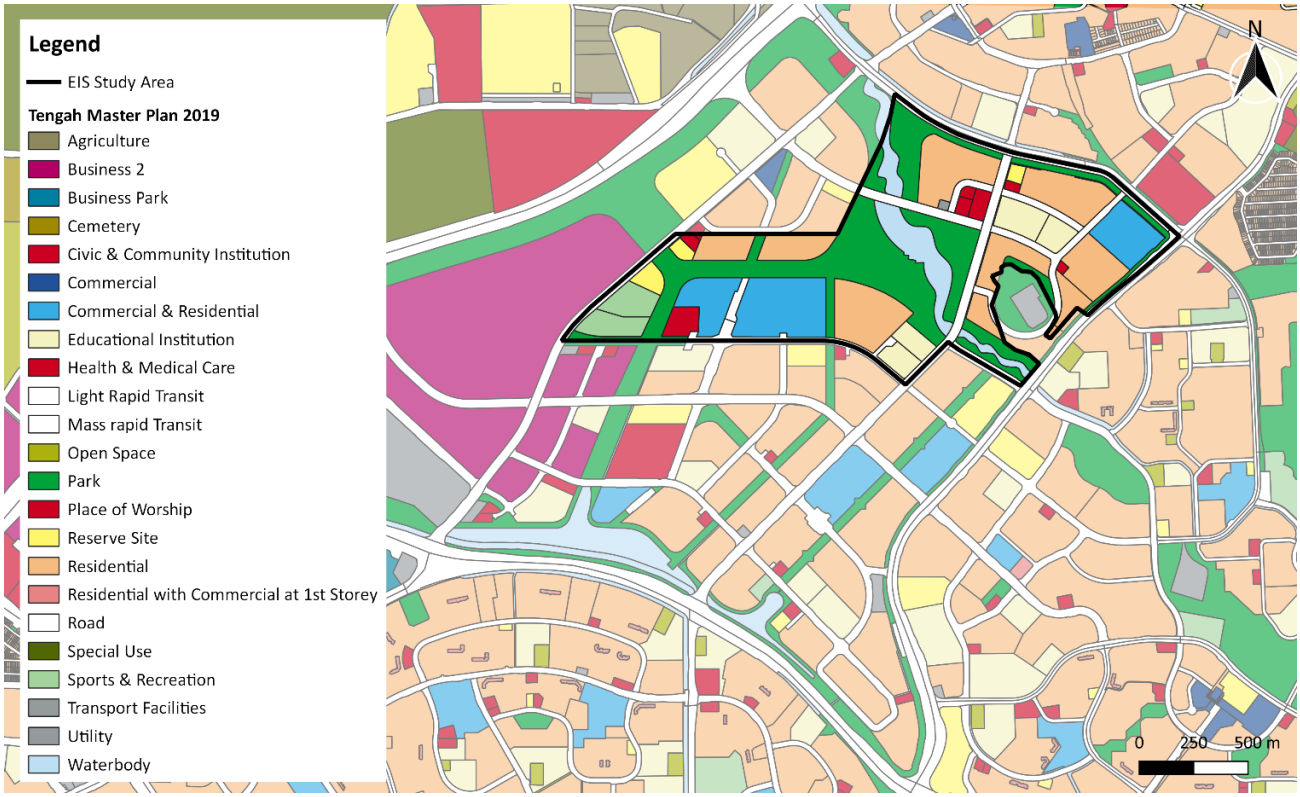


Figure 3.7: Location of the EIS Study Area within the Tengah development area, showing the land use zoned under the Tengah Master Plan 2019

Source: Base Map obtained from Tengah Master Plan 2019 gazetted by URA

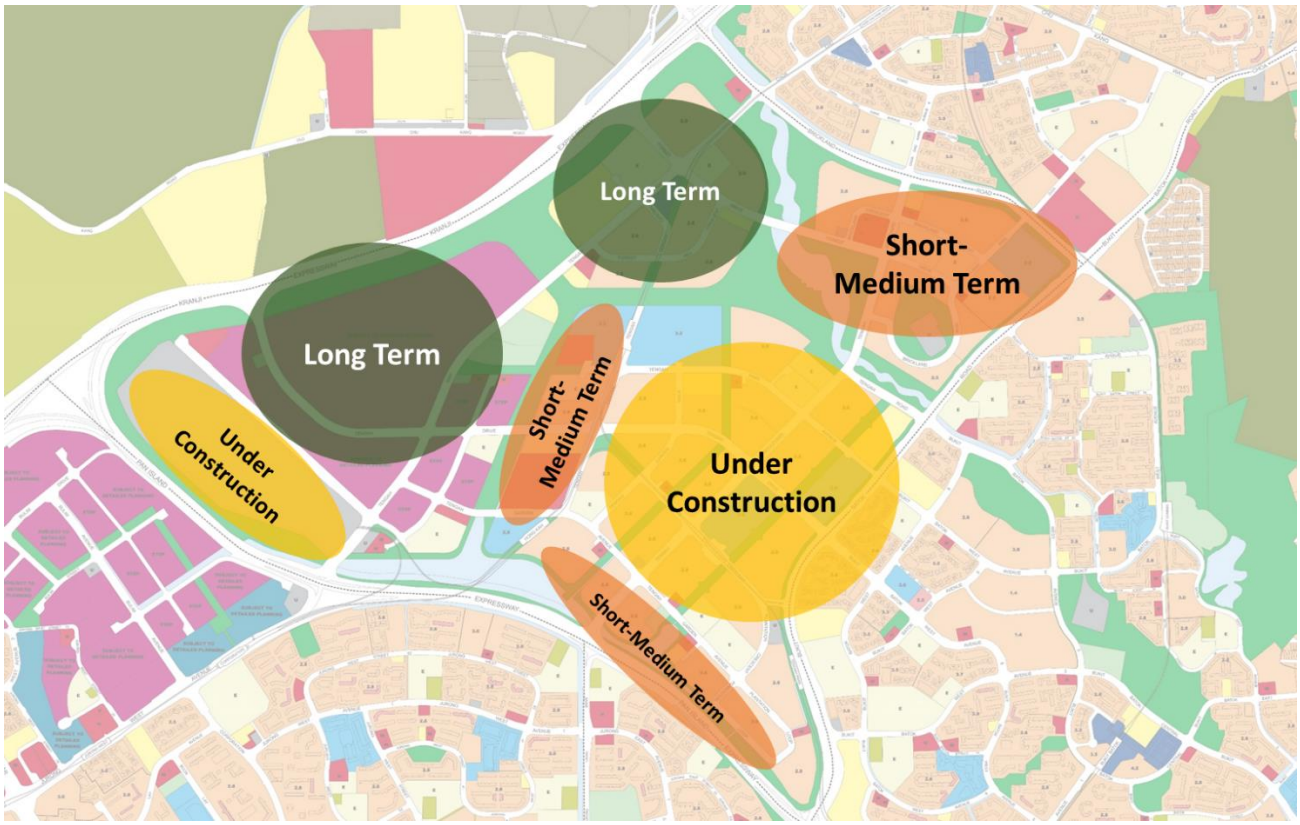


Figure 3.8: Tengah Town Development Broad Phasing (Subject to Change)

Multiple agencies are involved in the overall Tengah Town development and in refining the gazetted Tengah Master Plan 2019. This includes URA, HDB, LTA, PUB and NParks.

As indicated in **Section 2**, this EIS aims to assess the environmental impacts arising from the Project – HDB's Phase 3 development – the new housing districts, i.e. Brickland District and portion of Park District (P3-14 and P3-15). Given the presence of ecologically- and environmentally-sensitive receivers in the development footprint, immediate vicinity of the development footprint within the EIS Study Area and the sensitive buffer areas, the EIS is also to evaluate the cumulative impacts arising from committed developments by other stakeholders/ agencies interacting with the Project on these sensitive receivers.

The key committed upcoming developments that will be included in cumulative impact assessment of this EIS are listed in **Table 3.2** and with their respective development boundaries and locations indicated in **Figure 3.9**.

Table 3.2: Committed/ Future Developments for Cumulative Assessment in this EIS

Future/ Committed Development	Development Planning and Key Development Components	Location	Distance/ Direction from Project Development Footprint
Tengah Town Centre 	The first car free town centre in Singapore where roads run beneath the town centre to provide separation from road traffic for friendly walking, cycling and recreational activities.	Within the EIS Study Area	0.5 km to the west
Forest Hill District 	The district will be bordered by Forest Corridor and Central Park to bring nature to the doorsteps of the residents. Detailed land use planning was not available at the time of preparation of this EIS.	Eastern part of this Forest Hill District is within the EIS Study Area	0.5 km to the west
Central Park 	A 20-ha park which consists of an amphitheatre integrated with waterbodies for recreational purpose.	Within the EIS Study Area	0.3 km to the west
Forest Drive Construction 	A new road in Tengah Town.	Eastern arm encroaching to EIS Study Area	Less than 100 m adjacent to northwest

Future/ Committed Development	Development Planning and Key Development Components	Location	Distance/ Direction from Project Development Footprint
Forest Corridor, Forest Stream and Forest Fringe 	A 100 m wide and 5 km long Forest Corridor with forest fringe for ecological connectivity linking the two largest contiguous forest areas in Singapore – Western Water Catchment Area and the CCNR, with the forest fragments in Bukit Batok Hillside Park, Bukit Batok Town Park, and Bukit Batok Nature Park acting as connective intermediaries. There will be seven grade separated wildlife crossings and culvert planned along this Forest Corridor. Under the same project the design of the existing concrete canal, will be further studied to explore opportunities to naturalise into a "Forest Stream".	Eastern portion of the corridor is within the EIS Study Area. North-western portion of this corridor runs along the western border of Tengah Town/ KJE	Adjacent to the west
Jurong Region Line (JRL) 	A new elevated MRT line with total of 24 stations that planned to serve Choa Chu Kang, Tengah, Jurong West, Jurong Industrial Estate, Nanyang Technological University (NTU), and Jurong East to West Coast. The total route length is 23 km. The elevated alignment that runs 4.3 km between Choa Chu Kang and Tengah consisting of three stations (JS1 Choa Chu Kang Interchange, JS2 Choa Chu Kang West and JS3 Tengah) is under LTA Contract J102. Contract J102 scope is to build the three stations, viaducts and ancillary amenities. The construction commenced in September 2019 and is expected to be completed by March 2026.	The elevated MRT line will cross the western region of the EIS Study Area, with JS3 Tengah Station located within the EIS Study Area.	1 km to the west
Tengah Service Reservoir (TSR) 	A potable water reservoir that will serve up to 48,000 dwelling units, industrial and commercial developments in Tengah Town and nearby areas which. EIS for the project was completed in 2019.	Adjacent to EIS Study Area, within the 150 m buffer area for study. In Tengah Town.	50 m

Source: HDB, 2020a; HDB, 2020b; HDB, 2020c; HDB, 2020d; HDB, 2020e; HDB, 2019; LTA, 2019; LTA, 2020a; LTA, 2020b; LTA, 2020c; and Meinhardt, 2019

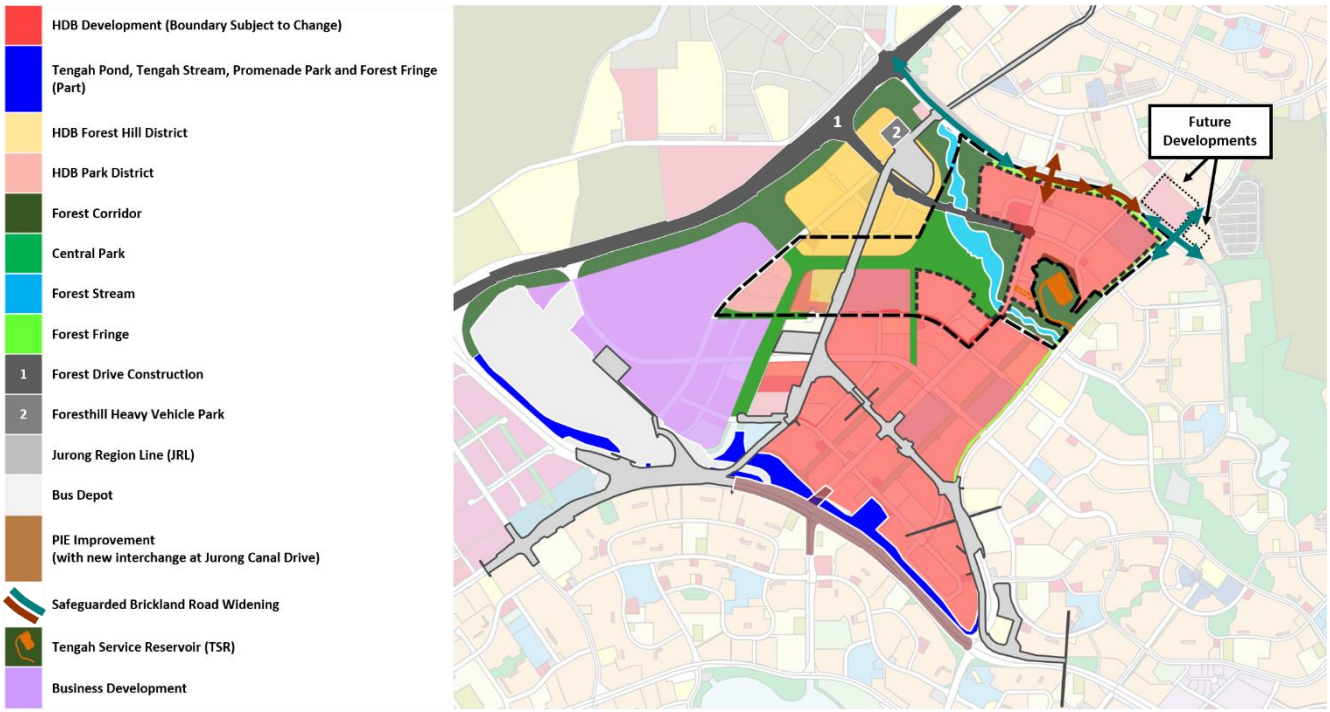


Figure 3.9: EIS Study Area and the Associated Developments within and in the Vicinity

Source: Tengah Master Plan 2019; HDB, 2020a; HDB, 2020b; HDB, 2020c; HDB, 2020d; HDB, 2020e, HDB, 2019; LTA, 2019; LTA, 2020a; LTA, 2020b; LTA, 2020c; Meinhardt, 2019; NG Engagement for Tengah, Aug 17, 2021; URA, 2021

The main housing districts in the Project, to be built in the future, are Brickland District and a portion of Park District. Based on the land use planning gazetted under the Tengah Master Plan 2019, the Project will have residential (public and private housing), educational institution and commercial buildings with other public utilities and amenities such as road, parks, schools, place of worship, health and medical care clinics, and community halls as illustrated in **Figure 3.10**.

Following the EIS findings and the review of the land use planning within the EIS Study Area against the Tengah Master Plan 2019, the Project boundary has been revised to provide greater wildlife connectivity and protection of conservation area. The new Project boundary for development is illustrated in **Figure 3.11**. This Project boundary is used for construction impact assessment in this EIS. The boundary, however, is subject to change with final gazettement required from URA/MND prior to construction commencement.

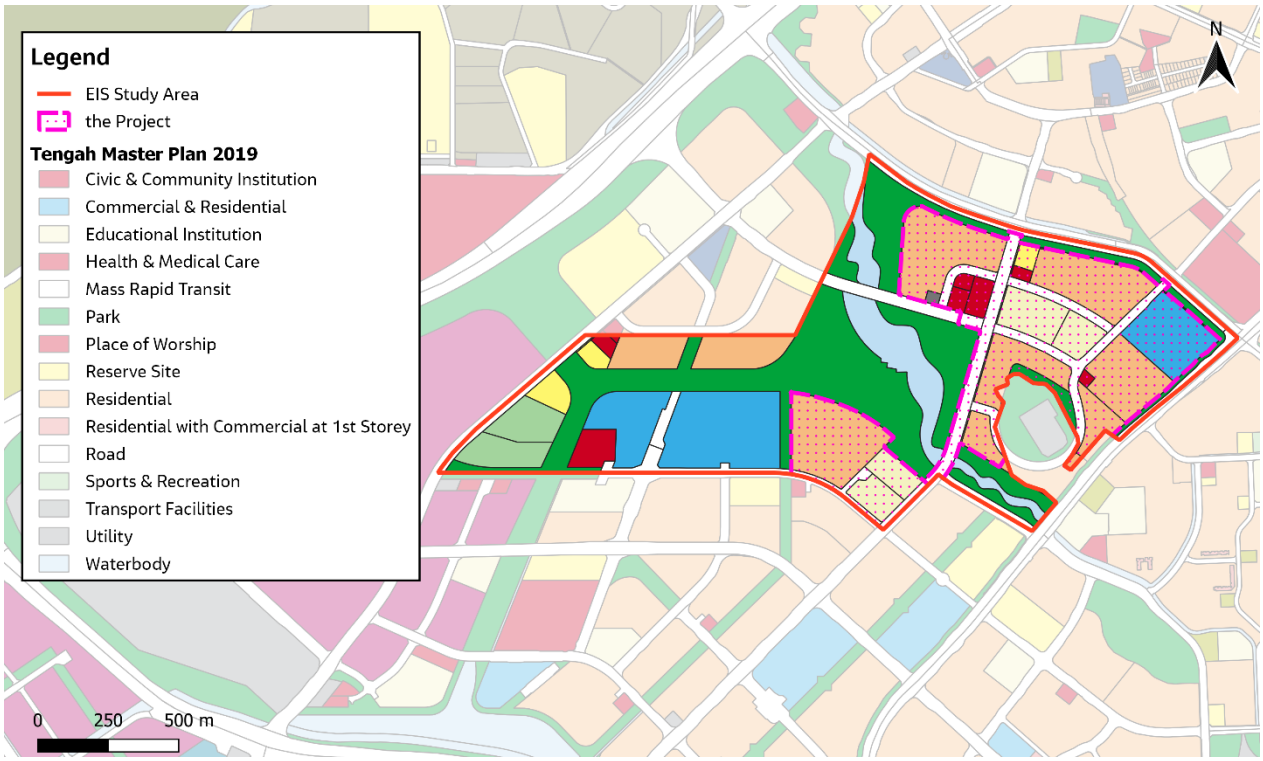


Figure 3.10: Land Use Planning for the Project under the Tengah Master Plan 2019

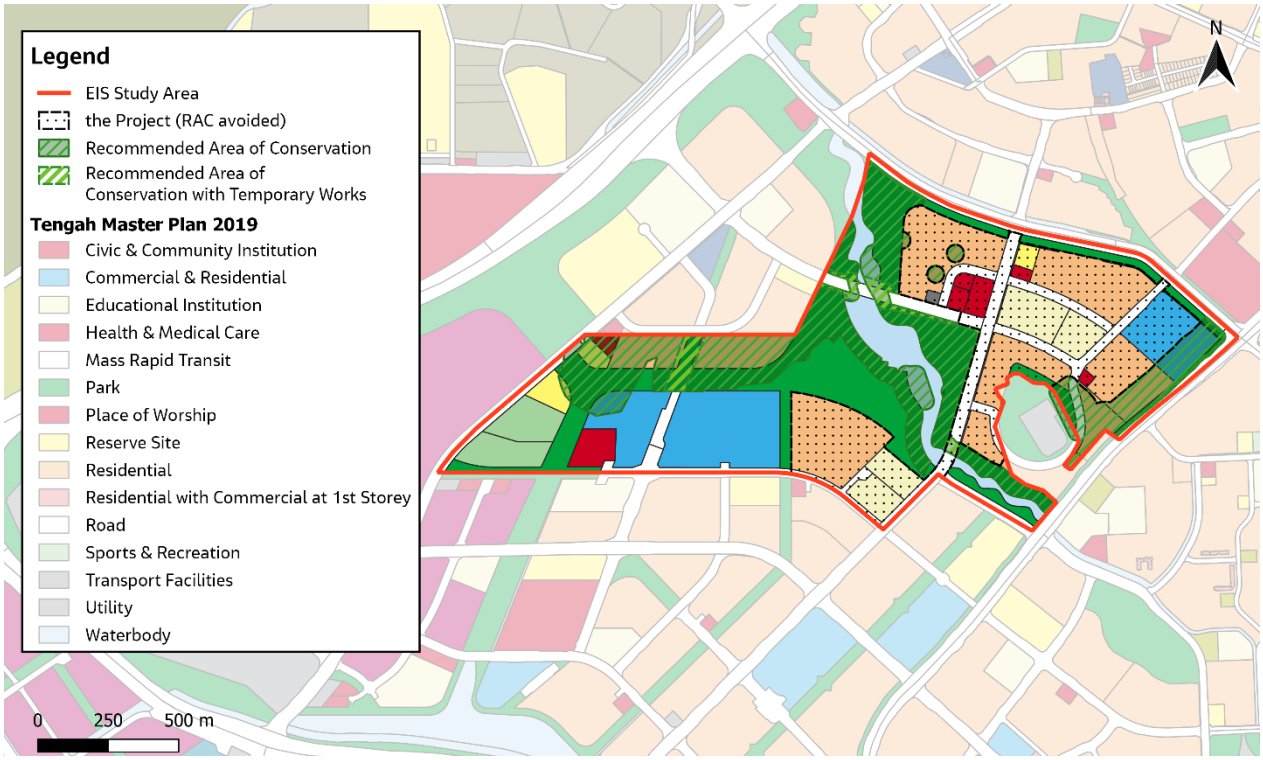


Figure 3.11: Revised Boundary of the Project Development

Source: Base Map obtained from Tengah Master Plan 2019 gazetted by URA

Note: For the purposes of this EIS, the figure shows an indicative revised boundary assuming that agencies will avoid the Recommended Area of Conservation (RAC). Agencies are studying possible changes to the land use plan to balance conservation and development in response to the RAC.

3.3 Project Implementation Schedule and Activities

The land uses in the Project will be built via various construction stages and associated construction activities over specific planned timeline for implementation as indicated in **Table 3.3**. The estimated work area size of the Project (Revised Boundary) is about 58 ha. Under the medium term development broad planning of Tengah Town, the Project has been planned to commence in 2022.

Table 3.3: Construction Stages, Estimated Duration and Construction Activities of the Project

Construction Stage	Estimated Duration	Project Activities
Stage 1: Advance Works	1 year	▪ Shepherding of wildlife from construction footprint Erection of temporary hoarding ▪ Erection of Tree Protection Zone (TPZ) and perimeter hoarding ▪ Tree felling, land/ vegetation clearance ▪ Vegetation and debris transportation ▪ Site preparation, this include entrance and access road, temporary facilities (i.e. site office, worker dormitories and mobile toilets), erection of mitigation measure (i.e. Earth Control Measures (ECM) facilities and noise barriers) ▪ General works, i.e. machinery maintenance, machinery/ construction material delivery, waste generation, temporary storage prior to disposal
Stage 2: Earthworks	14 months	▪ Soil and geotechnical investigation ▪ Demolition of existing structures ▪ Drainage and utilities diversion ▪ Cut and fill/ regrading/ levelling/ platforming, excavation ▪ Installing sheet pile/ soldier pile/ soil nail ▪ General works, i.e. machinery maintenance, machinery/ construction material delivery, waste generation, temporary storage prior to disposal
Stage 3: Infrastructure	3 years	▪ Road works ▪ Drainage and sewerage work ▪ Mechanical and Electrical works ▪ General works, i.e. machinery maintenance, machinery/ construction material delivery, waste generation, temporary storage prior to disposal
Stage 4: Building	3-5 years (varies) per development	▪ Bottom up construction – substructure foundation and base slap casting ▪ Bottom up construction – superstructure prefabrication and installation ▪ Finishing and exterior work ▪ General works, i.e. machinery maintenance, material and precast deliveries, precast delivery, storage and handling, waste management

4. Geomorphology, Soil and Hydrogeology

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

4.1 Applicable Legislation and Standards

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

4.2 Assessment Methodology

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

The topographical map from the Light Detection and Ranging (LiDAR) survey (a full topographical map was prepared and endorsed by the Singapore Land Authority (SLA) licensed surveyor with terrain levels within the EIS Study Area) was assessed and processed to generate a Digital Elevation Model (DEM). The DEM enables the visualisation of slopes with the proposed parcellation overlain. A generalized terrain analysis is made upon this DEM to evaluate its implication to the proposed development activities.

Geological maps were assessed and processed through GIS to generate a thematic map and likewise overlain with the proposed parcellation. This will indicate potential ground conditions to assess its implication to each project component.

For soil erodibility, the Modified Universal Soil Loss Equation (MUSLE) is used to assess the potential erodibility of soils within the Project site. Potential soil erodibility (PE) is given by:

$$PE = R \times K \times LS$$

Where R is rainfall erosivity factor, K is soil erodibility factor (PUB et al., 2013), and LS is the combined effects of slope length and steepness.

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

4.3 Pre-construction Baseline

4.3.1 Site History and Current Condition

Topographical maps were reviewed to identify changes in land use over the years in the EIS Study Area. The maps studied were obtained from the Map Resource Unit at the National University of Singapore (NUS), digitised by the Department of Geography. Detailed historical land use and changes has been discussed in **Section 3.2.3**.

4.3.2 Geological Investigation Desktop Review

Soil Investigation (SI) works were conducted to evaluate the sub-surface conditions of and present the knowledge of the geotechnical, geological and hydrogeological conditions in the surrounding vicinity of the EIS Study Area. The reports below were provided by HDB to CH2M HILL for review on the soil and groundwater conditions conducted at locations proximate to the EIS Study Area.

- PUB TD/33150295 Hydrogeological Investigation in Jurong Formation by Kiso-Jiban Consultants Co Ltd
- K6037 / HDB Term Contract No. 40 for Soil Investigation Works – Preliminary Soil Investigation Works for Tengah Park District (WI001) by Ryobi Geotechnique International Pte Ltd
- JB197/ HDB Term Contract No. 34 for Soil Investigation Works at Tengah Phase 2 & 3 (WI007) by Kimaro Geotechnical Engineering Pte Ltd

The general geological formation proximate to the EIS Study Area based on the available information provided in the list above indicates sandy SILT (Fill) with varying depths from 0 metre below ground surface (mbgs) to 3.0 mbgs, sandy SILT (residual soil Jurong Formation) with varying depths from 3 mbgs to 10 mbgs. Sandy CLAY (residual Jurong Formation) with varying depths from 3 mbgs to 6 mbgs, and sandy SILT (completely weathered Jurong Formation) with varying depths from 6 mbgs to 12 mbgs.

4.3.3 Geomorphology

4.3.3.1 Geology

Based on the Geology of the Republic of Singapore (DSTA, 2009) (**Figure 4.1**), the EIS Study Area is underlain by the Tengah Facies, and Queenstown Facies of the Jurong Formation, the Alluvial Member of the Kallang Formation and the Gombak Norite. The formational units are described as follows:

The Jurong formation comprises a sequence of sedimentary rocks, mainly marine mudstone, muddy siltstone, sandstone, conglomerate and limestone. These sedimentary rocks have been subjected to a low grade of metamorphism. Due to weathering, residual soils are mostly composed of interbedded layers of clayey SILT and sandy CLAY.

- Tengah Facies (Jt): Muddy marine sandstone with occasional grit beds and conglomerate. The member is usually deeply weathered but appears not to have been strongly lithified at any stage.
- Queenstown Facies (Jq): Red to purple mudstone and sandstone with minor conglomerate. Minor tuffs can also be found within the member. The red colouration is thought to come from tropical weathering in Triassic time, but volcanic material present may also have added to the colour.

Kallang Formation comprises sedimentary deposits and is found along the coastline and extending into the headwaters of the rivers draining Singapore.

- Alluvial Member (Ka): A variable terrestrial sediment ranging from pebble beds through sand, muddy sand, and clay to peat. The member is usually unconsolidated but lightly consolidated beds may be found.
- Gombak Norite (GN): Gabbroic and noritic rock shows metasomatic alteration close to the Bukit Timah Granite. The noritic and gabbroic rocks are coarse-grained and plagioclase-rich with varying amounts of clino- and orthopyroxene minerals appearing as interstitial grains giving an intergranular texture.

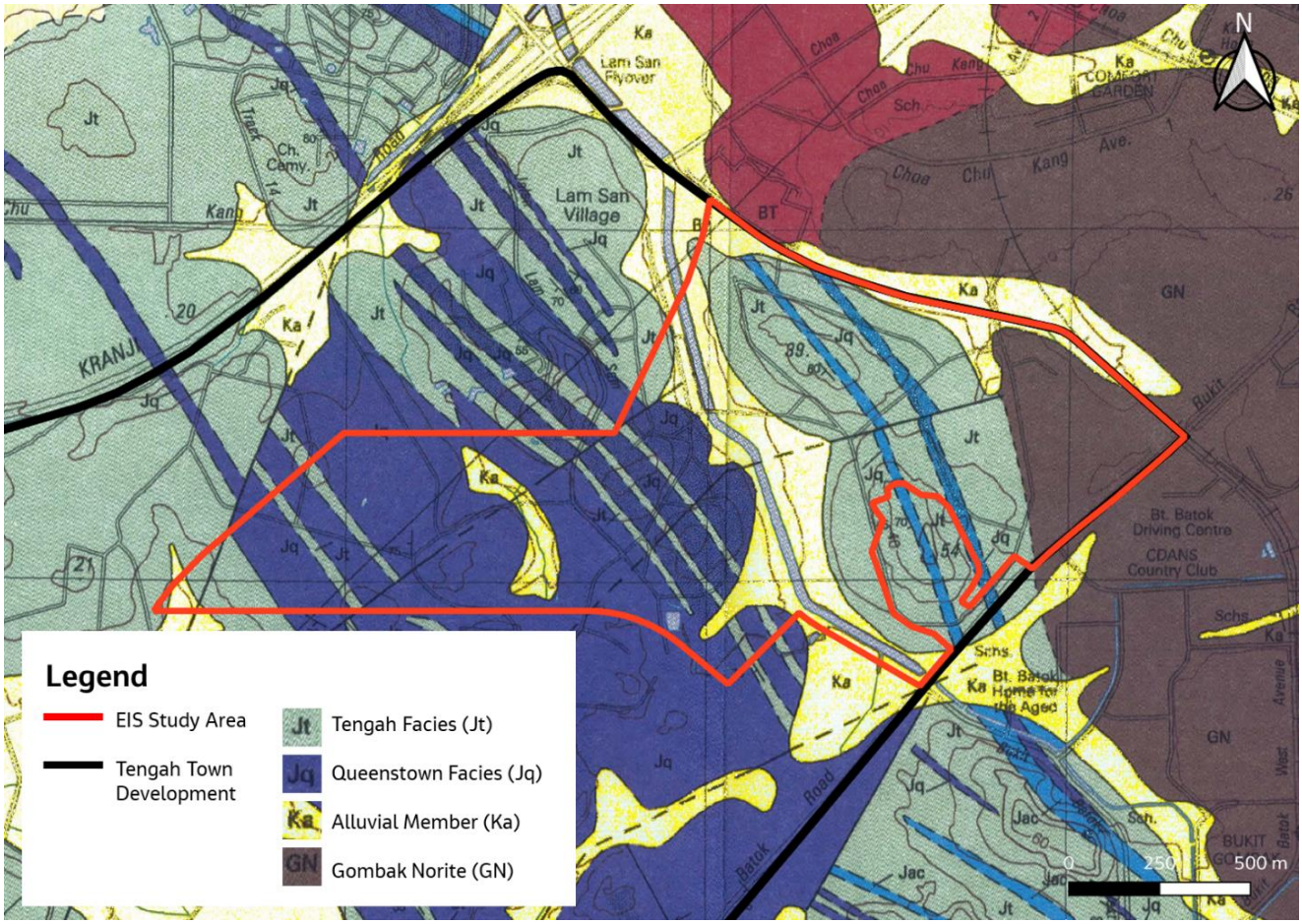


Figure 4.1: Geological Formation in the EIS Study Area

Base Map: Geology of the Republic of Singapore (DSTA, 2009)

4.3.3.2 Topography

The ground at the EIS Study Area is generally undulating across the centre and eastern sides of the area where the two prominent low-rise ridges separated by a narrow valley saddle is located (**Figure 4.2** and **Figure 4.3**).

Based on the topographical surveys, measured ground elevations vary from 5 to 35 metres above mean sea level (AMSL) with a general median 10 m elevation. This terrain reflects its historically undisturbed surface characteristic, and a correlation with the geological map the-ridge-saddle coincides it with three different rock units. The easternmost and centre ridge marked by the highest recorded elevations are underlain by rocks with greater resistance to erosion, whilst the narrow valley denoted by the alluvium indicate a depositional regime.

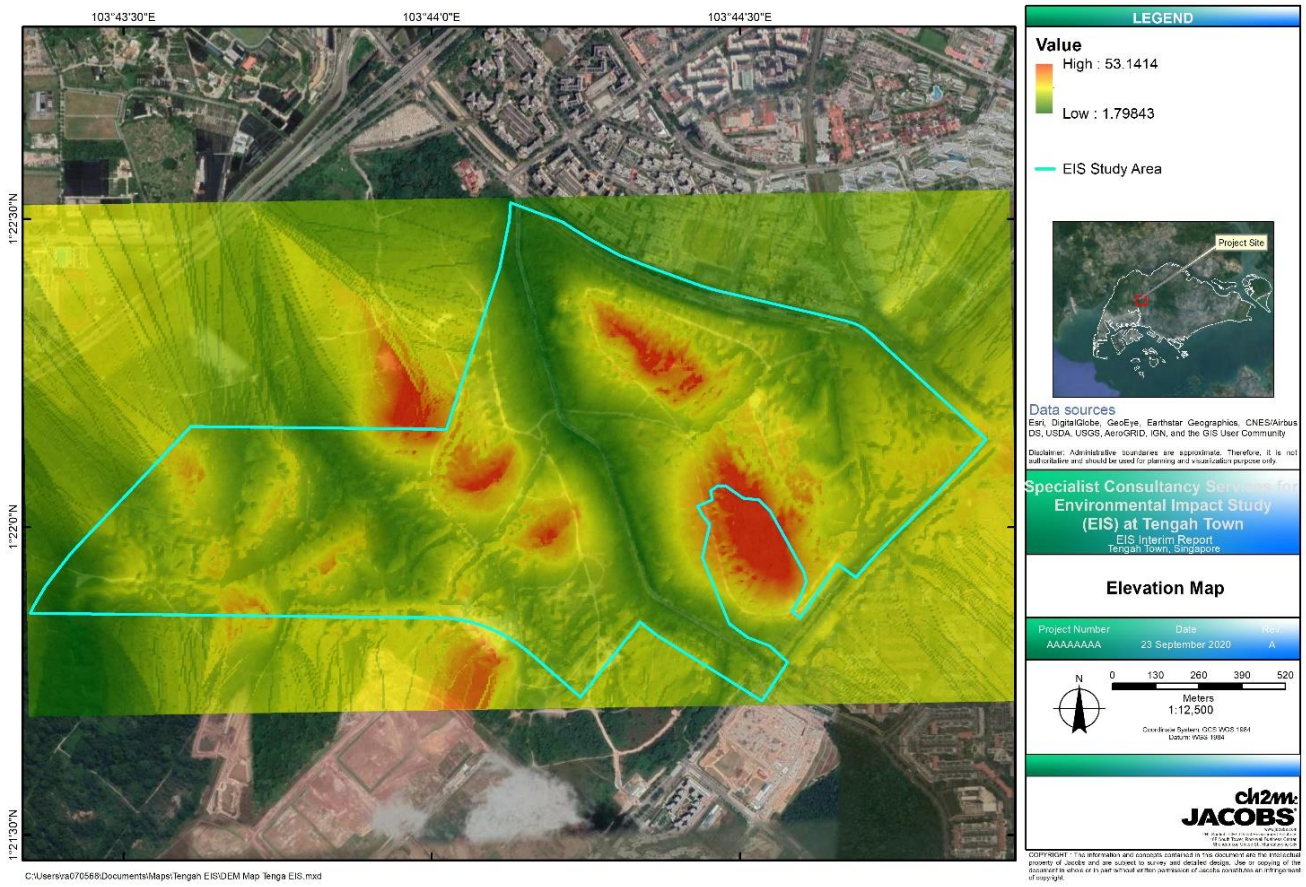


Figure 4.2: Elevation and Terrain Levels of the EIS Study Area

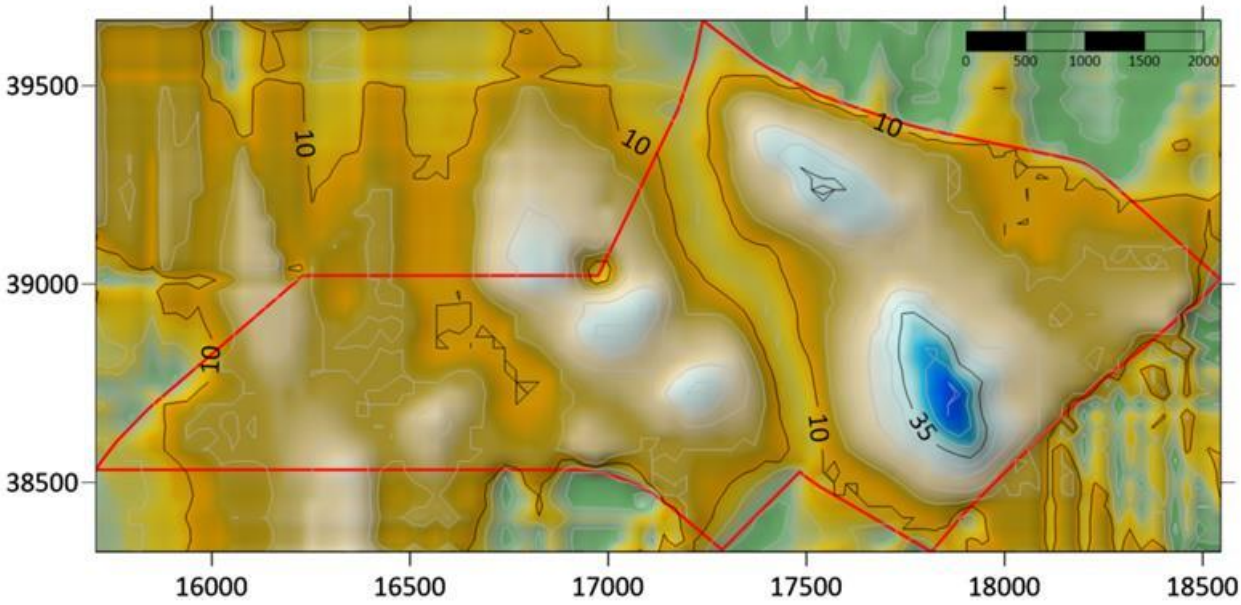


Figure 4.3: Digital Elevation Model (DEM) Three-Dimensional Visualization of the EIS Study Area (looking east-northeast) at 0.5 m Vertical Exaggeration

4.3.4 Soil

A TOHO rotary drilling rig utilising rotary wash techniques was used to drill the boreholes into the underlying hard layer. Flush jointed casings with nominal diameters of 100 millimetre (mm) were used to stabilise and prevent collapse of the borehole walls. A tricone roller bit/drag bit was used to advance the borehole and water was used as the flushing medium.

Sampling was performed at different depth intervals over the depth drilled, and the interval varied in order to suit the ground strata encountered. Undisturbed soil samples were recovered by means of a thin-walled/ thick-walled sampler.

The logging of boreholes was carried out by a geologist with wide experience on subsoil and geological condition of the site. The logging was carried out in accordance with Eurocode 7.

Based on the soil borings, the major soil type encountered were sandy SILT (made ground/ fill material) with varying depths from 0 mbgs to 3.0 mbgs, sandy SILT (residual soil Jurong Formation) with varying depths from 1.3 mbgs to 10 mbgs and sandy SILT (completely weathered Jurong Formation) with varying depths from 4.5 mbgs to 6 mbgs. At the western part of the EIS Study Area, sandy CLAY with silt (completely weathered Jurong Formation) was encountered at varying depths from 1.0 mbgs to 8.5 mbgs. The maximum depth drilled within the EIS Study Area was 10.5 mbgs (WSP2).

Soil drilling and groundwater level monitoring report (Factual Report) is presented in **Appendix 4A**. Results of geological testing of soil are as follows:

Table 4.1: Summary of Soil Laboratory Test

WSP No.	Sample Depth (m)	Moisture Content (%)	Bulk Density (mg/m^3)	Dry Density (mg/m^3)	Grain Size Distribution			
					Gravel %	Sand %	Silt %	Clay %
WSP1	4.0	17	2.02	1.73	7	32	25	36
	7.5	14	2.05	1.8	0	22	40	38
WSP2	3.5	26	1.84	1.46	0	17	58	25
	8.0	22	2.07	1.7	0	34	45	21
WSP3	3.5	17	2.01	1.72	0	57	24	19
	7.5	40	1.94	1.39	0	9	70	21
WSP4	1.5	21	1.93	1.6	0	76	18	6
	5.5	27	2.11	1.66	0	55	11	34
WSP5	2.0	11	2.19	1.97	0	45	25	30
	5.0	14	1.88	1.65	0	46	34	20
WSP6	2.0	24	1.97	1.59	0	55	25	20
	5.0	18	2.17	1.84	0	16	44	40
WSP7	3.5	21	1.99	1.64	0	54	31	15
	7.0	*	*	*	0	25	47	28
WSP8	3.0	37	1.93	1.41	9	8	31	52

Note: *sample could not be tested due to slurry condition

4.3.5 Hydrogeology

Soil boring and installation of water standpipes (WSP) were conducted to evaluate the subsurface conditions of and present the information of the geological and hydrogeological conditions beneath the EIS Study Area. The investigation works include advancing eight boreholes and converting into WSPs, associated with *in-situ* testing and soil laboratory testing for moisture, bulk density, dry density and grain analysis. The locations of the boreholes/ WSP are presented in **Figure 4.4** and strategically placed using the Environmental Protection Agency (EPA) Guidance on Choosing Sampling Design for Environmental Data Collection.

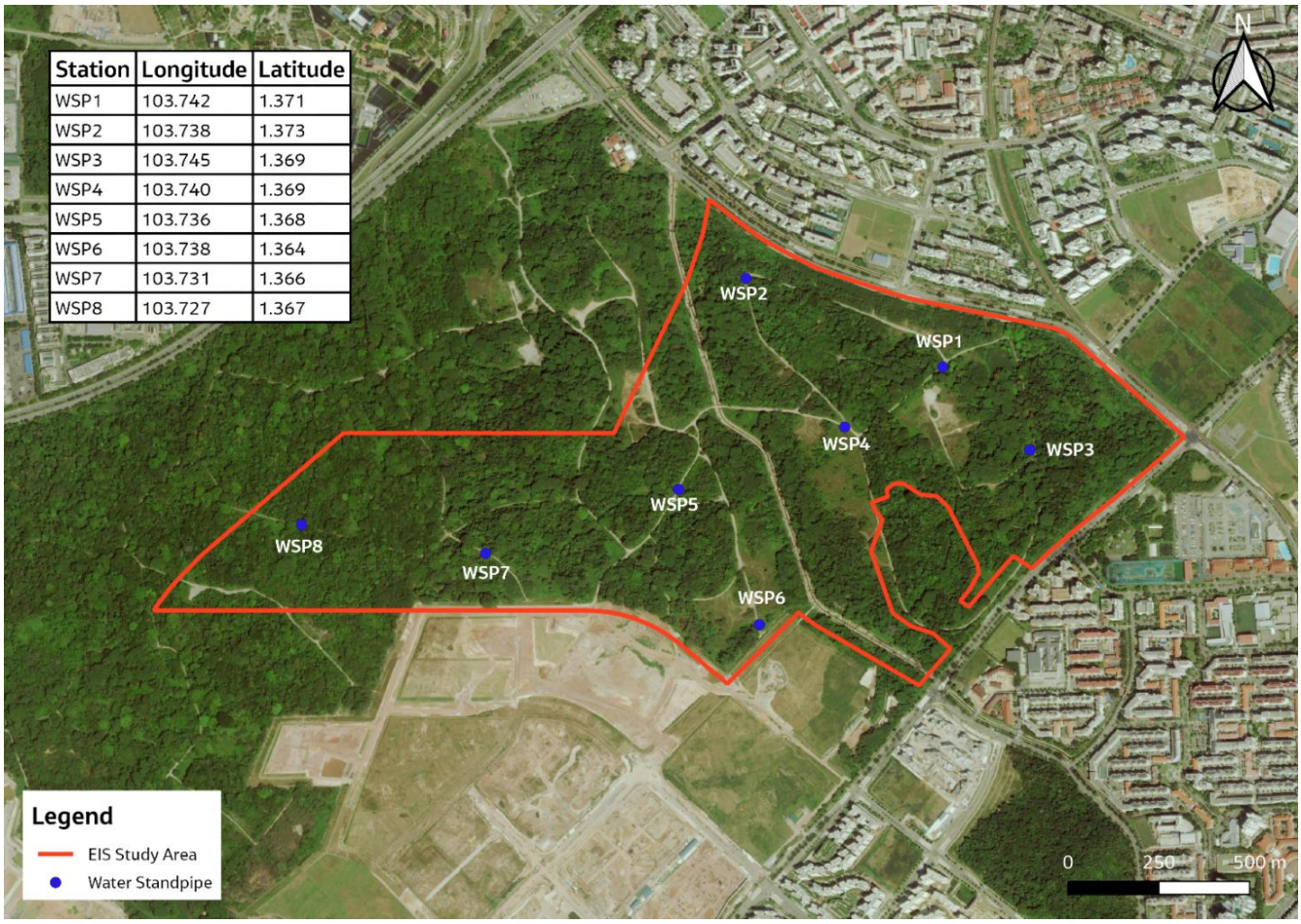


Figure 4.4: Water Standpipes Locations

Base Map: ESRI

Groundwater level measurements from eight WSPs were monitored during dry weather (48 hours no rain) and wet weather (within 2 hour of rain). Dry weather monitoring took place on Mar 30, 2020 while wet weather monitoring was on Mar 22, 2020.

The depth to the static water level (SWL) during the dry weather ranged from 11.910 m Singapore Height Datum (SHD) (WSP6) to 17.430 mSHD (WSP3) while the depth to SWL during wet weather ranged from 11.530 mSHD (WSP6) to 17.230 mSHD (WSP3). Groundwater flow converges to WSP1 and WSP4. From the models presented below (**Figure 4.5** and **Figure 4.6**), it appears there is minimal variance between the wet and dry seasons.

Groundwater elevation contour was based on the gauging data of all WSPs. The general groundwater flow indication was from the ridge system and towards the valley area and other lower elevation regions of the EIS Study Area.

The presence of a perennial spring near WSP2 (the "Spring Area" indicated in **Section 5**), and small ponds suggest the existence of an active groundwater aquifer in the EIS Study Area, with the surplus water leaking into the surface. From the DEM and groundwater flow models, it is also suggested that the north-northwest side of WSP2 is part of its recharge zone, in reference to the forested areas. From these information, there is indication that these surface water features are all correlated with the aquifer and groundwater behaviour beneath. The extents cannot be ascertained, however, due to the limited understanding of its characteristics, particularly outside of the perimeter of the flow contour model.

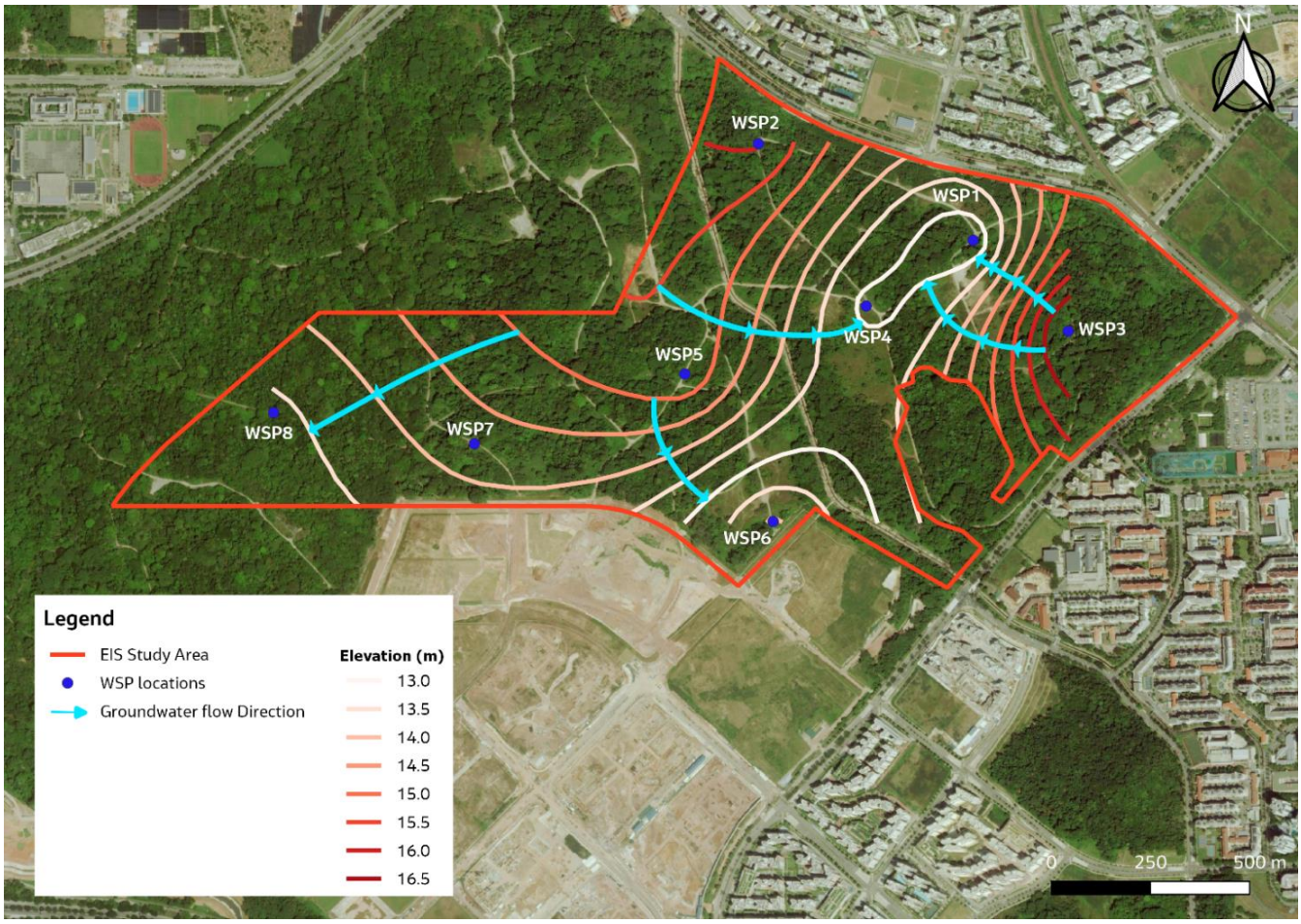


Figure 4.5: Groundwater Flow Contour during Dry Weather

Base Map: ESRI

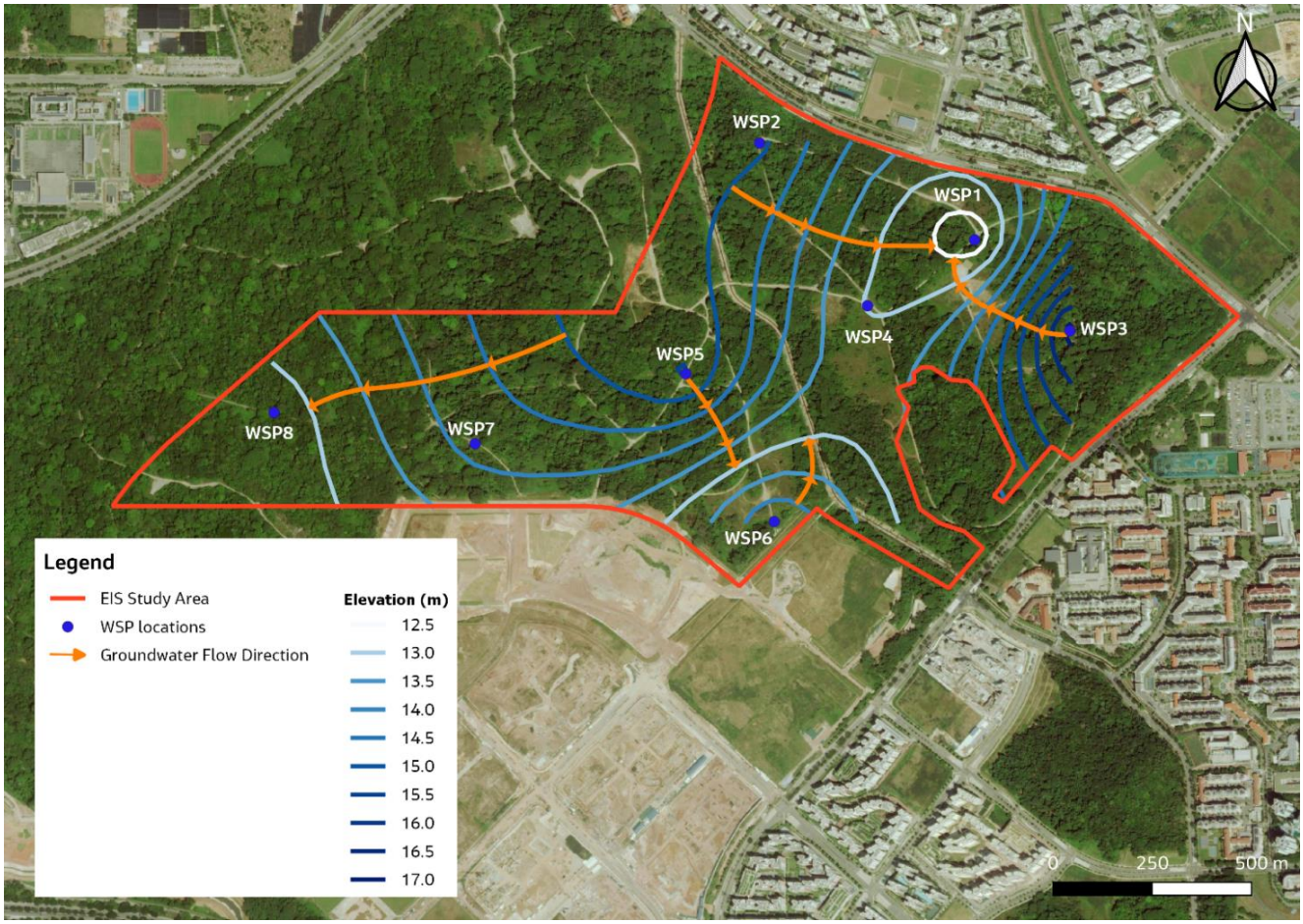


Figure 4.6: Groundwater Flow Contour during Wet Weather

Base Map: ESRI

4.4 Evaluation Potential Impact Before Mitigation Measures

4.4.1 Potential Source of Impact

Construction within the Project development parcels will involve one or more of the following activities that happens mainly during Stage 2 (earthworks) which is estimated to last about one to two years:

- Stripping of soil cover
- Cut and fill, and subsurface excavation
- Earth-moving
- Soils and spoils stockpiling

These activities were identified to have various impacts on the following environmental values of soil infiltration capacity, hydrogeology changes, soil loss and soil erosion. These are described below and are assessed with RIAM method accordingly.

4.4.2 Evaluation of Changes to Soil Infiltration Capacity

Soil compaction of the Project footprint and other development areas within the EIS Study Area where earthmoving will be undertaken may result in the temporary or permanent reduction of the soil infiltration capacity. Open areas where infrastructures will be built are expected to lose, if not reduce the soil infiltration

capacity. Hydraulic conductivity across the subsurface, however, may or may not be reduced, depending on the degree of ground compaction effected on disturbance areas.

As indicated in **Section 4.3.4**, the dominant soil type across the EIS Study Area is Sandy Silt, of which the reference Hydraulic Conductivity Value is 86.4 mm/day from WSP sampling representing the baseline infiltration rate at its present undisturbed state. During ground preparation and construction phase, a reduction below this value is expected to occur in working areas. Near-permanent loss (infiltration rate reduced to near zero) may occur where permanent removal of soil and subsurface materials will take place. We have therefore defined that should the reduction infiltration rate is less than and same with 10% of measured pre-construction infiltration rate, then the magnitude of changes is "Low". While should the infiltration rate reduction more than 50% of measured pre-construction infiltration rate, then the magnitude of change is evaluated as "High". The changes in between these are considered "Medium".

Table 4.2: Impact Significance for Soil Infiltration Capacity over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Soil is limited to local interest within the EIS Study Area (i.e. all areas defined under the Project and other future development where land clearance, earthworks and infrastructure works will take place).
A2.1: Impact Nature	-1: Negative	Loss or reduction of infiltration capacity in all development areas for permanent structures.
A2.2: Magnitude of Changes	2: Medium	Changes in infiltration capacity at working area within the Project site is predicted between 10% and 50%.
A2.3: Impact Extent	1: Local	Impact is limited within the disturbance areas where temporary and permanent earthworks will take place.
B1: Permanence	3: Medium Term	Construction phase that may involve earth moving and ground disturbance including advance, earthworks and infrastructure stages which are estimated last for over three years.
B2: Impact Pathway	3: Direct	Ground disturbance will directly involve stripping of surface material including topsoil cover, and ground excavation which will remove bedrock materials.
B3: Reversibility	3: Irreversible	Removed soil and spoil materials cannot be returned to their original locations where infrastructures have been completed. Permanent loss or reduction of infiltration capacity where surfaces will be stripped or excavated, and permanent structures will be built.
B4: Cumulative	2: Non-Cumulative	Change in conditions for soil infiltration capacity remains after completion of all earth-moving and construction activities within disturbance area for each phase and development taking place within the entire EIS Study Area.
Environmental Score (ES)	**(-2) x (11) = -22**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	

4.4.3 Evaluation of Soil Loss and Erodibility

The general soil erodibility factor K is set at 0.05 according to Singapore PUB based on the material percentages of the samples dominated by silt and sand at a maximum depth of 11.5 m below the Old Alluvium (OA) layer. The LS factor is determined to be at 0.623 given the steep elevations described for the EIS Study Area. Comparing the slope erodibility factor and topographic factor to published soil erodibility classes of USDA, the EIS Study Area's soil erosion class is classified as low to moderate with potential soil loss not exceeding 21.5 tonnes soil/hectare/year. There are two scenarios for the EIS Study Area that can be determined from this information and presented as follows:

1) Scenario 1 – It assumed that construction activities will increase the prevailing soil loss rate to a range of between 10-20 times (Pudasaini, 2004) the current value, depending on the degree of earth-moving activities. This suggest a probable range of 215-430 tonnes/hectare/year that may affect the entire extent of the Project, which is about 58 ha. The soil loss rate will fall to zero upon the completion of all construction work, as erodible material is assumed to be completely removed, and any previously exposed subsurface are permanently covered with concrete or other material within the proposed work site.
2) Scenario 2 – In areas that will be retained, and no disturbance will be undertaken, the predicted soil loss rate will remain at 21.5 tonnes/hectare/year, to be calculated for the actual size of all nominated conservation areas.

This evaluation presents a conservative assessment and should also consider additional factors such as current and future land cover, land use, and percentage of permanent surface structures that will occupy the land area which will restrict sediment transport from point sources. The erodibility potential serves mainly as a guide on the susceptibility of the area to soil loss given available assessment.

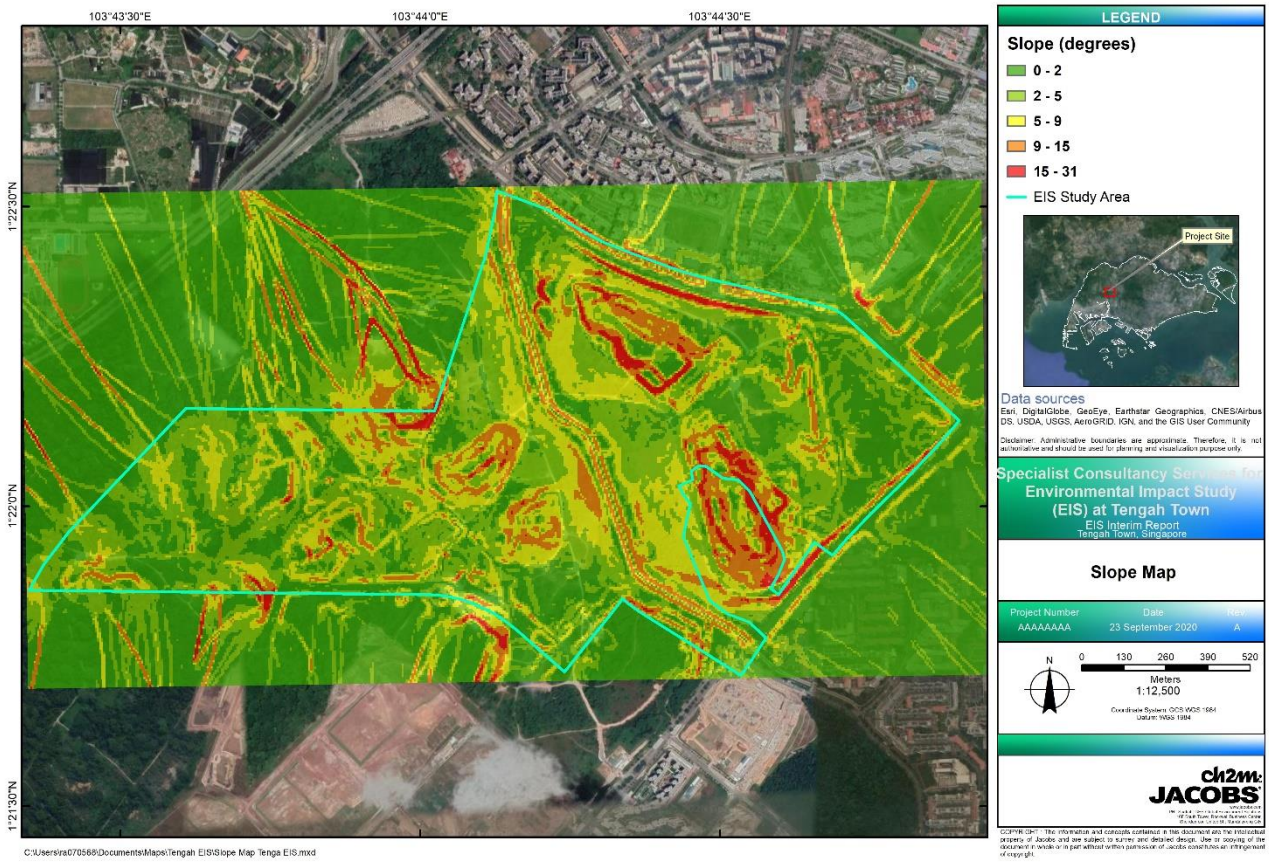


Figure 4.7: Generated Slope Map of the EIS Study Area

Table 4.3: Impact Significance for Changes to Soil Loss and Erodibility over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Soil is limited to local interest within the EIS Study Area.
A2.1: Impact Nature	-1: Negative	Loss of soil cover in all development areas for permanent structures, and increased erodibility in adjacent undeveloped areas.
A2.2: Magnitude of Changes	3: High	Soil loss may contribute to downstream siltation during construction period. Erodibility can increase to about 10-20 times the current soil loss volume estimates through earthmoving activities that will be involved during ground preparation and major excavation. It will fall to zero in construction sites upon the end of all activities and in areas where soil and other surface materials are either completely removed or permanent covered.
A2.3: Impact Extent	1: Local	Impact is limited within the disturbance areas where temporary and permanent earthworks will take place.
B1: Permanence	3: Medium Term	Construction phase that may involve earth moving and ground disturbance include advance, earthworks and infrastructure stages which are estimated last for over three years.
B2: Impact Pathway	3: Direct	Ground disturbance will directly involve stripping of soil cover and stockpiling.
B3: Reversibility	3: Irreversible	The original soil material and profiles cannot be returned to their original locations where infrastructures have been completed. Permanent loss of soil cover occurs where permanent structures will be built, and long-term risk of erodibility to areas adjacent to developments with remaining soil material.
B4: Cumulative	2: Non-cumulative	Soil loss resulting from surface stripping and stockpiling occurs only during earthwork activities.
Environmental Score (ES)	**(-3) x (11) = -33**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	

4.4.4 Evaluation of Changes to Hydrogeology

Changes in the topography of the EIS Study Area involving cut and fill operations is foreseen to alter the subsurface hydrogeological dynamics, wherein areas of high elevation that will be removed and low-elevation areas that will be backfilled may observe a reduction of the hydrostatic pressures across areas with elevation difference. The reduction of available open areas acting as natural groundwater recharge zones may also result in the lowering of the groundwater levels caused by a reduction of groundwater infiltration if no structural/ engineering intervention is made to divert accumulated runoff into designated remaining open areas that can act as alternate zones. Surface water features such as ponds and wetlands that are dependent or sustained by groundwater aquifers leaking to the surface may dry up temporarily or permanently. As discussed in **Section 4.3.5**, the pre-construction groundwater level across the EIS Study Area has an average 20 cm variance at different weather events (i.e. ranged between 11.530 and 17.430 mSHD during wet event and 11.910 and 17.43 mSHD during dry event). Variance less or equal to ±1 m level of pre-construction groundwater level is evaluated

as having low magnitude changes, while variance of ± 3 m is evaluated as high. Variance in between is evaluated as having "Medium" magnitude.

Table 4.4: Impact Significance for Changes to Hydrogeology over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Hydrogeology value is important to importance to area immediately outside local condition
A2.1: Impact Nature	-1: Negative	Hydrogeological conditions will be changed as a response to the proposed earthmoving, surface grading/stripping and various subsurface excavation.
A2.2: Magnitude of Changes	3: High	Groundwater hydrostatic pressure will change as a result of change in characteristics of the resulting subsurface during and after disturbance/ construction activities. Groundwater flow may be diverted away from areas where it originally flows, which can affect existing surface water features such as ponds that are dependent on this resource. Variance is predicted to be more than 3 m above or below pre-construction groundwater level.
A2.3: Impact Extent	2: Tengah	The change in hydrostatic conditions within the Project will affect the dynamics of aquifers outside of the area as these are potentially interrelated.
B1: Permanence	3: Medium Term	Construction phase that may involve earth moving and ground disturbance include advance, earthworks and infrastructure stages which are estimated last for over three years.
B2: Impact Pathway	3: Direct	Ground disturbance will directly affect the aquifer-hosting bedrock
B3: Reversibility	3: Irreversible	Changes in hydrogeological conditions after completion of all earthworks, excavation and construction activities that will disturb host rock aquifers remains permanent. Permanent change in hydrogeological conditions will occur where major excavation and earthmoving for infrastructures will take place. Subgrade developments will permanently remove bedrock acting as aquifers, and groundwater inflows will be diverted to areas where aquifers remain undisturbed.
B4: Cumulative	3: Cumulative	Ground disturbance of each development sector in succession will result to gradual accumulation of changes in hydrogeological dynamics, such as groundwater levels, hydrostatic pressures and groundwater flows across the EIS Study Area and the surrounding region where its subsurface could be characteristically contiguous with the aquifer units. This will, however, stop accumulating when all forms of ground and subsurface disturbance have ceased, of which the resulting hydrogeologic state will remain unchanged.
Environmental Score (ES)	**(-12) x (12) = -144**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

4.5 Applicable Prevention and Mitigation/ Enhancement Measures

4.5.1 Recommended Mitigation/ Enhancement Measures for Changes of Soil Infiltration Capacity and Soil Loss

Impact to the geomorphology and soil erodibility is expected based on the proposed changes to the site topography. The impact due to loss of topsoil may be further minimised with either any or a combination of the following mitigation measures:

- Undertake a programmatic Excavation, Cut and Fill and Earthmoving plan. The construction work should be done accordingly in stages and programmed segments to minimise the area disturbed at any given time. By minimising the disturbance area affected by excavation and earthworks to what is only necessary, potential erosion and topsoil loss may be reduced.
- Engage a Qualified Person (QP)/ Professional Engineer to conduct a slope stability and soil compaction study in areas of concern (i.e. with slope more than 15 degree according to Slope Map generated). The resulting detailed assessment will serve as part of the operational manual during earth-moving and excavation activities.
- Topsoil removed will be stockpiled in a designated area and covered as necessary to prevent soil loss from secondary erosion. Soil conserved can be used for backfilling and improvement of stream vegetation for areas that lack concrete slope protection. Excess soil material can be exported outside of the EIS Study Area where it can be reused. Spoil materials will be separately stockpiled and can be used as backfill materials within the development areas as necessary or outside where it can be of use.
- Assign RAC as non-disturbance zones/ buffer zones or design buffer zones with vegetation cover within the EIS Study Area to compensate for the loss of open surface areas where permanent infrastructures will be built. Temporary construction areas such as staging and stockpiling zones can be rehabilitated into additional buffer zones where applicable that can be revegetated.
- Open canopy areas where continued soil loss may occur may need placement of Erosion and Sediment Control (ESC) structures to capture eroded soil that can be returned back to the buffer zones for amelioration. ESC structures can likewise be strategically built adjacent to cut and fill, excavation and stockpiling sites.

4.5.2 Recommended Mitigation/ Enhancement Measures for Changes to Hydrogeology

The impact to hydrogeology resulting from future subsurface excavations and earthworks to accommodate sub-grade development is expected, as groundwater conditions will consequently change in response to construction and post-construction subsurface configuration. The impact can be managed though implementation of the following:

- It is recommended that a geo-resistivity survey be undertaken to complement the information from the standpipes, and assess the subsurface for aquifer characteristics beneath the "Spring Area" and the probable recharge zones located within the forested area with minimal disturbance. The result of this exercise will help define areas of recharge, as well as perennial surface water features that can be included in the conservation program.
- In development areas where groundwater hydrostatic pressure will be potentially high, piezometers and monitoring wells may be placed adjacent to proposed subsurface structures. Shoring and dewatering with pumps may be undertaken as needed during construction activities where increased hydrostatic pressure is expected to cause leaching into construction areas. Automatic pumps may be installed which will operate when critical piezometric levels are exceeded.
- Alternative *in-situ* recharge zones can be designated within the remaining conservation areas or green-belts to compensate for permanent loss of recharge areas that will be disturbed by the placement of at-grade and subsurface infrastructures. As discussed under soil loss and changes in infiltration, the designated buffer zones can partly alleviate the reduction of groundwater recharge to the aquifer system beneath the EIS Study Area.

- The impact on surface water features sustained by perched groundwater flow through springs and other surface conduits that can be affected by the disturbance of aquifer-hosting rock units during cut-and-fill activities can be alleviated by providing artificial recharge through installation of groundwater or diversion reinjection wells to replace the loss of surface water infiltration.

4.6 Residual Impact

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

- Permanent change in hydrogeological dynamics
- Permanent reduction of land area with soil cover
- Amelioration of conserved soil
- Reduction of soil loss
- Improvement of soil infiltration capacity
- Reduction of groundwater recharge loss

With the expected change in hydrogeological dynamics, the mitigation measures mentioned above will help to recover and sustain some of the groundwater in areas by managing the conditions through piezometers, pumps, collection ponds and drains strategically placed to coexist with the proposed subgrade development. The reduction of open areas at post-development to within the proposed buffer zones can serve both as locations for soil reuse up to a designated volume, and as groundwater recharge zones. Soil amelioration helps the soil recover some of the reduction in quality, and manage loss through erosion and surface runoff, and contribute to the recovery of lost soil infiltration capacity. The RAC or buffer zones shall be maintained as vegetated areas to offset vegetation removal in development areas and minimise the reduction of the catchment recharge zones.

Table 4.5: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
G-I1	Soil Infiltration Capacity	-22	**Minor Negative Impact**	-11	**Slight Negative Impact**
G-I2	Soil Loss and Erodibility	-33	**Minor Negative Impact**	-22	**Minor Negative Impact**
G-I3	Changes to Hydrogeology	-144	**Moderate Negative Impact**	-96	**Minor Negative Impact**

5. Surface Hydrology

This section describes the regulations and standards for surface hydrology changes and control that are applicable to the Project development and the methodology used for the baseline assessment. It also discusses the baseline data obtained and assesses the likely changes in surface hydrology consequences associated with the construction and operation phases of the Project. Mitigation measures are identified to mitigate the potential impacts arising from the surface hydrology changes on top of the embedded measures according to requirement from applicable legislation and standards.

5.1 Applicable Legislation and Standards

In Singapore, the Sewerage and Drainage Act (SDA) regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems as well as the discharge of sewage and trade effluent and for matters connected therewith.

- SDA Part IV, Section 23 indicates a clearance certificate, or the approval from PUB is required for any construction, alteration, termination or close up of any storm water drainage system.
- SDA Part IV, Section 26 indicates a clearance certificate, or the approval from PUB is required for any works which affect or are likely to affect any storm water drainage system, drain or drainage reserve, directly or indirectly.

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

5.2 Assessment Methodology

There is no legislation and standard in Singapore presently that describes the methodology for surface hydrology baseline and impact assessment. SDA, Code of Practice (COP) on Surface Water Drainage and Tender Specification Section 3.2.1(iv) are used as guideline for the assessment. The COP prescribes the drainage planning requirement, design requirement, and the integrity of storm water drainage system.

Baseline study and assessment on potential surface hydrology impacts involve the following tasks:

- Desktop study. It involved collecting and reviewing relevant meteorological, topographical, hydrological data and development planning as well as reviewing surface hydrology baseline in Tengah Environmental Baseline Study (EBS) Final Report conducted by AECOM Singapore Pte Ltd (AECOM) (2017) and Final EIA Report conducted by WSP Consultancy Pte Ltd. (2019). The following data were collected and reviewed:
  - Meteorological data (rainfall, wind and temperature) from Meteorological Service Singapore NEA (https://data.gov.sg/dataset/realtime-weather-readings).
  - Existing Tengah drain profiles from PUB, i.e. Kranji Catchment Drainage Scheme Improvement to Sungei Peng Siang Tributary 'A' (1987) and Kranji Catchment Drainage Scheme Improvement to Sungei Peng Siang Contract 1 (1986).
  - Tengah North Drainage Master Plan (Kranji Catchment) – C – (20200701) from HDB.
  - Tender Drawing Brickland Road (Choa Chu Kang Town Construction of Brickland Road) from HDB.
  - Bukit Batok New Town Bukit Batok West Avenue 2 (Part 3) and Outlet Drain from HDB.
  - Drainage catchment map (https://www.pub.gov.sg/Documents/DrainageMap.pdf) and Sewerage catchment map (https://www.pub.gov.sg/Documents/SewerageMap.pdf) from PUB.
  - Urban Redevelopment Authority (URA) Tengah Master Plan (2019) (https://www.ura.gov.sg/maps/?service=MP).

  - Singapore Master Plan Land Use (2014) (https://data.gov.sg/dataset/master-plan-2014-land-use).
  - Tengah Town Contour Plan from HDB (2014).
  - Satellites images from Google Earth.
  - Construction information of committed development within and outside the EIS Study Area, as well as consultation with relevant statutory bodies.

- Site Investigation and collection of surface hydrology baseline within the EIS Study Area conducted since February 2020 and completed end of September 2020 (activities suspended from April 7 to early July due to the impact from the COVID-19 pandemic):
  - Site walkover for waterbodies identification conducted between February and August 2020 with the following activities performed:
    - Verified the location and stretch of existing waterbodies collected from desktop study. A GPS device was used to mark waterbodies and track survey route.
    - Checked the access point of waterbodies for water quality sampling.
    - Traced the upstream/ downstream of the earth drain/ canal and inlet/ outlet of pond.
  - Site specific hydrographical survey, conducted by the appointed SLA Licensed Surveyor, YJP Surveyors Pte Ltd, according to tender requirement:
    - Drainage lines within the EIS Study Area were capture using Trimble Differential Global Positioning System (DGPS) model SPS551 at approximately 5 m apart or less if a significant bend in the streams occur. All drainage lines of 5 m or more in length are recorded. This DGPS is used as a primary positioning system providing an independent fixing solution. The DGPS Reference Station is at a known fixed position located at Raffles Lighthouse. The measured pseudo-range to each tracked satellite is compared to the computed range by the monitoring computer based on a precisely known location to produce a set of pseudo-range corrections. The positions received from the DGPS in WGS 84 are transformed to SVY21 grid coordinates.
    - Stream dimension is to be characterised through details in an interval of 20 m include stream cross-section, pool length and depth, substrate type, riparian vegetation composition, and wetted width.
    - Site specific stream velocity measurement. The upstream and downstream of the main canal flow velocity is estimated after receiving significant rainfall intensity of at least 7.6 mm/hour, as discussed and approved by TAs during Scoping Meeting on Jan 14, 2020. This rainfall intensity was considered as moderate based on NEA-Meteorological Service Singapore. The steam velocity was measured by using direct current meter from Aanderaa. The stream velocity measurement takes place one hour after a rainfall event.
- Analysis of surface hydrology baseline based on desktop review and collected field baseline.
- Assessment of proposed development of the Project, e.g. infrastructure (road, drainage and sewerage) and building (residential, commercial, commercial and residential, and institution) impact on the existing surface hydrology. This assessment will include the following utilising InfoWorks Integrated Catchment Modelling (ICM) software:
  - Evaluate the change in surface water flow direction by the proposed development.
  - Evaluate impacts of any modification of existing waterways such as change (increase/ decrease) in flowrate and volume.
- Recommend mitigation measures to minimise any identified adverse impacts on the surface hydrology from the proposed Project Development and identify appropriate monitoring requirements during pre-construction and construction phases.

5.3 Pre-construction Baseline

5.3.1 Climate and Meteorological Data

5.3.1.1 General Climate in Singapore

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

- Northeast monsoon season (December to early March)

  The early part of the northeast monsoon is the wetter period of the year when monsoon surges with moderate to heavy rain and gusty winds from December to early January. The late part of the northeast monsoon is windy and relatively dry.

- Inter-monsoon period (late March – May)

  Afternoon thunderstorms are common in the afternoon and early evening. Hot afternoons with maximum temperature above 32 degree Celsius (°C) can occur.

- Southwest monsoon season (June to September)

  Occasional gusty winds associated with Sumatra squalls occur between predawn hours and midday. Short duration showers or thunderstorms in the afternoon are common.

- Inter-monsoon period (October – November)

  This inter-monsoon period is generally wetter than the earlier inter-monsoon period. Thunderstorms occur in the afternoon and early evening.

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

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

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

5.3.1.2 Site Specific Weather during Baseline Study

The site-specific weather (rainfall, temperature and wind speed) for the EIS Study Area from March to August 2020 was obtained from publicly available data from the Meteorological Service Singapore of NEA (http://www.weather.gov.sg/climate-historical-daily/) and presented in **Table 5.1**. Three nearest Meteorological Stations (Met Stations) were selected (**Figure 5.1**).

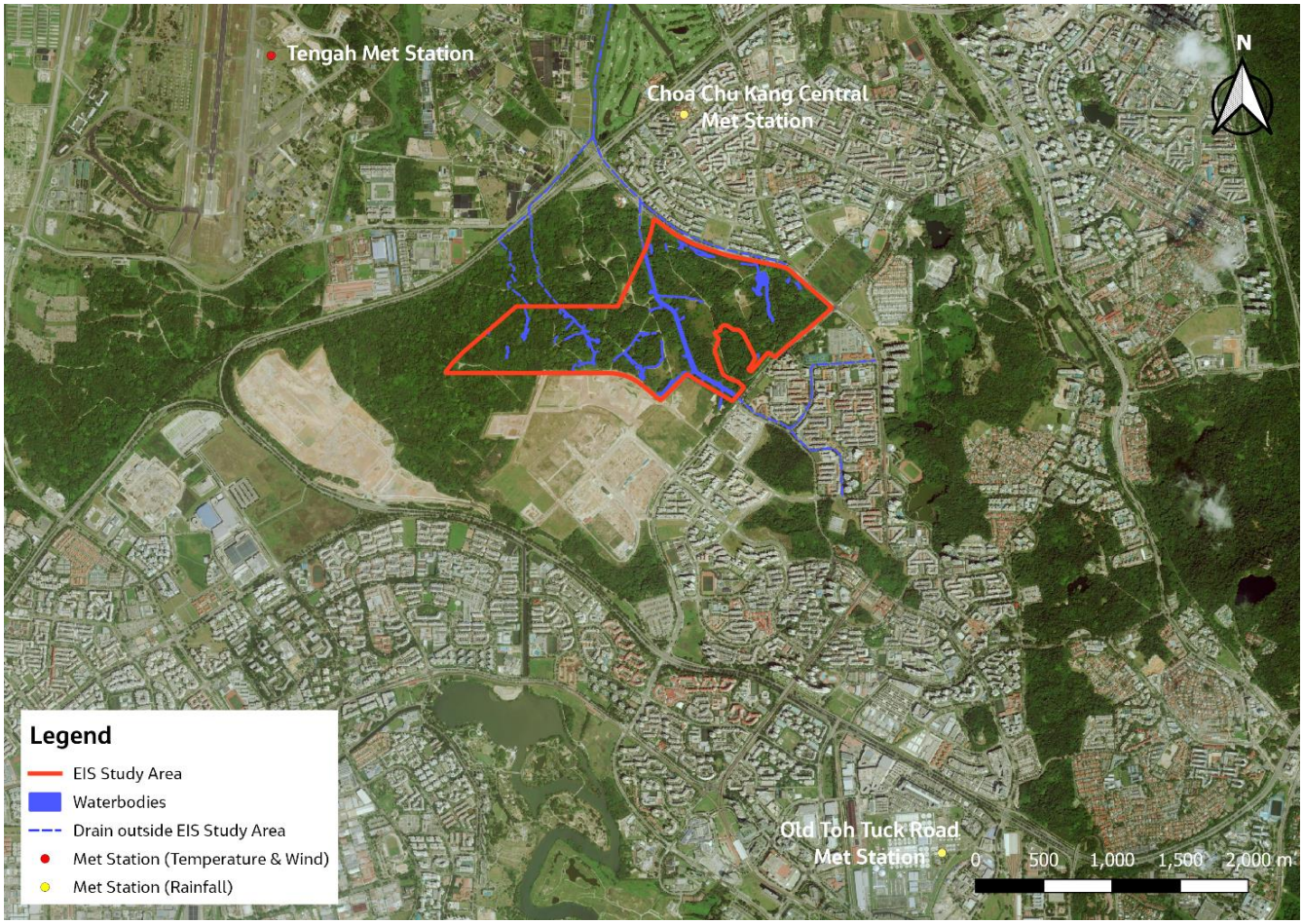


Figure 5.1: Locations of Met Stations nearest to the EIS Study Area

Base Map: ESRI

The site-specific rainfall was obtained from Choa Chu Kang Central Met Station and Old Toh Tuck Road Met Station. Choa Chu Kang Central Met Station is located 0.9 km north of the EIS Study Area (downstream). Old Toh Tuck Road Met Station is located 3.6 km southeast of the EIS Study Area (upstream). The site-specific temperature and wind speed were obtained from Tengah Met Station, located 3 km to the northwest of the EIS Study Area.

Based on the weather data recorded from March to August 2020, the site-specific weather can be described as follow:

- The highest 1-hour rainfall recorded at Choa Chu Kang Met Station was 56 mm on March 7, 2020. The highest 1-hour rainfall recorded at Old Toh Tuck Met Station was 53.4 mm on Aug 14, 2020.
- The highest daily rainfall total recorded at Choa Chu Kang Met Station was 87 mm on June 23, 2020. The highest daily rainfall total recorded at Old Toh Tuck Met Station was 80.2 mm on April 7, 2020.
- The daily maximum and minimum temperature recorded at Tengah Met Station from March to August 2020 did not change significantly. The lowest temperature ranged from 21.9°C to 24°C. The highest temperature ranged from 33°C to 35.6°C.
- The maximum wind speed recorded at Tengah Met Station ranged from 44.4 kilometre per hour (km/hr) to 83.2 km/hr.

Table 5.1: Site Specific Rainfall, Temperature and Wind Speed

Month	Highest Daily 1-hour Rainfall (mm) (date)		Highest Daily Rainfall Total (mm) (date)		Lowest Temperature (°C) (date)	Highest Temperature (°C) (date)	Highest Max Wind Speed (km/hr) (date)
	Choa Chu Kang Central Met Station	Old Toh Tuck Road Met Station	Choa Chu Kang Central Met Station	Old Toh Tuck Road Met Station	Tengah Met Station	Tengah Met Station	Tengah Met Station
March	56 (March 7, 2020)	40.4 (March 5, 2020)	60.6 (March 7, 2020)	42.6 (March 5, 2020)	24 (March 23, 2020)	35.5 (March 13, 2020)	83.2 (March 26, 2020)
April	38.2 (April 7, 2020)	45.6 (April 7, 2020)	68.2 (April 7, 2020)	80.2 (April 7, 2020)	23.6 (April 6, 2020)	35.6 (April 1, 2020)	46.4 (April 24, 2020)
May	47.6 (May 21, 2020)	31.4 (May 17, 2020)	49 (May 17, 2020)	67.2 (May 17, 2020)	23.5 (May 22, 2020)	35.2 (May 21, 2020)	50 (May 13, 2020)
June	31 (June 23, 2020)	17.8 (June 16, 2020)	87 (June 23, 2020)	34.6 (June 20, 2020)	23.4 (June 2 & 4, 2020)	33.9 (June 8, 2020)	44.4 (June 10, 2020)
July	52 (July 24, 2020)	36.6 (July 13, 2020)	54.2 (July 24, 2020)	43.4 (July 13, 2020)	21.9 (July 4, 2020)	33 (July 20, 2020)	68.5 (July 5, 2020)
August	36.6 (Aug 22, 2020)	53.4 (Aug 14, 2020)	43.8 (Aug 14, 2020)	75.6 (Aug 14, 2020)	22.3 (Aug 12, 2020)	34 (Aug 8, 2020)	51.9 (Aug 4, 2020)

5.3.1.3 Site-Specific Weather during Steam Velocity Measurement

Daily site-specific weather for stream velocity measurement on April 2, 2020 was obtained from the three nearest meteorological stations to the EIS Study Area as shown in **Figure 5.1**. The records are as follows:

- Maximum and minimum daily temperature was 35.2°C and 25.4°, respectively
- Average and maximum wind speed was 7.2 km/hr and 37.1 km/hr, respectively
- Highest 1-hour total rainfall depth was 37.8 mm which was recorded at Old Toh Tuck Road Met Station and 12 mm recorded at Choa Chu Kang Central Met Station

5.3.2 Microclimate

Microclimate is the distinctive climate of a small-scale area that varies from that of the surrounding areas or that which might be expected under the prevailing pressures and cloud covers. The weather variables that could differ include temperature, rainfall, wind or humidity (MET Office, 2017). It is suspected that Tengah has its own microclimate due to the large presence of forest cover whose canopies reflect solar radiation and can disrupt airflow above. In the case of rainfall, which is of interest in this section, microclimates of certain forests have been found to cause rainfall to be significantly lower than urban areas (Johnson et al., 1974). The full extent of Tengah's forest microclimate impact on the weather it experiences would require further studies, but it is therefore not unexpected for rainfall conditions to differ in Tengah as compared to the surrounding areas.

5.3.3 Flood Risk

There are no flood prone area within the EIS Study Area based on interactive map of flood prone areas by PUB.

5.3.4 Determination of Watercourse/ Hydrography Survey

5.3.4.1 Desktop Study

Based on our desktop study of available reference data as indicated in **Section 5.2**, various waterbodies are observed within the EIS Study Area at Tengah leading to Peng Siang River (**Figure 5.2**), which eventually drains to Kranji Reservoir at the north. Majority of the EIS Study Area (157.4 ha/94.8%) is located within Kranji Catchment with a smaller portion (8.6 ha/ 5.2%) at the southwestern of the EIS Study Area located within Jurong Catchment. Peng Siang River is located about 1 km north from the EIS Study Area and has been dammed to form the Kranji Reservoir. Kranji Reservoir is one of the 17 reservoirs in Singapore and is a national water supply source.

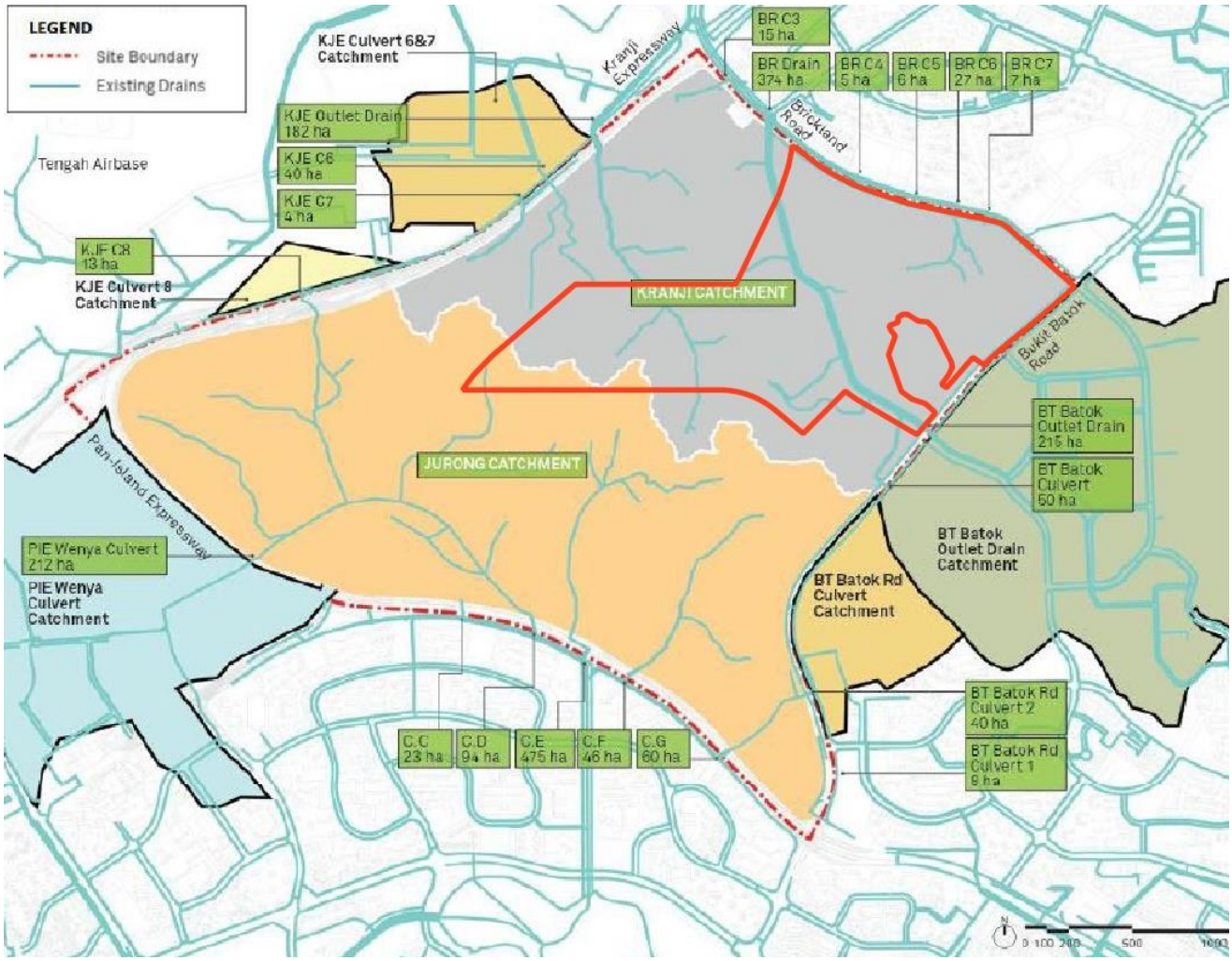


Figure 5.2: Water Catchments within EIS Study Area (outlined in red) based on Previous Environmental Baseline Study

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

5.3.4.2 Site Walkover and Hydrographical Survey

Various features of waterbodies (a combination of soft bank open/closed-canopy streams, concrete trapezoid or rectangular drain, surface drains and ponds) within the EIA Study Area were identified and documented during the surveys, these include: Main Canal, Spring Area, eight earth drains labelled as Earth Drain (ED)1, ED2, ED3, ED4, ED5, ED6, ED7, ED8, as well as six ponds labelled as Pond1, Pond2, Pond3, Pond4, Pond5 and Pond6. The types of waterbodies with photography are given in **Appendix 5A**.

The canal and earth drain basin catchments are developed based on the elevation data collected by topography survey. Within the main catchments of Kranji and Jurong, there are five smaller basin catchments (hereinafter refer as basin catchment) with their respective waterbodies are identified and illustrated in **Figure 5.3**, described below:

- Canal Basin 1 (approximately 78.7 ha) consists of Main Canal, Spring Area, ED3 and ED5. Main Canal was noted flowing in northerly direction to the canal along Brickland Road.
- Canal Basin 2 (approximately 25.4 ha) consists of ED2 and Pond6. ED2 was observed flowing to the earth drain at the north western portion of Tengah, which is leading to drain along Kranji Expressway (KJE). Canal Basin 3 (approximately 16.2 ha) consist of ED7, Pond3 and Pond4. ED7 was observed flowing in northerly direction to connect the earth drain at the north western portion of Tengah, which is then leading to the drain along KJE.

- Canal Basin 4 (approximately 50.4 ha) consists of ED1 and ED8 which was noted flowing towards the drain along Brickland Road and other earth drains (i.e. ED4 and ED6) that flows towards southerly direction.
- Canal Basin for Pond1 and Pond2 (approximately 4.5 ha) comprises of Pond1 and Pond 2.

Both drains along Brickland Road and the drain along KJE flow towards Sungei Peng Siang before ultimately reaching Kranji Reservoir.

The canal basin will be further delineated to form sub-catchments for hydraulic modelling exercise (see **Section 5.3.6**).

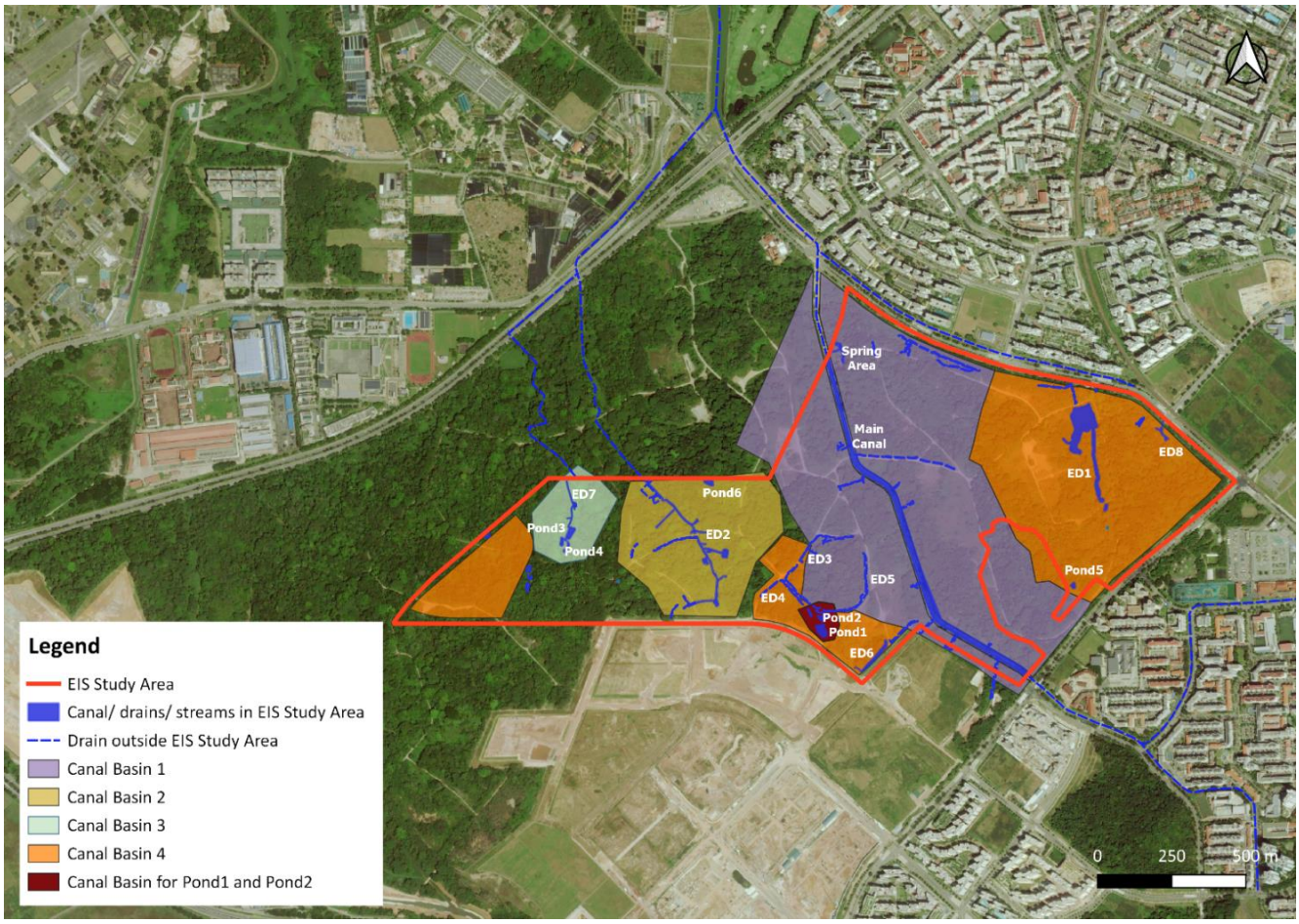


Figure 5.3: Waterbodies and Canal Basin within the EIS Study Area

Base Map: ESRI

No upstream and downstream stream flow and/or water level data for the Main Canal are available from the publicly available dataset portal established by the Singapore government (data.gov.sg). The unavailable data was also confirmed by PUB via email communication between CH2M HILL and PUB on July 20, 2020.

Upstream and downstream stream velocity at the Main Canal were measured by the Surveyor on Apr 2, 2020 after receiving significant rainfall of 37.8 mm/hr recorded at Old Toh Tuck Road Met Station and 12 mm/hr recorded at Choa Chu Kang Central Met Station. The stream velocity measurement locations are indicated in **Figure 5.4** and detailed in **Table 5.2** below.

Table 5.2: Stream Velocity Measurement at the Main Canal

Sampling ID	Date and Time	Flow Velocity * (m/s)	Depth (mm)**	Rationale
V1	April 2, 2020 at 17:33	1.048	350	This sampling location provides downstream stream velocity of the Main Canal.
	April 2, 2020 at 17:40	1.034		
V2	April 2, 2020 at 18:05	0.898	120	This sampling location provides upstream stream velocity of the Main Canal.
	April 2, 2020 at 18:10	0.811		
* Measurement obtained more than 2 hours after peak rainfall ** Depth estimated from picture taken during velocity measurement.				

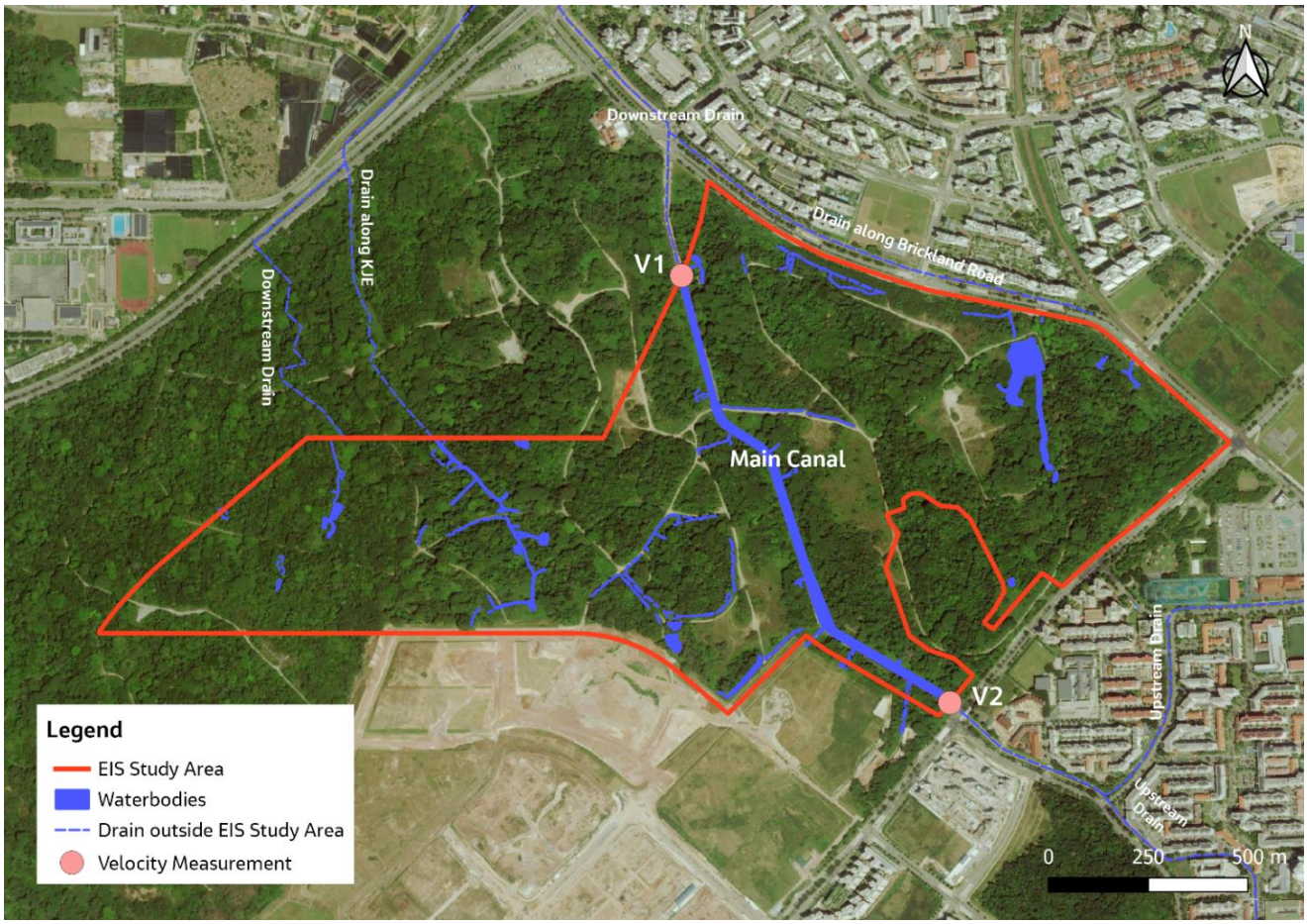


Figure 5.4: Location of Stream Velocity Measurement Stations at the Main Canal

Base Map: ESRI

5.3.5 Baseline Model Build

InfoWorks ICM is an integrated catchment model representing both the above (i.e. overland flow) and below ground (i.e. drainage system and canal) processes. It includes building of the one-dimensional (1D) component of the model including the representation of the storm drainage network and canal. Overland surface can be represented in the ICM model by construction of a two-dimensional (2D) model. The objective of the modelling is to develop a linked 1D/2D model of the EIS Study Area to better understand the existing surface water flow conditions and possible consequential impacts across the Study Area as a result of the development. The

hydraulic model is also able to assess the impacts from the flow of surcharge to nearby property from the surcharge source. Due to these reasons, InfoWorks ICM was therefore selected as the modelling software.

The baseline model begins from the road culvert at Bukit Batok Road and ends at Sungai Peng Siang. The model outside the EIS Study Area was built with information obtained from the desktop study accordingly.

5.3.6 Model Sub-catchment and Runoff Contributing Area

The sub-catchments in the model were delineated by on the overland flow direction as indicated by the contour elevation and topographical survey. The sub-catchments outside of EIS Study Area boundary; sub-catchments 1, 2, 3, 4, 5 and 6, were developed based on available data source (i.e. Singapore Master Plan Land Use 2014 and Google Earth (refer to **Figure 5.5**).

The runoff contributing area representing each sub-catchment within the EIS Study Area is assumed to be of a rural area based on the orthophoto LiDAR, topographical survey and Google Earth. In accordance to the COP, the fixed runoff coefficient is taken as 0.45 (See **Table 5.3**).

Table 5.3: Runoff Coefficient Value

Characteristics of catchment when fully developed	Value of C
Roads, highways, airport runways, paved up areas	1.00
Urban areas fully and closely built up	0.90
Residential/ industrial areas densely built up	0.80
Residential/ industrial areas not densely built up	0.65
Rural areas with fish ponds and vegetable gardens	0.45

Note: For catchment with composite land use surface characteristics, a weighted value of C may be adopted.

Source: PUB COP on Surface Water Drainage

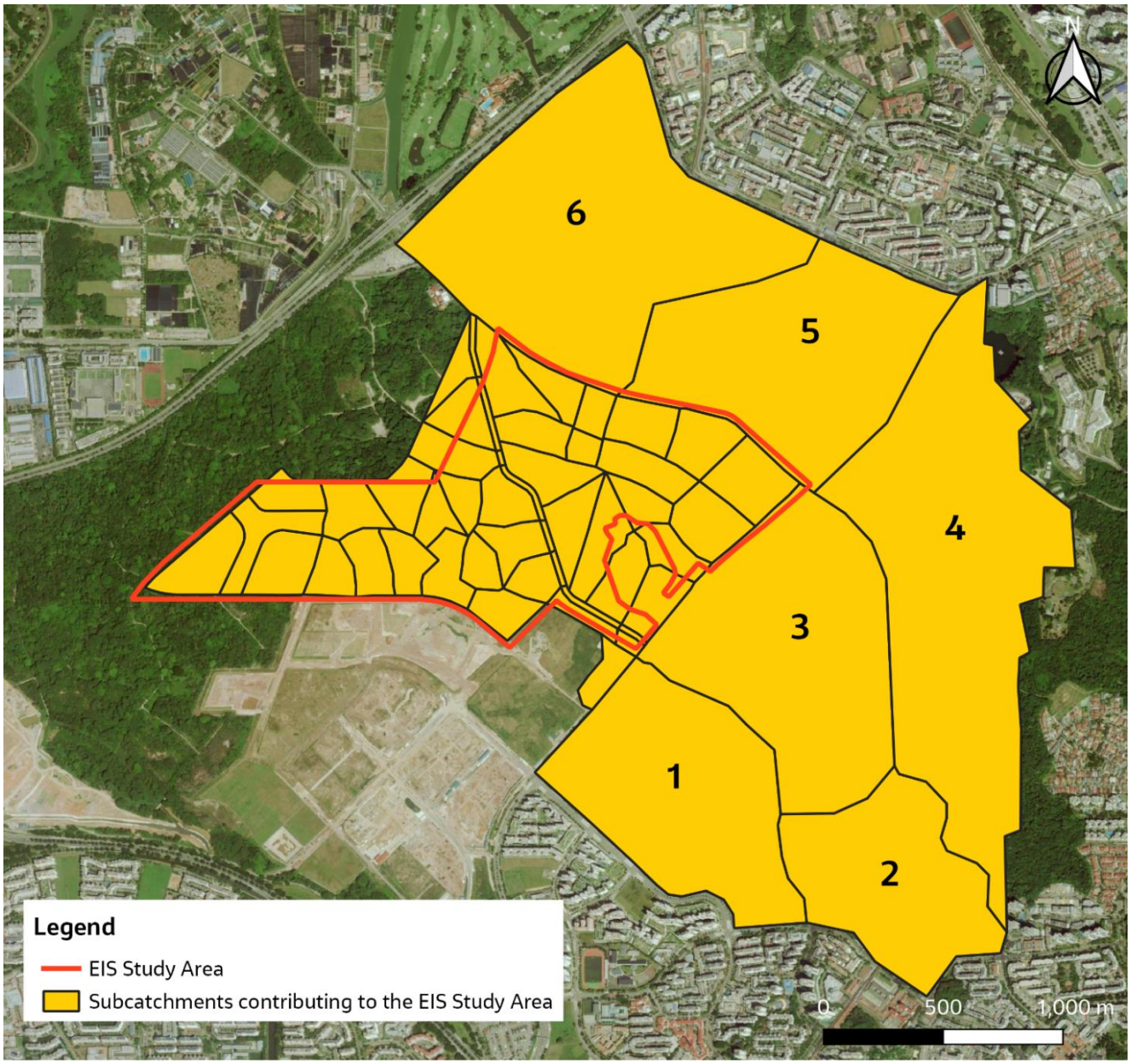


Figure 5.5: Sub-catchment for Baseline Model

Base Map: ESRI

For sub-catchments (1 to 6) outside of the EIS Study Area, the contributing area was established based on LiDAR, topographical survey and Google Earth. The runoff coefficient for the sub-catchments outside of the EIS Study Area were divided into two which are green areas and densely built areas. It is assumed that the densely built-up areas within these sub-catchments are with a runoff coefficient of 0.90 and for the green areas is 0.45 according to **Table 5.3** (refer to **Figure 5.6**).

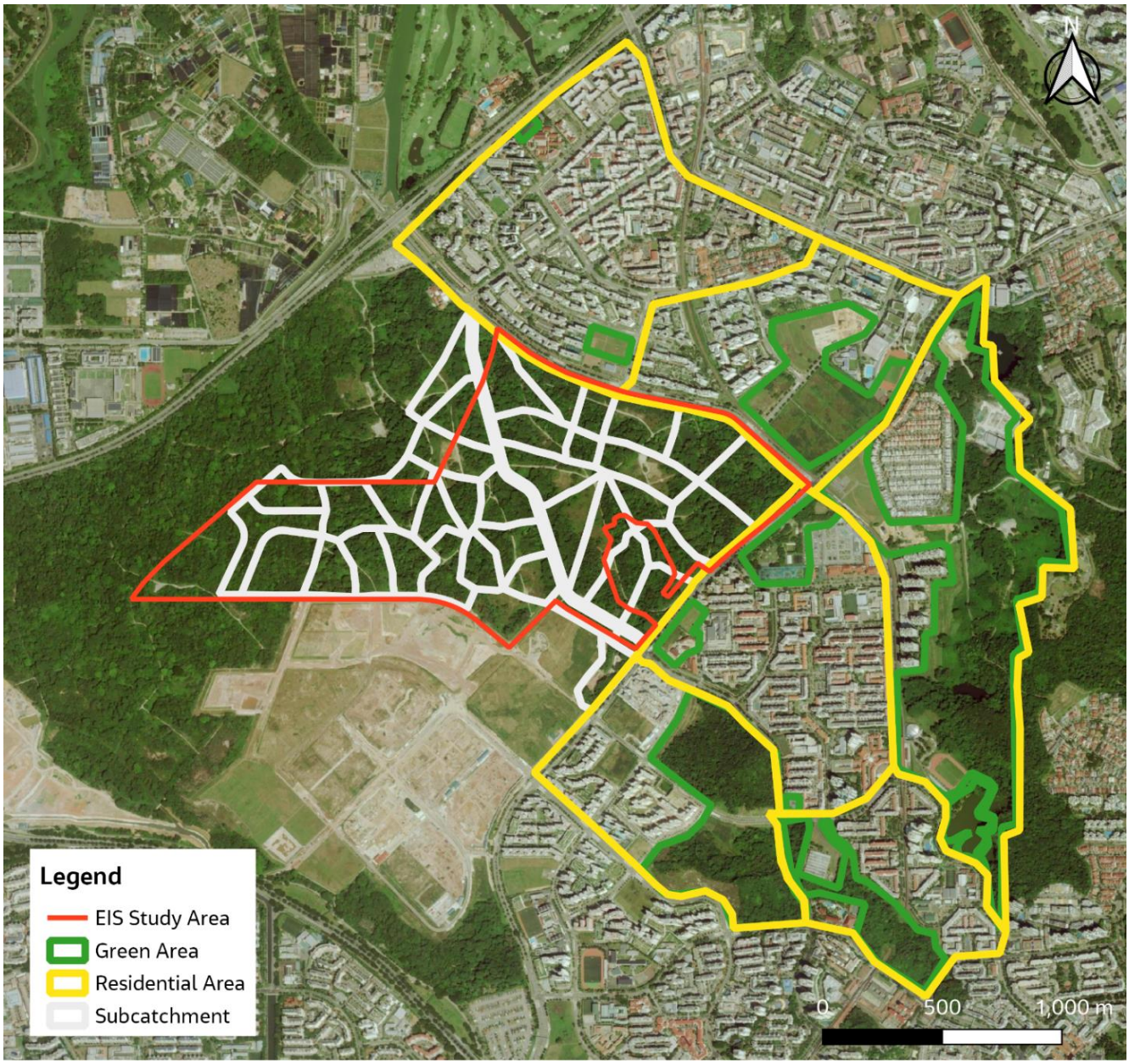


Figure 5.6: Land Use Applied in the Base Model

Base Map: ESRI

5.3.7 Baseline Conduit/ Canal Representation

A simplified model has been built to represent the existing condition of the EIS Study Area. The extent of the Main Canal in the model begins from the road culvert at Bukit Batok Road and ends at Peng Siang River. ED7 conveyance flows from far west of the EIS Study Area towards a northerly direction which will intercept with the earth drain at the northwestern portion of Tengah. Similarly, ED2 which serves a portion of the west EIS Study Area converges with the earth drain at the northwestern portion of Tengah. Both ED2 and ED7 were included in the model as rectangular-shaped open channel. The baseline model presented in **Figure 5.7** shows the route of the Main Canal across the EIS Study Area which is highlighted in red and represented by "multiple" links with available dimension and invert level survey information. In accordance with the COP, the model will be assessed with a 25-year return period design rainfall. The roughness coefficient (n) of the concrete canal is applied as 0.015. The groundwater and infiltration factors within the EIS Study Area, these were excluded in this assessment. The model has been assessed with 25 years return period design rainfalls (with durations of 15-min, 30-min, 60-min, 2-hour and 4-hour) with rainfall hyetograph developed using the Chicago Method.

The sectional dimension of the conduit is applied with a User defined Shape function in InfoWorks ICM to accurately represent the open channel size as per survey information. Due to inconsistencies of the surveyed top width canal dimension, an average dimension was taken for those with < 0.4 m different otherwise a new dimension was created and represented by a new conduit link.

Box culverts under access road is either modelled as a closed rectangular conduit or a user defined shape, whichever is appropriate.

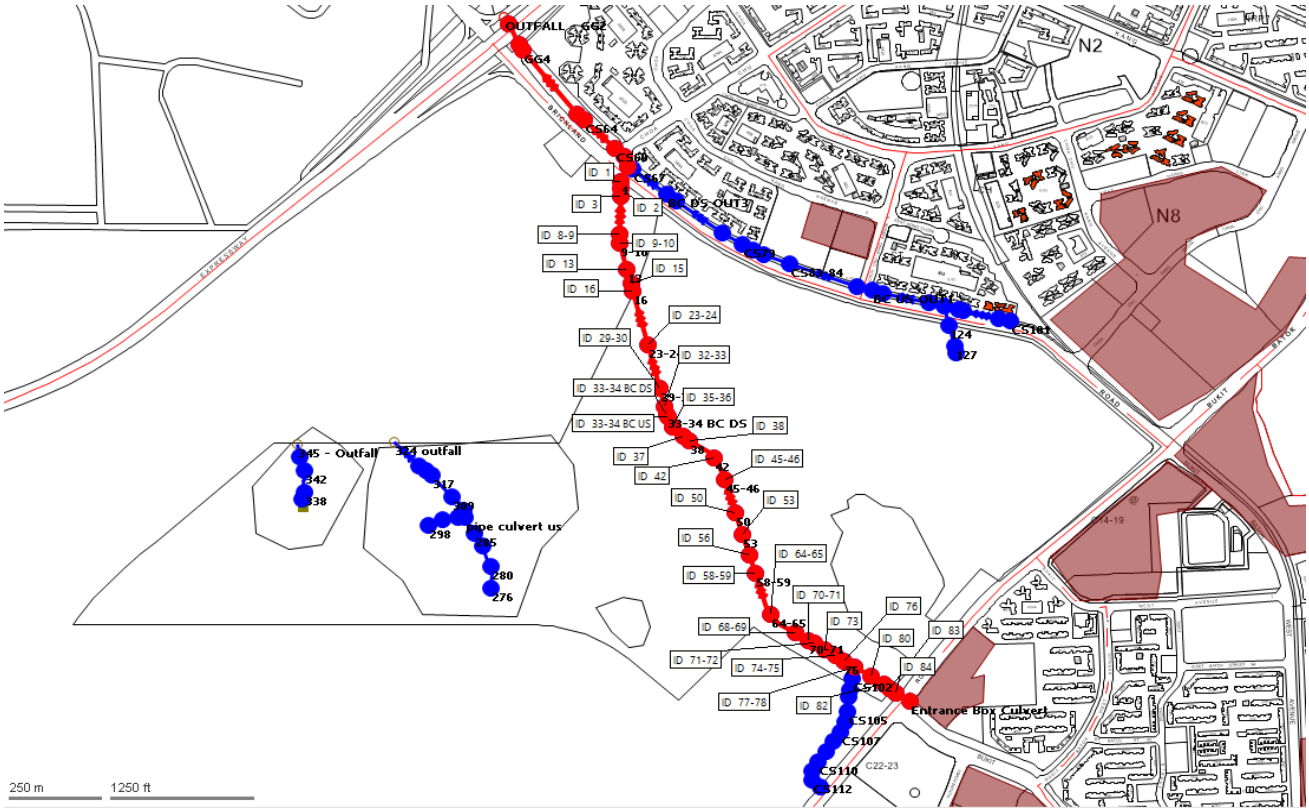


Figure 5.7: Baseline Network (Main Canal Highlighted in Red)

5.3.8 Drain Channel Roughness

To stimulate the flow capacity, Manning's equation of the existing main canal is estimated to have a roughness coefficient (manning's n) of 0.015 which represents the concrete roughness coefficient. The concrete roughness coefficient is in accordance with the COP.

5.3.9 Design Rainfall

In accordance with the COP guidelines, the design rainfall return period for the Main Canal shall be 1 in 25 years as the catchment area served by the canal is more than 100 ha. The rainfall intensity of the return period in this EIS was obtained from Singapore's rainfall intensity-duration-frequency (IDF) curves which was as per the COP of Surface Water Drainage. The dynamic modelling exercise requires a hyetograph for each rainfall return period with the associated durations.

The hyetographs were developed using the Chicago Method[5] to generate a 25-year return period design rainfall. The rainfall intensity at each time interval of 5 minutes was derived from the IDF relationships for the 25-year return period for five different durations: 15 minutes, 30 minutes, 1-hour, 2-hour and 4-hour. The resulting

[5] The Chicago Hyetograph Method is a classical method based on IDF curves for obtaining design hyetographs which present rainfall rates as continuous functions of time, one valid for times before peak and another for after peak.

rainfall profile will be used in assessing the impact of the development on the existing canal. Effects of climate change has not been covered in this EIS.

5.3.10 Tidal Level

Tidal levels were not considered as the distance of the EIS Study Area from the nearest shoreline is significantly distant enough such that tidal changes will not have any effect.

5.3.11 Groundwater and Infiltration Flow

No groundwater and infiltration flow have been considered in the model due to limited availability of information.

5.3.12 Model Calibration

The model has been calibrated to the flow survey results recorded last Apr 2, 2020. There are two calibration points, i.e. Points V1 (downstream) and V2 (upstream) (**Figure 5.8**), and the recorded flow information is presented on **Table 5.4** below. The rain gauge data for Old Choa Chu Kang is not available, in which case the model was calibrated using rainfall data from the Choa Chu Kang Central and Old Toh Tuck Road rain gauge data. It must be noted that the velocity and depth data were only recorded after an hour of the rainfall event.

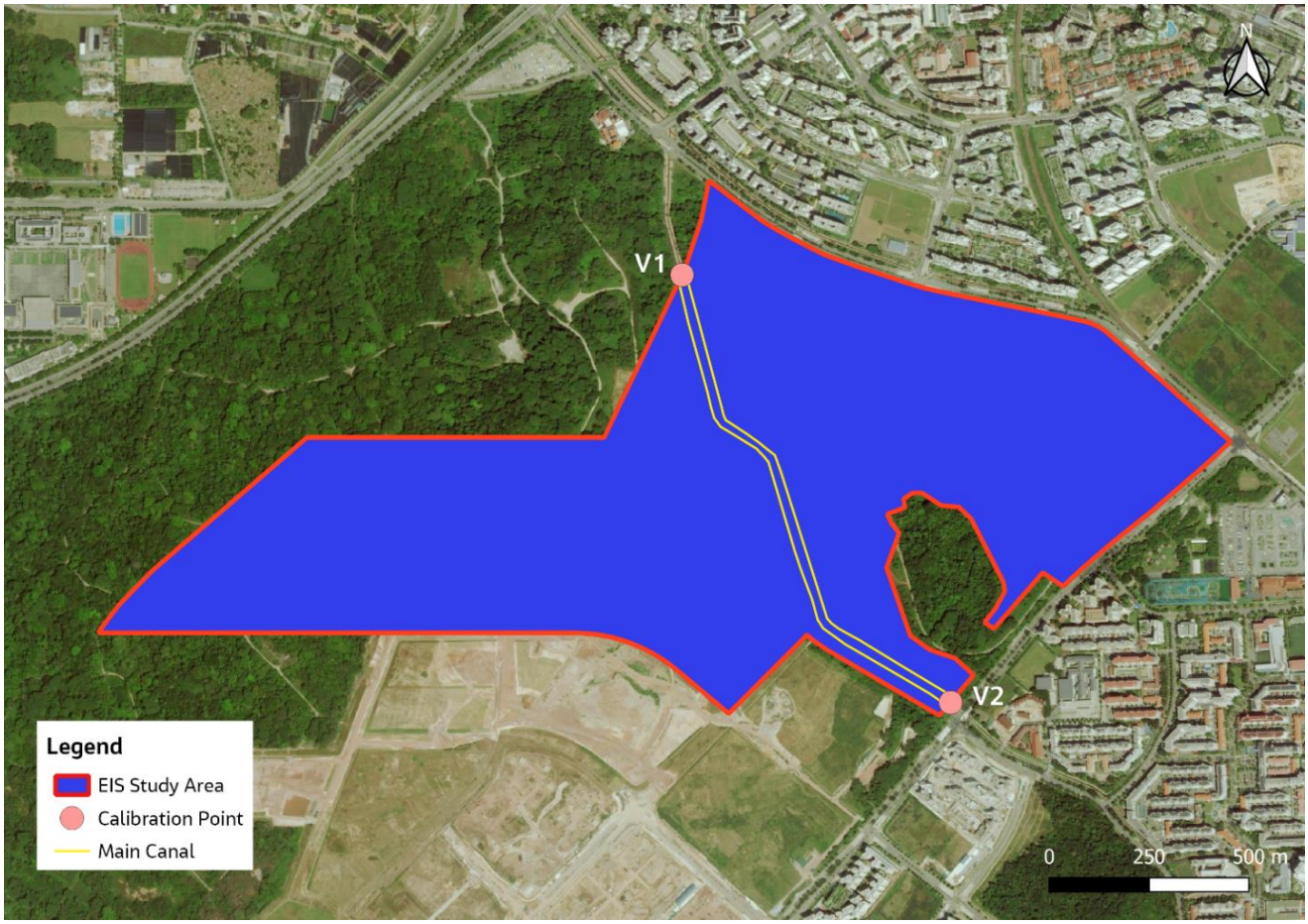


Figure 5.8: Flow Monitor Locations for Calibration (Main Canal Highlighted in Yellow)

Base Map: ESRI

Table 5.4: Recorded and Calculated Flow Velocity Data

Calibration Point	Recorded Time	Recorded Velocity (m/s)	Recorded Depth (mm)	Calculated Flow (m3/s)
V1	17:33	1.048	350	0.97
	17:40	1.034		0.96
V2	18:05	0.898	120	0.24
	18:10	0.811		0.22

The baseline model initially predicted a lower velocity and depth results compared with recorded data. In this case, the calculated time of concentration (Tc) for the sub-catchments upstream and outside of the EIS Study Area (upstream of V2) were increased by 40%. This improved the model prediction in terms of depth and velocity at location V1. Model predictions matched with the observed profiles reasonably well at V1, but not possible to match the observed profiles at upstream V2 due to low flow condition.

In the absence of collected flow data during the survey, these were calculated manually and compared with the model prediction at V1 and V2. The calculated flows were replicated successfully in the model as demonstrated by the good correlation between the observed and predicted flows presented in **Table 5.5**.

Table 5.5: Comparison of The Recorded Data and Calibrated Data

Calibration Point	Recorded Time	Recorded Velocity (m/s)	Calibrated Velocity (m/s)	Recorded Depth (mm)	Calibrated Depth (mm)	Calculated Flow (m^3/s)	Calibrated Flow (m^3/s)	Flow Percentage (%)
V1	17:33	1.048	0.729	350	384	0.970	0.990	102.060
	17:40	1.034	0.705		340	0.960	0.700	72.920
V2	18:05	0.898	0.060	120	61	0.240	0.000	0.000
	18:10	0.811	0.060		61	0.220	0.000	0.000

5.3.13 Model Caveats

In the preliminary stage, baseline models have been developed based on the surveyed data and available desktop data as indicated in **Section 5.2**. Where information is not available, engineering judgement/ assumptions were made. It should be noticed that the measured velocity and depth data at Points V1 and V2 were one hour after the rainfall event and did not measure peak flow during rainfall event. Hence the model will be calibrated to the available information. Detailed information of land uses (i.e. buildings, green and blue areas, internal road and utilities) for both existing and proposed developments were not available at the time modelling, hence the contribution area is estimated based on LiDAR, topography survey and Google Earth as well as development information with a blanket runoff coefficient applied.

5.3.14 Existing Conditions Assessment

The Project and other committed development within the EIS Study Area will involve significant earthmoving activities that will change the surface morphology in locations where this will take place. Existing natural and man-made water bodies, including flood control structures except the Main Canal will be disturbed, if not completely removed. The hydraulic model predicted changes in surface water flow direction of the development based on proposed new drainage system and platform levels, as well as the extent of changes.

A 2D simulation model was prepared for the EIS Study Area to better understand the existing conditions. Information from the topographical survey were converted into Digital Elevation Model (DEM) data using a maximum mesh size of 100 m^2 and minimum mesh size of 25 m^2 developed for the entire EIS Study Area and nearby areas. The mesh size is decreased to 5 m^2 (maximum) and 2 m^2 (minimum) respectively in areas of the earth drains, ponds and main canal. It is estimated that around 0.91 km^2 of areas will have changes in surface water flow direction in view of the proposed drainage system. This is presented below in **Figure 5.9**.

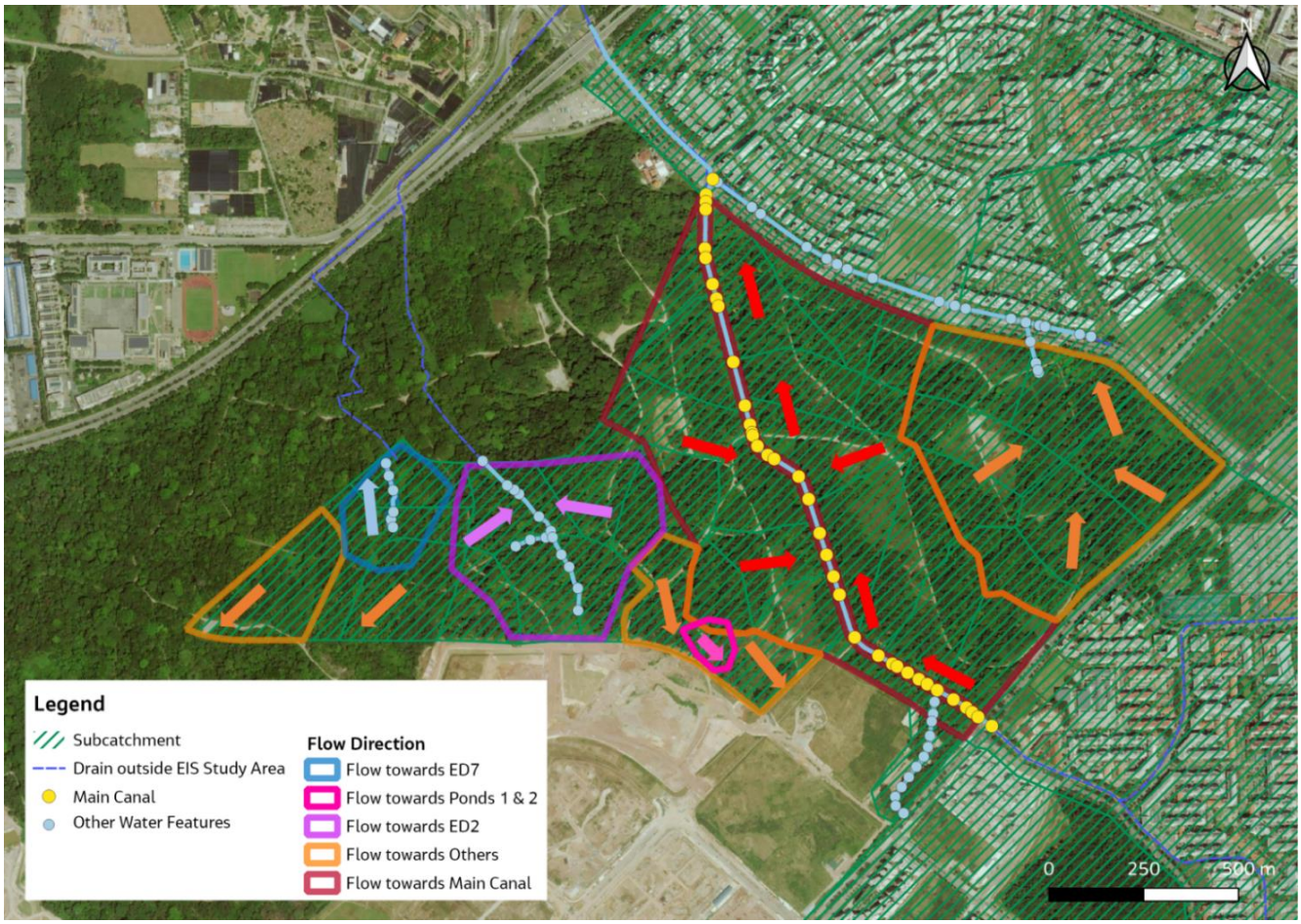


Figure 5.9: Flow Direction for the Existing Conditions Scenario

Base Map: ESRI

Existing conditions for the present Main Canal in the EIS Study Area was assessed from the upstream (south) to downstream (north), starting from Section 84 to Section 1. Under existing conditions, with a 25-year return period of design event and duration of 15- to 60-minute, no spillages were predicted. However, water overflowing the cope level were observed at several nodes with a depth of less than 0.6 m during the 25-year return period of 2- and 4-hour. Overview of the spillage locations under the existing conditions scenario can be seen in **Figure 5.10**. **Table 5.6** compares the ground level and backwater level (top water level) predicted at these nodes, whereas **Table 5.9** presents the minimum and maximum runoff volumes under the existing conditions scenario.

It is interesting to note that the low and peak 5-year return period flow rates for ED7 and ED2 are at 0.07-0.20 m^3/s and 0.04-9.01 m^3/s, respectively, which suggests that these surface water features are possibly sustained by sources other than surface flows. Conduits of perched or leaky aquifers may possibly provide flows which allow the existence of wetlands in these features. This assumption is subject to confirmation by subsurface assessment through a georesistivity survey to evaluate the aquifer dynamics beneath these areas.

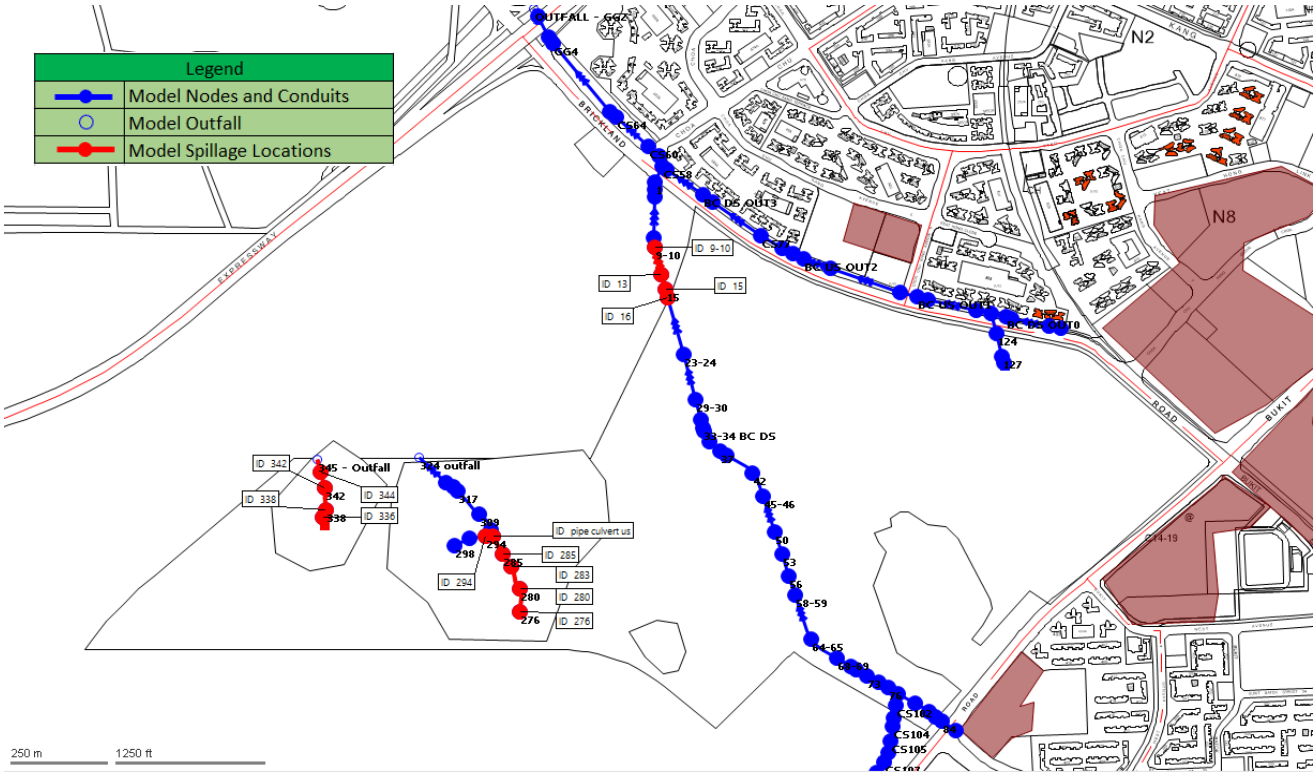


Figure 5.10: Overview of Predicted Locations for Spillages under Existing Conditions Scenario

Table 5.6: Spillage Locations under The Existing Conditions Scenario

Node ID	Ground Level (GL) (m SHD)	Backwater Level (TWL) (m SHD)	Difference (TWL-GL) (m)
Main Canal			
9-10	4.760	4.894	0.134
13	4.755	4.998	0.243
15	4.716	5.102	0.385
16	4.788	5.178	0.390
Earth Drain 2			
280	10.170	11.318	1.148
283	9.090	10.547	1.457
285	9.250	10.513	1.263
294	9.862	10.503	0.641
Pipe US	8.400	10.503	2.103
318	7.850	7.980	0.130
319	7.820	7.944	0.124
Earth Drain 7			
Pond ED7	13.690	14.447	0.757
336	12.787	13.860	1.073
338	12.579	13.521	0.942
342	11.340	13.164	1.824
344	10.899	12.564	1.665

Table 5.7: The Maximum and Minimum Predicted Runoff Volume under The Existing Conditions Scenario

Location	5-year return period				25-year return period			
	Min		Max		Min		Max	
	Peak Flow rate (m^3/s)	Volume (m^3)	Peak Flow rate (m^3/s)	Volume (m^3)	Peak Flow rate (m^3/s)	Volume (m^3)	Peak Flow rate (m^3/s)	Volume (m^3)
ED7	0.07	93.94	0.20	903.98	0.12	148.71	0.28	1,279
ED2	0.04	66.83	9.01	20,384	0.06	117.99	13.23	51,483
Main Canal	4.06	15,787	28.92	178,209	7.41	25,818	39.95	242,645
South Ponds	-	1,521,780	-	2,479,596	-	1,581,863	-	2,599,057

5.3.15 Proposed Condition Scenario

Storm drains proposed to be built across the EIS Study Area is presented in **Figure 5.11** below, which will result in change of flow directions – some may contribute to the storm drains (blue arrows) while some will convey to the downstream via the Main Canal (red arrows) when constructed.

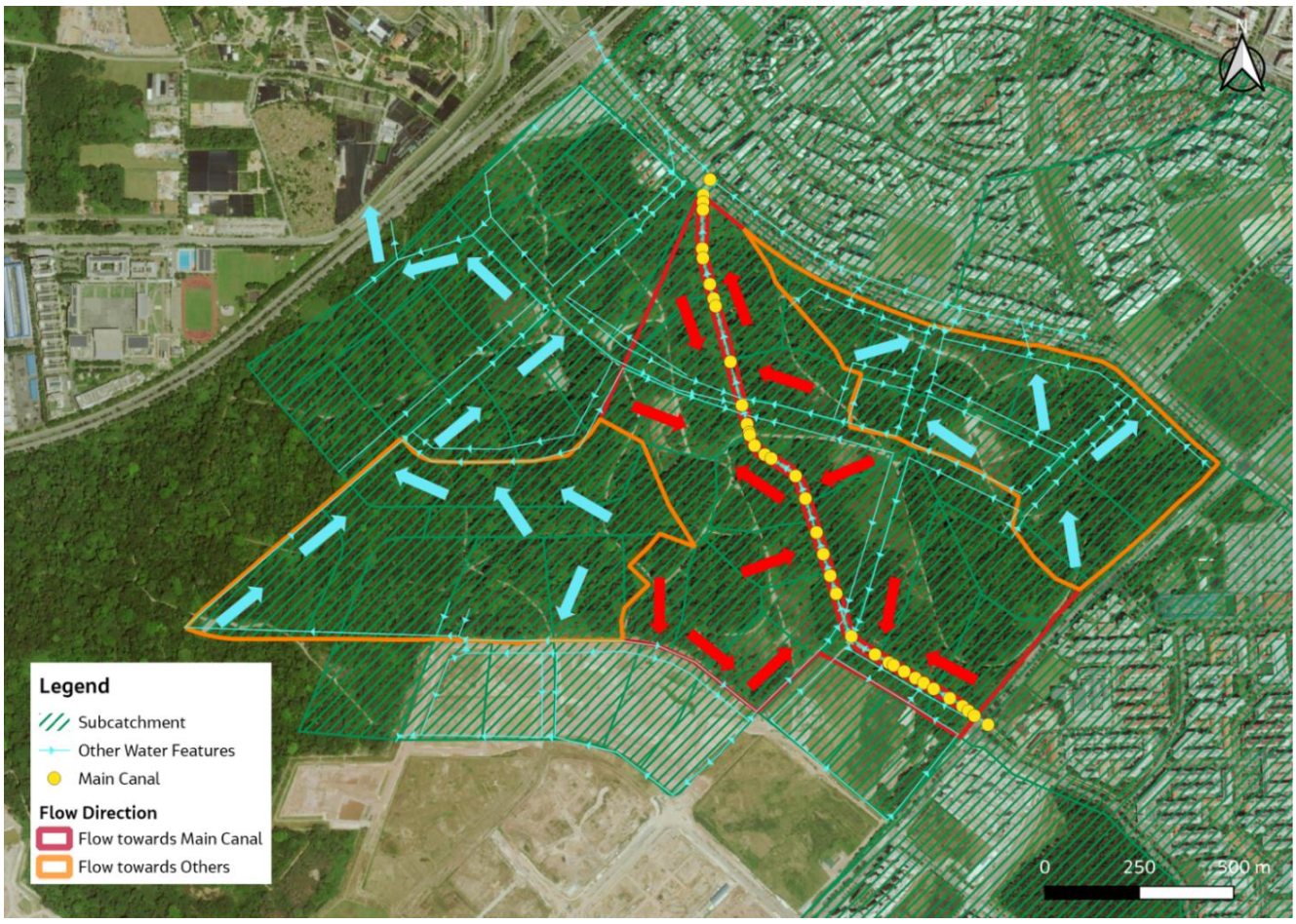


Figure 5.11: Overview of Predicted Locations for Spillages under Proposed Condition Scenario

Base Map: ESRI

5.4 Evaluation Potential Impact Before Mitigation Measures

5.4.1 Potential Source of Impact

Key activities of the Project within the EIS Study Area that will be involved in developing each of the construction stages include:

- Change in landform/geomorphology resulting from earth-moving, and cut-and-fill activities
- Diversion of surface water flows

These activities were identified to have various impacts on the surface water flow direction, capacity and flow rate changes. These are described below and are assessed with the RIAM method accordingly.

5.4.2 Evaluation of Changes in Surface Water Flow Direction

The changes of surface water flow direction is evaluated to have high magnitude if there is significant and permanent departure of surface flow from its original tributary, and may cause loss of streamflow discharge at recipient channel/drain. If there are only temporary or permanent partial or considerable departure of surface water flow from its original direction, and may cause reduction of streamflow discharge to recipient channel/drain, then the magnitude is considered "Medium". Insignificant or minimal departure of flow from its original direction is considered "Low" magnitude of changes.

The Project development will involve significant land use change across the EIS Study Area, particular on project construction footprint, from the current green space into residential, commercial, institutional and infrastructure. The diversion of existing streams, canals and earth drains is expected according to the land use and Drainage Master Plan. The Project development may cause changes in surface water flow direction as a result of a new drainage system and platform levels as seen with the comparison of **Figure 5.9** and **Figure 5.11**. As the concept of groundwater recharge zones was previously mentioned in the hydrogeology section (**Section 4**), surface flows diverted away from these still-unidentified recharge zones may indirectly contribute to the reduction of groundwater occurrence in the aquifers beneath the EIS Study Area. There may be an increase in flood risk in areas where additional flow is diverted to, as the existing drains serving these areas may not be able to cope with the increased runoff coming from other areas.

Table 5.8: Impact Significance for Surface Water Flow Direction Changes over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The EIS Study Area is part of the Kranji and Jurong Catchments, which extends beyond Project boundaries.
A2.1: Impact Nature	-1: Negative	Diversion of water away or into groundwater recharge zones and sensitive water features will alter their hydrogeological characteristics, which may lead to their deterioration if not outright loss. Channels receiving diverted water are at increased risk of flooding when the storm return period is exceeded.
A2.2: Magnitude of Changes	2: Medium	The effect of change in landform to the flow direction is limited to development areas, and the plan to develop new storm drains will accommodate these changes in flow direction. The scale of the changes is evaluated as temporary or partial permanent or considerable departure of surface water flow from its original direction, and may cause reduction of streamflow discharge to recipient channel/ drain.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	3: National	As part of the Kranji Catchment, the effects can extend into the areas that are part of this basin, which also includes the Kranji Reservoir downstream of the main canal. The same can be expected of the Jurong Catchment west of the EIS Study Area, both of which may have faster inflows as a result of diversion.
B1: Permanence	3: Medium Term	The flow directions will variably change as disturbance is on-going until project completion, of which it will achieve a permanent flow direction dictated by the resulting landform characteristics.
B2: Impact Pathway	3: Direct	Landform change and ground disturbance to accommodate both construction development and as well as changes to drainage configuration will directly alter the current hydrological regimes and therefore direction of surface flows.
B3: Reversibility	3: Irreversible	The ultimate result of landform changes to accommodate the infrastructure remains permanent. Flow direction will follow hydrological characteristics defined by the final landform.
B4: Cumulative	2: Non-cumulative	The variability of flow direction will end when activities cease and manifest its final direction according to surface morphology.
Environmental Score (ES)	(-18) x (11) = -198	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

5.4.3 Evaluation of Changes in Surface Water Flow Rate

As a result of change in surface water flow direction and change in land use type within the development, there is the potential to increase the inflows into the existing canal and future drains. The reduction of open, vegetated spaces currently acting as buffer zones to contain part of the rainwater that infiltrates into the ground will contribute to the increase in surface runoff that will flow into the storm drains. Water features that are dependent of received runoff water may be lost as future inflows are reduced or abandoned altogether due to diversion as part of flood control. Majority of water features within the EIS Study Area boundary will be abandoned as part of the Tengah North Drainage Master Plan, with new drains proposed to serve the land parcels, and the Main Canal retained. The hydraulic assessment on the Main Canal concluded that the Project with other developments within the EIS Study Area would have significant increase to the flow within the Main Canal and likely to detriment on the performance in future should upgrading works not being done to the Main Canal. If the variance of flow rate is more than 50% of recorded water inflow/outflow, the magnitude of change is evaluated as “High”. Should the variance only less or equal to 10%, then the magnitude is evaluated as “Low”. The variance in between high and low magnitude would be assessed as “Medium”.

Table 5.9: Impact Significance for Changes on Surface Water Flow Rate over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The EIS Study Area is part of the Kranji and Jurong Catchments, and extends beyond Project boundaries.
A2.1: Impact Nature	-1: Negative	Surface water features previously dependent on surface flows can be permanently lost if flow rates are ultimately reduced or removed. An increase in runoff flow rate will occur as open surface buffers are reduced in size, increasing the risk of flooding or exceeding the design capacity of receiving storm drains.
A2.2: Magnitude of Changes	2: Medium	The effect of change in landform to the hydrological characteristics is limited to development areas, and the plan to develop new storm drains will accommodate these changes. Based on the return period calculation predicted by the hydraulic model assessment, 10% variance from predicted runoff volume < recorded volume < 50% variance from predicted runoff volume. This is evaluated as moderate scale because the base values can vary between 10% and 50% of the predicted volume, with not more than 50% of recorded surface water inflow/outflow.
A2.3: Impact Extent	3: National	Changes in flow rates will have an effect downstream of the Kranji and Jurong Catchments. parts of the EIS Study Area can be considered as recharge zones for these two basins.
B1: Permanence	3: Medium Term	The flow rates will variably change in disturbance areas until project completion, of which it will achieve a permanent flow rate dictated by the resulting landform characteristics.
B2: Impact Pathway	3: Direct	Landform change and ground disturbance within development areas will directly alter the original flow characteristics.
B3: Reversibility	3: Irreversible	The effect of changes to landform is permanent to accommodate the infrastructures, of which flow rate properties will adapt to the new conditions.
B4: Cumulative	2: Non-cumulative	The ground disturbance during construction activities will result in the gradual change of hydrological conditions until the desired plan has been completed. The change ends when development activities have ceased, of which the flow rates become final.
Environmental Score (ES)	(-18) x (11) = -198	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

5.5 Applicable Prevention and Mitigation/ Enhancement Measures

Impact to the hydrological properties of flow direction and flow rate were considered as a response to the development plan which will involve significant changes on land morphology, landform and surface properties. The impact is expected based on the proposed changes on the site topography.

It is understood that hydraulic capacities of existing drains which are serving the development are being assessed under the Tengah North Drainage Master Plan for upgrading plan to cater for the increased runoff in tandem with development and infrastructure works. The proposed new or existing drains will be upgraded/ sized according to the requirement stated in the COP with additional 25% increase in rainfall intensity, to cater for climate change condition. The Main Canal will be redeveloped into the proposed Forest Stream, where it will be led by NParks. PUB will communicate with NParks so that the redevelopment of the Main Canal will follow the COP for stormwater management.

The impact due to change in surface flow direction and flow rate may be further minimised with either any or a combination of the following mitigations:

Planning Phase

- As part of the detailed design for the Project, undertake a detailed hydrological assessment to refine the conditions considered in the proposed design and placement of storm drains prior to the construction of these structures.
- Consideration or designation of non-disturbance zones or buffer zones with vegetation cover in conjunction with the recommended area of conservation (RAC) (refer to **Figure 7.83** in **Section 7**) within the EIS Study Area to compensate for the loss of open surface areas serving as recharge zones upon Project completion.
- For temporary and permanent waterways or drainage canals where design/ planning can allow, it is recommended to keep an additional 1-2 m buffer on both sides of the waterways beyond the required drainage reserves as prescribed by PUB's COP on Surface Water Drainage.

Pre-construction/ Construction Phase

- Undertake a programmatic Excavation, Cut and Fill and Earthmoving plan. The execution of construction work should follow the planned stages and programmed segments to avoid formation of uneven slopes or terrain that can influence surface flow direction and to avoid creation of conditions that can cause unchecked increase in surface water flow rate on temporary or permanent water features or drains.
- Minimise the disturbance area affected by excavation and earthworks to what is only necessary in accordance with the Site Development Plan. The Site Development Plan must consider allocation of some of the available land resource for buffer zones acting as recharge zones which can naturally accommodate excess surface runoff and thereby reduce the surface water flow rates entering drains and waterways and reducing the need for auxiliary equipment during peak rainfall regimes. These includes the existing wetlands, ponds, feeder canals as well as minor watercourses which help to naturally accommodate the runoff. Such buffer areas shall be maintained in their undisturbed condition where practicable, or retained where feasible, with appropriate modifications that can be integrated in the project plan. The RAC can also be considered as buffer zones for this purpose.
- Placement of temporary diversion channels strategically placed within construction or work areas to manage and direct surface flows.
- Waterways and drains designated as recipients of increased surface water flow rates may need to be designed with consideration of allowance of 5-10% above the design capacity. Alternatively, auxiliary equipment such as sluice gates and pumps shall be installed to provide operational support when excessive runoff enters these systems.

5.6 Residual Impact

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

- Permanent change in surface hydrological dynamics.
- Permanent reduction of regional catchment recharge zones.
- Reduction of flooding/ spilling risk in critical parts of drains/ waterways.
- Conservation of remaining buffer areas as recharge zones.
- Conservation of inflow-dependent water features.

The resulting change in surface hydrological dynamics can be mitigated in part by the measures mentioned previously as an adaptation to the new conditions established by a modified landform. The reduction of size of recharge zones which help mitigate the risk of flooding from excess runoff can be enhanced through conservation measures together with other areas identified as additional buffer zones. Sensitive water features such as wetlands and ponds that are partly sustained by surface water inflows can be conserved with intervention such as placement of diversion pumps which can operate on-demand. Properly designed drains and waterways to consider design criteria beyond the 1:25 return period can further reduce the risk of flood spills during peak runoff inflows. Auxiliary equipment such as flood control pumps may be installed as necessary as part of these structures.

Table 5.10: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
H-I1	Changes in Surface Water Flow Direction	-198	**Moderate Negative Impact**	-99	**Minor Negative Impact**
H-I2	Changes in Surface Water Flowrate	-198	**Moderate Negative Impact**	-99	**Minor Negative Impact**

6. Water Quality

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

6.1 Applicable Legislation and Standards

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

The waterbodies in EIS Study Area ultimately drain to Kranji Reservoir, which is one of the 17 reservoirs in Singapore. Under the *Public Utilities Act*, Kranji Reservoir is defined as a controlled watercourse as it forms part of the national water supply under PUB. Hence, a set allowable limit (**Table 6.1**) for controlled watercourse has been applied in this EIS. In addition, the *EPM (Trade Effluent) Regulations* specify a maximum discharge limit for total suspended solids (TSS) as 30 milligrams per litre (mg/L) into a controlled watercourse.

Table 6.1: Allowable Limits for Trade Effluent Discharge to Controlled Watercourse[6] Specified by *EPM (Trade Effluent) Regulations*

Item of Analysis	Standard	Discharge Limit Controlled Watercourse, mg/L
Turbidity	*In-situ*	-
Conductivity	*In-situ*	-
Potential of Hydrogen (pH) value	*In-situ*	6-9
5-day Biological Oxygen Demand (BOD_5) at 20°C	American Public Health Association (APHA) 5210B	20
Chemical Oxygen Demand (COD)	APHA 5220B/HACH 8000	60
Total Suspended Solids (TSS)	APHA 2540D	30
Total Dissolved Solids (TDS)	APHA 2540C	1,000
Phosphate (PO_4) as P	APHA 4110B / 4500-P(G)	2
Nitrate (NO_3) as N	APHA 4500-NO3 (I)	20
Total N	APHA 4500-N (C)	-
Total P	APHA 4500-P (H)	-

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

[6] Controlled Watercourse refers to a watercourse from which water supplied by Public Utilities Board (PUB) under the Public Utilities Act is obtained but does not include a watercourse from which water is pumped into a main of the PUB

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

- COP for Environmental Control Officer (ECO) issued by NEA
- COP on Surface Water Drainage (7th Edition, Dec 2018) issued by PUB
- COP of Practice on Sewage and Sanitary Works (2nd Edition, Jan 2019) issued by PUB
- *Sewerage and Drainage (Trade Effluent) Regulations*, issued by PUB
- Guidebook on Erosion and Sediment Control at Construction Sites, issued by PUB
- Guidebook for Qualified Erosion Control Professional (QECP), issued by PUB

6.2 Assessment Methodology

This EIS focuses on the assessment of potential water quality impacts during the construction phases of the Project. Given the nature of the Project, which is largely housing estates where sanitary wastewater would be collected by the property's sewer line and discharged to the public sewer managed by PUB, adverse impact to water quality is unlikely during the operational phase.

There is no legislation and standard in Singapore presently that describes the methodology for water quality impact assessment. Thus, we propose to use the Technical Memorandum Annex 14: Guidelines for Assessment of Water Pollution published by Hong Kong's Environmental Protection Division (HK EPD) adapted to the Singapore context. The Technical Memorandum Annex 14: Guidelines for Assessment of Water Pollution was chosen as it provides guidance on the identification of potential water pollution sources associated with the Project development as well as prediction and assessment of potential water pollution impacts.

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

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

6.3 Pre-construction Baseline

6.3.1 Determination of Waterbodies

Water quality sampling is performed for the identified waterbodies (**Section 5**) with ecological value and hydrological connection to the main waterbodies within and outside EIS Study Area, as follows: Main Canal, Spring Area, Earth Drains (ED1, ED2, ED3, ED4, ED5, ED6, ED7 and ED8) and Ponds (Pond1, Pond2, Pond3 and Pond 4).

6.3.2 Water Quality Baseline Sampling Plan

Locations of water quality baseline sampling plan are shown in **Figure 6.1** for wet and dry events sampling and summarised in **Table 6.2**. In accordance with the Tender Specification, the sampling interval is 50 m along each identified waterbody that has a length of more than 50 m.

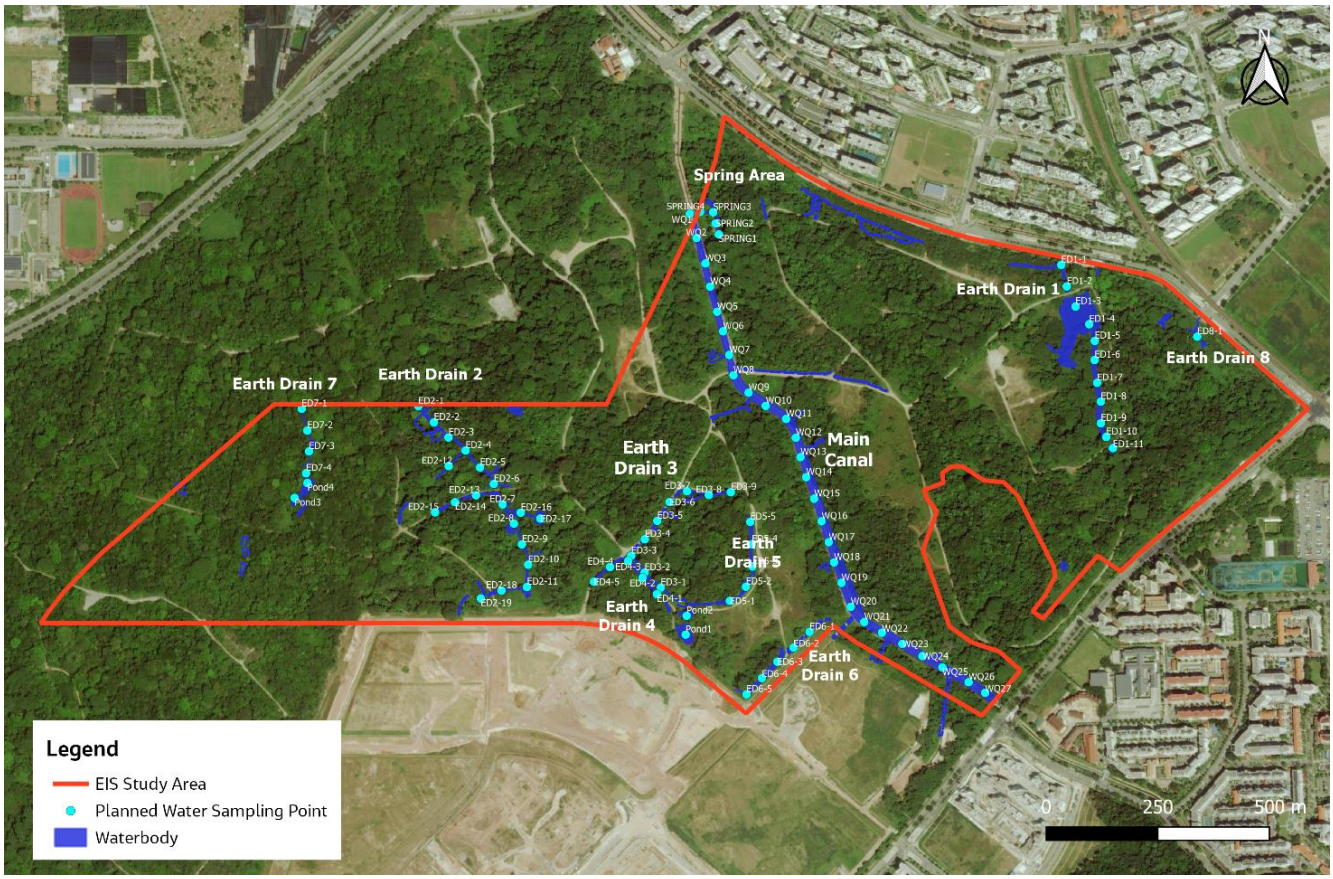


Figure 6.1: Locations of Identified Water Quality Points of Every 50 m Interval for Dry and Wet Event Sampling

Base Map: ESRI

Table 6.2: Water Quality (WQ) Baseline Sampling Location, Description and Rationale

Location	Sampling Point ID	Description	Rationale
Main Canal	WQ1 to WQ27	• Length of this canal within the EIS Study Area is approximately 1.35 km • A total of 27 points were identified with 50-m intervals • WQ1 is the most downstream point • WQ27 is the most upstream point	• To provide the surface water quality data of the Main Canal, which is the downstream of the drain along Brickland Road, Sungei Peng Siang and Kranji Reservoir • The Main Canal is part of proposed Forest Corridor study
Spring Area	SPRING1 to SPRING4	• Length of the streams within this area is approximately 0.12 km • A total of four sampling points were identified • SPRING1 is the most upstream point • SPRING4 is the most downstream point	• To provide the surface water quality data of Spring Area, which is the upstream of Main Canal • Water from Spring Area eventually drains to the Main Canal

Location	Sampling Point ID	Description	Rationale
Earth Drain 1 (ED1)	ED1–1 to ED1-11	• Length of the drain is 0.5 km with 11 sampling points identified • ED1–1 is the most downstream point • ED1–11 is the most upstream point • ED1–1 and ED1–2 are located at the lined drain; ED1–3 to ED1–11 are soft bank stream	• To provide the surface water quality data of Earth Drain 1, which is the downstream of the drain along Brickland Road, Sungei Peng Siang and Kranji Reservoir • Based on Drainage Master Plan provided by HDB, the lined portion of Earth Drain 1 will be retained
Earth Drain 2 (ED2)	ED2–1 to ED2–19	• Length of the drain is approximately 0.95 km with 19 sampling points identified • ED2–1 is the most downstream point • ED2–19 is the most upstream point	• To provide the surface water quality data for Earth Drain 2 and for aquatic fauna of conservation significance within (**Section 7**) • Earth Drain 2 is the downstream of drain along KJE, Sungei Peng Siang and Kranji Reservoir
Earth Drain 3 (ED3)	ED3-1 to ED3-9	• Length of the drain is approximately 0.45 km with nine sampling points identified • ED3–1 is the most downstream point • ED3–9 is the most upstream point	• To provide the surface water quality data of Earth Drain 3
Earth Drain 4 (ED4)	ED4-1 to ED4-5	• Length of the drain is approximately 0.2 km with five sampling points identified • ED4–1 is the most downstream point • ED4–5 is the most upstream point	• To provide the surface water quality data of Earth Drain 4
Earth Drain 5 (ED5)	ED5-1 to ED5-5	• Length of the drain is 0.29 km with five sampling points identified • ED5–1 is the most downstream point • ED5–5 is the most upstream point	• To provide the surface water quality data of Earth Drain 5
Earth Drain 6 (ED6)	ED6-1 to ED6-5	• Length of the drain is 0.28 km with five sampling points identified • ED6–1 is the most downstream point • ED6–5 is the most upstream point • ED6-1 and ED6-2 are located at the lined drain, ED6-3 to ED6-5 are located at earth drain	• To provide the surface water quality data of Earth Drain 6
Earth Drain 7 (ED7)	ED7-1 to ED7-4	• Length of the drain is 0.16 km with four sampling points identified • ED7–1 is the most downstream point • ED7–4 is the most upstream point	• To provide the surface water quality data of Earth Drain 7 and for aquatic fauna of conservation significance in Earth Drain 7 (**Section 7**)
Earth Drain 8 (ED8)	ED8-1	• Length of the drain is 0.07 km with one sampling point identified	• To provide the surface water quality data of Earth Drain 8 which flows out towards Brickland Road via a concrete drain.

Location	Sampling Point ID	Description	Rationale
Pond 1	Pond1	• One grab sample per pond	• To provide the surface water quality data of Pond1
Pond 2	Pond2		• To provide the surface water quality data of Pond2
Pond 3	Pond3		• To provide the surface water quality data for aquatic fauna of conservation significance in Pond3 (**Section 7**)
Pond 4	Pond4		• To provide the surface water quality data for aquatic fauna of conservation significance in Pond4 (**Section 7**)

6.3.3 Water Quality Baseline Sampling Event

In accordance with the Tender Specification, surface water quality samples were collected in two weather events i.e. wet event – within two hours of a significant rain event; and dry event – no rain event in the preceding 48 hours.

Water quality sampling commenced on Mar 16, 2020 with concurrent site survey carried out for watercourses identification and topography/hydrology mapping and was completed on Oct 22, 2020. It has to be noted here that the widespread of sampling dates/ days are due to the following reasons:

- Large sample size (a total of 188 water samples were planned to be collected).
- Microclimate weather condition of Tengah.
- Site access restrictions, where daily key collection and returning to designated location authorised by MINDEF is required with limited hours for sampling (particularly for wet event).
- COVID-19 measures imposed by the Singapore Government, this includes no water quality and watercourses identification during the Circuit Breaker (CB) period, from Apr 7 to June 1, 2020; and phased approach post-CB period with slow resumption of sampling/watercourses identification/hydrology mapping.

Details on sampling date, location, activity is summarised in **Table 6.3**. Location of wet and dry sampling events are presented in **Figure 6.2** and **Figure 6.3**, respectively. Photographic documentation of the sampling event is presented in **Appendix 6A**.

Table 6.3: Water Quality Baseline Sampling Activity

Sampling Date	Location	Activity	Remarks
Mar 16, 2020	Main Canal Spring ED1	Dry event sampling WQ1 to WQ20, WQ22 to WQ27 SPRING1, SPRING2, SPRING3 and SPRING4 ED1-1 and ED1-2	No rain for 48 hours ED1-3 to ED1-11 were dry during dry event sampling
Mar 27, 2020	Main Canal	Dry event sampling WQ21	No rain for 48 hours

Sampling Date	Location	Activity	Remarks
Apr 2, 2020	Main Canal	Wet event sampling WQ1 to WQ7	Total rainfall of 9.2 mm for past 1 hour, measured at Choa Chu Kang (Central) Met Station
Apr 3, 2020	ED1	Wet event sampling ED1-1, ED1-2, ED1-5, ED1-6, ED1-8, ED1-9, ED1-10 and ED-11	Total rainfall of 11.2 mm for past 1 hour, measured at Choa Chu Kang (Central) Met Station ED1-3, ED1-4, ED1-7 were dry during wet event sampling
Jun 16, 2020	Main Canal Spring Area	Wet event sampling WQ8 to WQ27 SPRING1, SPRING2, SPRING3 and SPRING4	Total rainfall of 17.8 mm for past 1 hour, measured at Old Toh Tuck Road Met Station
Aug 26, 2020	ED5 ED6	Wet event sampling ED5-1 and ED5-2 ED6-1 to ED6-5	Total rainfall of 13.4 mm for past 1 hour, measured at Old Toh Tuck Road Met Station ED5-3 to ED5-5 were dry during wet sampling
Sep 1, 2020	ED7 Pond3 Pond4	Wet event sampling ED7-2 Pond3 and Pond4	Total rainfall of 7 mm for past 1 hour, measured at Old Toh Tuck Road Met Station ED7-1, ED7-3 and ED7-4 were dry during wet sampling
Sep 3, 2020	ED2	Wet event sampling ED2-1 to ED2-6, ED2-12	Total rainfall of 9.8 mm for past 1 hour, measured at Choa Chu Kang (Central) Met Station ED2-13 to ED2-15 were dry during wet event sampling
Sep 10, 2020	ED2	Wet event sampling ED2-7 to ED2-11, ED2-16 and ED2-17	Total rainfall of 10.8 mm for past 1 hour, measured at Old Toh Tuck Road Met Station
Sep 14, 2020	Pond1 Pond2 ED2 ED3 ED4	Wet event sampling Pond1 Pond2 ED2-18 and ED2-19 ED3-1 to ED3-3 ED4-1 to ED4-5	Total rainfall of 0.6 mm[1] for past 1 hour, measured at Old Toh Tuck Road Met Station
Sep 29, 2020	ED3	Wet event sampling ED3-4 to ED3-9	Total rainfall of 18.8 mm for past 1 hour, measured at Old Toh Tuck Road Met Station
Oct 13, 2020	Pond1 Pond2 Pond3	Dry event sampling Pond1 Pond2	No rain for 48 hours ED7-1, ED5-3 to ED5-5, ED4-2 to ED4-5 and ED3-8 and ED3-9 were dry during dry event sampling.

Sampling Date	Location	Activity	Remarks
	Pond4 ED2 ED3 ED4 ED5 ED6 ED7	Pond3 Pond4 ED2-18 and ED2-19 ED3-1 to ED3-7 ED4-1 ED5-1 to and ED5-2 ED6-1 to ED6-5 ED7-2 to ED7-4	
Oct 14, 2020	ED2 ED8	Dry event sampling ED2-1 to ED2-12, ED2-16 and ED2-17 ED8-1	No rain for 48 hours ED2-13 to ED2-15 were dry during dry event sampling
Oct 22, 2020	ED8	Wet event sampling ED8-1	Total rainfall of 7.2 mm for past 1 hour, measured at Old Toh Tuck Road Met Station
[1]The Met Stations are not directly located at Tengah and are hence used as a gauge to the rainfall levels at Tengah. On Sep 14, 2020, at 1400 hrs, heavy rainfall over the Tengah area was observed but not picked up in the nearby Met Stations during the sampling time.			

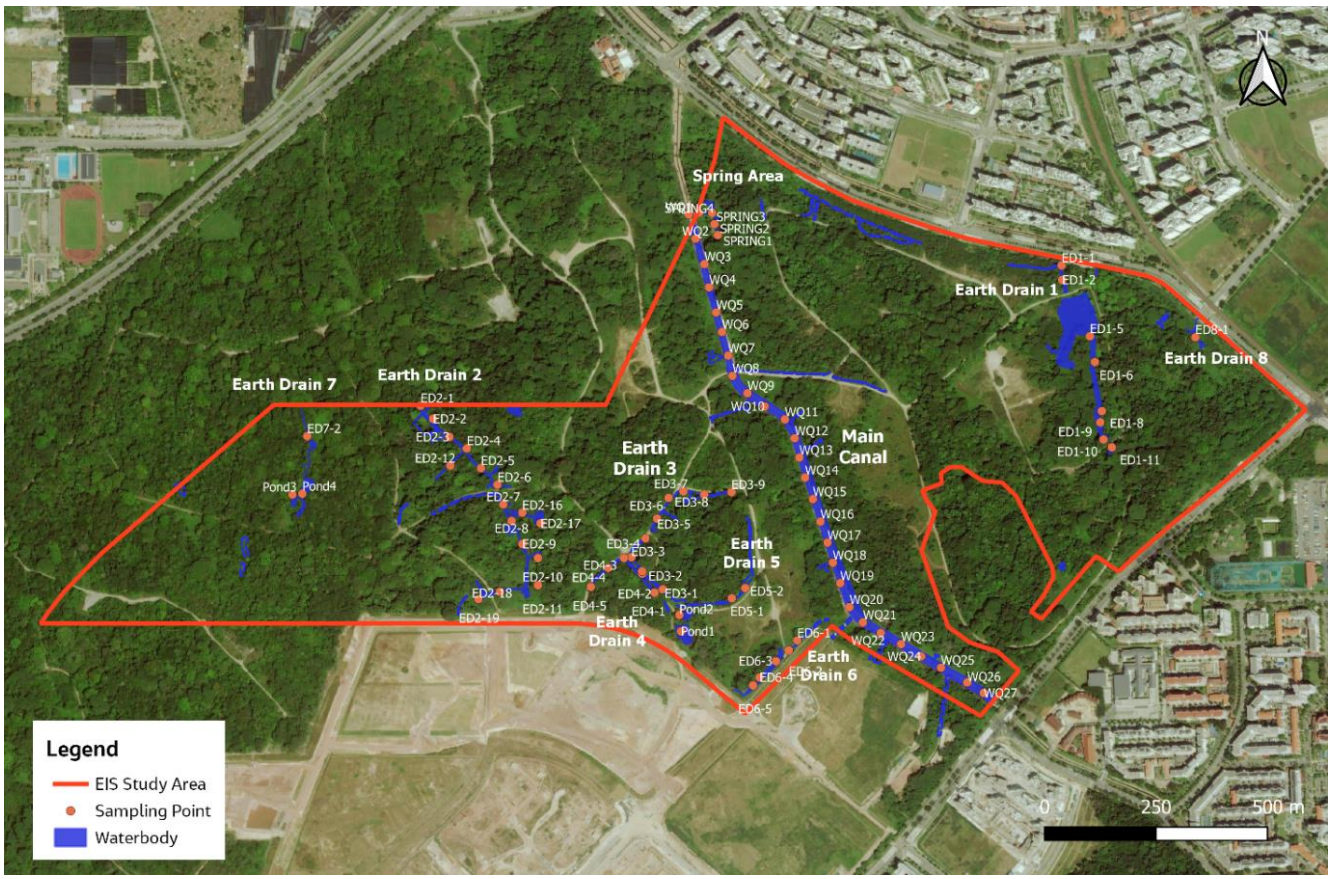


Figure 6.2: Locations of Water Quality Sampling during Wet Event

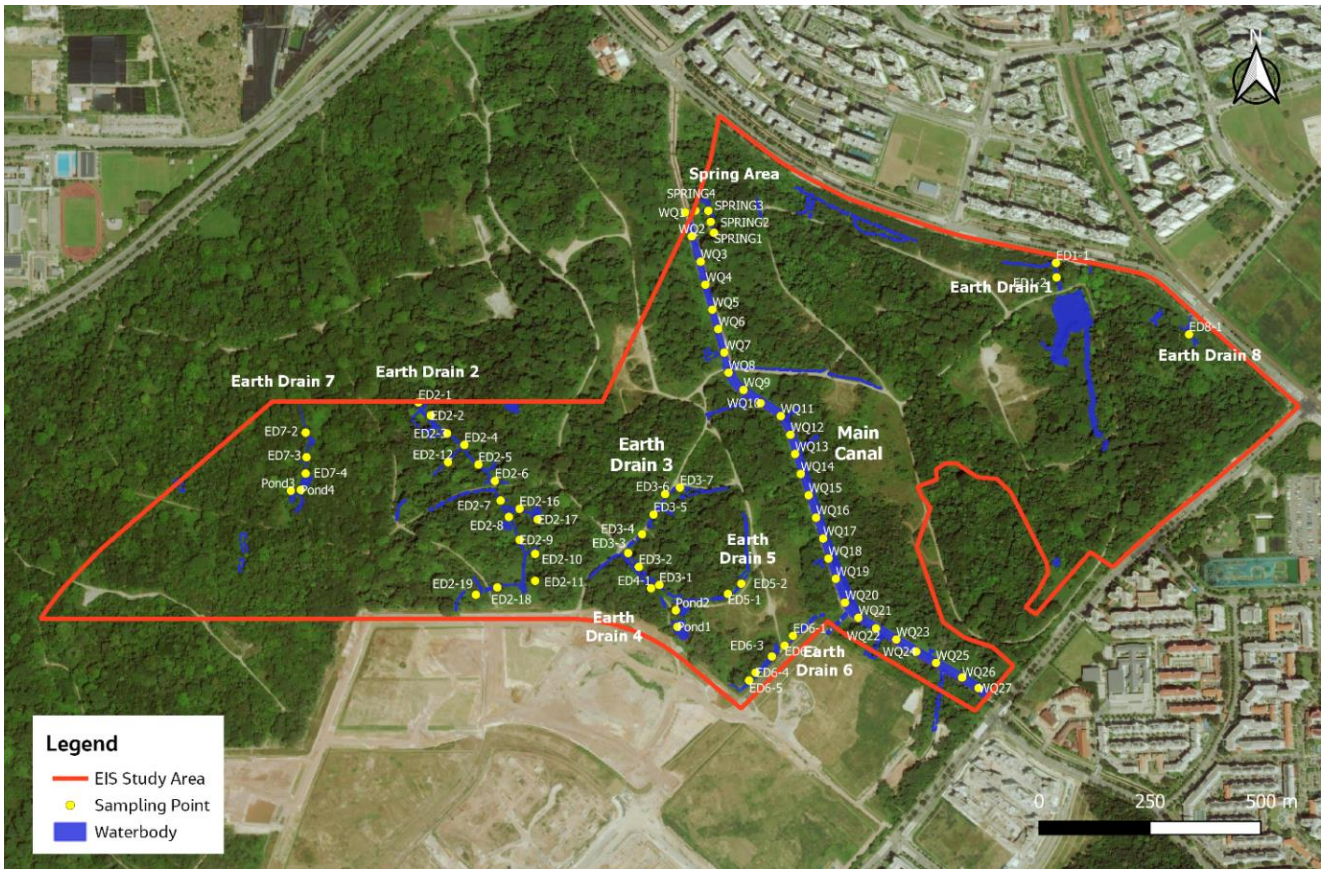


Figure 6.3: Locations of Water Quality Sampling during Dry Event

Base Map: ESRI

6.3.4 Result of Water Quality Baseline Sampling

A total of 71 dry event water samples and 83 wet event samples were collected. The parameters turbidity, conductivity and pH value were tested *in-situ*. All water samples collected were then sent to an accredited laboratory, Marchwood Laboratory Services (Singapore) Pte Ltd (MLS), for testing of parameters as listed in the Tender Specification and EIS Inception Report. The parameters include BOD_5 at 20°C, COD, TSS, TDS, PO_4 as P, NO_3 as N, total N and total P. The laboratory tested results were then compared with the applicable limits stipulated in *EPM (Trade Effluent) Regulations* as given in **Table 6.1**.

For both wet and dry events, water analytical results indicated that biological oxygen demand (BOD), chemical oxygen demand (COD), TSS and pH exceeded the limits for discharge into a controlled watercourse stipulated in *EPM (Trade Effluent) Regulations* in at least one of the water samples collected during wet and dry events. The summary of results discussion for each event are given in **Table 6.4** and **Table 6.5**, respectively. The lab analytical report is provided in **Appendix 6B**.

Table 6.4: Wet Weather Water Quality Baseline Results

Location	Results Discussion
Main Canal	• TSS is reported in sample WQ1 to WQ7 and WQ13 at concentrations ranging from 36 to 91 mg/L, exceeded the allowable limit of 30 mg/L
Spring Area	• TSS is reported in sample SPRING4 at concentration of 34.3 mg/L exceeded the allowable limit of 30 mg/L
ED1	• TSS reported in sample ED1-5, ED1-6 and ED1-8 at concentrations ranging from 38.7 to 98 mg/L exceeded its allowable limit of 30 mg/L

Location	Results Discussion
ED2	• COD reported in sample ED2-7 at concentration of 64 mg O_2/L and ED2-11 at 68 mg O_2/L, exceeded its allowable limit of 60 mg O_2/L • TSS reported in sample ED2-7 to ED2-10, ED2-16, ED2-17 and ED2-19 at concentrations ranging from 31 to 184 mg/L exceeded its allowable limit of 30 mg/L
ED3	• COD reported in sample ED3-7 to ED3-9 at concentrations of 73 to 115 mg O_2/L, exceeded its allowable limit of 60 mg O_2/L • TSS reported in sample ED3-6 to ED3-9 at concentrations of 35 to 208 mg/L exceeded its allowable limit of 30 mg/L
ED4	• TSS reported in sample ED4-5 at concentration of 54 mg/L exceeded its allowable limit of 30 mg/L
ED5	• No exceedance
ED6	• TSS reported in sample ED6-2 to ED6-5 at concentration ranging from 38.7 to 47.7 mg/L exceeded its allowable limit of 30 mg/L
ED7	• pH value reported in sample ED7-2 at concentration of 5.5 outside its allowable limit of 6 to 9
ED8	• No exceedance
Pond1	• No exceedance
Pond2	• No exceedance
Pond3	• pH value reported in sample Pond3 at concentration of 5.8 outside its allowable limit of 6 to 9
Pond4	• pH value reported in sample Pond4 at concentration of 5.6 outside its allowable limit of 6 to 9

High TSS reported in the water samples of Main Canal, Spring Area, ED1, ED2, ED3, ED4 and ED6 were likely related to silty water runoff from upstream and surrounding bare surface.

High COD reported in water samples of the ED2 and ED3 likely related to the oxidation and decomposition of organic/ inorganic matter by microorganisms.

Slightly acidic condition reported in water samples of Pond3 and Pond4 can be related to the respiration and decomposition process of organism in the waterbodies. Based on visual observation (see **Figure 6.4**), the surface of Pond3 and Pond4 appeared to have a layer of algae. Carbon dioxide is produced from respiration and decomposition process which can lower the level of hydroxide, hence lowering the pH. As Pond4 flows into ED7, it could be related to the acidic water found in ED7 as well.



a) Silty water runoff from upstream and surrounding Main Canal during sampling period





b) Presence of plants surrounding ED2-11 (Left) and soft-bank for silty runoff into ED2-19 (Right)



c) Presence of dead wood and slope where silty water can flow down into ED3-8



d) Condition of Pond3 during sampling period, covered with algae

Figure 6.4: Possible Sources to Cause Water Quality Exceedance during Wet Event

Table 6.5: Dry Weather Water Quality Baseline Results

Location	Results Discussion
Main Canal	• pH value reported in sample WQ9 to WQ27 at concentration ranging from 9.1 to 9.7 outside its allowable range of 6 to 9.
Spring Area	• BOD_5 reported in sample SPRING1 at concentration of 80.4 mg/L exceeded its allowable limit of 20 mg/L • COD reported in SPRING1 at concentration of 246 mg O_2/L, exceeded its allowable limit of 60 mg O_2/L • TSS reported in samples SPRING2 and SPRING3 at concentrations of 65 mg/L and 41 mg/L respectively exceeded its allowable limit of 60 mg/L
ED1	• BOD_5 reported in sample ED1-2 at concentration of 20.2 mg/L with slight exceedance as compared with its allowable limit of 20 mg/L • COD reported in sample ED1-1 at concentration of 83 mg O_2/L exceeded its allowable limit of 60 mg O_2/L • TSS reported in sample ED1-1 and ED1-2 at concentration of 376 mg/L and 143 mg/L respectively exceeded its allowable limit of 30 mg/L
ED2	• pH value reported in sample ED2-10 at concentration of 5.9 is slightly below of the allowable range of 6 to 9 • TSS reported in sample ED2-10 and ED2-16 at concentration of 48.3 mg/L and 43.3 mg/L respectively exceeded its allowable limit of 30 mg/L
ED3	• COD reported in sample ED3-7 at concentration of 79 mg O_2/L, exceeded its allowable limit of 60 mg O_2/L • TSS reported in sample ED3-7 at concentration of 134 mg/L exceeded its allowable limit of 30 mg/L
ED4	• No exceedance
ED5	• TSS reported in sample ED5-1 at concentration of 44.7 mg/L exceeded its allowable limit of 30 mg/L
ED6	• COD reported in sample ED6-5 at concentration of 62 mg O_2/L, exceeded its allowable limit of 60 mg O_2/L

Location	Results Discussion
ED7	• pH value reported in sample ED7-4 at concentration of 5.8 is slightly below of the allowable range of 6 to 9
ED8	• No exceedance
Pond1	• No exceedance
Pond2	• pH value reported at concentration of 5.6 is below the allowable range of 6 to 9
Pond3	• No exceedance
Pond4	• pH value reported at concentration of 5.6 is below the allowable range of 6 to 9

High TSS reported in the water samples of ED2 and ED3 are likely related to silty water runoff from upstream and surrounding bare surface during wet weather. As the streams are not fast-flowing streams, it may take some time for the silt to clear out as evident by the lower levels of TSS compared to the wet weather samples. TSS exceedance in ED1 (ED1-1 and ED1-2) is at a concretised section of the drain, right at the entrance to the drain at Brickland Road. As ED1-1 is downstream of ED1-2 and was found to have twice the concentration of TSS than the latter, it is likely to be a backflow contamination with the source of exceedance being from outside of the EIS Study Area Boundary. ED5-1 was a rather stagnant section of waterbody, and with the dry weather resulting in lower amounts water volumes, resulting in a higher concentration of TSS. High TSS in the spring area could be due to sediments being carried up by inflow from the spring. Indeed, while only two out of the four points exceeded the allowable limit of 30 mg/L, the other two samples were close to the limit, suggesting that TSS in the spring area is on the higher end.

Slightly basic condition (water quality with pH value >7) reported in water samples of Main Canal likely caused by geological setting of the area with natural occurrence of sodic and calcic rocks from Jurong Formation (see **Section 4.3.3.1**) that can naturally increase pH of surface water (see **Figure 6.5**).

Slightly acidic condition (water quality with pH value <7) reported in water samples of ED2-10, Pond3 and Pond4 can be related to the respiration and decomposition process of organism in the waterbodies. Based on visual observation (see **Figure 6.5**), the surface of ED2-10, Pond3 and Pond4 appeared to have a considerable amount of algae which suggest that some algae decomposition is going on (PUB, 2017) in addition to respiration of other organisms in the water body. Carbon dioxide is produced from respiration and decomposition process which can lower the level of hydroxide, hence lowering the pH. As Pond4 flows into ED7, it could be related to the acidic water found in ED7 as well.

High BOD_5 and COD reported in water samples of the Spring Area, ED1, ED3 and ED6 likely related to the oxidation and decomposition of organic/ inorganic matter by microorganisms.



a) Presence of aquatic plants/ algae in the Main Canal



b) Presence of sedimentary rock and plants/ algae in the Main Canal




c) ED1-1 (left; image facing north) and ED1-2 (right; image facing south), draining towards Brickland Road



d) Stagnant waterbody at ED5-1



e) Turbid water at SPRING2



f) Presence of algae layer in ED2-10



g) Clear water at ED7-4, suggesting source of acidity to be from connected Pond3



h) Presence of aquatic plants and dead wood in ED6-5

Figure 6.5: Possible Sources to Cause Water Quality Exceedance during Dry Event

6.4 Evaluation Potential Impact Before Mitigation Measures

6.4.1 Potential Source of Impact

Construction activities have the potential to result in adverse impacts on water quality. Construction activities may generate wastewater that may introduce silt and sediments, chemicals or other contaminants into the waterway causing water pollution. These pollutive elements could flow into the sensitive water receivers, Peng Siang River and Kranji Reservoir, which are approximately 1 km away from the EIS Study Area, and hence have been included as part of the local context. Potential sources of impacts include:

- Surface runoff from the construction site.

- Sewage discharge from sanitary facility at construction site.
- Diesel, oil and other pollutive substances spills.
- Trade effluent from the construction site.

The qualitative assessment of potential water quality impact using the RIAM considers the construction activities of the Project development and the applicable legislations, regulations and requirements mentioned in **Section 6.1** with key regulatory considerations listed in **Appendix 6C**. Impacts that are cumulative, unavoidable, or irreversible are also identified. The potential water quality impacts identified are also assessed to determine the significance of these impacts.

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

Sediment introduced into waterway from construction sites through surface runoff may cause water pollution and potentially affect the water quality of the receiving watercourse. The surface run-off from the construction activities may occur during rainfall event at exposed construction sites. These exposed surfaces (from tree felling, land clearance, backfilling, excavation, demolition of existing structure, ground improvement work, construction of infrastructure and building and stockpiles of construction materials/ soil/ waste/ vegetation debris/ demolition waste), most of which are planned during the advance and earthworks stage, can be eroded and contribute silt and sediment to the watercourses. As much of the current area designated for earthworks is vegetated and soil erodibility is expected to increase to about 10-20 times the current soil volume estimates through earthmoving activities that will be involved during ground preparation and major excavation (**Section 4.4.3**), a high amount of soil erosion and surface run off is expected. Although the regulations for earth control measures (i.e. PUB's COP on Surface Water Drainage) will be implemented alongside PUB's recommended best practices, the scale of the Project site in addition to the construction works from the Project and other identified committed developments may cause a large increase in volumetric loading of sediments and other pollutants to the receiving watercourse within the EIS Study Area, which are currently found to have low flow and stagnant waters even during wet events.

Table 6.6: Evaluation of Impact Significance for Soil Erosion and Surface Runoff from Construction Sites over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/Regional	The sensitive receivers to water quality changes from Tengah waterbodies include Peng Siang River and Kranji Reservoir, which is one of national water supply reservoirs.
A2.1: Impact Nature	-1: Negative	Water quality deteriorates from the sediment runoff into it.
A2.2: Magnitude of Changes	3: High	A large amount of construction work involving ground preparation and major excavation is planned that is expected to produce high amounts of surface runoff and soil erosion.
A2.3: Impact Extent	2: Beyond Local Context	Impact can extend to the sensitive receivers of Peng Siang River and Kranji Reservoir which are considered. Water quality impacts will diminish the further from the source.
B1: Permanence	2: Short Term	Impact only occurs during the advance work and earthworks stage, which is to take place over a period of less than three years.
B2: Impact Pathway	3: Direct	Hazard directly affects water quality.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B3: Reversibility	2: Reversible	Quality can be restored with remediation and over time.
B4: Cumulative	3: Cumulative	Presence/ plans for other construction sites located within and/ or in the vicinity of the proposed Project development with interconnecting water courses and which may similarly have runoffs.
Environmental Score (ES)	**(-18) x (10) = -180**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

6.4.3 Water Quality Deterioration due to Sewage Discharge

The construction sites will generate sewage from temporary sanitary facilities and dormitories onsite. If these facilities experience leakage and/or have inadequate capacity to contain the volume produced, untreated sewage may be discharged into the surrounding water streams either directly or indirectly and could adversely impact the water quality of the receiving watercourse. Sewage comprises high levels of BOD_5, Ammonia and Escherichia coli traces and can cause serious environmental and health issues. As regulations for sewage discharge (i.e. PUB's COP of Practice on Sewage and Sanitary Works) are well established to control used water/ sewage discharge from construction sites, the magnitude of change is expected to be medium scale despite a large number of workers who will work and reside on site.

Table 6.7: Evaluation of Impact Significance for Sewage Discharge over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/Regional	The sensitive receivers to water quality changes from Tengah waterbodies include Peng Siang River and Kranji Reservoir, which is one of national water supply reservoirs.
A2.1: Impact Nature	-1: Negative	Water quality deteriorates from the introduction of untreated sewage discharge.
A2.2: Magnitude of Changes	2: Medium	Leakage of temporary sanitary facilities or inadequate capacity to contain sewage relative to occupants of on-site dormitories is considered medium. Sewage from temporary sanitary facilities, including on-site dormitories are assumed to be managed according to relevant COPs.
A2.3: Impact Extent	2: Beyond Local Context	Impact can extend to the sensitive receivers of Peng Siang River and Kranji Reservoir. Water quality impacts will diminish the further from the source.
B1: Permanence	3: Medium Term	Impact only occurs during the construction phase, which will take place over a period of more than 3 years but less than 10 years.
B2: Impact Pathway	3: Direct	Hazard directly affects water quality.
B3: Reversibility	2: Reversible	Quality can be restored with treatment and over time.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B4: Cumulative	3: Cumulative	Presence/ plans for other construction sites located within and/ or in the vicinity of the proposed Project development with interconnecting water courses and which would have sewage facilities as well.
Environmental Score (ES)	**(-12) x (11) = -132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

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

The proposed construction activities are anticipated to require onsite storage and handling of fuel, diesel for the generator sets, lubrication oil to maintain the equipment used onsite, and water pollutive substances such as paint and thinner. If these substances are not properly stored or handled according to applicable COP (i.e. accidental spillage, poor handling practices, leaks or insufficient safeguards provided), they could be spilled and directly washed into the surrounding water streams, causing an adverse impact to the receiving watercourse and its aquatic species. Diesel and lubrication oil ranges from light to medium oil-types, and paints and thinner that has moderately low volatility and expected to contain medium concentrations of toxic (soluble) compounds, should such spills occur.

Table 6.8: Evaluation of Impact Significance for Diesel, Oil and Other Pollutive Substances Spills over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/Regional	The sensitive receivers to water quality changes from Tengah waterbodies include Peng Siang River and Kranji Reservoir, which is one of national water supply reservoirs.
A2.1: Impact Nature	-1: Negative	Water quality deteriorates from the introduction of sewage.
A2.2: Magnitude of Changes	2: Medium	A considerable amount of construction work is expected to produce medium amounts of such pollutive substances.
A2.3: Impact Extent	2: Beyond Local Context	Impact can extend to the sensitive receivers of Peng Siang River and Kranji Reservoir. Water quality impacts will diminish the further from the source.
B1: Permanence	3: Medium Term	Impact only occurs during the construction phase, which will take place over a period of more than 3 years but less than 10 years.
B2: Impact Pathway	3: Direct	Hazard directly affects water quality.
B3: Reversibility	2: Reversible	Quality can be restored with remediation and over time. Diesel is readily and completely degraded by naturally occurring microbes, over a period of one to two months. The lubrication oil, paints and thinner can also be cleaned up most effectively if conducted quickly.
B4: Cumulative	3: Cumulative	Presence/ plans for other construction sites located within and/ or in the vicinity of the proposed Project development with interconnecting water courses and possibility of spills.

Assessment Criterion	Score Rating	Rating Justification/ Definition
Environmental Score (ES)	**(-12) x (11) = -132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

6.4.5 Water Quality Deterioration due to Trade Effluent Discharge

The construction sites are expected to generate trade effluent from piling works, ground improvement works and other construction methods which may be adopted for the Project development. The trade effluent includes process wastewater such as bentonite slurry, concrete washout, and excess grouting materials from construction activities. If storage and treatment facilities have insufficient capacity, trade effluent may overflow and discharge into the watercourses. Direct or indirect discharge could adversely impact the water quality of the receiving watercourse, resulting in the degradation of the receiving watercourse quality as it potentially alters the pH, increases the COD, TSS and turbidity in the water. Trade effluent from other construction sites located within and/or in the vicinity of the Project development would potentially have a cumulative effect if the discharge flows into the same receiving watercourse.

Table 6.9: Evaluation of Impact Significance for Trade Effluent Discharge over Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/Regional	The sensitive receivers to water quality changes from Tengah waterbodies include Peng Siang River and Kranji Reservoir, which is one of national water supply reservoirs.
A2.1: Impact Nature	-1: Negative	Water quality deteriorates from the introduction of trade effluent discharge.
A2.2: Magnitude of Changes	3: Medium	Considerable amount of construction work which will produce a medium amount of trade effluent discharge.
A2.3: Impact Extent	2: Beyond Local Context	Impact can extend to the sensitive receivers of Peng Siang River and Kranji Reservoir. Water quality impacts will diminish the further from the source.
B1: Permanence	3: Medium Term	Impact only occurs during the construction phase, which will take place over a period of more than 3 years but less than 10 years.
B2: Impact Pathway	3: Direct	Hazard directly affects water quality.
B3: Reversibility	2: Reversible	Quality can be restored with remediation and over time.
B4: Cumulative	3: Cumulative	Presence/ plans for other construction sites located within and/ or in the vicinity of the proposed Project development with interconnecting water courses and trade effluent discharge.
Environmental Score (ES)	**(-12) x (11) = -132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

6.5 Applicable Prevention and Mitigation/ Enhancement Measures

A number of mitigation measures may be adopted to eliminate, minimise or reduce the potential impacts on water quality during construction of the Project development. The primary emphasis for water pollution control is on controlling the potential harmful impacts from construction works on water quality, the various COPs should be adhered to while good practices for construction sites recommended in the guidelines should be followed.

The following recommended mitigation measures for each particular potential impact are assumed to be additional mitigation measures apart from applicable embedded control measures in COPs (refer to list of these control measures in **Appendix 6C**) that need to be adhered to prior to applying these additional mitigation measures.

6.5.1 Mitigation Measures for Water Quality Deterioration due to Soil Erosion and Surface Runoff from Construction Sites

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

- **Erosion Control**: The objective is to reduce the amount of sediments that could be generated or are available to be washed off during rainfall. The key strategies are to minimise the extent and duration of bare earth areas (erodible surfaces) on-site and to protect the unavoidable bare earth surfaces.
- **Sediment Control**: The objective is to capture the sediments washed down from the site and reduce TSS in surface water discharges. The key strategies are to contain and treat the surface runoff from the site before discharge to the drains.
- **Water Recycling**: The objective is to minimise the amount of discharge from the construction site to the surface water drainage system.

The implementation of good site practices in line with the COPs and guidebooks will reduce the TSS in the surface runoff and facilitate easy management of site discharges. It is more cost-effective to implement good erosion control measures than to implement sediment control measures after erosion has occurred. As outlined in the COP, the site operator/ contractor should monitor the TSS and turbidity of the treated water in concentrations within the prescribed limits before the discharge enters the surface water drainage system. A discharge bypass pipe with valve connected to the sedimentation tank is recommended to be installed at the treated holding tank. If the prescribed limit for TSS in the discharge is exceeded, the bypass pipe should be opened to return the water to the sedimentation tank. This will prevent silty water discharge. In the event of uncontrolled release of high TSS due to abnormal weather conditions, water quality sampling in the canals should be undertaken at the same locations that were sampled in this study. This will help to determine the impact of the discharge on water quality. The contractor should have incident response plan, identified in their Environmental Management Plan, to follow in case of exceedance of the prescribed TSS limits. These may include stopping construction activities during periods of excessive rainfall.

The other recommended mitigation measures to reduce the potential sources of sediment-laden stormwater runoff contributing from the construction of the Project that could potentially deteriorate the receiving watercourse include:

- Provide storage tanks or reservoirs with additional 20% capacity and number to temporarily store/ contain muddy surface runoff before treatment.
- Whenever possible, segregate clean water flow from silty water flow to maximize the sedimentation tank holding capacity
- Provide sufficient treatment units or coagulant units to treat silty water before discharging into public drain within 10 hours of rain event.
- Concrete and demolition debris, water used for dust control, and groundwater should not be allowed to cause erosion within the work area or to run offsite.

6.5.2 Mitigation Measures for Water Quality Deterioration due to Sewage Discharge

The recommended mitigation measures, with the main objective to reduce the potential sources of untreated sewage discharge from sanitary facilities at the construction site of the Project that could potentially deteriorate the receiving watercourse, include:

- Provide sufficient numbers of and maintain proper sanitary facilities. It is recommended that there be one portable toilet per 10 pax and serviced 3 times per week. Appoint a NEA's Licensed Waste Collector (LWC) to conduct regular collection of sewage discharges for disposal.
- Portable toilets are recommended to be installed on paved ground and bunded.
- On-site dormitories are recommended to install container toilets and secure written approval from PUB to connect into public sewers.
- Establish a regular maintenance work schedule to check and maintenance cleanliness and functionability of sanitary facilities on site, at least once a week, depending on the amount of sanitary facilities.

6.5.3 Mitigation Measures for Water Quality Deterioration due to Diesel, Oil and Other Pollutive Substances Spills

The recommended mitigation measures, with the main objective to reduce the potential sources of oily and contaminated runoff from the construction site of the Project that could potentially deteriorate the receiving watercourse, include:

- Suitable containers shall be used to hold the chemical wastes to avoid leakage or spillage during storage, handling and transport.
- Chemical waste containers shall be labelled following the Globally Harmonised System of Classification and Labelling of Chemicals in the four national languages (i.e. English, Chinese, Malay and Tamil) and other commonly used languages on site to avoid accidents. There shall also be clear instructions showing what action to take in the event of an accident.
- Chemical storage areas should be adequate, on paved ground, bunded, sheltered and located away from waterways and drains. Safety data sheets (SDS) should be kept together with the stored chemicals
- Any construction equipment which causes pollution to the water system due to leakage of oil or fuel should be maintained or removed off-site immediately.
- Spillage or leakage of chemical waste to be controlled using suitable absorbent materials. Used absorbent materials should be disposed through a licensed third-party toxic industrial waste disposal contractor.
- Secondary containment with capacity of more than 10% volume for single large container and 25% of the total volume of multiple containers should be used for all chemical stores and diesel generators to minimise spillages and contamination of soil and surface water. Care should be taken around water channels to avoid toxic chemicals such as petrol/ diesel/ oil/ paint/ thinner leak from equipment.
- Emergency response procedures shall be developed and implemented.
- Good housekeeping practices shall be implemented to minimise 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.
- Any soil contaminated with chemicals or oils shall be removed from site and sent to a licensed third-party toxic industrial waste collector for offsite disposal. The void created shall be filled with suitable materials.

6.5.4 Mitigation Measures Water Quality Deterioration due to Trade Effluent Discharge

The recommended mitigation measures with main objective to reduce the potential sources of trade effluent discharge to receiving watercourse include:

- A temporary drainage channel and associated facilities shall be provided to collect the runoff generated and prevent concrete-contaminated water from entering watercourses. The trade effluent must be isolated and collected and may be treated offsite before being discharged if there are space constraints. Adjustment of pH can be achieved by adding a suitable neutralising reagent to wastewater prior to discharge. The treated water from construction activities be treated to levels prescribed by NEA/ PUB and must have written approval from NEA/ PUB if it will be discharged into public drains/ sewer.
- Appropriate concrete wash out areas shall be provided and shall not be performed in or near any of the streams.
- If on-site treatment is not feasible, wastewater must be stored separately and collected by licensed third-party toxic industrial waste collector for offsite treatment.

6.6 Residual Impact

The adoption of the applicable embedded control measures and mitigation measures recommended above will assist to reduce the magnitude of the water quality impacts by controlling the potential harmful impacts and reducing the likelihood and/or amount of such hazards polluting the watercourses. It also provides rapid treatment measures to reverse the impacts should they happen despite the best practices implemented. As a result, it is expected that water quality should only be impacted to a minor extent during this Project.

Table 6.10: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
WQ-I1	Water quality deterioration due to soil erosion and surface runoff from construction site	-180	**Moderate Negative Impact**	-120	**Moderate Negative Impact**
WQ-I2	Water quality deterioration due to sewage discharge from sanitary facilities from construction site	-132	**Moderate Negative Impact**	-66	**Minor Negative Impact**
WQ-I3	Water quality deterioration due to use, storage and handling of diesel, oil and other pollutive substances on construction site	-132	**Moderate Negative Impact**	-66	**Minor Negative Impact**
WQ-I4	Water quality deterioration due to discharge of trade effluent from construction activities	-132	**Moderate Negative Impact**	-66	**Minor Negative Impact**

7. Ecology and Biodiversity

7.1 Applicable Legislation and Standards

Local regulations relevant for ecology and biodiversity are listed in **Table 7.1**.

Table 7.1: Local Regulations relevant to Biodiversity

Environmental Aspects	Relevant Local Acts/ Regulations/ Action Plans	Jurisdiction/ Administrative/ Enforcement Agencies
Parks, Tree and Flora Protection	▪ Parks and Trees Act and its relevant Orders and Regulations	NParks
Animal/ Wildlife/ Fauna Protection [7]	▪ Wildlife Act	Animal & Veterinary Service (AVS) [8]

7.2 Assessment Methodology

7.2.1 Nomenclature, Taxonomy and Classification

7.2.1.1 Nomenclature and Taxonomy

The nomenclature and taxonomy for each taxonomic group follow these key references:

- Plants: Chong et al. (2009) and NParks (2020)
- Aculeate hymenopterans: Soh & Ngiam (2013) and Ascher & Pickering (2018)
- Odonates: Soh et al. (2019)
- Butterflies: Khew (2015)
- Freshwater fish: Suzuki et al. (2015), Kottelat (2013) and Ho et al. (2016)
- Freshwater decapod crustaceans: Ng (1997) and Cai et al. (2007)
- Birds: Gill and Donsker (2020)
- Amphibians, reptiles, non-volant mammals and bats: Baker & Lim (2012)

7.2.1.2 Flora Classification System

Species of flora are first classified as native, exotic, or cryptogenic. Native species are then further classified as nationally Extinct or Extant, i.e. still surviving. Extant native species are additionally classified as Common, Vulnerable, Endangered, or Critically Endangered. Exotic species are classified as Cultivated Only, Casual, or Naturalised (**Table 7.2**) The definition of each status is adapted from Chong et al. (2009).

Table 7.2: Classification System for Flora Species used in this EIS

Origin	Status	Definition
Native	Species that have originated in an area without human intervention or have arrived there without intentional or unintentional intervention of humans	
	Extinct	Native species that have not been seen or collected locally from the wild in the last 30 years
	Extant	Native species that are common, i.e. have more than 1,000 mature individuals locally, vulnerable, endangered, or critically endangered

[7] Formerly administered and enforced by Agri-Food & Veterinary Authority of Singapore (AVA)
[8] AVS is a cluster within NParks, formed on 1 April 2019, https://www.nparks.gov.sg/avs/who-we-are/about-avs/who-we-are

Origin	Status	Definition
Exotic	Species that are present in an area as a result of intentional or unintentional human involvement	
	Cultivated Only	Exotic species that persist locally as a result of cultivation or other direct human care
	Casual	Exotic species that persist locally by repeated introductions or limited asexual reproduction and do not form self-replacing populations
	Naturalised	Exotic species that persist locally without direct human intervention and are self-replacing, usually through sexual reproduction
Cryptogenic		Species with no historical or biogeographical evidence of being exotic, yet are restricted to only habitats modified or disturbed by humans

7.2.1.3 Species 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 Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery) (**Table 7.3**), 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 is 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. If the origin of a threatened species population is disputable or difficult to determine, we will corroborate findings from field surveys of fauna and/or adopt the more conservative approach by considering them of conservation significance. In carrying out such assessments, we are then able to prioritise conservation needs and focus resources in conserving them.

Faunal species of conservation significance include both threatened and non-threatened species regarded as notable records. Threatened species of fauna are those listed as Vulnerable, Endangered, Critically Endangered, or Extinct under its global or national status. Both global and national conservation statuses were considered to provide a more holistic picture of the conservation value of the EIS Study Area. The global conservation status for fauna follows the International Union for Conservation of Nature & Natural Resources Red list (IUCN; IUCN, 2012) (**Table 7.3**). The national conservation status for fauna follows mainly the Singapore Red Data Book (SRDB) (Davison et al., 2008) with reference to updated local checklists where available (i.e. Soh and Ngiam, 2019 for odonates) (**Table 7.3**).

Few resources with the national conservation status of species from the order Hymenoptera are available, with only a few bee species listed in the SRDB (Davison et al., 2008). A paper on the updated conservation status of bees and wasps found in Singapore by Ascher et al. is in preparation. However, no comparable study has been done for stinging wasps. For the purpose of this EIS, the assessment was conducted based on personal records by Lee JXQ, together with specimen records in the Lee Kong Chian Natural History Museum (LCKNHM) and NUS' Insect Diversity Lab (IDL) collections. The assessment adopts the same conservation statuses used in Ascher et al. (in prep).

Notable records of non-threatened species include species that are deemed of conservation interest within the EIS Study Area. The EIS Study Area may provide important habitats for these species, including breeding sites. Species deemed sensitive to construction impacts may also be highlighted as a notable record, and regarded as species of conservation significance.

Table 7.3: Definition of Each Global and/or National Conservation Status following the IUCN Red List (IUCN, 2012) and Singapore Red Data Book (Davison et al., 2008)

Global/ National Conservation Status	Definition
Vulnerable (VU)	Species facing a high risk of extinction in the wild/ in Singapore
Endangered (EN)	Species facing a very high risk of extinction in the wild/ in Singapore
Critically Endangered (CR)	Species facing an extremely high risk of extinction in the wild/ in Singapore
Presumed Nationally Extinct (NE)	There is no reasonable doubt that the last reproductively capable individual within Singapore has died or disappeared in the last 50 years (fauna) or 30 years (vascular plants).

7.2.2 Desktop Assessment

The desktop assessment involved a literature review of historical and present-day information on the EIS Study Area. This allowed for the generation of a preliminary vegetation map and a list of faunal species that may potentially exist in the EIS Study Area ("species of probable occurrence"). This list considered faunal species previously documented within and around a 2-km radius of the EIS Study Area that were expected to occur based on the habitats present. It was completed by reviewing online databases, existing literature, technical reports and consulting specialists. The vegetation map and species list were subsequently updated with findings from the field assessment.

Information on land use history was primarily gathered using old maps in the online collection of the National Archives of Singapore (NAS, 2020) as well as historical maps on the OneMap Portal (SLA, 2018). Records on vegetation types, as well as floristic and faunistic species composition were retrieved from databases and local literature (published and unpublished). Sources of databases include The Biodiversity of Singapore by Lee Kong Chian Natural History Museum (LCKNHM, 2020a), Flora and Fauna Web by National Parks Board (NParks, 2020a), and Plants of Southeast Asia (Slik, 2009). Local and regional references were examined for the various taxonomic groups: flora (Boo, 1996; Keng, 2003; Chong et al., 2009; Yee et al., 2016), odonates (Tang et al., 2010), butterflies (Khew, 2015), freshwater fish (Kottelat, 2013; Ho et al., 2016), birds (Yong et al., 2016), and herpetofauna and mammals (Baker & Lim, 2012). Other key references include the SRDB (Davison et al., 2008) and an encyclopaedia on Singapore's biodiversity (Ng et al., 2011).

7.2.3 Floristic Field Assessment

The floristic field assessment consisted of: 1) vegetation mapping; 2) vegetation plot sampling; 3) floristic surveys; and 4) arboricultural surveys. The assessment was conducted between Jan 31, 2020 and Aug 31, 2020.

7.2.3.1 Vegetation Mapping

A preliminary vegetation map was first drawn based on visual interpretations of satellite images from Google Earth Google Maps v.9.61.1 (Google Inc., 2020). Preliminary classification of the vegetation types was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were then made to the preliminary maps according to actual observations during ground truthing. Ground truthing was conducted throughout the survey area with the aid of a GPS receiver. 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 7.1.2.2041. Vegetation types in Singapore are divided into four categories (refer to **Table 7.4**):

- Primary vegetation: vegetation that has never been cleared or removed and has occupied the site continuously for thousands of years
- Secondary vegetation: vegetation that succeeds on a site where clearance or removal has been made by nature or mankind (Corlett, 1995). Based on the classification of Yee et al. (2016), secondary vegetation in Singapore

is split into the following three categories: 1) native-dominated forests; 2) abandoned-land forests; and 3) waste-woodlands

- Coastal vegetation: vegetation found growing at the edge of the sea
- Managed vegetation: comprises roadside plantings, public parks, gardens, golf courses and farms

Table 7.4: Classification of Vegetation Types Encountered in Singapore

Major Vegetation Types		Description	Dominant Species
Primary Forest	Primary lowland dipterocarp forest	Lowland forest dominated by dipterocarp trees that has never been cleared.	*Dipterocarpus grandiflorus, Shorea leprosula, Shorea macroptera, Shorea ovalis, Shorea parvifolia*
	Primary hill dipterocarp forest	Hill forest dominated by dipterocarp trees that has never been cleared.	*Dipterocarpus caudatus* ssp. *penangianus, Shorea curtisii*
	Primary freshwater swamp forest	Forest semi-permanently inundated by freshwater that has never been cleared.	*Palaquium xanthochymum, Salacca conferta, Xylopia fusca*
Secondary Forest (Native-Dominated)	Native-dominated tall secondary forest	Developed on land cleared before the 1950s. Developed from early successional forest and contains higher species richness.	*Adinandra dumosa, Archidendron clypearia, Calophyllum* spp., *Cyathocalyx* spp., *Elaeocarpus* spp., *Garcinia parvifolia, Lindera lucida, Litsea* spp., *Macaranga* spp., *Porterandia anisophylla, Rhodamnia cinerea, Timonius wallichianus, Xylopia* spp
	Native-dominated low secondary forest	Developed on land cleared before the 1950s. Dominated by native pioneer trees.	*Adinandra dumosa, Arthrophyllum diversifolium, Cyrtophyllum fragrans, Dicranopteris linearis, Dillenia suffruticosa, Eriachne pallescens, Ficus grossularioides Gahnia tristis, Lycopodiella cernua, Macaranga heynei, Melastoma malabathricum, Morella esculenta, Nepenthes* spp., *Ploiarium alternifolium, Rhodamnia cinerea, Rhodomyrtus tomentosa, Syzygium lineatum, Syzygium zeylanicum, Vitex pinnata*
Secondary Forest (Exotic-dominated)	Abandoned-land forests	Developed from abandoned plantations or kampong with mature trees largely left intact. Dominated by exotic plant species.	Abandoned plantation Dominated by rubber (*Hevea brasiliensis*). Abandoned kampong or orchard Dominated by fruit trees (*Artocarpus* spp., *Durio zibethinus, Lansium domesticum, Musa* spp., *Nephelium lappaceum)* or ornamentals and crops (*Aglaonema commutatum*, *Dieffenbachia seguine*, *Elaeis guineensis, Heliconia* spp., *Hevea brasiliensis, Spathodea campanulata,* and *Theobroma cacao*.
	Waste-woodlands	Developed on land cleared after the 1960s. Dominated by exotic	*Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala, Spathodea campanulata*

Major Vegetation Types		Description	Dominant Species
		plant species with high propagule pressure in surrounding landscape.	
Shrubland	Scrubland vegetation	Land dominated by shrubs and short trees.	*Dillenia suffruticosa, Lantana camara, Melastoma malabathricum, Trema* spp., sometimes with scattered trees of *Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala*
	Herbaceous vegetation	Land covered by non-woody vegetation.	*Imperata cylindrica, Panicum maximum, Urochloa mutica,* sometimes with scattered trees of *Acacia auriculiformis, Falcataria moluccana, Leucaena leucocephala, Mimosa pigra*
Coastal vegetation	Mangrove forest	Forest growing on anaerobic soils along coastal intertidal zones.	*Avicennia* spp., *Bruguiera* spp., *Rhizophora* spp., *Sonneratia* spp., *Xylocarpus* spp.
	Back mangrove forest	Mangrove forest situated far from the coast.	*Bruguiera* spp., *Ceriops* spp., *Heritiera littoralis, Xylocarpus* spp.
	Sandy beach vegetation	Vegetation growing along sandy coastlines.	*Barringtonia asiatica, Casuarina equisetifolia, Cerbera odollam, Ipomoea pes-caprae, Peltophorum pterocarpum, Scaevola taccada, Terminalia catappa, Taliparitiliaceum*
Vegetation	Managed vegetation	Vegetation that is maintained by humans such as parks, gardens, and roadsides.	Exotic and commercially available native species.

Source: Yee et al., 2016 and Yee et al., 2019

7.2.3.2 Vegetation Plots

Vegetation plots measuring 20 × 20 m were set up and surveyed in the EIS Study Area. The number of plots in each site were determined based on the sampling density of one plot for every 5 ha of spontaneous vegetation, i.e. vegetation that occurs naturally and is neither manicured nor managed by humans. Hence, the number of vegetation plots is proportionate to the relative size of the spontaneous vegetation within the site. This gives a total of 32 vegetation plots for this EIS Study Area, of which the locations were randomly generated in the statistical programming environment R version 3.4.3 (R Development Core Team, 2016) to generate community data analyses.

Actual plot locations were adjusted on-site based on accessibility and suitability, i.e. not covered in dense vegetation and/or tree falls that would render the site inaccessible. We identified to species and measured the girth of all woody tree and shrub specimens at breast height, as well as palms of $\geqslant$ 0.05 m girth. For *Ficus* stranglers and palm clusters, we estimated the size of spread and measured the circumference of each woody aerial root or stem, respectively, of $\geqslant$ 0.05 m girth. All other plant species observed in the plots were also recorded.



Figure 7.1: An Example of a Vegetation Plot Set Up in the EIS Study Area

7.2.3.3 Floristic Surveys

All plants observed in the EIS Study Area during floristic surveys were identified to species whenever possible. A checklist of all plant species recorded from the present floristic surveys was compiled. For plants that could not be immediately identified with certainty in the field, photographs and/or voucher specimens were taken. They were then identified using identification keys, taxonomic descriptions, online plant photo databases, with the help of taxonomic experts, and/or by matching the pressed and dried collected specimens with existing specimens in the Singapore Botanic Gardens' Herbarium (SING). For very tall unidentifiable trees with leaves that were too high in the canopy to photograph, dried leaves matching these trees were collected from the forest floor and used to aid in species identification.

a) Species of Conservation Significance

The geographic locations of plants of conservation significance (as defined in **Section 7.2.1.3**) were marked using a Global Positioning System (GPS) receiver (Garmin GPSMap® 64s), which records locations with accuracy of ± 4 m. Where there are clusters of plants of conservation significance, i.e. more than one individual occurring within 5 m or less of another individual, i.e. the geographic location of the approximated center of the area was marked using the GPS receiver.

b) Large Specimens

The GPS receiver was also used to record locations of all trees, excluding albizia (*Falcataria moluccana)*, African tulip (*Spathodea campanulata)*, and wild tamarind (*Leucaena leucocephala)*, which are storm-vulnerable species, of ≥ 3 m girth, as well as bamboo clusters, palm clusters, and strangling *Ficus* species of ≥ 3 m spread. The individuals were identified to species, whenever possible. Girth (for trees) and spread (for bamboo clusters, palm clusters, and strangling *Ficus* species) were measured and estimated, respectively. Specimen height was also estimated and recorded.

c) Other Specimens of Value

Geographic locations of other plants that are of value but do not meet the minimum size requirement, as detailed above, will also be recorded using the GPS receiver. Examples of such include bamboo clusters of < 3 m spread that may be important refugia for rare bamboo bats, amongst others, as well as exotic trees of < 3 m girth with active nests.

d) Keystone Species

Keystone species are species that are considered of great importance to the forest's ecosystem. These species can fall under the categories mentioned above (i.e. species of conservation and large specimens) and trees and/or strangling species of ≥ 1.0 m girth which is recorded during arboricultural survey (**Section 7.2.3.4**). Geographic locations of all keystone species were recorded using the GPS receiver (Garmin GPSMap® 64s or/and DGPS receiver (**Figure 7.3** and **Figure 7.4**).

7.2.3.4 Arboricultural Surveys

Trees, single-stemmed palms, and strangling *Ficus* species of ≥ 1.0 m girth or spread, respectively, as well as species of conservation significance of ≥ 0.3 m girth or spread, were assessed in arboricultural surveys. Single-stemmed palms are defined in this EIS as having one obvious and erect stem (**Figure 7.2A-B**). All tree species that have met the criteria mentioned above were assessed and tagged with an assigned serial number of "TEXXXX", except for exotic trees listed as follow: African tulip (*Spathodea campanulata)*, albizia (*Falcataria moluccana)*, earleaf acacia (*Acacia auriculiformis),* silver wattle (*Acacia mangium)*, betel-nut palm (*Areca catechu)*, wild tamarind (*Leucaena leucocephala)*, coconut (*Cocos nucifera)*, papaya (*Carica papaya)*, oil palm (*Elaeis guineensis)* and Macarthur palm (*Ptychosperma macarthurii)*. As agreed by the Scoping Meeting and Inception Report, these exotic trees with girth more than 1 m are to be mapped by the topography surveyor but not required to be assessed by arborist. The method applied by the surveyor was to use 3D point cloud for trees location extraction. Trees were then identified using a geospatial technology called 'Orthophoto' which used aerial images that has been geometrically rectified to correspond to the location of where the photos were captured. These trees were given a tag number of "NTEXXXX" in the topography map.

Arboricultural assessment of the trees was conducted using the Safe Useful Life Expectancy (SULE) method 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 (Barrell, 1993).



Figure 7.2: (A-B) Examples of Single-stemmed Palm, defined in the EIS as having one Obvious and Erect Stem

A DGPS receiver (Trimble® Geo 7X or CHC® Navigation HCE320 GNSS data controller with the CHC® Navigation i90 Pro GNSS receiver and Leica DISTO™ D810 touch rangefinder) (**Figure 7.3** and **Figure 7.4**), which records

locations with accuracy of ± 1 m and less, was used to record locations of the specimens using the SVY21 plane coordinate system. This is a local datum that gives a more accurate representation of the areas of coverage in Singapore and is used by the SLA (2015).

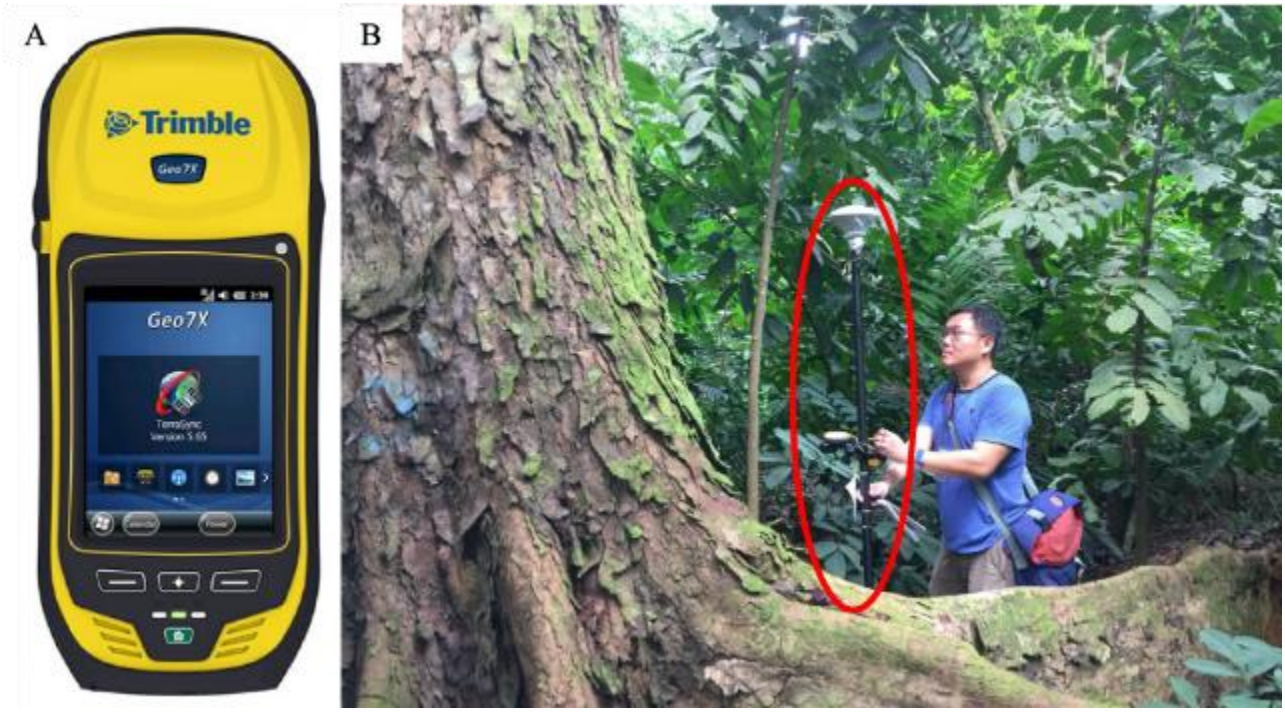


Figure 7.3: Trimble® Geo 7X. (A) Handheld Controller (source: gpsforestry-suppliers.com); (B) How it is used in the Field

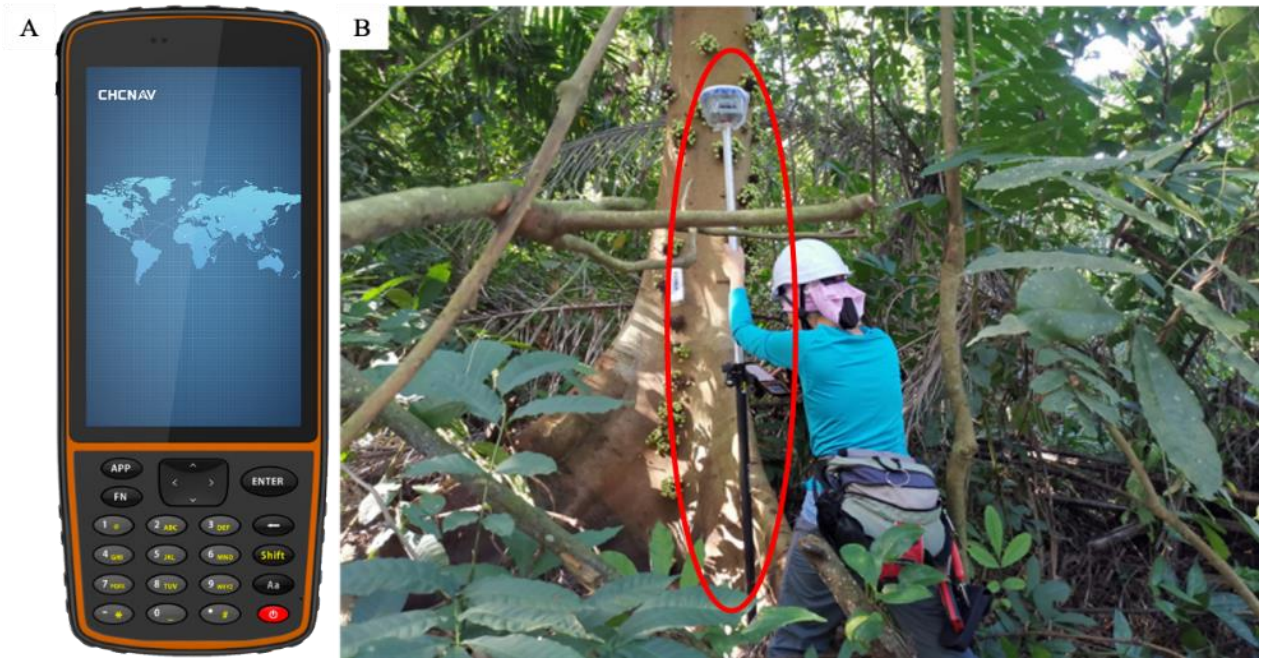


Figure 7.4: (A) CHC® Navigation HCE320 GNSS Data Controller (Source: Geo-matching.com); (B) How it is used in the Field

In addition, the girth/spread and height of the specimens were also recorded. Where there are clusters of specimens of the same species occurring within 1–2 m of each other, or are unable to access closely due to any

obstructions, (e.g. stream, nearby tree fall), all the specimens within the cluster were assessed by certified arborists, but only one specimen was tagged and its location marked using the DGPS.

7.2.3.5 Floristic Data Analyses

a) Community Data Analyses

All statistical analyses for this EIS were carried out in the statistical programming environment R version 3.4.3 (R Development Core Team, 2016). Community data analyses were conducted using the "vegan" package 2.5-6 (Oksanen et al., 2019) and "iNEXT" package 2.0.20 (Heish et al., 2019).

A species accumulation curve (SAC) was plotted using data on floristic diversity from the vegetation plots. Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/ survey adequacy, i.e. how extensively we have sampled the species in the community. According to Chao and Jost (2012), sample coverage refers to "the proportion of the total number of individuals in a community that belong to the species represented in the sample." The curve was extrapolated to provide an estimation of species richness and sample coverage if the sample size was doubled.

As some species will always remain undetected after sampling all the vegetation plots, total species richness had to be estimated via extrapolation. The total number of species was approximated using four estimators, namely Chao estimator (Chao, 1987; Chiu et al., 2014), first and second order Jackknife estimators (Smith & van Belle, 1984), and the Bootstrap estimator (Smith & van Belle, 1984), by estimating the number of undetected species and adding them to the observed species richness (Palmer 1990; Colwell & Coddington, 1994).

To visualize the differences among vegetation types based on species composition, non-metric multidimensional scaling (NMDS) ordination was used. The Bray–Curtis dissimilarity index was used to quantify dissimilarities between the observed communities. Permutational Multivariate Analysis of Variance (PERMANOVA) via bootstrapping with 999 permutations then tested for statistical significance. This was performed using the 'adonis' function in the "vegan" package 2.5-6 (Oksanen et al., 2019). The plots were nested within the respective vegetation types. The ordination was also tested to confirm that the assumption of homogeneity of multivariate dispersion holds true.

b) Forest Regeneration

The trees were broadly categorized into two main girth-size classes: ≥ 0.5 m and < 0.5 m. They were first ranked by abundance and examined to see which species made up the larger and smaller trees, respectively. The ten most abundant species present in the vegetation plots were then ranked according to their size-class distribution and examined.

7.2.4 Faunistic Field Assessment

7.2.4.1 Targeted Field Surveys

The faunistic field assessment was conducted between Jan 20, 2020 and Aug 20, 2020 (note: due to COVID-19 impact, fieldworks suspended during the Circuit Breaker period, from Apr 7, 2020 to June 1, 2020). Targeted field surveys were carried out for the following taxa: aculeate hymenopterans (bees and stinging wasps, excluding ants), odonates (dragonflies and damselflies), butterflies, freshwater decapod crustaceans, freshwater fish, herpetofauna (amphibians and reptiles), birds, non-volant mammals and bats. These taxa were chosen because they are of general interest to the public, well-documented, are generally easy to survey, have important ecological roles in the ecosystem and serve as ecological indicators. Amongst these groups, the aculeate hymenopteran is the least well-studied. Yet, as expertise was available, they were included in the EIS to provide a better representation of the site's faunal diversity.

All terrestrial fauna (except bats) were surveyed via visual and/or auditory encounter surveys along terrestrial sampling routes traversing major habitat types within the EIS Study Area (**Figure 7.5**). Two sampling routes

measuring 6.81 km were identified. At least two surveyors walked along the sampling routes at approximately 1 km/hr to search for targeted fauna.

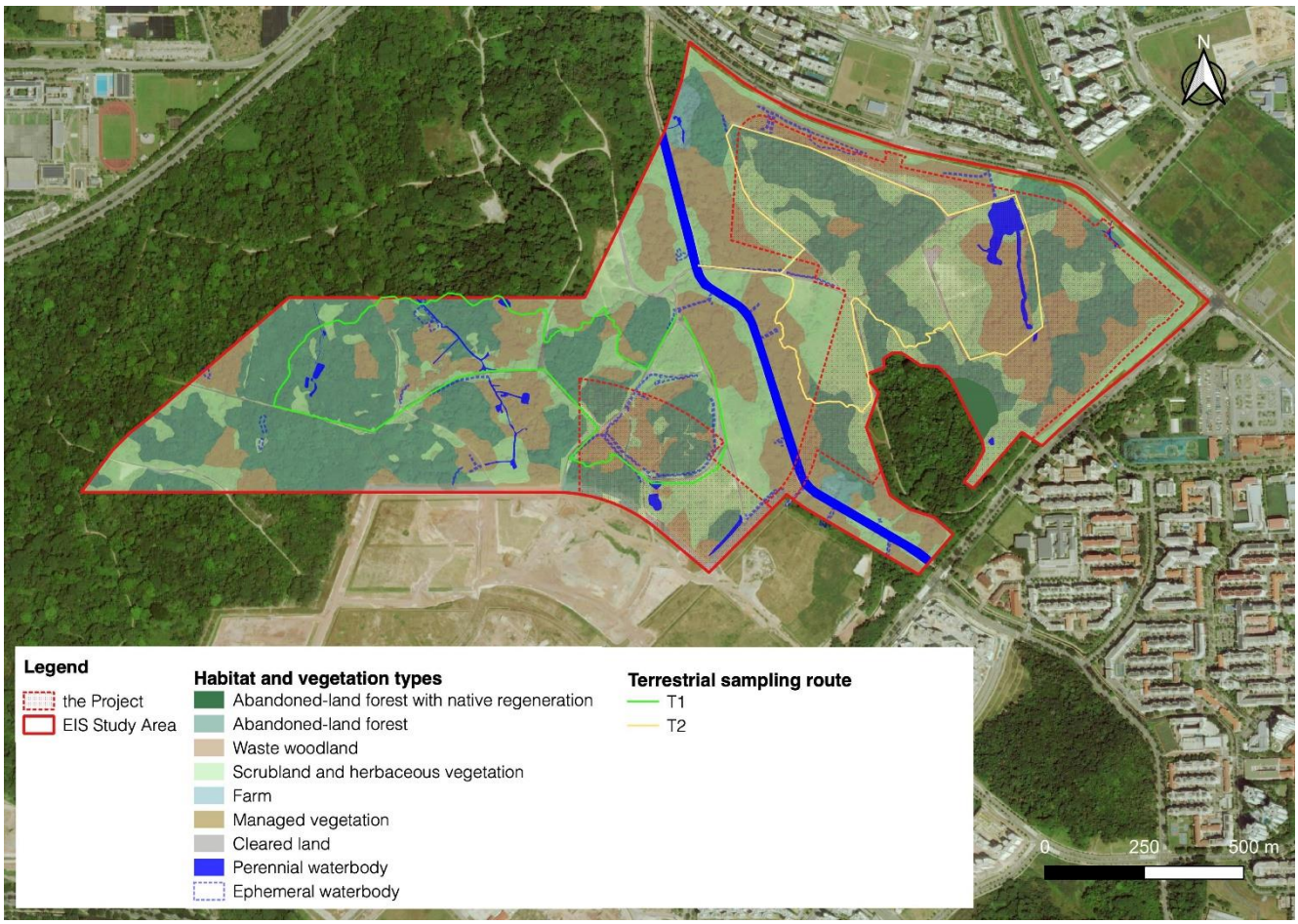


Figure 7.5: Terrestrial Sampling Routes undertaken during Faunal Surveys

Base Map: ESRI

Aquatic fauna was surveyed at each aquatic sampling point placed at 50-m intervals along each waterbody (**Figure 7.6**). This is with the exception of ED1 which was initially assessed to be separate waterbodies due to dry conditions, but subsequently identified to be a connecting waterbody. The points in ED1 are hence placed 120 m and 200 m apart. One sampling point was placed at each pond. A combination of five-minute point counts, tray netting, and minnow trapping were conducted at each sampling point. Minnow traps were only deployed in locations with sufficient water depth. A total of 27 aquatic sampling points were identified, and minnow trapping was conducted at 17 locations at the waterbodies. Surveys were conducted twice at each terrestrial route or aquatic sampling point for each taxon, where applicable.

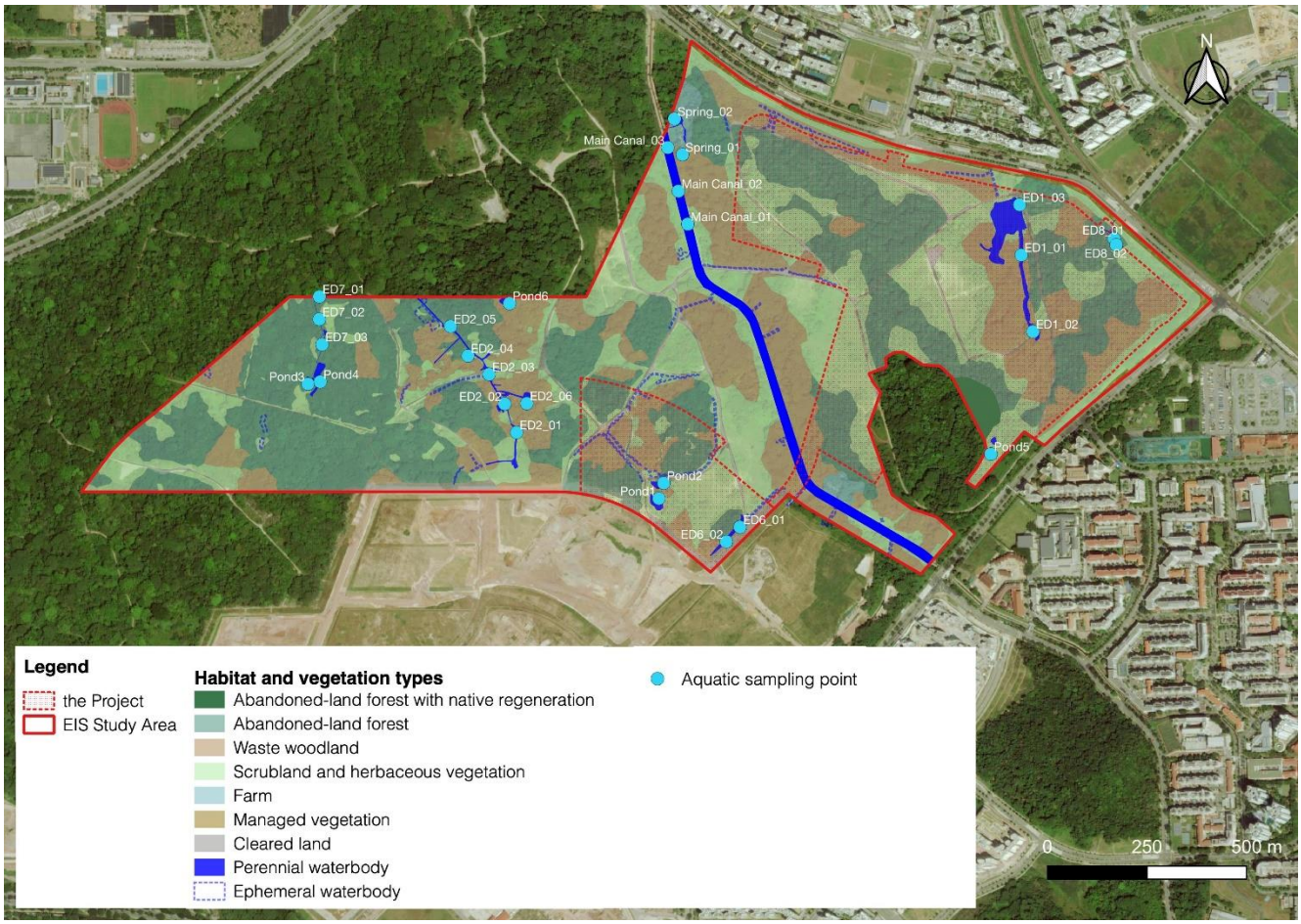


Figure 7.6: Aquatic Sampling Points undertaken during Faunal Surveys

Base Map: ESRI

Locations of all fauna sightings were recorded using a handheld GPS receiver (Garmin GPSMap® 64s). All fauna encountered were identified to species, or the next lowest taxonomic level possible. Important observations were also noted down, such as reproductive behaviour (e.g. displaying, guarding, mating and ovipositing), and plant species that butterflies and birds are observed to be feeding on, laying eggs or nesting on, and/or with caterpillars.

While bat trapping had been initially planned for, it was subsequently cancelled in light of the COVID-19 outbreak. Instead, roost emergence surveys for bamboo bats were conducted for bamboo clusters present to determine if there are potentially conservation significant bamboo bats residing in them. In addition, 26 camera traps were deployed to complement the documentation of mammal composition within the EIS Study Area.

A summary of the survey methods for each faunal group is described in **Table 7.5** and further described in the following section.

Table 7.5: Summary of the Survey Timings and Methods for Each Faunal Group

Faunal Group	Survey Timing	Survey Method
Aculeate Hymenopterans	• 9 a.m. – 2 p.m.	• Diurnal visual encounter surveys along two terrestrial sampling routes
Odonates	• 9 a.m. – 2 p.m.	• Diurnal visual encounter surveys along two terrestrial sampling routes and diurnal point counts at 27 aquatic sampling points
Butterflies	• 9 a.m. – 2 p.m.	• Diurnal visual encounter surveys along two terrestrial sampling routes
Decapod Crustaceans	• 9 a.m. – 2 p.m. • 8 p.m. – 11.59 p.m.	• Diurnal point count surveys with tray-netting at 27 aquatic sampling points • Nocturnal point count surveys with spot-lighting at 27 aquatic sampling points
Fishes	• 9 a.m. – 2 p.m. • 8 p.m. – 11.59 p.m.	• Diurnal point count surveys with tray-netting at 27 aquatic sampling points • Nocturnal point count surveys with spot-lighting at 27 aquatic sampling points • Minnow trapping at 17 strategic locations along waterbodies
Herpetofauna (Amphibians and Reptiles)	• 7 a.m. – 2 p.m. • 8 p.m. – 11.59 p.m.	• Diurnal and nocturnal visual and auditory encounter surveys along two terrestrial sampling routes • Diurnal and nocturnal point count surveys at 27 aquatic sampling points
Birds	• 7 a.m. – 10 a.m. • 8 p.m. – 11.59 p.m.	• Diurnal and nocturnal visual and auditory encounter surveys along two terrestrial sampling routes
Non-volant Mammals	• 7 a.m. – 10 a.m. • 8 p.m. – 11.59 p.m. • Continuous (Camera Traps)	• Diurnal and nocturnal visual and auditory encounter surveys along two terrestrial sampling routes • 26 camera traps deployed across the site
Mammals (Bats)	• 6.30 p.m. – 9 p.m.	• Visual roost emergence survey for 43 bamboo clusters present

Aculeate Hymenopterans (Bees and Stinging Wasps, excluding Ants)

Adult bees and stinging wasps, nests, and food plants were visually surveyed along the terrestrial sampling routes. Surveys were conducted between 9 a.m. and 2 p.m. Bees and wasps were identified by sight or photography whenever possible. Otherwise, they were captured using handheld insect nets. Individuals were released immediately after identification. When identification in the field was not possible, live specimens were collected and examined *post-hoc* under microscope. The specimens were identified to the lowest taxonomic level possible using relevant references, identification keys, or in consultation with taxonomic experts.

Odonates (Dragonflies and Damselflies)

Visual encounter surveys were conducted along terrestrial sampling route and five-minute point counts were conducted at each aquatic sampling point between 9 a.m. and 2 p.m. Owing to the difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Adults were identified by sight (with the aid of binoculars where necessary) in flight or while perched. Specimens were also photographed or caught with insect nets if required for species identification. Individuals collected were released immediately after they had been identified.

Butterflies

Visual encounter surveys were carried out for adult butterflies, caterpillars, pupae, eggs, and host plants along terrestrial sampling routes from 9 a.m. and 2 p.m. Butterflies were identified by sight (with the aid of binoculars where necessary), photographed, or captured using insect nets.

Freshwater Decapod Crustaceans and Fish

Surveys comprised diurnal (9 a.m. – 2 p.m.) and nocturnal (8 p.m. – 11.59 p.m.) five-minute visual point counts at aquatic sampling points, tray netting and minnow trapping. Point counts involved tray netting using a rigid-frame push net (61 × 49 cm; 5 mm mesh) to capture species within the water column or on the streambed. However, where tray-netting was deemed unsuitable as a result of low water levels, visual surveys were conducted instead. In addition, minnow traps were baited with halal meat (e.g. sausage or liver) and systematically deployed at locations with deeper water (**Figure 7.7**). Traps were left overnight, then checked and removed the following morning. Nocturnal surveys involved spot-lighting for nocturnal species, especially the walking catfishes (*Clarias* spp.).

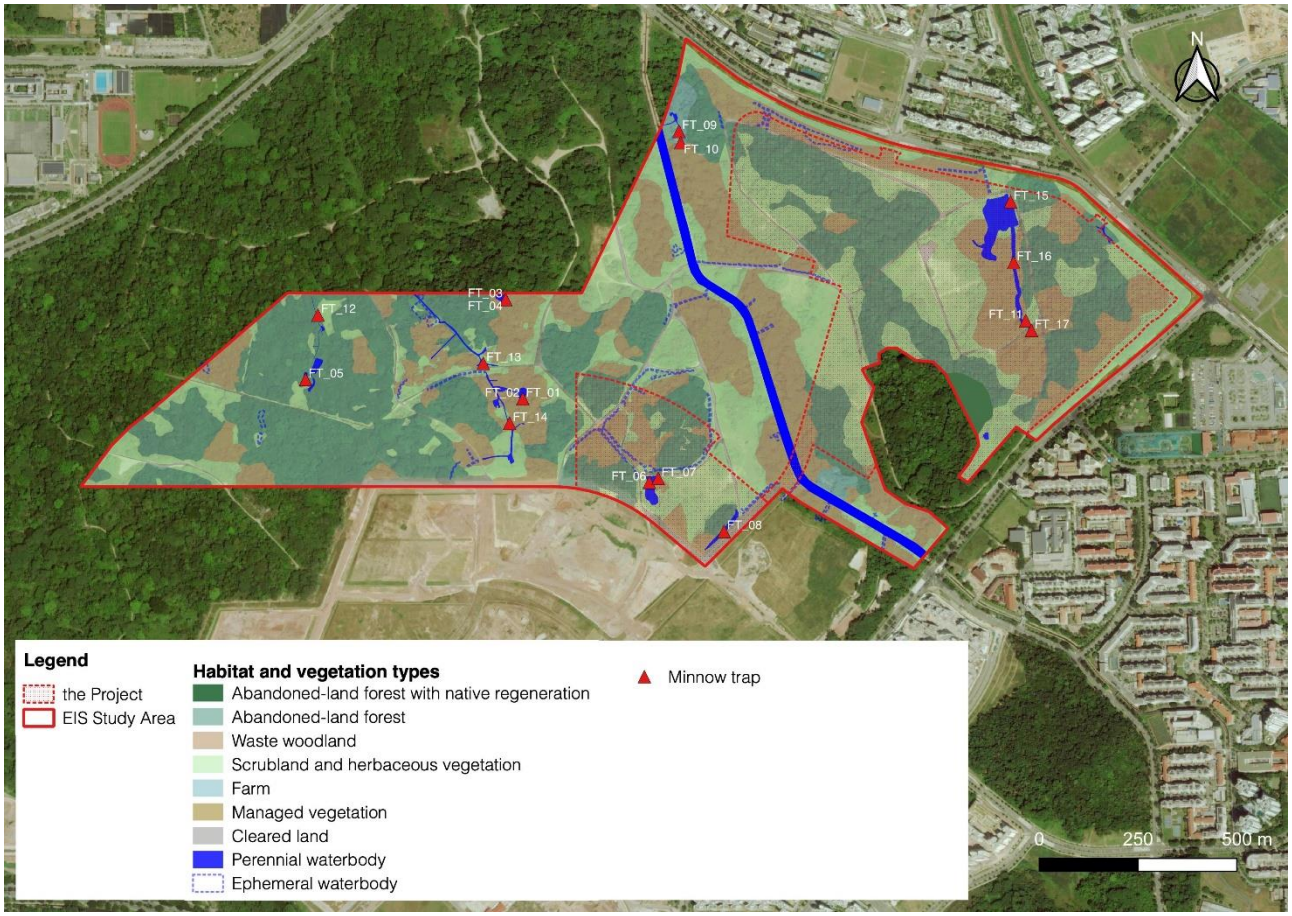


Figure 7.7: Locations of Minnow Traps

Base Map: ESRI

Herpetofauna (Amphibians and Reptiles)

Diurnal (7 a.m. – 2 p.m.) and nocturnal (8 p.m. – 11.59 p.m.) visual encounter surveys were performed along both terrestrial sampling routes and at aquatic sampling points. Visual encounter surveys were conducted along terrestrial sampling routes, while five-minute point counts were conducted at aquatic sampling points. Surveys involved searching for individuals on the ground, below rocks, logs, leaf litter and debris, in the water, and on vegetation. For nocturnal spot-lighting surveys, torches were used to elicit eyeshine. 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. Vocalising geckos and frogs were also located or identified by call recognition, whenever possible.

Birds

Surveys comprised diurnal (7 a.m. – 10 a.m.) and nocturnal (8 p.m. – 11.59 p.m.) visual encounter surveys performed along terrestrial sampling routes. All birds were identified by sight (with the aid of binoculars and cameras where necessary) and/or through call recognition. Nocturnal birds (e.g. owls and nightjars) were detected using torches to elicit eyeshine and through call recognition. Majority of the surveys were conducted within the bird migratory season (September to March), except for two nocturnal surveys.

Non-volant Mammals

Surveys comprised diurnal (7 a.m. – 10 a.m.) and nocturnal (8 p.m. – 11.59 p.m.) visual encounter surveys performed along terrestrial sampling routes. Mammals were surveyed on the ground and on vegetation, and in burrows and tree holes. In addition, tracks and scats were also recorded as they can aid in species identification. All mammals were identified by sight (with the aid of binoculars and cameras where necessary). Squirrels were also identified through call recognition. Nocturnal mammals were detected using torches to elicit eye shine, which aids in detection at night.

Camera traps were also used to survey for non-volant ground-dwelling mammals, particularly medium- to large-sized mammals. A total of 26 camera traps were spaced across the EIS Study Area (**Figure 7.8**), with approximately one camera trap per 6.25 ha which was optimised for the home range of the target species, Sunda pangolin (*Manis javanica*) (Chua, 2016). Each trap was kept at least 20 m away from terrestrial sampling routes where possible, to maximise coverage of areas not visible from terrestrial sampling routes. They were deployed at approximately 20 – 30 cm above ground, and at strategic locations with obvious animal signs. They operated 24 hours a day and were programmed to record a 10-second (sec) footage per motion trigger with a 10-sec quiet period following each trigger. Each trap was deployed for at least 40 nights per location (Si et al., 2014).

The two camera trap models used are; 1) Browning Strike Force Explorer BTC-EXP; and 2) Browning Strike Force HDB Pro BTC-5HDP. They have the same specifications for trigger time, field of view and distance of infrared flash illumination.

Bats

A handheld acoustic detector, the Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.), connected to a mobile device, was used during nocturnal surveys along terrestrial sampling routes to detect insectivorous bats. Insectivorous bats produce ultrasonic echolocation calls that are unique to each species and can be used to identify bats (Fenton and Bell, 1981). The detector converts the ultrasonic calls to low frequency signals below 20 kilohertz (kHz), a range that is audible to the human ear, which are then streamed on a spectrogram of the Echo Meter Touch app. All bat calls are automatically recorded on the device.

In light of the COVID-19 outbreak, bat live trapping was not conducted. However, roost emergence surveys were conducted at bamboos to determine the possible residency of bamboo bats. The surveys occur between 6.30 p.m. and 9 p.m., during which two to three personnel were stationed around each bamboo to observe for bats flying out from or towards the bamboo, and identify potential slits of at least 1 cm by 1 cm that bamboo bats may use. Active slits and the number of individuals residing within each slit were documented. An acoustic detector was also used to obtain acoustic recordings.

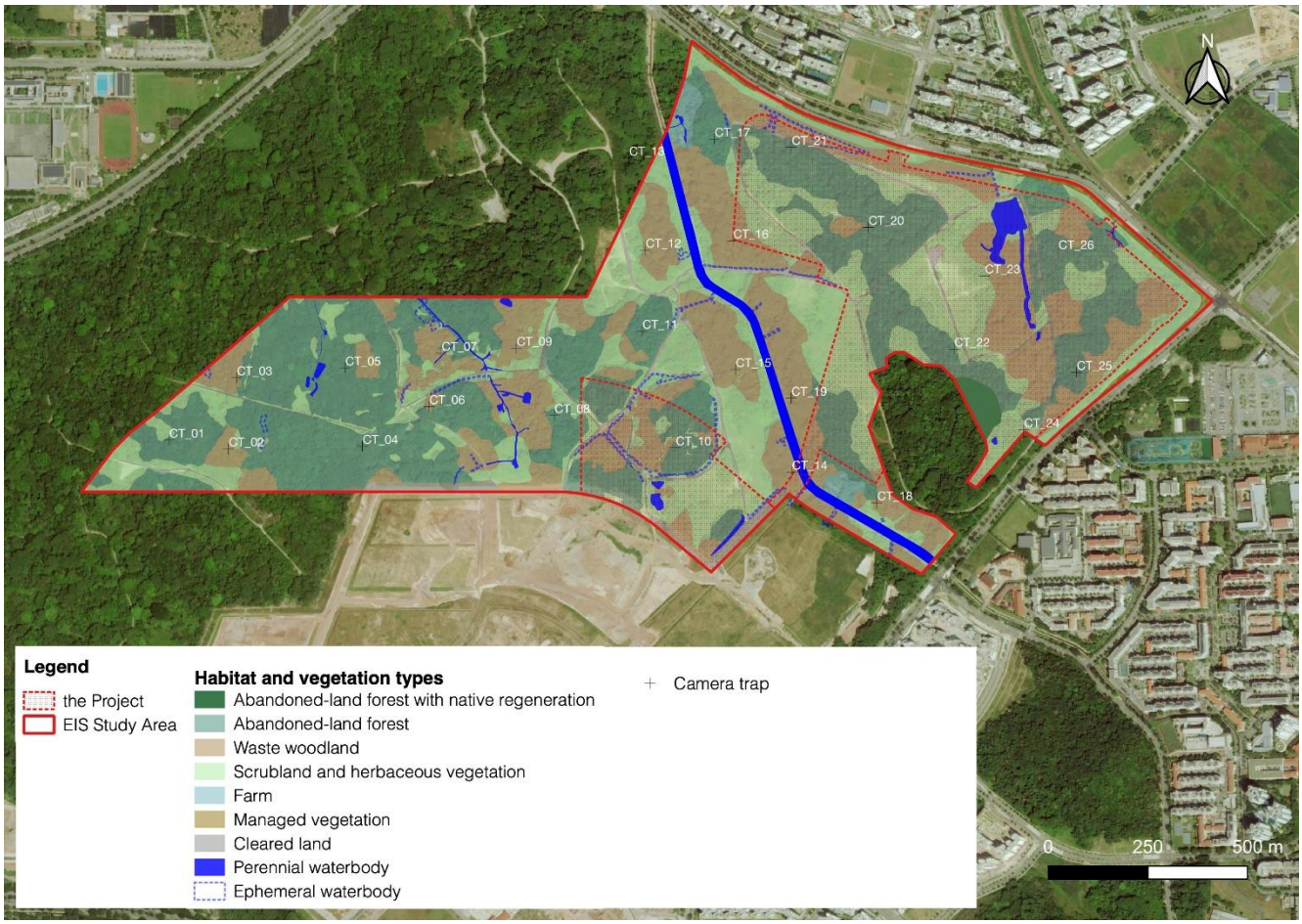


Figure 7.8: Locations of Camera Traps

Base Map: ESRI

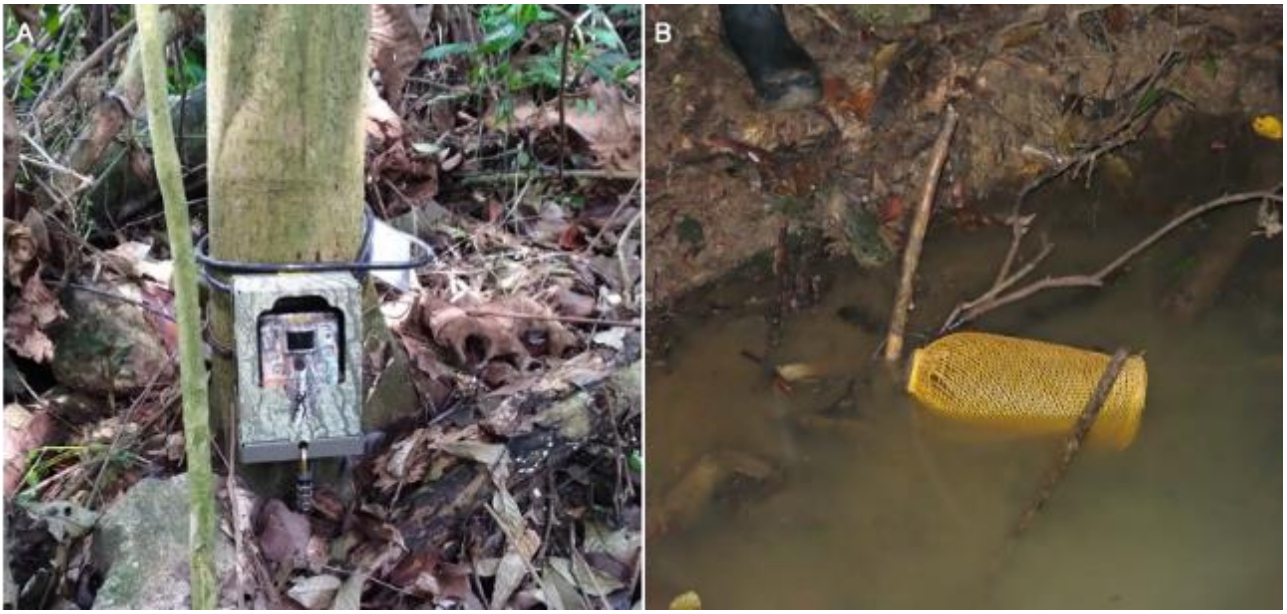


Figure 7.9: Photographs of (A) A Camera Trap Setup and (B) A Minnow Trap Deployed in a Waterbody

7.2.4.2 Data Analyses

Species Richness

In order to examine the distribution of species richness across the Study Area, the number of targeted faunal species recorded during surveys were calculated for each 100-m interval along terrestrial sampling routes and at aquatic sampling points. Similar to the aquatic sampling points, the 100-m intervals along the terrestrial sampling routes are then represented as points on the maps. The maps were generated using QGIS 3.40 (Quantum GIS Development Team, 2020).

Acoustic Bat Recordings

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

Camera Trapping

The camera trap location, species identity, and 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 or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap. The number of independent detections were used to calculate detection rate of each faunal species, as well as for all fauna and all mammalian species.

Sampling Coverage

The sampling coverage for each taxon along terrestrial sampling routes, aquatic sampling points and camera traps were carried out in the statistical programming environment R version 3.4.3 (R Development Core Team, 2016) using the "iNEXT" package 2.0.20 (Hsieh et al., 2020).

A coverage-based sampling curve as plotted using data from targeted surveys of fauna. Species richness was plotted against sample coverage to estimate the adequacy of survey effort. According to Chao and Jost (2012), sample coverage refers to "the proportion of the total number of individuals in a community that belong to the species represented in the sample." iNEXT uses the observed sample of incidence data to compute the estimated species richness, as well as the associated standard error and 95% confidence interval. The standard error represents the 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.

The curve was extrapolated to provide an estimation of species richness and sample coverage if the sample size was doubled. In addition, since some species may remain undetected from sampling, the total species richness was estimated via extrapolation using the Chao estimator (Chao et al., 2012). The respective coverage-based sampling curves were then represented on a graphic plot.

7.3 Pre-construction Baseline

7.3.1 Ecological Significance

The 700-ha Tengah Town occupies a large area in Singapore and provides habitat for many flora and fauna residing within it. The EIS Study Area (166 ha) occupies approximately one-quarter of the Tengah Town, thus contributing significantly to this role.

More importantly, the current site of the future Tengah Town serves an important role in ecological connectivity as it facilitates the dispersal of flora and fauna between the Western Water Catchment Area, Bukit Timah Nature Reserve and Central Catchment Nature Reserve (CCNR), which are biodiversity hotspots across the fragmented landscape in Singapore (**Figure 7.10**). Ecological connectivity is important as it maintains a healthy ecosystem through crucial processes such as seed dispersal and genetic exchanges.



Figure 7.10: Ecological Connectivity of the EIS Study Area with other Forested Areas in the Vicinity

Base Map: ESRI

7.3.2 Habitat and Vegetation Types

7.3.2.1 Vegetation Types

There are four main vegetation types present within the EIS Study Area. It is largely covered with abandoned-land forest (57.20 ha; 34.4%) (**Table 7.6**; **Figure 7.11**). This is followed by scrubland and herbaceous vegetation (49.95 ha; 30.0%) and waste woodland (45.47 ha; 27.3%). Another forest type similar to abandoned-land forest but with a higher recruitment of native species occupies a small area of 1 ha (0.6%). The remaining area of

spontaneous vegetation is covered by farms (1.42 ha; 0.9%) and managed vegetation (1.98 ha; 1.2%). Cleared land and non-vegetated areas made up a total of 6.37 ha (3.8%).

Vegetation plot data indicates that species richness is the highest in abandoned-land forest, with 103 species in total, followed by a total of 73 species in all scrubland and herbaceous plot, 68 species in waste woodlands plot and 37 species for the abandoned-land forest with native regeneration. This trend is also the same for native species richness, where plots within abandoned-land forest recorded the highest count (**Table 7.6**).

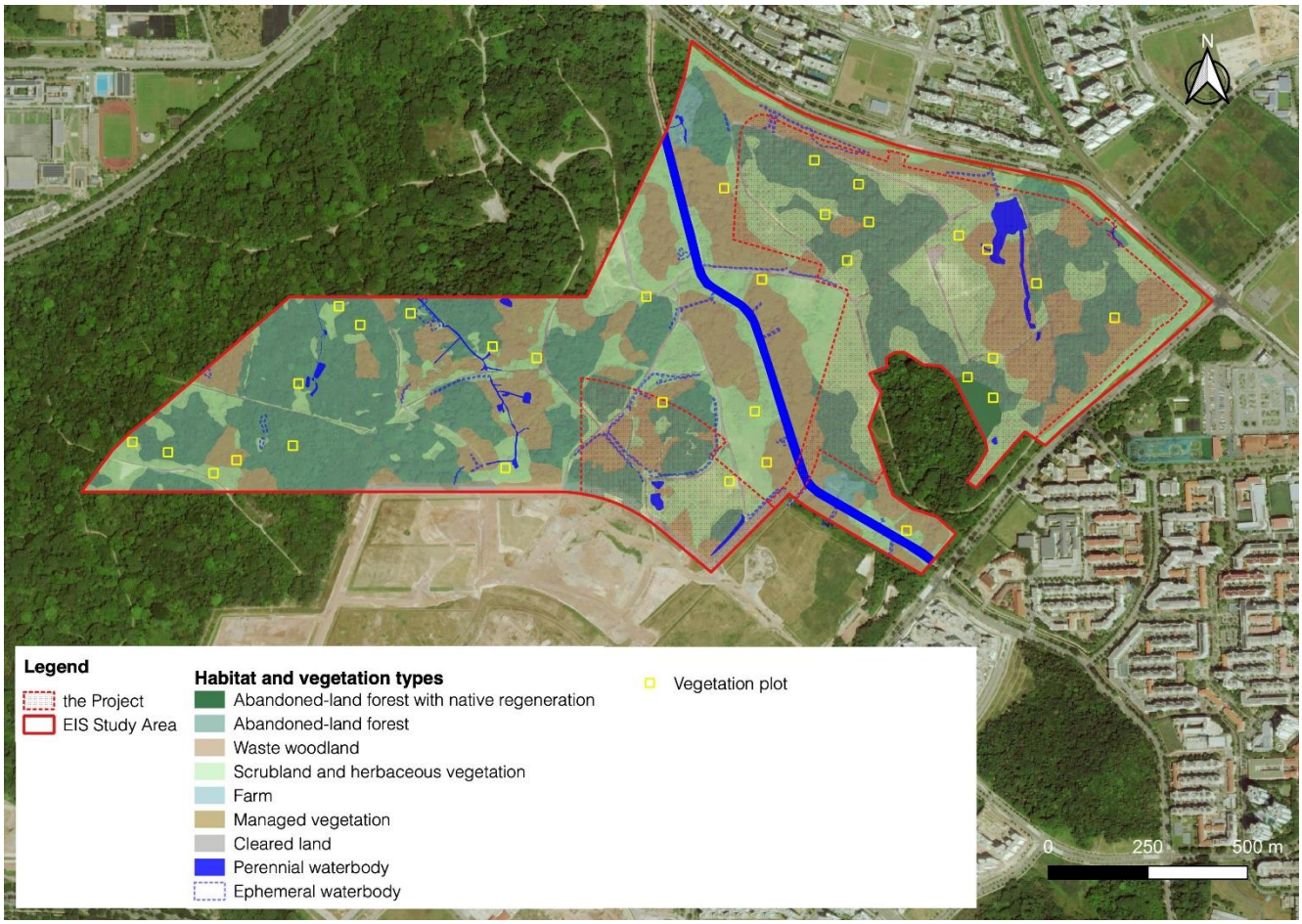


Figure 7.11: Vegetation Distribution of the EIS Study Area and Locations of All 32 Sampling Plots

Base Map: ESRI

Table 7.6: Absolute (ha) and Relative (%) Sizes, Number of Vegetation Plots, and Species Richness of Each Vegetation Type

Vegetation Type	Area (ha)	% of EIS Study Area	Number of Vegetation Plots	Species Richness per Vegetation Type		
				*Total	Native	Exotic and Cryptogenic
Abandoned-land Forest with Native Regeneration	1.00	0.6	2	**37**	29	8
Abandoned-land Forest	57.20	34.4	12	**103**	61	42

Vegetation Type	Area (ha)	% of EIS Study Area	Number of Vegetation Plots	Species Richness per Vegetation Type		
				*Total	Native	Exotic and Cryptogenic
Waste Woodlands	45.47	27.3	8	**68**	32	36
Scrubland and Herbaceous Vegetation	49.95	30.0	10	**73**	33	40
Others (Farms)	1.42	0.9	–	–	–	–
Cleared Land, Non-vegetated Areas	6.37	3.8	–	–	–	–
Managed Vegetation	1.98	1.2	–	–	–	–
Canal	2.96	1.8	–	–	–	–
Total Spontaneous Vegetation	**153.62**	**93.0**	**32**	–	–	–
Total Area	**166.35**	**100.0**	–	–	–	–

Note: *refers to the total number of species recorded across all plots in each vegetation type

a) Abandoned-land Forest with Native Regeneration

This forest patch is located on top of a hill and extends downhill at the east of the EIS Study Area. The floristic assemblage of the native forest patch on top of the hill comprises of native species such as *Macaranga gigantea, Macaranga hypoleuca and* Tembusu *(Cyrtophyllum fragrans;* **Figure 7.12A**) that makes up the canopy stratum while the understorey stratum consists of *Arthrophyllum diversifolium* and threatened native species, *Litsea firma* (**Figure 7.12C**). On the lower section of the forest patch, a cluster of five to six mature trees of *Ixonanthes reticulata* dominates the canopy (**Figure 7.12B)**. There are also fruit tree saplings observed like durian (*Durio zibethinus*) and rambutan (*Nephelium lappaceum*) in the canopy and understorey stratum. This could be contributed by the presence of abandoned-land forests located within the vicinity.

The recruitment and species composition of high native species in this forest patch may be contributed by its proximity to another native-dominated vegetation in the adjacent land that is catered for the development of TSR (AECOM, 2017). It shares some similar floristic composition, with stands of mature Tembusu (*Cyrtophyllum fragrans)* and *Ixonanthes reticulata* making up the canopy stratum of the forest (AECOM, 2017).

The number of the native species richness in this forest patch is almost similar to waste woodlands as well as scrubland and herbaceous vegetation type despite only having two plots sampled. There is also a large margin between the native species and exotic species recorded. Of the total 37 species recorded, 29 (78%) were native species and only 8 (22%) were exotic species (**Table 7.6**).

Few saplings of the vulnerable threatened species, *Ficus aurata* var. *aurata* were also recorded in this forest patch. The nationally Critically Endangered climber species, *Connarus semidecandrus,* was recorded in clusters at the higher forest patch. The clusters were assessed to be of good health and condition.



Figure 7.12: (A) Tembusu (*Cyrtophyllum fragrans*) and (B) *Ixonanthes reticulata* make up the canopy stratum of the forest patch; and (C) Nationally Vulnerable *Litsea firma* growing at the understorey stratum of the forest

b) Abandoned-land Forest

This forest type consists of past fruit orchards and crop plantations (**Figure 7.13A–B**). Thus, the plant species that constitute the abandoned-land forest type are mainly fruit trees and crop plants that have persisted from past cultivation. Some fruit plant species found in this forest type include durian (*Durio zibethinus*), mata kuching (*Dimocarpus longan* ssp. *malesianus*), rambutan (*Nephelium lappaceum*) and cacao (*Theobroma cacao*). Crop plant species found in this forest type include rubber tree (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*). Recruitment of saplings are mostly from the fruit trees and native species, such as *Claoxylon indicum*, *Terminalia catappa*, *Leea indica*, *Arthrophyllum diversifolium* and *Cinnamomum iners* (**Figure 7.13D**). Within the understorey layer of the abandoned-land forest, there are commonly cultivated ornamental shrub and herbs that were planted in the past such as *Dracaena fragrans*, *Dieffenbachia seguine* var. *seguine* and *Piper sarmentosum* (**Figure 7.13C**).

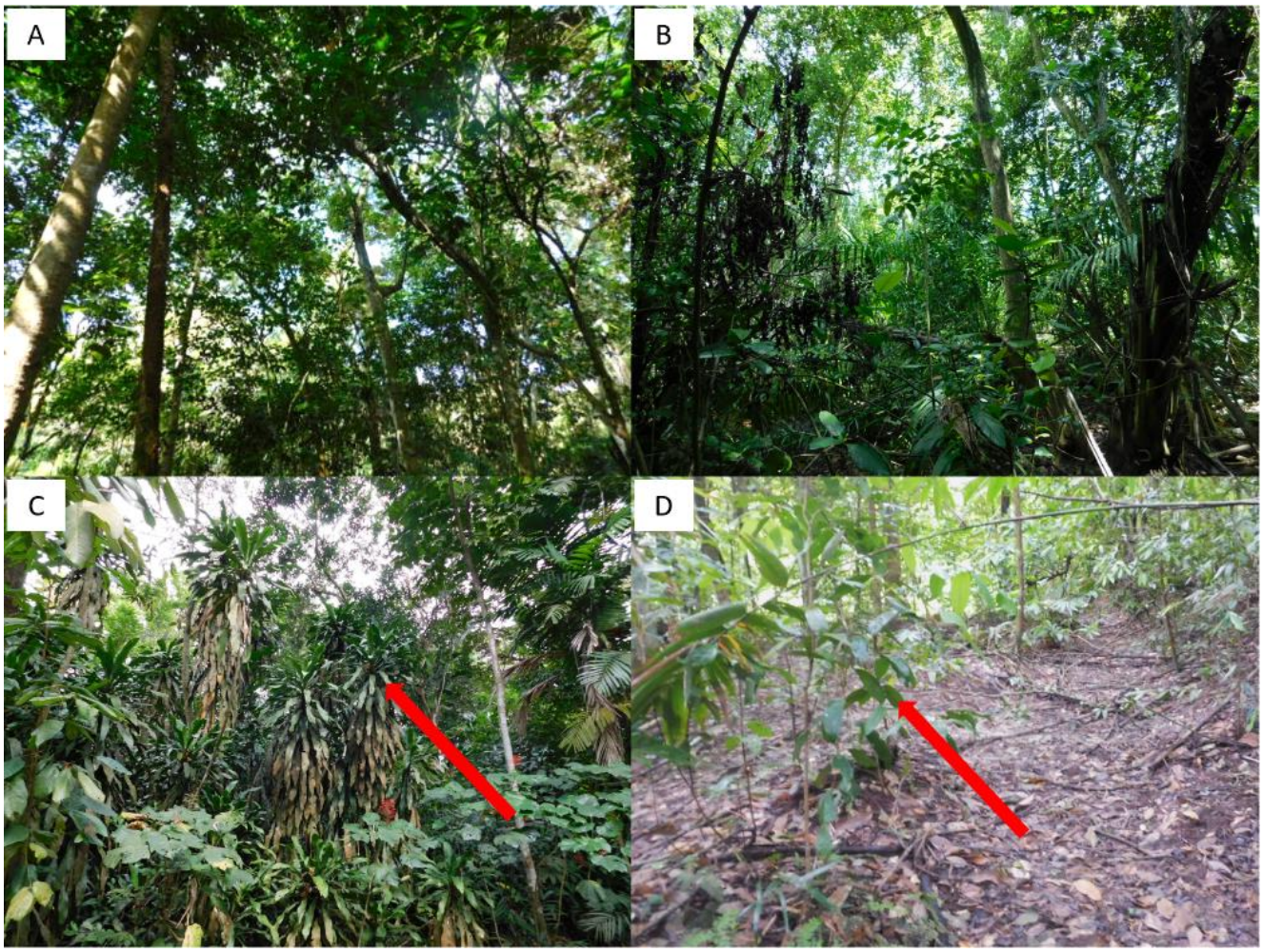


Figure 7.13: Abandoned-land forest in the EIS Study Area. (A-B) : Canopy stratum of abandoned-land forest; (C) *Dracaena fragrans* forming the understorey; (D) *Cinnamomum iners* found in the understorey of abandoned-land forest

c) Scrubland and Herbaceous Vegetation

This vegetation type is scattered across the EIS Study Area. As trees fail over time due to biotic and abiotic factors, such events open up previously close-canopy forest and encourage the colonization of sun-loving herbaceous plants resulting in formation of scrubland vegetation. These areas are characterized by short vegetation with open canopy, typically made up of shrubs, climbing/creeping plants, and grasses (**Figure 7.14B**). Some of these species include exotic shrubs, grasses and climbers like Guinea grass (*Megathyrsus maximus),* mile-a-minute weed (*Mikania micrantha*) and *Ischaemum* sp. Some native grasses like *Ottochloa nodosa* and shrubs such as Singapore rhododendron (*Melastoma malabathricum)* can also be seen in this vegetation type. Along the edges of the roads, species that dominate the edges include elephant grass (*Pennisetum purpureum*; **Figure 7.14A**) and weeds such as *Bidens alba*. Scrubland vegetation dominated by simpoh air (*Dillenia suffruticosa*) can also found in areas that are of close proximity or within the abandoned-land forest (**Figure 7.14C**).

Clusters of native Vulnerable tree species, *Glochidion zeylanicum* var. *zeylanicum*, found at a patch of scrubland and herbaceous vegetation in the central part of the EIS Study Area. This is discussed further in **Section 7.3.3.2**. Another noteworthy observation would be the presence of common native orchids species, the bamboo orchids (*Arundina graminifolia;* **Figure 7.14D**) and *Spathoglottis plicata* that were found growing naturally in the scrubland and herbaceous vegetation located along both sides of the canal.

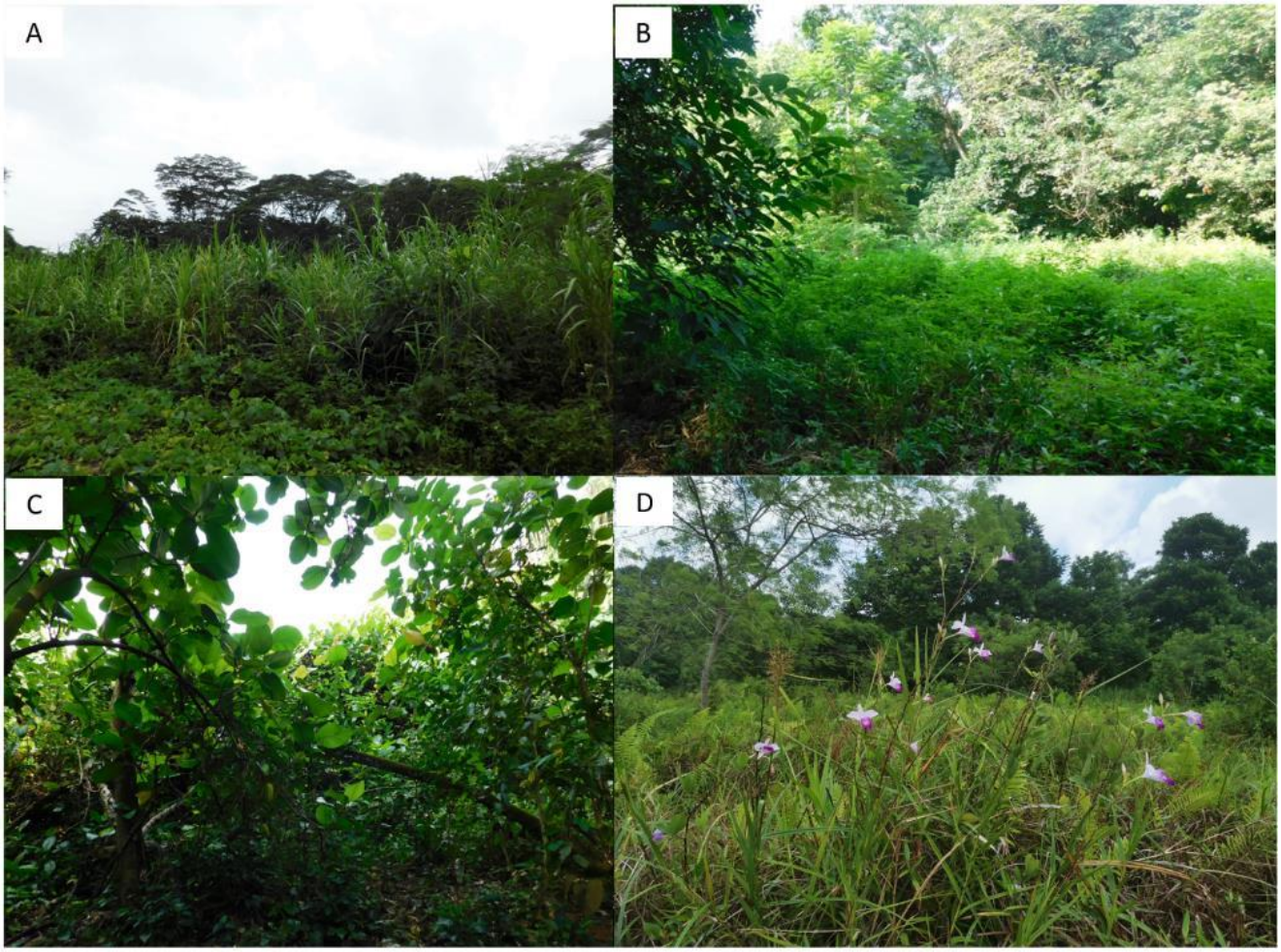


Figure 7.14: Scrubland and Herbaceous Vegetation in the EIS Study Area. (A) Scrubland dominated by elephant grass (*Pennisetum purpureum*) mostly along roadsides; (B) Herbaceous vegetation made up of shrubs, climbing/creeping plants and grasses; (C) An example of *Dillenia suffruticosa* scrubland area; (D) Clusters of Bamboo orchids (*Arundina graminifolia*) found in the scrubland and herbaceous area

d) Waste Woodland

Although waste woodland vegetation type is generally scattered throughout the EIS Study Area, the largest patches are adjacent to the present canal that cuts from north to south of the EIS Study Area. The dominant species here are albizia tree (*Falcataria moluccana*) and African tulip (*Spathodea campanulata)*; **Figure 7.15A-B**. Large specimens of these trees are found at larger patches of waste woodlands abutting the canal area and towards the west of the Study Area. This is probably because these areas are more disturbed due to the construction of the present canal and the periodic military trainings that are conducted around the proximity of this area. These exotic tree species are fast-growing "with high propagule pressure in the surrounding landscape" (Yee et al., 2016), which causes higher rates of establishment than native species with low propagule pressure. It supports our findings on site, whereby a higher number of African tulip's sapling recruitment is observed at most waste woodland forest patches (**Figure 7.15D**).

A noteworthy encounter made during the floristic survey is the rare climber, *Mucuna biplicata,* located at a waste woodland patch in the south of the EIS Study Area. As of date, no official records of this species can be found in Singapore. More information about the *Mucuna* species is elaborated in **Section 7.3.3.2**.



Figure 7.15: Waste Woodlands in the Study Area. (A-B): Canopy layer of the waste woodlands dominated by albizia (*Falcataria moluccana)* and African tulip (*Spathodea campanulata)*; (C) Overall profile of the waste woodlands; (D) Recruitment of African tulip saplings in the understorey stratum

e) Managed Vegetation

The EIS Study Area also includes a linear area of managed vegetation located parallel to Brickland Road at the east and Bukit Batok Road at the southeast of the EIS Study Area. The vegetation type is made up of predominantly turf areas that are regularly maintained and also roadside trees.

f) Others (Small-scale Farms)

Small parts of the forested area have been cleared for small-scale farming practices (**Figure 7.16**). Two such farms were found and encountered during the floristic surveys. They appear to be regularly maintained.



Figure 7.16: Small-scale Farms that Appeared to be Regularly Maintained

g) Others (Cleared Land and Non-vegetated Area)

There are two areas of cleared land. One patch is located along the southwest boundary of the EIS Study Area. This area seemed to be cleared for ongoing Phase 2 earthworks for the Tengah Town Development (**Figure 7.17A**). The other patch of cleared land is located in the south and has water draining to Pond1 and Pond2 that abuts the EIS Study Area boundary (**Figure 7.17B**). The remaining non-vegetated areas in the EIS Study Area are taken up by roads and military training sheds.



Figure 7.17: (A) Cleared land located south of EIS Study Area; (B) Water ponding abutting the southeastern boundary of the EIS Study Area

7.3.2.2 Waterbodies

A variety of waterbodies including the Main Canal, streams/ earth drains, ponds, and ephemeral waterways are present within the EIS Study Area as discussed in **Section 5** (Surface Hydrology) and **Section 6** (Water Quality). Amongst these waterbodies, six streams and six ponds were identified for aquatic sampling. These waterbodies are perennial in nature and are described in **Table 7.7**. The locations of these waterbodies are shown in **Figure 7.18**.

Ephemeral waterways can be found in multiple locations across the EIS Study Area, often along the sides of the tracks/roads or in channels within the forest (**Figure 7.18**). These areas are mostly unshaded and poorly vegetated.

Table 7.7: Description of Waterbodies within the EIS Study Area

Type	Stream/ Pond*	Description
Closed-canopy streams	ED2, ED7	These are slow-flowing closed-canopy streams in the western side of the EIS Study Area. Both streams flow northwards, and are characterised by high canopy cover, lower temperatures, and high accumulation of leaf litter. **ED2** A section of the ED2 (along ED2_03; **Figure 7.18A**) is situated within scrubland and herbaceous vegetation where the canopy is open and the temperatures are higher. The downstream section of the stream along ED2_04 and ED2_05 has lusher riparian vegetation (**Figure 7.18B**) than the upstream sections along ED2_01 and ED2_02 (**Figure 7.18C**). To the east of ED2_02, there is a pond (ED2_06) that appears to be connected to the stream. It is well-vegetated on the banks but is unshaded in the middle as the pond is large (**Figure 7.18D**). ED2 stream flows in northerly direction to an earth drain at the northwestern portion of Tengah, then leading to drain along KJE. The source of this stream is possibly located within Phase 2 boundary. **ED7** ED7 is considered perennial although it was observed to be dry during the period of low rainfall in January and February 2020. It remained filled from April to August 2020 during the time of sampling period. The riparian vegetation here is also not as lush as along ED2 (**Figure 7.18E**).
Open-country streams	Spring, ED1, ED6 and ED8_01	These are slow-flowing open-country streams with low canopy cover and higher temperatures. **Spring** The Spring is situated at the Spring Area within a patch of farmland, with cultivated plants such as *Pandanus amaryllifolius* on its banks (**Figure 7.18G**). **ED1** ED1 is an extensive waterbody with varying conditions along its length. At ED1_01, the waterbody resembles a semi open-country stream. As it is situated within a patch of waste woodland, the canopy is only partially closed and the riparian vegetation is sparse (**Figure 7.18H**). ED1_02 is a ponded area across the track/road but is connected to the remaining waterbody by a culvert that runs under the track/road (**Figure 7.18I**). It is well-shaded with lower temperatures. At ED1_03, the waterbody is a marshy area situated within a patch of scrubland and herbaceous vegetation without any canopy cover. The area was dominated by the water-loving *Neptunia plena* (**Figure 7.18J**). **ED6** ED6 is a deep waterbody situated adjacent to the hoarding of a construction site. The opposite bank is well vegetated and partially

Type	Stream/ Pond*	Description
		shaded by the trees in the adjacent abandoned-land forest. However, the bank is high and steep (**Figure 7.18K**). **ED8** ED8_01 is a shallow semi open-country stream that is partially shaded by the canopy of the abandoned-land forest and has lush riparian vegetation (**Figure 7.18L**).
Closed-canopy & semi open-country ponds	Pond3, Pond4, Pond5, Pond6, and ED8_02	**Pond3 and Pond4** Pond3 and Pond4 are large ponds that are well vegetated on the sides and covered with floating aquatic plants. The areas beyond the reach of the canopy of the trees are exposed to the sun (**Figure 7.18P–Q**). **Pond5, Pond6 and ED8_02** Pond5, Pond6 and ED8_02 are small ponds situated under the forest canopy (**Figure 7.18M–N**). The vegetation along the edges of the ponds is sparse and the area around Pond6 was littered with significant amounts of trash.
Open-country ponds	Pond1, Pond2	Pond1 and Pond2 are large open-country ponds situated in an area of scrubland and herbaceous vegetation. The vegetation on the edges of the ponds is very lush, and most of the water surface is covered by floating plants as well (**Figure 7.18O**). During periods of high rainfall, water overflowed onto the surrounding low-lying vegetated areas, creating marshy conditions. Water also overflowed onto the adjacent track/ road, along with fish and other aquatic animals.
Canal	Main Canal	It bisects the EIS Study Area from south to north. The area within the canal is open and unvegetated. The water is fast-flowing and the water level does not seem to exceed the baseflow channel (**Figure 7.18F**).

Note: *Reference can be found in **Section 5: Surface Hydrology** and **Section 6: Water Quality.**



Figure 7.18: Waterbodies in the EIS Study Area Identified for Aquatic Sampling. (A) Stream at ED2_03, (B) stream at ED2_05, (C) stream at ED2_02, (D) pond at ED2_06, (E) stream at ED7, (F) Main Canal, (G) stream at Spring Area, (H) stream at ED1_01, (I) pond at ED1_02, (J) pond at ED1_03, (K) stream at ED6, (L) stream at ED8_01, (M) Pond6, (N) pond at ED8_02, (O) Pond2, (P) Pond3, (Q) Pond4.

7.3.3 Floristic Field Findings

7.3.3.1 Overall

A total of 332 species, six species groups (i.e. plants that could not be identified to species with certainty) belonging to 93 families and 1 unknown Pteridophyte species, are recorded from the present study's floristic surveys at the EIS Study Area. The six species groups are: 1) *Acacia* sp.; 2) *Durio* sp.; 3) *Drynaria* sp.; 4) *Guioa* cf. *pubescens*; 5) *Litsea* cf. *cordata*; and 6) *Pinus* sp. All species groups were tabulated into the total species count in **Table 7.8**, except for the unknown Pteridophyte species, as we are unable to determine if it is of native, exotic or cryptogenic origin.

The *Acacia* sp. specimen that we encountered was a climber, a growth habit distinct from that of Acacia (*Acacia auriculiformis)* and *Acacia mangium*, which grow as trees. Though the identity of the specimen could not be determined with certainty, we have ruled out the possibility of it being the other two *Acacia* species recorded at EIS Study Area owing to the distinct growth form. Hence, it was also included as in the tabulation of total species count (**Table 7.8**; **Appendix 7A**). This was listed as a 'Cryptogenic' species as the origin could not be determined.

The *Durio* sp. specimen that we encountered is most probably exotic as it could be another species that was cultivated in the past as part of the abandoned fruit orchards. Vegetative specimens were collected and compared against the existing durian species found in EIS Study Area, *Durio zibethinus*. Most characteristics found from the *Durio* sp. specimen resemble the latter. The only distinctive difference that possibly differentiate the two species, is the presence of leaf pubescent, i.e. leaf hairs, on abaxial side of the leaf (**Figure 7.19A**). Thus, it was listed as a 'Exotic' species in the tabulation of total species count (**Table 7.8**; **Appendix 7A**).

All species of Oak Leaf ferns (*Drynaria* sp.), i.e. *Drynaria quercifolia* and *Drynaria sparsisora,* listed in Chong et al. (2009) are known as common native species in Singapore. Both species are similar looking and could only be told apart by the arrangement of sori, i.e. spore-producing structures, on their foliage. As this species is epiphytic by nature, in most cases, plant specimens are usually out of reach. Hence, we were unable to obtain a voucher specimen. This species was included in the tabulation of total species count as a native species (**Table 7.8**; **Appendix 7A**). Similarly, *Pinus* sp. that was encountered during the survey (**Figure 7.19B**) is categorised under 'Exotic' as all *Pinus* species are listed as 'Cultivated' in Chong et al. (2009).

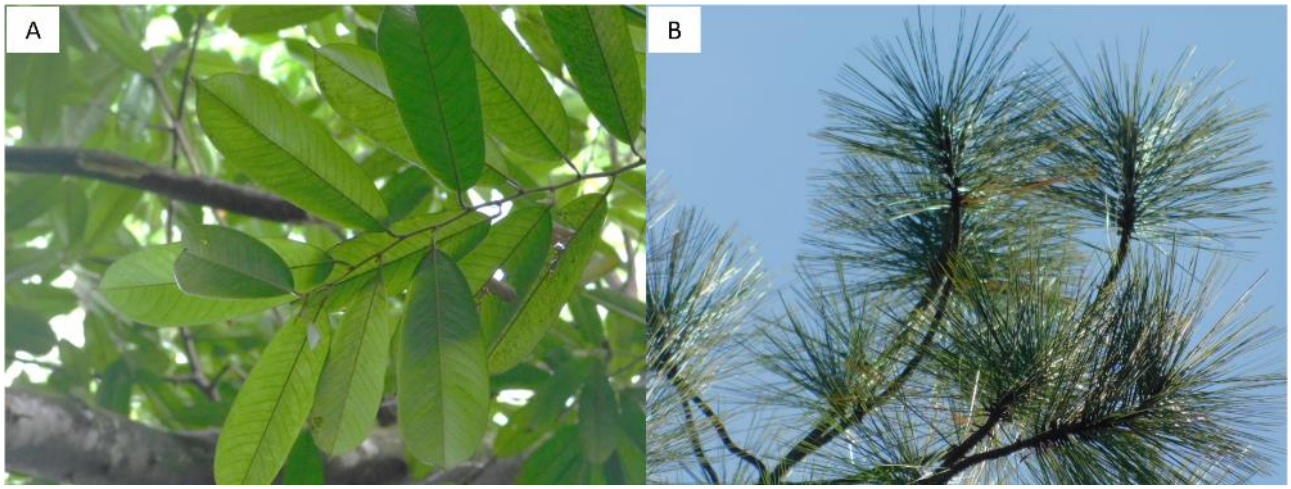


Figure 7.19: (A) Leaves of *Durio* sp. (B) Close-up image of *Pinus* sp. found in the EIS Study Area.

The remaining two species group, *Litsea* cf. *cordata and Guioa* cf. *pubescens* could not be identified to species level with certainty even with voucher specimens and/or photographs, but could possibly be nationally threatened species, were also included in the tabulation of total species count in **Table 7.8** and **Appendix 7A**.

An unknown Pteridophyte (i.e. seedless vascular plants that reproduces by spores) species was found growing at the base of a *Bouea oppositifolia* tree. Only one specimen was observed throughout the entire EIA Study Area. Vegetative specimens were collected to identify the species to match against identification keys and books. There is a possibility that this unknown fern could be *Asplenium nitidum* (Recently rediscovered; previously nationally Extinct). However, due to the absence of spores from the specimen, we were unable to confirm the identity of the species with certainty. Presence of fertile structure would be needed to determine the species in greater detail.

Of all the plant species recorded, 161 (47.6%) are native, 150 (44.4%) are exotic, and 27 (8.0%) are cryptogenic, i.e. of unknown/uncertain origins. The recently discovered *Mucuna biplicata* is listed as 'NA – Not Assessed' **(Table 7.9**; **Section 7.3.3.2**).

The number of native threatened species makes up 30.3% (70 species) of total flora species count. However, some threatened species are cultivated locally and/or are relics from past cultivation in Tengah and hence may not be of conservation significance. This is discussed in greater detail in **Section 7.2.1.3** and **Section 7.3.3.2**.

Table 7.8: Number and Percentage of Species belonging to Each Status Category in the EIS Study Area

Origin	Status	Number of Species	%
Native		**161**	**47.6**
	Common	91	26.9
	Vulnerable	31	9.2
	Endangered	17	5.0
	Critically Endangered	15	4.4
	Extinct (Cultivated)	5	1.5
	Presumed Extinct	1	0.3
	Not Assessed; Recently discovered	1	0.3
Exotic		**150**	**44.4**
	Cultivated Only	50	14.8
	Casual	47	13.9
	Naturalised	53	15.7
Cryptogenic		**27**	**8.0**
	Total	**338**	**100.0**

7.3.3.2 Species of Conservation Significance

Fifty-one species in the EIS Study Area are considered species of conservation significance (**Section 7.2.1.3**; **Table 7.9**). Some species were considered of conservation significance even though they are/had been planted locally, such as *Planchonella obovata, Ardisia elliptica* and *Sterculia rubiginosa*. The origin of those species mentioned was difficult to determined, which led us to adopt a more conservative approach and considered them to be species of conservation significance. Locations of all species of conservation significance are reflected in **Figure 7.20**.

Table 7.9: Number of Plant Species of Conservation Significance

Species Conservation Status*	VU	EN	CR	EX	NA
Non-cultivated Threatened Species	17	11	6	1	1
Cultivated Threatened Species	9	3	3	0	0
Total Number of Species of Conservation Significance	26	14	9	1	1

Note: *VU – Vulnerable; EN – Endangered; CR – Critically Endangered; EX – Presumed Extinct (Re-discovery); NA – Not Assessed (Recently discovered)

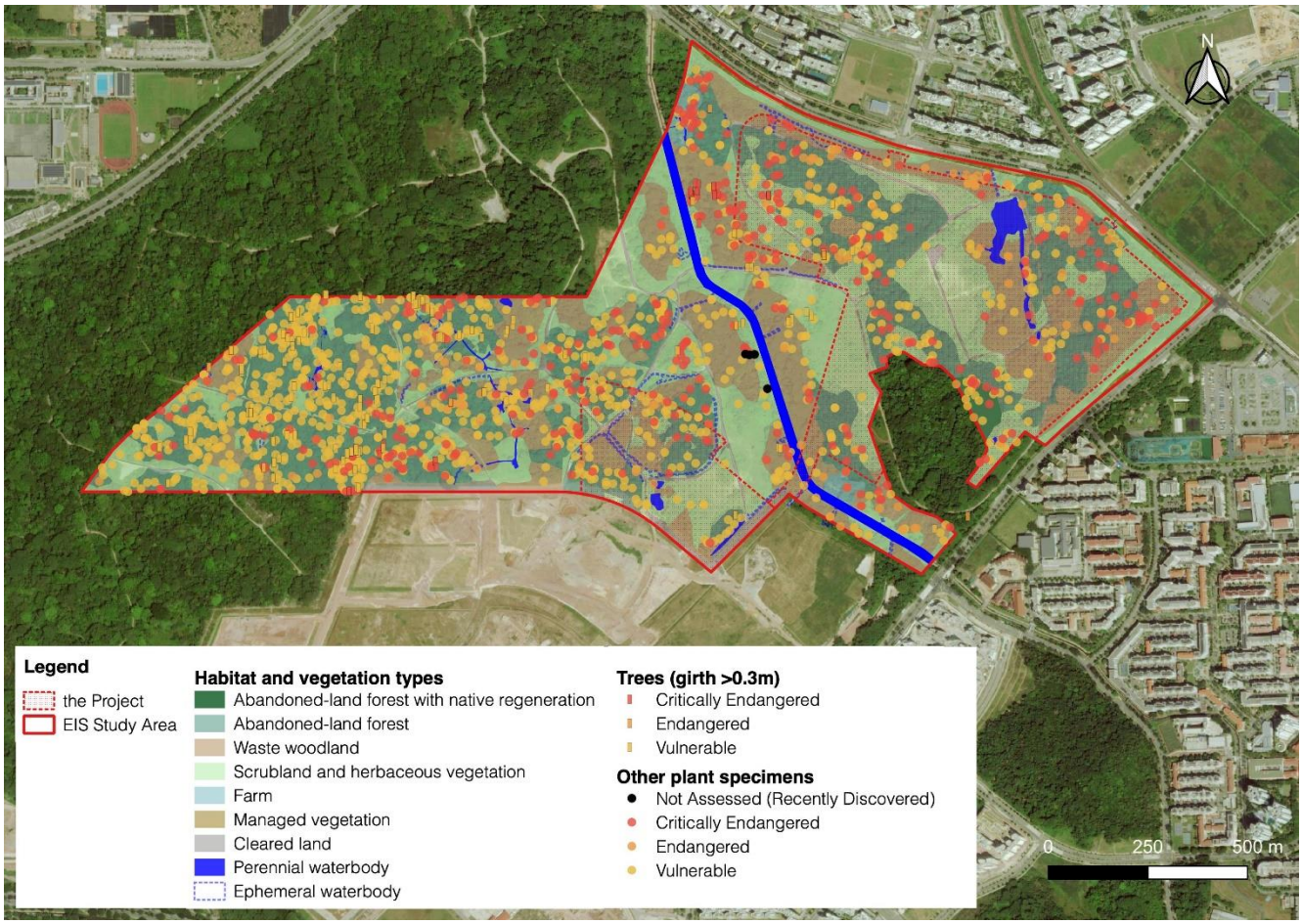


Figure 7.20: Distribution of All Plant Species of Conservation Significance in the EIS Study Area

Base Map: ESRI

Approximately 2,084 individuals and clusters of specimens of conservation significance were recorded within the EIS Study Area. A higher number of these specimens were concentrated in the western half of the EIS Study Area, especially within the abandoned-land forest (**Table 7.10**). Three species of conservation significance, *Oxyceros longiflorus*, *Macaranga griffithiana* and *Bridelia stipularis* contributed to the high count of vulnerable native species and can be found across the EIS Study Area, although more clusters were recorded in the western area (**Figure 7.21**).

Species of conservation significance in the waste woodlands patches and abandoned land forest patches located at the centre and east of the EIS Study Area are generally well distributed. Around 33 (64.7%) and 28 (54.9%) species of conservation significance can be found in abandoned-land forest and waste woodland respectively.

Table 7.10: Number of Individuals and/or Clusters of Plant Specimens of Conservation Significance in each Vegetation Type

Vegetation Type	Number of Individuals and Clusters						Number of Species					
	VU	EN	CR	EX	NA	Total	VU	EN	CR	EX	NA	Total
Abandoned-land Forest	816	61	201	4	0	**1,082**	18	7	7	1	0	**33**
Waste Woodland	285	54	103	0	4	**446**	13	7	7	0	1	**28**
Scrubland and Herbaceous Vegetation	119	30	58	0	0	**207**	8	3	4	0	0	**15**
Abandoned-land Forest with Native Regeneration	19	2	7	300	0	**328**	4	2	3	1	0	**10**
Others (Farm and Cleared Land)	10	0	11	0	0	**21**	3	0	2	0	0	**5**

Note: Total species richness of the EIS Study Area is not the sum of species richness per vegetation type as some species occur in more than one vegetation type. VU – Vulnerable; EN – Endangered; CR – Critically Endangered; EX – Presumed Extinct; NA – Not Assessed; Recently discovered.

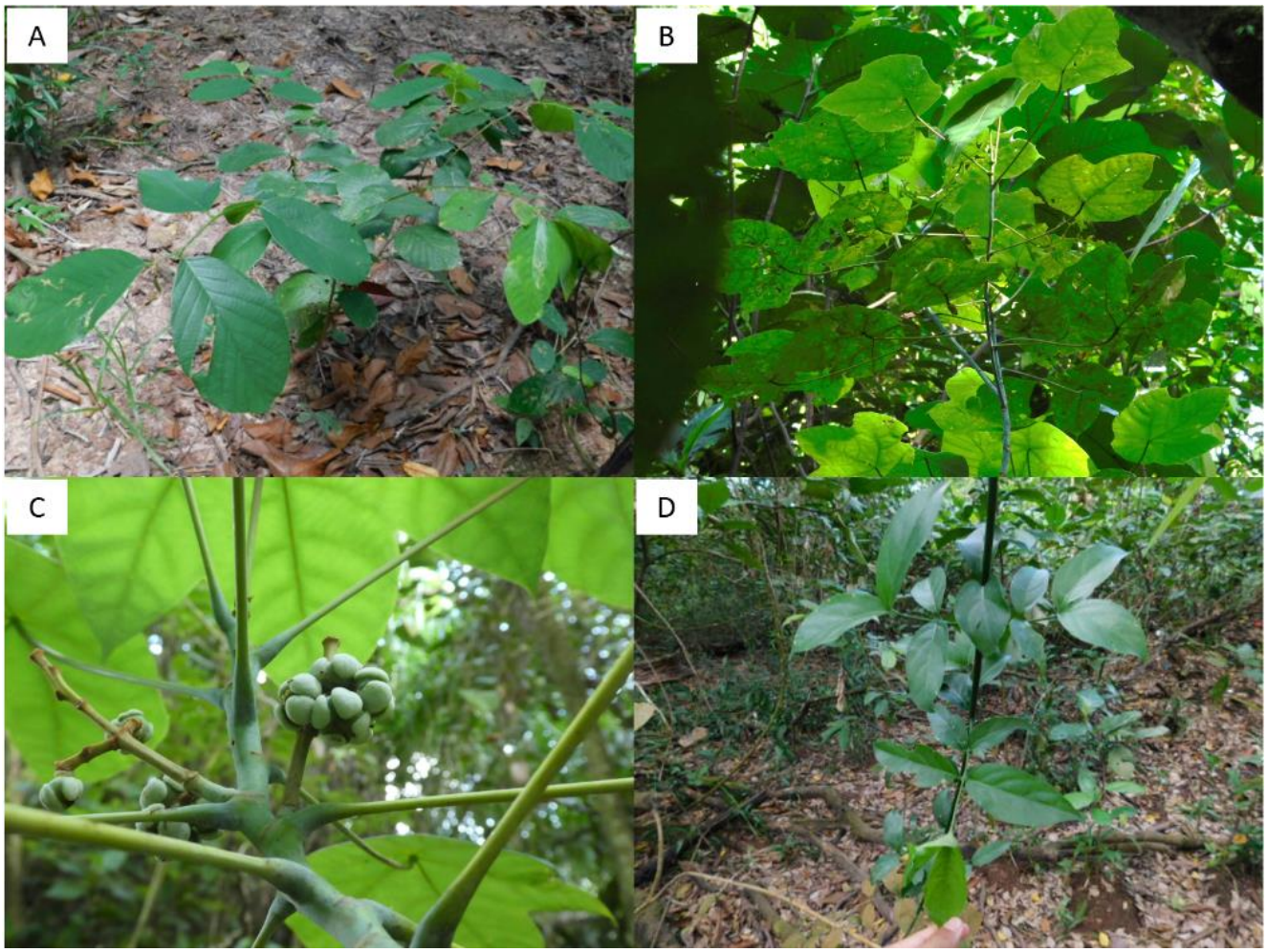


Figure 7.21: Photos of Three Threatened Species that can be Found in Abundance across the EIS Study Area. (A) *Bridelia stipularis*; (B) *Macaranga griffithiana* with (C) noticeable bluish stem and immature fruit capsules; (D) *Oxyceros longiflorus*.

In the scrubland and herbaceous vegetation patch located at the centre of the EIS Study Area, clusters of *Glochidion zeylanicum* var. *zeylanicum* were found to be healthy and thriving (**Figure 7.22**). A few trees with girth size measured within 0.6 m to 0.9 m were captured and included in the arboricultural survey (**Figure 7.22A**). Saplings of this tree were also found scattered around 20 m within the proximity of the parent tree (**Figure 7.22B**), which indicates active recruitment of this nationally Vulnerable species. The presence of the large cluster of this species explains the presence of the rare Malay staff sergeant butterfly (*Athyma reta moorei*) observed during the faunal survey (**Section 7.3.4.5**), as it is the host plant of the butterfly. Hence, the *Glochidion zeylanicum* var. *zeylanicum* clusters are considered as a habitat of interest.



Figure 7.22: (A) Clusters of *Glochidion zeylanicum* var. *zeylanicum* trees growing healthily; (B) In close proximity, more clusters are found in the scrubland and herbaceous vegetation patch as indicated by the red oval near a parent tree indicated by the red arrow; (C) Close-up photo of *Glochidion* foliage.

a) Vulnerable Species

Large clusters of tree fern, also known as *Alsophila latebrosa,* were also found in numerous locations in the EIS Study Area. This nationally Vulnerable species are usually recorded near the edges of waterbodies and areas that are of higher grounds (**Figure 7.23B**). Generally, tree ferns are known to be important in providing an important structural component due to their wide fronds spread as they mature. They also help to contribute to the species composition of a forest as their trunks are able to support the growth of various species of epiphytic plants (Blair et al., 2017). In recent years, small quantities of *Alsophila latebrosa* have been salvaged from the native forests islandwide and used for reforestation or landscaping in nature areas, contributing to the conservation of their native stock (Camphora Pte Ltd, personal observation).

Other notable records of nationally Vulnerable species is the nibong palm (*Oncosperma tigillarium)* which are known for their hardy and spiny stems (**Figure 7.23A**). They are usually found naturally in back mangroves or in mangroves with lower salinity level. However, it can also be found in freshwater swamp or places with sandy soil that occasionally flood (LLIFLE, 2005). In the past, the stems of the palm were used for construction of kelongs and other wooden structures due to their durability, hardiness and resistance to rot and water which eventually, led to their decline in population. The declination in coastal and mangrove habitat in Singapore could also be a contributing factor that has caused them to be identified as a threatened species (Liow, 2000).



Figure 7.23: (A) *Oncosperma tigillarium* found within EIS Study Area; (B) *Alsophila latebrosa* growing near the stream

b) Nationally Critically Endangered Species

Nine nationally Critically Endangered species were recorded within the EIS Study Area. The photographs of these species are shown in **Figure 7.24**. The records of these species are also elaborated in sections below.

i) *Centotheca lappacea*

The *Centotheca lappacea* **(Figure 7.24A**) has been recorded in the nature reserves (Chew et al., 1997). *Centotheca lappacea* has been observed in most secondary forest in Singapore along the forest edges (Camphora Pte Ltd, personal observation). This corroborates to our findings as more than 241 clusters of *Centotheca lappacea* were recorded along the forest edges and near areas with open canopy throughout the EIS Study Area. Although *Centotheca lappacea* are known to be cultivated, they were not found in nurseries until recent years. Hence, it is believed to belong from the native population in the EIS Study Area.

ii) *Cissus repens*

The Cissus repens **(Figure 7.24B**) has been recorded in the nature reserves (Chew et al., 1997). *Cissus repens* can also be found in coastal areas such as Pulau Ubin and Nee Soon Freshwater Swamp Forest (NParks, 2020b; Ali Ibrahim et al., 1996). Similar to Centotheca lappacea, this species is believed to belong from the native population in the EIS Study Area.

iii) *Connarus semidecandrus*

There is limited information on *Connarus semidecandrus* **(Figure 7.24C**). This native climber is usually recorded in secondary forests in nature reserves, nature catchment areas and in forest that are in close proximity to nature reserves (Chew et al., 1997; Camphora Pte Ltd, personal observation). Few clusters of this species were found in the small patch of abandoned-land forest with native regeneration in the EIS Study Area.



Figure 7.24: Nine Critically endangered species encountered in the EIS Study Area. (A) *Centotheca lappacea*; (B) *Cissus repens;* (C) *Connarus semidecandrus*; (D) *Crytococcum patens*; (E) *Ficus binnendijkii* juvenile leaves; (F) *Hoya diversifolia*; (G) *Leea angulata*; (H) *Litsea* cf. *cordata* and (I) *Melicope lunu-ankenda.*

iv) *Crytococcum patens*

The native grass *Crytococcum patens* (**Figure 7.24D**; **Figure 7.25A**) was recorded near to the canal located at the centre and at the lower east of the EIS Study Area. A few specimens of this grass were flowering when encountered, which aids in the identification of the grass. According to Duistermaat (2004), the first record of this species in SINU was collected in 1993 in Pulau Hantu, Singapore. It was only in recent years that the identification of this species in Singapore was confirmed. The characteristic and features of this plant can vary significantly, especially with the size and the form of the panicles (Chen & Philips, 2006; **Figure 7.25B**) As such, due the variation of panicles size and form, along with the absence of the inflorescence on some specimens, there is a possibility that this grass might have been overlooked by many.

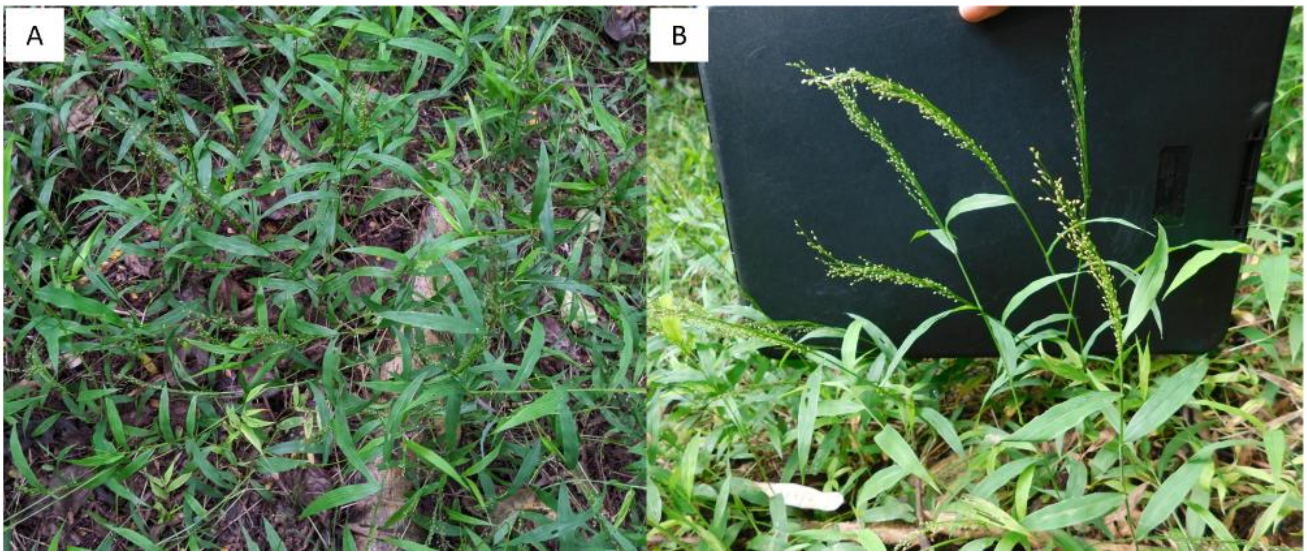


Figure 7.25: (A) Picture of *Crytococcum patens*. (B) Close-up of the inflorescence and panicle arrangement.

v) *Ficus binnendijkii*

Two mature individuals of *Ficus binnendijkii* and few saplings were found only on the south-west of the EIS Study Area. Unlike the common stranglers like *Ficus microcarpa* or *Ficus benjamina*, this species goes through a process of leaf dimorphy, where the appearance of the juvenile leaves (**Figure 7.24E**) differs from the mature leaves (Berg, 2007). The species is found naturally in Nee Soon Swamp Forest and is not known to be cultivated in the past (Camphora Pte Ltd, personal observation; Wong et al., 2013). Hence, it is believed that the matured specimens encountered are from the native population.

vi) *Hoya diversifolia*

A small cluster of *Hoya diversifolia* **(Figure 7.24F**) was encountered at a waste-woodland forest patch at near the edges of ED2_06 pond*. This species* is usually found naturally in mangroves or coastal habitat. Hence, they are considered to have a restricted distribution pattern. In Singapore, this species was previously recorded in places such as Sungai Cina which stretches along Lim Chu Kang to Woodlands, Kranji (Yap, 2005). Since Tengah Forest is located strategically near Western Water Catchment Area and mangrove reserves such as Sungei Buloh Wetland Reserve and Sungai Cina, there is a high possibility that they native population of this species were dispersed from those locations. This species is listed as one out four critically endangered *Hoya* species that is native (Ang & Rodda, 2012). Similar to the nibong palm (*Oncosperma tigillarium*), the declination in coastal and mangrove habitat in Singapore in could have contributed to the conservation status of this species.

vii) *Leea angulata*

Clusters of the native shrub, *Leea angulata,* are situated in the waste woodland forest patch located at the north of the Study Area. A few clusters of this species were also recorded at an adjacent small forest patch. Saplings with girth size up to 1.2 m were captured (**Figure 7.26A**) and the species is actively recruiting due to the high number of healthy saplings present only within the proximity. As such, the cluster of *Leea angulata* is considered as habitat of interests. The site where the plant is thriving at are moist and slightly waterlogged due to the change in gradient of the terrain as it approaches near the canal. The canopy stratum of the area was sparse due to numerous fallen albizia (*Falcataria moluccanna*), which allows more sunlight to reach to the understorey layer (**Figure 7.26B**). All the site conditions mentioned provides a favourable environment for *Leea angulata* to thrive (NParks, 2020c).

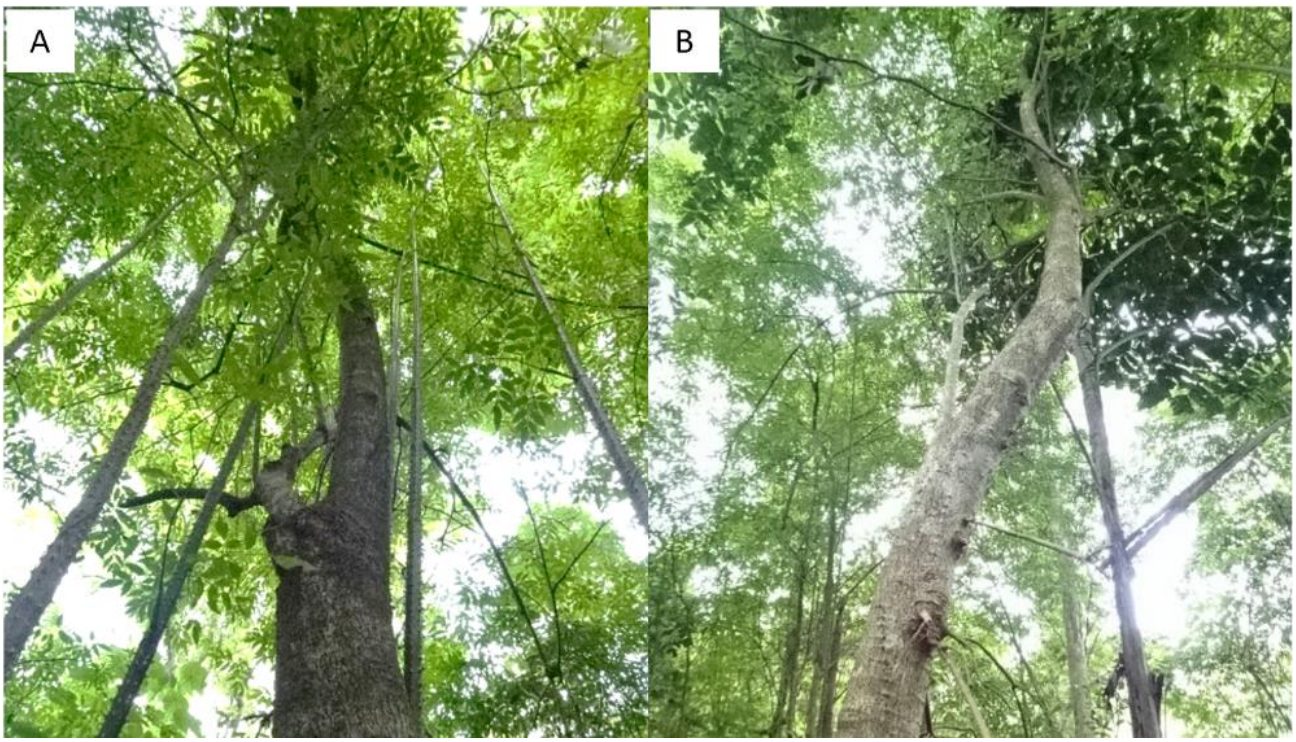


Figure 7.26: (A) Big specimens of *Leea angulata* of girth 1.2m; (B) *Leea angulata* found thriving at spots with sparse canopy stratum

viii) *Litsea* cf. *cordata*

An individual specimen of *Lisea* cf. *cordata* (**Figure 7.24H**) was found at the south-west section of the EIS Study Area. The young specimen with girth of 0.05 m and 1 m in height, was observed to be attacked by unknown leaf-eating insect. Hence, we were unable to identify this specimen with confidence. However, certain characteristics of the specimen like the presence of cordate leaf base (**Figure 7.27B**), broadly ovate shaped leaves (**Figure 7.24H**), brown and hairy leaf petiole with raised midrib on the abaxial side of the leaf (**Figure 7.27A**), resembles the key description of *Litsea cordata* listed in a journal by Chong et al. (2016). In the same journal, it is stated that previous samples of this species were also collected from Kranji and Western Water Catchment Area which is located nearby.

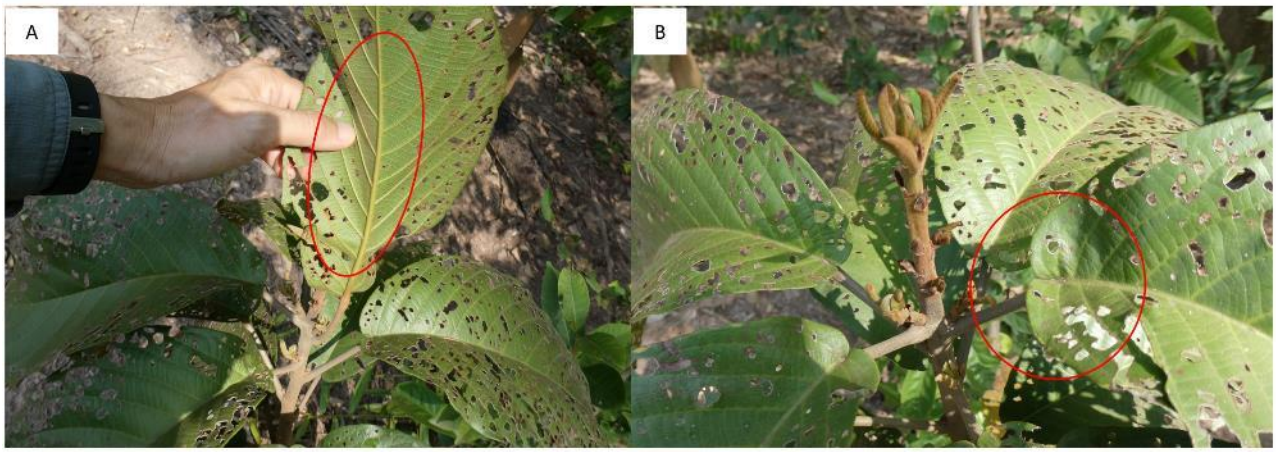


Figure 7.27: (A) Raised midrib indicated by the red oval at the abaxial side of the *Litsea* cf. *cordata* leaf; (B) Close-up of the cordate leaf base indicated by the red circle.

ix) *Melicope lunu-ankenda*

Around more than 70 individuals and/or clusters of *Melicope lunu-ankenda* (**Figure 7.24I**) were recorded throughout the entire EIS Study Area. This includes four mature individuals of more than 0.3 m girth found on the West in the EIS Study Area. It is observed that this species can also be found in disturbed secondary forests in Singapore, with individuals also recorded in Bukit Batok Hillside Park located less than 2 km from the cluster of mature specimens were found in the EIS Study Area (Neo et al., 2013).

c) Nationally Endangered Species

Fourteen nationally Endangered species were recorded during the floristic survey. Of these, four species are highlighted below as they were recorded in only one region and/or location within the Study Area. They are *Ardisia elliptica*, *Hoya latifolia, Ficus vasculosa and Ficus apiocarpa*.

i) *Ficus vasculosa*

Three mature individuals and a few clusters of the *Ficus vasculosa* saplings were encountered in the north-east section of the EIS Study Area (**Figure 7.28A**). Two out of three mature individuals had girth sizes of 1.8 m and 2.0 m and were assessed to be in good health, towering at an average height of 15 m. Like most *Ficus* species, it holds an important role in providing both ecosystem functions and services for other wildlife. According to Bronstein (1988) and Schatz et al. (2008), *Ficus vasculosa* supports a large community of insectivorous insects and birds. *Ficus vasculosa* is known to be the only host plant for the *Dolichoris* fig wasp. It is estimated that only less than 250 but more than 50 specimens are left in Singapore (Tan et al., 2014).

ii) *Hoya latifolia*

Another notable species is *Hoya latifolia*, a slow-growing climber that was found climbing on an Angsana tree (*Pterocarpus indicus)* in the southern section of the EIS Study area (**Figure 7.28B**). It is one of the 12 native species of *Hoya* recorded in Singapore (Ang & Rodda, 2012). Recorded sightings of these species are known from forest reserves such as Mandai Forest Reserves, Bukit Timah Nature Reserve and Singapore Botanic Gardens (Yap, 2006). Only one individual was observed in the EIS Study Area.

iii) *Ardisia elliptica*

A small cluster of *Ardisia elliptica* was recorded near the eastern part of the EIS Study Area (**Figure 7.28C**). Despite the recent increase of cultivation intensity of this species, *Ardisia elliptica* is regarded as a valuable plant to conserve as it is a host plant for the nationally Endangered harlequin butterfly (*Taxila haquinus*; **Section 7.3.4.5**. This plant is food source for numerous other butterflies and moth species.



Figure 7.28: (A) Mature specimen of *Ficus vasculosa* found in EIS Study Area; (B) *Hoya latifolia* climbing on Angsana tree; (C) Flowering specimen of *Ardisia elliptica* encountered in EIS Study Area.

iv) *Ficus apiocarpa*

A large cluster of nationally Endangered *Ficus apiocarpa* were encountered in an abandoned land forest patch (**Figure 7.29**). There were no other records of this species in the EIS Study Area, except at the stated location. As such, the *F. apiocarpa* cluster is considered as a habitat of interest. *Ficus apiocarpa* is a root climber that has a distinctive leaf characteristic that is pale green colour with dark green reticulated veins on the abaxial side of the leaf (**Figure 7.29A**). It was found scrambling on the forest floor (**Figure 7.29B**). Some specimens were found climbing on an African tulip (*Spathodea campanulata*; **Figure 7.29C**) to seek more sunlight.

In Malaysia and South Borneo and Sumatra, Indonesia, this *Ficus* species is usually found in lowland swamp forests, along streams and rivers. It depends mostly on river flow or floods for dispersal as its fruits are rather distasteful and dry and hence, not likeable by many animals (Corner, 1939). Given that the clusters were found 80 m from the nearest stream, dispersal might have been facilitated by the flow of the stream during periodic floods or heavy rain before the connectivity of the stream was disconnected by the development of roads in the EIS Study Area. The moist ground and semi-shaded canopy created a conducive environment might have encouraged them to populate in that area.

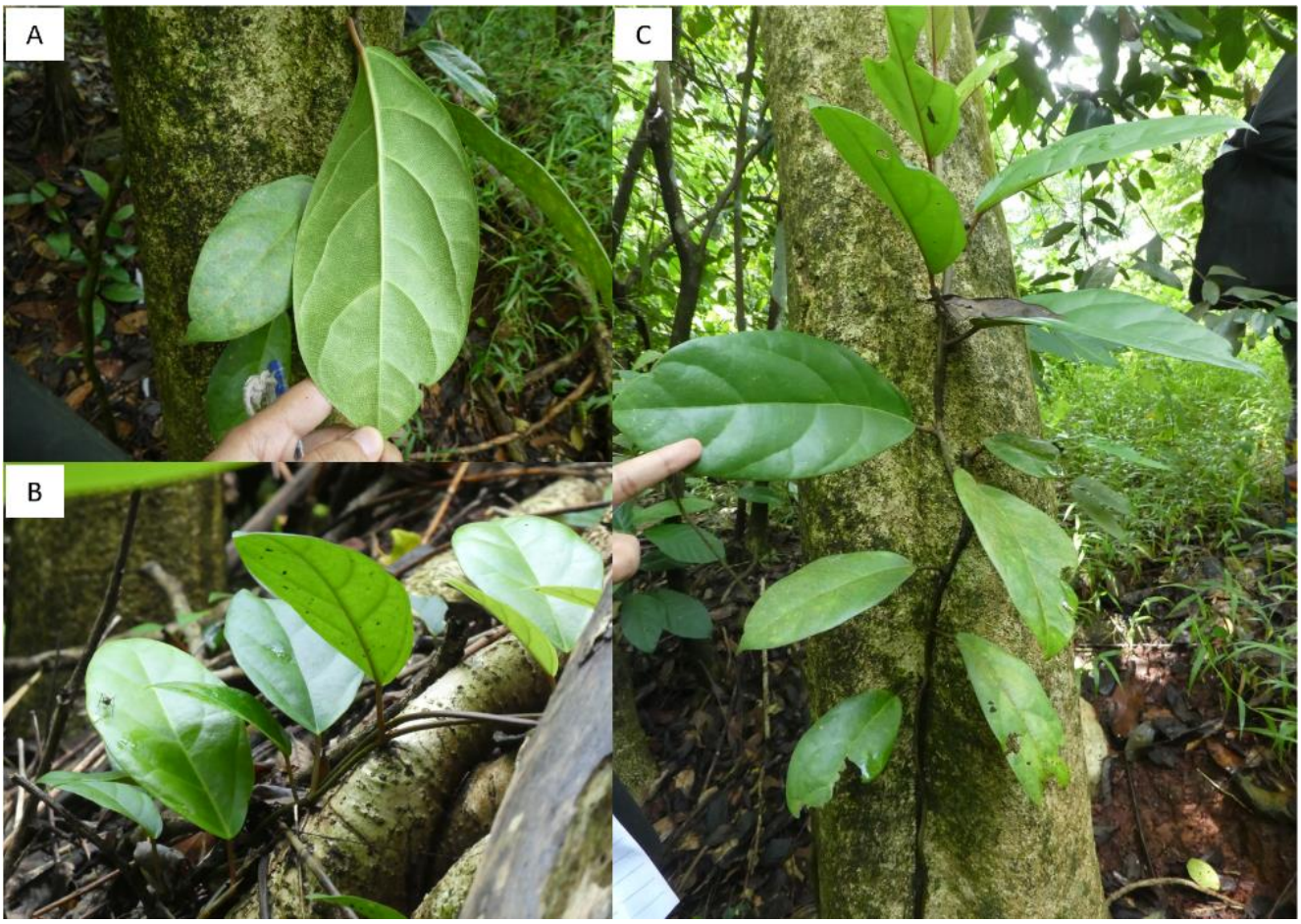


Figure 7.29: (A) The abaxial side of *Ficus apiocarpa* leaves; (B) the *Ficus* species can also be found creeping on forest floors and on the trunk flares of trees; (C) *Ficus apiocarpa* growing on the trunk of an African tulip (*Spathodea campanulata*).

d) Discovery of Rare Plant Species: *Mucuna biplicata*

Mucuna biplicata, was encountered at a waste woodland forest patch located south of the EIS Study Area. The approximate location matches with the information that was shared by NParks before the commencement of the floristic surveys. Few individuals of this climber species were found climbing on African Tulip (*Spathodea campanula*) tree and *Ficus microcarpa* and were flowering and fruiting during the point of encounter (**Figure 7.30A-B**). As of date, the conservation status of *M. biplicata* is undetermined as no local records of this species can be found in Chong et al. (2009) or in any published journals. Hence, Tengah could possibly be the first and only location of this *Mucuna* species in Singapore (NParks 2020, pers. comm., 12 August).

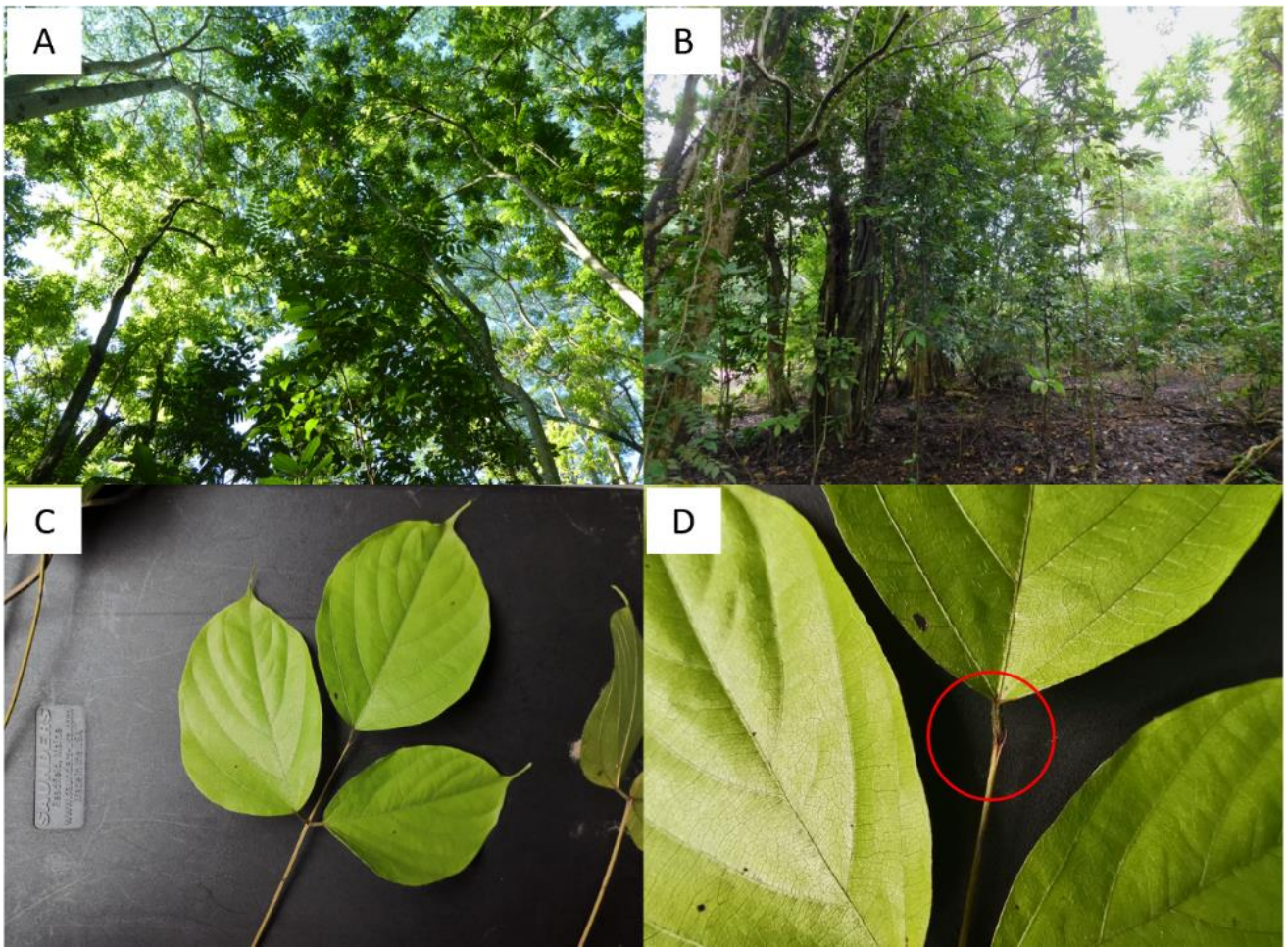


Figure 7.30: Waste woodland forest patch where *Mucuna biplicata* is found. (A) Canopy stratum dominated by African tulip (*Spathodea campanulata*); (B) Sparse understorey and undergrowth with moist soil located beside the canal on the left; (C) Leaflet of *Mucuna biplicata*; (D) Close-up photo of the 'claw' located at the bottom of the node of the terminal leaflet.

According to Wiriadinata et al., (2016), the distribution of this climber species is spread across regions of Malesia, specifically in Sumatra, Peninsular Malaysia and Borneo. It is usually found growing along rivers and near riverbanks in primary, secondary or disturbed forests. This information coincides with the environment where the specimen was found in Tengah, where the climber was growing on loamy and wet soil, with very little undergrowth (**Figure 7.30B**).

The trifoliate leaflet is sericeous and ovate (**Figure 7.30C**), and has a distinctive 'claw' that is 2-4 mm long located at the at the bottom of the node of the terminal leaflet (**Figure 7.30D**). The inflorescence is known to be violet or purple and it held in short and branching inflorescences (**Figure 7.31A;** Leong et al., 2017). Each flower measures to about 6 cm in length. Like most *Mucuna* species, the seed pod is covered with irritant hairs, which for this *Mucuna* species, has small red hairs (**Figure 7.31B**). The seed pods are known to be lamellated which gives a 'jaggedly toothed appearance' (**Figure 7.31C**). In each pod, three to five seeds are enclosed inside (**Figure 7.31D**).

Given the rarity of this species, it is considered as a species of interest. Seeds should also be harvested when possible as a conservation action and for future research and studies of this particular species in Singapore.

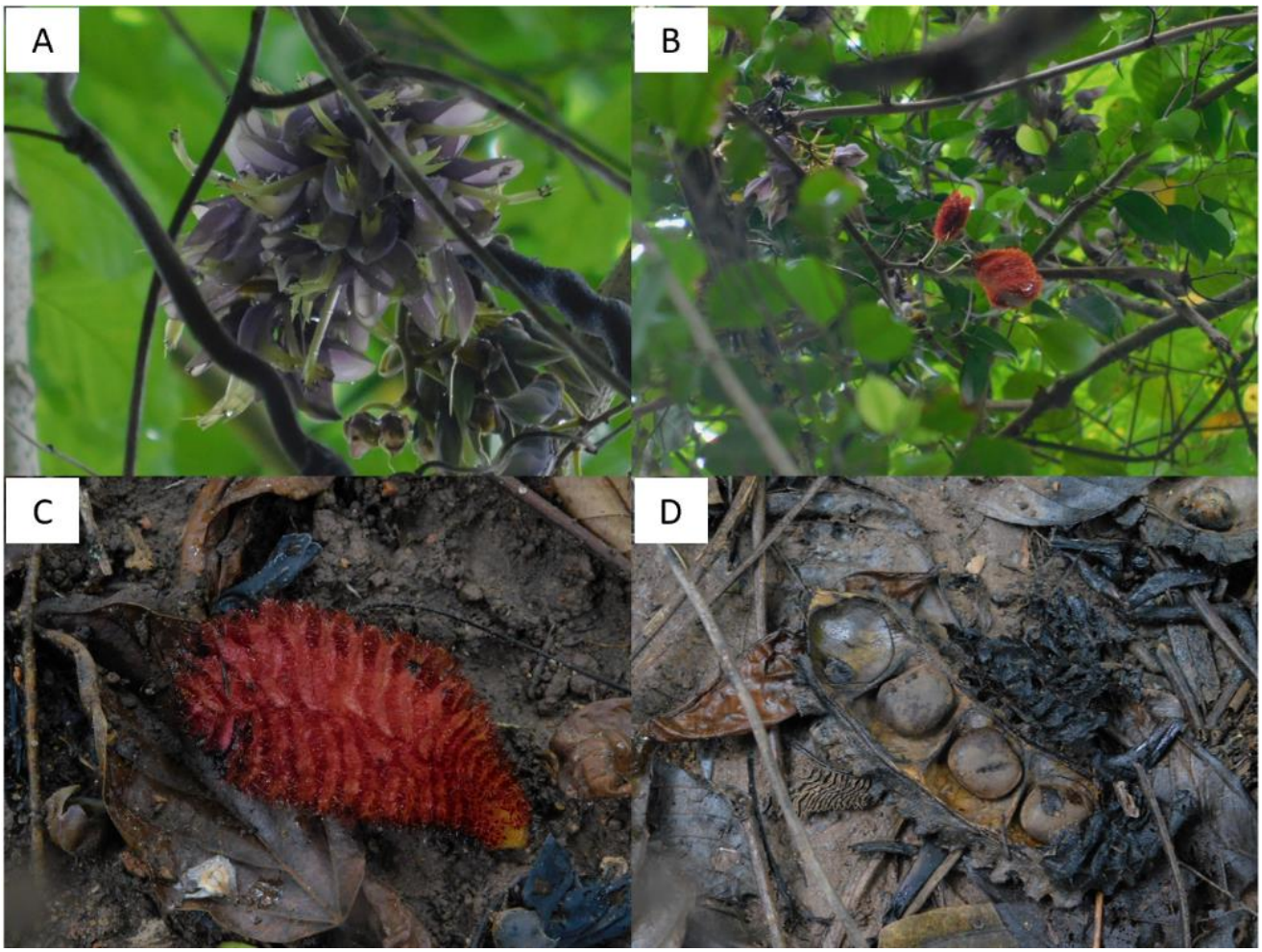


Figure 7.31: (A) Inflorescence and (B) seed pods of *Mucuna biplicata* found during the point of encounter; (C) Close-up of the lamellated seed pod that is covered by red irritant hair; (D) Seeds of the *Mucuna* species found inside a dried seedpod.

7.3.3.3 Large Specimens

Three hundred and fifteen large specimens were encountered in the EIS Study Area (**Figure 7.32**). Of these specimens, 99 individuals are large trees (3.0 – 6.0 m girth),192 individuals are stranglers of *Ficus* spp. of (3.0 – 50.0 m spread), while the remaining 24 are bamboo clusters (3 – 12 m spread) (**Figure 7.33C-D Table 7.11**). The 99 individual large trees belong to 18 species and 10 families. Two notable large specimens are the Malayan banyan (*Ficus microcarpa)* that were recorded during the arboriculture survey under the tag number TE3233 and TE2343 (**Figure 7.33A-B**). They were recorded with a sheer spread of 30 m and 50 m, respectively, and are regarded as habitat of interest.

According to Bajpai et al. (2016), sapling densities of *Ficus* sp. located in close proximity to the parent tree is twice as high compared to other non-*Ficus* trees. With the presence of Ficus trees in a region, it will be able to assist in the restoration of disturbed forest patch within the same region. Hence, it is important to retain the parent trees of *Ficus* species, or in this case, the two large specimens mentioned, to assist in the regeneration of forest patches surrounding it. In addition, large trees also play an important role to frugivores as a source of diet and shelter against predators (Murray et al., 2008). They also play a critical ecological role such as regulating microclimates of the forest, influence hydrological processes and storing large amount of carbon (Bradford & Murphy, 2019).

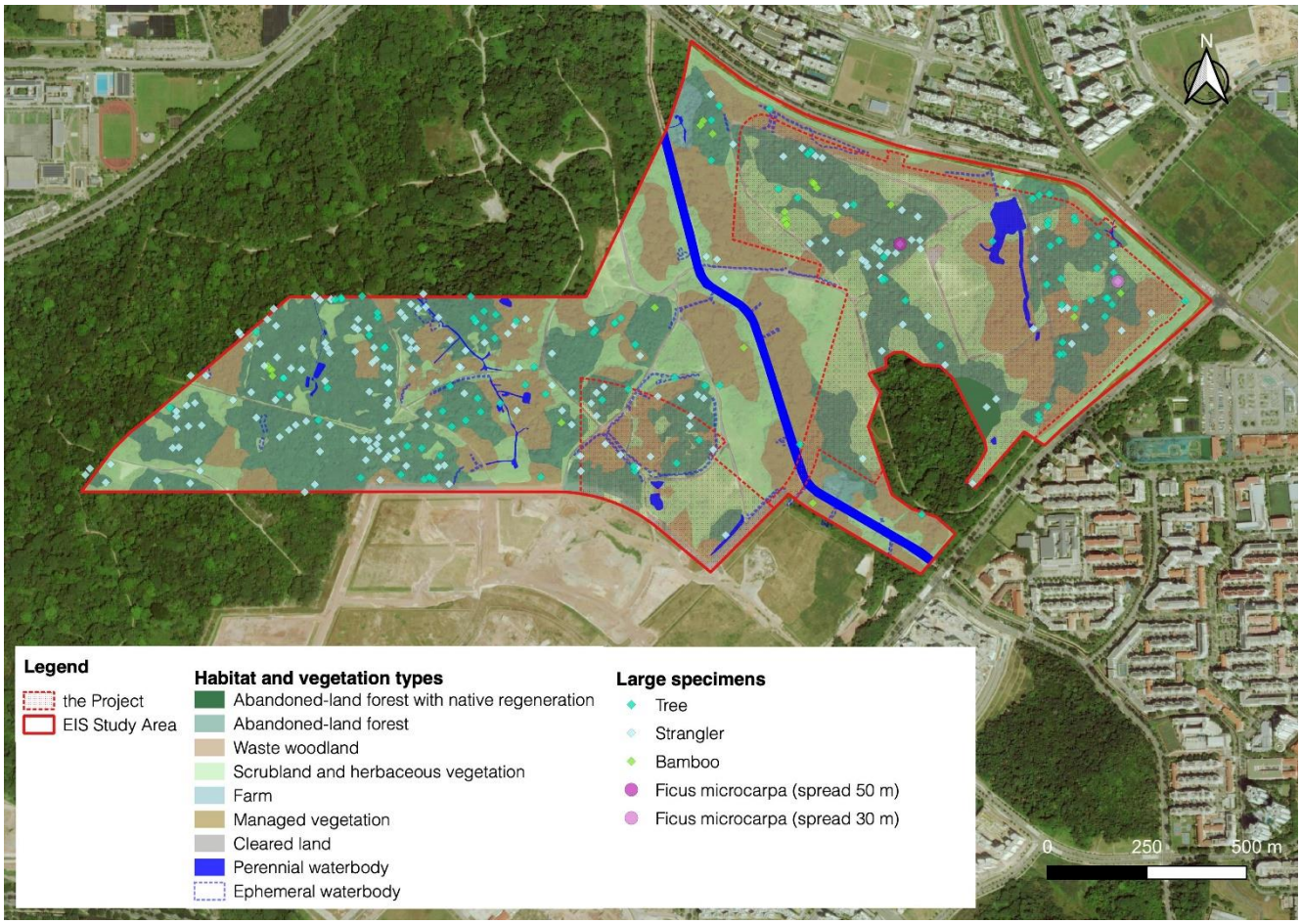


Figure 7.32: Large Specimens Encountered in the EIS Study Area, including two *Ficus microcarpa* of 30 m and 50 m spread

Base Map: ESRI

Table 7.11: Type and Species of Large Specimens found in the EIS Study Area, Accompanied by the Count of Individuals of Each Species

Type	Species	No. of Specimens
Trees	*Alstonia angustiloba*	2
	Alstonia scholaris	2
	Artocarpus altilis	1
	Cinnamomum iners	2
	Cyrtophyllum fragrans	1
	Dimocarpus longan ssp. *malesianus*	1
	Durio zibethinus	17
	Ficus religiosa	1
	Ficus variegata	11
	Hevea brasiliensis	2
	Litchi chinensis	1

Type	Species	No. of Specimens
	Macaranga griffithiana	1
	Mangifera indica	1
	Nephelium lappaceum	2
	Pithecellobium dulce	1
	Pterocarpus indicus	41
	Samanea saman	4
	Terminalia catappa	8
Stranglers	*Ficus benjamina*	30
	Ficus binnendijkii	1
	Ficus microcarpa	158
	Ficus caulocarpa	3
Bamboos	*Bambusa heterostachya*	19
	Bambusa multiplex	1
	Bambusa cf. *multiplex*	1
	Bambusa vulgaris	3
	Total	**315**

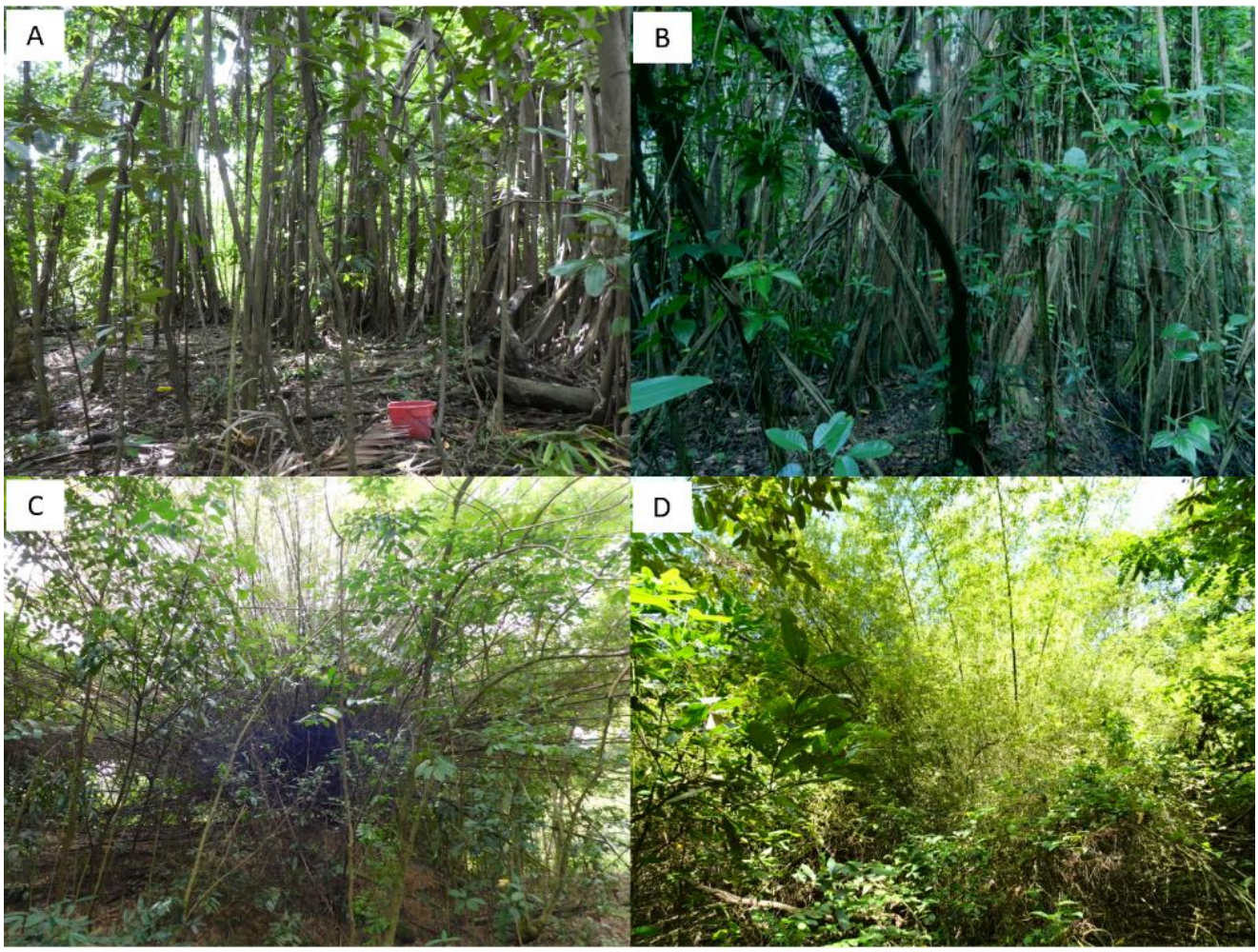


Figure 7.33: Some of the Large Specimens encountered in the EIS Study Area. (A-B) Extensive pillar roots of Malayan Banyan (*Ficus microcarpa*) of spread 30 m and 50 m; (C) *Bambusa vulgaris*; (D) *Bambusa* cf. *multiplex.*

7.3.3.4 Other Specimens of Value

Other specimens of values recorded at Tengah includes *Falcataria moluccana*, bamboo clusters, *Ficus* species and common native orchids *Spathoglottis plicata* and bamboo orchid *Arundina graminifolia*. (**Figure 7.34**). Two of the specimens are albizia (*Falcataria moluccana)* trees, which are exotic and naturalised, but were observed to each have one raptor nest respectively (**Figure 7.35**; **Section 7.3.4.10**). As the observations were made from a distance, it was challenging to estimate tree girth. Locations of these trees were also taken from the position of the observer, which was approximately 30 – 50 m away. These points were then adjusted post-hoc to indicate the approximate locations on the map (**Figure 7.34**).

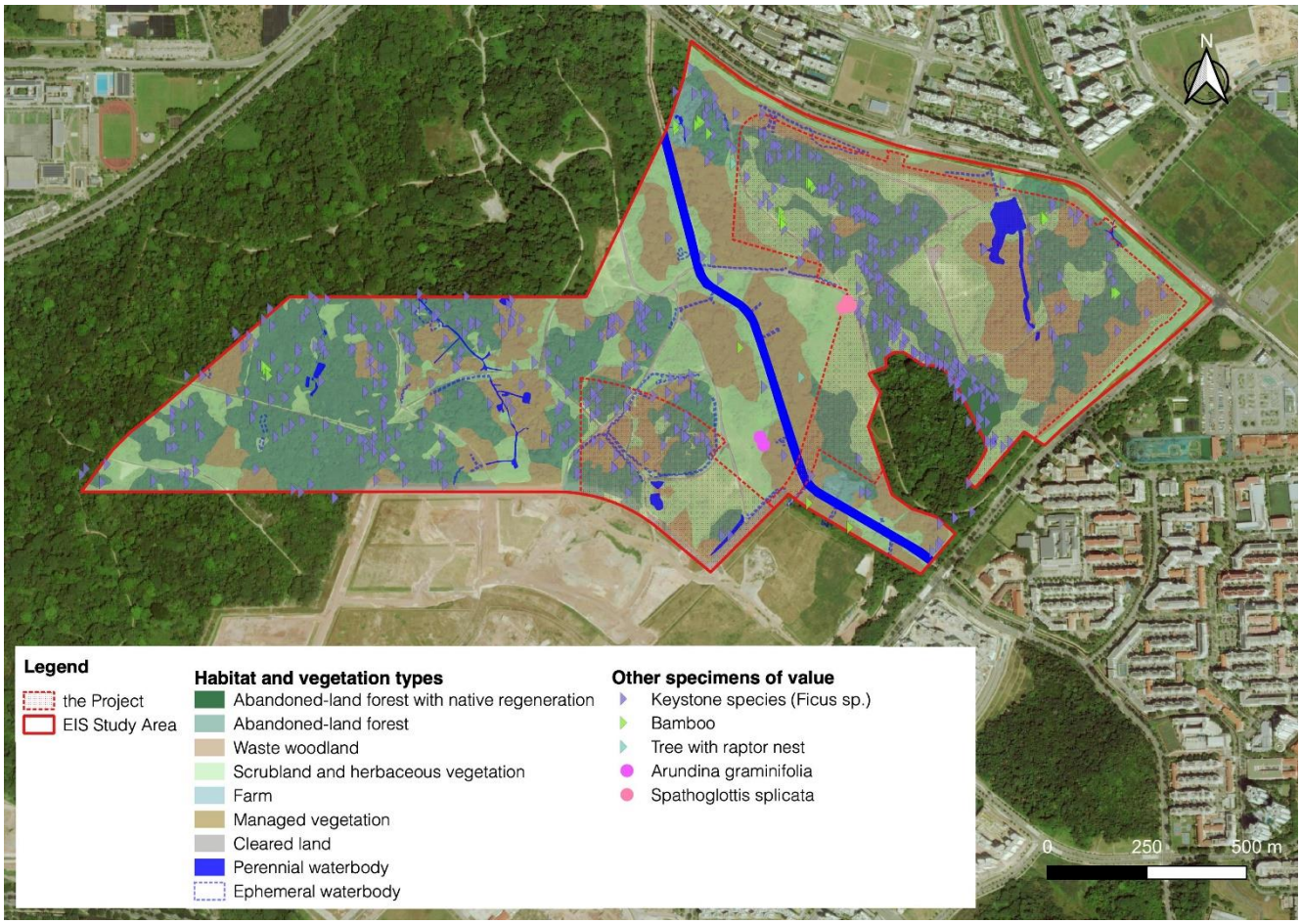


Figure 7.34: Location of All Other Specimens of Value in the EIS Study Area. Note that only the locations of *Ficus* sp. that is of ⩾ 1 m of girth/spread is represented in the map.

Base Map: ESRI



Figure 7.35: Albizia (*Falcataria moluccana*) trees with active raptor nests.

All bamboo clusters recorded within the EIS Study Area were surveyed for roosting of bamboo bats (*Tylonycteris* spp.). This also include bamboos that has less than a 3 m spread (**Figure 7.36**). Although these specimens do not meet the criteria of a large specimen defined in this study, they may still be important sources of food and shelter for fauna communities. The findings of bamboo bat surveys are presented in **Section 7.3.4.12**.



Figure 7.36: Two of the Bamboo Clusters (*Bambusa heterostachya*) with Confirmed Roosting of Bamboo Bats

Few individuals of common native terrestrial orchids, *Spathoglottis plicata* (**Figure 7.37A**) and clusters of bamboo orchid *Arundina graminifolia* (**Figure 7.37B**), were found thriving in the scrubland and herbaceous vegetation located at the center of the EIS Study Area (**Figure 7.34**). There are five common native orchids that can be found in Singapore, including these two species. Although these orchids are known to be cultivated for ornamental purposes, it is considered to be a rare sight to see their natural population thriving scrubland or grassland areas due to the rapid rate of urban development in Singapore which led to the destruction of this type of habitat (Yam et al., 2011).

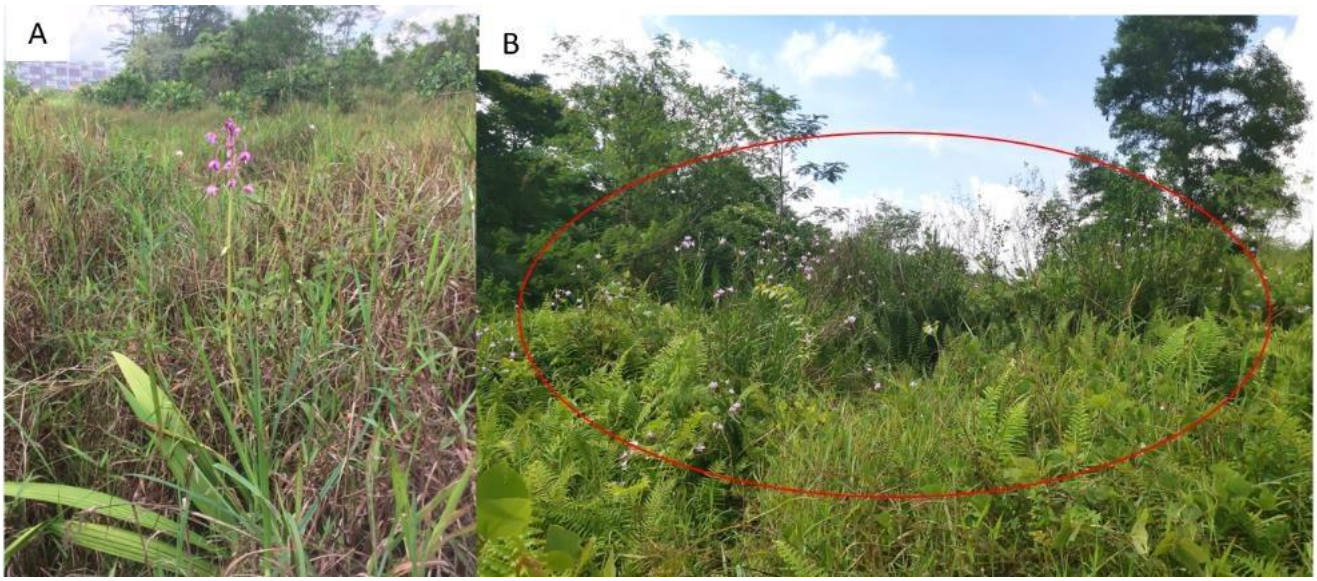


Figure 7.37: A) An individual specimen of *Spathoglottis plicata*. B) Clusters of *Arundina graminifolia* indicated by the red oval

7.3.3.5 Keystone Species

Keystone species are defined as "important plants that other animals in the community depend heavily on" (Lok et al., 2013). According to Mills et al. (1993), keystone species are extremely essential that the removal of these species would most likely cause an extirpation of dependant animals such as pollinators and seed dispersers. In most tropical rainforest in the South-east Asia region, *Ficus* species or also known as figs, are known to be a keystone species. Monoecious figs (i.e. species that bear both male and female reproductive organs within the same individual), are able to produce fruits all year round. This makes figs an important food source for many frugivores, especially during the time of the year where no other fruits are available (Kinnaird et al., 1999; Korine et al., 2000). Dioecious figs are also important as they provide food for numerous avian insectivores that feeds on fig wasps.

During the floristic surveys, 15 fig species were recorded, of which 4 species are considered to be threatened species (**Appendix 7A**). Most of the figs recorded in the EIS Study Area can be found in the abandoned land forest patches across the entire site. A total of 294 individuals of *Ficus variegata* were recorded during the arboricultural survey, which makes up the largest population of fig species in the EIS Study Area. More than half of these individuals are located in the east and the centre of the EIS Study Area and most of them are located within the boundary of the Project development work. *Ficus microcarpa* forms the second largest population of fig species, whereby 170 individuals were recorded during the arboricultural survey and can be found across the entire EIS Study Area. Altogether, it is estimated that approximately 40% of the entire population of the recorded *Ficus* species will be affected by the Project development work (**Figure 7.34**).

The rapid increase of urban development around and within Tengah Forest would mean that the keystone species would play a vital role in providing food for the fauna community not just within the EIS Study Area, but also for western region of Singapore. The continual existence of these keystone species helps to encourage the recruitment and population growth of native frugivores from neighbouring forest reserves and those that are already found in the urban areas (Lok et al., 2013).

7.3.3.6 Community Data Results

Taxon sampling curves were plotted using data on floristic diversity from the vegetation plots. Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/ survey adequacy, i.e. how extensively we have sampled the species in the community. The sample coverage from sampling 32 vegetation plots is 93.3% (**Figure 7.38**). Upon extrapolation, i.e. sample sizes were theoretically doubled using the statistical programme, sample coverage increases to 97.4% and species richness increases to 184.75 (the 95% confidence interval is between 178.38 and 260.04). This implies that even with increased survey effort via vegetation plot sampling, a small proportion of plant species in the community, i.e. around 3%, will remain undetected in the vegetation plots.

Hence, to account for undetected species, species estimators were used to predict the total number of species (**Table 7.12**). Four commonly-used species estimators, namely, i.e. Chao, first and second order Jackknife (Jakknife 1 and Jackknife 2), and Bootstrap, estimated species richness to be between 175.51 and 225.54. This was performed using the 'specpool' function in the vegan 2.5-6 package (R Development Core Team, 2016).

Using the 'ChaoRichness' function in the iNEXT 2.0.20 package (R Development Core Team, 2016), total species richness was approximated to be 205.12 ± 19.8 (standard error). The 95% confidence interval is between 178.38 and 260.04.

Table 7.12: Approximate Total Number of Species (± the Standard Error) Estimated using Four Commonly-used species Estimators

Estimator	Chao	Jackknife 1	Jackknife 2	Bootstrap
Predicted number of species	203.5645 ± 19.25	200.4688 ± 10.20	225.54	175.51 ± 5.54

In this EIS, the recorded total species richness is 338 (**Table 7.8**), excluding the unknown Pteridophyte species mentioned in **Section 7.3.3.1**. This figure exceeds the number of species predicted using all four estimators, including the two more conservative estimates, i.e. Chao and Jackknife2 (**Table 7.12**). It also exceeds the 95% confidence interval for total species richness estimated using the Chao estimator and the higher bound predicted total number of species of 260 (to the nearest integer). This could be attributed to the fact that species undetected or absent in the vegetation plots were encountered during general floristic surveys instead. Therefore, comparatively, the combined survey efforts of general floristic surveys and vegetation plot sampling in this present study were adequate in documenting floristic composition of the plant community in the EIS Study Area.

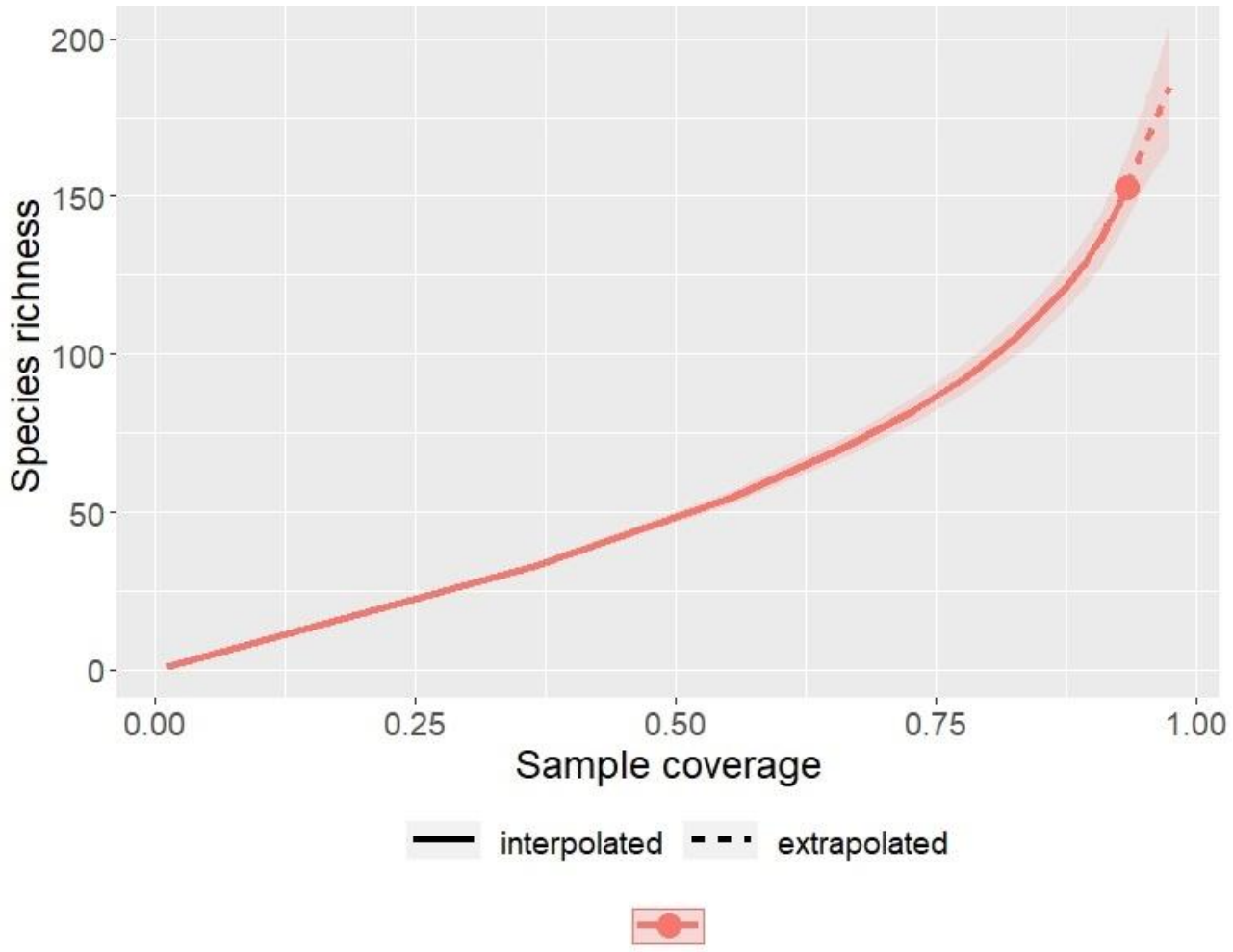


Figure 7.38: Coverage-based Sampling Curve using Data from 32 Vegetation Plots (20 m × 20 m)

The NMDS ordination shows that part of the species composition of abandoned-land forest overlaps with that of waste woodlands (**Figure 7.39**). This shows that both habitat types have similar floristic composition. This could be contributed by the close proximity of these two habitats. Some of the propagules may be dispersing from the abandoned-land forest areas to the adjacent waste woodlands patches. Considering that majority of the spontaneous vegetation presently found in Singapore are secondary forests (Yee et al., 2011), if left undisturbed, the forest would slowly regenerate as seedling dispersals and recruitment take place, among many other ecological processes.

As for the abandoned-land forest with native regeneration, the ordination suggest that this habitat type is considered to be an abandoned land forest since both sampling plots are nestled in the polygon of the abandoned land forest (**Figure 7.39**). In this case, the species composition collected in both sampling plots did not have much distinction to show any difference in the habitat type. It is important to note that this could also be contributed by the fact that few native species such as Tembusu (*Cyrtophyllum fragrans*) and *Macaranga spp*.

that were observed in this forest patch were also not included in the species composition as these native species did not fall within the two sampling plots. It is also observed that this particular forest patch has relatively higher recruitment of native species such as *Arthrophyllum diversifolium*, *Cinnamomum iners* than exotic fruit tree saplings such as rambutan *Nephelium lappaceum* or *Syzygium polyanthum* that was observed in most abandoned land forest sampling plots.

Scrubland herbaceous vegetation is the most distinctive among the four vegetation types, as indicated by the non-overlapping polygons. Results of the PERMANOVA using Bray–Curtis distance as a measure of dissimilarity indicates that floristic community of scrubland and herbaceous vegetation is statistically different from the others (pseudo-*F* = 5.328; *p*-value = 0.001) **(Table 7.13)**. Scrublands are an important habitat type for numerous bird species, both local dwellers and migratory. These areas are usually used by the birds for nesting and breeding (Chang, 2005). This seem to be the case for the Endangered red-wattled lapwing (*Vanellus indicus*) which was found in large area of the scrubland and herbaceous habitat (**Section 7.3.4.10**). It is also a habitat where wild population of native orchid species like *Spathoglottis plicata* and bamboo orchid (*Arundina graminifolia*) can be found. Scrubland and herbaceous habitats have since decreased in its size as urban development rapidly progressed in Singapore. Hence, this habitat type is valuable to the EIS Study Area.

Table 7.13: Results of Permutational Multivariate Analysis of Variance (PERMANOVA) comparing Floristic Composition among Habitat Types

Terms	*df*	pseudo-*F*	R^2	*p*-value
Habitat	3	4.0482	0.3634	0.001
Residuals	28	–	0.6366	–

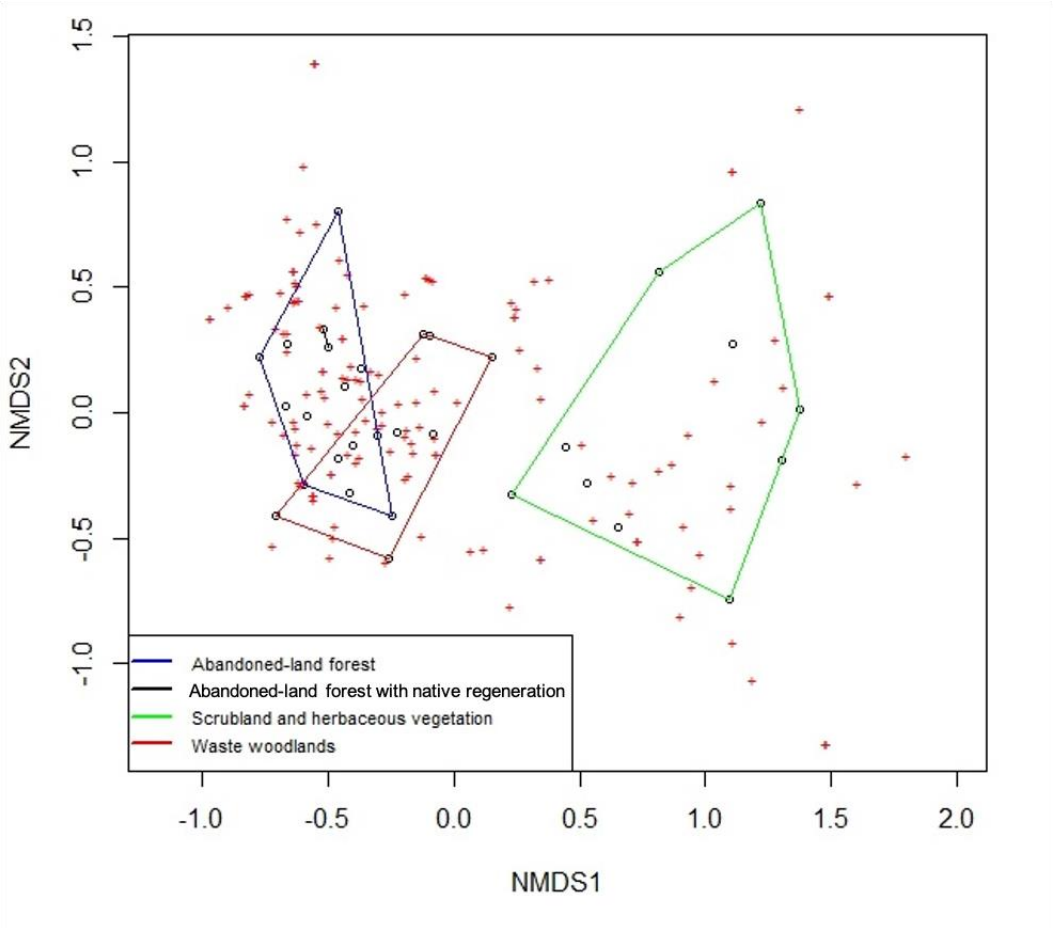


Figure 7.39: NMDS ordination of the 32 vegetation plots (open circles) based on species composition. Red crosses represent plant species found in the plots. Stress value = 0.18, k = 2.

7.3.3.7 Forest Regeneration

In this analysis, the girth of specimens with multiple stems was taken to be that of its largest stem. In view of this, large strangling figs were excluded in the count analysis as a single strangler has several woody aerial roots of ⩾ 0.5 m girth; it would be imprecise to record the girth (spread) of a large strangler that lies partially within a vegetation plot as that of the thickest woody aerial root. Given the large spread of most of the stranglers found in the Study Area, it is more appropriate to document count and spread of stranglers recorded during general floristic surveys, as opposed to vegetation plot sampling. This is discussed in **Section 7.3.3.3.**

Within the vegetation plots, there were 288 specimens of ⩾ 0.5 m girth belonging to 38 species (excluding strangling fig species) (**Figure 7.40**) and 5147 specimens of < 0.5 m girth belonging to 67 species (**Figure 7.41**). The top ten most abundant species in these two broad girth-size classes, i.e. ⩾ 0.5 m girth and < 0.5 m girth, respectively, are listed in descending order in **Table 7.14**. Both girth-size classes were further divided whereby the diameter distribution for the top ten species for ⩾ 0.5 m girth-size class, and the top ten most abundant species for < 0.5 m girth-size class are shown in **Table 7.14** and **Figure 7.43**, respectively.

Table 7.14: The Top Ten Most Abundant Species ranked in Descending Order for Specimens of ⩾ 0.5 m and < 0.5 m Girth

S/N	Species with Specimen ⩾ 0.5 m Girth	Species with Specimen < 0.5 m Girth
1.	*Spathodea campanulata*	*Cinnamomum iners*
2.	*Cinnamomum iners*	*Syzygium polyanthum*
3.	*Dillenia suffruticosa*	*Dillenia suffruticosa*
4.	*Nephelium lappaceum*	*Nephelium lappaceum*
5.	*Durio zibethinus*	*Dracaena fragrans*
6.	Elaeis guineensis	*Dimocarpus longan* ssp. *malesianus*
7.	*Theobroma cacao*	*Spathodea campanulata*
8.	*Falcataria moluccana*	*Syzygium grande*
9.	*Claoxylon indicum*	*Arthrophyllum diversifolium*
10.	*Piper aduncum*	*Ficus fistulosa*

Most of the very large specimens, i.e. 1.5 m girth or larger, belong to, in descending order, African tulip (*Spathodea campanulata)*, albizia *(Falcataria moluccana*), durian (*Durio zibethinus)* and rambutan *(Nephelium lappaceum)* (**Figure 7.41**). The result of the top ten most abundant species for large specimens also corroborates the findings of vegetation type reflected in **Section 7.3.2** whereby the EIS Study Area are taken up mostly by abandoned-land forest and waste woodland. Large specimens of African tulip and albizia trees were found in most of the waste woodland forest patches while large specimens of durian and rambutan tree can be found in most abandoned-land forest patches and are likely to have persisted from past cultivation.

Cinnamomum iners, though ranked as the species with second highest number of large specimens (**Table 7.14**), has mostly trees in the lower range within the large girth-size class, i.e. 0.5 – 0.9 m (**Figure 7.42**). It appears to display the highest recruitment of seedlings and saplings with stem counts exceeding 800 and up to 1250 specimens belonging to this species were encountered, majority (70 %) of which have < 0.05 m girth or smaller (**Figure 7.43**). This is a common native species. The second highest recruitment and seedling comes from *Syzygium polyanthum* which is cultivated locally. Up to 793 specimens belonging to this species were encountered and similar to *Cinnamomum iners*, approximately 82% of them have 0.05 m girth or smaller

(**Figure 7.43**). The presence of large *Cinnamomum iners* could act as potential seed sources in the forest, thus explaining the higher number of seedlings of these species found in the understory.

Six species from the lower girth-size class (< 0.5 m) exhibit a typical reverse-J distribution pattern (**Figure 7.43**), indicating that there is a high recruitment of small trees. These six species are: 1) *Arthrophyllum diversifolium*, 2) *Cinnamomum iners*, 3) *Dimocarpus longan* ssp. *malesianus*, 4) *Dracaena fragrans*, 5) *Nephelium lappaceum* and 6) *Syzygium polyanthum*. Four out of six species are native, of which two species, *Nephelium lappaceum* and *Syzygium polyanthum*, are threatened native species but specimens of these species in the forest are likely to be relics from past cultivation.

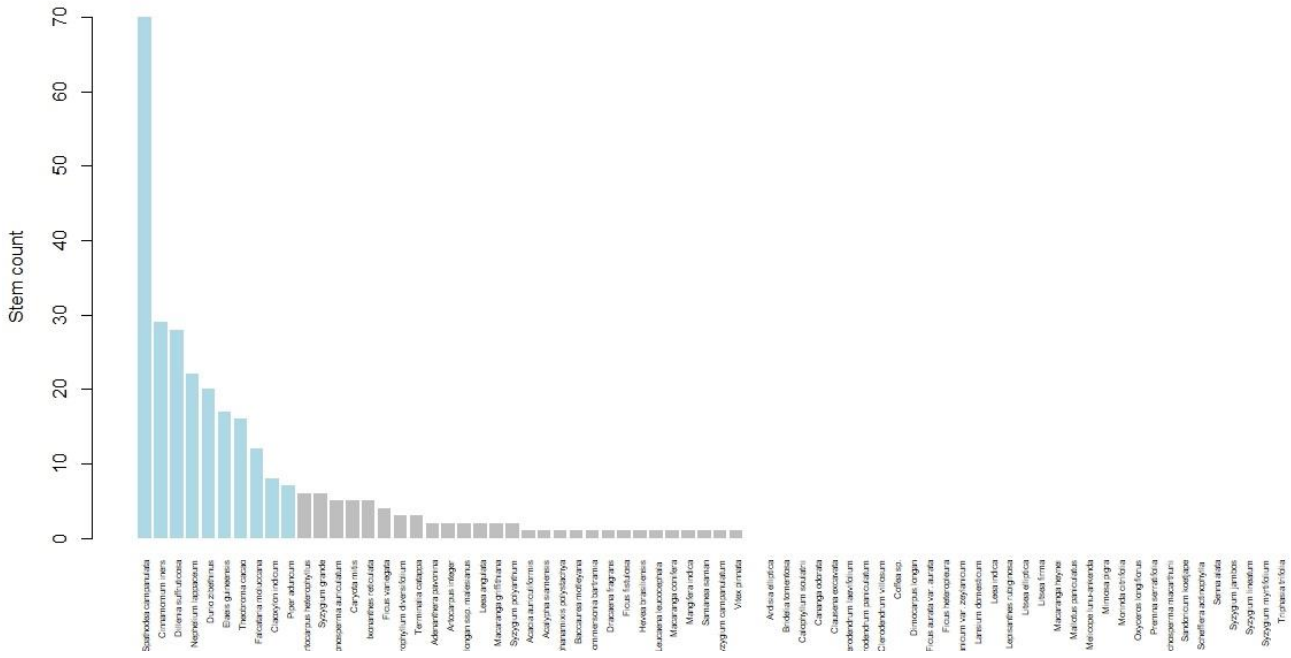


Figure 7.40: Number of specimens with ⩾ 0.5 m girth for each species across all vegetation plots. Bars in light blue belong to the ten most abundant species.

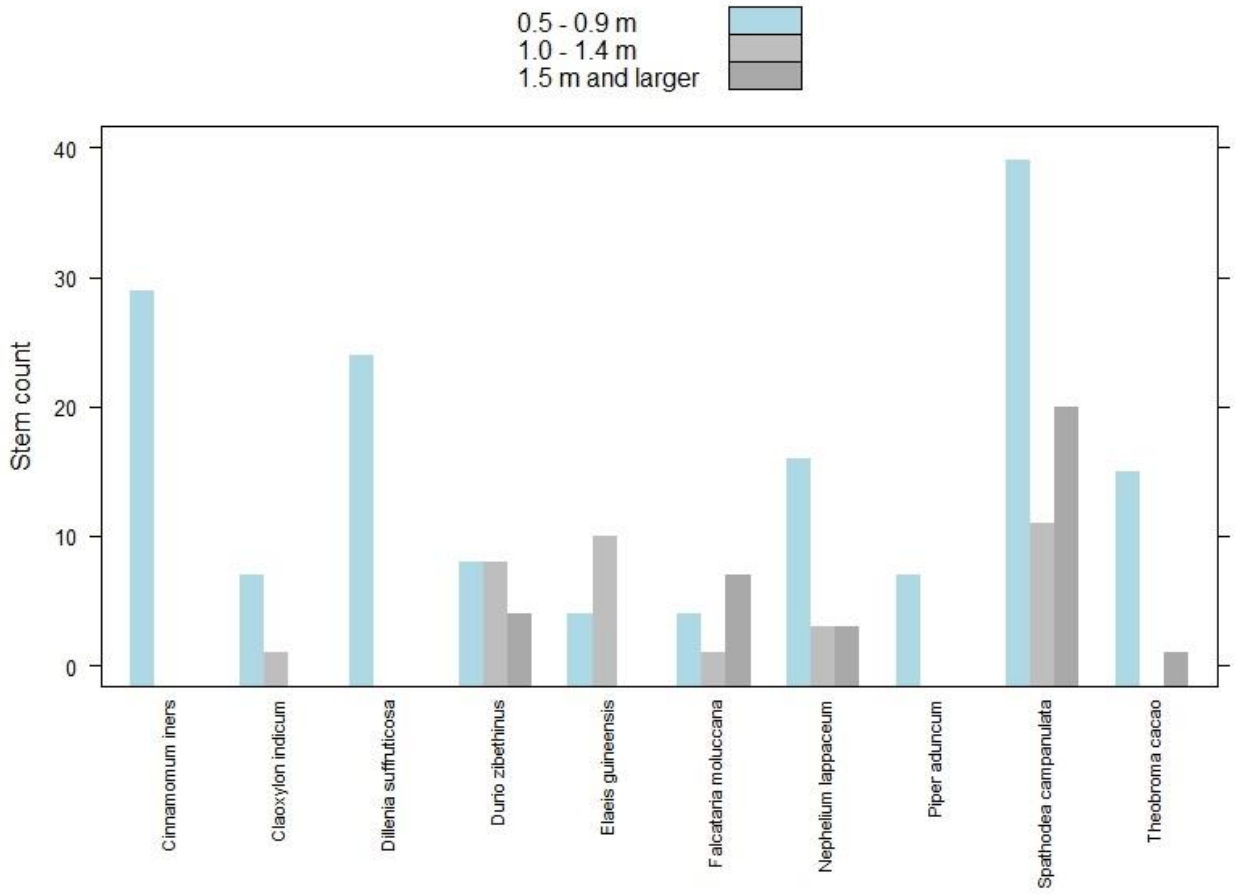


Figure 7.41: Girth-size class distribution of all top ten most abundant species with specimens of ⩾ 0.5 m girth.

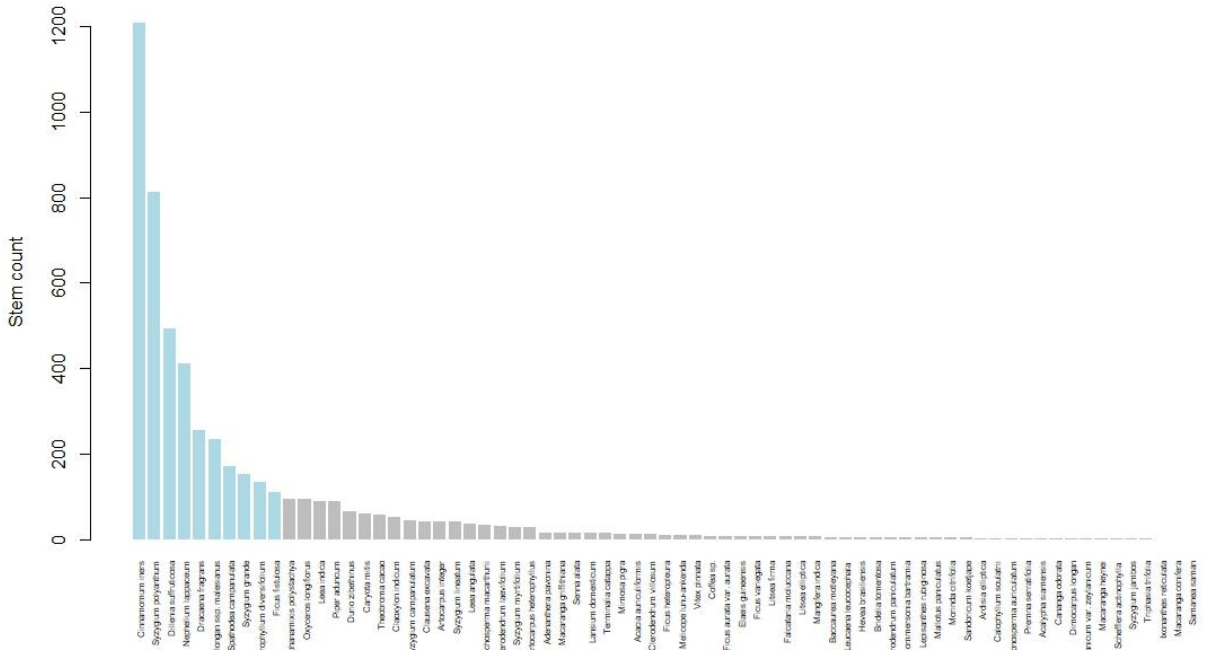


Figure 7.42: Number of specimens with < 0.5 m girth for each species across all vegetation plots. Bars in light blue belong to the ten most abundant species.

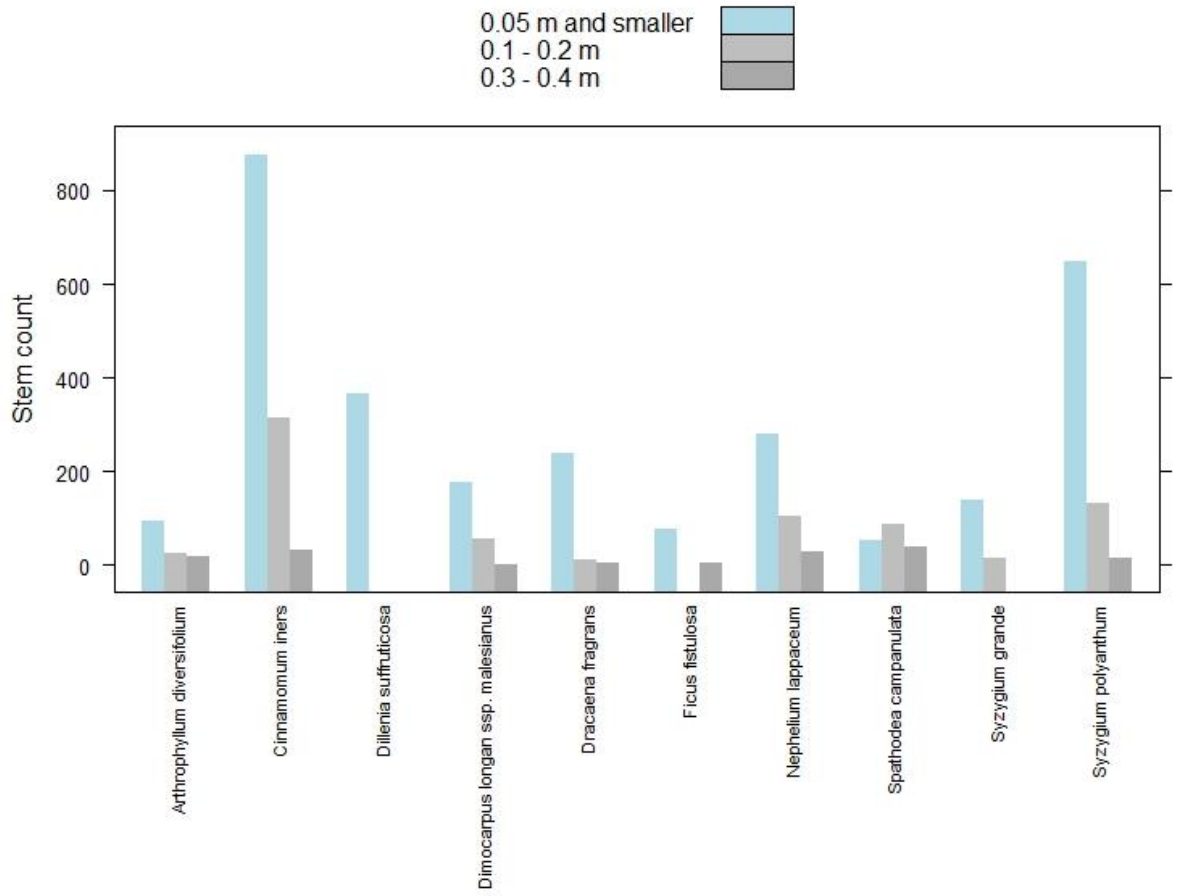


Figure 7.43: Girth-size class distribution of the ten most abundant species with specimens of < 0.5 m girth.

7.3.3.8 Arboricultural Survey Findings

A total of 3,350 specimens belonging to 83 species and 2 species groups were tagged and recorded during arboricultural surveys. Ten specimens belonging to four species group could not be identified with certainty due to reasons such as tall height and obscured view of the tree crown due forest canopy or little foliage. Altogether, all species belong to 30 families.

Durian (*Durio zibethinus)*, rambutan (*Nephelium lappaceum),* para rubber *(Hevea brasiliensis)* and wild cinnamon (*Cinnamomum iners*) trees make up majority (> 50%) of all the specimens assessed during arboricultural surveys in descending order. One hundred and forty-eight specimens belong to 12 species of conservation significance, namely, *Alsophila latebrosa, Ficus binnendijkii, Ficus vasculosa, Glochidion zeylanicum* var. *zeylanicum, Leea angulata, Litsea firma*, *Lindera lucida*, *Macaranga griffithiana*, *Macaranga* cf. *griffithiana*, *Melicope lunu-ankenda*, *Sandoricum koetjape* and *Symplocos fasciculata*. Majority (65%) of these specimens were *Macaranga griffithiana* that had a median girth range of 0.5 m – 0.8 m.

As some specimens occur in clusters, i.e. within 1 – 2 m of each other, they were recorded under the same tree tag and only one specimen was tagged. However, all specimens within each cluster were assessed. Hence, there were more trees assessed than there were tagged.

Out of the 3,350 specimens, 2,365 specimens of $\geqslant$ 1m girth size were assessed to be good specimens to retain in the EIA Study Area. Majority of these trees are found in the abandoned-land forest and the patch of abandoned-land forest with native regeneration (**Figure 7.44**). Around 56.4% (1,335) of these trees are native specimens while the remaining percentage of specimens are exotic and/or cryptogenic.

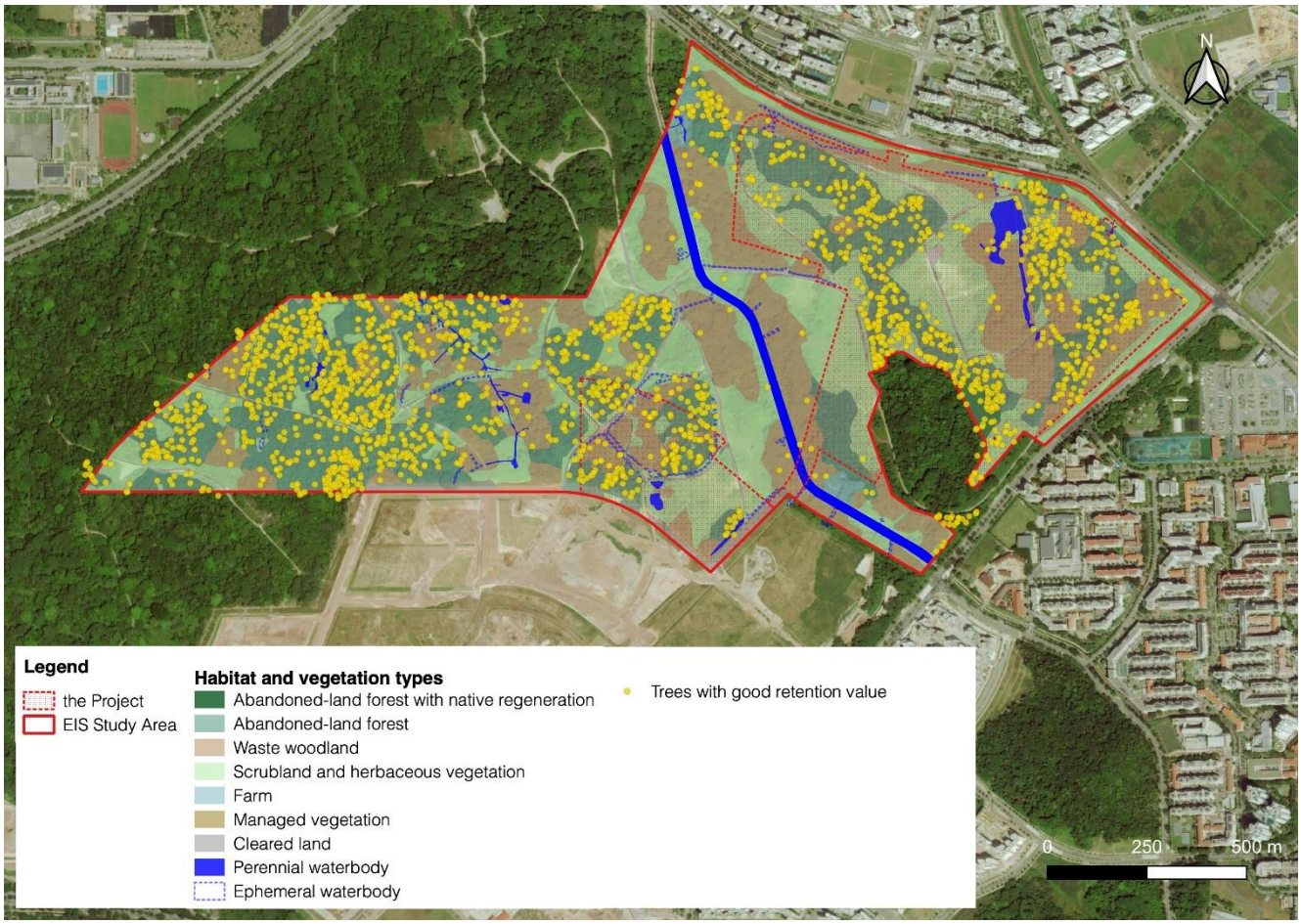


Figure 7.44: Trees with Good Rentention Value

Base Map: ESRI

7.3.4 Faunistic Field Findings

7.3.4.1 Overall

The desktop assessment identified 612 faunal species of probable occurrence at the EIS Study Area, including 64 species of conservation significance (**Table 7.15**). The field assessment recorded 297 species with more than half of the recorded assemblage dominated by bird (86 species) and butterfly (73 species) species (**Table 7.15**). This includes two odonate species and one fish species that are not listed as probable species. There are 31 species of conservation significance, including 23 threatened species and 8 other notable species (**Table 7.16**). Species of conservation significance were distributed across the EIS Study Area with no distinct hotspot (**Figure 7.45**). The list of probable and recorded species is in **Appendix 7B**.

Table 7.15: Summary of Probable and Recorded Faunal Species

Faunal Group	No. of Probable Species		No. of Recorded Species		No. of Recorded Species Not on Probable List	
	All Species	CS Species	All Species	CS Species	All Species	CS Species
Aculeate Hymenopterans	78	0	43	0	0	0
Bees	38	0	18	0	0	0
Stinging Wasps	40	0	25	1	0	0

Faunal Group	No. of Probable Species		No. of Recorded Species		No. of Recorded Species Not on Probable List	
	All Species	CS Species	All Species	CS Species	All Species	CS Species
Odonates	54	1	40	3	2	1
Dragonflies	44	0	32	1	1	0
Damselflies	10	1	8	2	1	1
Butterflies	201	23	72	4	0	0
Freshwater Decapod Crustaceans	3	0	0	0	0	0
Freshwater Fish	22	1	9	1	1	0
Herpetofauna	49	7	29	2	0	0
Amphibians	13	0	12	0	0	0
Reptiles	36	7	17	2	0	0
Birds	177	24	86	15	0	0
Mammals	28	7	17	5	0	0
Non-volant Mammals	17	4	9	3	0	0
Bats	11	3	8	2	0	0
Total	**612**	**64**	**296**	**31**	**3**	**1**

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

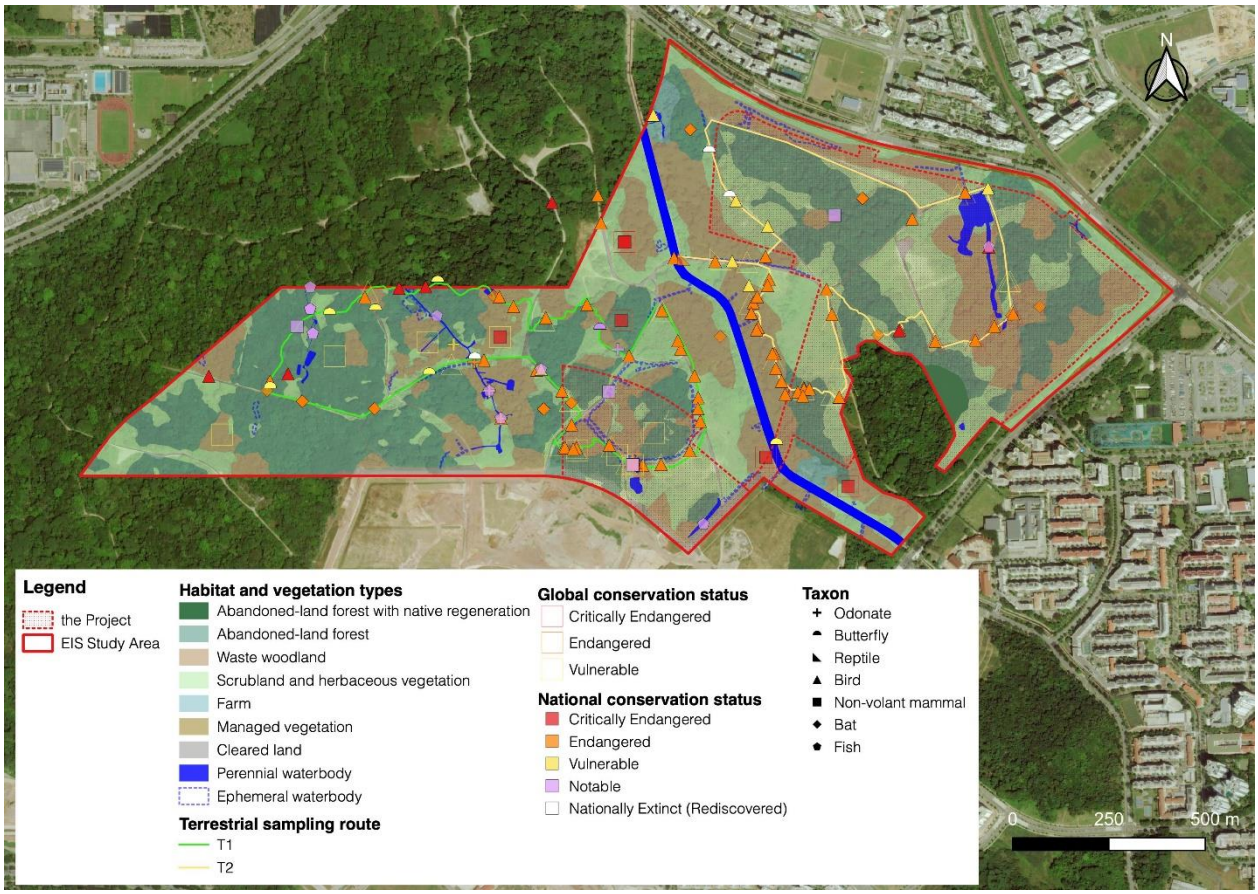


Figure 7.45: Locations of Faunal Species of Conservation Significance from Surveys and Camera Trapping

Base Map: ESRI

Table 7.16: List of Faunal Species of Conservation Significance Recorded in the EIS Study Area

Faunal Group	Scientific Name	Common Name	National Status	Global Status	Locations of Records
Aculeate Hymenopteran	*Ropalidia marginata*	NA	Near Threatened	Not Assessed	NA
Odonate	*Agriocnemis nana*	Dwarf wisp	Endangered	Least Concern	ED2_03
	Copera vittata	Variable featherlegs	Vulnerable	Least Concern	ED2_01, ED2_02 and ED2_04
	Cratilla lineata	Lined forest skimmer	Near Threatened	Not Assessed	T1_34
Butterfly	*Potanthus trachala tytleri*	Detached dart	Nationally Extinct (Rediscovered)	Not Assessed	T1_14, T2_06, T2_07
	Pachliopta aristolochiae asteris	Common rose	Vulnerable	Not Assessed	T1_15, T1_26
	Troides helena cerberus	Common birdwing	Vulnerable	Not Assessed; CITES protected (Appendix II)	T1_20, T1_23, T1_26
	Athyma reta moorei	Malay staff sergeant	Not Assessed	Not Assessed	T1_33
Freshwater Fish	*Clarias cf. batrachus*[9]	Common walking catfish	Least Concern	Not Assessed	ED2_01, ED2_02, ED2_05, ED1_01, ED6_02, ED7_01, ED7_02, ED7_03, T1_12
Reptile	*Coelognathus flavolineatus*	Common Malayan racer	Endangered	Least Concern	T2_01
	Cuora amboinensis	Malayan box terrapin	Not Assessed	Vulnerable; CITES protected (Appendix II)	T2_02, ED8_02
Bird	*Haliaeetus ichthyaetus*	Grey-headed fish eagle	Critically Endangered	Near Threatened	T1_21 and >100 m from T1_21

[9] Although assessed as Nationally Least Concern and Globally Not Assessed, it has seen a marked decline in its populations outside of the protected forests of the CCNR due to competition with and displacement by the invasive African sharptooth catfish (*Clarias gariepinus*; Ng et al., 2014). Furthermore, most of its known localities are slated for development (Nyanasengeran M, pers comm). It is hence a species of conservation significance.

Faunal Group	Scientific Name	Common Name	National Status	Global Status	Locations of Records
Bird	*Nisaetus cirrhatus*	Changeable hawk-eagle	Endangered	Least Concern	T1_03, T1_04, T1_07, T1_29, T1_34, T2_23, T2_26, T2_31, T2_33
	Spilornis cheela	Crested serpent eagle	Critically Endangered	Least Concern	T1_26
	Alcedo meninting	Blue-eared kingfisher	Critically Endangered	Least Concern	T1_25
	Nycticorax nycticorax	Black-crowned night heron	Critically Endangered	Least Concern	130 m outside of EIS Study Area (central)
	Vanellus indicus	Red-wattled lapwing	Endangered	Least Concern	T1_04, T1_09, T1_30, T2_01, T2_02, T2_27, T2_31, T2_33, T2_34, 45 m outside of EIS Study Area (central)
	Copsychus saularis	Oriental magpie-robin	Endangered	Least Concern	T2_15, ED2_01
	Gallus gallus	Red junglefowl	Endangered	Least Concern	T1_02, T1_05 to T1_09, T1_11, T1_14, T1_20, T2_03, T2_30 to T2_34
	Psittacula longicauda	Long-tailed parakeet	Not Assessed	Vulnerable	T1_01, T1_05 to T1_09, T1_11, T1_15, T1_24, T1_30, T2_03, T2_15, T2_18, T2_27 to T2_31, T2_33, T2_34
	Pycnonotus zeylanicus	Straw-headed bulbul	Endangered	Critically Endangered	T1_07, T2_19 to T2_21
	Rallina fasciata	Red-legged crake	Vulnerable	Least Concern	T1_12, T2_02, T2_04, T2_06, T2_16, T2_34, Spring_02
	Strix seloputo	Spotted wood owl	Critically Endangered	Least Concern	T2_23, ED1_01

Faunal Group	Scientific Name	Common Name	National Status	Global Status	Locations of Records
Bird	*Loriculus galgulus*	Blue-crowned hanging parrot	Endangered	Least Concern	T1_01, T1_02, T1_08–T1_10, T1_12, T1_24, T1_28, T1_32, T2_15, T2_29, T2_30–T2_33
	Collocalia affinis	Plume-toed swiftlet	Not Assessed	Not Assessed	T1_09, T1_11
	Pitta moluccensis	Blue-winged pitta	Not Assessed	Least Concern	CT_12
Non-volant Mammal	*Macaca fascicularis*	Long-tailed macaque	Not Assessed	Vulnerable	T1_07, T1_09
	Manis javanica	Sunda pangolin	Critically Endangered	Critically Endangered	CT_09, CT_11, CT_12, CT_14, CT_18
	Sundasciurus tenuis	Slender squirrel	Not Assessed	Least Concern	T1_22
Bat	*Taphozous melanopogon*	Black-bearded tomb bat	Endangered	Least Concern	T1_11, T1_17, T1_19, T1_28, T2_19, T2_24, BB_03, BB_05, BB_09, BB_16 to BB_24
	Tylonycteris spp.	Bamboo bat	Critically Endangered (*T. fulvida*) or Not Assessed (*T. malayana*)	Least Concern	T1_23, BB_01, BB_02, BB_05, BB_09 to BB_11, BB_16 to BB_19, BB_22 to BB_24, BB_26

Higher terrestrial species richness was recorded in the western half (T1) and at the eastern end (T2_16 to T2_19) of the EIS Study Area (**Figure 7.46**). The southern tip of the EIS Study Area (T1_05 to T1_07) appears to be a hotspot with high species richness. The high species richness here was mainly contributed by birds, and several bird species of conservation significance such as the straw-headed bulbul (*Pycnonotus zeylanicus*), red-wattled lapwing (*Vanellus indicus*), and changeable hawk-eagle (*Nisaetus cirrhatus*) were also recorded in the area (**Section 7.3.4.10**). Several odonate species were also recorded at T1_07, which is situated near a pond that is a habitat of interest for odonates (**Section 7.3.4.4**). The vegetation in these areas is dominated by abandoned-land forest with closed canopy, and provides food and shelter for many faunal species, including forest-dependent species. For aquatic species, the waterbodies in the western half of the EIS Study Area recorded higher richness (**Figure 7.47**).

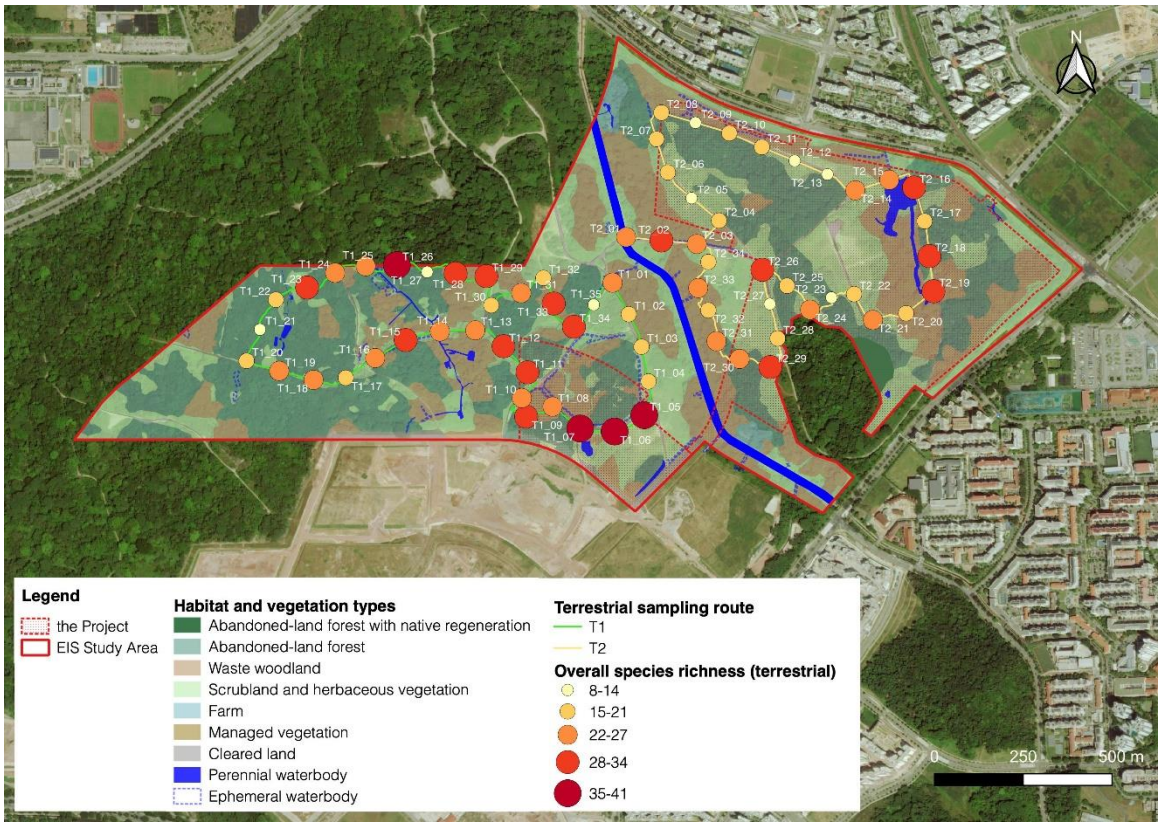


Figure 7.46: Number of Faunal Species Recorded at Each 100-m interval along the Terrestrial Sampling Routes, excluding Incidental Records

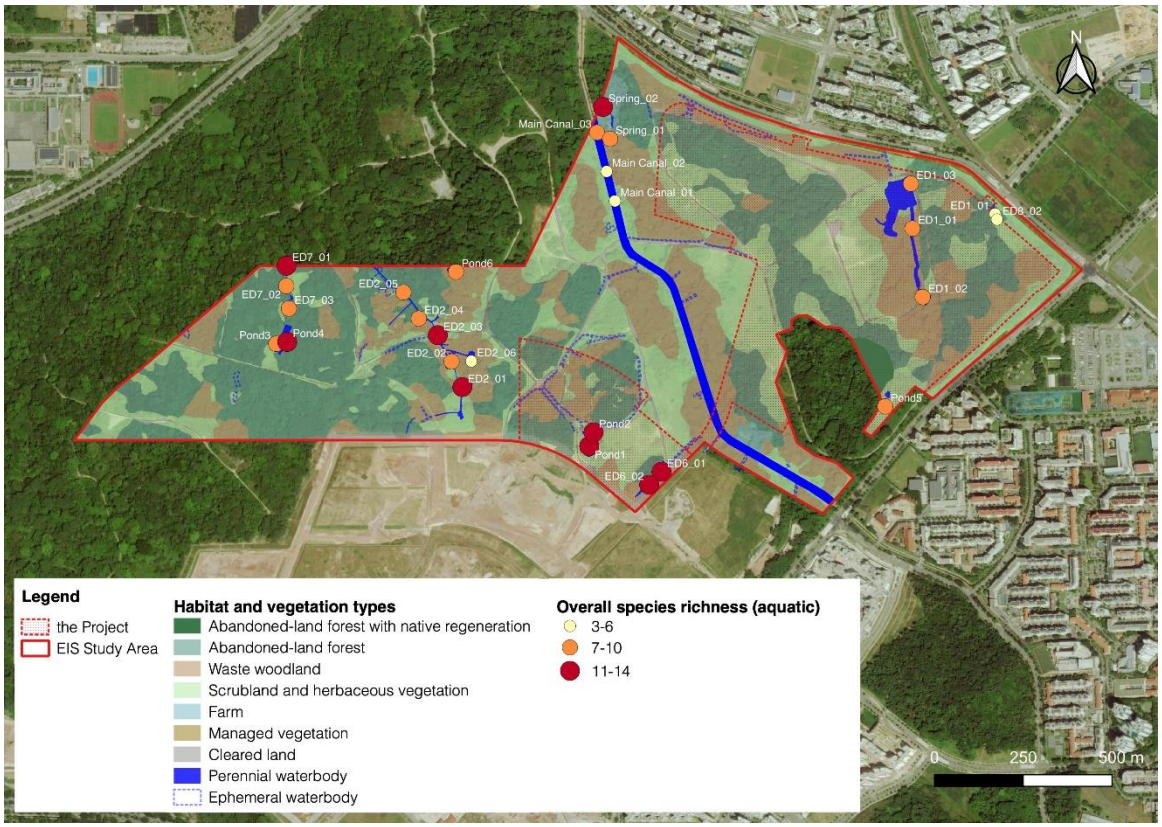


Figure 7.47: Number of Faunal Species Recorded at Each Aquatic Sampling Point, excluding Incidental Records

Base Map: ESRI

The EIS Study Area supports local populations of species of conservation significance (**Figure 7.45**). Singapore is a stronghold for two globally threatened species, namely the straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*) that were recorded, emphasising the importance of conserving forest patches where these species reside, as discussed in **Sections 7.3.4.10** and **Section 7.3.4.11** respectively. The EIS Study Area also supports populations of forest-dependent species and species with restricted distributions that are increasingly threatened by habitat loss.

The EIS Study Area sits within the Tengah site, which is Singapore's largest remaining patch of forest that lies outside a protected area. It is a critical point of connection for fauna moving between the CCNR and Western Water Catchment Area. As such, it facilitates the dispersal of forest-dependent species moving between these two biodiversity hotspots.

In order to further understand the value of the various vegetation types for native species and species of conservation significance, each 100-m interval along the terrestrial sampling routes was categorised by the dominant vegetation type surrounding it – abandoned-land forest, scrubland and herbaceous vegetation, or waste woodland. Similarly, this was done for the aquatic sampling points, which were categorised into stream, pond and canal. The average number of native species and species of conservation significance was then calculated per 100-m interval for each vegetation type and each aquatic sampling point.

The average number of native species was comparable for the three vegetation types (15–17 species; **Table 7.17**). However, the average number of species of conservation significance was considerably higher for waste woodland than abandoned-land forest or scrubland and herbaceous vegetation (**Table 7.17**). The species of conservation significance recorded within the waste woodland include species that are tolerant of disturbance open habitats. Examples of such species include the red junglefowl (*Gallus gallus*), long-tailed macaque (*Macaca fascicularis*), changeable hawk-eagle (*Nisaetus cirrhatus*), long-tailed parakeet (*Psittacula longicauda*) and straw-headed bulbul (*Pycnonotus zeylanicus*).

The average number of native species was low across all aquatic habitat types, but were slightly higher for closed-canopy streams (5 species), open-country pond (4.5 species) and isolated ponds (4 species) (**Table 7.17**). Species of conservation significance was only recorded at the closed-canopy streams.

Table 7.17: Average Number of Native Faunal Species and Faunal Species of Conservation Significance at Each 100-M Interval along the Terrestrial Sampling Routes for Each Vegetation Type, and at Each Sampling Point for each Aquatic Habitat Type

Vegetation Type	No. of Intervals or Points	Average No. of Native Species	Average No. of CS Species
Abandoned-land forest	24	16	1.0
Waste woodland	18	17	1.6
Scrubland and herbaceous vegetation	27	15	1.1
Closed-canopy stream (ED2, ED7)	9	5	0.4
Open-country stream (Spring, ED1, ED6, ED8_01)	8	2	0
Open-country pond (Pond1, Pond2)	2	4.5	0
Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5, ED8_02)	5	4	0
Main Canal	3	1	0

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

7.3.4.2 Sampling Coverage

Along the terrestrial sampling routes, the sample coverage for faunal groups were above 90%, with the exception of aculeate hymenopterans at 86.1% (**Table 7.18; Figure 7.48**). Similarly, the sample coverage for faunal groups at aquatic sampling points were above 90%, with the exception of odonate at 85.2% and reptiles at 3.7% (**Table 7.18; Figure 7.48**). Sample coverage was not calculated for bats as only one species was observed. Camera trapping obtained a coverage of 100% (**Figure 7.49**).

Doubling the sampling effort of fauna survey may yield higher sampling coverage and additional detections of 1–16 species across the faunal groups. A summary is provided in **Table 7.18**.

Table 7.18: Result Summary of Taxon Sampling Analysis

Faunal Group	Sample Coverage (%)	Observed Richness	Est. Richness (± s.e)	95% ci for est. Richness	Est. Coverage with Doubled Effort (%)	Est. Richness (and additional species) with Doubled Effort
Terrestrial Sampling Routes						
Aculeate Hymenopteran	86.1	24	33 ± 8.3	26.4 – 65.1	94.9	30 (+6)
Odonate	92.4	23	39 ± 14.6	26.7 – 96.5	95.5	30 (+7)
Butterfly	90.4	59	90 ± 17.5	70.4 –146.3	95.5	75 (+16)
Amphibian	96.1	10	11 ± 3.7	10.2 – 31.8	98.6	11 (+1)
Reptile	96.1	8	9 ± 3.7	8.2 – 29.8	98.6	9 (+1)
Bird	97.5	69	87 ± 12.0	74.5 – 128.4	98.9	79 (+10)
Mammal	97.4	7	8 ± 3.7	7.2 – 28.8	99.0	8 (+1)
Mammal (Bat)	N.A.	1	N.A.	N.A.	N.A.	N.A.
Aquatic Sampling Routes						
Odonate	85.2	27	108 ± 93.5	40.4 – 518.3	87.3	38 (+11)
Fish	98.7	9	9 ± 1.3	9.0 – 17.2	99.8	9 (+0)
Amphibian	95.5	12	14 ± 3.3	12.3 – 30.4	98.8	13 (+1)
Reptile	3.7	3	5 ± 4.1	3.4 – 25.9	65.2	4 (+1)
Camera Trapping						
Mammal	100.0	7	7 ± 0.5	7.0 – 8.3	N.A.	N.A.

Note: CI = confidence interval; s.e. = standard error; Est = estimated; N.A. = Not Applicable

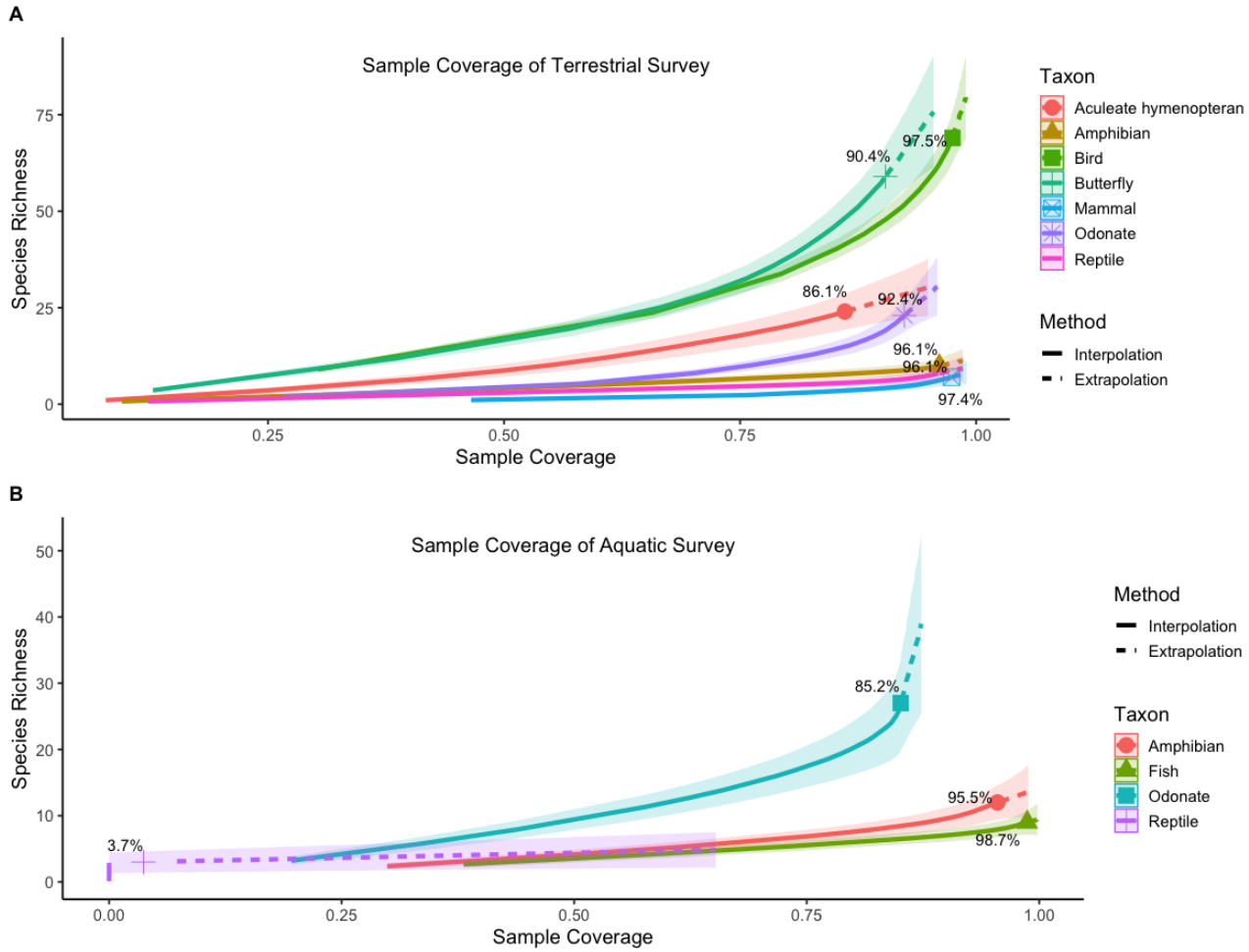


Figure 7.48: Taxon Sampling Curves for (A) Terrestrial Survey and (B) Aquatic Survey

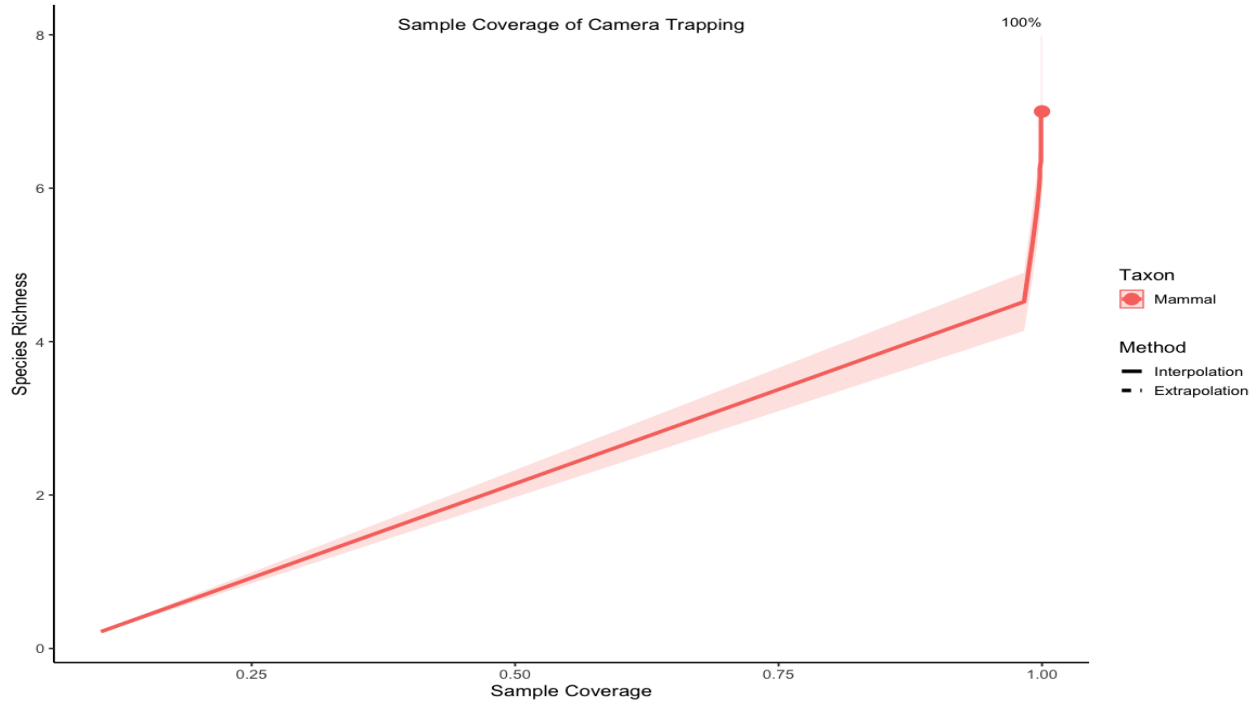


Figure 7.49: Taxon Sampling Curve of Mammals from Camera Trapping

7.3.4.3 *Aculeate Hymenopterans*

A total of 43 species of aculeate hymenopterans were recorded, comprising 18 bees and 25 stinging wasps **(Table 7.15)**. Most of the species recorded are habitat generalists, although two species, namely the *Ropalidia marginata* and *Eumenes* sp., are considered forest specialists (Lee JXQ, pers. comm.). The *R. marginata* was recorded incidentally recorded north of the EIS Study Area within the Tengah site. The habitat within the EIS Study Area is deemed suitable for the species, which is a "truly rare" species listed as nationally Near Threatened (Ascher et al., in prep). Thus, *R. marginata* is considered a notable record in this study. Along the terrestrial sampling routes, more species were recorded in the western half of the EIS Study Area (T1), where the vegetation is dominated by abandoned-land forest with closed canopy (**Figure 7.50**).

In view of the number of probable species (78 species), the number of species recorded appears to be much lower than expected. However, this could be attributed to the generally lower than normal diversity and abundance of aculeate hymenopterans observed throughout Singapore since 2017, although no formal studies have been done to verify this (Lee JXQ, pers. comm.). Nonetheless, the EIS Study Area contains habitats for a variety of aculeate hymenopteran species including forest specialists and those adapted to open-country conditions.

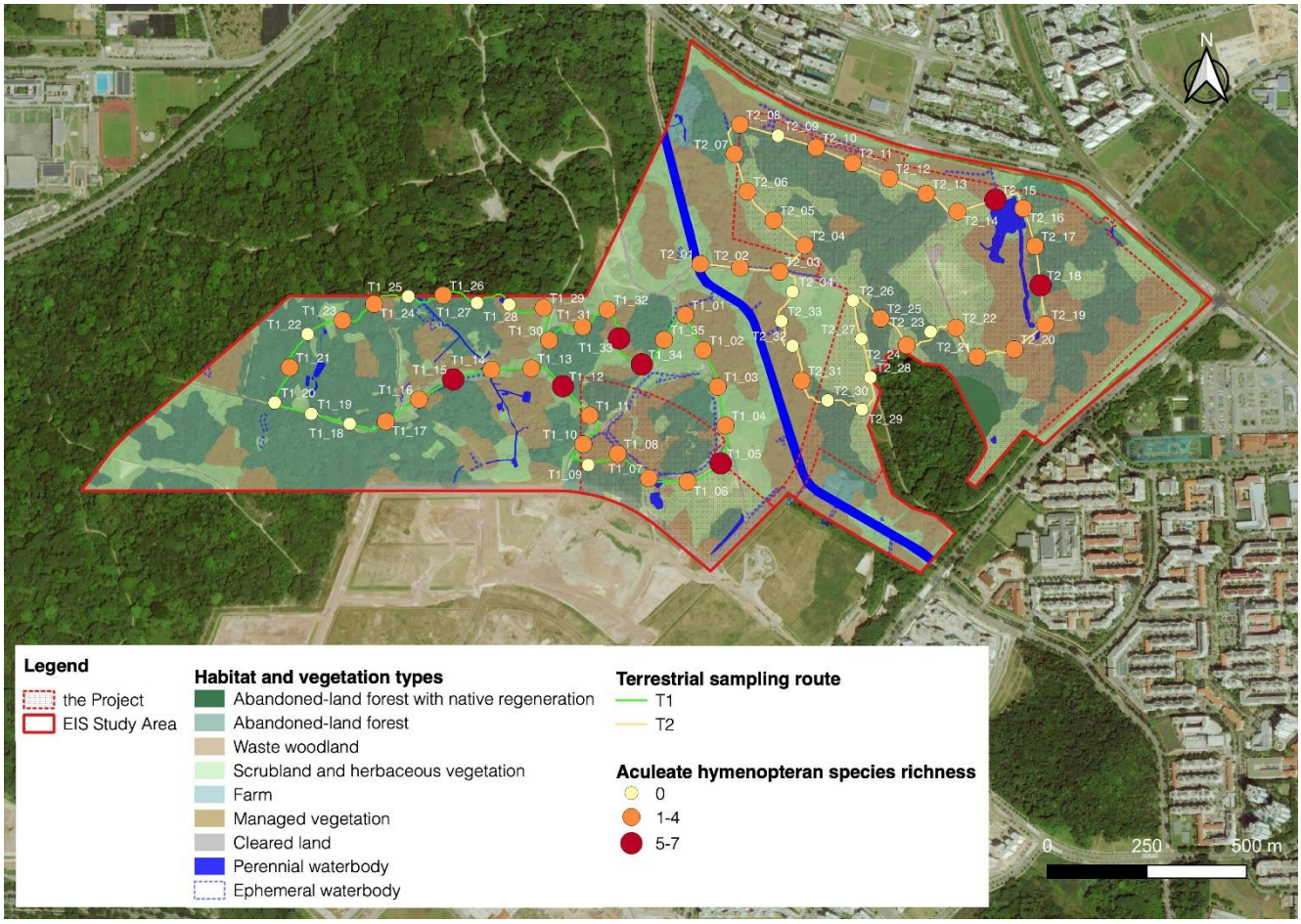


Figure 7.50: Number of aculeate hymenopteran species recorded at each 100-m interval along the terrestrial sampling routes, excluding incidental records

Base Map: ESRI

7.3.4.4 Odonates

Most of the 54 odonate species expected in the EIS Study Area are widespread and common (**Figure 7.51; Table 7.15**; and **Appendix 7B**). Fourteen species are widespread but uncommon. One species, the red-tailed sprite (*Teinobasis ruficollis*), is widespread but rare. This species was recorded in the J1001 EIA (2017). Another species, the variable featherlegs (*Copera vittata*), is restricted and rare. The field assessment recorded 40 odonate species including 3 species of conservation significance (**Table 7.15; Appendix 7B**), the variable featherlegs (*C. vittata*), dwarf wisp (*Agriocnemis nana*) and lined forest skimmer (*Cratilla lineata*).

Along the terrestrial sampling routes, the highest species richness (8 species) was recorded in the western part at T1_07 and T1_26 (**Figure 7.51**). These points are near to waterbodies where odonates frequent. At the aquatic sampling points, higher species richness (6–7 species) was recorded at various waterbodies at ED2_03, Spring_02, Pond1, ED6_01, and ED6_02 (**Figure 7.52**).

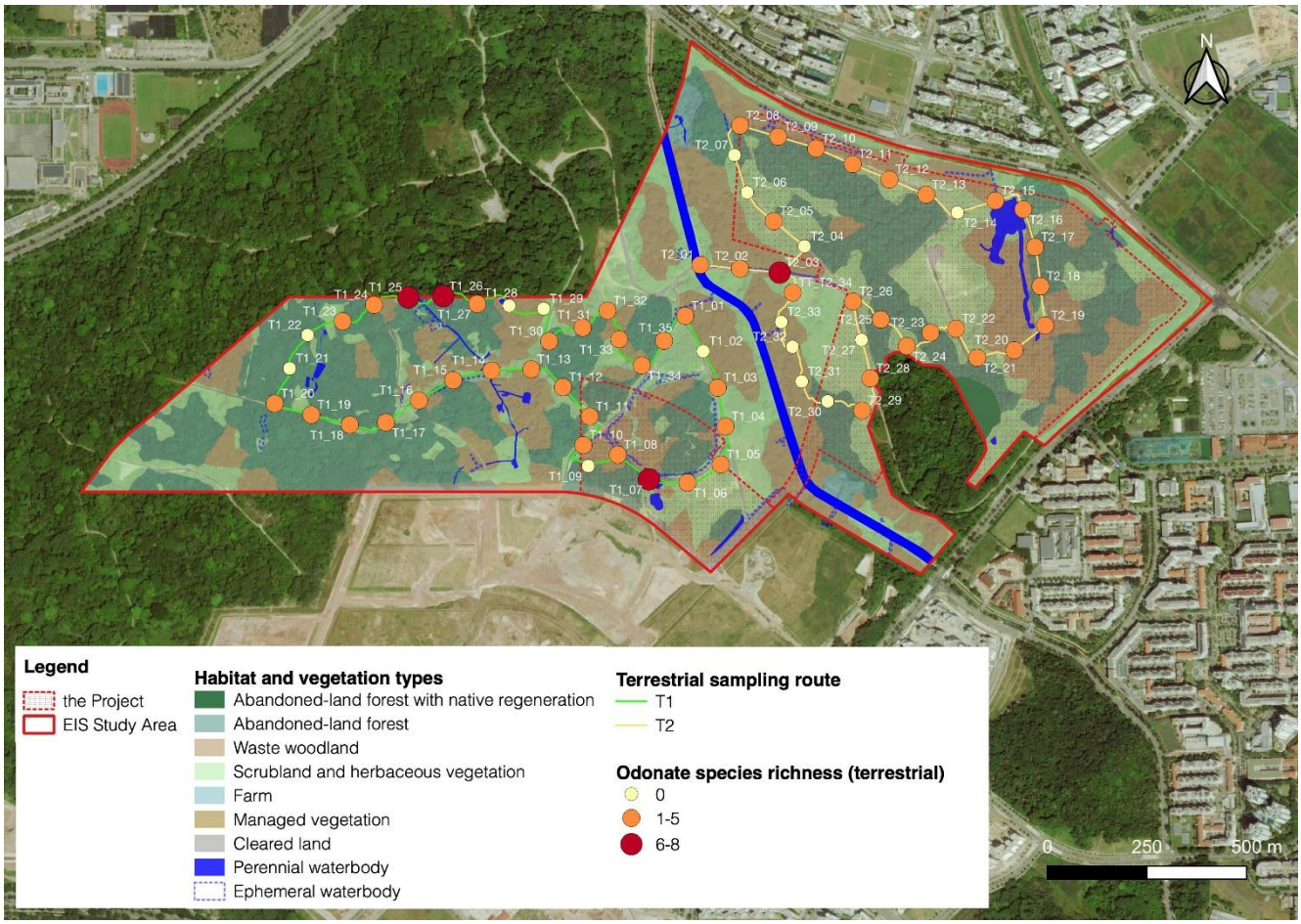


Figure 7.51: Number of Odonate Species Recorded at Each 100-m Interval Along the Terrestrial Sampling Routes, excluding Incidental Records

Base Map: ESRI

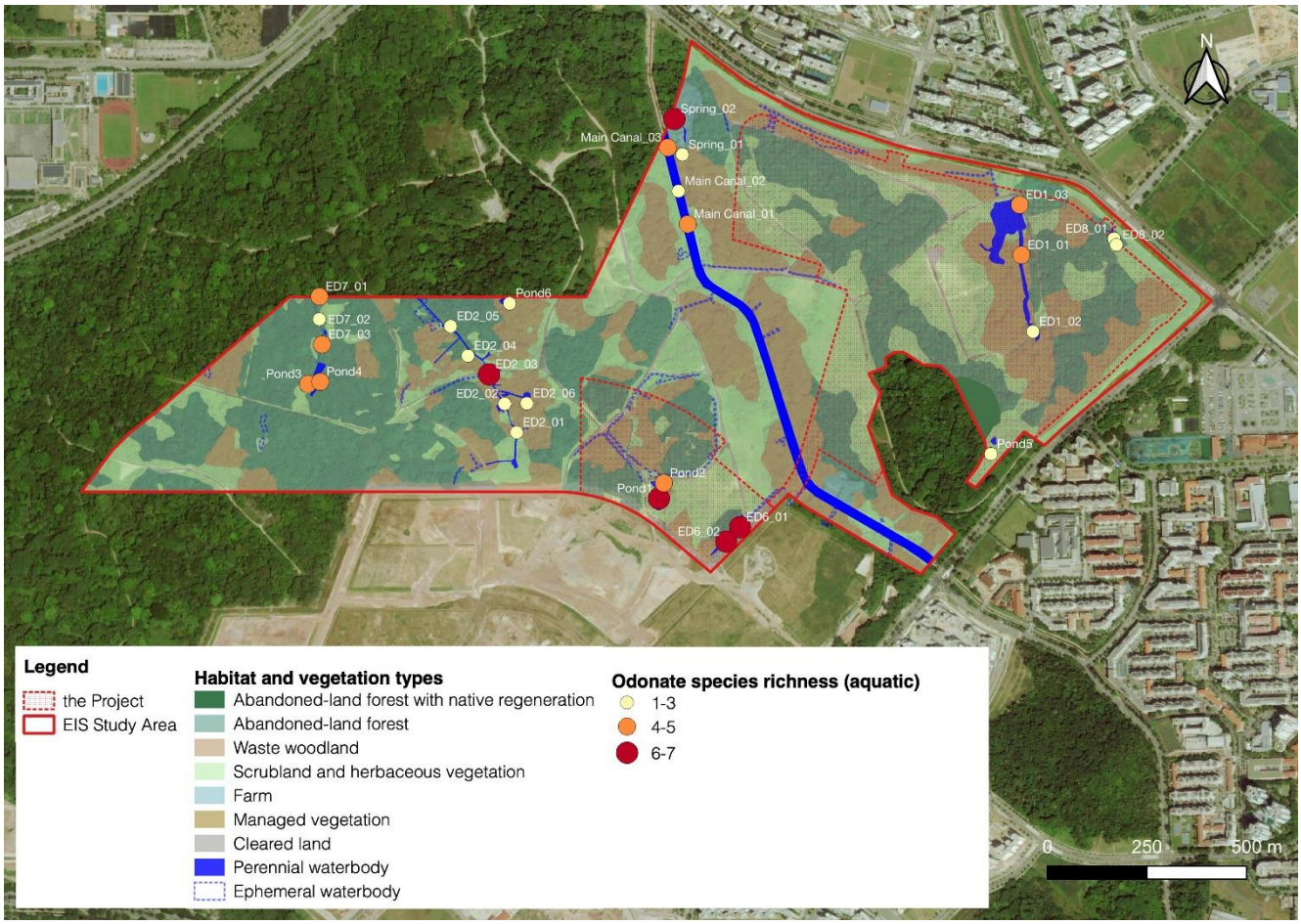


Figure 7.52: Number of Odonate Species Recorded at Each Aquatic Sampling Point, Excluding Incidental Records

Base Map: ESRI

The nationally Vulnerable variable featherlegs (*C. vittata*; **Figure 7.53A**) inhabits sluggish channels and shallow pools in swampy forests (Tang et al., 2010). Three records were obtained along the ED2 stream, particularly the areas shaded by the forest canopy (**Figure 7.54**). The nationally Endangered dwarf wisp (*A. nana*) inhabits small streams and grassy marshes in open forests, and is known to be confined to the CCNR (Tang et al., 2010). This is potentially the first record of the species outside the CCNR and was not considered as a probable species at the EIS Study Area. It was recorded once along the stream at ED2_03, where the canopy is open and the water is slow-flowing (**Figure 7.54**). Another notable record is the rare lined forest skimmer (*C. lineata*; **Figure 7.53B**), which was not considered a probable species as it has only been recorded at Mandai, Pulau Tekong, Pulau Ubin and Punggol (Tang et al., 2010). It inhabits shallow ponds in closed forest, and it was recorded once along the terrestrial route (T1_34). The various types of waterbodies on-site including perennial and ephemeral ponds and streams have different characteristics such as water depth, flow rate, and canopy cover. Thus, they support diverse assemblages of odonates.

Due to the presence of odonate species of conservation significance, ED2 stream is a habitat of conservation interest. Although no species of conservation significance were recorded at ED7 stream, forest streams are an uncommon habitat type and can potentially provide for forest-dependent species. The open-country ponds in the south (Pond1 and Pond2) are well-vegetated and provide habitat for open-country species within the EIS Study Area. These ponds are habitats of interest as they are good representatives of this habitat type that serves a different assemblage of odonates as compared to the forest streams. Hence, the forest streams and the open-country ponds (Pond1 and Pond2) are habitats of conservation interest for odonates (**Figure 7.54**). The Pond1, Pond2, ED2 and ED7 waterbodies are located within Canal Basin 3–5, with catchment size of 71.3 ha, 27.4 ha and 6.6 ha, respectively.

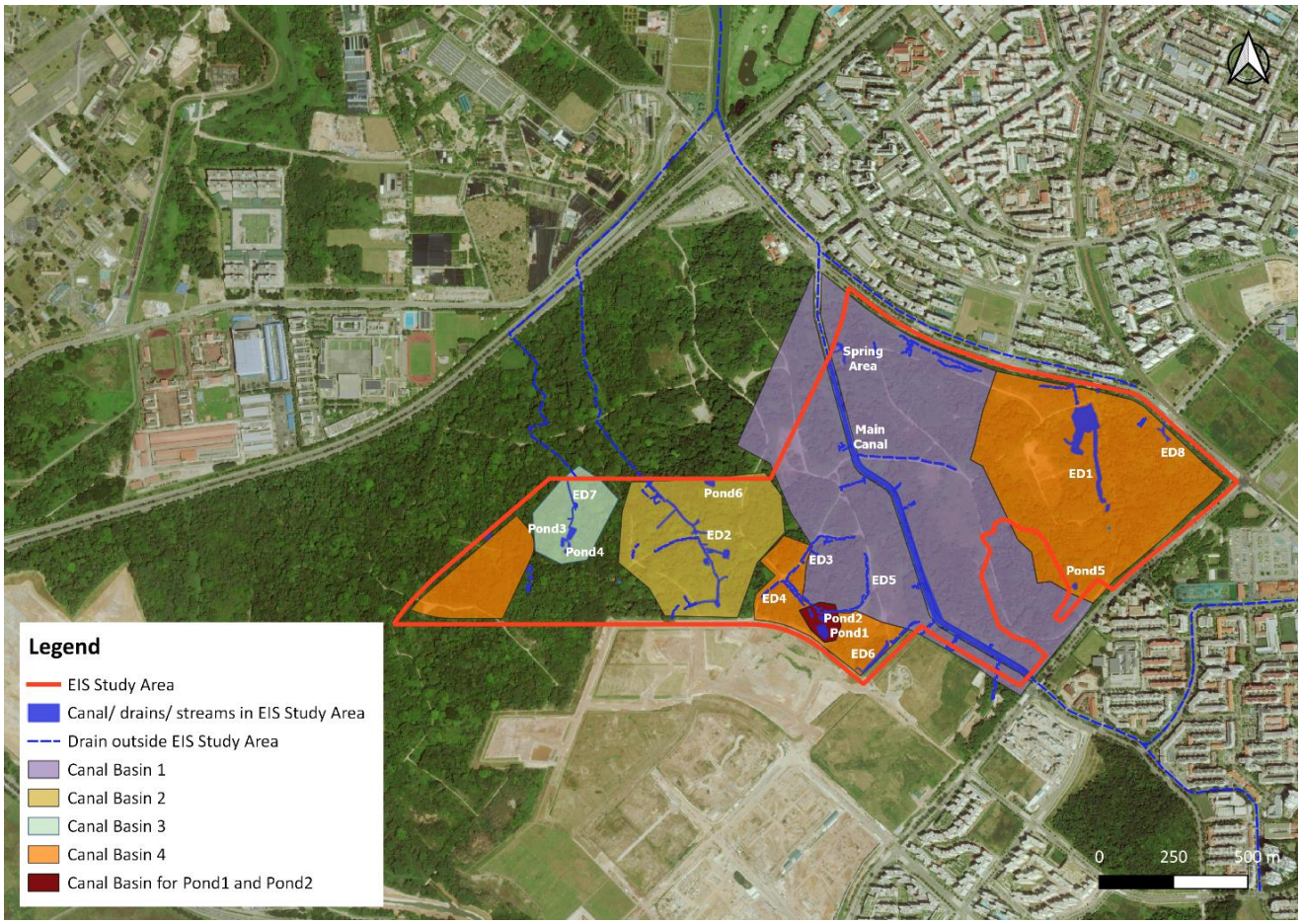




Figure 7.53: Odonates of conservation significance recorded in this study. (A) Variable featherlegs (*Copera vittata*), (B) Lined forest skimmer (*Cratilla lineata*).

Base Map: ESRI

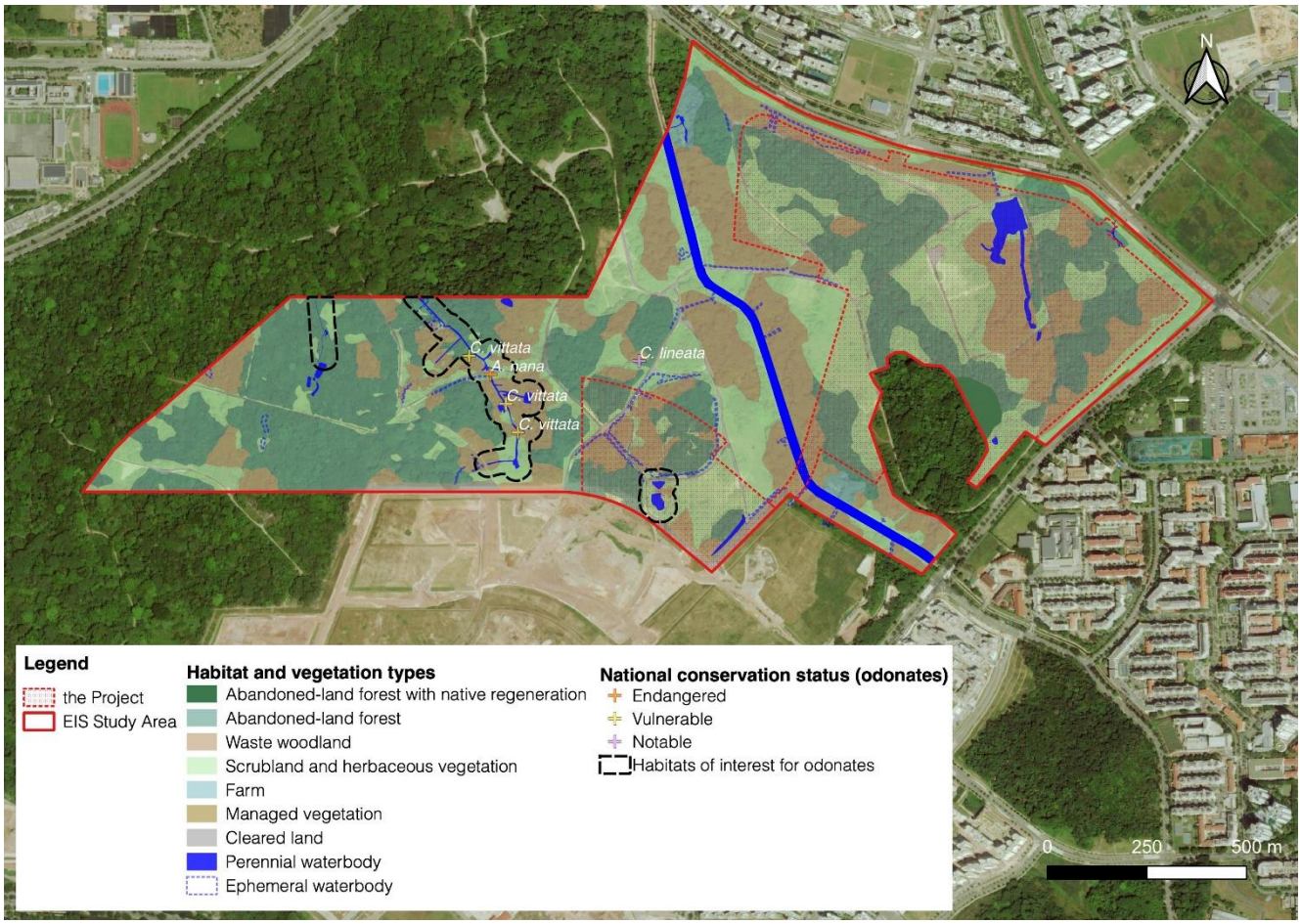


Figure 7.54: Locations of Odonate Species of Conservation Significance and Habitats of Interest for Odonates

Base Map: ESRI

7.3.4.5 Butterflies

A total of 201 species were deemed of probable occurrence within the EIS Study Area, with 23 species of conservation significance (**Table 7.15; Appendix 7B**). Most species are common or moderately common throughout Singapore (63.7%; 128 species). Yet, 35.8% (72 species) are considered moderately to very rare due to the rarity of host plants or sightings. The rarity of one species was not assessed in Khew (2015). The field assessment recorded 72 species, including 4 species of conservation significance (**Table 7.16; Appendix 7B**).

The species richness was quite evenly distributed across the EIS Study Area with no distinct hotspots (**Figure 7.55**). Nonetheless, the highest richness (10 species) was recorded at T1_23 and T2_18.

One of the species of conservation significance, the detached dart (*Potanthus trachala tytleri*; **Figure 7.56A**) is listed as Nationally Extinct in Davison et al. (2008) but has since been rediscovered (Jain et al., 2018), although it remains moderately rare. Its host plants, grasses in the Poaceae family can be found in the extensive scrubland and herbaceous vegetation areas in the EIS Study Area. The nationally Vulnerable common rose (*Pachliopta aristolochiae asteris*) and the common birdwing (*Troides helena cerberus*) are now listed as moderately common (Khew, 2015). They can also be found in urban parks and gardens where their host plants *Aristolochia* spp. is planted. One species, the Malay staff sergeant (*Athyma reta moorei*, **Figure 7.56B**), that is not listed as threatened in Davison et al. (2008) was identified as a notable record. The Malay staff sergeant (*A. r. moorei*) was recorded once in this study. It is known to occur in the protected forests of the CCNR and could have dispersed over to the EIS Study Area via forested corridors in the landscape. A cluster of its host plant, the Vulnerable *Glochidion zeylanicum* var. *zeylanicum*, was recorded in the central part of the EIS Study Area during floristic

field assessment. Since butterflies are host-specific, the locations of the host plants of rare species are habitats of conservation interest for butterflies.

The nationally Endangered harlequin (*Taxila haquinus haquinus*) was considered of probable occurrence but was not recorded during the field assessment. Nonetheless, it is a noteworthy species that has been recorded in forested areas with similar habitat characteristics in the vicinity. Its host plant, the Endangered *Ardisia elliptica*, was also recorded across the EIS Study Area with a large cluster in the eastern part of the EIS Study Area during the floristic field assessment. The harlequin is a strict forest specialist that only dwells in the shade of the forest canopy and typically found in the vicinity of its host plant. The forests in the vicinity of the EIS Study Area is known to be a stronghold for the species. This area represents the only known population on the main island of Singapore. The area where a concentration of its host plant was recorded is a habitat of interest for the butterfly.

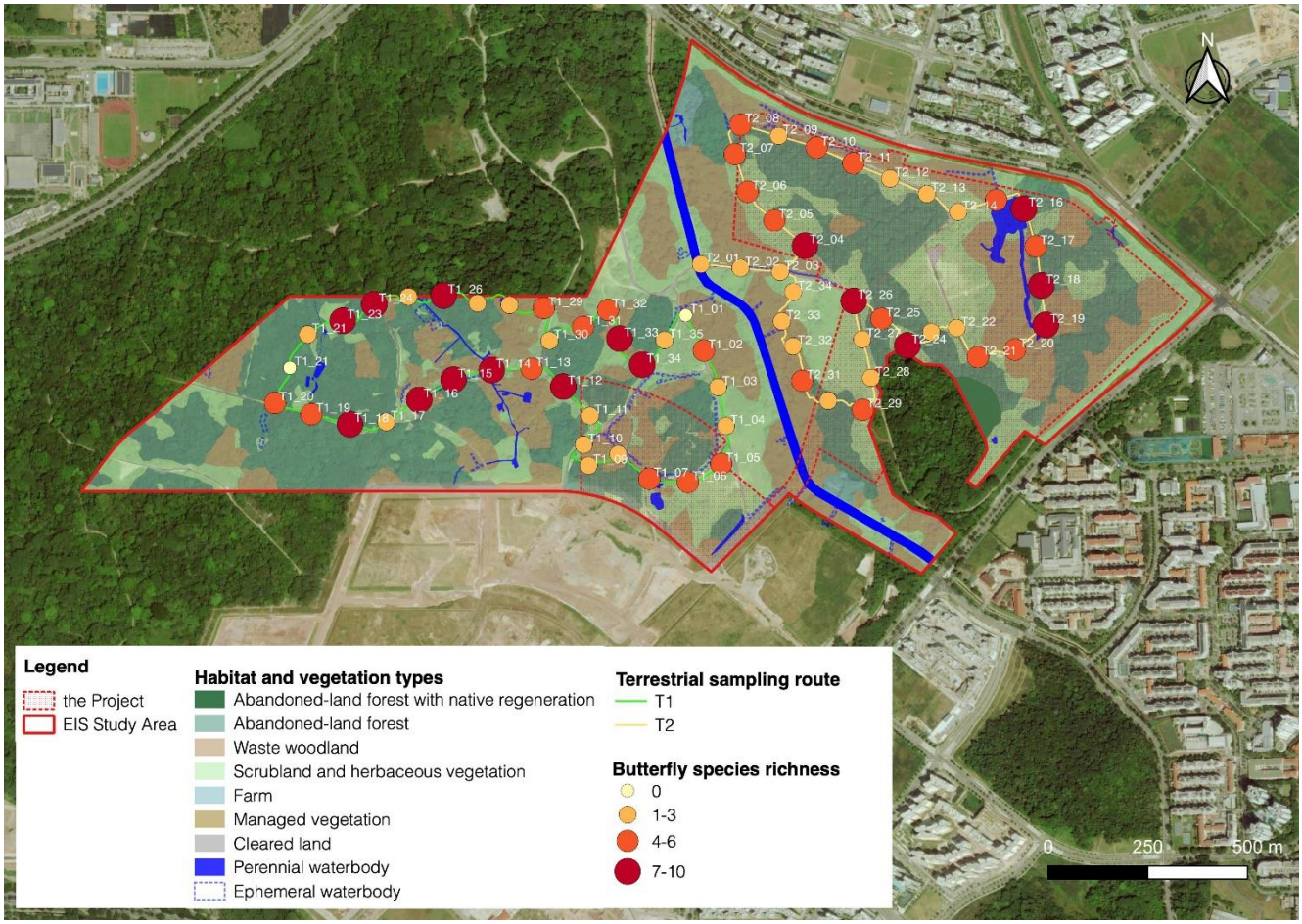


Figure 7.55: Number of Butterfly Species Recorded at Each 100-m Interval Along the Terrestrial Sampling Routes, Excluding Incidental Records

Base Map: ESRI



Figure 7.56: Butterflies of conservation significance recorded in this study. (A) Detached dart (*Potanthus trachala tytleri*), and (B) Malay staff sergeant (*Athyma reta moorei*).

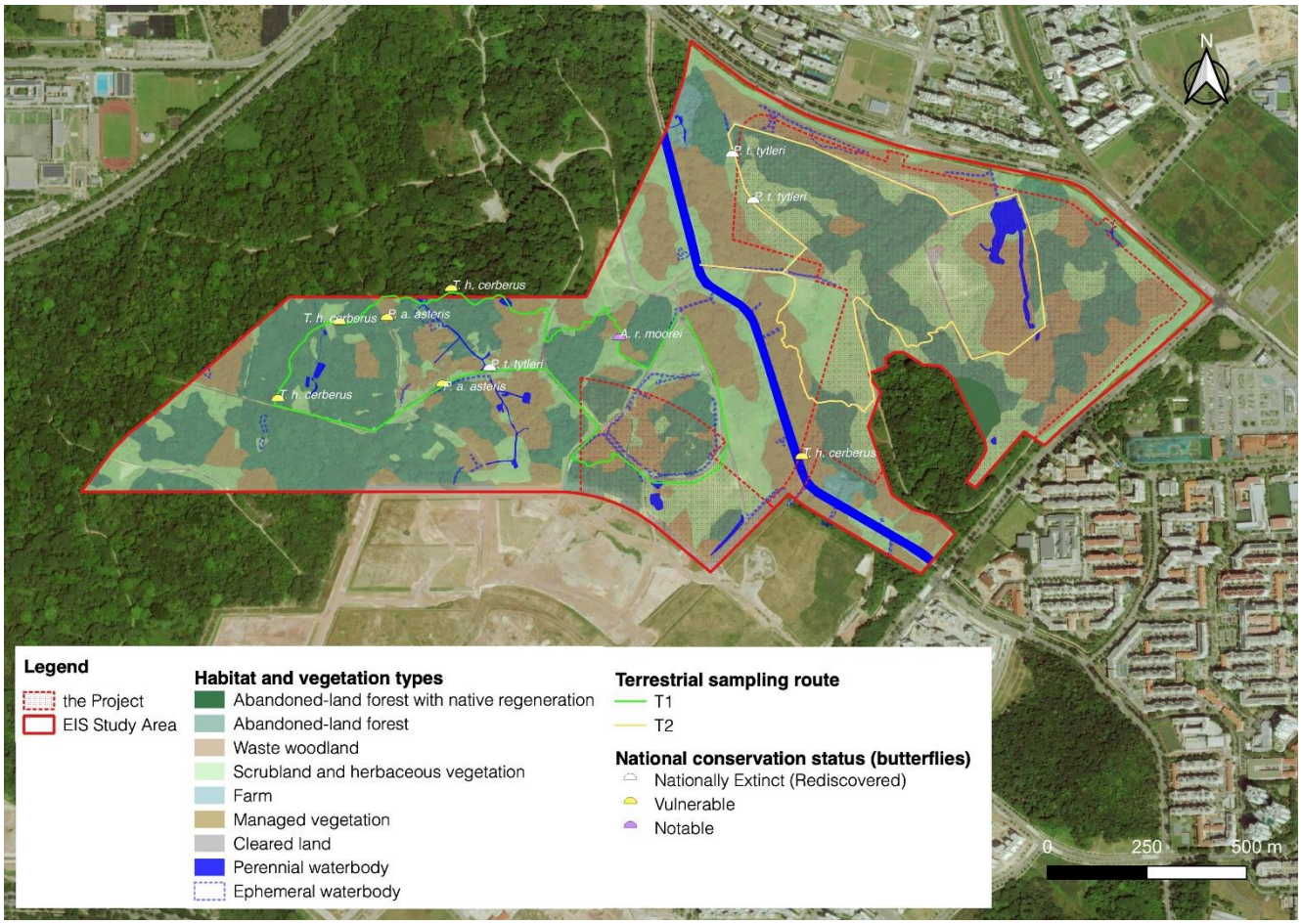


Figure 7.57: Locations of Butterfly Species of Conservation Significance

Base Map: ESRI

7.3.4.6 Freshwater Decapod Crustaceans

Given the lack of connectivity between the waterbodies in the EIS Study Area to the more biodiverse freshwaters of the CCNR and the poor dispersal capability of most freshwater decapods, only three species, the native maculate freshwater crab (*Parathelphusa maculata*), the non-native Oriental river prawn (*Macrobrachium nipponense*), and the non-native ghost shrimp (*Macrobrachium lanchesteri*), are considered of probable occurrence (**Table 7.15; Appendix 7B**). No decapod crustaceans were encountered in the field assessment.

7.3.4.7 Freshwater Fish

The desktop assessment identified 22 species of probable occurrence (**Table 7.15; Appendix 7B**). These species are mainly species that are tolerant of disturbance such as the non-native poeciliids and native osphronemids. The canal can also provide habitat for larger-bodied species such as the non-native cichlids. Nine species of freshwater fish were recorded, with the majority made up of native species (**Table 7.15; Appendix 7B**). One recorded species, the barcheek goby (*Rhinogobius giurinus*) was not listed as a probable species as it is an introduced species and there no known records in the vicinity. It was recorded in the canal where the habitat is suitable for this species. The minnow traps only obtained two species, the common snakehead (*Channa striata*) and the croaking gouramy (*Trichopsis vittata*), which were also recorded during the visual surveys.

The species richness in the waterbodies on the western half of the EIS Study Area was distinctly higher than those in the canal and the eastern half (**Figure 7.58**). This suggests that the waterbodies in the western half of the EIS Study Area are better connected to other waterbodies and have better habitat conditions (e.g. lower temperature, closed canopy). During periods of heavy rainfall, fish such as the common walking catfish (*Clarias* cf. *batrachus*) and Asian swamp-eel (*Monopterus javanensis*) were observed in the ephemeral waterbodies and even on the roads in the western portion get filled with water. Such events are likely to aid in the dispersal of these fish, which are also capable of breathing air.

The presence of the common walking catfish (*C.* cf. *batrachus*; **Figure 7.59**) is notable. They were mainly recorded in the streams ED2 and ED7 (**Figure 7.60**). Though a previously widespread species in the non-forested waterways of Singapore, it has seen a marked decline in its populations outside of the protected forests of the CCNR due to competition with and displacement by the invasive African sharptooth catfish (*Clarias gariepinus*; Ng et al., 2014). Furthermore, most of its known localities are slated for development (Nyanasengeran M, pers comm). Thus, streams with populations of the common walking catfish are of conservation interest, as shown in **Figure 7.60**.

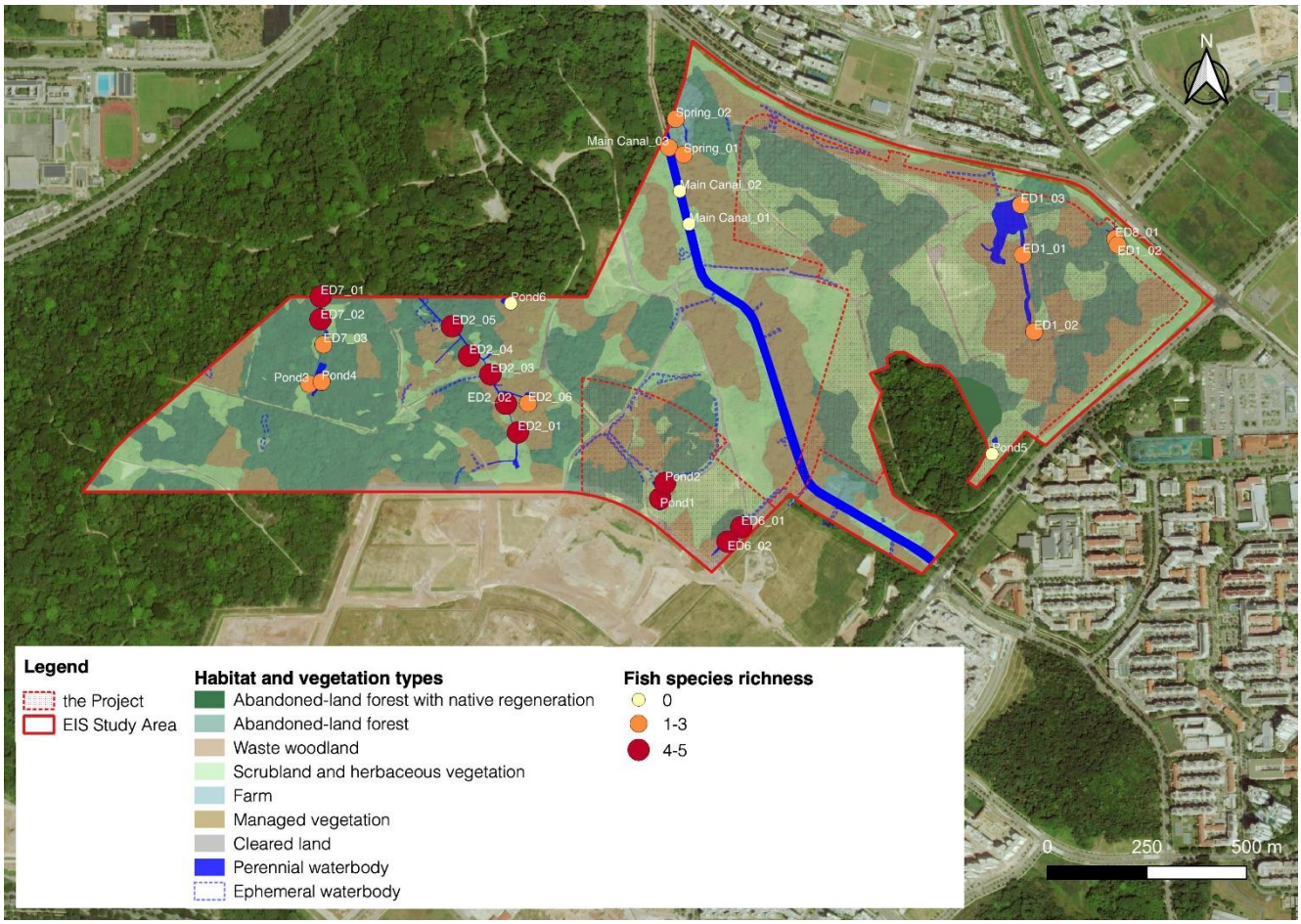


Figure 7.58: Number of Freshwater Fish Species Recorded at Each Aquatic Sampling Point, Excluding Incidental Records

Base Map: ESRI



Figure 7.59: Common Walking Catfish (*Clarias* cf. *Batrachus*), A Species of Conservation Significance Recorded in this EIS

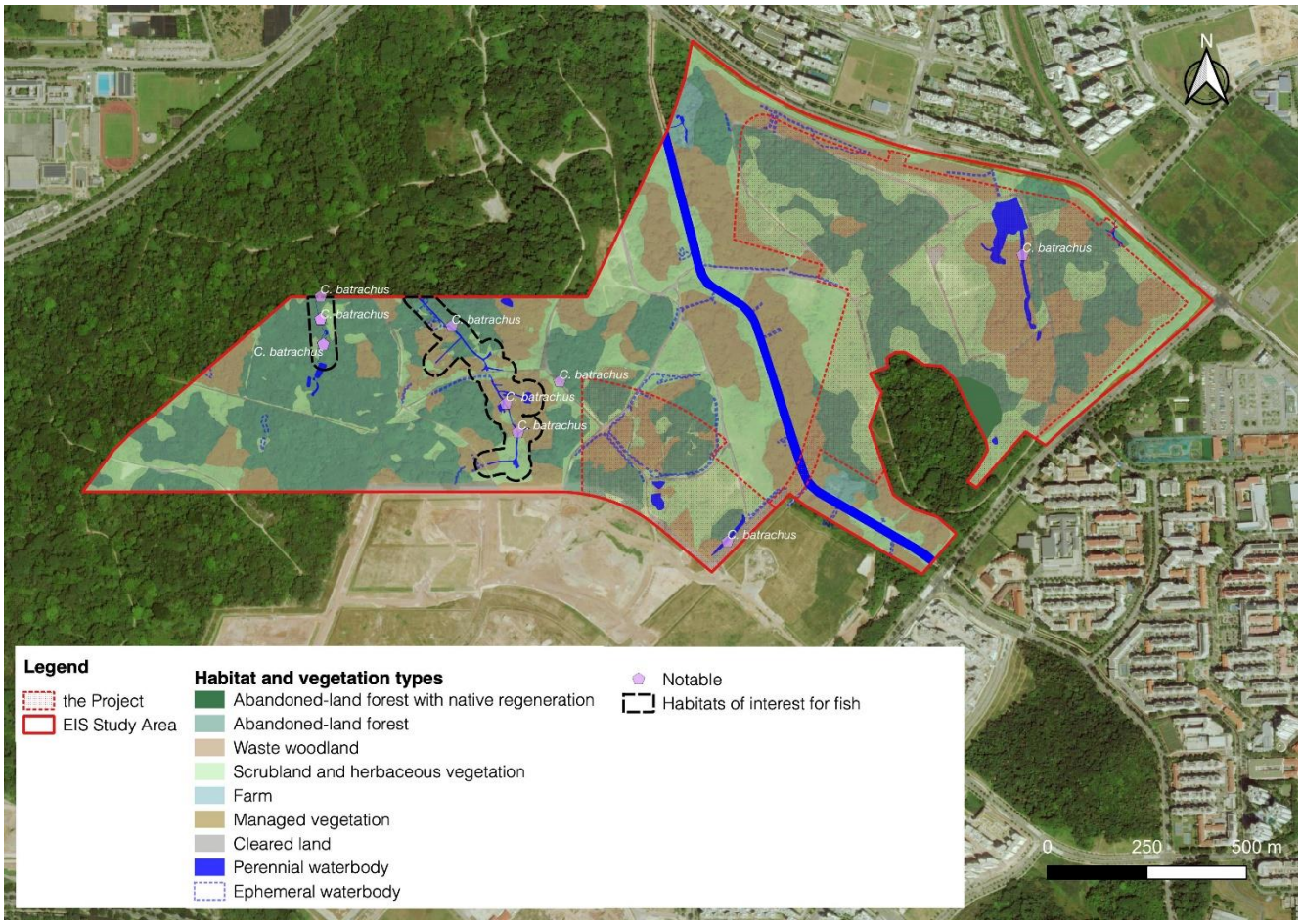


Figure 7.60: Locations of Freshwater Fish Species of Conservation Significance and Habitats of Interest for Freshwater Fish

Base Map: ESRI

7.3.4.8 Amphibians

A total of 13 amphibians, none of conservation significance, were deemed of probable occurrence (**Table 7.15; Appendix 7B**). The field assessment recorded 12 of these species (**Table 7.15; Appendix 7B**). All the species recorded are widespread and common except for the East Asian ornate chorus frog (*Microhyla mukhlesuri*; restricted and rare) and the Guenther's frog (*Sylvirana erythraea*; widespread and uncommon). However, these species are non-native.

Along the terrestrial sampling routes, higher species richness was recorded near waterbodies where amphibians frequent (**Figure 7.61**). Six species were recorded at T1_28, which is near a stream; five species were recorded at T1_06, which is near a pond. Overall, there appears to be a higher diversity of amphibians in the western half of the EIS Study Area, probably attributed to the variety of waterbodies there.

Similarly, higher species richness was recorded at the aquatic sampling points on the western half of the EIS Study Area. The highest number of species (6 species) was recorded at Pond6_Pond, followed by five species at ED2_01, Pond4_Pond, ED7_03, and Pond5 (**Figure 7.62**).

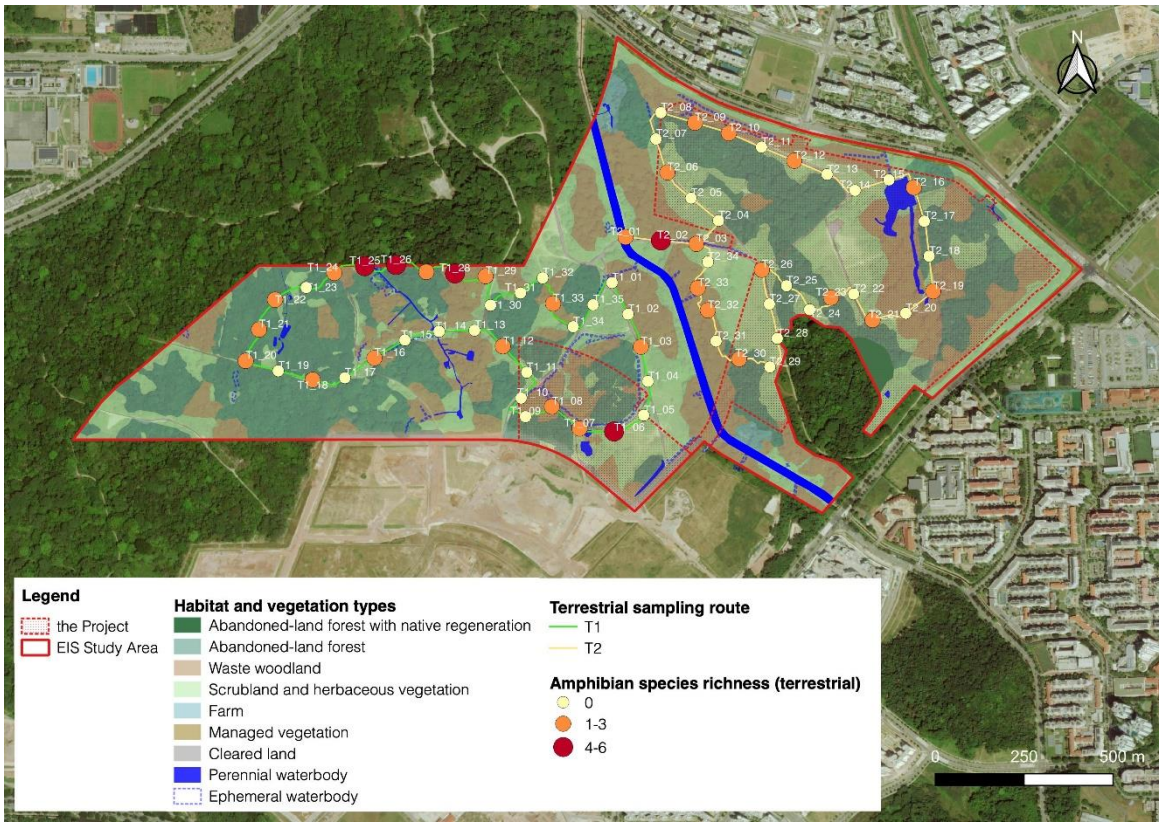


Figure 7.61: Number of amphibian species recorded at each 100-m interval along the terrestrial sampling routes, excluding incidental records.

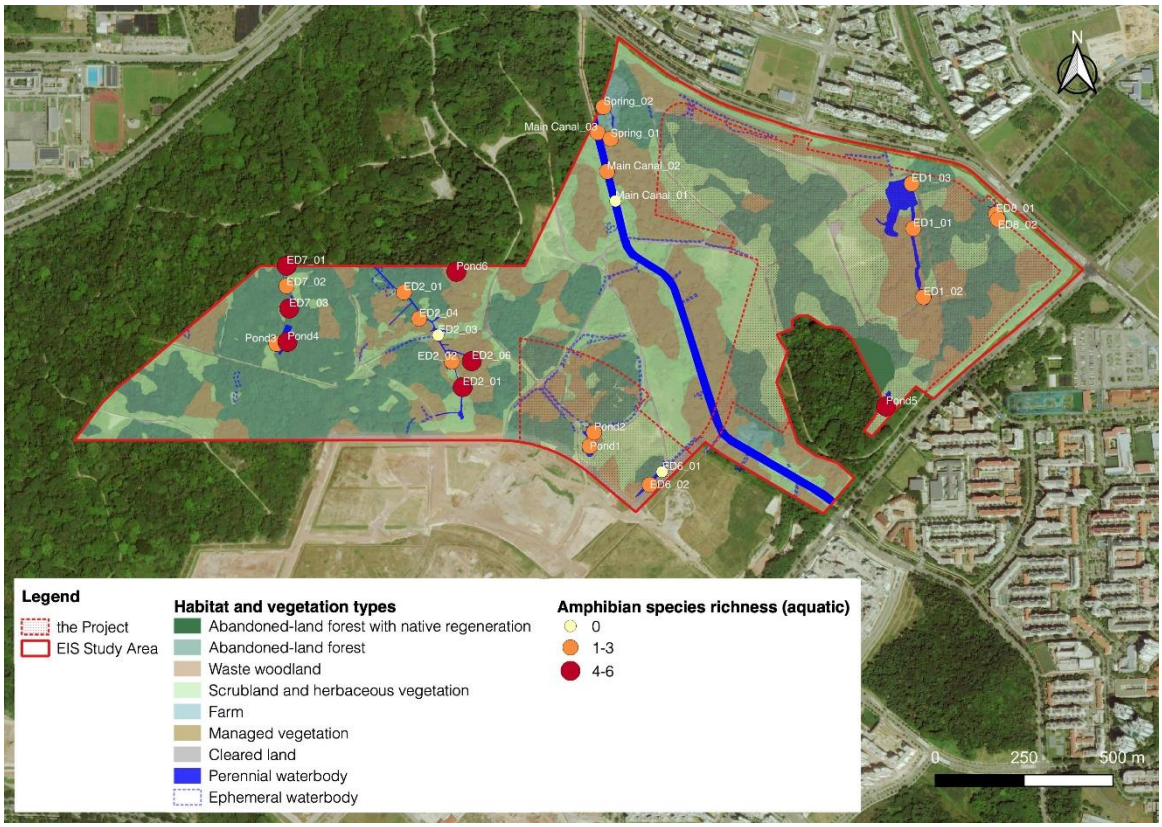


Figure 7.62: Number of Amphibian Species Recorded at Each Aquatic Sampling Point, Excluding Incidental Records

Base Map: ESRI

7.3.4.9 Reptiles

The probable species list amounted to 36 reptiles comprising 13 lizards, 19 snakes, and 4 turtles (**Table 7.15; Appendix 7B**). Of these, 7 species (1 lizard, 5 snakes, and 1 turtle) were of conservation significance. The field assessment recorded 17 reptiles, including 2 of conservation significance (**Table 7.15; Appendix 7B**).

The richness of reptiles was generally low across the terrestrial sampling routes, with only up to four species recorded per 100-m interval (**Figure 7.63**). For the aquatic sampling points, only up to one species was recorded per point (**Figure 7.64**). Most of the reptilian species recorded were widespread and common, although the uncommon green crested lizard (*Bronchocela cristatella*) and the rare common Malayan racer (*Coelognathus flavolineatus*) were also recorded. Two common species that have restricted distributions were also recorded. They are the clouded monitor (*Varanus nebulosus*) and the Malayan box terrapin (*Cuora amboinensis*).

The Malayan racer (*C. flavolineatus*) is a nationally Endangered species. Although it is adapted to disturbed habitats including urban areas, it is rarely encountered due to its "nervous disposition and intense shyness of humans" (Lim, 2014). There was only one incidental sighting of this species during the field assessment (**Figure 7.65**). The Malayan box terrapin (*Cuora amboinensis*; **Figure 7.66**) is a globally Vulnerable species. In Singapore, it is considered restricted but common, and a large proportion of the population may be released individuals (Baker & Lim, 2012). It is uncertain if the two individuals recorded in this assessment were released individuals. Nevertheless, the waterbodies in the EIS Study Area serve as important habitats for this species. The locations where the species was recorded are shown in **Figure 7.65**.

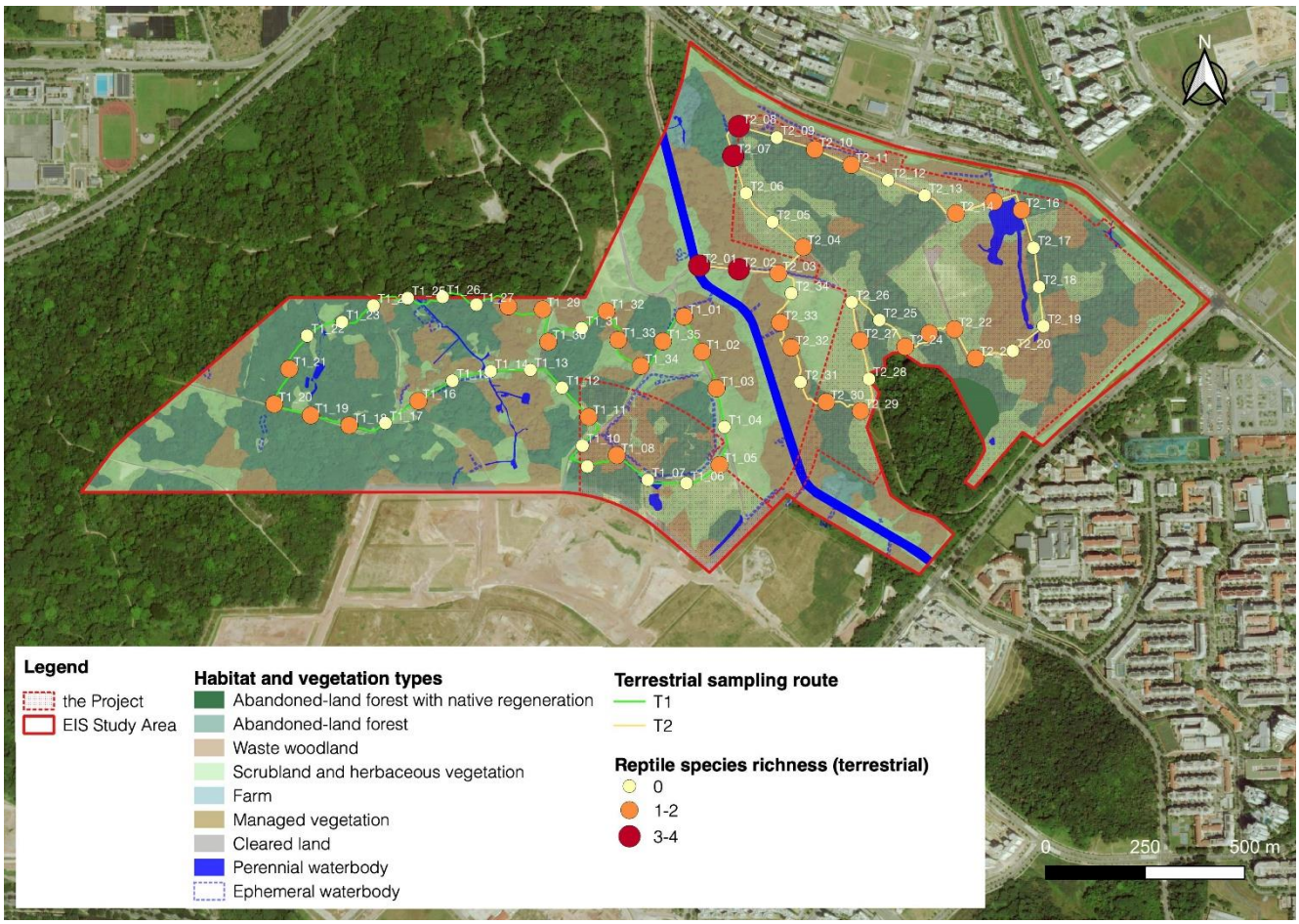


Figure 7.63: Number of Reptilian Species Recorded at Each 100-M Interval Along the Terrestrial Sampling Routes, Excluding Incidental Records

Base Map: ESRI

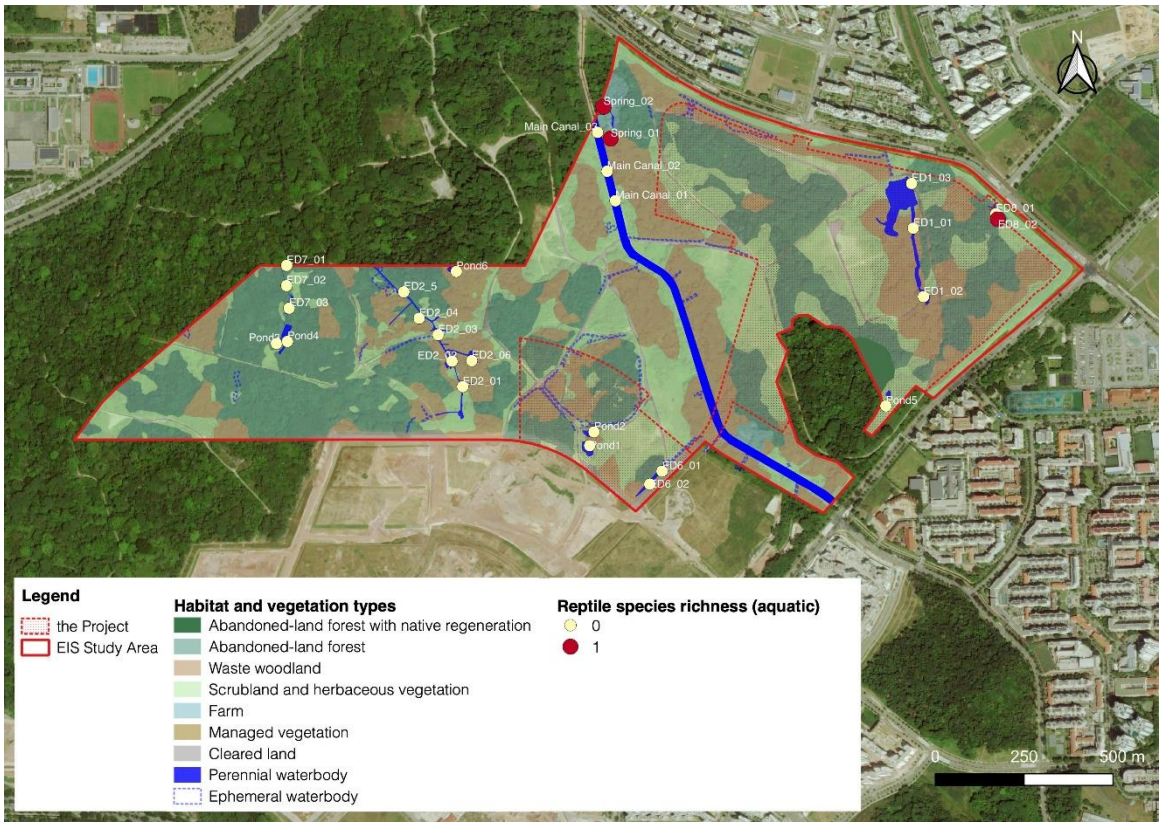


Figure 7.64: Number of Reptilian Species Recorded at Aquatic Sampling Point, excluding Incidental Records

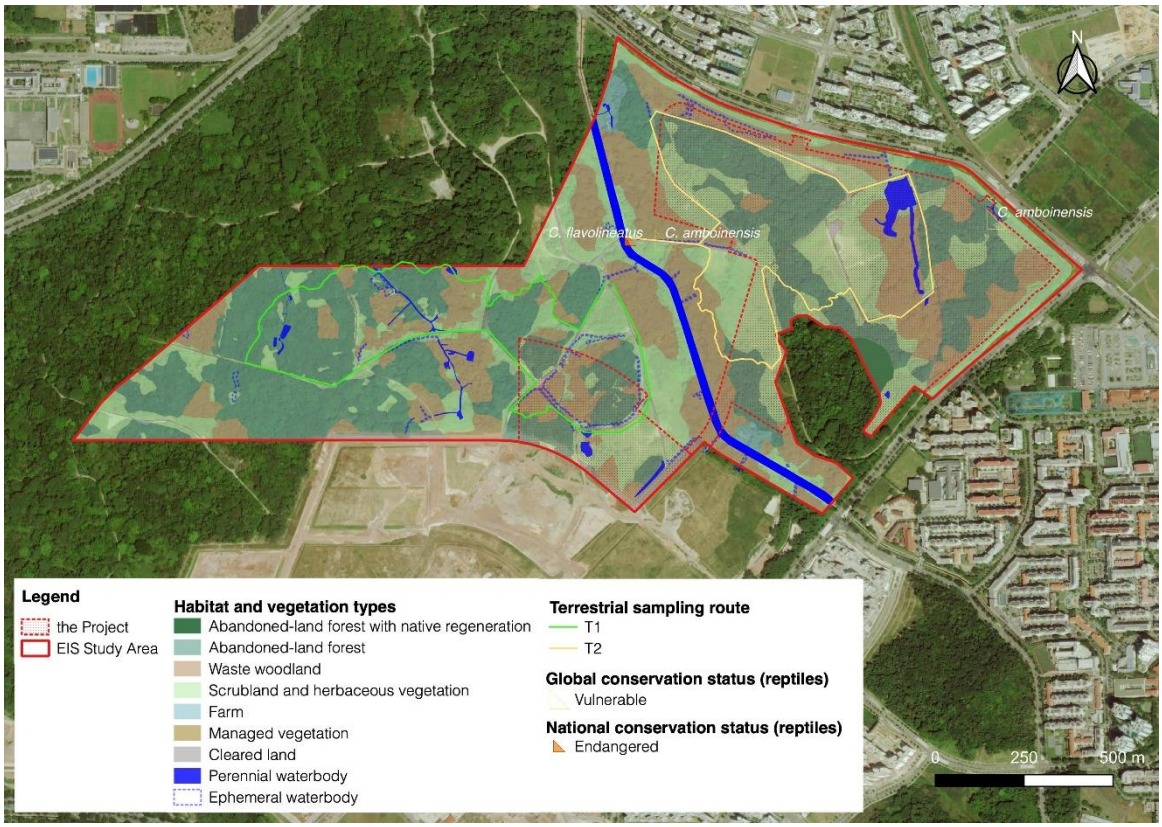


Figure 7.65: Locations of Reptilian Species of Conservation Significance

Base Map: ESRI



Figure 7.66: Malayan Box Terrapin (*Cuora amboinensis*), A globally Vulnerable Species Recorded in this EIS

7.3.4.10 Birds

A total of 177 species of birds were deemed of probable occurrence, comprising 118 residents (19 introduced), 4 introduced non-residents, and 55 migrant/ visitor species (**Table 7.15; Appendix 7B**). The field assessment recorded 86 species, of which 73 are residents (12 introduced), 2 are introduced non-residents, and 10 are migrant/ visitor species. One species (*Aerodramus* sp.) was only identifiable to genus level and was thus not classified by its native status. Two species were only recorded via camera traps – orange-headed thrush (*Geokichla citrina*) and Malayan night heron (*Gorsachius melanolophus*).

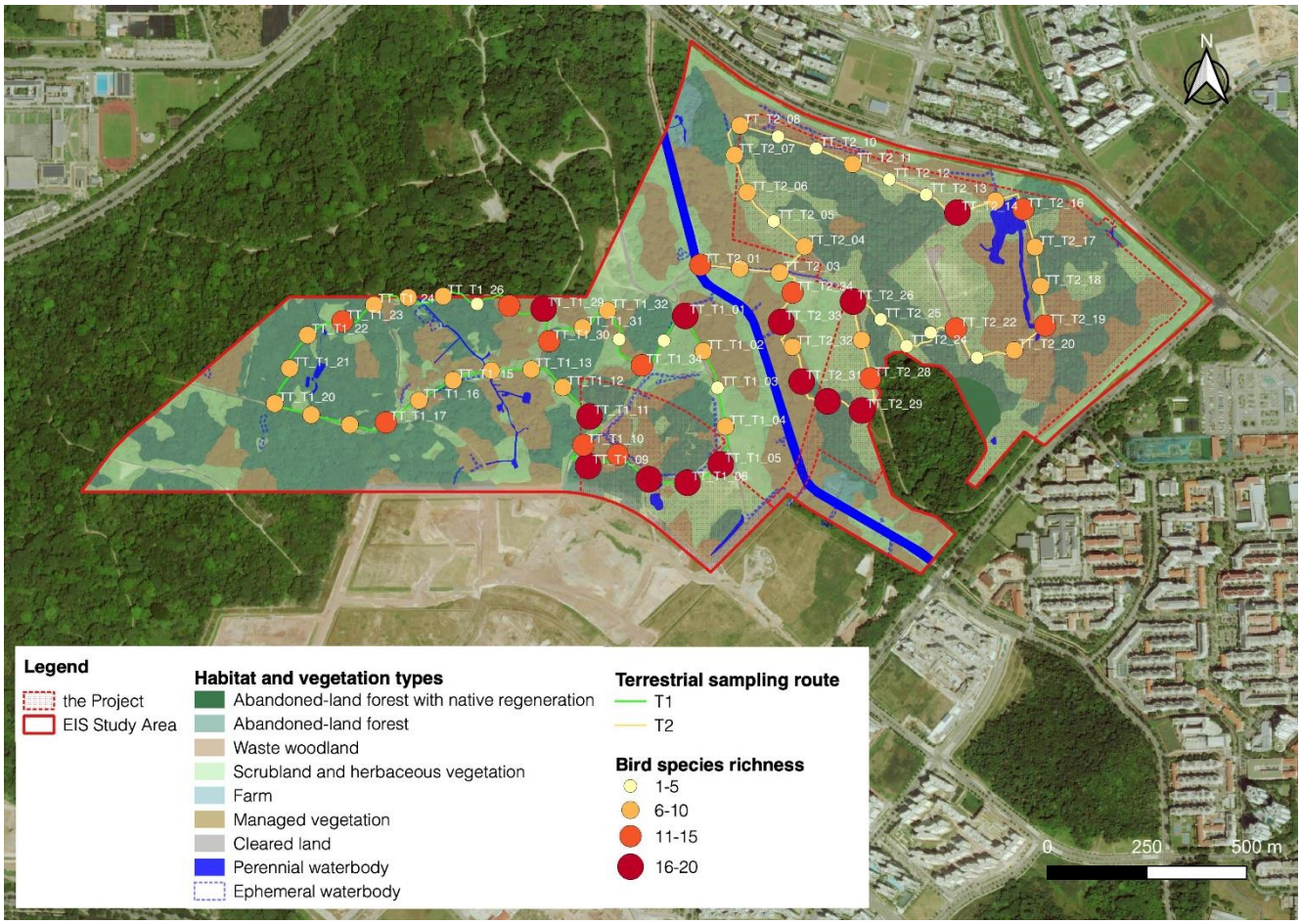


Figure 7.67: Number of Bird Species Recorded at Each 100-M Interval along the Terrestrial Sampling Routes, Excluding Incidental Records

Base Map: ESRI

Higher richness of birds was observed in the central part of the EIS Study Area, particularly between T1_05 and T1_11, as well as between T2_26 to T2_33 (**Figure 7.67**). These areas are characterised by open canopy waste woodland and scrubland and herbaceous vegetation, which may have made it easier to detect birds, particularly those that are flying above the canopy.

The migratory species recorded include the rare Malayan night heron (*G. melanolophus*; **Figure 7.68A**), the uncommon yellow-rumped flycatcher (*Ficedula zanthopygia*), and the uncommon orange-headed thrush (*G. citrina*; **Figure 7.68B**). The breeding range of these species lie at the northern latitudes, in countries such as China, Taiwan and Japan. They migrate south during winter to the warmer latitudes. Singapore lies along a major migratory path known as the East Asian-Australasian Flyway, and receives a high number of migratory species shifting between northern breeding grounds and southern overwintering haunts (Yong et al., 2016). The rare and uncommon migratory species recorded in the field assessment depend on forested areas in Singapore such as the Tengah site as wintering grounds. The abandoned-land forest patches in the EIS Study Area provide suitable habitats for these species. As the field surveys for birds were conducted between February and March (with the exception of two nocturnal surveys that were conducted in June), which are within the migratory season in Singapore (September to March), they only coincided with the end of the season. This could be the reason why only 18% of the probable migrant/ visitor species were recorded in the field assessment.



Figure 7.68: Rare and uncommon migratory birds recorded in this study. (A) Malayan night heron (*Gorsachius melanolophus*), (B) Orange-headed thrush (*Geokichla citrina*).

Distribution of bird species of conservation significance and habitats of conservation interest is illustrated in **Figure 7.69**.

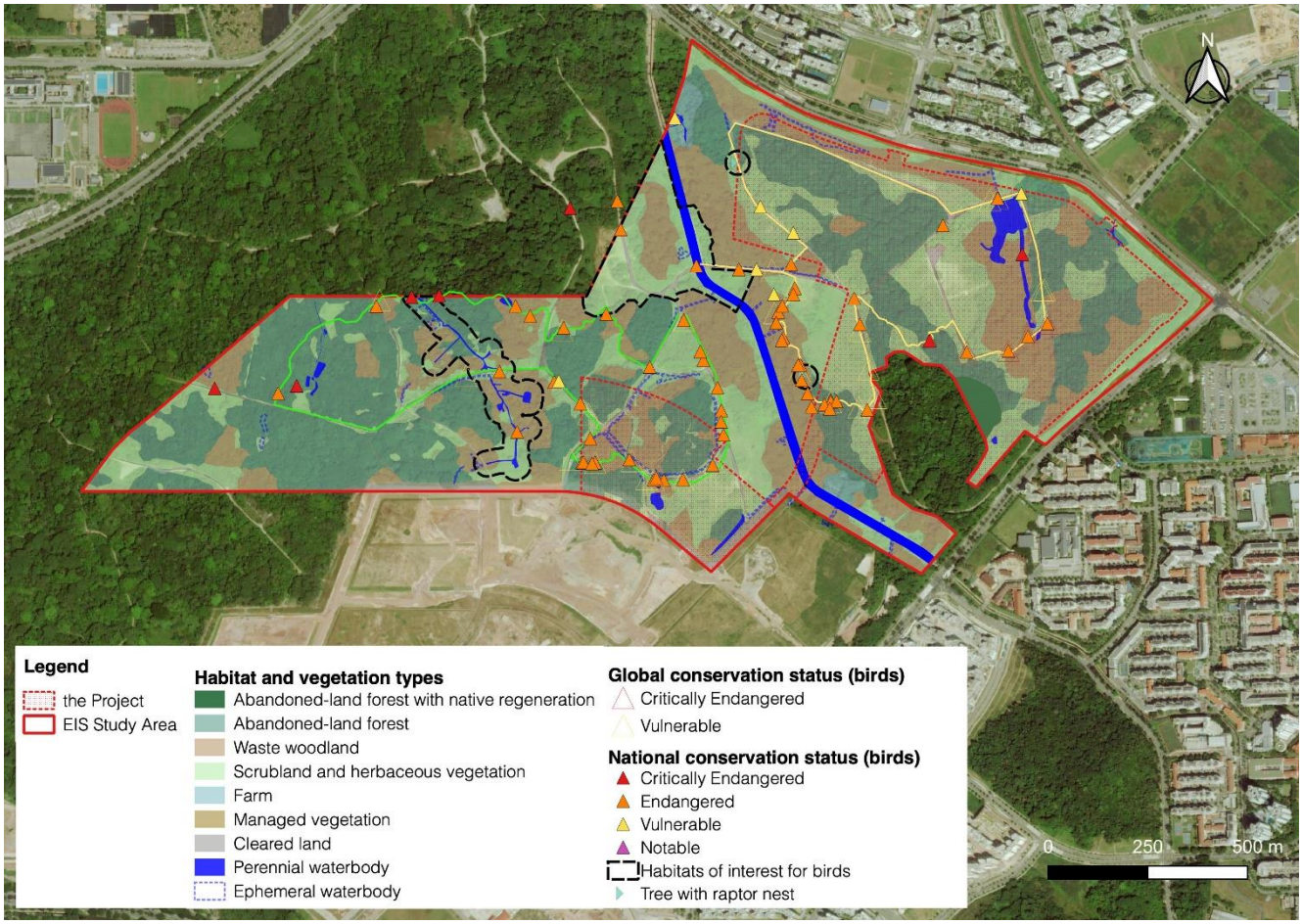


Figure 7.69: Locations of Bird Species of Conservation Significance and Habitats of Conservation Interest for Birds

Base Map: ESRI

Fifteen species of conservation significance were recorded, including 13 threatened species and 2 other notable species (**Figure 7.69**; **Table 7.15; Appendix 7B**). Most of the threatened species were previously regarded as rare but have since increased in range and numbers. Such nationally threatened species include the grey-headed fish eagle (*Haliaeetus ichthyaetus*; Critically Endangered), changeable hawk-eagle (*N. cirrhatus*; Endangered), Oriental magpie-robin (*Copsychus saularis*; Endangered), red junglefowl (*G. gallus*; Endangered), blue-crowned hanging-parrot (*Loriculus galgulus*; Endangered), straw-headed bulbul (*P. zeylanicus*; Endangered), and red-legged crake (*Rallina fasciata*; Vulnerable) (Lim & Yong, 2013). The population status of the spotted wood owl (*Strix seloputo*; Critically Endangered) is indeterminate as there were insufficient records, likely due to the lack of nocturnal monitoring surveys for birds (Lim & Yong, 2013). The long-tailed parakeet (*Psittacula longicauda*) is a globally Vulnerable species but is regarded as common in Singapore. The straw-headed bulbul (*P. zeylanicus*) is listed as nationally endangered although its population appears to be growing more stable in Singapore. However, it is regarded as a globally Critically Endangered species due to its melodious and attractive songs, making it highly sought-after for the songbird trade. This has resulted in its extirpation throughout much of its range and making it necessary to list it as a CITES-protected species. Furthermore, it is also threatened by the loss of forest habitat. Its global conservation status was recently revised in 2018 from Endangered to Critically Endangered as populations have been declining extremely rapidly (BirdLife International, 2018). According to Yong et al. (2017), the estimated population size in Singapore is slightly over 200 birds, possibly making up one-third of the global population (Neo, 2016). However, in Singapore, habitat loss to development remains a primary threat to species. There were five records of the straw-headed bulbul (*P. zeylanicus*) during the field assessment and they were mainly recorded at the eastern part of the EIS Study Area, which is dominated by waste woodland (**Figure 7.69**). An individual was recorded feeding on the figs of *Ficus microcarpa*. This species is not fastidious in its nesting habitat requirements. It nests on trees in wooded areas and has even been observed nesting in urban parks and gardens (Zheng, 2017). The EIS Study Area provides suitable habitat for its nesting. This species requires wooded corridors to move across the landscape.

A juvenile changeable hawk-eagle (*N. cirrhatus*) was recorded in a nest located on a tall tree (*Falcataria moluccana*) during the field assessment (**Figure 7.70A**). This indicates that a breeding population exists in the EIS Study Area. Another nest belonging to a raptor (likely the changeable hawk-eagle) was also recorded, although its usage was not confirmed. As raptors tend to reuse their nests, these trees are habitats of conservation interest. The locations of these trees are shown in **Figure 7.69**. The nationally Critically Endangered crested serpent eagle (*Spilornis cheela*) is still considered moderately rare in Singapore. The population was reported to remain stable with no increase or decrease in ranges and abundance (Lim & Yong, 2013). There were two incidental records of it flying overhead (**Figure 7.69**). While nesting of this species was not observed, large trees within the EIS Study Area provide nesting opportunities for this species. The other birds of prey that are of conservation significance, namely the grey-headed fish eagle (*H. ichthyaetus*) and spotted wood owl (*S. seloputo*), also nest in tall trees. The spotted wood owl, in particular, tends to use bird's nest ferns (*Asplenium nidus*) on tall trees as nests. The EIS Study Area provides plentiful nesting opportunities for this species. The grey-headed fish eagle, however, is unlikely to nest in the EIS Study Area as it prefers areas adjacent to large waterbodies such as quarry lakes, reservoirs and marshes (Yong et al., 2017). Aside from the birds of prey, the threatened parrots, namely the long-tailed parakeet (*P. longicauda*) and blue-crowned hanging parrot (*L. galgulus*) also rely on large trees, living or dead, as nesting grounds within the EIS Study Area. These birds nest in cavities in tree trunks.

The nationally Critically Endangered blue-eared kingfisher (*Alcedo meninting*) prefers forested habitats near streams such as the one where it was recorded during the field assessment. It was recorded once during a nocturnal survey where it was perched above the stream and sleeping (**Figure 7.69; Figure 7.70B**). Blue-eared kingfishers nest in burrows on the banks of forest streams (Yong et al., 2016). Although nesting was not recorded in the field assessment, the forest streams are deemed as suitable nesting grounds. The stream where the species was recorded is therefore a habitat of interest for this species (**Figure 7.69**).

The nationally Critically Endangered black-crowned night heron (*Nycticorax nycticorax*) was recorded once in a puddle along the track beyond the boundary of EIS Study Area (**Figure 7.69**). The outlook for the conservation of the species appears bleak as disturbance to nesting sites has threatened the national population (Yong et al., 2016). No nesting/roosting sites were observed in the EIS Study Area. However, it is possibly using the site as a foraging ground (such as the canal) and as a stepping stone to move between green spaces.

The nationally Endangered red-wattled lapwing (*Vanellus indicus*) was frequently encountered during the field assessment at the scrubland and herbaceous vegetation patches (**Figure 7.69**). Juveniles were also observed **(Figure 7.70C**), indicating the existence of a breeding population at the EIS Study Area. Red-wattled lapwings use shallow scrapes on rocky ground as nests, preferably near waterbodies and obscured by scrubby vegetation (Yong et al., 2016). The western part of Singapore is known to be a stronghold of the species (Yong et al., 2016). However, the population may be threatened by the rapid loss of habitat as a result of the ongoing and upcoming developments. Habitats of conservation interest for this species are indicated in **Figure 7.69**.

The plume-toed swiftlet (*Collocalia affinis*) was previously recognized as the nationally Critically Endangered glossy swiftlet (*C. esculenta*). As its scientific name was updated in 2017 (Rheindt et al., 2017), its conservation status is not reflected in the Singapore Red Data Book (Davison et al., 2008). Yong et al. (2016) noted that it appears to be localized to the Bukit Batok and Bukit Timah areas, where they are likely to be nesting in a drain culvert. Therefore, it likely remains as a threatened species and is regarded as a notable record in this study. It was recorded on two occasions near the central part of the EIS Study Area (**Figure 7.69**), where flocks of at least 10 individuals were seen.

The blue-winged pitta is listed as an uncommon migrant breeder. It is listed as "Not Assessed" in the SRDB and "Least Concern" on IUCN Red List. There were several records of this bird on a camera trap (CT_12) in May, well after the migratory season had ended (September to March) (**Figure 7.70D**). This could be an indication that a breeding population exists within the EIS Study Area. Low et al. (2016) reported that blue-winged pittas have been heard calling at "western Singapore, around the periphery of a military training area" between late April and July since 2008. Currently, the only confirmed local breeding record of this species is from Pulau Ubin (Low et al., 2016). This makes it a notable species record for the EIS Study Area. Blue-winged pittas nest on the ground among the dense vegetation of the forest understorey. The abandoned-land forest patches in the EIS Study Area provide suitable breeding habitats for this species, as well as other ground-nesting birds of conservation significance including the red junglefowl (*Gallus gallus*) and red-legged crake (*R. fasciata*) that require similar habitat conditions.



Figure 7.70: Birds of Conservation Significance Recorded in this EIS. (A) changeable hawk-eagle (*Nisaetus cirrhatus*; juvenile in nest), (B) blue-eared kingfisher (*Alcedo meninting*), (C) red-wattled lapwing (*Vanellus indicus*; juvenile), (D) blue-winged pitta (*Pitta moluccensis*)

7.3.4.11 Non-volant Mammals

A total of 17 species of non-volant mammals were deemed of probable occurrence, including 4 species of conservation significance (**Table 7.15; Appendix 7B**). Most of the species of probable occurrence are widespread, common, and tolerant of disturbance. However, species with restricted distributions, such as the Annandale's rat (*Rattus annandalei*) and slender squirrel (*Sundasciurus tenuis*), were also expected to occur based on past records. Visual encounter surveys and camera trapping documented nine species of non-volant mammals (**Table 7.19; Appendix 7B**). Mammal richness was generally low across the EIS Study Area, with only one to three species recorded at each 100-m interval along the terrestrial sampling routes (**Figure 7.71**). The Sunda Pangolin (*M. javanica*) and the feral dog (*Canis lupus familiaris*) were only recorded via camera trapping while the rest of the non-volant mammal species were also recorded during the visual encounter surveys.

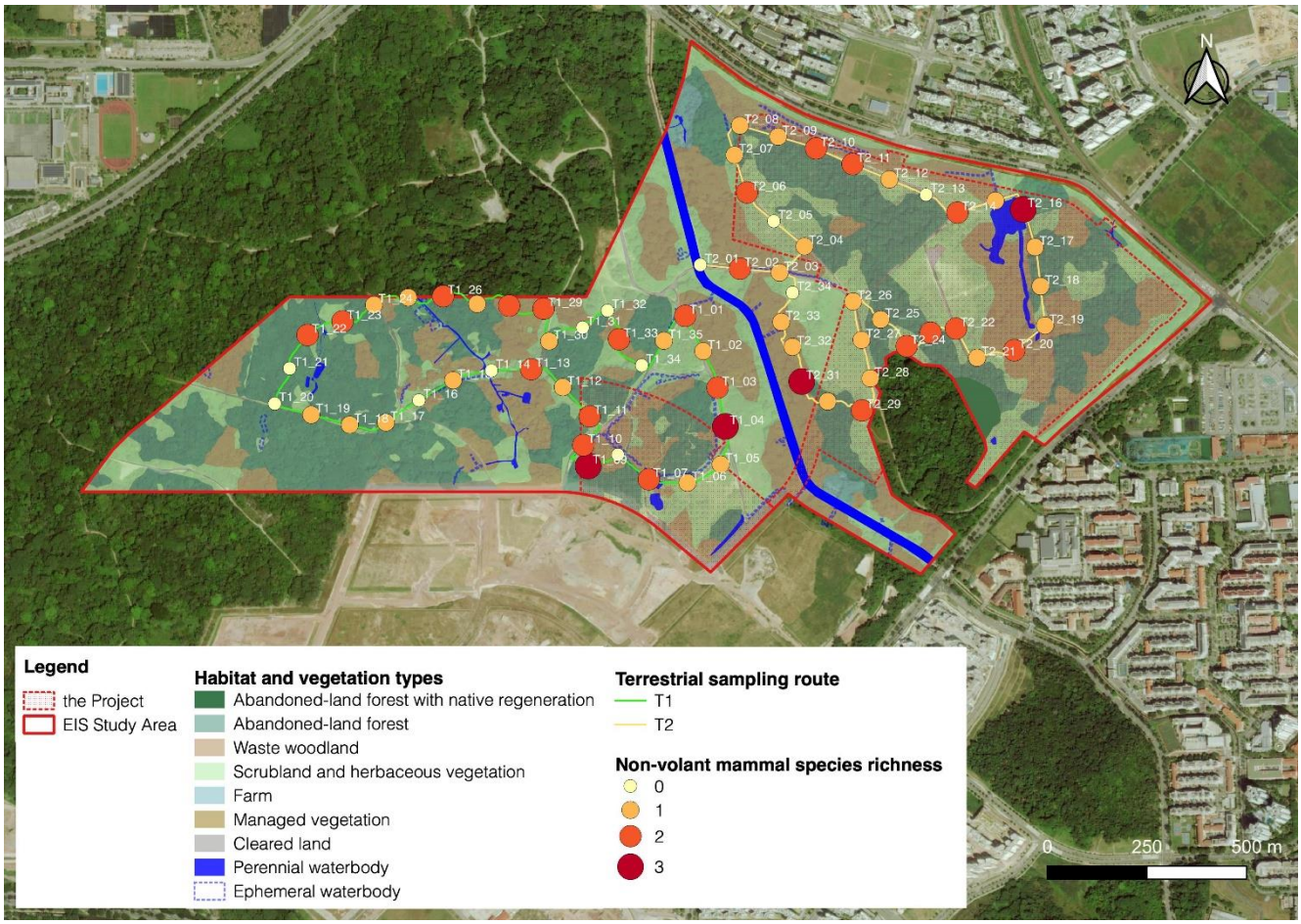


Figure 7.71: Number of Non-Volant Mammalian Species Recorded at Each 100-M Interval Along the Terrestrial Sampling Routes, Excluding Incidental Records

Base Map: ESRI

There were six independent records of the globally and nationally Critically Endangered Sunda Pangolin (*M. javanica*) on the camera traps (CT_09, CT_11, CT_12, CT_14, CT_18; **Figure 7.72; Figure 7.73A).** These camera traps were mostly on the western half of the EIS Study Area. The species has been recorded from the nature reserves and degraded forest fragments in Singapore (Nash et al., 2020). Notably, Singapore is a global stronghold for the species and is crucial in contributing to the conservation of pangolin populations globally. Unlike other countries where it ranges, it faces low poaching pressure in Singapore (Lee et al., 2018; Nash et al., 2020). Yet, habitat loss, degradation and fragmentation, and road kills threaten the viability of the national population (Lee et al., 2018). This species requires wooded areas to move across the landscape.

The nationally widespread and common long-tailed macaque (*M. fascicularis*; **Figure 7.73B**) was recently up-listed as a globally vulnerable species as a result of human persecution across the rest of South-east Asia (Eudey et al., 2020). Based on the field assessment, there is likely a resident troop that was recorded only on the western half of the EIS Study Area (**Figure 7.72**), which is dominated by fruit trees planted by villagers in the past, and serves as an abundant food resources for the macaques.

The slender squirrel (*Sundasciurus tenuis*) is considered a notable record in this study because it is a forest-dependent species with a distribution that is restricted to the CCNR, Bukit Batok Nature Park, and Singapore Botanic Gardens (Baker & Lim, 2012). Although its presence beyond these localities is not recorded in published reports, it was recorded within the Tengah site in the J1002 EIS (2016), J1001 EIA (2017), and Tengah EBS (2017) and hence was deemed a probable species. Three records were obtained across the EIS Study Area during the field assessment, in areas dominated by abandoned-land forest here its food resources (e.g. fruits) are

abundant. The population here could be a remnant one that managed to survive after the Tengah site was cut off from Bukit Batok Nature Park and the CCNR. The species could also have utilized the forest patches in the vicinity as stepping stones to reach the Tengah site. Regardless, its presence is a good indication of the forest quality for forest-dependent species within the EIS Study Area.

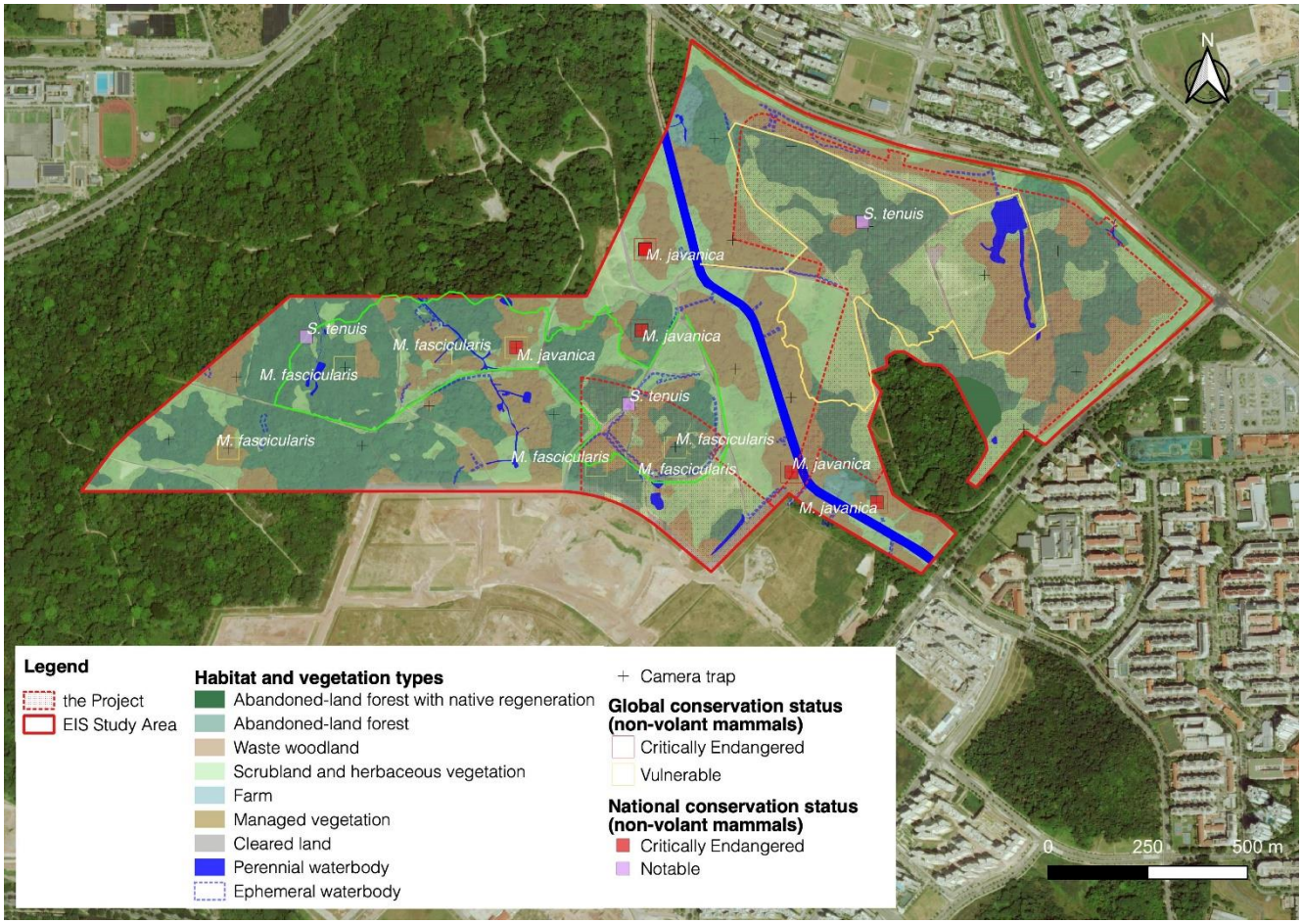


Figure 7.72: Locations of Non-Volant Mammalian Species of Conservation Significance

Base Map: ESRI



Figure 7.73: Mammals of Conservation Significance Recorded in This EIS (A) Sunda pangolin (*Manis javanica*), (B) long-tailed macaque (*Macaca fascicularis*)

The 26 camera traps yielded 2354 independent detections and 8 species of non-volant mammals over 1267 trap-nights (**Table 7.19; Table 7.20**).

The most commonly recorded non-volant mammalian species was the wild pig (*Sus scrofa*), with 1565 independent detections across all the camera traps. Rats (*Rattus* sp.) were also frequently recorded with 337 independent detections. The highest non-volant mammal species richness (six species) was recorded at CT_05, CT_07, CT_09, CT_11, CT_12, CT_14 that were all situated within the western half of the EIS Study Area (**Figure 7.74**). This part of the EIS Study Area is dominated by abandoned-land forest with closed canopy, which provides ample food and shelter for a diversity of non-volant mammals, including forest-dependent species like the Sunda Pangolin (*M. javanica*). The high species richness here could also be attributed to the fact that this part of the EIS Study Area is contiguous with the larger forested Tengah site, unlike the eastern half which is cut off by the canal and largely inaccessible for non-volant mammals.

Table 7.19: Locations and Number of Independent Detections of Non-Volant Mammals

Scientific Name	Common Name	Station	No. of Independent Detections
Callosciurus notatus	Plantain squirrel	All (01–26 except for 04, 11, 15)	242
Canis lupus familiaris	Feral dog	08	1
Macaca fascicularis	Long-tailed macaque	02, 05, 07, 09, 10, 11	11
Manis javanica	Sunda pangolin	09, 11, 12, 14, 18	7
Paradoxurus musangus	Common palm civet	03, 04, 05, 07, 09, 11, 12, 14, 15, 26	22
***Rattus* sp.**	Unidentified rat	03, 05, 07, 09, 10, 11, 12, 13, 14, 17, 18, 20, 21, 23, 24, 26	337
Sus scrofa	Wild pig	All (01–26)	1,565
Tupaia glis	Common treeshrew	03, 05, 06, 07, 10, 11, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26	169
		Total	**2,354**

Table 7.20: Number of Species and Detection Rate of Non-volant Mammals Recorded at Each Camera Trap

Station	No. of Trap-nights	No. of Species	Detection Rate
CT_01	57	2	1.19
CT_02	57	3	1.19
CT_03	51	5	3.71
CT_04	56	2	2.00
CT_05	42	6	2.40
CT_06	57	3	0.26
CT_07	46	6	3.91
CT_08	57	3	0.28

Station	No. of Trap-nights	No. of Species	Detection Rate
CT_09	57	6	1.11
CT_10	54	5	0.85
CT_11	57	6	1.18
CT_12	40	6	2.75
CT_13	2	3	2.50
CT_14	56	6	2.63
CT_15	57	2	0.26
CT_16	49	3	0.96
CT_17	49	4	0.47
CT_18	49	5	1.49
CT_19	9	3	1.11
CT_20	43	4	8.33
CT_21	63	4	1.90
CT_22	49	3	1.90
CT_23	49	4	2.27
CT_24	49	4	2.12
CT_25	63	3	2.38
CT_26	49	5	1.29

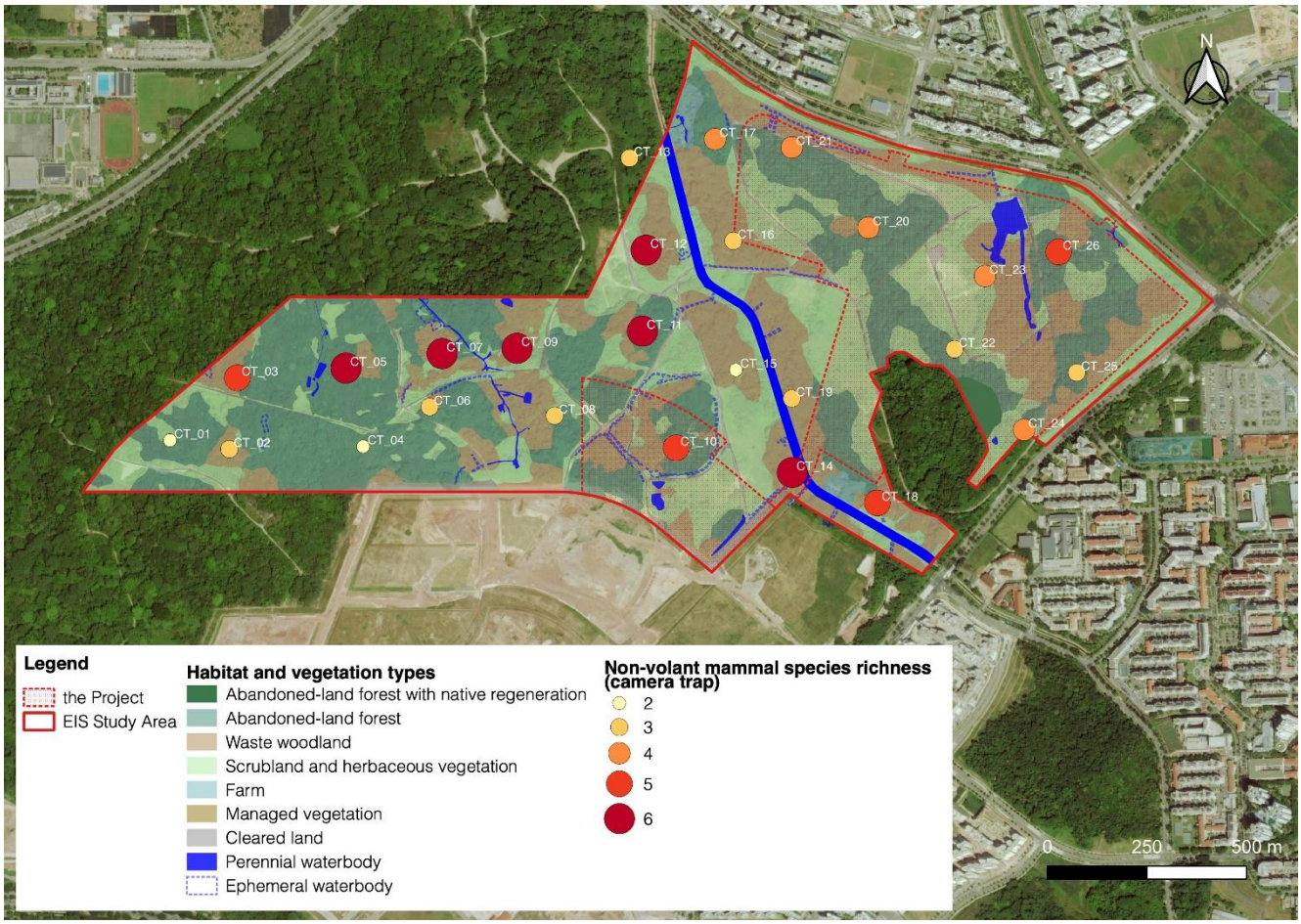


Figure 7.74: Number of Non-Volant Mammalian Species Recorded at Each Camera Trap

Base Map: ESRI

7.3.4.12 Bats

Only 11 bats were deemed of probable occurrence within the EIS Study Area and 8 were recorded (**Table 7.15; Appendix 7B**). Only the lesser dog-faced fruit bat (*Cynopterus brachyotis*), large flying fox (*Pteropus vampyrus*) and bamboo bat (*Tylonycteris* spp.) was recorded visually and the rest were insectivorous bats recorded via acoustic sampling (**Figure 7.75**). One individual of the large flying fox (*P. vampyrus*) was seen on Jul 2, 2020 just beyond the northern part of EIS Study Area boundary. It was recorded at dusk as it was flying overhead. This species used to exist in large numbers, but presently, only appears occasionally in Singapore as a visitor (Lane et al., 2006). Prior to this sighting, a large colony of more than 100 flying foxes was also seen in June 2020 at the CCNR (Tan, 2020).

Bat species richness was distinctively higher in the western half of the EIS Study Area where the vegetation type is dominated by abandoned-land forest and probably has greater insect prey availability (**Figure 7.76**).

One of the recorded species, the black-bearded tomb bat (*Taphozous melanopogon*), is a nationally Endangered species that may be found in forested or urban areas and is considered widespread but rare (Baker & Lim, 2012). 43 bamboo clusters were examined for their (potential) use by bamboo bats (*Tylonycteris* spp.). Of these, bamboo bats (*Tylonycteris* spp.) were found roosting within six bamboo clusters across the EIS Study Area (**Figure 7.77; Figure 7.78**). They were also recorded visually or acoustically at 14 bamboo clusters, and a further 12 bamboo clusters were determined as potential roosting sites although no bamboo bats were recorded. The acoustic signatures of the nationally Critically Endangered lesser bamboo bat (*T. fulvida*) and the widespread and common greater bamboo bat (*T. malayana*) overlap, making it difficult to distinguish the identity of our records and determine if they are of conservation significance. Nevertheless, both species are known to roost in

bamboo internodes and are especially susceptible to injury or mortality if their roosts are removed/damaged during developments. Hence, the bamboo bat is regarded as a notable record in this study. Habitats of interest for bamboo bats include clusters at which roosting was confirmed and where roosting was not confirmed but bamboo bats were recorded. Additionally, clusters that were determined as potential roosting sites are also habitats of interest as bamboo bats are known to switch roosts and utilize multiple bamboo clusters (Zhang et al., 2004) The habitats of interest for bamboo bats are shown in **Figure 7.79**.

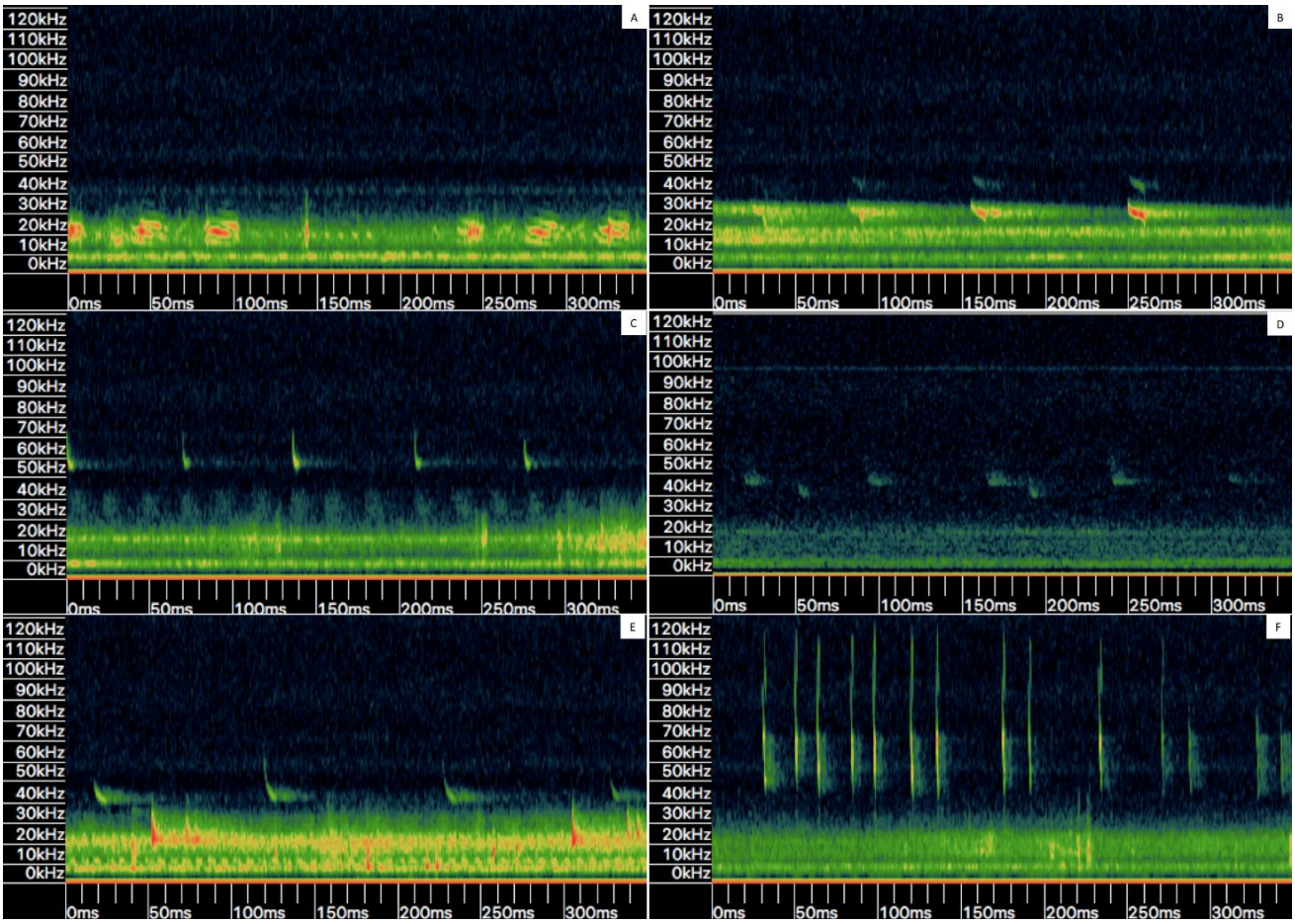


Figure 7.75: Spectrogram of Echolocation Calls from Insectivorous Bats Recorded in this EIS. (A) Pouch-bearing bat (*Saccolaimus saccolaimus*), (B) Black-bearded tomb bat (*Taphozous melanopogon*), (C) Whiskered myotis (*Myotis muricola*), (D) Javan pipistrelle (*Pipistrellus javanicus*), (E) Asiatic lesser yellow house bat (*Scotophilus kuhlii*), (F) bamboo bat (*Tylonycteris* sp.).

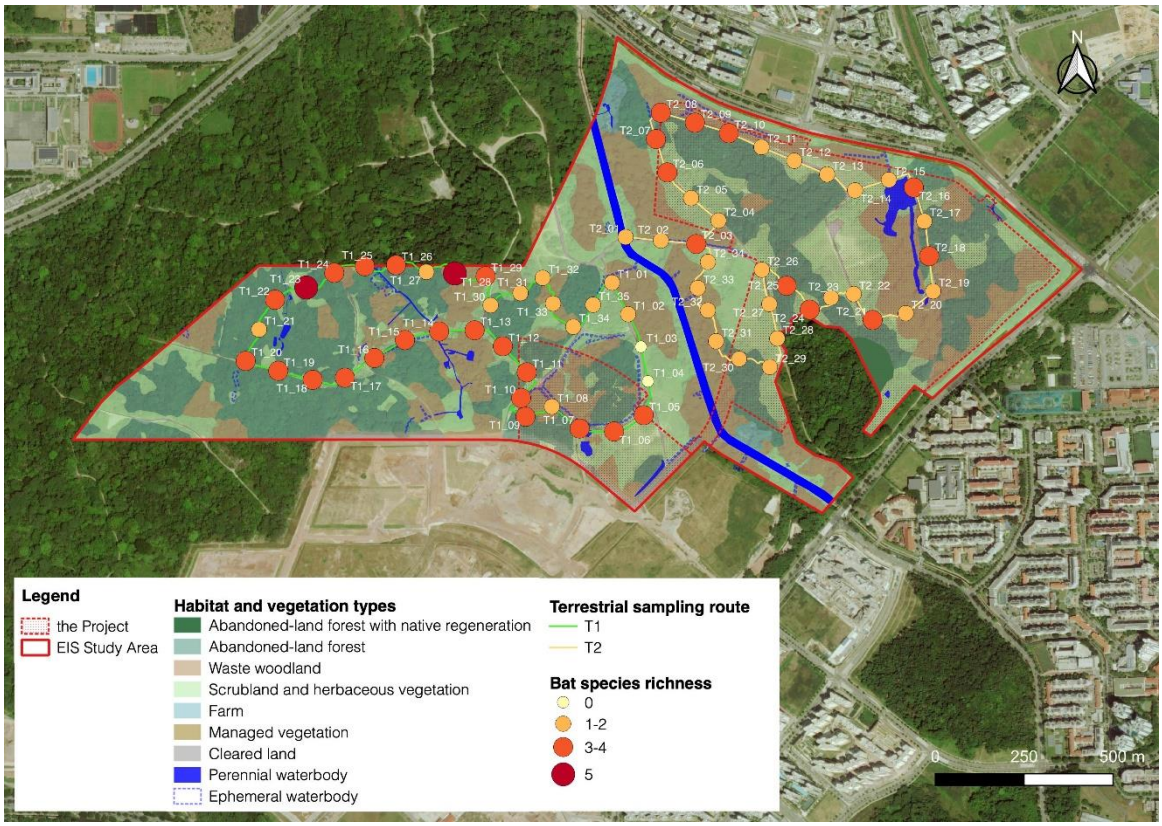


Figure 7.76: Number of Bat Species Recorded at Each 100-M Interval along the Terrestrial Sampling Routes, Excluding Incidental Records

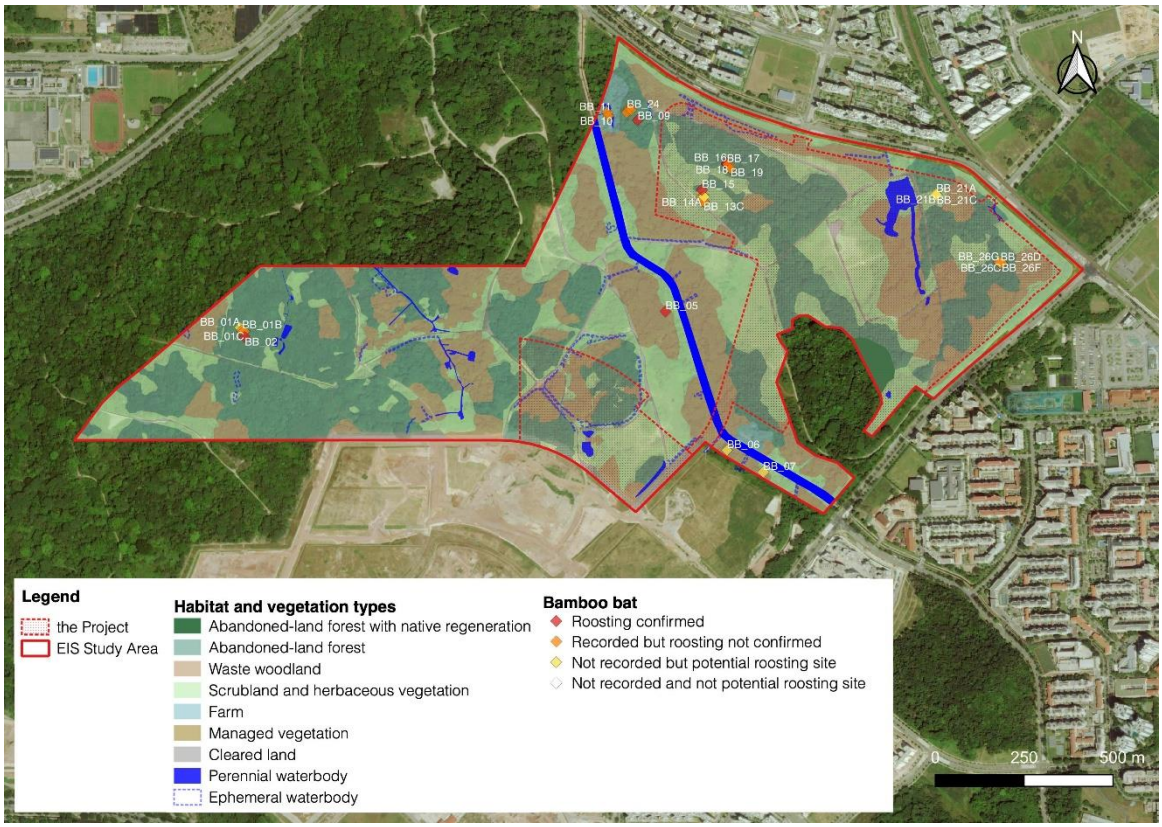


Figure 7.77: Observations of Bamboo Bats at Bamboo Clusters during Roost Emergence Surveys

Base Map: ESRI



Figure 7.78: A Bamboo Bat (*Tylonycteris* sp.) Roosting within a Bamboo Internode Recorded during a Roost Emergence Survey

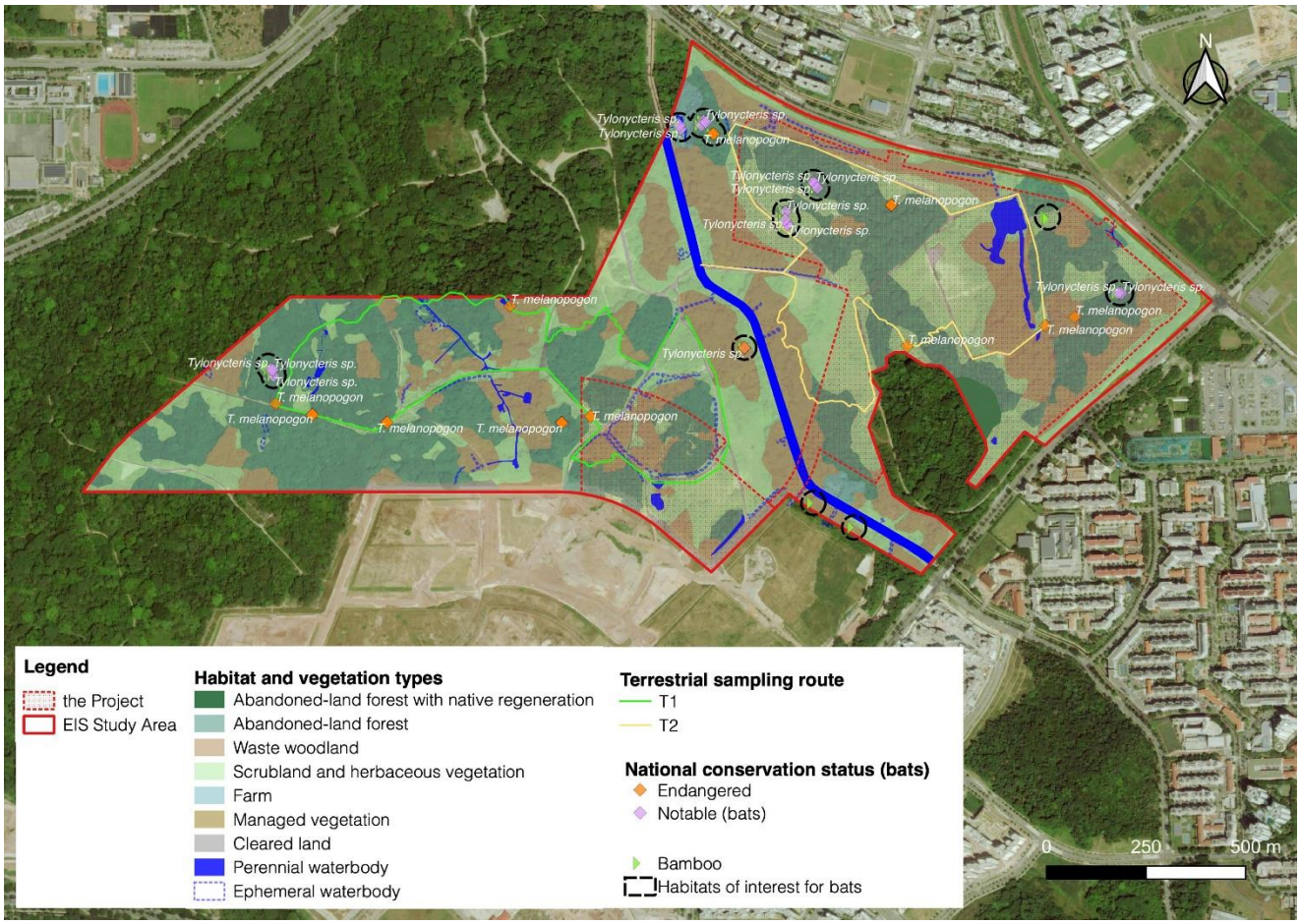


Figure 7.79: Locations of Bat Species of Conservation Significance and Habitats of Conservation Interest for Bats

Base Map: ESRI

7.4 Assessment of Ecological Value

The ecological value of habitats and species within the EIS Study Area were categorised based on the criteria described in **Table 7.21** and **Section 7.4.2** respectively (EPD, 2011). Habitats or species with higher ecological value were regarded of higher importance for conservation, relative to other habitats or species respectively, within the EIS Study Area. Features with no conservation importance are rated as 0.

Table 7.21: Criteria used in Assessing the Ecological Value of a Habitat

Criterion	Definition
Naturalness	The degree to which a habitat is free from modification or disturbances from man (i.e. man-made, naturalised and natural). • In a *terrestrial habitat*, it is indicated by species composition. A man-made habitat is created; a naturalised habitat is dominated by exotic plant species; a natural habitat is dominated by native plant species. • In an *aquatic habitat*, it is indicated by the extent of human modification or disturbances. A man-made habitat is created; a naturalised habitat is modified by human actions; a natural habitat is largely pristine and not affected by human actions.
Size	The physical space/area occupied by a habitat within the Study Area. Assuming all else are equal, larger areas can support more resources, species, and populations, thus have higher carrying capacity and ecological value.
Rarity	The frequency at which a certain habitat is observed locally or globally. The less common the habitat, the higher its rarity. The local assessment takes priority as it has greater relevance. Rarer habitats are usually harder to recreate, thus have higher ecological value.
Ecological Linkage	The value of a habitat increases if it lies in close proximity and/or links functionally to a highly valued habitat of any type.
Large Specimens and Other Specimens of Value	The number of large specimens and other specimens of value. Habitats with higher number of these specimens have higher ecological value.
Native Species	Number of native floral and faunal species, and number of individuals of these species in a habitat. A habitat with higher number of native species and/or more individuals of these species has higher ecological value.
Species of Conservation Significance	Number of species of conservation significance or other faunal species of value, and number of individuals of these species in a habitat. A habitat with higher number of these species and/or more individuals of these species has higher ecological value.

7.4.1 Habitat Evaluation

Within the EIS Study Area, nine habitats were assessed. Three habitats, the abandoned-land forest with native regeneration, abandoned-land forest and closed-canopy streams (ED2 and ED7) have high ecological value. Four habitats, the waste woodland, scrubland and herbaceous vegetation, open-country ponds (Pond1 and Pond2), and open-country streams have medium ecological value. The other closed-canopy and semi open-country ponds and canal have low ecological value. The assessment of the ecological value of each habitat is described below and summarised in **Table 7.22**.

Table 7.22: Assessment of Ecological Value of each Habitat Type within the EIS Study Area

Criterion/ Habitats Type within EIS Study Area	Abandoned-land Forest with Native Regeneration	Abandoned-land Forest	Waste Woodland	Scrubland and Herbaceous Vegetation	Closed-canopy Streams (ED2 and ED7)	Open-country Streams (Spring, ED1, ED6 and ED8_01)	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	Open-country Ponds (Pond1 and Pond2)	Main Canal
Ecological Value	**High**	**High**	**Medium**	**Medium**	**High**	**Medium**	**Low**	**Medium**	**Low**
Naturalness	Natural	Naturalised	Naturalised	Naturalised	Natural	Natural	Man-made	Naturalised	Man-made
Size (% of Study Area)	1.0 ha (0.6 %)	57.2 ha (34.5 %)	45.5 ha (27.4 %)	51.6 ha (31.1%)	0.46 ha	1.26 ha	0.19 ha	0.12 ha	3 ha
Rarity	High	Medium	Low	Low	High	Medium	Low	Medium	Low
Ecological Linkage	High	High	High	High	Low	Low	Low	Low	Low
Large Specimens and Other Specimens of Value	Low	High	Medium	Low	N.A.	N.A.	N.A.	N.A.	N.A.
Native Species	Flora: Low Fauna: N.A.	Flora: High Fauna: High	Flora: Intermediate Fauna: High	Flora: Low Fauna: High	Flora: Low Fauna: Intermediate	Flora: Low Fauna: Low	Flora: Low Fauna: Low	Flora: Low Fauna: Intermediate	Flora: Low Fauna: Low
Species of Conservation Significance	Flora: High Fauna: N.A.	Flora: High Fauna: Intermediate	Flora: Intermediate Fauna: High	Flora: Low Fauna: Intermediate	Flora: Low Fauna: Intermediate	Flora: Low Fauna: Low	Flora: Low Fauna: None	Flora: Low Fauna: None	Flora: None Fauna: None

Habitat Assessed with *High* Ecological Value
a) Abandoned-Land Forest with Native Regeneration This forest patch occupies 1.0 ha (0.6%) within the EIS Study Area. Natural populations of the Vulnerable (*Litsea firma*), several saplings of the Vulnerable *Ficus aurata* var. *aurata* and clusters of the Critically Endangered *Connarus semidecandrus* are present here. This forest harbours native species assemblage and several tall, mature trees. The forest type is also contiguous with other vegetation types, and provides high value in ecological linkage. Native plant species that is present and actively recruiting, supports faunal diversity, particularly butterflies, which are dependent on native floral host or food plants, thus have conservation value. Therefore, this forest type has high ecological value.
b) Abandoned-land Forest Abandoned-land forest is an uncommon habitat type in Singapore and not easily being created. It occupies 57.2 ha and is the most expansive vegetation type (34.5%) within the EIS Study Area. This habitat is mainly dominated by exotic fruit trees and crop plants cultivated in the past. Despite that, majority of the nationally threatened plant species recorded within the EIS Study Area resides within this habitat type. This vegetation type harbours the highest number of native species (61 species) and conservation significant plant species (33 species, 1078 individuals) across all vegetation types. A cluster of Endangered *Ficus apiocarpa* was only recorded in this vegetation type in the western part of the EIS Study Area. This vegetation type also comprises the highest density of large specimens (3.9 individuals per ha). In addition, two large stranglers of 30-m and 50-m spread were documented. Features of such size are uncommonly encountered and have conservation value. A high number of faunal species (16 species) and species of conservation significance (1 species) were recorded per point along terrestrial sampling routes. Rare and restricted species of conservation significance were recorded, including the Critically Endangered Sunda pangolin (*Manis javanica*) and spotted wood owl (*Strix seloputo*). Three bamboo clusters were confirmed as roosting sites for bamboo bats and nine had bamboo bat records although roosting was not confirmed. An additional three clusters were considered potential roosting sites although bamboo bats were not recorded. The abandoned-land forest exists in patches distributed across the EIS Study Area, and is contiguous with other vegetation types – scrubland and herbaceous vegetation and waste woodland. Therefore, it is of high value in terms of ecological linkage, allowing floral and faunal species to disperse or move across the EIS Study Area. Therefore, the abandoned-land forest has high ecological value.
c) Closed-canopy Streams ED2 and ED7 are closed-canopy streams, which measure 0.46 ha. Such natural stream habitats are uncommon in Singapore and not easily recreatable. The waterbody provides connectivity for aquatic species but is considered low in ecological linkage as it is not observed to be directly connected to larger waterbodies. The streams are characterised with low floral richness and low numbers of species of conservation significance. The vegetation type present around the stream is associated with the vegetation types that it is located within. It is also characterised by an intermediate number of native faunal species (5 species) and species of conservation significance (0.4 species) per aquatic sampling point. Species recorded were largely common and widespread. Yet, some of these streams support fish and odonate species that are considered uncommon or rare. The ED2 stream provides habitat for the nationally vulnerable variable featherlegs (*Copera vittata*), endangered dwarf wisp (*Agriocnemis nana*) and the common walking catfish (*Clarias cf. batrachus*), which has seen a decline in its local population in recent years. Similarly, a relatively high number of common walking catfish (*Clarias cf. batrachus*) was observed within the ED7 stream. Therefore, these streams were considered to have high ecological value.

Habitat Assessed with *Medium* Ecological Value

a) Waste Woodland

Waste woodland is a common and easily recreatable habitat in Singapore. Waste woodland occupies 45.5 ha (27.4 %) within the EIS Study Area. Like for the abandoned-land forest, the waste woodland patches are contiguous with other vegetation types, and provide high value in ecological linkage.

This vegetation type ranks low in richness of native species and conservation significant plant species, with only 32 native species, and 29 species with 444 individuals of conservation significant plant species recorded. A native climber species, *Mucuna biplicata*, was encountered in the southern part of the site. This is believed to be a newly recorded species for Singapore. Currently, the conservation status of *Mucuna biplicata* is "Not Assessed" as no local records are presented in Chong et al. (2009). Therefore, Tengah could be the first and only location of this species in Singapore. In addition, a cluster of the Critically Endangered *Leea angulata* was also recorded in the northern part of the EIS Study Area. Individuals with girth size of >1 m were also recorded. This vegetation type also ranks second in density of large specimens (1.0 individuals per ha). Two large strangers and one tree with raptor nest are present here.

The highest number of faunal species richness (17 species) and species of significance (1.6 species) were recorded per point along terrestrial sampling routes. The Sunda pangolin (*Manis javanica*) was recorded mostly recorded within this vegetation type (4 out of 5 locations). One bamboo cluster was confirmed as a roosting site for bamboo bats and an additional two clusters were considered potential roosting sites although bamboo bats were not recorded. Therefore, the waste woodland has medium ecological value.

b) Scrubland and Herbaceous Vegetation

Scrubland and herbaceous vegetation is commonly encountered in Singapore. It occupies 51.6 ha (31.1 %). It mostly occupies the forest edges where temperature and light levels are higher, although there are also small, scattered patches within the forest. Like for the abandoned-land forest, the waste woodlands are contiguous with other vegetation types, and provides high value in ecological linkage. Though considered to be a highly disturbed habitat, some native and nationally threatened flora species were recorded.

This vegetation type ranks second in richness of native species and conservation significant plant species. It recorded 33 native species and 15 species (207 individuals) of conservation significant plant species. A cluster of *Glochidion zeylanicum*, with specimens of girth size between 0.5 m and 0.9 m, was observed in this vegetation type. This vegetation type has the lowest density of large specimens (0.7 individuals per ha).

A high number of faunal species (15 species) and an intermediate number of species of conservation significance (1.1 species) were recorded per point along terrestrial sampling routes. Species present are generally common and widely distributed, with some rare and restricted species that favour such habitat types, including the red-wattled lapwing (*Vanellus indicus*) that prefers low vegetation cover. The rare Malay staff sergeant (*Athyma reta moorei*) was also recorded within this vegetation type, where a cluster of its host plant, the *Glochidion zeylanicum*, was also found. One bamboo cluster was confirmed as roosting sites for bats and two had bamboo bats records although roosting was not confirmed. An additional five clusters were considered potential roosting sites although bats were not recorded. Therefore, the scrubland and herbaceous vegetation type is considered medium ecological value.

c) Open-country Streams

Spring, ED1, ED6 and ED8_01 streams total to 1.25 ha. Such natural stream habitats are uncommon in Singapore and not easily recreatable. However, as compared to closed-canopy streams (ED2 and ED7 streams), these streams may be more common. The waterbody provides connectivity for aquatic species but is considered low in ecological linkage as it is not connected to larger waterbodies.

The streams are characterised with low floral richness and low numbers of species of conservation significance. The vegetation type present around the stream is associated with the vegetation types that it is located within. It is also characterised with a low number of native faunal species (two species). No

species of conservation significance were observed but may support common aquatic species. Therefore, the open-country streams have medium ecological value.
d) Open-country Ponds Pond1 and Pond2 are naturalised open-country ponds with no connection to a larger waterbody. They made up 0.12 ha. Species recorded here include the uncommon blue adjudant (*Aethriamanta aethra*) and scarlet adjudant (*Aethriamanta brevipennis*), typical of open pond habitats. A total of 20 faunal species can be found here although no conservation significant floral or faunal species were recorded. However, due to their large size, presence of lush vegetation and macrophytes, they are considered representatives and favourable habitats for aquatic faunal species associated with open-country pond habitats. Furthermore, they are the only open-country ponds that exists within the EIS Study Area, meaning that this habitat provides a unique ecological function that is not replaceable on site. The unique environment found here results in a high ecological value. Here, the recommendation of the U.S. Geological Survey's Gap Analysis Project (GAP; 2020) is followed, of "keeping common species common" before they become threatened and costly for conservation actions. It is important to recognize that both common and rare species contribute ecological functions in an ecosystem. Common species form a dominant structure and overall biomass in the ecosystems and therefore are disproportionately influential in shaping ecosystem functions (Gaston & Fuller, 2007; Lindenmayer et al., 2011; Walls, 2018; Winfree et al., 2015). Conservation of common species may also offer a protective umbrella for threatened species (Frimpong, 2018).
Habitat Assessed with *Low* Ecological Value
a) Closed-canopy and Semi-open Country Ponds The Pond6, Pond3, Pond4, Pond5, ED8_02 ponds measures at least 0.19 ha. They are isolated and not connected to a larger waterbody. No conservation significant floral or faunal species were recorded. Species recorded were common with widespread distribution. Therefore, these streams have low ecological value.
b) Main Canal The canal is a man-made habitat. No vegetation is present within the canal. Low faunal richness and no conservation significant floral or faunal species were recorded. Species recorded were common with widespread distribution. Therefore, the canal has low ecological value.

7.4.2 Species Evaluation

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

- High ecological value: Species of conservation significance (**Section 7.2.1.3**)
- Medium ecological value: All other native species
- Low ecological value: Exotic and cryptogenic species

Plant species that were tentatively assigned medium (all other native species) or low (exotic and cryptogenic species) ecological value were then evaluated individually based on the criteria listed in **Table 7.23**. The evaluation of individual species served to either maintain or raise the pre-assigned ecological value. The following paragraphs detail how each criterion was considered in the further evaluation of plant species.

Association with important fauna (native, exotic, and cryptogenic species): The ecological value of plant species that directly support the growth and survival of important fauna at one or various life cycle stages were

raised to high, irrespective of plant species origin, cultivation intensity and effects, as well as national distribution. Examples of such plant species include caterpillar host plants for rare butterfly species and bamboos that are refugia for nationally threatened bamboo bats. The ecological value of plant species without associations with important fauna was maintained at the original level, i.e. medium or low.

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

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

There are, however, a few exceptions in which the highest ecological value was automatically assigned to species regardless of the criteria listed below. They are (1) species endemic to Singapore, (2) keystone fig species (*Ficus* sp.) as they fruit all year round and provide a steady source of food for frugivores (Lok et al., 2013), and (3) species planted for reforestation and/or previously thought to be extinct and are planted for species reintroduction. Additionally, the exotic rain tree (*Samanea saman*) was also automatically raised from low to medium ecological value given that it often supports the growth of epiphytes that provide habitats for fauna.

Table 7.23: Criteria for Assessing the Ecological Value of Plant Species

Criterion	Definition
Conservation Significance	Listed as nationally threatened, i.e. Vulnerable, Endangered, Critically Endangered, or Extinct, and are considered of conservation significance in this EIS.
Cultivation Intensity and Effects	Cultivated previously or presently for various purposes such as reforestation, landscaping, species reintroduction, commercial sale, etc., and populations of relics and/or escapees are present/absent in forests.
National Distribution	Extent of spread and/or occurrence at one or multiple forest patches in Singapore.

7.5 Recommended Area of Conservation

7.5.1 Preliminary Recommended Area of Conservation

The entire EIS Study Area has ecological importance as detailed in **Section 7.3.1**. However, a preliminary recommended area of conservation (RAC) was identified within the EIS Study Area to prioritise conservation efforts. It was determined based on key considerations including:

i) ecological connectivity within the EIS Study Area and to surrounding green spaces
ii) the presence of high ecological value habitat and species
iii) the potential for sustaining biodiversity

Ecological connectivity is of paramount importance for the dispersal of flora and fauna, including species of conservation significance, such as the Sunda pangolin (*Manis javanica*) and straw-headed bulbul (*Pycnonotus zeylanicus).* Existing habitats and ecological features within the preliminary RAC are proposed to be fully retained, i.e. no construction works are expected to occur in these areas. The total area with conservation value amounts to 68.8 ha and represents 41.5% of the EIS Study Area.

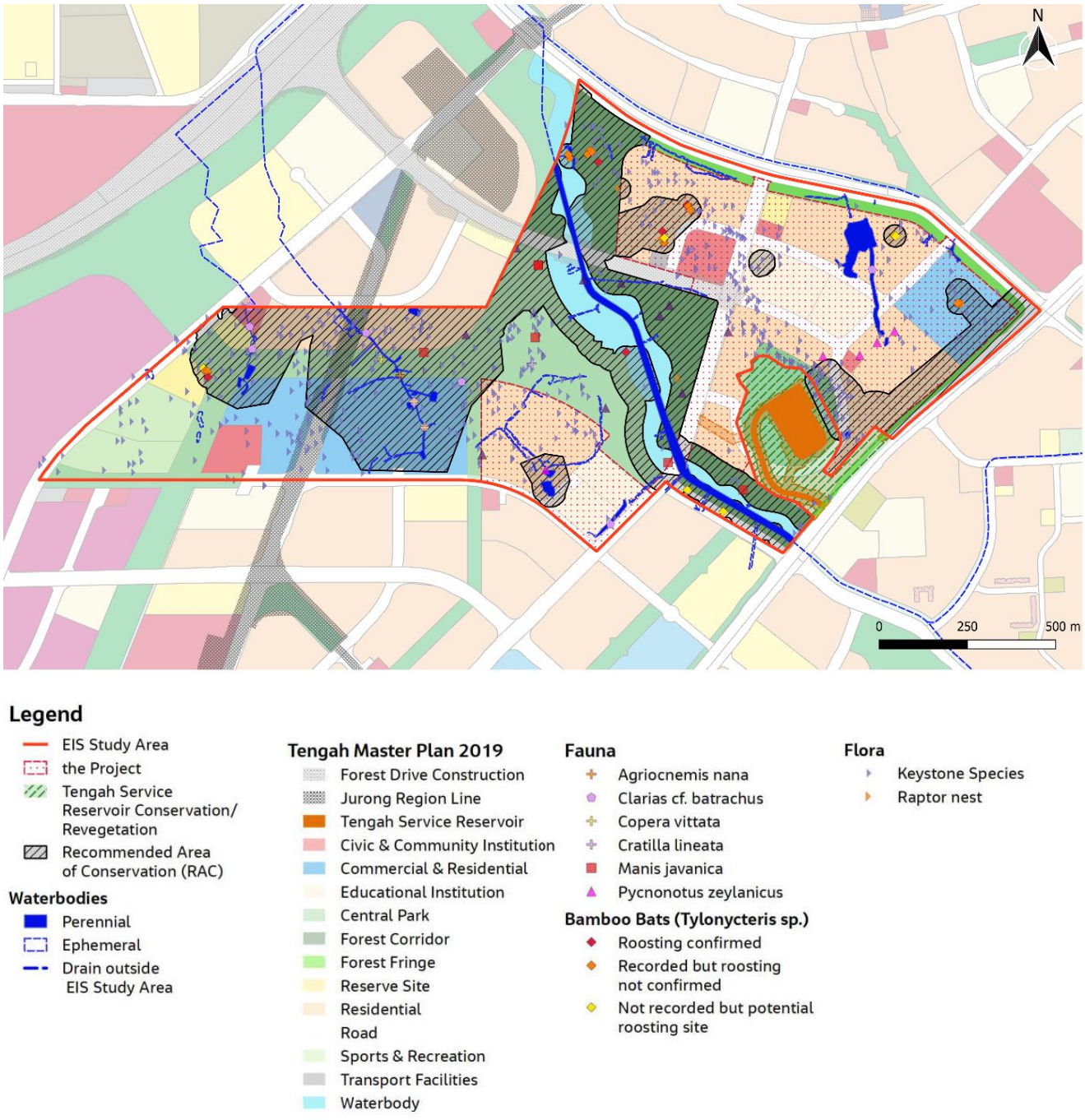


Figure 7.80: Preliminary Recommended Area of Conservation within EIS Study Area (Shaded in Black)

Source: URA

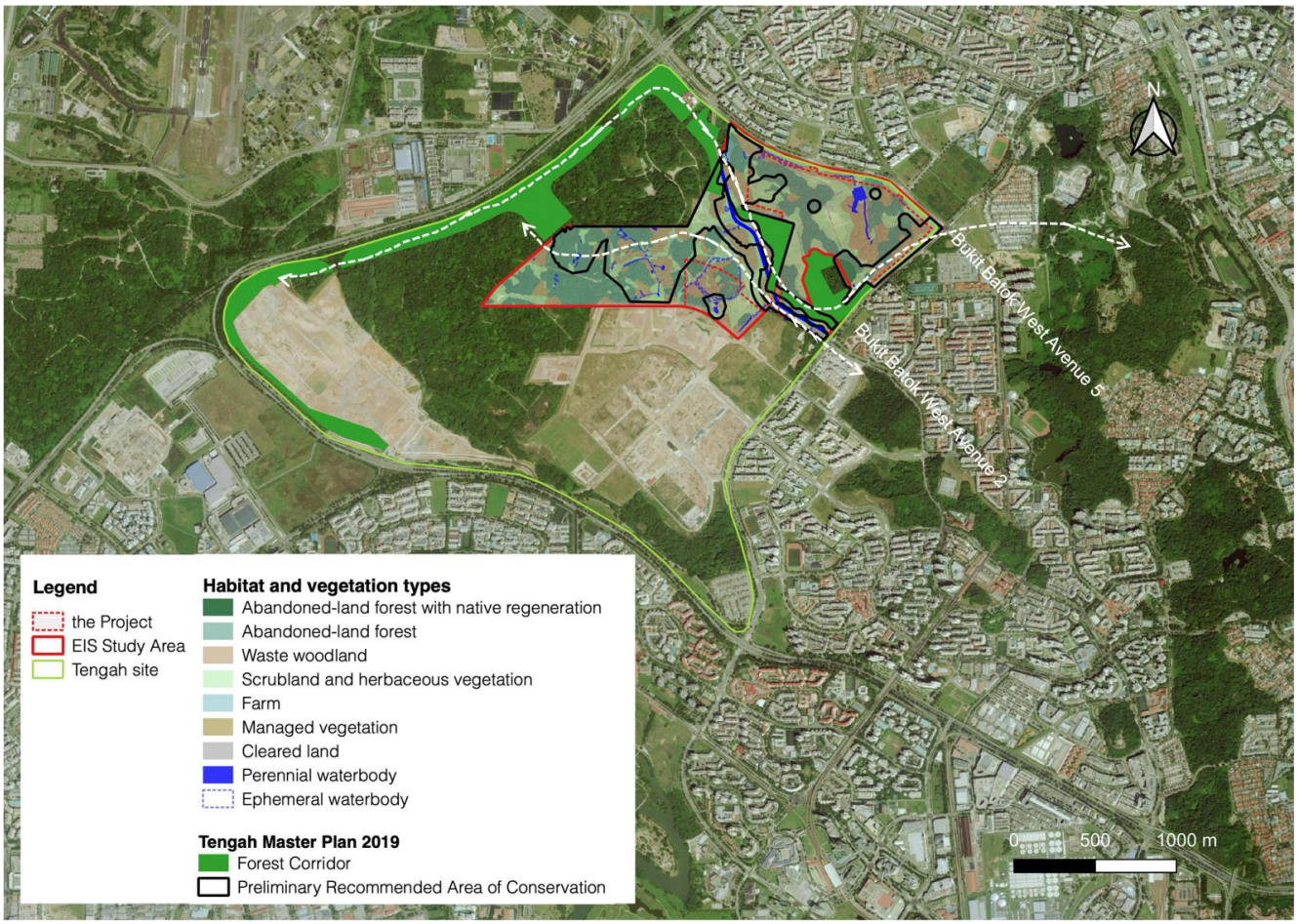


Figure 7.81: Connectivity of Preliminary Recommended Area of Conservation with the Surrounding Forested Areas. White arrows show potential connectivity through the site.

Base Map: ESRI

Two areas important for ecological connectivity were highlighted. Firstly, the vegetation on both sides of the canal/ proposed Forest Stream is of high conservation value. These areas adjoin and enhances the connectivity of the larger green network around Tengah Town, and to the forests in Bukit Batok and Bukit Gombak, situated east of the EIS Study Area. A 17.7 ha and 38.9 ha of vegetation is delineated on the eastern and western banks of the proposed Forest Corridor, respectively, as part of the preliminary RAC. The vegetation to the east of the canal is characterised with scrubland and herbaceous vegetation. It falls within the proposed Forest Corridor and includes the clusters of Critically Endangered *Leea angulata*, Vulnerable *Glochidion zeylanicum* var. *zeylanicum*, clusters of common native orchid *Spathoglottis plicata*, trees with raptor nest and bamboo clusters with roosting bamboo bats. The *G. zeylanicum* is a host plant for the rare Malay staff sergeant (*Athyma reta moorei*). The vegetation to the west of the canal also encompasses the *Mucuna biplicata,* clusters of common native orchid *Arundina graminifolia* and scrubland habitat for the nationally Endangered red-wattled lapwing (*Vanellus indicus*). It adjoins the abandoned-land forest of high ecological value and enhance connectivity of the site. The abandoned-land forest provides habitats for species of conservation significance, cluster of nationally Vulnerable *Ficus apiocarpa*, and *Ficus* spp. which are keystone species that serve ecological functions. It also includes the closed-canopy streams, ED2 and ED7, and its corresponding sub-basin that is required for the retention of its hydrology. Also, it includes bamboo clusters with roosting bamboo bats that are of high ecological value. The Sunda pangolin (*Manis javanica*) was also largely recorded to the west of the canal.

Secondly, vegetation along the eastern boundary was included as part of the preliminary RAC. It enhances the connectivity of the proposed Forest Corridor from the proposed Forest Stream to the forests in Bukit Batok and Bukit Gombak. It comprises abandoned-land forest and waste woodlands, and includes the 1-ha abandoned-land forest patch with native regeneration. The straw-headed bulbul was also largely recorded near the eastern

boundary. While there is no direct vegetation connectivity to the forests in Bukit Batok and Bukit Gombak, it is targeted at providing connectivity for flying species, particularly birds and butterflies, that can transverse the surrounding infrastructures. The corridor also provides habitat for terrestrial species. Despite the absence of direct vegetation connection to Bukit Batok forests, it is the most plausible point for additional connectivity for terrestrial species should there be an opportunity to do so in future. This corridor, is therefore, important. As the vegetation within the Tengah Service Reservoir (TSR) will be largely retained, it provides a good connectivity between the vegetation along the canal to that along the eastern boundary. This area is approximately 100-m wide and 10 ha in size. The width of the recommended 100-m corridor in the east and west follows the width of proposed Forest Corridor, consistent with the Tengah Master Plan 2019.

In addition to the above areas, several habitats and species of high ecological value were included. A 30-m wide buffer is delineated around each ecological feature to preserve the microclimate and minimise disturbances to these features. It includes the open-country ponds (Pond1 and Pond2) and its corresponding sub-basin that make up 1.4 ha and potential roosting sites for bamboos. The function of the buffer zone are:

i) A "safety net" for the conservation area from edge effects (including tree falls) due to surrounding developments.
ii) Provides ample space for enhancement planting, which contributes towards maintaining or enhancing the microclimatic conditions for the conservation area.
iii) Minimise encroachment of and disturbances from humans into the sensitive conservation area.

Three factors were considered in the proposal of a 30-m buffer:

a) While edge effects of vegetation have been documented up to 150 m (Murcia, 1995), 30 m is regarded as the minimum distance required to buffer the conservation area against tree falls, a key concern resulting from edge effects, since the tree height ranges up to 30 m. It also helps to protect the conservation area from other associated edge effects, such as changes in microclimatic conditions and changes to riparian plant communities (Olden et al., 2019).
b) Literature suggest 30 m buffers to be most effective in maintaining the water quality of waterbodies (Beacon Environmental Ltd, 2012; Dillaha et al.,1986; Environmental Law Institute 2003; Wenger 1999). They allow for more consistent and complete attenuation of nutrients and sediments.
c) By maintaining a distance away from work activities, it minimises physical spillage, damage and disturbances to the habitat to be conserved.

While *Ficus microcarpa* is not of conservation significance, specimens of 50-m and 30-m spread are rare and have ecologically valuable functions. The buffer area considered for these specimens are 20 m and 10 m respectively due to their large size.

A summary of the important ecological considerations in delineating the preliminary RAC can be found in **Figure 7.82**.

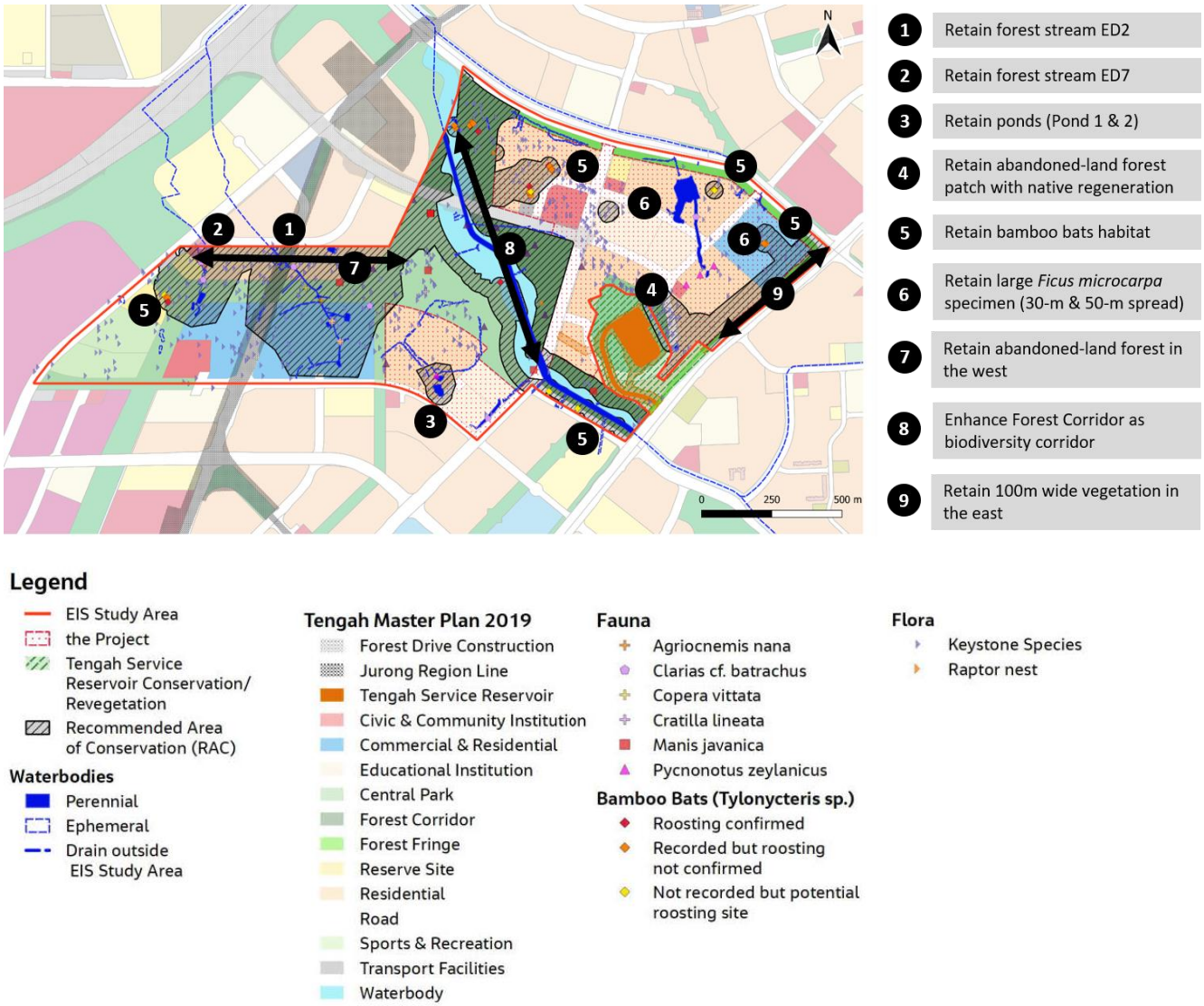


Figure 7.82: Summary of Ecological Consideration in Delineating Preliminary Recommended Area of Conservation within EIS Study Area (Shaded in Black)
Source: URA

7.5.2 Recommended Area of Conservation

Following intensive consultations and robust discussion with agencies and Nature Groups (NGs), the preliminary RAC was revised (area shaded in green) considering the land use limitations, incorporating as much of the area as possible and providing compensatory measures where possible (**Figure 7.83** and **Table 7.24**). In addition, areas which are required to be cleared, have infrastructure built or used as working space, within were delineated as "RAC with temporary works", which should be re-vegetated with native species as soon as work was completed. The total area of the revised RAC amounts to 48.9 ha, which represents 29.5% of EIS Study Area of which 4.0 ha are areas with temporary works, (8.2% of Revised RAC Area).

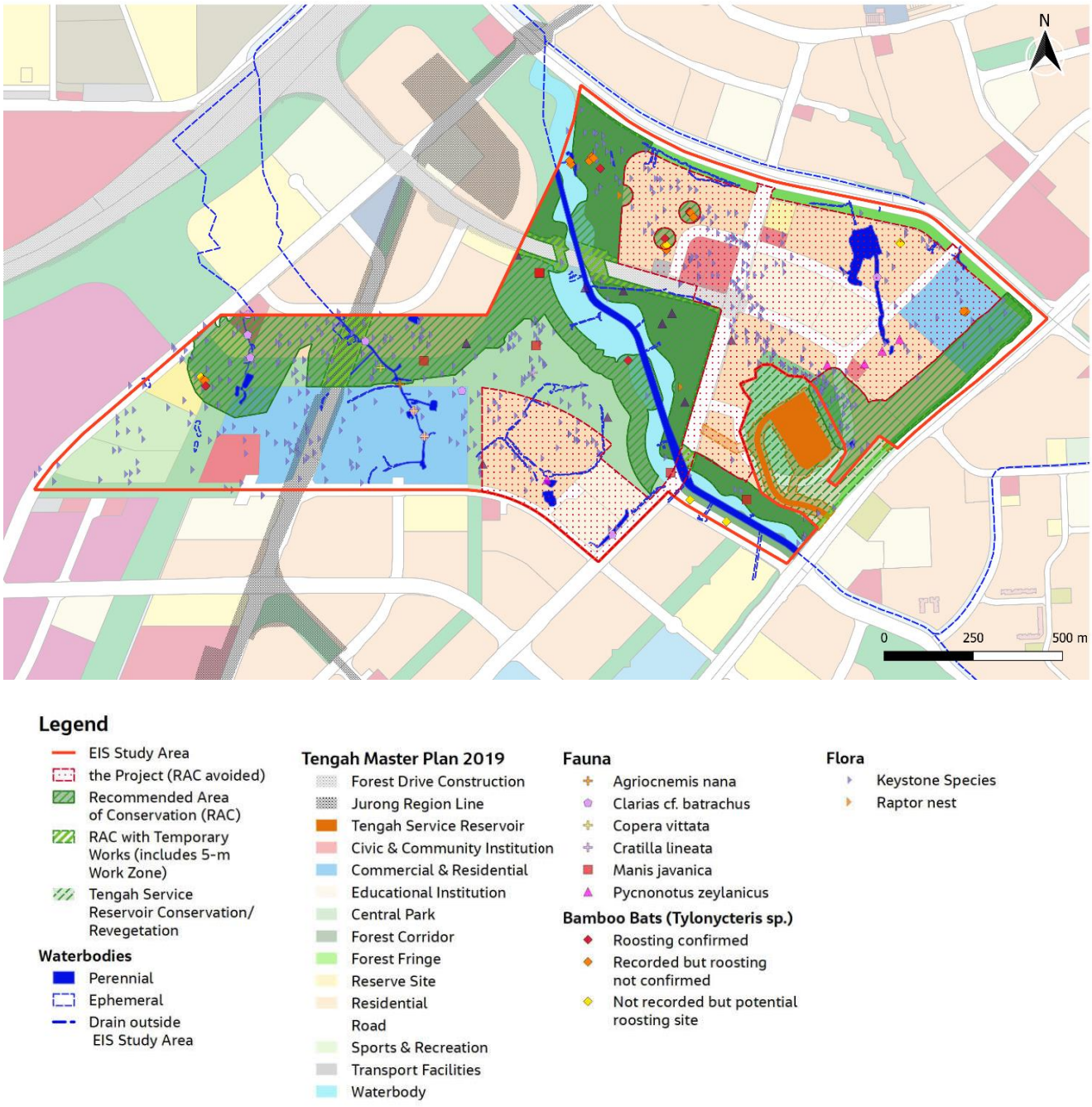


Figure 7.83: Recommended Area of Conservation

Source: URA

Note: RAC with Temporary Works are areas which can be cleared for required works and minimal infrastructure and increased mitigation measures but should be re-vegetated as soon as possible to incorporate back into the RAC.

Table 7.24: Considerations for Revised RAC

Feature	Preliminary RAC	Revised RAC
Forest stream (ED2)	Full retention of the forest stream (ED2) and its sub-basin	Considering land use limitations of Tengah Town Centre, partial retention of the northern portion of the stream and its sub-basin is proposed for the adjusted RAC. Under the MRT viaduct (JRL work area), the vegetation has been cleared and the stream has been diverted using earth drains. The area including both sides of the earth drain will be revegetated by LTA with native species with the aim of habitat creation, upon the completion of JRL works. Detailed study of the upstream catchment and drains will be needed to ensure there is no flood risk arising from the retention of forest stream ED2.
Forest stream (ED7)	Full retention of the forest stream (ED7) and its sub-basin	Full retention of the forest stream (ED7) and its sub-basin. Detailed study of the upstream catchment and drains will be needed to ensure there is no flood risk arising from the retention of forest stream ED7.
Open-country pond (Pond1, Pond2)	Full retention of the open-country pond (Pond1, Pond2) and their sub-basin	Considering land use limitations, it was excluded from the revised RAC. Agencies (NParks with support from HBD and PUB) are examining the possibility of re-creating the habitat elsewhere within the EIS Study Area.
Abandoned-land forest with native regeneration	Full retention of the forest with a 30-m wide buffer	Full retention of the forest with a 30-m wide buffer.
Plants of conservation significance	Retain of transplant plants of conservation significance	All specimens of plants of conservation significance will be retained where possible. Specimens that fall outside of the revised RAC will be assessed for transplantation.
Bamboo bats	Retain all bamboos with roosting confirmed, those with presence of bats, but no roosting confirmed and transplant those unable to be retained.	Bamboo clusters with bamboo bat roosting confirmed, were incorporated in the revised RAC. Otherwise, bamboo clusters with roosting bats are proposed to be transplanted. Where the above are not feasible, bamboo bats found within affected bamboo clusters will be rescued and translocated. Additionally, new bamboo clusters will be planted within the Forest Corridor.
Large *Ficus microcarpa* specimens	Retain specimens with buffer area of 20 m and 10 m for the 50 m and 30 m specimens respectively.	Due to extensive platform level changes expected in the surrounding areas, it was found to be difficult to retain the specimens. The specimens are also too large to be transplanted. Hence, the specimens were excluded from the revised RAC.
Recommended Area of Conservation (West)	Retain abandoned-land forest as a forested corridor.	The Central Park designated in the Tengah Master Plan 2019 will be realigned to incorporate the abandoned-land forest as a forested corridor in the revised RAC as per the preliminary RAC.

Feature	Preliminary RAC	Revised RAC
Forest Corridor	Enhance the Forest Corridor as biodiversity corridor for wildlife usage only	Incorporated into the revised RAC and will be enhanced as a corridor for wildlife use, with minimal trails for maintenance. We recommend for dense strip of vegetation to planted between the Forest Corridor and development areas to buffer against light and noise disturbances.
Road working buffer	N.A.	Up to 5-m wide strips of the preliminary RAC were excluded in the revised RAC to provide working buffers required for the road widening works along Brickland Road, Forest Drive and Tengah Boulevard. For the RAC (East), which will be affected by road widening works along Bukit Batok Road, the conserved area was shifted west to maintain a 100-m wide corridor.
Temporary works within revised RAC	N.A.	Where construction works for committed developments (i.e. JRL, TSR, Forest Drive Construction) bisect the revised RAC, areas should be revegetated as soon as possible for the purpose of habitat creation and temporary wildlife crossings across these sites should be provided.

A summary of the important ecological and land use considerations in delineating the revised RAC can be found in **Figure 7.82**.

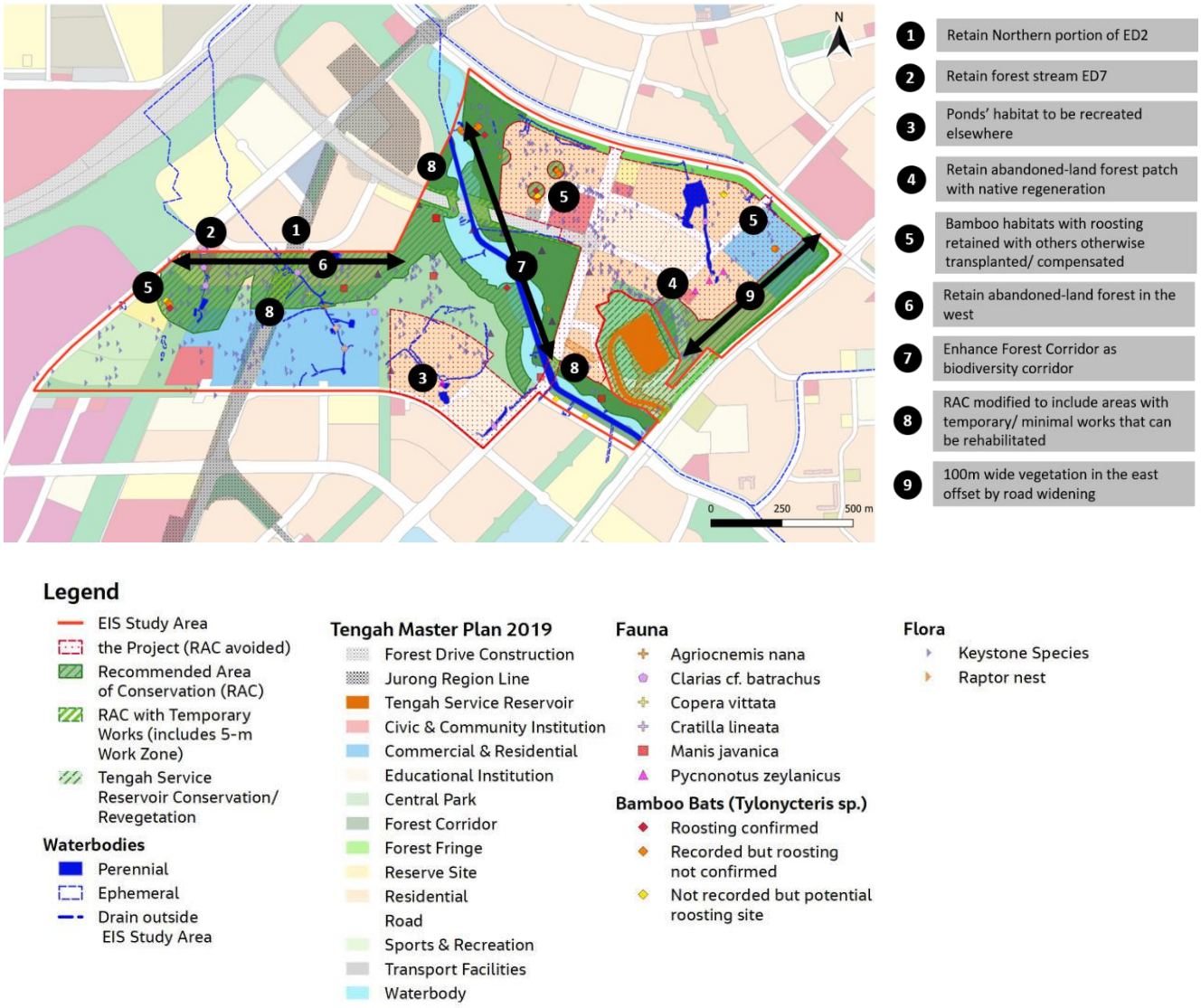


Figure 7.84: Summary of Ecological and Land Use Consideration in Delineating Revised Recommended Area of Conservation (RAC)

Source: URA

Note: For the purposes of this study, the figure shows an indicative revised boundary assuming that agencies will avoid the Recommended Area of Conservation (RAC). Agencies are studying possible changes to the land use plan to balance conservation and development in response to the RAC.

7.6 Identification of Biodiversity-sensitive Receivers

Ecological impacts were identified within the Project boundary based on the construction and operational activities described in **Section 3.3**. The impacts were separately assessed for habitats, plant and faunal species (**Table 7.25**). Direct impacts refer to impacts occurring from the Project work activities and indirect impacts refer to impacts occurring outside the Project boundary. All impacts assessed were deemed likely to occur. When more than one impact is identified for a species, the highest impact is evaluated in the assessment.

The construction phase consists of four stages. Three main activities that have direct impacts to habitat/species occur at Stage 1 advance works – i) wildlife shepherding, ii) tree felling and site clearance and iii) establishment of access roads and temporary site offices. Machineries such as excavator and lorry crane will be used for site clearance and transportation of equipment. Stages 2 to 4 involve earthworks and building of sub- and super-structures, which will involve drilling, piling, hacking and soil excavation or levelling.

The operational phase will have completed roads and structures such as housing flats, and parks. Features present include the Forest Corridor (15.6 ha), Forest Stream (10.1 ha), Forest Fringe (4.3 ha) and Central Park (26.3 ha).

Table 7.25: Description of Ecological Impacts for Habitats, Plant Species and Faunal Species.

Biodiversity-sensitive Receiver	Impact type	Description
Construction Phase		
Habitats	Loss of vegetation/habitat	Direct removal of vegetation (with extensive underground root systems that protect against soil erosion) to create space for construction activities
	Habitat pollution	Improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents) to retained vegetation/habitats
	Habitat degradation	Changes in microclimatic conditions (i.e. dust, noise, and light, temperature, and humidity) and hydrology to retained vegetation/habitats
	Loss of ecological connectivity	Habitat fragmentation from the removal of vegetation
	Change in species composition	Formation of forest edge habitats that favour the growth of certain exotic plants and fauna, and accidental introduction of exotic species from construction materials (such as soil with seeds or bio-degradable erosion blankets with insect eggs)
Plant Species	Mortality	Direct removal of vegetation to create space for construction activities
	Impediment to seedling recruitment	Pollution of habitats from improper disposal of construction waste and accidental release of hazardous materials (such as construction slurry, paint, and/or solvents)
	Competition from exotic plant species	Formation of forest edge habitats that favour the growth of certain exotic plants and accidental introduction of exotic species from construction materials (such as soil with seeds)
	Decline in plant health and survival	Changes in microclimatic conditions (i.e. dust, noise, and light, temperature, and humidity) and hydrology

Biodiversity-sensitive Receiver	Impact type	Description
Faunal Species	Loss of/reduction in habitats and food sources	Direct removal of vegetation to create space for construction activities
	Injury or mortality	Collisions with machineries/vehicles, entrapments in construction materials (such as non-biodegradable erosion control blankets) and structures (such as exposed pits or drains), and accidental kills by construction personnel
	Impediment to faunal movement	Habitat fragmentation from the removal of vegetation which affects the dispersal of fauna
	Disturbances from light	Disturbances from light generated from construction activities
	Disturbances from human presence	Disturbances from human presence (i.e. workers, site personnel)
Operational Phase		
Habitat	Change in plant species composition	Long-term changes in light, temperature, and humidity in habitats surrounding facility structures
	Habitat degradation	Trampling on vegetation and pollution from increased human traffic
Plant Species	Mortality	Stealing/poaching of plants by humans
	Competition from exotic plant species	Accidental and/or intentional release of exotic plants by humans
Faunal Species	Injury or mortality	Navigation failures into the wrong areas and entrapment in facility structures, as well as collisions with vehicles.
	Impediment to faunal movement	Habitat fragmentation from the removal of vegetation
	Disturbances from light	Disturbances from light generated from development
	Disturbances from human presence	Disturbances from human presence (i.e. residential or park users)
	Collisions with buildings (birds only)	Distorted perceptions of reflective surfaces on buildings as flyways, greenery, and/or water

7.7 Minimum Controls for Potential Ecological Impacts

Several measures of minimum controls are assumed to have been implemented at each phase and are described in **Table 7.26**.

Table 7.26: Description of Minimum Controls Implemented at Each Phase

Phase	Description of Minimum Controls
Advance Stage in Construction Phase	▪ Arborist to clearly mark out Tree Protection Zones (TPZs) for trees to be retained. The TPZs are to be set up in accordance with NParks guidelines and no works are to be allowed here. ▪ Prior to vegetation removal, pre-felling fauna inspection should be conducted by an Ecologist to identify wildlife or nesting features that are actively used. Examples are bird nests, tree hollows and burrows. ▪ Execute wildlife response plan. ▪ Implement soil erosion control measures.
Construction Phase	▪ Implement soil erosion control measures. ▪ Situate machineries and materials that may leech harmful chemicals away from waterbodies or sensitive habitats (streams and ponds). ▪ Situate machineries and materials that may leech harmful chemicals away from waterbodies or sensitive habitats (streams and ponds). ▪ Dust and noise 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 roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, effective drainage flow. – Daily checks by Environmental Manager on site.
Operational Phase	▪ Dust and noise 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 roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, effective drainage flow. – Daily checks by Environmental Manager on site.

7.8 Evaluation of Potential Impacts Before Mitigation Measures

The impact assessment assumes that all minimum controls are implemented correctly and adequately.

7.8.1 Assessment Criteria for Biodiversity-sensitive Receivers

The definition and scoring of each assessment criterion for biodiversity-sensitive receivers are described in **Table 7.27.**

Table 7.27: Definition and Scoring of Each Assessment Criterion for Biodiversity-sensitive Receivers.

Group A Criterion	Definition	Scores
A1 – Value	Ecological value of a receiver	**0:** for feature with no ecological value **1:** for habitat or species with low ecological value **2:** for habitat or species with moderate ecological value **3:** for habitat or species with high ecological value **4:** for habitat or species with high ecological value and has international importance
A2 – Magnitude	Measure of the scale of benefit/dis-benefit (impact nature) of an impact or a condition with the extent	**A2.1 – Impact Nature (Benefit or Dis-benefit an Impact)**
		+1: for impacts that increase the ecological value of a habitat **-1:** for impacts that decrease the ecological value of a habitat **0:** for no change/ status quo
		A2.2 – Magnitude of Changes
		<u>Positive impact</u> **2:** for enhancement or creation of habitats in a forested site that potentially improve ecological functions. **1:** for planting within a managed landscape context or small localised areas, with potential but limited value in improving ecological functions. <u>Negative impact</u> **3:** for major impacts **2:** for moderate impacts **1:** for minor impacts **0:** for no change/ status quo The magnitude is individually defined for each ecological impact in **Table 7.28**.
		A2.3 – Impact Extent (Extent of the Induced Change)
		3: for transboundary (extent beyond Singapore) **2:** for national (within Singapore) **1:** for local (within EIS Study Area) **0:** for no change/ status quo

Group A Criterion	Definition	Scores
B1 – Permanence	A condition whether is temporary or permanent, and should be seen only as a measure of the temporal status of the condition. The time period the impact is expected to last.	**4:** for long-term (permanent) duration, i.e. > 10 years (over the lifespan of the Project) **3:** for medium-term duration, i.e. ≥ 3 years but ≤ 10 years **2:** for short-term duration, i.e. less than 3 years **1:** for temporary, i.e. less than one month
B2 – Impact Pathway	Whether the receivers are directly or indirectly impacted.	**3:** for direct impact **2:** for indirect impact **1:** for no change/ not applicable
B3 – Reversibility	Whether a condition can be changed and is a measure of the control over the effect of the conditions.	**3:** for impacts that are irreversible within medium term, or only reversible in the long term. **2:** for impacts that are reversible within medium term with significant compensatory measures. **1:** for no change/ not applicable
B4 - Cumulative	A measure whether the effect will have a single direct impact or whether there will be a cumulative effect over time or synergistic effect with other conditions	**3:** for cumulative/ synergistic **2:** for non-cumulative/ single **1:** for no change/ not applicable

A few assumptions were made in defining the levels of impact intensity for plant species receptors:

a) Habitats within 30 m from the Project boundary are assumed to experience the greatest extent of edge effects, though some studies have shown that edge effects could be up to 150 m. The effects of forest edges may be experienced by species more sensitive to microclimatic changes more than 30 m away from the worksites; these are considered during species-specific impact evaluations.

b) For tree/ strangler species that are not bamboos or of conservation significance (i.e. native common or exotic species), and hence do not have count data, total specimen count was taken from arboricultural survey data. Note that the area for arboricultural surveys is a subset of the entire study area. For species with zero counts (i.e. those not recorded during arboricultural surveys), it is assumed that the intensity of impacts of work activities on them is negligible. The impacts, however, will still be considered specifically for each species during evaluation.

c) For native common or exotic climbing fig species/species associated with important fauna that do not have count data from both floristic and arboricultural surveys, it is assumed that the intensity of impacts of work activities on them is negligible since most of these species are expected to be widespread. The impacts, however, will still be considered specifically for each species during evaluation (e.g. *Ficus heteropleura* and *Ficus punctata*).

Table 7.28: Definition of Each Level of Magnitude of Changes for Each Ecological Impact during Construction Phase

Potential Ecological Impact	Major	Moderate	Minor
Habitats			
Loss of vegetation/habitat	A major impact constitutes either of the following: ▪ Loss of >40% of original habitat ▪ Retention of <60% of original habitat	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Retention of >60% of original habitat	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Retention of >90% of original habitat
Loss of ecological connectivity	A major impact constitutes either of the following: ▪ Loss of >40% of original area ▪ High degree of habitat fragmentation ▪ Dispersal of floral and faunal species greatly impeded	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Moderate degree of habitat fragmentation ▪ Dispersal of floral and faunal species partially impeded	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Habitat patches remain largely contiguous ▪ Dispersal of floral and faunal species remains the same, or unimpeded
Habitat pollution Habitat degradation Change in species composition	A major impact constitutes either of the following: ▪ Obvious signs of degradation (erosion, presence of invasive species and changes in microclimatic conditions) ▪ Major impact to hydrology ▪ Impacts a habitat of high sensitivity ▪ Effective habitat area significantly reduced ▪ Habitat type transitions to one of poorer ecological value	A moderate impact constitutes either of the following: ▪ Some signs of degradations (erosion, presence of invasive species and changes in microclimatic conditions) ▪ Moderate impact to hydrology ▪ Impacts a habitat of moderate sensitivity ▪ Effective habitat area partially reduced ▪ Habitat type remains unchanged but habitat condition declined	A minor impact constitutes either of the following: ▪ Imperceptible signs of degradation (erosion, presence of invasive species and changes in microclimatic conditions) ▪ Minor impact to hydrology ▪ Impacts a habitat of low sensitivity or ecological value ▪ Effective habitat area minimally reduced ▪ Habitat type and condition remain unchanged

Potential Ecological Impact	Major	Moderate	Minor
Plant Species			
Mortality	More than 50% of all plant specimens of this species are within the Project boundary	30–50% of all plant specimens of this species are within the Project boundary	Less than 30% of all plant specimens of this species are within the Project boundary (construction phase)
Impediment to seedling recruitment			
Competition from exotic plant species	More than 50% of all plant specimens of this species are within 30 m from the Project boundary	30–50% of all plant specimens of this species are within 30 m from the Project boundary	Less than 30% of all plant specimens of this species are within 30 m from the Project boundary
Decline in plant health and survival			
Faunal Species			
Loss of/reduction in habitats and food sources	A major impact constitutes either of the following: ▪ Loss of >40% of original habitat ▪ Retention of <60% of original habitat	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Retention of 60-90% of original habitat	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Retention of >90% of original habitat
Injury or mortality	Species with high susceptibility to collisions with vehicles and/or entrapment in construction materials: ▪ All amphibians ▪ All reptiles ▪ Mammals: long-tailed macaque, wild pig, Sunda pangolin, etc.	Species that are mobile and would generally be able to move away from vehicles, but are still possibly susceptible to injury/mortality from entrapment in construction materials: ▪ Amphibious aquatic species ▪ Mammals: squirrels, shrews	Species with low susceptibility to collision with vehicles and entrapment in construction materials: ▪ Volant species (e.g. odonates, butterflies, birds and bats)

Potential Ecological Impact	Major	Moderate	Minor
Impediment to faunal movement	A major impact is applicable for species with either of the following characteristics: ▪ Highly dependent on connected and forested habitats for dispersal (i.e. low dispersal ability) ▪ Susceptible to roadkill ▪ Has large home range	A moderate impact is applicable for species with either of the following characteristics: ▪ Dependent on connected and forested habitats for dispersal (i.e. intermediate dispersal ability) ▪ Possibly susceptible to roadkill ▪ Has moderate home range	A minor impact is applicable for species with either of the following characteristics: ▪ Not dependent on connected and forested habitats for dispersal and able to traverse urban infrastructures (i.e. high dispersal ability) ▪ Low susceptibility to roadkill ▪ Has small home range
Disturbances from light	Species that are susceptible to changes in light levels: nocturnal and crepuscular fauna	Species that are possibly susceptible to changes in light levels: diurnal birds, reptiles and mammals	Species that are not susceptible to changes in light levels: aculeate hymenopterans, odonates, butterflies, aquatic species
Disturbances from humans	Species that are sensitive to human presence: rarely observed in urban environments	Species that are possibly sensitive to human presence: occasionally observed in urban environments	Species that are not sensitive to human presence: commonly observed in urban environments

Table 7.29: Definition of Each Level of Magnitude of Changes for Each Ecological Impact during Operational Phase

Potential Ecological Impact	Major	Moderate	Minor
Habitats			
Loss of vegetation/habitat	A major impact constitutes either of the following: ▪ Loss of >40% of original habitat ▪ Retention of <60% of original habitat	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Retention of 60-90% of original habitat	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Retention of >90% of original habitat

Potential Ecological Impact	Major	Moderate	Minor
Loss of ecological connectivity	A major impact constitutes either of the following: ▪ Loss of >40% of original area ▪ High degree of habitat fragmentation ▪ Dispersal of floral and faunal species greatly impeded	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Moderate degree of habitat fragmentation ▪ Dispersal of floral and faunal species partially impeded	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Habitat patches remain largely contiguous ▪ Dispersal of floral and faunal species remains the same, or unimpeded
Habitat pollution Habitat degradation Change in species composition	A major impact constitutes either of the following: ▪ Obvious signs of degradation (i.e. erosion, presence of invasive species and changes in microclimatic conditions) ▪ Major impact to hydrology ▪ Impacts a habitat of high sensitivity ▪ Effective habitat area significantly reduced ▪ Habitat type transitions to one of poorer ecological value	A moderate impact constitutes either of the following: ▪ Some signs of degradations (i.e. erosion, presence of invasive species and changes in microclimatic conditions) ▪ Moderate impact to hydrology ▪ Impacts a habitat of moderate sensitivity ▪ Effective habitat area partially reduced ▪ Habitat type remains unchanged but habitat condition declined	A minor impact constitutes either of the following: ▪ Imperceptible signs of degradation (i.e. erosion, presence of invasive species and changes in microclimatic conditions) ▪ Minor impact to hydrology ▪ Impacts a habitat of low sensitivity or ecological value ▪ Effective habitat area minimally reduced ▪ Habitat type and condition remain unchanged
Plant Species			
Mortality Impediment to seedling recruitment	More than 50% of all plant specimens of this species are within the Project boundary	30–50% of all plant specimens of this species are within the Project boundary	Less than 30% of all plant specimens of this species are within the Project boundary (construction phase)
Competition from exotic plant species Decline in plant health and survival	More than 50% of all plant specimens of this species are within 30 m from the Project boundary	30–50% of all plant specimens of this species are within 30 m from the Project boundary	Less than 30% of all plant specimens of this species are within 30 m from the Project boundary

Potential Ecological Impact	Major	Moderate	Minor
Faunal Species			
Loss of/reduction in habitats and food sources	A major impact constitutes either of the following: ▪ Loss of >40% of original habitat ▪ Retention of <60% of original habitat	A moderate impact constitutes either of the following: ▪ Loss of 10–40% of original habitat ▪ Retention of 60-90% of original habitat	A minor impact constitutes either of the following: ▪ Loss of <10% of original habitat ▪ Retention of >90% of original habitat
Injury or mortality	Species with high susceptibility to collisions with vehicles: ▪ All amphibians ▪ All reptiles ▪ Mammals: long-tailed macaque, wild pig, Sunda pangolin, etc.	Species that are mobile and would generally be able to move away from vehicles, but are still possibly susceptible to injury/mortality: ▪ Amphibious aquatic species ▪ Mammals: squirrels, shrews	Species with low susceptibility to collision with vehicles: ▪ Volant species (e.g. odonates, butterflies, birds and bats)
Impediment to faunal movement	A major impact is applicable for species with either of the following characteristics: ▪ Highly dependent on connected and forested habitats for dispersal (i.e. low dispersal ability) ▪ Susceptible to roadkill ▪ Has large home range	A moderate impact is applicable for species with either of the following characteristics: ▪ Dependent on connected and forested habitats for dispersal (i.e. intermediate dispersal ability) ▪ Possibly susceptible to roadkill ▪ Has moderate home range	A minor impact is applicable for species with either of the following characteristics: ▪ Not dependent on connected and forested habitats for dispersal and able to traverse urban infrastructures (i.e. high dispersal ability) ▪ Low susceptibility to roadkill ▪ Has small home range
Disturbances from light	Species that are susceptible to changes in light levels: nocturnal and crepuscular fauna	Species that are possibly susceptible to changes in light levels: diurnal birds, reptiles and mammals	Species that are not susceptible to changes in light levels: aculeate hymenopterans, odonates, butterflies, aquatic species
Disturbances from humans	Species that are sensitive to human presence: rarely observed in urban environments	Species that are possibly sensitive to human presence: occasionally observed in urban environments	Species that are not sensitive to human presence: commonly observed in urban environments

7.8.2 Construction Phase (Before Mitigation Measures)

7.8.2.1 Habitats

During the construction phase, four vegetation types and four waterbodies will be impacted. It will result in the complete loss of the abandoned-land forest with native regeneration, and more than half of the abandoned-land forest present within the EIS Study Area (**Table 7.30**). Almost half of the waste woodland as well as scrubland and herbaceous vegetation will be cleared (**Table 7.30**). The closed-canopy streams, ED2 and ED7 will not be affected as they lie outside the Project works boundary. Other waterbodies that lie within the Project boundary, namely ED1, Pond1, Pond2, ED6, Pond5 and ED8_02 would be cleared. The areas impacted are described in **Figure 7.21**.

The main direct impacts occurring during the construction phase are loss of vegetation/habitat, habitat degradation and loss of ecological connectivity. The impact significance on each habitat receiver during construction phase is summarised in **Table 7.31**.

Table 7.30: Area of Habitat Directly Impacted by the Project Works during Construction Phase

Biodiversity-sensitive Receiver	Area Impacted Directly by the Project Works	Total Habitat Type Present in EIS Study Area Impacted
Abandoned-land forest with native regeneration	1.0 ha	100%
Abandoned-land forest	31.3 ha	54.7%
Scrubland and herbaceous vegetation	18.1 ha	49.9%
Waste woodland	12.6 ha	45.5%
Closed-canopy stream	0.6 ha	100%
Open-country streams	1.1 ha (ED1); 0.1 ha (ED6)	95.2%
Closed-canopy & semi open-country ponds	0.02 ha (Pond5); ED8_02	10.5% (min)
Open-country pond	0.12 ha (Pond1 and Pond2)	100%
Main Canal	3 ha	100%

a) Loss of Vegetation/Habitat

Major negative impacts are expected from loss of vegetation. It is likely to have major negative impact on several habitats including the abandoned-land forest with native regeneration, abandoned-land forest, waste woodland, scrubland and herbaceous vegetation, open-country streams and open-country pond. The effects are direct, long-term and irreversible. Vegetation loss represents disruption of ecological processes in an ecosystem that was originally intact. It loses the ecological functions of nutrient cycling, carbon cycling, water cycling, seed dispersal, pollination and temperature regulation. While these specific impacts are harder to evaluate, the loss of such functions are likely to have detrimental impacts on the ecosystem. Due to the developments in other parts of Tengah Town, cumulative impacts are also expected. Correspondingly, moderate negative impacts are expected for closed-canopy and semi open-country ponds, as well as open-country ponds, and impacts may be reversible in the medium term with significant compensatory measures. A minor negative impact is expected for the canal. Since the closed-canopy stream ED2 and ED7 lie outside of the Project boundary, no impacts were expected from habitat loss due to the Project works.

b) Loss of Ecological Connectivity

Loss of ecological connectivity is also expected from the Project works. Tengah Town is an important stepping stone for species moving between Western Water Catchment Area and Bukit Batok/Bukit Gombak forests before arriving at Bukit Timah Nature Reserve and CCNR. The Project boundary lies on the north-eastern of the Tengah Town, which is in the closest proximity to the forest in Bukit Batok and Bukit Gombak. Habitat loss here therefore represents a loss of habitat connectivity and impedes the movement of floral and faunal species, particularly species that are averse to crossing urban areas. Moderate and major negative impacts are expected across all habitats except for the main canal.

c) Habitat Pollution

Major negative impacts may occur to the abandoned-land forest with native regeneration since it is a sensitive habitat. Moderate negative impacts are also expected to abandoned-land forest and other waterbodies. Improper disposal of construction waste can impede seedling recruitment and reduce the attractiveness of habitats for fauna. Furthermore, aquatic communities are sensitive to water pollution, hence impacts for waterbodies were also moderate negative. Since the open-country pond (Pond1 and Pond2) will be cleared during construction, they were not assessed for habitat pollution.

d) Habitat Degradation

Edge effects were expected across all terrestrial habitat types. Major negative impacts are expected to the abandoned-land forest with native regeneration and abandoned-land species as they are sensitive habitats. Moderate negative impacts are expected to the waste woodland, and scrubland and herbaceous vegetation as they may be less sensitive to less edge effects.

All waterbodies on site are subjected to hydrological changes which may affect the persistence of aquatic communities present. Therefore, moderate negative impacts were expected. Since the open-country pond (Pond1 and Pond2) will be cleared during construction, they were not assessed for habitat degradation.

e) Change in Species Composition

The growth of certain exotic plants and fauna are expected with the presence of edge effects, which is expected across all terrestrial habitat types. Major negative impacts are expected to the abandoned-land forest with native regeneration and abandoned-land species as they are sensitive habitats. Moderate negative impacts are expected to the waste woodland, and scrubland and herbaceous vegetation as they may be less sensitive to less edge effects. Moderate negative impacts were also expected to waterbodies present since introduced aquatic species may be released here through construction materials.

Table 7.31: Pre-mitigation Impact Significance for Biodiversity-sensitive Habitat Receivers during Construction Phase

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance
Loss of vegetation	Abandoned-land Forest with Native Regeneration	-351	Major Negative Impact
	Abandoned-land Forest	-351	Major Negative Impact
	Waste Woodland	-234	Major Negative Impact
	Scrubland and Herbaceous Vegetation	-234	Major Negative Impact
	Closed-canopy Stream (ED2)	-324	Major Negative Impact
	Closed-canopy Stream (ED7)	-324	Major Negative Impact
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	Major Negative Impact
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	Moderate Negative Impact
	Open-country Ponds (Pond1 and Pond2)	-216	Moderate Negative Impact
	Main Canal	-44	Minor Negative Impact
Loss of ecological connectivity	Abandoned-land Forest with Native Regeneration	-351	Major Negative Impact
	Abandoned-land Forest	-351	Major Negative Impact
	Waste Woodland	-234	Major Negative Impact
	Scrubland and Herbaceous Vegetation	-234	Major Negative Impact
	Closed-canopy Stream (ED2)	-324	Major Negative Impact
	Closed-canopy Stream (ED7)	-324	Major Negative Impact
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	Major Negative Impact
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	Moderate Negative Impact
	Open-country Ponds (Pond1 and Pond2)	-216	Moderate Negative Impact
	Main Canal	-72	Minor Negative Impact
Habitat pollution	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)	
	Abandoned-land Forest	-198	Moderate Negative Impact
	Waste Woodland	-88	Minor Negative Impact
	Scrubland and Herbaceous Vegetation	-88	Minor Negative Impact
	Closed-canopy Stream (ED2)	-180	Moderate Negative Impact
	Closed-canopy Stream (ED7)	-180	Moderate Negative Impact
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-132	Moderate Negative Impact

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-132	**Moderate Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	Not Applicable (N.A.) (cleared during construction phase)	
	Main Canal	N.A. (cleared during construction phase)	
Habitat degradation	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)	
	Abandoned-land Forest	-234	**Major Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-156	**Moderate Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-156	**Moderate Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)	
Change in species composition	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)	
	Abandoned-land Forest	-234	**Major Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-104	**Moderate Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-104	**Moderate Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)	
	Main Canal	N.A. (cleared during construction phase)	

7.8.2.2 Species Evaluation

Impacts to 85 floral and faunal species of high ecological value were specifically evaluated. This includes 51 plants species, 1 aculeate hymenopteran, 3 odonate, 6 butterfly, 1 freshwater fish, 2 reptilian, 15 bird, 4 non-volant mammalian and 1 bat species. Several assumptions were made during the evaluation of impacts to each species, namely that selected plant species for this evaluation were based on the following:

- Species with specimens of conservation significance, large specimens, and/or other specimens of value found inside and within 30 m from the Project boundary.
- Keystone species, which are only the *Ficus* species in this study.
- Species associated with important fauna.
- Species that make up ≤ 1% of the total number of specimens of conservation significance.

The impact assessment for key species are summarised below.

Twenty-five plant species are assessed with major impact significance as a result of more than 30% of their total population or the whole population recorded in the EIS Study Area will be directly affected by the Project works as total land clearance is expected. This includes plant species such as the *Leea angulata*. For indirect impacts *such as* impediment to seedling recruitment, competition from exotic species and decline in plant health and survival, plant specimens that are situated within 30 m from the Project boundary were assessed. The distance of 30 m was decided to account for the greatest extent of edge extent as explained in **Section 7.8.1**.

Moderate to critically negative impacts were expected from loss of habitats or food sources for most faunal species. Critically negative impacts were expected for the straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*) as they are both globally and nationally threatened. Moderate negative impacts were expected for the remaining faunal species, except for 2 odonate species whose habitats (ED2 and ED7) are not affected by the Project works.

Moderate to critically negative impacts were expected from impediment to faunal movement. Species that have higher dispersal ability are likely to be impacted to a lesser degree. Critically negative impacts were expected for the straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*) which depend on connected vegetation for dispersal.

Moderate negative impacts were expected injury or mortality for most species. In addition, six species experience major negative impacts, including the long-tailed macaque (*Macaca fascicularis*), common Malayan racer (*Coelognathus flavolineatus*) and Sunda pangolin (*Manis javanica*).

Disturbances from light and human presence are likely to result in moderate negative impacts and moderate to major negative impacts respectively. Impact assessment of noise disturbances to fauna presented in **Section 8.4** suggests that minor to major impacts were expected across the ground-dwelling and understorey fauna, as well as arboreal fauna, during the construction phase.

Plants of Conservation Significance

- The impact of mortality during the construction phase is assessed for all plant species of conservation significance. Twenty-one plants species of conservation significance is assessed with major negative impact significance. For these plant species, more than 30% of their total population, or the entire population recorded in the EIS Study Area will be directly affected by the Project works. The threatened status of these species also contributes to the major negative impact significance as any loss to the population of these plant species will have in effect in their national population as well. An example of this would *Rubus moluccanus var. moluccanus* whereby the entire population of these species will be affected by the Project works.
- Plant species that are of threatened status and also has an association for fauna communities like *Ardisia elliptica*, are also assessed with a major negative impact significance as any loss to the species' population would possibly affect the population of butterflies that rely on the plant species as its host plant (e.g. *Ardisia elliptica*). Species like *Connarus semidecandrus* and *Hoya latifolia,* are usually recorded in forest reserves or nature reserves and forests that lie in close proximity to those locations (Chew et al., 1997; Yap, 2006). Due to their rarity and restricted distribution of these species, mortality to the specimens is detrimental to the local and national population of these species.

- Four plant species of with conservation significance were assessed with moderate negative impact. For these plants, less than 30% of their total population recorded in the EIS Study Area will be directly affected by the Project works. Examples of these species are *Alsophila latebrosa* and *Melicope lunu-ankenda*. As for the remaining threatened plant species, no change in the impact significance is assessed as they are located away from the Project boundary.
- As for remaining ecological impacts such as impediment to seedling recruitment, competition from exotic plants and decline in plant health and survival, all plant species with high ecological value were given either a moderate, minor or no change in their impact significance. Two plant species, *Ardisia elliptica* and *Callicarpa longifolia* which has more than 33% of the total population situated 30 m away from the Project boundary are given a moderate negative impact significance for all three ecological impacts listed above.

Keystone Species

- Ten *Ficus* species that were recorded during the floristic survey are assessed as high ecological value, despite their nativeness and national status (**Appendix 7A**). Three *Ficus* species, *Ficus religiosa, Ficus microcarpa* and *Ficus variegata* were assessed to have major negative impact significance when assessed for impact of mortality towards these species. More than half the specimens will be affected by the Project works. The loss of individual specimens located in the Project boundary may cause a chain reaction of negative ecological impact that would eventually lead to the gradual decline of faunal species that depend on these species. Gradual deterioration of the ecological processes of the forest may also occur not just within the Project boundary, but at a bigger scale (Lok et al., 2013; Mills et al., 1993). Further elaboration on the importance of keystone species in a forest is discussed in **Section 7.3.3.5.**
- Two large individuals of *Ficus vasculosa* are located in the Project boundary. These individual specimens play a vital role as part of being a keystone species in the forest as discussed in **Section 7.3.3.5** and also being the last remaining mature specimens of *F. vasculosa* found in Singapore (**Section 7.3.3.2**). Given that most of the secondary forest patches in Singapore are also rapidly diminishing due to urban developments, protecting this species is crucial for the continuity of their survival.
- For decline in health and survival towards the plant species, only one *Ficus* species, *Ficus fistulosa*, were assessed to with moderate negative impact significance for this ecological impact as 50% of the population (one out two individuals) recorded during the arboricultural survey is located within 30 m away from the Project boundary. Hence, the impact magnitude for this species was assessed as major and this contributed to the moderate negative impact significance. All *Ficus* species, except for the species mentioned below, were given a minor negative impact significance for the remaining ecological impacts.
- Ficus species that has zero counts like *Ficus hispid*a, *Ficus heteropleura*, *Ficus grossularioides var. grossularioides*, *Ficus pumila* var. *awkeotsang* are assessed with no change in their impact significance for all ecological impacts.

Common Native and Exotic Species

- Native orchids, *Spathoglottis plicata*, boat orchid *Arundina graminifolia,* and common native species *Campnosperma auriculata* were included in the species evaluation. Both orchids were assessed to have high ecological value despite their nativeness and their high cultivation intensity. The importance of these native terrestrial orchids is elaborated further in **Section 7.3.3.4**. As forementioned *Campnosperma auriculata*, this species is considered of high ecological value due to its restrictive national distribution since this species is mostly found in the limited number of old secondary forest in Singapore. Majority of the individuals of *Spathoglottis* orchid will be affected by the Project works as they are located in the Project boundary. Hence, this orchid species will face with mortality from the proposed development works as total land clearance is expected. As such, the *Spathoglottis* orchid were assessed to face with a major negative impact significance. Similarly, for *Campnosperma auriculata*, 7 out of 16 individuals of this species will be affected by the Project works as they are located in the Project boundary. Hence, this increases the impact magnitude to a moderate which contributes to the negative impact significance being major. There is no change in impact significance for *Arundina graminifolia* as the clusters of orchids is located away from the Project boundary.

- Other individuals of *Spathoglottis plicata* are located within 30m from the Project boundary. Hence, they are prone to face all indirect impacts listed. Intentional or accidental release of hazardous material from the nearby construction site that would make the surrounding environment unfavourable for seedling recruitment. The increase competition in exotic species may be encouraged by the forest edge effect as a result to the clearance of habitat nearby. Fast-growing exotic species may eventually outcompete the orchid population. As for *Campnosperma auriculata* and *Arundina graminifolia*, there is no change in impact significance for indirect impacts as there are no specimens residing within close proximity to the Project boundary.

Odonates

- The dwarf wisp (*Agriocnemis nana*) is nationally Endangered, and restricted and very rare in Singapore. The variable featherlegs (*Copera vittata*) is nationally Vulnerable, and restricted and rare in Singapore. These two species were recorded at ED2 stream in western part of the EIS Study Area, located >200 m away from the Project boundary. As the life cycle of odonates are associated with waterbodies, loss of and degradation of their aquatic habitats are considered major and permanent impacts. Moderate negative impacts may occur to the stream habitats. Due to loss of forest habitat in the Project boundary, which is potentially used by these species for habitat and dispersal, major negative impacts are expected from impediment to faunal movement. Moderate negative impacts are expected from loss of/reduction of habitat or food sources, injury or mortality, as well as disturbances from light and human presence.
- Minor impacts from noise disturbances were expected for odonate species (**Section 8.4**).

Butterflies

- The forest-dependent butterfly, Malay staff sergeant (*Athyma reta moorei*), is very rare in Singapore. Individuals of the host plant *G. zeylanicum* are mostly located within the proposed Forest Corridor and assumed to be not directly impacted. However, the loss of forest habitat accompanied with increased forest edge effects may be detrimental to the local population in the EIS Study Area. Therefore, impact significance from the loss of host and food plants, as well as impediment to faunal movement are expected to be to be major negative.
- The butterfly, harlequin (*Taxila haquinus haquinus*) is nationally Endangered and moderately rare. This species was not recorded in the EIS Study Area. Yet, the forests in the vicinity of the EIS Study Area harbours the only known population on the main island of Singapore. Given that it has been recorded in nearby forested areas with similar habitat characteristics, this species may occur within the EIS Study Area. This species is a forest-dependent species and the loss of forest habitat accompanied with increased forest edge effects may be detrimental. The host plant of this species, *A. elliptica*, was present in small numbers at several locations across the site. Some of these individuals are affected within the Project works, and some lie outside of the Project works. Due to its rarity, loss of local populations in the EIS Study Area is likely to be detrimental to the national population and may constitute a major impact. The impact significance from loss of habitat and host plants, and impediment to faunal movement are expected to be major negative.

Birds

- The blue-winged pitta (*Pitta moluccensis*) is uncommon in Singapore. A breeding population may exist within the EIS Study Area. Due to lack of breeding records of this species, loss of habitat may be regarded as a major impact. Furthermore, disturbances to this species are expected in the form noise, light and vibration. As this species breeds on the ground, vibration may reduce the suitability of habitat for its breeding. Impacts of noise and light disturbances to this species are unclear, but noise disturbances may affect its communication with other individuals and light disturbances may reduce the suitability of habitat for its breeding. The impact significance from loss of habitat and host plants, impediment to faunal movement and disturbance from human presence are expected to be major negative.
- The straw-headed bulbul (*Pycnonotus zeylanicus*) is globally and nationally threatened. In Singapore, habitat loss to development remains a primary threat to this species. This species requires wooded corridors to move across the landscape. Since Singapore is a stronghold for this species globally, impact significance from habitat loss and impediment to faunal movement, are regarded as critically negative.

- The red-wattled lapwing (*Vanellus indicus*) is nationally Endangered. The survey indicates the existence of a breeding population at the EIS Study Area. The western part of Singapore is known to be a stronghold of the species. However, the population may be threatened by the rapid loss of habitat as a result of the ongoing and upcoming developments, thus impact may be major. Furthermore, disturbances to this species are expected in the form of noise, light and vibration. As this species breeds on the ground and is shy to human presence, the suitability of the habitat for its breeding may be reduced. The impact significance from loss of habitat and host plants, impediment to faunal movement and disturbance from human presence are expected to be major negative.
- Minor to major impacts from noise disturbances were expected for bird species (**Section 8.4**).

Non-volant Mammals

- The Sunda pangolin (*Manis javanica*) is both globally and nationally threatened. The species has been recorded from the nature reserves and degraded forest fragments in Singapore. Notably, Singapore is a global stronghold for the species and is crucial in contributing to the conservation of pangolin populations globally. Yet, habitat loss, degradation and fragmentation, and road kills threaten the viability of the local population. This species also requires large trees as natal dens. The Project works will result in the loss of habitats, including large trees that are used by pangolins as natal dens. Furthermore, the presence of roads may contribute to the increased incidence of road kills. Since Singapore is a stronghold for this species globally, impact significance from habitat loss and impediment to faunal movement, are regarded as critically negative.
- The long-tailed macaque (*Macaca fascicularis*) is globally Vulnerable. This species was recorded on site and locally common. This species is considered susceptible to roadkill and injury or mortality from construction activities. Impact significance is expected to be major for injury or mortality.
- Minor to major impacts from noise disturbances were expected for mammal species (**Section 8.4**).

Bats

- There are two species of bamboo bats present in Singapore. The lesser bamboo bat (*Tylonycteris fulvida*) is nationally Critically Endangered while the greater bamboo bat (*Tylonycteris malayana*) is not assessed. Bamboo bats were not identified to species level due to difficulty in field identification. They were also recorded visually or acoustically at 20 bamboo clusters, and a further 12 bamboo clusters were determined as potential roosting sites although no bamboo bats were recorded.
- Amongst the 20 bamboo clusters with presence of bamboo bats, 14 bamboo clusters lie within areas proposed for development. As habitats for bamboo bats will be cleared, major impacts are expected during construction phase. Six are present within the proposed Forest Corridor and lie at least 50 m away from the Project works, thus it is not directly impacted. During construction phase, generation of noise, and dust are expected at a distance from daytime activities. However, moderate levels of increase in noise, and dust generation are expected within 100 m. This species may also be susceptible to noise and light disturbance as it is nocturnal, and may cause them to abandon their roost site. impact significance from habitat loss, impediment to faunal movement and injury or mortality are regarded major negative.
- Minor to major impacts from noise disturbances were expected for bat species (**Section 8.4**).

7.8.3 Operational Phase (Before Mitigation Measures)

7.8.3.1 Habitat Evaluation

During the operational phase, most of the existing vegetation and several of the waterbodies would have been cleared. Therefore, impacts were assessed for the remaining habitats outside of the Project boundary. As the abandoned-land forest with native regeneration will be fully cleared, it will not be assessed. In addition, since the original main canal would be enhanced and transformed into a forest stream, impacts were not assessed. Moderate negative impacts are expected from change in plant species composition and habitat degradation across most habitat types, except for the closed-canopy and semi open-country ponds. The impact significance on each habitat receiver during operational phase is summarised in **Table 7.32**.

Table 7.32: Pre-mitigation Impact Significance for Biodiversity-sensitive Habitat Receivers during Operational Phase

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance
Change in plant species composition	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)	
	Abandoned-land Forest	-234	**Major Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**
	Open-country Streams (Spring) *ED1, ED6 and ED8_01 cleared during construction phase	-96	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4) *Pond5 and ED8_02 cleared during construction phase	-96	**Minor Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)	
Habitat degradation	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)	
	Abandoned-land Forest	-234	**Major Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**
	Open-country Streams (Spring) *ED1, ED6 and ED8_01 cleared during construction phase	-96	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4) *Pond5 and ED8_02 cleared during construction phase	-96	**Minor Negative Impact**

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)	

7.8.3.2 Species Evaluation

Impacts to 80 floral and faunal species of high ecological value were specifically evaluated. This includes 46 plant species, 1 aculeate hymenopteran, 3 odonate, 6 butterfly, 1 freshwater fish, 2 reptilian, 15 bird, 4 non-volant mammalian and 1 bat species. Several assumptions were made during the evaluation of impacts to each species and elaborated below.

Eight plant species of conservation significance that were initially assessed in the construction phase are not included in this round of assessment as it is assumed that they will be cleared during the construction phase. These species are: (1) *Artabotrys suaveolen;* (2) *Aspidopterys concava*; (3) *Carallia brachiata*; (4) *Cayratia mollissima;* (5) *Ficus religiosa*; (6) *Hoya latifolia*; (7) *Limacia scandens* and (8) *Rubus moluccanus* var. *moluccanus.*

Mortality to the selected plant species due to it being stolen/poached by human can be based on certain characteristics that the species possess. Generally, plants with aesthetic values (e.g. orchid species), medicinal properties, market value due to their rarity or can be used as a food (e.g. edible fruits, etc.) are mostly likely subjected to be stolen by people. All specimens that resides along the 30 m from the Project boundary is assessed based on the factors listed above.

Only two plant species, *Callicarpa longifolia* and orchid species *Spathoglottis plicata,* are assessed with major negative impact significance. Remaining population of these species are found within 30 m from the Project boundary. This means that all specimens of these plant are prone to face with mortality which increases the impact magnitude for these plants. To add on, both plants possess aesthetic features such as attractive flowers and fruits that may increase their chances of being stolen. Although *Spathoglottis plicata* is a common native orchid, orchids are usually valued and collected by people which increases the chance of it to be stolen. Since the natural population of this orchid is decreasing nationally, the effect of mortality would affect the national population too.

Ten other plant species which are of threatened status, are given moderate negative impact mostly due to their conservation status. Although the risk of these specimens being stolen or poached, are relatively low, there is still a small possibility of it occurring as they are of certain conservation status. Other plant species such as the common native or exotic *Ficus sp*. were not assessed with any impact significance as the chances of these species being stolen or poached by people are unlikely. Plants that did not fall within 30 m from the Project boundary were not given any impact significance.

For the indirect impact assessed for competition from exotic species, specimens that resides along the 30 m from the Project boundary is assessed. The impact significance is determined based on their proximity from any common green spaces (e.g. parks, green verges along residential estate, etc.) that resides within the proposed Central Park and Forest Corridor feature that will be developed concurrently during the operational phase of the Project.

Plants that will be planted in the proposed Central Park as well as in the common green as part of landscaping efforts is assumed be a mix of exotic and native species. The exotics species will most likely be of those listed as casual species, i.e. species that "do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence" (Chong et al., 2009), giving an impact magnitude of moderate. This is a possible event as some original vegetation are expected to be retained, with some others cleared and

replaced with landscaping. Hence, this justifies the impact of competition from exotic species to be generally minor. This depends on their national status as well. As for the proposed Forest Corridor that will be overseen by NParks, since the main purpose of this feature is for an ecological connectivity function for flora and fauna community, it is assumed that native species will be chosen to be plants for any enhancement of reforestation efforts, as seen in most of NParks past habitat reforestation/enhancement projects. Hence, species which is situated only in the Forest Corridor will not have any change in their impact significance.

Thirteen plant species, of which two are species of conservation significance, were given a minor negative impact significance. The remaining 28 plant species do not have any change in their impact significance as there are no individuals situated 30 m within the Project boundary to assess for.

During operational phase, the impediment of faunal movement is expected for all fauna due to reduced habitat for dispersal. Fauna is now restricted to moving along the proposed Forest Corridor and across the grade-separated wildlife crossings. Major to critically negative impacts are expected. Furthermore, the presence of light and noise around the proposed Forest Corridor may still result in the less-than-optimal condition for nocturnal species to move.

While there will be grade-separated crossings in place to allow fauna to cross at certain junctions, with the increase in road infrastructures, the risk of roadkill, which results in the injury or mortality for fauna, will also be correspondingly increased. Major to critically negative impacts are expected. Furthermore, there is a higher chance of birds colliding with high rise buildings within the development. Species affected by collisions can include rare or migrant birds. Major negative impacts are expected across bird species.

Lastly, disturbances to fauna are expected in the form of noise, light and human presence. For diurnal species, higher noise levels may affect their rhythmic patterns and may reduce the suitability of habitats. Similarly, the higher noise and light levels may reduce the suitability of habitats for nocturnal species. For example, bamboo bats affected by noise and light may be forced to abandon their roost sites. Moderate negative impacts are expected from disturbances from light and human presence. The detailed assessment of impacts of noise to species are discussed in **Section 8.4**. Moderate to major impacts were expected across the ground-dwelling and understorey fauna, as well as arboreal fauna, during the operational phase.

7.9 Applicable Prevention and Mitigation/ Enhancement Measures

7.9.1 Design Phase

Below are preliminary recommended mitigation measures during design planning stage for HDB's consideration in land use planning:

Mitigation Hierarchy	Recommended Mitigation Measures
Avoidance	• Avoid revised RAC identified in **Section 7.5**. • Generate cut and fill plan, assess how soil level changes will affect core conservation areas, and review platform levels to retain areas of higher conservation value and/or tree clusters of higher retention values. Please also see hydrology below. • Incorporate and retain other ecological features within the common green areas, Forest Corridor, Forest Stream, Central Park and Forest Fringe as much as possible, to enhance connectivity of the larger green network within EIS Study Area • Review development plans and construction methods to avoid or reduce working space and impacts to ecological features. • Any slope stabilisation and grading works will not impact the retained waterbodies • During the detailed design stage, hydrology studies should be undertaken to accurately determine how the development and any land grade change around the retained waterbodies will affect the existing volume of water flowing within the catchments. In planning the drainage, the retained waterbodies could be incorporated as ABC Waters features. Some surface flow could be diverted from the proposed development into the retained waterbodies to provide a minimum ecological flow. Care should also be taken not to drain too much additional water into these waterbodies that it overburdens them. • Retain all bamboo clusters with bamboo bat roosting confirmed and presence of bamboo bats but no roosting confirmed.
Minimisation	• Review road and drain plans, and provide safe crossings for ground-dwelling fauna in locations where there is a gap in connectivity between green spaces. • Construct grade-separated wildlife crossings before directional site clearance occurs. • Implement traffic calming measures, such as road narrowing, speed bumps and road strips, to reduce incidence of roadkill. This can be incorporated with signages that warn drivers of wildlife crossing. • Integrate bird-friendly building designs to reduce bird-building collisions. Strategies include breaking up reflections on glass façade and incorporating features to increase the visibility of glass (Sheppard & Phillips, 2015). • Design the Forest Corridor primarily for wildlife use; include minimal trails for maintenance and hiking only. • Minimise and manage ecological light pollution through managing the placement, height, orientation, lighting intensity and operational considerations. • Plant a dense strip of vegetation between the Forest Corridor and development areas to buffer against light and noise disturbances. • Keep sensitive habitats that are affected by the works for as long as possible before they are cleared to allow for establishment of new features and fauna colonisation. For example, natural waterbodies may be replicated to a certain degree and integrated with ABC Waters features. The plant and habitat establishment period in landscaped ABC Waters features can be up to a year, depending on the plant species required. Having both the original habitats and new features at the same time will allow fauna to colonise the new features while reducing the risk of a total population collapse if the original habitats are removed prior to the establishment of the new ones.

Mitigation Hierarchy	Recommended Mitigation Measures
	• Where it is not feasible to retain, transplant bamboo clusters with roosting bamboo bats (see below). Otherwise, rescue and translocate bamboo bats found in affected bamboo clusters. – For small bamboo clusters (< 3-m spread), seal the entrances of bat roosts with bats inside and transplant the bamboo cluster. – For large bamboo clusters (> 3-m spread), seal the entrances of bat roosts with bats inside, cut sections of the bamboo steams bearing the roosts and move the cut sections to a suitable receptor site, or transplant a smaller portion of the bamboo cluster including the stems bearing the roosts. • Transplant all specimens of plants of conservation significance that fall outside the revised RAC.
Compensation	• Create a diversity of aquatic and terrestrial habitats, such as ABC Waters features, skyrise greenery and pollinator houses. • Create vegetated landscapes between infrastructures and along roads to maintain ecological connectivity within the site. • Re-create a similar open-country pond habitat to compensate for the loss of Pond1 and Pond2.
Enhancement	• Provide enhancement plantings at the Forest Corridor and Forest Stream and other retained habitats (e.g. planting different native plants in the 30 m buffer strip of the abandoned-land forest with native regeneration). Refer to **Appendix 7C** under 'Creation and Enhancement of Terrestrial Habitats' • Plant keystone species such as fig trees. These trees have uncoordinated fruiting periods and fruit abundantly when in season. Fig trees are an important food source for many animals including birds and small mammals. • Plant butterfly host and nectar plants, particularly for butterflies that currently occur within the EIS Study Area. Plants such as *Glochidion zeylanicum* and *Ardisia elliptica* that are the host plants for the forest-dependent Malay staff sergeant (*Athyma reta moorei*) and harlequin (*Taxila haquinus haquinus*) respectively, should be planted in retained forest areas such as the Forest Corridor. • Increase vegetation structural complexity by incorporating different layers and forms of vegetation including ground cover, shrubs, trees and epiphytes. • Adopt a native planting palette considering the existing and surrounding vegetation. Refer to **Appendix 7D** for a list of proposed native planting palette. • Prioritise intensive greening along streets or in areas with low levels of human disturbance (e.g. low traffic volume/speed, light human activities). • Enhance vegetation connectivity along Bukit Batok Road, Bukit Batok West Avenue and Bukit Batok West Avenue 2 to enhance connectivity to forests in Bukit Batok and Bukit Gombak; provide grade-separated wildlife crossings across Bukit Batok West Avenue 2 and Bukit Batok West Avenue 5. • Provide permanent wildlife crossings to maintain long-term ecological connectivity (**Figure 7.85**): – Jurong Region Line (JRL) – box culverts, retaining wall – Forest Drive Construction – Grade-separated flyover (vehicular bridge) wildlife crossing – Tengah Service Reservoir – Box culvert crossings – The Project – Grade-separated wildlife crossing across Tengah Boulevard Overpass – Forest Corridor and Forest Stream – Provide habitat features across Forest Stream; green Sungei Peng Siang and connect habitats to the north along Warren Golf Course

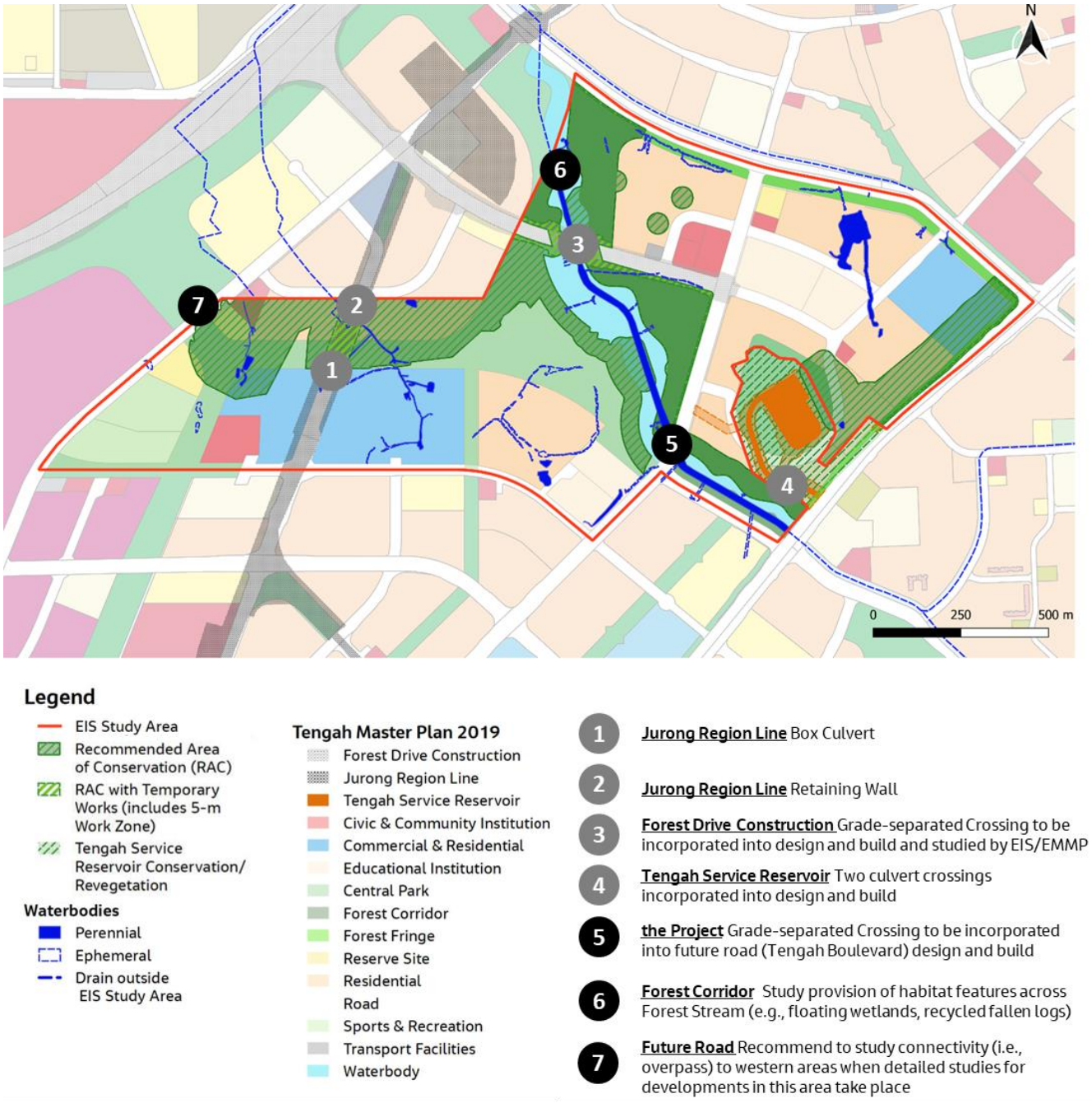


Figure 7.85: Overview of Planned and Recommended Permanent Wildlife Crossings within EIS Study Area

Source: Base Map obtained from Tengah Master Plan 2019 gazetted by URA

7.9.2 Construction Phase

Mitigation Hierarchy	Recommended Mitigation Measures
Avoidance	• Avoid felling trees and clearing vegetation during the peak bird breeding season (March to July).
Minimisation	• Transplant, salvage and/or harvest plants of conservation significance and the unknown specimen of Pteridophyte mentioned in **Section 7.3.3.1.** This should be planned and overseen by a Botanist/Flora Specialist. • Transplant important butterfly host plants such as *Glochidion zeylanicum* and *Ardisia elliptica* in retained forest areas (e.g. Forest Corridor) prior to site clearance. • Implement enhancement planting at the Forest Corridor and Forest Stream prior to site clearance so these areas can serve as refugia for wildlife. • Adopt directional clearance of vegetation from the site boundary towards areas of refuge (Forest Corridor). It allows space and time for animals to move towards the area of refuge and minimise impacts on habitat loss and disturbances. This should be planned and overseen by an Ecologist. • Conduct pre-felling fauna inspection before felling any trees or removing any vegetation. This should be planned and overseen by an Ecologist. • Retain ground cover for as long as possible before removal. • Applying mitigation measures as recommended in hydrology, water quality and waste sections with approved earth control measures (ECM) in place. • Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes. • Provide biodiversity awareness training to site personnel on management of wildlife encounters on site. • Execute wildlife response protocol during wildlife encounters. • Monitor water quality and aquatic faunal community at waterbodies to be conserved, particularly those adjacent to construction works. • Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials away from waterbodies. • Implement dust control measures such as dust screens and water suppression systems as recommended in air quality section. • Implement noise control measures such as source for quieter construction equipment (e.g. silent piler) as recommended in noise section. • Conduct regular site inspections for compliance, identify potential fauna entrapments, monitor health of trees and vegetation to be retained. • Conduct regular monitoring surveys to monitor the presence of faunal species within the site. • Conduct detection and translocation of bamboo bats (*Tylonycteris* spp.) prior to felling of bamboo clusters. This should be planned and executed by an Ecologist. • Provide temporary wildlife crossings to facilitate wildlife movement across the various developments interfacing with the Project (See **Figure 7.86**): – JRL – Box drain below temporary access road, temporary bridge over forest stream (ED2) – Forest Drive – Temporary wildlife crossing to be studied – Tengah Service Reservoir – Temporary wildlife crossing to be studied – The Project – Temporary wildlife crossing across Tengah Boulevard Overpass • Revegetate work areas with native species with the aim of habitat creation upon completion of works.

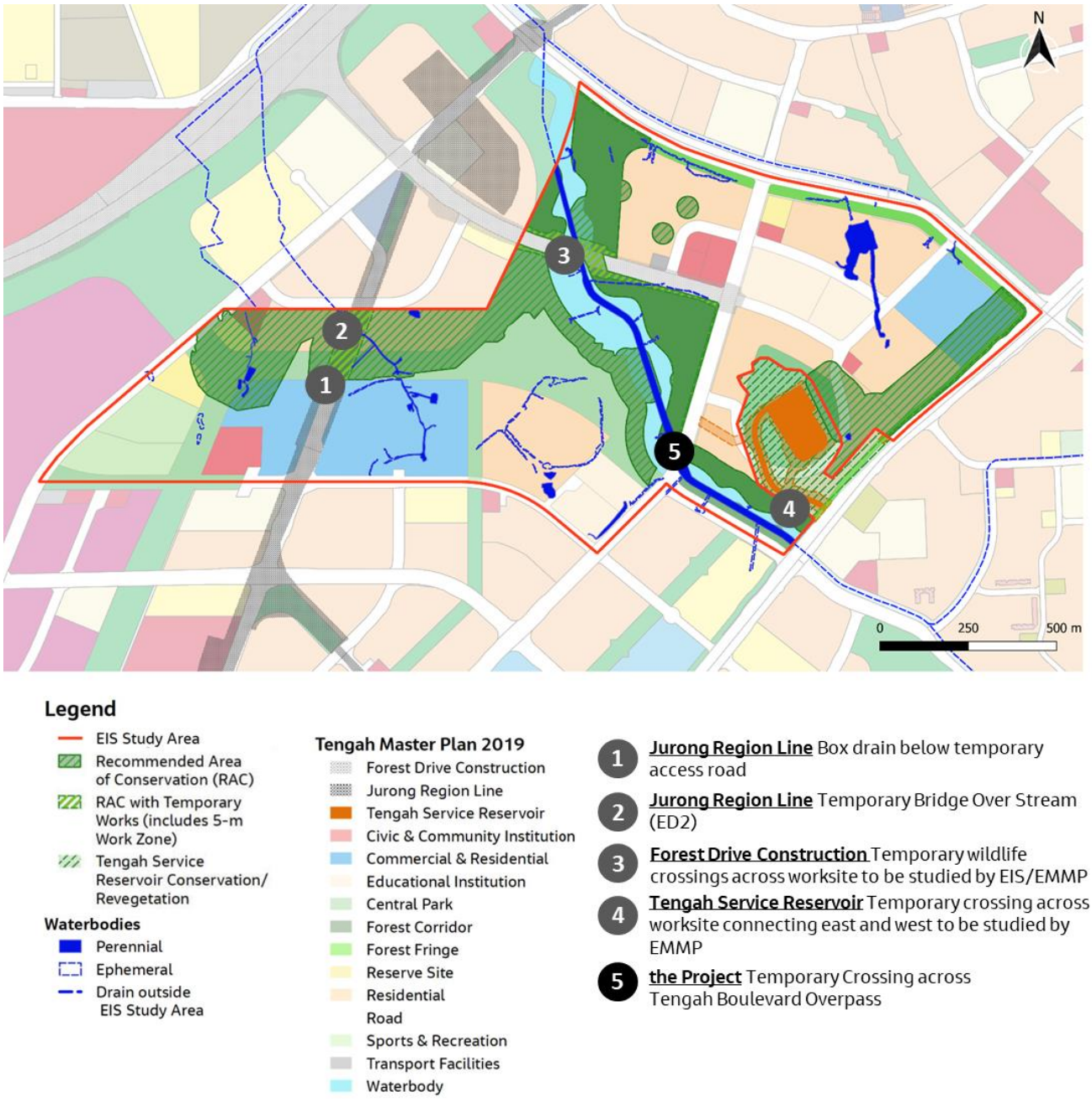


Figure 7.86: Overview of Temporary Wildlife Crossings within EIS Study Area

Source: Base Map obtained from Tengah Master Plan 2019 gazetted by URA

7.9.3 Operational Phase

During operational phase, measures should focus on minimising edge effects, disturbances to wildlife and human-wildlife conflict. Mitigating measures proposed at design phase should be applied together with the additional mitigation measures stated below:

- Unused areas should be replanted. Adopt a native planting palette considering the existing and surrounding vegetation.
- Place educational signages in public spaces around the township to advise residents on appropriate behaviours during wildlife encounters, including no feeding of macaques and no retaliatory attack/killing of snakes. These signs should target fauna usually implicated in human-wildlife conflict, such as the snakes, wild pig, long-tailed macaque, as well as threatened species such as the Sunda pangolin.
- Conduct regular monitoring during early operational phase to monitor for edge effects and other biodiversity concerns. Implement additional mitigation measures if required.

7.9.4 Targeted Faunal Species at for both Construction and Operational Phases

7.9.4.1 Straw-headed Bulbul

- Retain or plant fruit and fig trees, which are known food sources. Some examples are *Leea indica*, *Bridelia tomentosa*, *Clausena excavata*, *Dillenia suffruticosa* and *Ficus* spp. (LCKNHM, 2020b).
- Avoid felling trees and clearing vegetation during the bird breeding season (March to July).
- Conduct regular monitoring surveys during the construction and operational phases to monitor their presence within the site
- Conduct monthly wildlife surveys in adjacent and retained forested areas forested areas to monitor the distribution, abundance, food resource use and breeding behaviour of straw-headed bulbuls.
- Maintain wooded corridors to allow the species to move through the landscape and to surrounding green spaces.

7.9.4.2 Sunda Pangolin

- Retain large trees (≥ 0.5 m diameter at breast height (DBH)) and fallen logs which are known to be used by the Sunda pangolin for their natal dens (Lim & Ng, 2007).
- Implement traffic calming measures, such as road narrowing, speed bumps and road strips, to reduce incidence of roadkill. This can be incorporated with signages that warn drivers of wildlife crossing events.
- Provide grade-separated animal crossings in areas with gaps in vegetation connectivity, particularly across roads, to maintain ground connectivity and prevent roadkill. The details of specific strategies are provided in **Appendix 7C**.
- Incorporate fencing features to channel pangolins and other wildlife to crossings and the proposed Forest Corridor.
- Conduct pre-felling fauna inspection of trees and habitats before clearance. This allows the ecologists to identify pangolins residing on trees or in vegetation if visible, and potential habitats where pangolins may reside in (e.g. burrows and tree cavities). If potential habitats are present, contractors are required to carefully check for pangolin inside the burrow/cavity before felling the tree. If pangolins are found, the wildlife response protocol would be executed to remove it from the site.
- Conduct regular site inspections to look out for fauna potentially trapped or hiding within the site (e.g. storage materials). If pangolins are found, the wildlife response protocol would be executed to remove it from the site.
- Conduct monthly wildlife surveys in adjacent and retained forested areas forested areas to monitor for its presence within and around the site.

7.9.4.3 Bamboo Bat

Bamboos should be retained as much as possible as mitigation for bamboo bats have not obtained any success. If unable to retain them, transplantation is the preferred option. Yet, if the bamboo is too large for transplantation, translocation may be considered as the last option. However, transplantation and translocation will not lower the impact significance of the works as the success rate of the translocation exercise cannot be secured as many environmental factors have to be considered and cannot be pre-determined. For example, the sex and number of individuals captured for the translocation exercise, finding similar habitat conditions which provide food and refuge for the species translocated and existing populations in the receptor sites, the stress that translocated individuals face and whether the individuals translocated return to the original habitats which are meant to be cleared.

- Retain bamboos within the Forest Corridor.
- Transplant bamboos that are suitable transplant candidate (together with resident bats).
- Translocate bamboos that are not suitable transplant candidates.

7.9.4.4 Wild Pig

The wild pig is the largest mammal in EIS Study Area. This species has been involved in human-wildlife conflict, contributed by the increasing interface between humans and wildlife from urbanisation, as well as feeding of wildlife. Being a highly adaptable species, the wild pig is able to exploit and persist in the urbanised landscape. While it is not a species of conservation significance, this native species is susceptible to collision with vehicles and poses a safety risk to drivers. Thus, this issue needs to be addressed. It is recommended to maintain ground connectivity for wild pigs through providing forested corridors and wildlife crossings, and implementing traffic calming measures to reduce incidences of collisions. The details of specific strategies are provided in **Appendix 7C**.

7.9.4.5 Long-tailed Macaques

Like wild pigs, long-tailed macaques are highly adaptable and able to thrive in the urbanised landscape. In Singapore, a key concern for this species is collision with vehicles. It is therefore, important to implement traffic measures to reduce incidences of collisions. It is necessary to implement traffic calming measures to reduce incidences of collisions. More importantly, measures should focus on maintaining a proper waste disposal system in the estate, and educating the public on the negative consequences of feeding macaques and appropriate behaviours during wildlife encounters. The development is imperative for the users to recognise, embrace and be tolerant of the presence of wildlife in their estate for human-wildlife coexistence. The details of specific strategies are provided in **Appendix 7C**.

7.10 Evaluation of Residual Impacts

7.10.1 Construction Phase

7.10.1.1 Habitat Evaluation

Ecological impacts evaluated to have major or moderate negative impact significance for habitat receivers in **Section 7.8** were addressed with appropriate mitigation measures to help reduce the impact as much as possible. The residual impact significance was evaluated based on the mitigation measures agreed to be adopted by HDB, as shown in **Table 7.34**.

However, the significance of certain impacts such as loss of habitat and loss of ecological connectivity remains as major for most habitats because it is a permanent and irreversible impact that cannot be mitigated. Hence, the greatest impact significance is still expected to be major/moderate (**Table 7.34**). This is within the exception of abandoned-land forest with native regeneration species which will be retained, i.e. not impacted. However, with implementation of good practices during construction phases, the impact significance of habitat pollution, habitat degradation and change in species composition may be reduced from moderate to minor negative

impacts (**Table 7.34**). Yet, it remains as major negative for the abandoned-land forest with native regeneration as it is a highly sensitive habitat.

Table 7.33: Area of Habitat Directly Impacted by the Project Works during Construction Phase

Biodiversity-sensitive Habitat Receiver	Area Impacted Directly by the Project Works if Revised Recommended Area of Conservation Retained	Total Habitat Type Present in EIS Study Area Impacted
Abandoned-land Forest with Native Regeneration	1.0 ha	Not affected
Abandoned-land forest	21.2 ha	37.1%
Scrubland and herbaceous vegetation	20.6 ha	45.4%
Waste woodland	12.8 ha	25.6%
Closed-canopy stream	0.3 ha	59.4%
Open-country streams	1.1 ha (ED1); 0.1 ha (ED6)	95.2%
Closed-canopy & semi open-country ponds	0.02 ha (Pond5); ED8_02	10.5% (min)
Open-country pond	0.12 ha (Pond1 and Pond2)	100%
Main canal	3 ha	100%

Table 7.34: Summary of Evaluation of Residual Impacts during Construction Phase

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environmental Score (Post-mitigation)	Residual Impact Significance
Loss of vegetation/ habitat	Abandoned-land Forest with Native Regeneration	-351	**Major Negative Impact**	Without mitigation, 1 ha (100%) of the abandoned-land forest with native regeneration, 31.3 ha (54.7%) of abandoned-land forest, 18.1 ha (49.9%) of scrubland/ herbaceous vegetation and 12.6 ha (45.5%) of waste woodland will be affected. Mitigation measures: ▪ **Avoid:** Complete retention of the forest & its 30-m buffer by redesigning the road alignment. ▪ **Minimise:** Retention of 2.5 ha (4.3%) of abandoned-land forest (vegetation corridor along north-eastern boundary). ▪ **Minimise:** Retention of 1.9 ha (4.9%) of scrubland/ herbaceous vegetation (vegetation corridor along north-eastern boundary). ▪ **Minimise:** Retention of 2.2 ha (3.7%) of waste woodland (vegetation corridor along north-eastern boundary). ▪ **Minimise:** Keep sensitive habitats affected by works as long as possible before clearance. ▪ **Compensate:** creation of open-country pond (Pond1, Pond2) as an ABC Water Feature ▪ **Enhance:** enhancement of vegetation corridor along the north-eastern boundary.	0	**Not Impacted**
	Abandoned-land Forest	-351	**Major Negative Impact**		-234	**Major Negative Impact**
	Waste Woodland	-234	**Major Negative Impact**		-234	**Major Negative Impact**
	Scrubland and Herbaceous Vegetation	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-324	**Major Negative Impact**		-324	**Major Negative Impact**
	Closed-canopy Stream (ED7)	-324	**Major Negative Impact**		0	**Not Impacted**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	**Major Negative Impact**		-234	**Major Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	**Moderate Negative Impact**		-216	**Moderate Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	-216	**Moderate Negative Impact**		-216	**Moderate Negative Impact**
	Main Canal	-44	**Minor Negative Impact**		Since only minimal impacts are expected, no residual impacts are presented	
Total Environmental Score (Pre-mitigation)		**-2,528**		**Total Environmental Score (Post-mitigation)**	**-1,614**	

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environmental Score (Post-mitigation)	Residual Impact Significance
Loss of ecological connectivity	Abandoned-land Forest with Native Regeneration	-351	**Major Negative Impact**	The loss of ecological connectivity is largely associated with habitat loss and fragmentation. As such, it includes the mitigation measures for habitat loss listed above. Additional considerations/measures for ecological connectivity are: ▪ **Minimise:** vegetation corridor along north-eastern boundary provides a stepping stone habitat for fauna to disperse to Bukit Batok/Gombak forest in the north-east ▪ **Compensate:** provision of grade-separated wildlife crossings within site (including use of drains and streams). ▪ **Compensate:** provision of wildlife crossings to surrounding green spaces (i.e. Bukit Batok/Gombak forest through Bukit Batok Avenue 5 and Bukit Batok Hillside Park through Bukit Batok Avenue 2). ▪ **Compensate:** connect planted vegetation to retained habitats or corridors to maximise connectivity throughout the site ▪ **Enhance:** enhancement of habitats along wildlife crossings. ▪ **Enhance:** enhancement of habitats to surrounding green spaces (i.e. along Bukit Batok Avenue 2 and 5).	0	**Not Impacted**
	Abandoned-land Forest	-351	**Major Negative Impact**		-234	**Major Negative Impact**
	Waste Woodland	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Scrubland and Herbaceous Vegetation	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Closed-canopy Stream (ED2)	-324	**Major Negative Impact**		-324	**Major Negative Impact**
	Closed-canopy Stream (ED7)	-324	**Major Negative Impact**		0	**Not Impacted**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	**Major Negative Impact**		-234	**Major Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	**Moderate Negative Impact**		-216	**Moderate Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	-216	**Moderate Negative Impact**		-216	**Moderate Negative Impact**
	Main Canal	-72	**Minor Negative Impact**		Since only minimal impacts are expected, no residual impacts are presented	
Total Environmental Score (Pre-mitigation)		**-2,556**		**Total Environmental Score (Post-mitigation)**	**-1,614**	

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environmental Score (Post-mitigation)	Residual Impact Significance
Habitat pollution	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Habitat pollution may occur to retained habitats within and outside the Project works, including abandoned-land forest with native regeneration and closed-canopy streams (ED2 and ED7). Key mitigation measures are: ▪ **Avoid:** Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise:** Adhere strictly to working space and practise good housekeeping to minimise unnecessary and unauthorised clearance of retained habitats within and outside the Project. ▪ **Minimise:** Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. ▪ **Minimise:** Retain ground cover for as long as possible. When ground cover is removed, erosion control measures are to be in place. ▪ **Minimise:** Engage a qualified erosion control professional to formulate and implement ECM plan in accordance with pub requirements. ▪ **Minimise:** Monitor the water quality and aquatic faunal community in retained streams and vegetation adjacent to the Project works. ▪ **Minimise:** Conduct regular inspections for compliance and identify any impacts/ unnecessary clearance in adjacent forest areas and retained habitats.	-216	**Major Negative Impact**
	Abandoned-land Forest	-198	**Moderate Negative Impact**		-66	**Minor Negative Impact**
	Waste Woodland	-88	**Minor Negative Impact**		Since only minimal impacts are expected, no residual impacts are presented	
	Scrubland and Herbaceous Vegetation	-88	**Minor Negative Impact**		Since only minimal impacts are expected, no residual impacts are presented	
	Closed-canopy Stream (ED2)	-180	**Moderate Negative Impact**		-60	**Minor Negative Impact**
	Closed-canopy Stream (ED7)	-180	**Moderate Negative Impact**		-60	**Minor Negative Impact**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-132	**Moderate Negative Impact**		-44	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-132	**Moderate Negative Impact**		-44	**Minor Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	
Total Environmental Score (Pre-mitigation)		**-998**		**Total Environmental Score (Post-mitigation)**	**-490**	

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environmental Score (Post-mitigation)	Residual Impact Significance
Habitat degradation	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Habitat degradation may occur to retained habitats within and vegetation on the boundary of the Project works. Key mitigation measures are: ▪ **Avoid:** Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise:** Provide sufficient hydrological flow within retained waterbodies. ▪ **Minimise:** Conduct regular inspections for compliance and identify any impacts/ unnecessary clearance in adjacent forest areas and retained habitats. ▪ **Enhance:** Enhancement of conserved habitats and its buffer.	-216	**Moderate Negative Impact**
	Abandoned-land Forest	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-156	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-156	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	
Total Environmental Score (Pre-mitigation)		**-1,186**		**Total Environmental Score (Post-mitigation)**	**-724**	

Potential Ecological Impact	Habitat Receiver	Environmental Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environmental Score (Post-mitigation)	Residual Impact Significance
Change in species composition	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Change in species composition may occur from forest edge effects, hence mitigation measures from habitat degradation would also apply. Additional mitigation measures are: ▪ **Avoid:** Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise:** Quarantine plant materials at external nursery before transferring to site	-234	**Major Negative Impact**
	Abandoned-land Forest	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	
Total Environmental Score (Pre-mitigation)		**-1,082**		**Total Environmental Score (Post-mitigation)**	**-742**	

7.10.2 Species Evaluation

For species of high ecological value, especially threatened species, they are subjected to being salvaged/ harvested/ transplanted/ propagated. However, it is important to note that these methods might not be applicable to all species. For instance, large specimens of *Ficus microcarpa* or *Campnosperma auriculata* would still be directly affected by the Project works as transplanting these specimens is not a viable option. As a general rule of thumb, specimens with girth size of < 0.05 m- 0.3 m will be able to be salvaged/transplanted from the affected area. However, any specimens above 0.3 m girth size will have a lower success rate of being salvaged/transplanted. Hence, the assessment of the residual impact significance reflected in Appendix I are mostly determined by the viability and success rate of salvaging/transplanting these species and the number of specimens of each species located within the Project boundary. Species that was assessed with minor pre-mitigation negative impact significance are not assessed for any residual impact.

Plants of Conservation Significance

Only six species of conservation significance are assessed with major negative impact significance in the evaluation of residual impact. Three of this species, i.e. *Oncosperma tigillarium*, *Ficus vasculosa* and *Symplocos fasciculata*, were recorded as trees and/or palms which are not suitable to be transplanted due to their low success rate in transplanting. For *Oncosperma tigillarium*, transplanting or salvaging would be difficult to carry out due the presence of sharp thorns on the stem. This is similar for Vulnerable species *Rubus moluccanus var. moluccanus*, a shrub species which are known covered by prickles. For species that are not suitable to be transplanted or salvaged, other methods such as propagation or harvesting may be carried out instead. However, this method involves taking only vegetative or reproductive parts (e.g. by cutting the stems, or harvesting the seeds) of the specimen and leaving the parent plant in its initial location. Hence, the specimen will still be faced with mortality.

Five species of conservation significance are assessed with moderate negative impact significance. For these species, the success rate of transplanting/salvaging these species is unknown. However, due to the retention of strip of vegetation located along the eastern boundary of the EIS Study Area, lesser specimen of these species is affected by the proposed works, Hence, this decreases their impact magnitude and residual impact significance. The remaining twenty-six species of conservation significance are assessed with no change in impact significance as: (1) specimens are not located within the Project boundary; or (2) specimens located within the Project boundary can successfully be salvaged/transplanted out from the affected area.

As for remaining ecological impacts such as impediment to seedling recruitment, competition from exotic plants and decline in plant health and survival, since the specimens assessed are those within 30 m from the Project boundary, the impact significance for the plant species did not change much. These plants will still be subjected to the ecological impact stated above due to forests edge effects and change in microclimate conditions due to the construction works and land clearance. Only two species, *Ardisia elliptica* and *Callicarpa longifolia*, were assessed with moderate impact significance.

Keystone Species

Four *Ficus* specie (i.e. *Ficus religiosa*, *Ficus microcarpa*, *Ficus variegata* and *Ficus vasculosa*) were assessed with major negative impact significance when assessed for impact of mortality towards these species. More than half the specimens would still be affected by the Project works. All recorded specimens of these species are large trees. Hence, transplanting these specimens is not a viable option. This seem to be the same for *Ficus benjamina*, which was assessed with a moderate impact significance.

Impact significance for *Ficus aurata* var. *aurata* which was initially a major, was reduced into moderate impact significance as only 25% of the total species count will be affected by the Project works after the implementation of mitigation measures. The remaining nine species of Ficus were assessed with no change to the impact significance. This includes Ficus species that has zero counts like *Ficus hispida*, *Ficus heteropleura*, *Ficus grossularioides var. grossularioides* and *Ficus pumila* var. *awkeotsang*.

Only *Ficus fistulosa* was assessed with a moderate impact significant for decline in plant health due to microclimatic condition. This is because all specimen count of this species, which is only two counts that was extracted from arboricultural survey, are within 30 m from the Project boundary. Hence, the impact magnitude given for this species is moderate and this resulted to the impact significance to remain as moderate. The remaining 11 out of 15 *Ficus* species were not assessed with any impact significance as they are not located within 30 m from the Project boundary. For other two indirect ecological impact, impediment to seedling recruitment and competition from exotic species, all no assessment is given to all *Ficus* species as most species were already given the lowest impact, which is a minor, for their pre-mitigation impact significance.

Common Native Species

For the assessment of direct impact, common native species *Campnosperma auriculata* was assessed with a major negative impact significance which did not differ to its pre-mitigation impact significance. This is because transplanting is not a viable option since it is a large tree species. Hence, approximately 43% of the total species count will be affected by the Project works. As for common native orchids *Arundina graminifolia* and *Spathoglottis plicata*, no impact assessment for direct impact is given. The impact significance for *Spathoglottis plicata* reduces from major to 'no change' after the implementation of mitigation measures as the specimens will be subjected to salvaging/transplanting.

As for the assessment of indirect impacts, other individuals of *Spathoglottis plicata* located within 30 m from the Project are prone to face all indirect impacts listed even after mitigation measure has put into place. Hence, the impact significance for this species was assessed to be moderate. Other common native species, *Campnosperma auriculata* and *Arundina graminifolia*, do not have any change in their impact significance as there are no specimens located within 30 m from the Project boundary.

Faunal Species

Impacts from the loss of/reduction in habitats and food sources, as well as impediment to faunal movement, cannot be mitigated to a lower level during construction phase. However, it may be reduced through the retention of Areas of High Conservation Value. Injury and mortality of species may be reduced through execution of Environmental Management and Monitoring Plan (EMMP) as detailed in **Section 12**. Disturbances to species from light and human disturbances by ensuring no night works and no encroachment of site personnel into retained habitats. Mitigation measures for noise disturbances to fauna are also described in **Section 8.4**.

7.10.3 Operational Phase

7.10.3.1 Habitat Evaluation

The highest pre-mitigation impact significance during operational phase was major impacts from change in species composition and habitat degradation to abandoned-land forest. Minor to moderate negative impacts were expected for the remaining habitats. The residual impact significance was evaluated based on the mitigation measures agreed to be adopted by HDB, as shown in **Table 7.34**. Most impacts remain although magnitude of changes is minor, due to the high ecological value of the habitat features.

7.10.3.2 Species Evaluation

Plant Species

With the implementation of mitigation measures, eight plant species are not included in the direct impact assessment for operational phases as the only specimens of these species in the entire EIS Study Boundary has already been salvaged/transplanted or cleared during the Construction Phase. These species are: (1) *Artabotrys suaveolens;* (2) *Aspidopterys concava*; (3) *Carallia brachiata*; (4) *Cayratia mollissima*; (5) *Ficus religiosa*; (6) *Hoya latifolia*; (7) *Limacia scandens* and (8) *Rubus moluccanus* var. *moluccanus.* The basis of the species evaluation for the Operation Phase is explained in **Section 7.8**.

There is no change in the impact significance for all species when compared to their pre-mitigation impact significance except for *Spathoglottis plicata.* Only one species*, Callicarpa longifolia,* is assessed with major impact significance as the only remaining specimen of this species in the entire EIS Study Area is prone to be affected by mortality from being stolen/poached. Due to its attractive features such as its attractive looking flowers and berry-like fruits, and medicinal properties of this plant, it is subjected to being stolen by those who are aware of its medicinal properties or who is attracted by its aesthetic look. Any loss of few individuals of this species would be detrimental to the total species richness of the region have an effect on the national population as this species is a threatened species.

Twelve plant species were assessed to face with moderate impact significance as a result of mortality. All of these species are of threatened species, except *Spathoglottis plicata.* For this orchid species, the impact significance reduces from major to moderate. Since the remaining specimens is also located within the proposed Forest Corridor, it is assumed that there would be restricted access to this corridor as it is catered only for wildlife connectivity. This decreases the chances of the orchid to be stolen. The remaining thirty species are assessed with no change to their impact significance, due to the fact that it is located beyond the 30 m from the Project boundary and/or it is not likely to get stolen/poached. Examples of these species are *Ficus benjamina and Ficus microcarpa.*

As for the assessment of indirect impacts, no assessment is done for all species due to these three reasons: (1) the only population of these species have either been cleared or salvaged/transplanted during Construction Phase; (2) the species are not located within 30 m from the Project boundary and/or (3) species that was assessed with minor pre-mitigation negative impact significance were not assessed for any residual impact.

Faunal Species

Impacts from the impediment to faunal movement cannot be mitigated to a lower level. However, compensatory measures such as retention of Areas of High Conservation Value that provides habitats for species to disperse. In addition, a wildlife-friendly overhead bridge may be constructed as a compensatory measure to facilitate the dispersal of both terrestrial and flying species towards Bukit Batok/Gombak forests. The injury and mortality of species from roadkill ranged from critically negative for Sunda pangolin (*Manis javanica*) to moderate negative. This can be reduced by providing adequate wildlife crossings at strategic locations. Collision of birds with buildings remains as major negative but may be reduced by providing visual markers on buildings. Disturbances to species from light and human disturbances by providing a buffer zone between retained habitats and urban development, as described in **Appendix 7C**.

Table 7.35: Summary of Evaluation of Residual Impacts during Operational Phase

Potential Ecological Impact	Habitat Receiver	Environment Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environment Score (Post-mitigation)	Residual Impact Significance
Change in plant species composition	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Key mitigation measures are: ▪ **Avoid:** Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Enhance:** Enhancement of conserved habitats and its buffer. ▪ **Minimise:** Conduct regular biodiversity surveys or inspections to monitor the flora and faunal community in retained and forest adjacent to the construction areas. If impacts are detected, management measures should be followed up.	-234	**Major Negative Impact**
	Abandoned-land Forest	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**		-72	**Minor Negative Impact**
	Open-country Streams (Spring)	-96	**Minor Negative Impact**		-48	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4 and Pond5)	-96	**Minor Negative Impact**		-48	**Minor Negative Impact**
Total Environmental Score (Pre-mitigation)		**-1,066**		**Total Environmental Score (Post-mitigation)**	**-734**	

Potential Ecological Impact	Habitat Receiver	Environment Score (Pre-mitigation)	Impact Significance	Mitigation Measures	Environment Score (Post-mitigation)	Residual Impact Significance
Habitat degradation	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Key mitigation measures are: ▪ **Minimise:** keep sensitive forested habitats inaccessible to the public. ▪ **Minimise:** install educational signages to educate the public about the sensitivity of the forested habitats. ▪ **Minimise:** Conduct regular biodiversity surveys or inspections to monitor the flora and faunal community in retained and forest adjacent to the construction areas. If impacts are detected, management measures should be followed up.	-234	**Major Negative Impact**
	Abandoned-land Forest	-234	**Major Negative Impact**		-156	**Moderate Negative Impact**
	Waste Woodland	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative Impact**		-52	**Minor Negative Impact**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative Impact**		-144	**Moderate Negative Impact**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative Impact**		-144	**Moderate Negative Impact**
	Open-country Streams (Spring)	-96	**Minor Negative Impact**		-48	**Minor Negative Impact**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4 and Pond5)	-96	**Minor Negative Impact**		-48	**Minor Negative Impact**
Total Environmental Score (Pre-mitigation)		**-1,066**		**Total Environmental Score (Post-mitigation)**	**-879**	

7.11 Ongoing Studies

As a result of extensive discussion, the findings of the ecology and biodiversity findings in this EIS, several studies have been initiated in order to provide more insights and targeted recommendations for the conserved areas.

7.11.1 Study of Land Use Plan

In response to the RAC, HDB and various agencies are undergoing a land use re-planning against the gazetted Tengah Master Plan 2019 to balance conservation and developmental needs.

7.11.2 Study of Light Impact on Forest Corridor

Light pollution was highlighted by various stakeholders as an important area of study for the forest corridor due to its proximity to urban areas. Buffer areas have been recommended in this EIS which mitigate such impacts, and future developments are studying incorporating designs where no lightings are allowed to face the forest corridor.

7.11.3 Forest Connectivity and Crossings

Studies for the forest corridor, stream and fringe is currently in its early initial planning stages. Studies are being conducted on how connectivity (e.g. area, type of vegetation and crossing structures) can be improved to cater for a larger range of fauna species as well as how connectivity from Tengah to other green bodies in Singapore can be improved.

8. Airborne Noise

This section describes the regulations and standards for noise pollution control that are applicable to the Project development and the methodology used for the noise impact assessment[10]. It also discusses the noise baseline data obtained and assessment of the likely noise impacts associated with the construction phase of the Project development. Recommended mitigation measures and monitoring requirements are also provided.

8.1 Applicable Legislation and Standards

8.1.1 For Affected Community

Noise emissions from construction sites are regulated by NEA using the *EPM (Control of Noise at Construction Sites) Regulations*. A set of maximum allowable noise limits are prescribed for different time periods of the day and for different types of affected premises under *EPM (Control of Noise at Construction Sites) Regulations*, Second Schedule (**Table 8.1**).

Table 8.1: Maximum Permissible Noise Levels

Period	Types of Affected Buildings	Maximum Permissible Noise Levels in A-weighted decibels (dBA)		
		7 a.m. – 7 p.m.	7 p.m. – 10 p.m.	10 p.m. – 7 a.m.
Monday to Saturday	(a) Hospitals, schools, institutions of higher learning, homes for the aged sick etc.	60 (L_{Aeq} 12 hrs)	50 (L_{Aeq} 12 hrs)	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	
	(b) Residential buildings located less than 150 m from the construction site	75 (L_{Aeq} 12 hrs)	65 (L_{Aeq} 1 hr)	55 (L_{Aeq} 1 hr)
		90 (L_{Aeq} 5 mins)	70 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)
	(c) Buildings other than those in (a) and (b) above	75 (L_{Aeq} 12 hrs)	65 (L_{Aeq} 12 hrs)	
		90 (L_{Aeq} 5 mins)	70 (L_{Aeq} 5 mins)	
Sunday and Public Holidays	(a) Hospitals, schools, institutions of higher learning, homes for the aged, sick etc.	60 (L_{Aeq} 12 hrs)	50 (L_{Aeq} 12 hrs)	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	
Sunday and Public Holidays	b) Residential buildings located less than 150 m from the construction site	75 (L_{Aeq} 12 hrs)	-*	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	

[10] The noise assessed in this section refers to airborne noise. No ground-borne noise is assessed in this section.

Period	Types of Affected Buildings	Maximum Permissible Noise Levels in A-weighted decibels (dBA)		
		7 a.m. – 7 p.m.	7 p.m. – 10 p.m.	10 p.m. – 7 a.m.
	(c) Buildings other than those in (a) and (b) above	75 (L_{Aeq} 12 hrs)	65 (L_{Aeq} 12 hrs)	
		90 (L_{Aeq} 5 mins)	70 (L_{Aeq} 5 mins)	

* No limits provided by NEA.

With effect from September 1, 2011, construction site is prohibited to commence work from 7 p.m. every Saturday to 7 a.m. on the following Monday and from 10 p.m. on the eve of a public holiday to 7 a.m. on the day following the public holiday as stipulated in *EPM (Control of Noise at Construction Sites) Regulations*, Fourth Schedule.

8.1.2 For Fauna Receptor

There is presently no specific legislation, standard or widely accepted guidelines in Singapore that describe the noise levels or threshold limit for fauna. Humans and faunas have different hearing abilities and acoustic behaviours and it is not possible to directly extrapolate from human standards to fauna. For instance, the range of frequencies that fauna can hear differ greatly from humans and amongst themselves. Humans have a hearing range of approximately 64 to 23,000 hertz (Hz) while dogs can hear between 67 and 45, 000 Hz, owls between 200 and 12,000 Hz and bats between 2, 000 and 110, 000 Hz. Fauna also have different sound sensitivities, with some able to hear very low or very high frequencies once crossing a certain threshold of sound intensity (Strain, 2017).

We therefore propose to assess fauna's response to continuous, intermittent or instantaneous noise based on publicly available literature. It shall be recognised that amongst and within different fauna taxon, there is substantial variation of auditory capabilities and behaviours which translate to a wide range of physiological and behavioural reactions to sound that current literature has limited coverage over. Fauna that rely on vocal communication for a range of functions such as mating courtship, prey location, threat detection and navigation are more severely affected by noise pollution. However, there are a few known fauna exceptions where current research point towards a greater tolerance to noise due to lower hearing capabilities such as odonates (Robert, 2005) and snakes (Christensen et al., 2012) who depend on other sensory faculties. It is also noted for bats, that acoustic interference with the bat calls based on frequencies rather than the specific noise levels have a larger impact on their response to noise pollution (Bunkley et al., 2015).

In general, the main impacts which are noted in most research are; behavioural changes, psychological impacts, auditory damage and masking of auditory signals. A brief summary of selected laboratory and field research which broadly investigated road and construction noise is shown in **Table 8.2**: to highlight the broad range of noise levels and their impacts on different taxon.

Table 8.2: Summary of Noise Levels and Impacts on Fauna

Taxon	Noise Levels (in dBA)	Observed Impacts
Non-volant Mammals	43	• Behavioural and psychological responses of fear such as vocalisations and movement away from noise.
	45-58	• Behavioural response such as lowered above-ground activity, reduced foraging and increased vigilance.

Taxon	Noise Levels (in dBA)	Observed Impacts
	70-90	• Psychological responses of reduced reproductive efficiency.
Avian	45-70	• Behavioural response resulting in decline in species diversity.
	44 – 80	• Acoustic masking resulting in changes in vocalisations and community interactions.
	68	• Psychological response of reduced reproductive success.
Frogs	48-77	• Acoustic masking resulting in possible reduced breeding success.
	60 – 72	• Acoustic masking resulting in increased call amplitude and thus increased energy expenditure.

Source: (Kight et al., 2012; Parris et al., 2009; Rasmussen et al., 2009; Shannon, Crooks, Wittemyer et al., 2016; Shannon, McKenna, Angeloni et al., 2016; Westlund et al., 2012)

As seen from **Table 8.2**, the impact of noise level ranges differs greatly across various species and taxon and impacts can begin from levels as low as 43 dBA. We therefore take a multi-pronged approach to fauna receptor assessments, by categorising fauna found on site into three impact priority levels based on their noise-sensitivity and conservation significance as shown in **Table 8.3**. Noise sensitive fauna includes those which use auditory communication for survival including for successful reproduction, while non-noise sensitive fauna tends to rely less heavily, or not at all, on auditory means for survival.

Table 8.3: Noise Impact Priority Categories for Fauna

Impact Priority	Fauna	General Taxon
Priority/ Sensitivity - High	Fauna of conservation significance (i.e. threatened species) who are sensitive to sound	• Aculeate hymenopterans • Lepidoptera (butterflies/ moths) • Birds • Amphibians • Reptiles (lizards/ geckos/ skinks) • Mammals
Priority/ Sensitivity – Medium	Fauna of non-conservation significance (i.e. common species) who are sensitive to sound	
Priority/ Sensitivity - Low	Fauna who have lower sensitivity to sound	• Odonates • Amphibious fish (i.e. Common walking catfish and Asian swamp-eel)

In addition, we use airborne noise baseline levels as the threshold limit for fauna taking the reasonable assumption that fauna in the EIS Study Area have since adapted to current baseline noise levels even if these levels may be higher than literature suggests. This may still be considered a conservative approach as it is possible that the fauna has adapted to having a higher threshold than the baseline noise in order to reside comfortably in Tengah.

8.2 Assessment Methodology

As this EIS focuses on the assessment of noise impacts during the construction phase, we are using the following guidance documents to identify noise impact effluence area (buffer) to the EIS Study Area, the Noise Sensitive Receivers (NSRs), the baseline study, the maximum permissible noise level and to estimate noise level at NSRs and assess the potential noise impacts:

a) Singapore Standard SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites published by Spring Singapore.

b) EPM (Control of Noise at Construction Sites) Regulation.

c) British Standards BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise.

d) Technical Memorandum Annex 13: Guidelines for Noise Assessment published by HK EPD adapted to Singapore situation.

8.2.1 Determination of Noise Sensitive Receivers

The criteria considered for determination of NSRs for the Project are listed below:

a) Affected community

- Hospital, clinic, convalescence, home for the aged, and orphanage
- Education institution including nursery, kindergarten, school, higher learning institution such as college and university
- Residential premise including temporary housing
- Hotel and hostel
- Court of laws
- Places of worship
- Library and museum
- Public meeting hall
- Auditorium, concert hall, theatre, recording studio, and broadcasting studio
- Country parks

b) Fauna

- Ground-dwelling and understory fauna
- Arboreal fauna

The affected community NSRs potentially affected by the Project development are identified through a combination of desktop study (i.e. review publicly available street directory and satellite map) and visual site survey. The fauna NSRs were identified via site surveys and through probable occurrence as described in **Section 7.2.4.**

8.2.2 Baseline Noise Sampling

a) Affected Community

The noise levels are measured using a Type 1 integrating sound level meter in 'A' weighted level (in dBA). The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1-hour and L_{Aeq} 12-hour.

Noise levels are monitored at 5-minute interval over three different periods of time, i.e. day time (7 a.m. – 7 p.m.), evening-time (7 p.m. – 10 p.m.), and night time (10 p.m. – 7 a.m.) for one week (including one weekend) on a continuous basis to present a representative existing noise background.

b) Fauna Receptor

The noise levels are measured using a Type 1 integrating sound level meter in 'A' weighted level (in dBA) with 1/1 octave band. The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1-hour and L_{Aeq} 12-hour in 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. Frequency.

Noise levels are monitored at 5-minute interval over three different periods of time, i.e. day time (7 a.m. – 7 p.m.), evening-time (7 p.m. – 10 p.m.), and night time (10 p.m. – 7 a.m.) for one week (including one weekend) on a continuous basis to present a representative existing noise background in Tengah.

8.2.3 Noise Impact Magnitude

The impact magnitude of the exceedance in noise limits are based on the subjective perception in decibel levels by humans as in **Table 8.4**. The table describes their response to changes in dBA levels and are taken as a guide to the impact magnitude on the noise sensitive receptors when noise exceeds the permissible limits. Although fauna is likely to respond differently to these changes in dB levels, there are no known studies that have investigated responses to varying changes, the same impact magnitude criteria is therefore taken.

Table 8.4: Noise Impact Magnitude Table

Exceedance dBA Level	Subjective Response	Impact Magnitude
< 5 dB	Just perceptible	Minor
5-10 dB	Clearly perceptible	Moderate
> 10 dB	More than twice as loud	Major

Source: Adapted from (Murphy & King, 2014)

8.3 Pre-construction Baseline

8.3.1 Determination of Noise Sensitive Receiver

Based on the mentioned criteria on **Section 8.3.1** and the Site Reconnaissance carried out on Jan 7, 2020, the list of NSRs within the EIS Study Area and its buffer area (i.e. 150 m from the EIS Study Area) that are potentially affected by the Project development is listed in **Table 8.5** and illustrated below (**Figure 8.1**).

Table 8.5: Identified Noise Sensitive Receivers (NSRs) for the Project

NSR Cluster	Cluster Description	Nature of Business	Location and Distance of Cluster to the EIS Study Area
NSR Cluster 1	Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5, iNZ Residence Condominium (affected community)	Residential	80 m to the north of the EIS Study Area
NSR Cluster 2	Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7, Ichiban Montessori Childcare Centre (affected community)	Residential and Preschool	70 m to the north of the EIS Study Area
NSR Cluster 3	Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7, HomeTeam NS Adventure Centre @ Bukit Batok, Dunearn Secondary School and Bukit Batok Golf Range (affected community)	Residential, School and park	60 m to the south/southeast of the EIS Study Area

NSR Cluster	Cluster Description	Nature of Business	Location and Distance of Cluster to the EIS Study Area
NSR Cluster 4	Fauna group	Forest	Within eastern portion of the EIS Study Area
NSR Cluster 5	Fauna group	Forest	Within western portion of the EIS Study Area

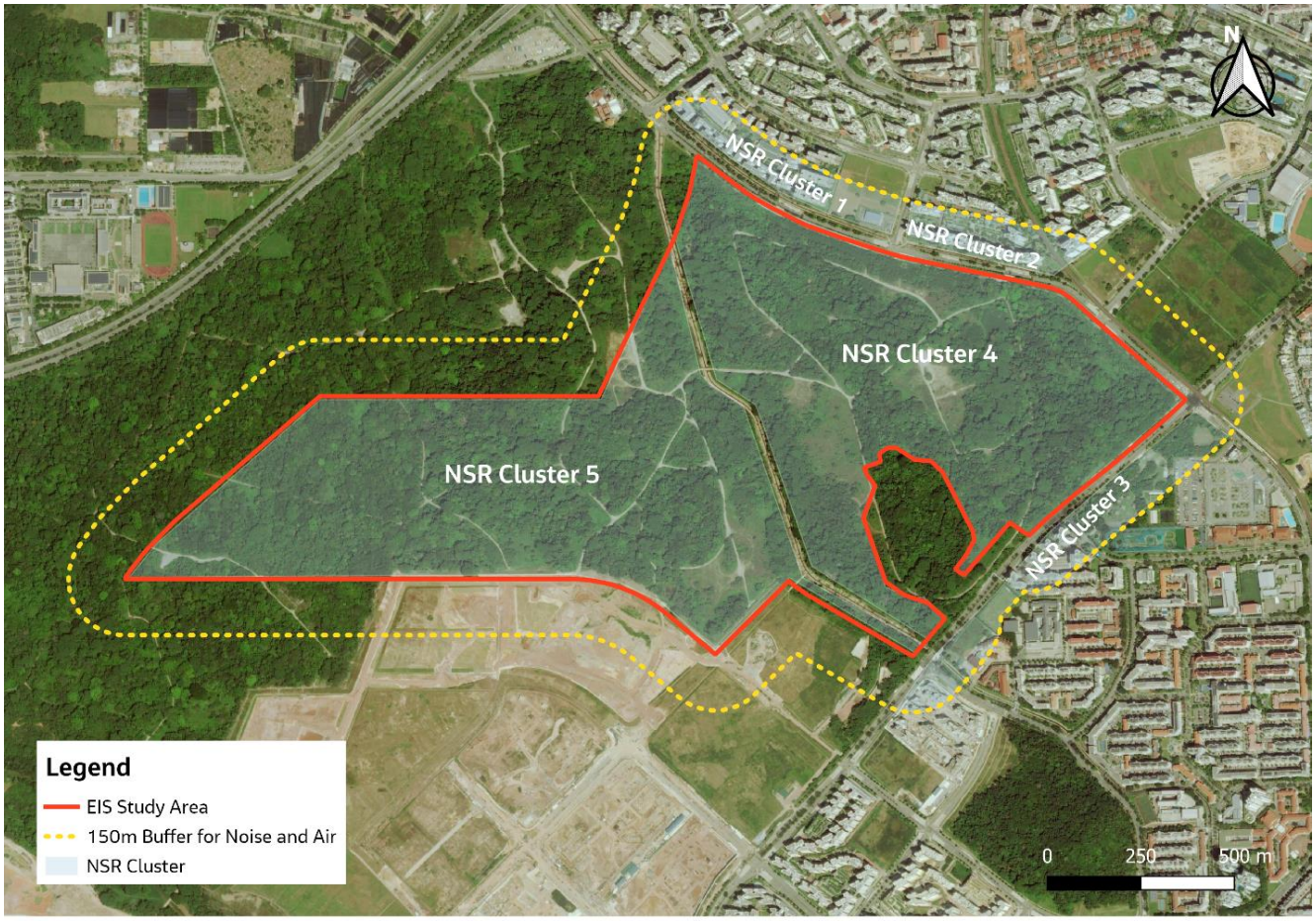


Figure 8.1: Noise Sensitive Receivers (NSR) Clusters

Base Map: ESRI

8.3.2 Noise Baseline Sampling

Three noise sampling points for affected community and two noise sampling points for fauna were selected. The locations of the noise baseline samplings are shown in **Figure 8.2** and described below:

Table 8.6: Location of Noise Sampling Station

Noise Sampling Points	Description
N1	At an open space of the ground floor of Block 484B Choa Chu Kang Avenue 5
N2	At an open space of the ground floor of Block 805C Keat Hong Close
N3	At an open space of the ground floor of Block 405 Bukit Batok West Ave 7

Noise Sampling Points	Description
N4	Within eastern portion of the EIS Study Area
N5	Within western portion of the EIS Study Area

Note: Based on our site reconnaissance, the major noise source in the vicinity of NSR 1, NSR 2 and NSR 3 is traffic noise. Placing the noise meter on the ground floor is preferable as the measured noise level will be the actual perceived levels by the residents staying at the lower floors.

The noise levels for affected community are measured using a Type 1 integrating sound level meter in dBA at 5-minute interval over three different periods of time, i.e. day time (7 a.m. – 7 p.m.), evening-time (7 p.m. – 10 p.m.), and night time (10 p.m. – 7 a.m.) for one week (including one weekend) on a continuous basis to present a representative existing noise background. The parameters measured include A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1 hour and L_{Aeq} 12 hour.

The noise level for affected fauna are measured using Type 1 sound level meter at 5-minute interval over three different periods of time, i.e. day time (7 a.m. – 7 p.m.), evening-time (7 p.m. – 10 p.m.), and night time (10 p.m. – 7 a.m.) for one week on a continuous basis to present a representative baseline of the existing environment. The parameters measured include sound pressure level (in dBA) for each frequency in 1/1 octave band and total sound pressure (in dBA).

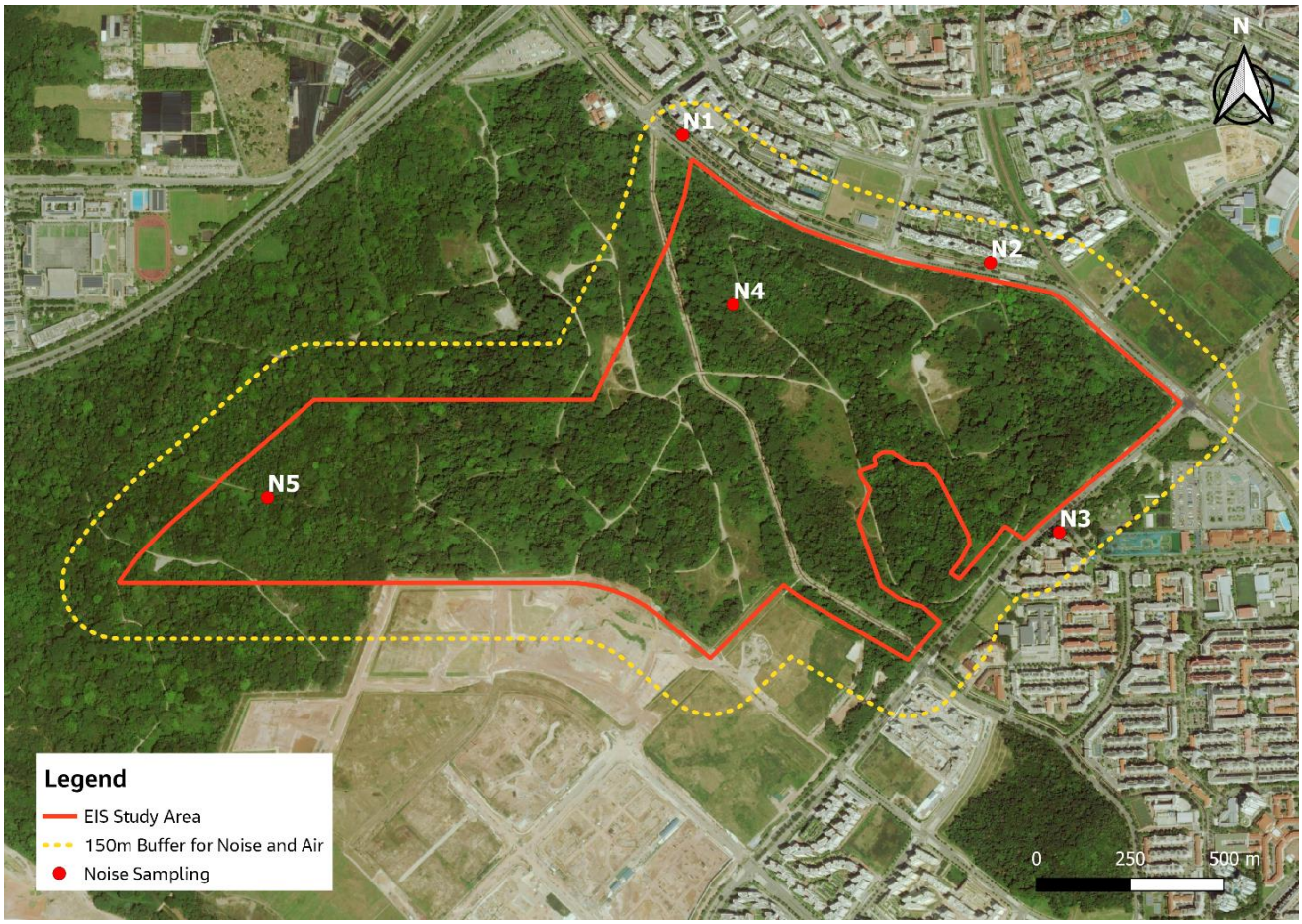


Figure 8.2: Location of Noise Baseline Measurement Station

Base Map: ESRI

8.3.3 Results and Discussion

8.3.3.1 For Affected Community

The noise baseline sampling for affected community was conducted from Feb 10 to March 2, 2020. Photographic logs for the baseline noise survey are provided in **Appendix 8A** with noise baseline summary results are tabulated in **Table 8.7**.

The noise baseline sampling results are summarised below:

a) For N1 (Residential):

- During day time, L_{Aeq} 5 mins on weekday (74.4 dBA) and on Sunday (70.8 dBA) comply with the respective maximum permissible noise levels for weekday (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekday (65.5 dBA) and on Sunday (64.4 dBA) comply with the respective maximum permissible noise levels for weekday (75 dBA) and Sunday (75 dBA).
- During evening time, L_{Aeq} 5 mins on weekday (76.4 dBA) and on Sunday (65.9 dBA) exceed the respective maximum permissible noise levels for weekday (70 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekday (68.0 dBA) exceeds the maximum permissible noise levels for weekday (65 dBA).
- During night time, L_{Aeq} 5 mins on weekday (73.2 dBA) and on Sunday (70.0 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekday (65.0 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

b) For N2 (Residential):

- During day time, L_{Aeq} 5 mins on weekday (78 dBA) and on Sunday (70.2 dBA) comply with the respective maximum permissible noise levels for weekday (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekday (65 dBA) and on Sunday (64.1 dBA) comply with the respective maximum permissible noise levels for weekday (75 dBA) and Sunday (75 dBA).
- During evening time, L_{Aeq} 5 mins on weekday (68.7 dBA) complies with maximum permissible noise level for weekday (70 dBA) and on Sunday (65.5 dBA) exceeds the maximum permissible noise levels for Sunday (55 dBA); L_{Aeq} 1 hour on weekday (66.7 dBA) exceeds the maximum permissible noise levels for weekday (65 dBA).
- During night time, L_{Aeq} 5 mins on weekday (67.6 dBA) and on Sunday (64.5 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekday (65.0 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

c) For N2 (School):

- During day time, L_{Aeq} 5 mins on weekday (78 dBA) exceeds the maximum permissible noise level (75 dBA) and on Sunday (70.2 dBA) complies with the respective maximum permissible noise levels for Sunday (75 dBA); L_{Aeq} 12 hours on weekday (65 dBA) and on Sunday (64.1 dBA) comply with the respective maximum permissible noise levels for weekday (60 dBA) and Sunday (60 dBA).
- During day time, L_{Aeq} 5 mins on weekday (78 dBA) exceeds the maximum permissible noise level (75 dBA) and on Sunday (70.2 dBA) complies with the respective maximum permissible noise levels for Sunday (75 dBA); L_{Aeq} 12 hours on weekday (65 dBA) and on Sunday (64.1 dBA) comply with the respective maximum permissible noise levels for weekday (60 dBA) and Sunday (60 dBA).
- During evening time, L_{Aeq} 5 mins on weekday (68.7 dBA) and on Sunday (65.5 dBA) exceed the respective maximum permissible noise level for weekday (55 dBA) and on Sunday (55 dBA).
- During night time, L_{Aeq} 5 mins on weekday (67.6 dBA) and on Sunday (64.5 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA).

d) For N3 (Residential):

- During day time, L_{Aeq} 5 mins on weekday (74.5 dBA) and on Sunday (72.1 dBA) comply with the respective maximum permissible noise levels for weekday (90 dBA) and Sunday (75 dBA); L_{Aeq} 12 hours on weekday (67.9 dBA) and on Sunday (66.8 dBA) comply with the respective maximum permissible noise levels for weekday (75 dBA) and Sunday (75 dBA).
- During evening time, L_{Aeq} 5 mins on weekday (73.0 dBA) and on Sunday (69.0 dBA) exceed the respective maximum permissible noise levels for weekday (70 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekday (67.9 dBA) exceeds the maximum permissible noise levels for weekday (65 dBA).
- During night time, L_{Aeq} 5 mins on weekday (71.3 dBA) and on Sunday (67.5 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA); L_{Aeq} 1 hour on weekday (69.7 dBA) exceeds the maximum permissible noise levels for weekdays (55 dBA).

e) For N3 (School):

- During day time, L_{Aeq} 5 mins on weekday (74.5 dBA) and on Sunday (72.1 dBA) comply with the respective maximum permissible noise level (75 dBA) and on Sunday (75 dBA); L_{Aeq} 12 hours on weekday (67.9 dBA) and on Sunday (66.8 dBA) exceed the respective maximum permissible noise levels for weekday (60 dBA) and Sunday (60 dBA).
- During evening time, L_{Aeq} 5 mins on weekday (73.0 dBA) and on Sunday (69.0 dBA) exceed the respective maximum permissible noise level for weekday (55 dBA) and on Sunday (55 dBA).
- During night time, L_{Aeq} 5 mins on weekday (71.3 dBA) and on Sunday (67.5 dBA) exceed the respective maximum permissible noise levels for weekday (55 dBA) and Sunday (55 dBA).

Due to the proximity to the road, the noise baseline levels at NSR clusters 1, 2 and 3 were generally high. The exceedances were likely related to the road traffic. If the difference between baseline noise level and maximum permissible noise level were less than 10 dBA, the maximum permissible noise levels were further adjusted according to *EPM (Control of Noise at Construction Sites) Regulations*, Third Schedule.

8.3.3.2 For Affected Fauna

The noise baseline sampling for fauna was conducted from Mar 3, 2020 to March 17, 2020. Photographic logs for the baseline noise survey are provided in **Appendix 8A** with noise baseline summary results are tabulated in **Table 8.8**. The noise baseline sampling results are summarised below:

a) For N4:

- L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during day time and evening time on weekdays were generally higher than Sunday.
- L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during night time on weekdays were lower than Sunday.
- On weekday, during day time and evening time, the dominant frequency ranged from 250 Hz to 8,000 Hz (low, medium and high frequency[11]). During night time, the dominant frequency ranges from 1000 Hz to 8,000 Hz (high frequency).
- On Sunday, during day time the dominant frequency ranged from 500 Hz to 8,000 Hz (low, medium and high frequency). During evening time and night time, the dominant frequency was 2,000 Hz to 8,000 Hz (high frequency).

b) For N5:

- The L_{Aeq} 5 mins, L_{Aeq} 1 hour and L_{Aeq} 12 hours during day time, evening time and night time on weekdays were higher than Sunday.

[11] Low frequency is about 500 Hz and below, medium frequency is between 500 and 2000 Hz and high frequency is 2000 Hz and above (https://intermountainhealthcare.org/ckr-ext/Dcmnt?ncid=520408218)

- On weekday, during day time the dominant frequency ranged from 250 Hz to 1,000 Hz (low and medium frequency). During evening time, the dominant frequency ranged from 250 Hz to 4,000 Hz (low, medium and high frequency). During night time, the dominant frequency ranged from 250 Hz to 8,000 Hz (low, medium and high frequency).
- On Sunday, during day time the dominant frequency ranged from 250 Hz to 8,000 Hz (low, medium and high frequency). During evening time, the dominant frequency was 4,000 Hz (high frequency). During night time, the dominant frequency was 4,000 Hz (high frequency).

Table 8.7: Noise Baseline Result for Affected Community

Sampling Point	Type of Affected Premises*	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA) [2]			Correction factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
N1	Residential	Weekday	L_{Aeq} 5 mins	74.4	76.4	73.2	90	70	55	0	1	0	90.0	77.4	73.2
			L_{Aeq} 1 hour	68.2	68.0	65.0	-	65	55	-	2	0	-	70.0	65.0
			L_{Aeq} 12 hours	65.5	63.0	63.0	75	-	-	1	-	-	76.0	-	-
		Sunday	L_{Aeq} 5 mins	70.8	65.9	70.0	75	55	55	1	0	0	76.0	65.9	70.0
			L_{Aeq} 1 hour	66.0	64.0	64.2	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	64.4	62.0	62.0	75	-	-	0	-	-	75.0	-	-
N2	School	Weekday	L_{Aeq} 5 mins	78.0	68.7	67.6	75	55	55	2	0	0	80.0	68.7	67.6
			L_{Aeq} 1 hour	70.6	66.7	65.0	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	65.0	62.9	62.9	60	50	50	1	0	0	66.0	62.9	62.9
		Sunday	L_{Aeq} 5 mins	70.2	65.5	64.5	75	55	55	1	0	1	76.0	65.5	65.5
			L_{Aeq} 1 hour	65.2	63.1	63.2	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	64.1	60.6	60.6	60	50	50	1	0	0	65.1	60.6	60.6
N2	Residential	Weekday	L_{Aeq} 5 mins	78.0	68.7	67.6	90	70	55	0	3	0	90.0	73.0	67.6
			L_{Aeq} 1 hour	70.6	66.7	65.0	-	65	55	-	-	-	-	-	-
			L_{Aeq} 12 hours	65.0	62.9	62.9	75	-	-	0	-	-	75.0	-	-
		Sunday	L_{Aeq} 5 mins	70.2	65.5	64.5	75	55	55	1	0	1	76.0	65.5	65.5
			L_{Aeq} 1 hour	65.2	63.1	63.2	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	64.1	60.6	60.6	75	-	-	0	-	-	75.0	-	-

Sampling Point	Type of Affected Premises*	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA)[2]			Correction factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
N3	School	Weekday	L_{Aeq} 5 mins	74.5	**73.0**	**71.3**	75	55	55	3	0	0	78.0	73.0	71.3
			L_{Aeq} 1 hour	69.3	67.9	69.7	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	**67.9**	**64.8**	**64.8**	60	50	50	1	0	0	68.9	64.8	64.8
		Sunday	L_{Aeq} 5 mins	72.1	**69.0**	**67.5**	75	55	55	2	0	0	77.0	69.0	67.5
			L_{Aeq} 1 hour	68.2	65.9	65.9	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	**66.8**	**63.4**	**63.4**	60	50	50	1	0	0	67.8	63.4	63.4
N3	Residential	Weekday	L_{Aeq} 5 mins	74.5	**73.0**	**71.3**	90	70	55	0	2	0	90.0	75.0	71.3
			L_{Aeq} 1 hour	69.3	**67.9**	**69.7**	-	65	55	-	-	-	-	-	-
			L_{Aeq} 12 hours	67.9	64.8	64.8	75	-	-	1	-	-	76.0	-	-
		Sunday	L_{Aeq} 5 mins	72.1	**69.0**	**67.5**	75	55	55	2	0	0	77.0	69.0	67.5
			L_{Aeq} 1 hour	68.2	65.9	65.9	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	66.8	63.4	63.4	75	-	-	1	-	-	76.0	-	-

[1] Maximum equivalent continuous noise level over specific period from noise baseline measurement [D = day time 7 a.m. – 7 p.m.; E = evening time 7 p.m. -10 p.m.; N = night time 10 p.m. – 7 a.m.]. **Bold red**: measured noise level exceeds the maximum permissible noise level stipulated by *EPM (Control of Noise at Construction Sites) Regulations*

[2] Based on *EPM (Control of Noise at Construction Sites) Regulations*, Second Schedule.

[3] Based on *EPM (Control of Noise at Construction Sites) Regulations*, Third Schedule.

Table 8.8: Noise Baseline Result for Fauna

Sampling Point	Sampling Time	Period	Parameter / Frequency (Hz)	Maximum Baseline Noise Level (dBA)								
				63	125	250	500	1k	2k	4k	8k	Total
N4	Weekday	Day 7 a.m. – 7 p.m.	L_{Aeq} 5 mins	49.8	61.4	69.1	68.5	67.8	68.4	65.7	59.6	75.3
			L_{Aeq} 1 hour	44.0	54.4	62.5	62.2	62.1	63.2	60.6	54.3	69.5
			L_{Aeq} 12 hours	34.4	44.6	51.9	51.7	52.1	53.6	51.2	46.2	59.5
		Evening 7 p.m. – 10 p.m.	L_{Aeq} 5 mins	36.6	36.6	55.3	48.0	51.2	53.9	56.5	51.3	61.4
			L_{Aeq} 1 hour	31.7	31.7	48.0	41.3	46.4	46.3	53.0	50.0	56.7
			L_{Aeq} 12 hours	29.4	29.4	38.0	35.9	43.4	44.2	47.6	48.4	52.7
		Night 10 p.m. – 7 a.m.	L_{Aeq} 5 mins	32.1	37.7	36.6	42.0	52.6	57.6	53.4	52.1	60.7
			L_{Aeq} 1 hour	30.9	34.6	33.4	39.7	50.5	51.1	48.9	50.3	56.4
			L_{Aeq} 12 hours	29.4	29.4	38.0	35.9	43.4	44.2	47.6	48.4	52.7
	Sunday	Day 7 a.m. – 7 p.m.	L_{Aeq} 5 mins	39.5	54.3	59.5	60.1	60.9	63.6	61.3	55.0	68.7
			L_{Aeq} 1 hour	34.4	45.6	51.0	51.6	53.4	56.3	54.0	48.3	61.0
			L_{Aeq} 12 hours	30.3	37.2	41.6	43.5	46.5	50.0	47.1	44.3	54.2
		Evening 7 p.m. – 10 p.m.	L_{Aeq} 5 mins	30.3	30.3	31.9	37.5	47.6	56.4	49.6	50.4	58.5
			L_{Aeq} 1 hour	28.8	28.8	28.9	35.0	41.7	48.4	47.7	49.1	53.6
			L_{Aeq} 12 hours	28.2	28.2	28.3	35.0	42.3	43.3	50.1	47.3	53.0
		Night 10 p.m. – 7 a.m.	L_{Aeq} 5 mins	34.1	38.9	34.5	41.1	48.8	49.8	63.0	51.0	63.7
			L_{Aeq} 1 hour	32.9	36.7	33.5	39.5	45.2	45.5	56.6	49.6	58.1
			L_{Aeq} 12 hours	28.2	28.2	28.3	35.0	42.3	43.3	50.1	47.3	53.0

Sampling Point	Sampling Time	Period	Parameter / Frequency (Hz)	Maximum Baseline Noise Level (dBA)								
				63	125	250	500	1k	2k	4k	8k	Total
N5	Weekday	Day 7 a.m. – 7 p.m.	L_{Aeq} 5 mins	51.5	64.5	75.1	76.7	74.0	69.5	63.2	56.7	80.7
			L_{Aeq} 1 hour	42.3	56.9	67.3	69.3	66.7	60.9	56.6	54.0	73.2
			L_{Aeq} 12 hours	37.6	49.8	58.2	59.4	57.0	53.3	50.8	50.5	64.1
		Evening 7 p.m. – 10 p.m.	L_{Aeq} 5 mins	43.4	51.4	66.3	68.2	69.1	67.6	64.5	54.6	74.5
			L_{Aeq} 1 hour	36.5	43.2	58.3	59.9	61.1	58.7	63.0	51.1	67.7
			L_{Aeq} 12 hours	31.1	37.6	51.6	52.6	51.8	48.3	59.3	49.2	61.7
		Night 10 p.m. – 7 a.m.	L_{Aeq} 5 mins	41.3	50.0	61.1	60.8	57.0	49.4	64.8	55.5	68.2
			L_{Aeq} 1 hour	33.1	40.5	50.5	50.5	47.0	39.7	62.7	54.0	63.8
			L_{Aeq} 12 hours	31.1	37.6	51.6	52.6	51.8	48.3	59.3	49.2	61.7
	Sunday	Day 7 a.m. – 7 p.m.	L_{Aeq} 5 mins	51.5	57.5	67.9	66.8	59.7	52.3	58.4	55.0	71.4
			L_{Aeq} 1 hour	41.3	47.6	57.3	56.4	49.5	42.4	51.1	52.5	61.6
			L_{Aeq} 12 hours	33.2	39.2	47.5	46.6	42.6	38.4	46.9	48.6	54.1
		Evening 7 p.m. – 10 p.m.	L_{Aeq} 5 mins	29.2	29.2	36.7	43.5	45.2	39.4	64.0	52.1	64.4
			L_{Aeq} 1 hour	27.8	27.8	34.3	39.3	41.0	33.5	62.2	50.5	62.5
			L_{Aeq} 12 hours	26.7	26.7	33.4	37.4	36.8	31.3	59.3	47.9	59.6
		Night 10 p.m. – 7 a.m.	L_{Aeq} 5 mins	31.5	38.7	37.8	41.6	47.0	46.9	64.8	54.2	65.3
			L_{Aeq} 1 hour	30.6	36.1	36.0	39.4	39.8	38.4	62.7	49.2	63.0
			L_{Aeq} 12 hours	26.7	26.7	33.4	37.4	36.8	31.3	59.3	47.9	59.6

8.4 Evaluation Potential Impact Before Mitigation Measures

8.4.1 Potential Source of Impact

Noise levels generated by construction equipment vary greatly depending on the construction stages (i.e. Stage 1 - Advance Works, Stage 2 - Earthworks, Stage 3 - Infrastructure, and Stage 4 - Building), construction methodology, type of equipment, model and condition of equipment, quantity and duration of operation. The noise levels are also affected by distance, locations (either stationary or mobile sources), variations in the power of the equipment, and noise characteristics (e.g. continuous or intermittent noise, low frequency or high frequency noise) of the equipment.

At the time of this report preparation, exact and final details on the construction methodology, power mechanical equipment (PME) and their approximate numbers that will be used during construction activities are only expected be available at a later stage when the construction contractor is on-board. Therefore, for this EIS, the construction methodology, type of equipment, quantity and duration of operation that are likely to be used at each construction stage were estimated based on typical construction works and our past experience on similar construction projects.

Noise is expected to be mainly generated from the following sources during construction:

- Operation of fuel burning equipment (e.g. generator), handheld tool (e.g. electric drilling, nail gun, welding, grinder, gas cutter, chainsaw).
- Operation and movement of heavy vehicle/ machinery (e.g. excavators, piling machines, dozers, drilling machines, cranes, asphalt pavers, rollers, lorry cranes, transit mixers, and dump trucks).
- Demolition of existing paved and unpaved road.
- Dropping of construction material or waste from height.

The quantitative assessment of potential noise impacts distinguishes between those that are positive or negative nature; major, moderate or minor magnitude of changes; transboundary, national, or local extend; long or short term; direct or indirect pathway; reversible or irreversible; cumulative and non-cumulative. The noise impacts may affect NSRs with international, national or local value.

8.4.2 Noise Modelling Assumption

The prediction of the potential noise levels generated by the construction activities is simulated using noise modelling software CadnaA version 2020 (CadnaA), developed by DataKustik. The following assumptions were made in undertaking this assessment:

- Only PME that will generate significant noise emission is considered in the noise modelling. The sound power levels are obtained from SS 602: 2014 and BS 5228-1: 2009
- PME is modelled as point source in CadnaA, except PME for road works, drainage and sewerage work, material and waste transportation which is modelled as line source in CadnaA and wildlife shepherding activities which are modelled as area source in CadnaA.
- Construction activities are assumed to be conducted during day time (7am – 7 pm) over weekdays.
- Construction activities and their noise sources are spread equally in the five assumed construction parcels. Their locations are assumed as follow:
    - Erection of TPZ: at plants/ tree recommended to be retained.

  - Tree felling: forested area outside of Recommended Area of Conservation (RAC).
  - Site office: near to external road or internal road.
  - Erection of noise barrier, installation of perimeter hoarding: along site boundary.
  - Machinery/ construction material delivery: along Bukit Batok Road, Brickland Road, Jalan Lam Sam and existing paths within Tengah site.
  - Demolition: internal road and existing structure.
  - Drainage diversion: at existing earth drains/ drains/ forest drains.
  - Cut and fill: at the area where the surface is undulating and at different level from the proposed level.
  - Sheet piling/ soldier piling: near site boundary.
  - Road works: at proposed road.
  - Drainage and sewerage work: according to Drainage Master Plan.
  - Others: spread evenly all over the construction site outside RAC (**Section 7**).
- Only existing buildings within the 150 m EIS Study Area are considered in the noise modelling. A reflection loss of 2 dBA is considered as the existing buildings are not of smooth façade.
- Noise level generated from construction activities to affected community are estimated along the building façade facing the construction site using building evaluation.
- Noise level generated from construction activities to affected fauna are estimated by receiver points of 0.5 m high for ground-dwelling and understory fauna and by receiver points of 15 m high for arboreal fauna. The arboreal fauna receptor height of 15 m was chosen as the general height of trees around the Project is approximately 16 m, and arboreal fauna can often be found perching below the canopy. Both receiver points are located around the Project boundary.
- Where different parcels have different predicted noise levels for a single fauna NSR (i.e. NSR4 or NSR5), the highest exceedance will be used to assess the impact.
- Noise contour is estimated with 10 m x 10 m horizontal grid spacing and 1.5 m vertical grid spacing.
- Predicted noise levels at NSRs were determined by adding background noise levels from the baseline monitoring to the output of the modelling.
- Predicted noise levels at NSRs are used to determine the impact magnitude and the overall impact significance. Unmitigated construction noise levels for the different construction stages at the identified NSRs are first predicted. Depending on the predicted noise levels at NSRs, mitigation measures (e.g. noise barrier, enclosures and screening). Noise barrier is modelled as barrier in CadnaA. Enclosure and screening are modelled as attenuation to the PME's sound power level.
- Following the EIS findings and the review of the land use planning within the EIS Study Area against the Tengah Master Plan 2019, the revised Project boundary has been revised to provide greater wildlife connectivity and protection of conservation area. The revised Project boundary for development as illustrated in **Figure 3.11** is used for construction noise impact assessment in this EIS revision.

Summary results of unmitigated noise levels during construction stages generated over period (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins) are presented in **Table 8.9** and **Table 8.10** respectively. Noise contours are provided in **Appendix 8B**.

The predicted noise levels over specific period (L_{Aeq} 12 hours) presented in **Table 8.9** indicates that in the absence of any mitigation measures, there will be exceedances of the maximum adjusted permissible noise level at the following affected communities:

- Ichiban Montessori (NSR 2 – School) during Stage 2 – Earthwork, Stage 3 – Infrastructure and Stage 4 – Building.

- Hong Kah Primary School and Dunearn Secondary School (NSR 3 – School) during Stage 3 – Infrastructure.

In addition, in the absence of any mitigation measures, the predicted noise levels at the affected fauna will generally exceed the baseline noise levels of more than 5 dBA for all stages.

The predicted noise levels over 5 mins (L_{Aeq} 5 mins) presented in **Table 8.10** indicates that in the absence of any mitigation measures, there will be exceedance of the maximum adjusted permissible noise level at affected community, and exceedances of more than 5 dBA from baseline noise level in general at the affected fauna during Stage 2 – Earthwork, Stage 3 – Infrastructure and Stage 4-Building.

Table 8.9: Unmitigated Noise Level (L_{Aeq} 12 hours)

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	57.4	66.1	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	58	65.8	60	66.0	Minor
	HDB Buildings[4]	Residential	65	58.7	65.9	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	47.3	67.9	60	68.9	Minor
	Dunearn Secondary School	School	67.9	45.2	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	54.7	68.1	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	54.7	68.1	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	74.2	**74.3**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	75.3	**75.4**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	75.5	**75.6**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	74.9	**75.0**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	61.1	**65.9**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	70.8	**71.1**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	71	**71.3**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	71.2	**71.5**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	71	**71.3**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	62.2	**66.3**	-	64.1	Minor
Stage 2 - Earthworks								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	64.9	68.2	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	64.4	**67.7**	60	66.0	Minor
	HDB Buildings[4]	Residential	65	64.6	67.8	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	52.9	68.0	60	68.9	Minor
	Dunearn Secondary School	School	67.9	50.8	68.0	60	68.9	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
	HDB Buildings[5]	Residential	67.9	58.5	68.4	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	58.5	68.4	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	76.5	**76.6**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	76	**76.1**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	80	**80.0**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	78.8	**78.9**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	76.3	**76.6**	-	64.1	Major
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	76.7	**76.8**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	76.3	**76.4**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	78.5	**78.6**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	77.3	**77.4**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	76.2	**76.5**	-	64.1	Major
Stage 3 - Infrastructure								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	71.4	72.4	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	71.9	**72.7**	60	66.0	Moderate
	HDB Buildings[4]	Residential	65	73.9	74.4	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	65.9	**70.0**	60	68.9	Minor
	Dunearn Secondary School	School	67.9	64.7	**69.6**	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	67.5	70.7	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	67.5	70.7	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	82	**82.0**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	83.6	**83.6**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	84.4	**84.4**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	82.2	**82.2**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	81.6	**81.7**	-	64.1	Major
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	87.7	**87.7**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	72.3	**72.5**	-	59.5	Major

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	75.1	**75.2**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	88.5	**88.5**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	81.9	**82.0**	-	64.1	Major
Stage 4 - Building								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	63.4	67.6	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	62.9	**67.1**	60	66.0	Minor
	HDB Buildings[4]	Residential	65	64	67.5	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	55.1	68.1	60	68.9	Minor
	Dunearn Secondary School	School	67.9	53	68.0	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	62.9	69.1	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	62.9	69.1	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	70.1	**70.5**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	68.4	**68.9**	-	59.5	Moderate
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	85	**85.0**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	83.1	**83.1**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	68	**69.5**	-	64.1	Moderate
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	72.2	**72.4**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	71.1	**71.4**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	75.3	**75.4**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	75	**75.1**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	70.5	**71.4**	-	64.1	Moderate

Note :

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

[3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5

[4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7

[5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7

Bold red indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR 5)

Table 8.10: Unmitigated Noise Level (L_{Aeq} 5 mins)

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	59.7	74.5	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	60.1	78.1	75	80.0	Minor
	HDB Buildings[4]	Residential	78	61.1	78.1	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	52.1	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	49.9	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	59.4	74.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	59.4	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	75.2	**78.3**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	76.3	**78.8**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	76.7	**79.1**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	75.9	**78.6**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	71.2	**81.2**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	72	**77.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	72.1	**77.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	73	**77.3**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	72.1	**77.0**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	72.3	**81.3**	-	80.7	Minor
Stage 2 - Earthworks								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	65.9	75.0	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	65.5	78.2	75	80.0	Minor
	HDB Buildings[4]	Residential	78	65.7	78.2	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	55	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	52.5	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	59.8	74.6	90	90.0	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
	HomeTeam NS Adventure	Residential	74.5	59.8	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	77.3	**79.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	76.7	**79.1**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	80.8	**81.9**	-	75.3	Moderate
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	79.8	**81.1**	-	75.3	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	77.3	**82.3**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	77.7	**79.7**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	77.3	**79.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	79.5	**80.9**	-	75.3	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	78.3	**80.1**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	77.2	**82.3**	-	80.7	Minor
Stage 3 - Infrastructure								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	72.3	76.5	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	72.9	79.2	75	80.0	Minor
	HDB Buildings[4]	Residential	78	74.9	79.7	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	67.4	75.3	75	78.0	Minor
	Dunearn Secondary School	School	74.5	66.1	75.1	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	69	75.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	69	75.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	83	**83.7**	-	75.3	Moderate
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	84.6	**85.1**	-	75.3	Moderate
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	85.4	**85.8**	-	75.3	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	83.2	**83.9**	-	75.3	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	82.6	**84.8**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	88.7	**88.9**	-	75.3	Major
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	72.9	**77.3**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	76.3	**78.8**	-	75.3	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	89.4	**89.6**	-	75.3	Major
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	82.7	**84.8**	-	80.7	Minor
Stage 4 - Building								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	64.6	74.8	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	64.2	78.2	75	80.0	Minor
	HDB Buildings[4]	Residential	78	65.2	78.2	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	57.4	74.6	75	78.0	Minor
	Dunearn Secondary School	School	74.5	54.8	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	64.2	74.9	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	64.2	74.9	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	70.8	**76.6**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	69	**76.2**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	86	**86.4**	-	75.3	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	84.1	**84.6**	-	75.3	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	68.8	**81.0**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	73.2	**77.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	72.1	**77.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	76.3	**78.8**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	76	**78.7**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	71.5	**81.2**	-	80.7	Minor

Note :

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

[3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5

[4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7

[5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7

Bold red indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR 5)

8.4.3 Evaluation of Noise Disturbance from Construction Activities to Identified NSRs (Affected Community)

Affected community (NSR 1, NSR 2, NSR 3) is considered of local value. Potential noise impacts to affected community located near construction activities are expected to be negative and direct. The impact magnitude is expected to range from minor to moderate depending on the construction stages and NSR. Duration is anticipated to be short term and reversible as the impacts will cease upon completion of the construction activities. The geographical extent of noise impacts is considered to be local, within the EIS Study Area. Construction activities from other construction sites located within and in the vicinity of the Project development, may cause cumulative negative impacts, if constructions happen concurrently. Therefore, the overall impact severity of potential noise impacts from construction activities to affected community is considered minor negative.

Impact significant for noise generated over specific period (L_{Aeq} 12 hours) is presented in **Table 8.11**. Impact significant for noise generated over 5 mins (L_{Aeq} 5 mins) is presented in **Table 8.12**. The detailed assessment of noise impact for each particular construction stage can be found in **Appendix 8C**.

Table 8.11: Impact Significance for Unmitigated Noise (L_{Aeq} 12 hours) to Affected Community for All Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 150 m buffer (area immediately outside of EIS Study Area).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	From Minor (1) to Moderate (2)[1]	Minor: 0 < exceedance < 5 dBA of the max adjusted permissible noise level Moderate: 5 ⩽ exceedance < 10 dBA of the max adjusted permissible noise level.
A2.3: Impact Extent	2: Tengah	Noise impacts are anticipated to extend past the Project footprint to the buffer area.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**From -40 to -80**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	**All four construction stages and all NSRs**

[1] All NSRs is predicted to have minor impact magnitude, except for Ichiban Montessori Childcare Centre (NSR 2 - school) which is predicted to have moderate impact magnitude.

Table 8.12: Impact Significance for Unmitigated Noise (L_{Aeq} 5 mins) to Affected Community for All Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Noise levels generated during all construction stages are expected to have impacts to the NSRs in the 150 m buffer (area immediately outside of EIS Study Area).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Minor	Minor: 0 < exceedance < 5 dBA of the max adjusted permissible noise level.
A2.3: Impact Extent	2: Tengah	Noise impacts are anticipated to extend past the Project footprint to the NSRs in buffer area.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**(-4) x (10) = -40**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	**All four construction stages and all NSRs**

8.4.4 Evaluation of Noise Disturbance from Construction Activities to Identified NSRs (Affected Fauna)

There are three categories of receivers with different noise-sensitivities and conservation priorities for the affected fauna at NSR 4 and NSR 5 clusters. Noise impacts to fauna can range in severity and form. In the most severe of cases, fauna could experience damaged hearing from the exposure to sound above a certain threshold. Fauna may also have an increased psychological response of stress and fear which could lead to higher mortality and lower reproductive efficiency. Some may have behavioural responses, moving away from the noise into other patches of forests. This could possibly result in overcrowding in other forest patches and a competition of limited resources. For fauna which depend on vocalisation for communication, mating displays and navigation, the noise pollution may reduce their abilities to do so. This could result in greater energy expenditure as they adapt their vocalisation to the noise or the inability to successful find mates and or prey.

The noise impact assessment to affected fauna over various construction stages is conducted in accordance the assessment methodology described in **Section 8.2**. The score rating for each assessment criteria under each construction stage is summarised in **Table 8.13** to **Table 8.16**. The detailed assessment of noise impact for each particular construction stage can be found in **Appendix 8C**.

Table 8.13: Impact Significance for Unmitigated Noise (L_{Aeq} 12 Hours) to Affected Noise-Sensitive Fauna Over Various Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e. threatened species) who are sensitive to sound (i.e. aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles - lizards/ geckos/ skinks, and mammals).
	2: Priority/ Sensitivity Level - Medium	Fauna of non-conservation significance (i.e. common species) who are sensitive to sound (i.e. aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles - lizards/ geckos/ skinks, and mammals).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna.
A2.2: Magnitude of Changes	From Minor (1) to Major (3)	Major: Noise levels expected to increase, to more than 10 dBA above the baseline levels. Moderate: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels. Minor: Noise levels expected to increase, to no more than 5 dBA above the baseline levels.
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**From -99 to -297**	For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level - high
	From -66 to -198	For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level - medium
Range Bands ES/ Impact Severity Significance	**Minor to Major Negative Impact**	**For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level – high and medium**

Table 8.14: Impact Significance for Unmitigated Noise (L_{Aeq} 12 Hours) to Affected Fauna with Lower Noise Sensitivity Over Various Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Priority/ Sensitivity Level - Low	Fauna who have lower sensitivity to sound (i.e. odonates, amphibious fish – Common walking catfish and Asian swamp-eel).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna.
A2.2: Magnitude of Changes	From Minor (1) to Major (3)	Major: Noise levels expected to increase, to more than 10 dBA above the baseline levels. Moderate: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels. Minor: Noise levels expected to increase, to no more than 5 dBA above the baseline levels.
A2.3: Impact Extent	2: Tengah	Fauna which are less sensitive to noise are not expected to move away extensively from the noise and hence anticipated to extend within the EIS Study Area and Tengah area.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	Fauna are less sensitive to noise and will unlikely experience permanent impacts of noise such as loss of hearing or difficulties in mating. They are also likely to return when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**From -20 to -60**	For ground-dwelling/ understory fauna of priority/ sensitivity level - low
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	**For ground-dwelling/ understory fauna of priority/ sensitivity level - low**

Table 8.15: Impact Significance for Unmitigated Noise (L_{Aeq} 5 Minutes) to Affected Noise-Sensitive Fauna Over Various Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: Priority/ Sensitivity - High	Fauna of conservation significance (i.e. threatened species) who are sensitive to sound (i.e. aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles - lizards/ geckos/ skinks, and mammals).
	2: Priority/ Sensitivity Level - Medium	Fauna of non-conservation significance (i.e. common species) who are sensitive to sound (i.e. aculeate hymenopterans, lepidoptera, birds, amphibians, reptiles - lizards/ geckos/ skinks, and mammals).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna.
A2.2: Magnitude of Changes	From Minor (1) to Major (3)	Major: Noise levels expected to increase, to more than 10 dBA above the baseline levels. Moderate: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels. Minor: Noise levels expected to increase, to no more than 5 dBA above the baseline levels.
A2.3: Impact Extent	3: National	Noise impacts are anticipated to force noise-sensitive fauna away from the noise into other patches of forests outside of Tengah. This could possibly result in overcrowding in other forest patches and a competition of limited resources and or fauna moving into less favourable habitats.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	3: Irreversible	Noise-sensitive fauna could experience damaged hearing from the exposure to sound above a certain threshold. They may also experience higher mortality and lower reproductive efficiency due to increased psychological response of stress and fear. These are irreversible impacts.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**From -99 to -297**	For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level - high
	From -66 to -198	For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level - medium
Range Bands ES/ Impact Severity Significance	**Minor to Major Negative Impact**	**For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level – high**
	Minor to Moderate Negative Impact	**For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level – medium**

Table 8.16: Impact Significance for Unmitigated Noise (L_{Aeq} 5 Minutes) to Affected Fauna with Lower Noise Sensitivity Over Various Construction Stages

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Priority/ Sensitivity Level - Low	Fauna who have lower sensitivity to sound (i.e. odonates, amphibious fish – Common walking catfish and Asian swamp-eel).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities and negatively impact fauna.
A2.2: Magnitude of Changes	From Minor (1) to Major (3)	Major: Noise levels expected to increase, to more than 10 dBA above the baseline levels. Moderate: Noise levels expected to increase, to more than 5 dBA but less than 10 dBA above the baseline levels. Minor: Noise levels expected to increase, to no more than 5 dBA above the baseline levels.
A2.3: Impact Extent	2: Tengah	Fauna which are less sensitive to noise are not expected to move away extensively from the noise and hence anticipated to extend within the EIS Study Area and Tengah area.
B1: Permanence	2: Short Term	Noise impacts for each phase are less than three years each and will cease when construction works stops.
B2: Impact Pathway	3: Direct	Noise impacts are direct impacts to the NSRs.
B3: Reversibility	2: Reversible	Fauna are less sensitive to noise and will unlikely experience permanent impacts of noise such as loss of hearing or difficulties in mating. They are also likely to return when construction activities stop.
B4: Cumulative	3: Cumulative	Noise generated from other construction projects are expected to cause cumulative impacts to the local noise levels when happen concurrently.
Environmental Score (ES)	**From -10 to -60**	For ground-dwelling/ understory and arboreal fauna of priority/ sensitivity level - low
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	**For ground-dwelling/ understory fauna of priority/ sensitivity level - low**

8.5 Applicable Prevention and Mitigation/ Enhancement Measures

Mitigation measures to eliminate, minimise or reduce the potential noise impacts during construction are presented in this section. It should be noted that the assumptions used in formulating mitigation measures and their practicality are based on the available information and assumptions at this current EIS stage. During the construction, contractor may use different construction methodology and PME (quantity, sound power level, operating time) from what was modelled.

8.5.1 Noise Barrier

A noise barrier should ideally be constructed such that it blocks the line of sight between receiver and the noise source. Lower floors of HDB building at the same height of the noise barrier and ground-dwelling/ understory fauna are expected to have more noise reduction from noise barrier than higher floor of HDB building and arboreal fauna.

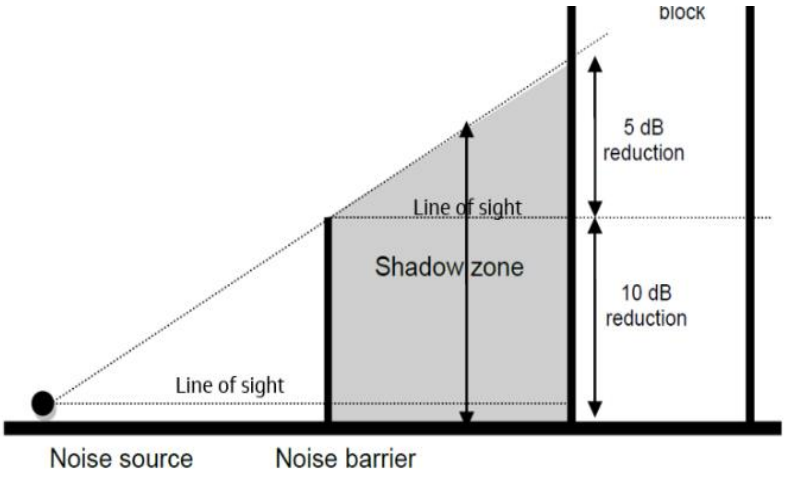


Figure 8.3: The Effectiveness of a Noise Barrier

Source: Figure F.6 of SS 602: 2014

The particular deployment of noise barriers will depend on specific construction site circumstances, which are unknown until construction site works commence. The detail specification and positioning of noise barrier would be best determined by the contractor in consultation with the provider of the noise barrier during the construction phases depending on the actual noise level emission and distance of the construction equipment from the affected NSRs.

As the ground-dwelling/ understory fauna are likely to be found at the forested area e.g. Forest Fringe, Forest Corridor and Central Park, noise barriers are recommended to be erected between the Project site boundary and the area designated as Forest Fringe, Forest Corridor and Central Park (see **Figure 8.4**). Ground-dwelling/ understory fauna is unlikely to be found at the southern part of PAC-1 where the Phase 2 constructions are on-going, hence no noise barrier is recommended.

Noise barriers shall be with a minimum of Sound Transmission Class (STC) 20, with height of 6 m to be effective to reduce noise level for ground-dwelling/ understory fauna and affected community at lower floors. Actual height of noise barriers subject to site constraints and further noise construction assessment during EMMP stage once method statements and equipment inventory are available.

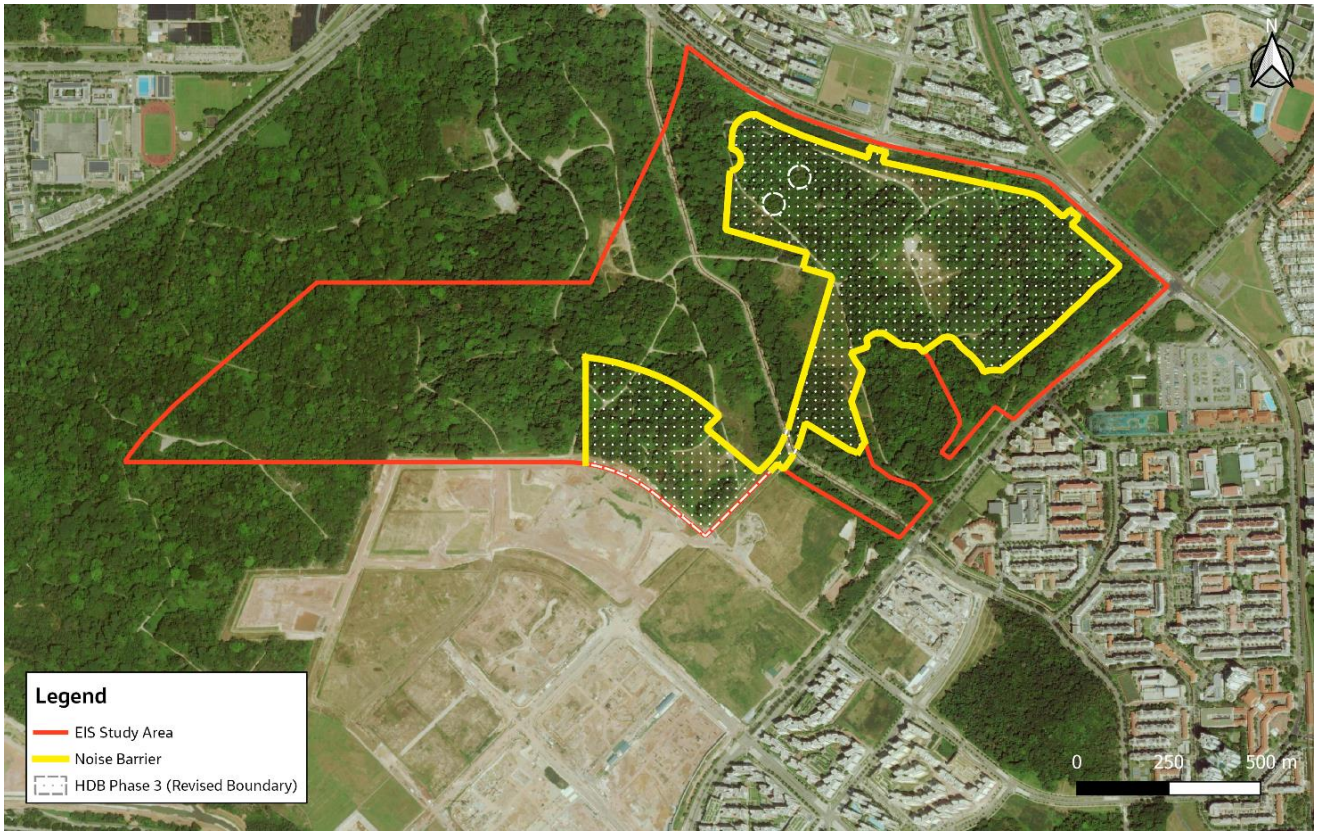


Figure 8.4: Recommended Location of Noise Barrier

Base Map: ESRI

Notes: No noise barrier is included at the southern boundaries as there are existing construction activities adjacent to it. For the purposes of this study, the figure shows an indicative revised boundary assuming that agencies will avoid the Recommended Area of Conservation (RAC). Agencies are studying possible changes to the land use plan to balance conservation and development in response to the RAC.

Summary results of noise levels during construction stages generated over period (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins) with noise barrier are presented in **Table 8.17** and **Table 8.18**, respectively.

For affected community NSR, the predicted noise levels over specific period (L_{Aeq} 12 hours) presented in **Table 8.17** indicates that with noise barrier, the overall noise level is reduced up to 3.6 dBA. However, there will still be exceedances of the maximum adjusted permissible noise level at the following affected community.

- Ichiban Montessori Childcare Centre (NSR 2 – School) during Stage 2 – Earthwork, Stage 3 – Infrastructure and Stage 4 – Building.
- Hong Kah Primary School (NSR 3 – School) during Stage 3 – Infrastructure.

As for affected fauna NSR, even with the noise barriers, the predicted noise levels still exceed the baseline levels at the following affected fauna:

- Ground-dwelling and Understory fauna:
  - Exceedances of less than 5 dBA above baseline noise during Stage 1 – Advance Works, Stage 2 – Earthworks and Stage 4 – Infrastructure.
  - Exceedance of more than 10 dBA above baseline noise during Stage 3 – Infrastructure.
- Arboreal fauna:
  - Exceedance of more than 10 dBA above baseline noise for all stages.

The predicted noise levels over 5 mins (L_{Aeq} 5 mins) presented in **Table 8.18** indicates that with noise barriers, there will be no exceedance of the maximum adjusted permissible noise level for affected community. However, it is predicted that noise levels with noise barrier will exceed the baseline levels at the following affected fauna:

- Ground-dwelling and Understory fauna:
  - Exceedances of less than 5 dBA above baseline noise during Stage 1 – Advance Works and Stage 4 – Infrastructure.
  - Exceedances of more than 5 dBA but less than 10 dBA above baseline noise during Stage 2 – Earthworks.
  - Exceedance of more than 10 dBA above baseline noise during Stage 3 – Infrastructure.
- Arboreal fauna:
  - Exceedances of less than 5 dBA of the baseline noise level in general during Stage 1 – Advance Works and Stage 4 – Infrastructure.
  - Exceedances of more than 5 dBA but less than 10 dBA above baseline noise during Stage 2 – Earthworks and Stage 3 – Infrastructure.

Table 8.17: Mitigated Noise Level (L_{Aeq} 12 hours) with Noise Barrier

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	55.9	66.0	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	56.5	65.6	60	66.0	Minor
	HDB Buildings[4]	Residential	65	57.8	65.8	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	45	67.9	60	68.9	Minor
	Dunearn Secondary School	School	67.9	42.7	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	52.4	68.0	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	52.4	68.0	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	56.2	**61.2**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	57.2	**61.5**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	69.3	**69.7**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	63.2	**64.7**	-	59.5	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	52.5	**64.4**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	66.4	**67.2**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	70.8	**71.1**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	69.1	**69.6**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	71.2	**71.5**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	62	**66.2**	-	64.1	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 2 - Earthworks								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	64.5	68.0	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	64.1	**67.6**	60	66.0	Minor
	HDB Buildings[4]	Residential	65	64.3	67.7	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	49.3	68.0	60	68.9	Minor
	Dunearn Secondary School	School	67.9	47	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	58.2	68.3	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	58.2	68.3	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	58	**61.8**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	57.6	**61.7**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	72.4	**72.6**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	69.4	**69.8**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	57.7	**65.0**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	76.2	**76.3**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	76.5	**76.6**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	76.7	**76.8**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	78.5	**78.6**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	75.8	**76.1**	-	64.1	Major

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 3 - Infrastructure								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	66.2	68.9	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	68.7	**70.2**	60	66.0	Minor
	HDB Buildings[4]	Residential	65	70.3	71.4	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	61.6	68.8	60	68.9	Minor
	Dunearn Secondary School	School	67.9	60.7	68.7	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	64.7	69.6	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	64.7	69.6	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	71.7	**72.0**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	70.8	**71.1**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	74.5	**74.6**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	69.1	**69.6**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	68.8	**70.1**	-	64.1	Moderate
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	73.1	**73.3**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	78.5	**78.6**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	81.7	**81.7**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	82.3	**82.3**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	78.5	**78.7**	-	64.1	Major

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 4 - Building								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	63.3	67.5	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	62.8	**67.0**	60	66.0	Minor
	HDB Buildings[4]	Residential	65	63.9	67.5	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	53.3	68.0	60	68.9	Minor
	Dunearn Secondary School	School	67.9	51	68.0	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	62.1	68.9	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	62.1	68.9	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	58.7	**62.1**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	54.4	**60.7**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	75.1	**75.2**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	73.8	**74.0**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	54.4	**64.5**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	72.4	**72.6**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	72.2	**72.4**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	71	**71.3**	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	72.8	**73.0**	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	69.3	**70.4**	-	64.1	Moderate

- Note :
- [1] Noise modelling output. Noise level is from construction activities only, without background noise
- [2] Addition of background noise to modelling output
- [3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5
- [4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7
- [5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7
- **Bold red** indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR 5)

Table 8.18: Mitigated Noise Level (L_{Aeq} 5 mins) with Noise Barrier

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	65.5	74.9	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	65.2	78.2	75	80.0	Minor
	HDB Buildings[4]	Residential	78	65.4	78.2	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	52.1	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	49.2	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	59.6	74.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	59.6	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	59.4	**75.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	58.6	**75.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	73.4	**77.5**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	70.4	**76.5**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	58.6	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	77.2	**79.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	77.5	**79.5**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	77.7	**79.7**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	79.5	**80.9**	-	75.3	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	76.7	**82.2**	-	80.7	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 2 - Earthworks								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	67.2	75.2	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	69.7	78.6	75	80.0	Minor
	HDB Buildings[4]	Residential	78	71.3	78.8	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	63.1	74.8	75	78.0	Minor
	Dunearn Secondary School	School	74.5	62.1	74.7	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	65.9	75.1	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	65.9	75.1	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	72.7	**77.2**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	71.8	**76.9**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	75.5	**78.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	70.3	**76.5**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	69.9	**81.0**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	74.2	**77.8**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	79.5	**80.9**	-	75.3	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	82.7	**83.4**	-	75.3	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	83.3	**83.9**	-	75.3	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	81.3	**84.0**	-	80.7	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 3 - Infrastructure								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	67.2	75.2	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	69.7	78.6	75	80.0	Minor
	HDB Buildings[4]	Residential	78	71.3	78.8	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	63.6	74.8	75	78.0	Minor
	Dunearn Secondary School	School	74.5	62.8	74.8	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	65.8	75.0	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	65.8	75.0	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	72.7	**77.2**	-	-	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	71.8	**76.9**	-	-	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	72.7	**77.2**	-	-	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	69.4	**76.3**	-	-	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	69.9	**81.0**	-	-	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	81	**82.0**	-	-	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	82.7	**83.4**	-	-	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	83.3	**83.9**	-	-	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	81.3	**82.3**	-	-	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	80.3	**83.5**	-	-	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 4 - Building								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	64.5	74.8	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	64.1	78.2	75	80.0	Minor
	HDB Buildings[4]	Residential	78	65.1	78.2	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	56	74.6	75	78.0	Minor
	Dunearn Secondary School	School	74.5	53.1	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	63.3	74.8	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	63.3	74.8	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	63.8	**75.6**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	56.9	**75.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	76	**78.7**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	74.7	**78.0**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	55.7	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	73.6	**77.5**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	73.2	**77.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	72	**77.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	73.8	**77.6**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	70.3	**81.1**	-	80.7	Minor

Note :

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

[3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5

[4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7

[5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7

Bold red indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR

8.5.2 Additional Control Measures

Additional control measures such as enclosure, noise screen/ noise panel, portable noise barrier are recommended for all construction stages to further reduce excessive noise impacts for the affected arboreal fauna:

- Enclosure at stationary PME such generator and it shall be of sufficient height and width to accommodate for machinery/equipment housed within. The proposed enclosures should achieve noise level reduction of at least 15 dBA (Table F.3 of SS 602: 2014).
- Noise screen/ noise panel at moveable PME such excavator and crawler/ mobile crane and it shall be of sufficient height and width to shield the noisy part. The proposed screening should achieve noise level reduction of at least 10 dBA (Table F.3 of SS 602: 2014).
- Portable noise barrier at construction activities e.g. soil investigation drilling activities, road and drainage work which are close to site boundary. The proposed portable noise barrier should achieve noise level reduction of at least 10 dBA (Section F.3.3.4 of SS 602: 2014).
- Quieter construction methodology such as silent piler instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling. It is estimated a 20 dBA reduction can be achieved by substitution (based on LTA's Noise Guidance: Developing a Noise Management Plan)

Summary results of noise levels during construction stages generated over period (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins) with noise barrier and additional control measures are presented in **Table 8.19** and **Table 8.20,** respectively. Noise contours for mitigation with noise barrier and additional noise controls are provided in **Appendix 8B**.

The predicted noise levels over specific period (L_{Aeq} 12 hours) presented in **Table 8.19** indicate that with noise barrier and additional control, the overall noise level is reduced and there is only a marginal exceedance (0.2 dBA) to the maximum adjusted permissible noise level for affected community i.e. Ichiban Montessori (NSR 2 – School) during Stage 3 – Infrastructure.

In addition, predicted noise levels with noise barrier and other measures will exceed the baseline levels at the following affected fauna:

- Ground-dwelling and Understory fauna
  - Exceedances less than 5 dBA above baseline noise during all stages
- Arboreal fauna:
  - Exceedances more than 5 dBA but less than 10 dBA above baseline noise during Stage 1 – Advance Works, Stage 3 – Infrastructure and Stage 4 - Building
  - Exceedance more than 10 dBA above baseline noise during Stage 2 - Earthwork

The predicted noise levels over 5 mins (L_{Aeq} 5 mins) presented in **Table 8.20** indicates that with noise barrier and additional control measures, there will be no exceedance to the maximum adjusted permissible noise level for affected community. Predicted noise levels at all affected ground-dwelling/ understory fauna and arboreal fauna will exceed by less than 5 dBA during all stages.

Table 8.19: Mitigated Noise Level (L_{Aeq} 12 hours) with Noise Barrier and Additional Control Measures

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	54.5	65.8	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	54.6	65.4	60	66.0	Minor
	HDB Buildings[4]	Residential	65	56	65.5	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	43.6	67.9	60	68.9	Minor
	Dunearn Secondary School	School	67.9	40.9	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	51.5	68.0	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	51.5	68.0	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	50.9	60.1	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	51.8	60.2	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	70.8	71.1	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	71.2	71.5	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	49.1	64.2	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	65.9	66.8	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	66	66.9	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	67.6	68.2	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	66.5	67.3	-	59.5	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	61.7	66.1	-	64.1	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 2 - Earthworks								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	52.8	65.7	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	52.9	65.3	60	66.0	Minor
	HDB Buildings[4]	Residential	65	53.6	65.3	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	42.8	67.9	60	68.9	Minor
	Dunearn Secondary School	School	67.9	40.1	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	51.7	68.0	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	51.7	68.0	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	50.7	**60.0**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	47.7	**59.8**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	63.6	**65.0**	-	59.5	Moderate
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	65.4	**66.4**	-	59.5	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	47.3	**64.2**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	63.9	**65.2**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	64.1	**65.4**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	64.1	**65.4**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	66.3	**67.1**	-	59.5	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	61.6	**66.0**	-	64.1	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 3 - Infrastructure								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	58.1	66.2	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	60	66.2	60	66.0	Minor
	HDB Buildings[4]	Residential	65	61.1	66.5	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	52.6	68.0	60	68.9	Minor
	Dunearn Secondary School	School	67.9	51.2	68.0	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	56.7	68.2	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	56.7	68.2	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	61.6	63.7	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	60.6	63.1	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	65.7	66.6	-	59.5	Moderate
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	63.6	65.0	-	59.5	Moderate
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	58.8	65.2	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	66.2	67.0	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	68.9	69.4	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	71.7	72.0	-	59.5	Major
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	72.2	72.4	-	59.5	Major
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	70.6	71.5	-	64.1	Moderate

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 4 - Building								
NSR 1	HDB Buildings[3] & iNZ Residence Condominium	Residential	65.5	59	66.4	75	76.0	Minor
NSR 2	Ichiban Montessori Childcare Centre	School	65	58.7	65.9	60	66.0	Minor
	HDB Buildings[4]	Residential	65	59.8	66.1	75	75.0	Minor
NSR 3	Hong Kah Primary School	School	67.9	49.6	68.0	60	68.9	Minor
	Dunearn Secondary School	School	67.9	46.5	67.9	60	68.9	Minor
	HDB Buildings[5]	Residential	67.9	57.9	68.3	75	76.0	Minor
	HomeTeam NS Adventure	Residential	67.9	57.9	68.3	75	76.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	59.5	57.5	**61.6**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	59.5	50.8	**60.0**	-	59.5	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	59.5	72.6	**72.8**	-	59.5	Major
NSR 4_0.5m	Fauna - Parcel 4	Forest	59.5	72.9	**73.1**	-	59.5	Major
NSR 5_0.5m	Fauna - Parcel 5	Forest	64.1	50.5	**64.3**	-	64.1	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	59.5	67.3	**68.0**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 2	Forest	59.5	68.5	**69.0**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 3	Forest	59.5	66.4	**67.2**	-	59.5	Moderate
NSR 4_15m	Fauna - Parcel 4	Forest	59.5	68.4	**68.9**	-	59.5	Moderate
NSR 5_15m	Fauna - Parcel 5	Forest	64.1	65.6	**67.9**	-	64.1	Minor

Note :

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

[3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5

[4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7

[5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7

Bold red indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR 5)

Table 8.20: Mitigated Noise Level (L_{Aeq} 5 mins) with Noise Barrier and Additional Control Measures

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 1 - Advance Works								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	57.9	74.5	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	57.9	78.0	75	80.0	Minor
	HDB Buildings[4]	Residential	78	59.4	78.1	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	49.9	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	47	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	58.1	74.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	58.1	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	59.6	**75.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	54.4	**75.3**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	72.6	**77.2**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	72.2	**77.0**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	54.8	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	68.6	**76.1**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	67.5	**76.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	68.7	**76.2**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	70.4	**76.5**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	72.2	**81.3**	-	80.7	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 2 - Earthworks								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	55.2	74.5	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	55.4	78.0	75	80.0	Minor
	HDB Buildings[4]	Residential	78	55.7	78.0	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	48.8	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	44.8	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	54.4	74.5	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	54.4	74.5	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	59.3	**75.4**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	51.6	**75.3**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	64.8	**75.7**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	66.5	**75.8**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	49	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	64.9	**75.7**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	65.3	**75.7**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	65.2	**75.7**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	67.4	**76.0**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	62.8	**80.8**	-	80.7	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 3 - Infrastructure								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	59.9	74.6	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	61.6	78.1	75	80.0	Minor
	HDB Buildings[4]	Residential	78	62.4	78.1	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	55.4	74.6	75	78.0	Minor
	Dunearn Secondary School	School	74.5	53.2	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	58.9	74.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	58.9	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	63.5	**75.6**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	62	**75.5**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	66.9	**75.9**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	64.8	**75.7**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	59.9	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	67.2	**75.9**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	69.9	**76.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	72.7	**77.2**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	73.3	**77.4**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	71.5	**81.2**	-	80.7	Minor

NSR Cluster	NSR	Type of Affected Premises	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities (dBA)[1]	Predicted Noise Level (dBA)[2]	Max Permissible Noise Level (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Stage 4 - Building								
NSR1	HDB Buildings[3] & iNZ Residence Condominium	Residential	74.4	60.7	74.6	90	90.0	Minor
NSR2	Ichiban Montessori Childcare Centre	School	78	60.5	78.1	75	80.0	Minor
	HDB Buildings[4]	Residential	78	61.4	78.1	90	90.0	Minor
NSR3	Hong Kah Primary School	School	74.5	53.6	74.5	75	78.0	Minor
	Dunearn Secondary School	School	74.5	49.8	74.5	75	78.0	Minor
	HDB Buildings[5]	Residential	74.5	59.6	74.6	90	90.0	Minor
	HomeTeam NS Adventure	Residential	74.5	59.6	74.6	90	90.0	Minor
NSR 4_0.5m	Fauna - Parcel 1	Forest	75.3	63.4	**75.6**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 2	Forest	75.3	55.1	**75.3**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 3	Forest	75.3	73.6	**77.5**	-	75.3	Minor
NSR 4_0.5m	Fauna - Parcel 4	Forest	75.3	73.9	**77.7**	-	75.3	Minor
NSR 5_0.5m	Fauna - Parcel 5	Forest	80.7	54	**80.7**	-	80.7	Minor
NSR 4_15m	Fauna - Parcel 1	Forest	75.3	68.8	**76.2**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 2	Forest	75.3	69.7	**76.4**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 3	Forest	75.3	67.6	**76.0**	-	75.3	Minor
NSR 4_15m	Fauna - Parcel 4	Forest	75.3	69.4	**76.3**	-	75.3	Minor
NSR 5_15m	Fauna - Parcel 5	Forest	80.7	66.6	**80.9**	-	80.7	Minor

Note :

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

[3] Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5

[4] Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa Chu Kang Ave 7

[5] Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7

Bold red indicates exceedance to max adjusted permissible noise level (for NSR 1, NSR 2 and NSR 3) and exceedance to max baseline noise level (for NSR 4 and NSR 5)

A number of additional administrative measure and good site practices shall be adopted to eliminate, minimise or further reduce the potential impacts on noise levels during construction of the Project development.

a) Contractor shall engage an Environmental Control Officer (ECO) as stipulated in Section 3 of Code of Practice for Environmental Control Officers (COP for ECO).

b) ECO to prepare the Site Environmental Control Program in accordance with the format in Appendix 4 of COP for ECO, which is to be submitted by Contractor to the Director-General of Public Health of NEA two weeks before the commencement of construction. Contractor should implement the Environmental Control Programme specific to the construction works undertaken by the contractor.

c) ECO to prepare and submit bi-weekly Site Environmental Control Report to Contractor in accordance with the format in Appendix 5 of COP for ECO.

d) Contractor should engage Public Relation Officer (PRO) to establish good rapport with the community, handle and feedback complaints from the community.

e) Contractor to prepare noise management plan (NMP) to help to implement noise mitigation measure. The suggested NMP template is indicted in Annex H of SS 602: 2014.

f) Contractor to use engineering methodology to control noise at source (**Figure 8.5**), such as:

- Noise enclosure to cover stationary PME such as generator.
- Noise screen/ noise panel to partially shield noise generated from noisy PME such as crane and excavator.
- Portable noise barrier for noisy construction activities e.g. soil investigation drilling activities and road and drainage work which are close to site boundary.
- Quieter construction methodology such as silent piler instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling.

g) Contractor to use noise barrier with minimum 6 m high along the site boundary facing affected NSRs.

h) Conduct continuous real time noise monitoring using Type 1 sound level meter with data logging at the affected NSRs. When noise level exceeds the maximum adjusted noise level, contractor should investigate and apply appropriate mitigation measures. Recommended monitoring locations:

- For Affected community (NSR 1, NSR 2 and NSR 3) during Stage 1 – Advance Works, Stage 2 - Earthworks and Stage 3 – Infrastructure: at the same location as baseline noise monitoring
- For Affected community (NSR 1, NSR 2 and NSR 3) during Stage 4 – Building: at the same location as baseline noise monitoring and at building rooftops.
- For Affected fauna (NSR 4 and NSR 5) at all stages: at site boundary adjacent to forested area.

i) Implement industry best practices:

- Only well-maintained PME shall be operated on-site and shall be serviced regularly during the construction.
- The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the NSRs.
- Use of alternative equipment with less noise emission such as use of rubber mallets instead of metal hammer.
- Care shall be taken during loading or unloading, dismantling or moving materials to reduce impact noise.
- Silencers or mufflers on PME (e.g. generator sets) shall be utilized and shall be properly maintained during the construction.

- Mobile PME, if any, shall be sited as far from NSRs as possible.
- PME (such as trucks and cranes) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum possible.
- PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the nearby NSRs.
- Noisy construction activities shall be avoided at nights and Sundays and public holidays when the noise limits are more stringent.



Figure 8.5: Example of Noise Mitigation at Source

j) Consider limiting heavy construction working hours to 8 a.m. to 6 p.m. where possible to avoid the timings when crespular species may be active. Toolbox meetings and winding down of work can be done outside of these hours.

k) Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense.

8.6 Residual Impact

The adoption of the mitigation measures recommended above will assist to further reduce the noise impacts during construction phase of the Project. After implementation of these recommended mitigation measures, the residual significance of noise impacts is anticipated to be minor negative impacts for the affected residential receptors.

The residual significance for fauna is anticipated to be mitigated to mostly minor negative impacts with a smaller number of receptors still facing moderate and major negative impacts over the 12 hour period due to their sensitivity to noise. Although it is possible that fauna will move away from loud noises, of which some may have to expend considerable energy to find new home ranges, there remains some which are less mobile who are unable to do so. This could lead to higher mortality rates and contribute to greater ecosystem pressures.

A summary of the noise impact significance pre- and post- mitigation can be found in **Table 8.21**. A detailed summary which expands on the specific receptors and construction stages and their residual impacts can be found in **Appendix 8C**.

Table 8.21: Summary of Evaluation of Residual Impacts to Residential Receptors for All Construction Stages

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
Over Specific Period (L_{Aeq} 12 hours)					
N-I1	Noise emission from construction activities to NSR 1, NSR 2 and NSR 3	From -40 to -80	**Minor Negative Impact**	-40	**Minor Negative Impact**
Over 5 mins (L_{Aeq} 5 mins)					
N-I1	Noise emission from construction activities to NSR 1, NSR 2 and NSR 3	-40	**Minor Negative Impact**	-40	**Minor Negative Impact**

Table 8.22: Summary of Evaluation of Residual Impacts to Fauna Receptors for All Construction Stages

Impact Register		Impact Register		Impact Register	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
Over Specific Period (L_{Aeq} 12 hours)					
N-I2	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	**From -99 to -297**	**Minor to Major Negative Impact**	**From -99 to -198**	**Minor to Moderate Negative Impact**
	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High	**From -99 to -297**	**Minor to Major Negative Impact**	**From -99 to -297**	**Minor to Major Negative Impact**
N-I3	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	**From -66 to 198**	**Minor to Moderate Negative Impact**	**From -66 to -198**	**Minor to Moderate Negative Impact**

Impact Register		Impact Register		Impact Register	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
N-I3	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium	**From -132 to 198**	**Moderate Negative Impact**	**From -66 to -132**	**Minor to Moderate Negative Impact**
N-I4	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	**From -20 to -60**	**Minor Negative Impact**	**From -20 to -60**	**Minor Negative Impact**
Over 5 mins (L_{Aeq} 5 mins)					
N-I2	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	**From -99 to -298**	**Minor to Major Negative Impact**	**-99**	**Minor Negative Impact**
	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - High	**From -99 to -297**	**Minor to Major Negative Impact**	**-99**	**Minor Negative Impact**
N-I3	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	**From -66 to -198**	**Minor to Moderate Negative Impact**	**-66**	**Minor Negative Impact**
	Noise emission from construction site to arboreal fauna of Priority/ Sensitivity Level - Medium	**From -66 to -198**	**Minor to Moderate Negative Impact**	**-66**	**Minor Negative Impact**
N-I4	Noise emission from construction site to ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	**From -20 to -60**	**Minor Negative Impact**	**-20**	**Minor Negative Impact**

8.7 Potential Additional Noise Sensitive Receivers

At the time of preparing this report, it is noted by HDB that the Project development schedule may be extended due to the COVID-19 situation in Singapore. It is possible that there are construction activities from this development area when the HDB's Phase 2 residential buildings located at the south to the current EIS Study Area are occupied.

The noise levels at those future occupied building(s) are dependent on the various factors: number of construction sites around it, type of construction activities at their surroundings, noise control measures taking by construction contractors, distance between the site and the future occupied buildings, building design and road/traffic noises.

We recommend a detailed noise impact assessment to be included in the construction contract specific Environmental Management and Monitoring Plan (EMMP) to consider the impacts to the future occupied building(s) when the building details and the Project development schedule are confirmed. A noise measurement at the future occupied building location(s) before the commencement of the construction of this Project would be required to provide the baseline noise level. Additional noise mitigation measures such as noise barriers (**Section 8.5.1**) may be considered along the section of the construction site boundary facing the future occupied building(s), if the predicted noise level at the future occupied building(s) exceeds the noise criteria determined based on the baseline noise level and potential correction factor as stipulated in *EPM (Control of Noise at Construction Sites) Regulations*, Third Schedule.

9. Ambient Air Quality

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

9.1 Applicable Legislation and Standards

NEA has published Singapore's Air Quality Targets by 2020 and Long Term Targets based on the World Health Organisation (WHO) Air Quality Guidelines (AQGs). The standard for Particulate Matter of diameter 10 micrometres or less (PM_{10}), and Particulate Matter of diameter 2.5 micrometres or less ($PM_{2.5}$) are presented in **Table 9.1**.

Table 9.1: Singapore Ambient Air Quality Targets

Pollutant	Singapore Targets by 2020	Long Term Targets
Particulate Matter ($PM_{2.5}$)	Annual mean: 12 µg/m^3 (Sustainable Singapore Blueprint target) 24-hour mean: 37.5 µg/m^3 (WHO Interim Target)	Annual mean: 10 µg/m^3 24-hour mean: 25 µg/m^3 (WHO Final)
Particulate Matter (PM_{10})	Annual mean: 20 µg/m^3 24-hour mean: 50 µg/m^3 (WHO Final)	

NEA also regulates air emissions from industrial plant or trade premises[12] and exhaust emissions from vehicles, and prohibits the use of open fires, through the EPMA and its subsidiary regulations. The EPM (Air Impurities) Regulations repeal the original set of Clean Air Standards that had been in place since 1978. These latest regulations stipulate the emission standards for industrial plant and fuel-burning equipment used in industrial and trade premises.

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

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

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

NEA also sets penalties through the Environmental Public Health Act (EPHA) for violations by construction site occupiers that contribute to an air pollution nuisance to the public. These violations include littering, dropping or scattering of sand, earth, gravel, clay, refuse, stone or other similar material at public places such as public roads;

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

and dust pollution, accumulations or deposits that are a nuisance or are injurious or dangerous to the health of the public. The Act also requires persons carrying out any construction or earth works to provide or construct a suitable device or facility for the removal of dirt, earth, sand or other particles from any vehicle used in connection with the construction or earth works.

9.2 Assessment Methodology

This EIS assesses the potential air quality impacts during construction phase of the Project. The operational phase of the Project is not expected to emit air pollution as well as nuisance impacts due to dust, fume or smell that could adversely impact adjoining premises. There is no legislation and standard in Singapore presently that describes the methodology for air quality baseline studies. Thus, the Technical Memorandum Annex 12: Guidelines for Air Quality Assessment published by HK EPD was used and adapted to Singapore situation. This Technical Memorandum was chosen as it provides guidance on determination of study area, air sensitive receiver (ASR) and baseline study.

Determination of Ambient Air Sensitive Receivers

The criteria considered for determination of ASRs for the proposed Project are listed below:

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

Baseline Ambient Air Quality Sampling

The six air pollutants used by NEA to report Singapore's ambient air quality status were used as the basis for this air quality impact assessment. These six (6) air pollutants are: Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2), Ozone (O_3), Particulate Matter of diameter 10 micrometres or less (PM_{10}), and Particulate Matter of diameter 2.5 micrometres or less ($PM_{2.5}$).

Fugitive dust emissions and emission from combustion from construction activities such as soil excavation, backfilling transportation, machineries combustion, and handling and storage of excavated soil and other construction debris are significant contribution to the increment of PM_{10} and $PM_{2.5}$ concentration. In consideration that the EIS focuses on the assessment of ambient air quality impacts during the construction stage, the parameters of concern for the baseline description only includes PM_{10} and $PM_{2.5}$. The Singapore Ambient Air Quality Targets (SAAQT) by 2020 is used as benchmark to the baseline for impact assessment.

PM_{10} and $PM_{2.5}$ are measured using Met One Aerocet 531S Particle Mass Profiler & Counter for one week on a continuous basis to present a representative existing ambient air quality background. It uses light scattering laser photometer, providing real time aerosol mass reading and data logging.

9.3 Pre-construction Baseline

9.3.1 Weather Conditions

9.3.1.1 General Weather Conditions

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

- Northeast monsoon season (December to early March): northeast winds prevail, sometimes reaching 20 km/h. Cloudy conditions in December and January with frequent afternoon showers. Spells of widespread moderate to heavy rain occur lasting from 1 to 3 days at a stretch. Relatively drier in February till early March. It is generally windy with wind speeds sometimes reaching 30 to 40 km/h in the months of January and February.
- Inter-monsoon period (late March to May): Light and variable winds with afternoon and early evening showers often with thunder.
- Southwest monsoon season (June to September): Southeast and southwest winds. Isolated to scattered late morning and early afternoon showers. Early morning "Sumatra" line squalls are common.
- Inter-monsoon period (October to November): Light and variable winds. Sea breezes in afternoon. Scattered showers with thunder in the late afternoon and early evening.

We purchased the hourly wind data recorded at Changi Weather Station for the years 2015 to 2019 from Meteorological Service Singapore of NEA. Based on the wind rose generated from recordings at the Changi Weather Station for the years 2015 to 2019 (**Figure 9.1**), the prevailing wind direction in overall Singapore context over the represented period was from the northeast (14% of the time) and north (11% of the time):

- For the wind that blows from northeast, the speeds were 0.5 – 2.1 metres per second (m/s) about 1% of the time, 2.1 – 3.5 m/s about 5% of the time, 3.6 – 5.7 m/s about 6% of the time and 5.7 – 8.8 m/s about 2% of the time.
- For the wind that blows from north, the speeds were 0.5 – 2.1 m/s about 8.5% of the time, 2.1 – 3.5 m/s about 2.3% of the time and 3.6 – 5.7 m/s about 0.2% of the time.

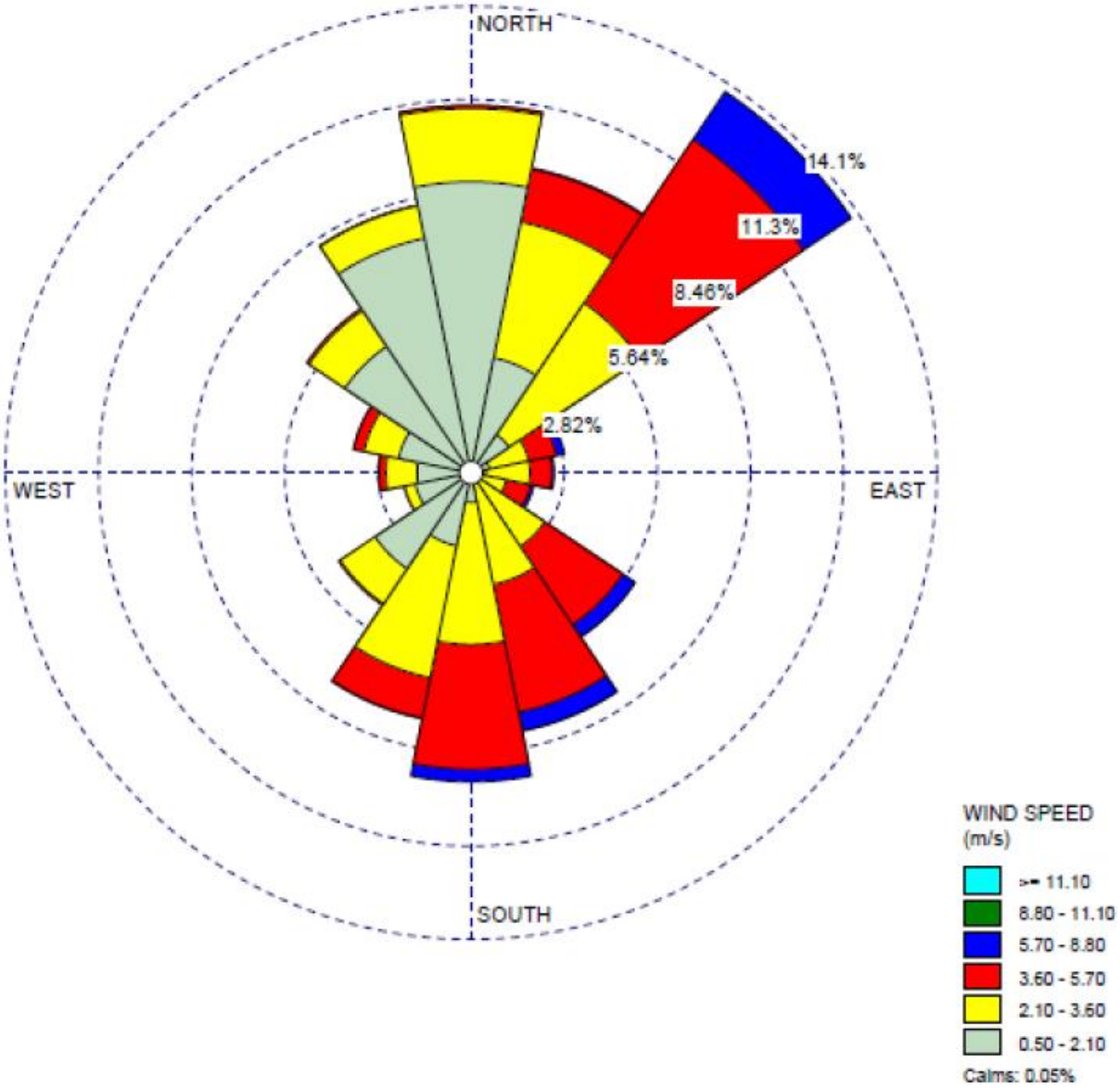


Figure 9.1: Wind Rose Plot – Changi Weather Station from 2015 to 2019

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

9.3.1.2 Specific Weather Condition

The nearest weather monitoring stations to EIS Study Area is Choa Chu Kang Weather Station, located 0.9 km north of the proposed Project. However, this station does not record the wind speed and direction during the monitoring period (Feb 10 – March 2, 2020). The weather data recorded at Ngee Ann Polytechnic Weather Station (https://data.gov.sg/dataset/realtime-weather-readings), located 5 km southeast of the proposed Project, is therefore used in this EIS. A wind rose generated from recordings at Ngee Ann Polytechnic Weather Station during the monitoring period is presented in **Figure 9.2** below. The wind rose illustrates that the prevailing wind direction, for the represented period, is mainly from the north-northeast as indicated by the size of the branch which represents wind coming from that direction. Each branch is divided into segments of different thickness and colour which represents the frequencies of each wind speed category from that direction.

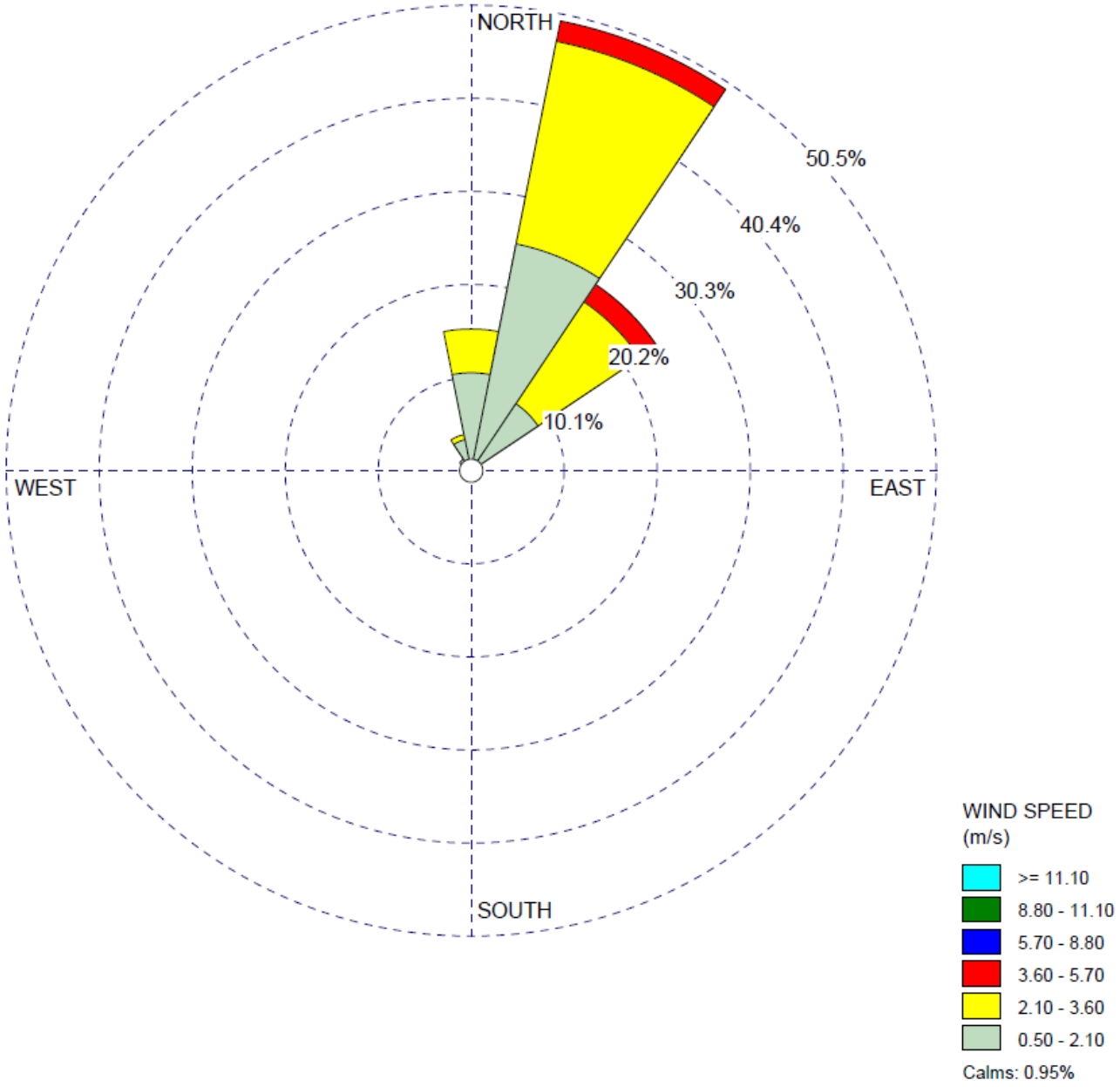


Figure 9.2: Wind Rose Plot – Ngee Ann Polytechnic Weather Station from Feb 10 to Mar 2, 2020

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

9.3.2 Historical Air Quality Data

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

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

The monitoring stations monitor both ambient and roadside air quality. The automatic analysers and equipment at the stations monitor the concentrations of major pollutants such as CO, NO_2, SO_2, PM_{10}, and $PM_{2.5}$. Historical

ambient air quality data for PM_{10} and $PM_{2.5}$, between 2012 and 2018 provided by Singapore Department of Statistics (Singstat, 2019) are summarised in **Table 9.2**. Only PM_{10} and $PM_{2.5}$ are considered because they are the major air pollutants for construction site.

Table 9.2: Background Concentration in Singapore from 2015 to 2019 (µg/m^3)

Air Pollutants	2015	2016	2017	2018	2019	Average	SAAQT by 2020	Singapore Long Term Target
PM_{10} Annual Mean	**37**	**26**	**25**	**29**	**30**	**29**	20	20
PM_{10} 99th percentile 24-hour mean	**186**[1]	**61**	**57**	**59**	**90**[1]	**59**	50	50
$PM_{2.5}$ Annual Mean	**24**	**15**	**14**	**15**	**16**	**17**	12	10
$PM_{2.5}$ 99th percentile 24-hour mean	**145**[1]	**40**	34	32	**62**[1]	35	37.5	25

Source: Yearbook of Statistics Singapore (2019). Climate and Air Quality, Section 1.3 Air Pollution Levels; and data.gov.sg

Note:
Figures in **bold red:** Concentration higher than the Singapore Targets by 2020
[1] High 24 hours PM_{10} and $PM_{2.5}$ concentrations are related to haze episode occurred in October 2015 and September 2019. These concentrations are not considered into the average over 2015-2019 data.

It is noted that the average PM_{10} (59 µg/m^3 for 24-hour mean and 29 µg/m^3 for annual mean) and $PM_{2.5}$ (17 µg/m^3 for annual mean) ambient air concentrations measured from 2015 to 2019 have yet to fulfil the Singapore Targets by 2020.

9.3.3 Determination of Air Sensitive Receiver

Based on the mentioned criteria on **Section 9.2** and the Site Reconnaissance carried out on Jan 7, 2020, the list of ASRs within the EIS Study Area and its buffer area (i.e. 150m from the EIS Study Area) that are potentially affected by the Project development is listed **Table 9.3** and illustrated below (**Figure 9.3**).

Table 9.3: Identified Air Sensitive Receiver (ASRs) for the Project

ASR Cluster	Cluster Description	Location and Distance of Cluster to the EIS Study Area
ASR Cluster 1	Block 483, 484, 484A, 484B, 484C, 484D, 485, 485A, 484B, 485C, 486 Choa Chu Kang Avenue 5, iNZ Residence Condominium (affected community)	80 m to the north of the EIS Study Area
ASR Cluster 2	Block 803C, 803D, 804A, 804B, 805A, 805B, 805C, 805D Kean Hong Close, Block 811B, 812C Choa	70 m to the north of the EIS Study Area

ASR Cluster	Cluster Description	Location and Distance of Cluster to the EIS Study Area
	Chu Kang Ave 7, Ichiban Montessori Childcare Centre (affected community)	
ASR Cluster 3	Block 402, 403, 404, 405, 406, 407, 408, 410 Bukit Batok West Ave 7, HomeTeam NS Adventure Centre @ Bukit Batok, Dunearn Secondary School, Bukit Batok Golf Range (affected community)	60 m to the south/southeast of the EIS Study Area

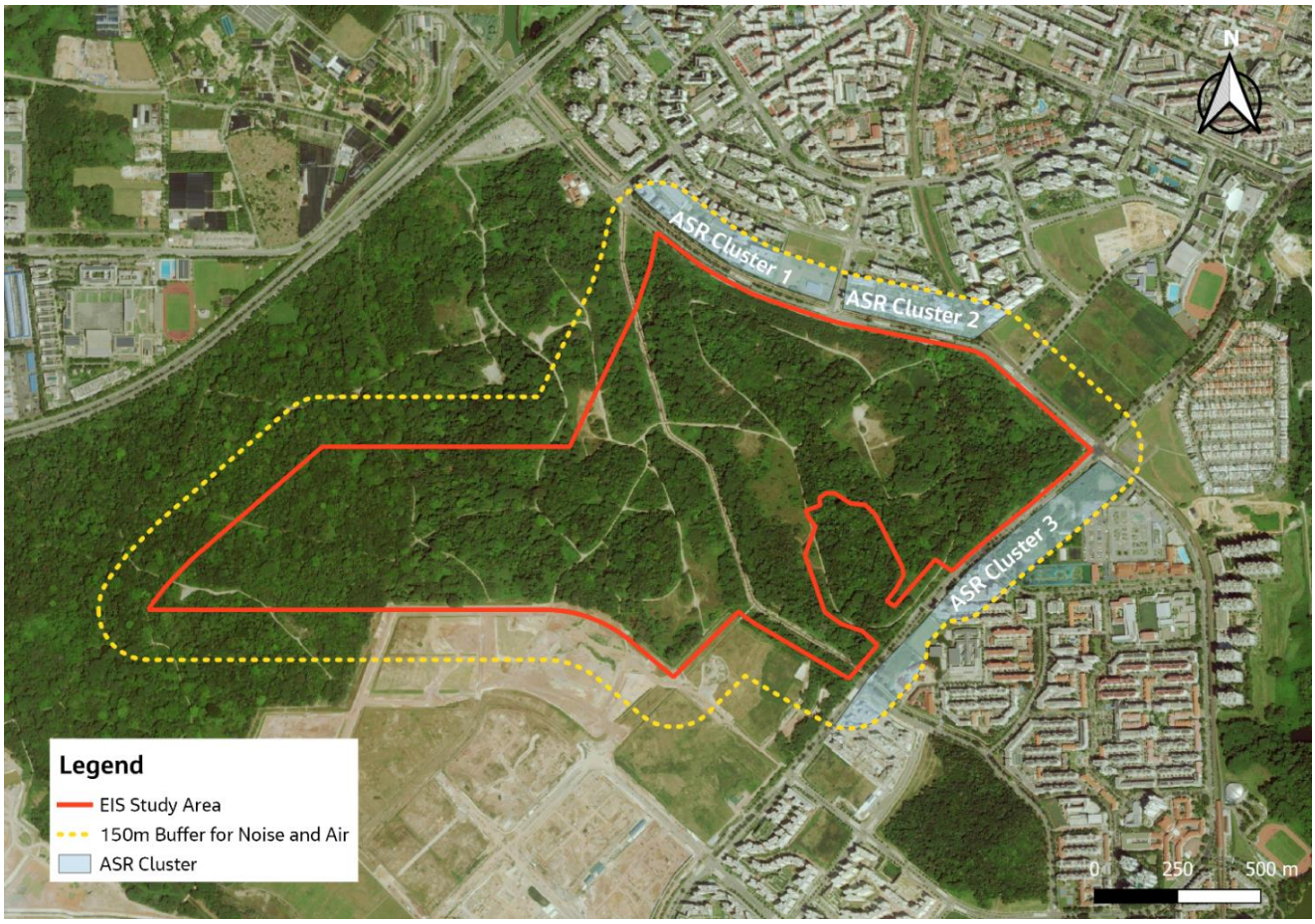


Figure 9.3: ASR Cluster

Base Map: ESRI

9.3.4 Ambient Air Quality Baseline Sampling

Three ambient air quality sampling points for affected community are selected. The locations of the ambient air quality baseline sampling are shown in **Figure 9.4** and described below:

Table 9.4: Location of Ambient Air Quality Sampling Station

Ambient Air Quality Sampling Points	Description
A1	At an open space of the ground floor of Block 484B Choa Chu Kang Avenue 5
A2	At an open space of the ground floor of Block 805C Kean Hong Close
A3	At an open space of the ground floor of Block 405 Bukit Batok West Ave 7

The equipment for ambient air quality baseline sampling is Met One Aerocet 531S Particle Mass Profiler & Counter. It uses light scattering laser photometer, providing real time aerosol mass reading and data logging. PM_{10} and $PM_{2.5}$ are measured using for one week on a continuous basis to present a representative existing ambient air quality background.

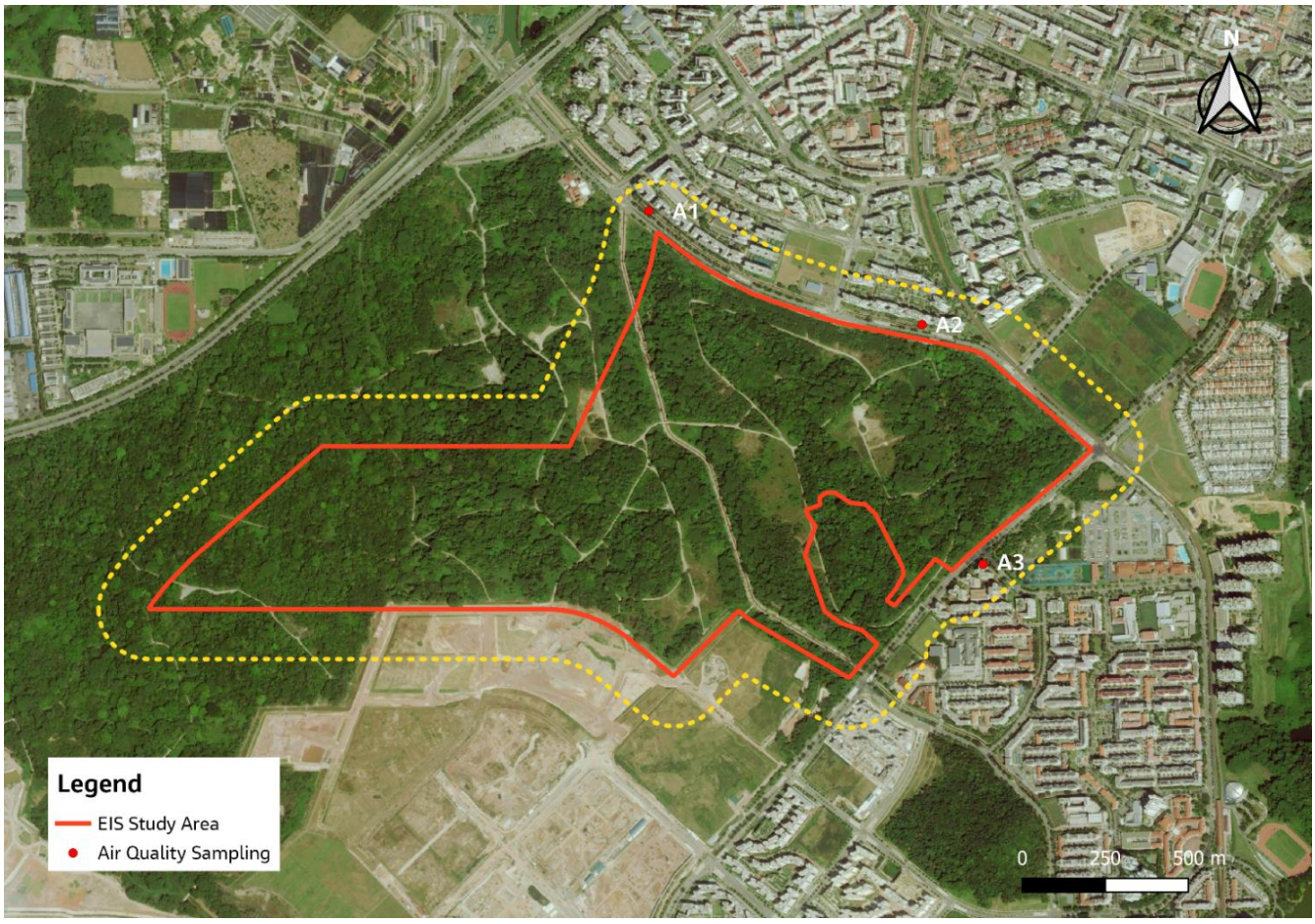


Figure 9.4: Location of Ambient Air Quality Sampling Station

Base Map: ESRI

9.3.5 Results and Discussion

The ambient air quality baseline sampling was conducted by MLS laboratory accredited by the Singapore Accreditation Council and supervised by our environmental engineers from Feb 10 to March 2, 2020. The results of the ambient air quality baseline sampling were used to established pre-construction ambient air quality and benchmarked against the SAAQT by 2020.

Ambient air quality baseline sampling reports and photographic logs are provided in **Appendix 9A** and **Appendix 9B** respectively, and summary results are tabulated in **Table 9.5**.

Table 9.5: Ambient Air Quality Baseline Results

Sampling Points	Day	Date	PM_{10} (µg/m^3) 24hr mean*	$PM_{2.5}$ (µg/m^3) 24hr mean*
A1	1	Feb 10 – 11, 2020	22.6	14.6
	2	Feb 11 – 12, 2020	25.2	15.1
	3	Feb 12 – 13, 2020	40.1	19.0
	4	Feb 13 – 14, 2020	37.0	18.3
	5	Feb 14 – 15, 2020	34.3	18.0
	6	Feb 15 – 16, 2020	32.0	17.5
	7	Feb 16 – 17, 2020	38.2	23.2
A2	1	Feb 17 – 18, 2020	14.4	7.9
	2	Feb 18 – 19, 2020	22.7	12.9
	3	Feb 19 – 20, 2020	32.9	16.6
	4	Feb 20 – 21, 2020	33.9	17.1
	5	Feb 21 – 22, 2020	31.6	17.9
	6	Feb 22 – 23, 2020	29.8	15.4
	7	Feb 23 – 24, 2020	28.5	16.8
A3	1	Feb 24 – 25, 2020	**57.8**	25.3
	2	Feb 25 – 26 Feb 2020	39.7	19.0
	3	Feb 26 – 27, 2020	31.7	14.5
	4	Feb 27 – 28, 2020	24.3	12.1
	5	Feb 28 – 29, 2020	31.1	15.4
	6	Mar 29 – Feb 1, 2020	34.7	17.2
	7	Mar 1 – 2, 2020	26.9	13.4
SAAQT by 2020			**50**	**37.5**

Note: *24-hour average from 5 p.m. to 4 p.m. the next day. In **bold red:** Concentration higher than the SAAQT by 2020

The table above showed that with the exception of the ambient air quality baseline concentrations for PM_{10} 24-hours on day 1 (24 – 25, Feb 2020) at A3, the ambient air quality baseline concentrations at all stations for PM_{10} 24-hours and $PM_{2.5}$ 24-hours complied with their respective SAAQT by 2020. A further review of the PM_{10} monitoring data of A3 with meteorological data, regional ambient air quality data from West region of Singapore and site-specific conditions was conducted and presented as below.

9.3.5.1 Meteorological Data

Wind rose generated from Ngee Ann Polytechnic Weather Station during the ambient air quality monitoring period (**Figure 9.2**) indicated that the wind direction was dominantly blowing from the North-Northeast. Thus, A3 is at downwind from Bukit Batok Road. As there were no exceedances from day 2 to day 7, the vehicles emission at Bukit Batok Road did not pose strong evidence to have affected the ambient air quality.

9.3.5.2 Regional Ambient Air Quality

The PM_{10} 24-hours concentration for A3 was then compared with the regional ambient air quality data from west region of Singapore collected from NEA website during the same monitoring period (referred to **Table 9.6** and **Figure 9.5** below). As per NEA website, west region refers to Lim Chu Kang, Choa Chu Kang, Bukit Panjang, Tuas, Jurong East, Jurong West, Jurong Industrial Estate, Bukit Batok, Hillview, West Coast and Clementi.

Table 9.6: Comparison of Ambient Air Quality of A3 with Singapore Ambient Air Quality for West Region

Sampling Points	Day	Date	PM_{10} (µg/m^3) 24hr mean		$PM_{2.5}$ (µg/m^3) 24hr mean	
			Site	West Region	Site	West Region
A3	1	Feb 24 – 25, 2020	**57.8**	39	25.3	12
	2	Feb 25 – 26, 2020	39.7	40	19	12
	3	Feb 26 – 27, 2020	31.7	30	14.5	11
	4	Feb 27 – 28, 2020	24.3	28	12.1	9
	5	Feb 28 – 29, 2020	31.1	29	15.4	9
	6	Feb 29 – Mar 1, 2020	34.7	40	17.2	18
	7	Mar 1 – 2, 2020	26.9	40	13.4	18
2020 SAAQT			**50**		**37.5**	

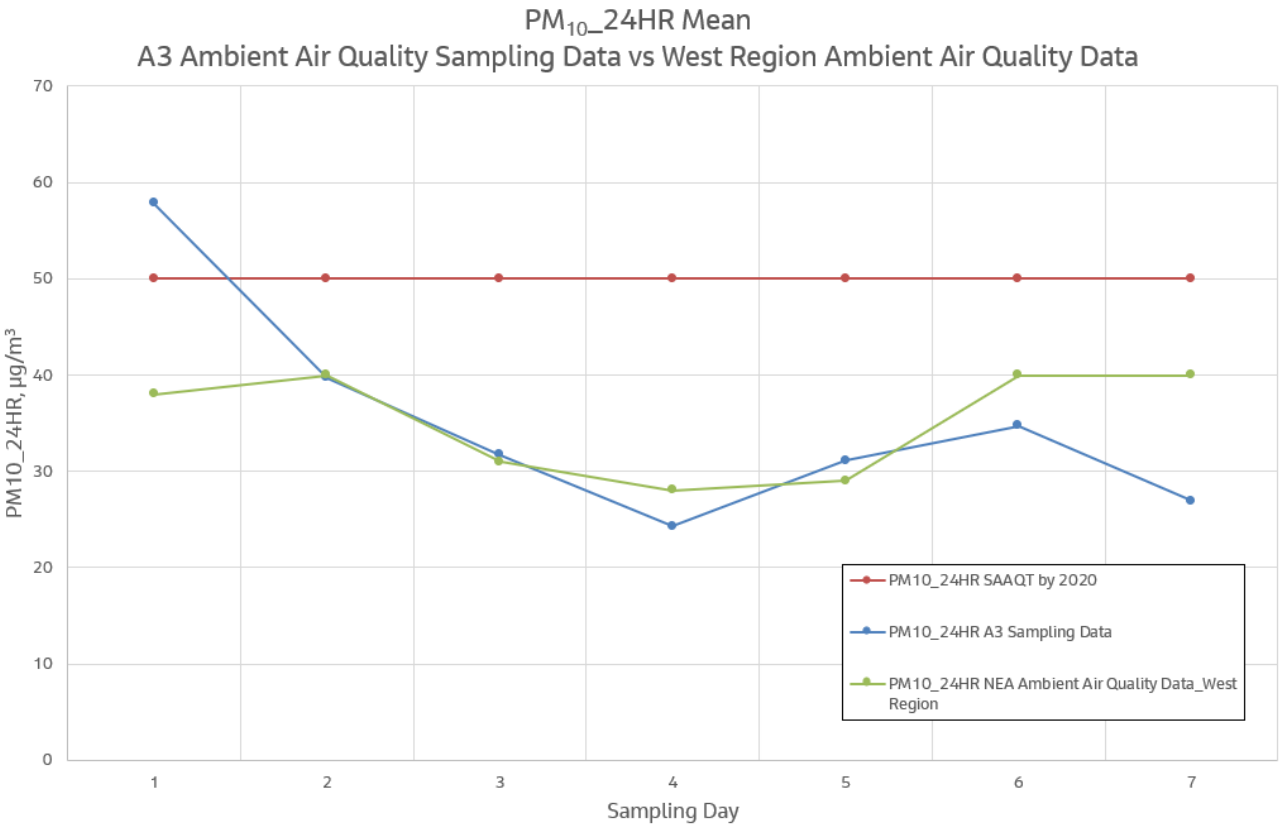


Figure 9.5: PM_{10} 24-hours A3 Ambient Air Quality Sampling Comparison with West Region Ambient Air Quality

Based on **Table 9.6** and **Figure 9.5**, the regional PM_{10} 24-hours concentrations from the west region of Singapore from day 1 to day 7 are below the SAAQT by 2020. Regional PM_{10} 24-hours concentration on day 1 is lower than A3 sampling result. Hence, the exceedance of PM_{10} on day 1 was unlikely correlated with regional PM_{10} concentrations.

9.3.5.3 Site Specific Condition

There are high peaks of hourly PM_{10} concentration ranging from 74.9 µg/m^3 to 83.3 µg/m^3 recorded on Feb 25, 2020 from 5 a.m. to 7 a.m. from an unknown source. These high peaks are likely related to human activities (e.g. brush/ waste burning) and not traffic, as they were observed only one day (Tuesday) and not the other days of the week.

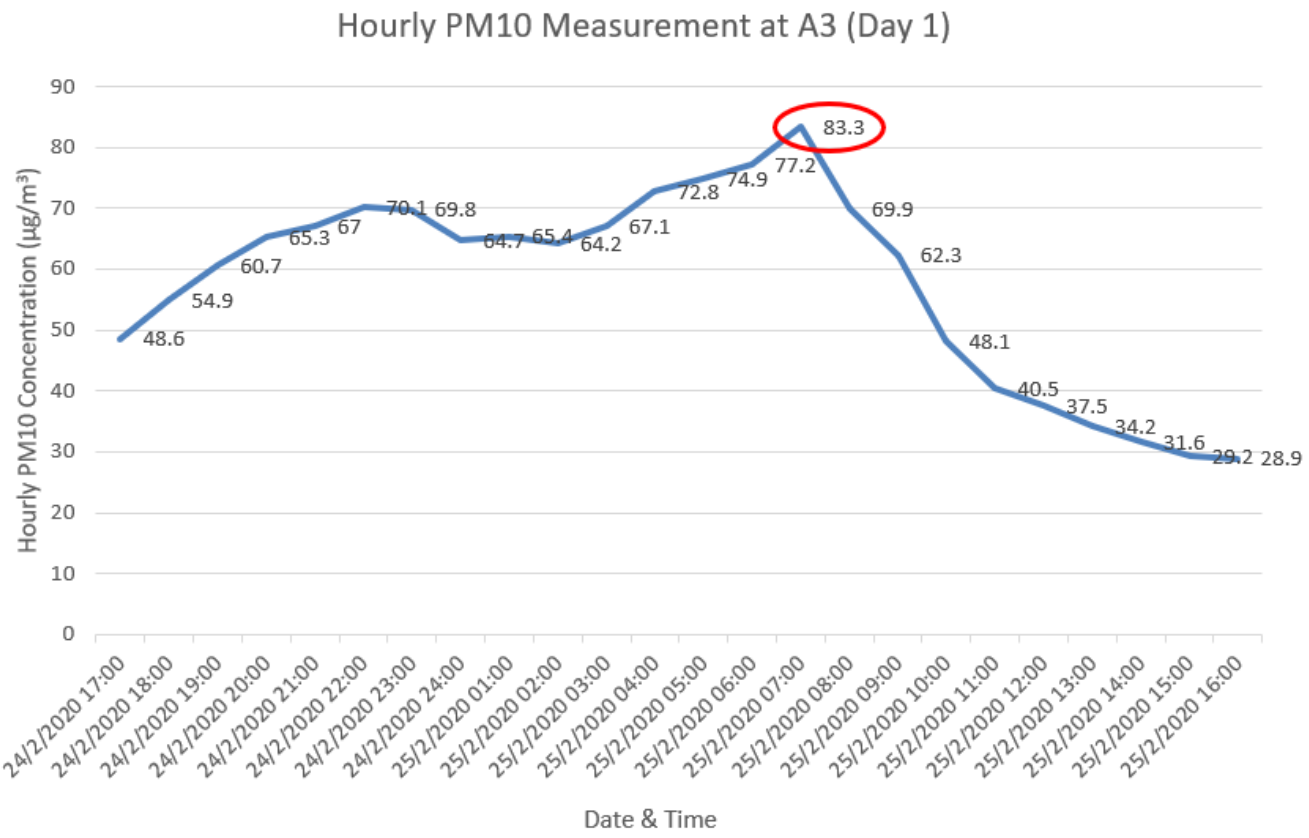


Figure 9.6: Hourly PM_{10} Concentration on Day 1 at A3 Sampling Point

Note: Red oval indicates the highest concentration

9.3.6 Ambient Air Quality Baseline Limitation

The sampling points are sited strategically to provide representative coverage of the Project. However, the ambient air quality baseline sampling program has the following limitations:

- The criteria air pollutants which have been monitored by NEA include particulate matter ($PM_{2.5}$ and PM_{10}), SO_2, NO_2, CO and O_3. The main air pollutants that will generated from the construction activities are PM_{10} and $PM_{2.5}$. Hence, only these two parameters are monitored.
- For the purpose of this EIS, the ambient air quality baseline sampling program is limited to three locations for a monitoring duration of seven days. This primary data complimented with the historical ambient air quality data is considered sufficient to provide representative ambient air quality baseline.

Although some general conclusions can be drawn from the data, many variables may influence ambient air quality such as geographic variation, weather effects, emissions variations from surrounding facilities, changes in road traffic movements and activity around the ambient air quality baseline sampling points.

9.4 Evaluation Potential Impact Before Mitigation Measures

9.4.1 Potential Source of Impact

Construction activities have the potential to result in adverse impacts on ambient air quality as well as to generate significant local nuisance effects if uncontrolled. Potential sources of impacts include:

- Fugitive dust emissions from construction works from tree felling, land clearance, excavation, backfilling, demolition of existing structure, utilities diversion, ground improvement work, stockpiles of construction materials/ waste/ vegetation debris/ demolition waste, construction of infrastructure and building, and vehicle movements on haul/ unpaved roads.
- Exhaust emissions from construction fuel-burning equipment and transport vehicles. Information on specific equipment, machineries and vehicles that are used for the proposed Project development and potentially cause exhaust emissions will be available when the contractor is on-board. However, it is anticipated that the construction activities will use fuel-burning equipment (e.g. generator) and heavy vehicle/ machinery (e.g. excavators, piling machines, dozers, drilling machines, cranes, asphalt pavers, rollers, lorry cranes, transit mixers and dump trucks) that may cause air emissions in the form of exhaust.

The qualitative assessment of potential ambient air quality impacts distinguishes between those that are positive or negative nature; major, moderate or minor magnitude of changes; transboundary, national, or local extend; long, medium or short term; direct or indirect pathway; reversible or irreversible; and cumulative or non-cumulative. The ambient air quality impacts may affect ASRs with international, national or local value.

Potential impact evaluation of ambient air quality impact assessment by using the modified Rapid Impact Assessment Matrix (RIAM) as indicated in **Section 2** for affected community is discussed in the following sections.

PM_{10} and $PM_{2.5}$ were assumed to be the major pollutants during construction activities and firstly monitored. However, nitrogen oxides (NOx) are produced when fuel is combusted in the engine in the presence of air. NOx comprises a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2). The proportion of harmful NO_2 in the NOx emissions of a diesel vehicle is far higher than the proportion found in the emissions of a conventional petrol vehicle. Based on the motor vehicle population by type of fuel used (Annual Vehicle Statistics 2019, LTA), it was assumed the vehicle fleet would consist of 95% diesel-powered trucks and 5% petrol-powered trucks. In view of the fuel type assumed for the vehicle fleet (95% diesel and 5% petrol), the EIS Study Area and the final total number of construction vehicles estimated as part of the Project development, the impact assessment of NO_2 from construction vehicles exhaust is also included.

SO_2, CO and ozone emissions from construction vehicles exhaust were not included in the qualitative impact assessment considering the following:

- All new and used petrol or diesel vehicles imported for registration in Singapore shall comply with the latest Euro VI emission standards.
- Introduction of the Commercial Vehicle Emissions Scheme (CVES) for all new and used imported Light Goods Vehicles (LGVs), Goods-cum-Passenger Vehicles (GPVs), and small buses, all with maximum laden weight (MLW) not exceeding 3,500 kg, from 1 Apr 2021 to 31 Mar 2023. The CVES covers 5 pollutants: CO_2, HC, CO, NOx and PM.
- Based on the age distribution of goods and other vehicle population (Annual Vehicle Statistics 2019, LTA), more than 70% of the goods and other vehicle fleet is less than 10 years with more than 50% less than 5 years.
- Based on the motor vehicle population by type of fuel used (Annual Vehicle Statistics 2019, LTA), it was assumed the vehicle fleet would consist of 95% diesel-powered trucks and 5% petrol-powered trucks. Since

July 2013 and July 2017, Singapore has mandated the supply of Near Sulphur-Free Diesel (NSFD) with a sulphur content of 0.001% and cleaner petrol for motor vehicles with sulphur content lower than 0.001%, so SO_2 emissions from vehicles are considered minimum.

- CO forms primarily when carbon fuels are not burned completely. Mobile sources account for the majority of CO emissions. These sources include both on-road vehicles (e.g. cars, trucks, motorcycles) and nonroad vehicles and engines (e.g. construction equipment, aircraft, marine vessels). Consequently, high concentrations of CO generally occur in areas with heavy traffic congestion (U.S. EPA, 2018) which is not expected at the site. In addition, CO was considered below the Singapore Ambient Air Quality Target due to the high target values (CO 1-hr: 30 mg/m^3 and CO 8-hrs: 10 mg/m^3).

9.4.2 Fugitive Dust Emissions

Actual concentrations of fugitive dust emissions from the construction site will depend on a number of factors, including the frequency of operations, application and effectiveness of in-place control measures, ambient weather conditions (e.g. rainfall, wind speeds and wind directions), and the specific activities carried out. Fugitive dust emissions would therefore be expected to vary significantly from day to day.

Table 9.7: Impact Significance for Fugitive Dust Emissions

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Fugitive dust emissions are expected to have impact on the ambient air quality at the ASR locations.
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fugitive dust emissions from construction activities.
A2.2: Magnitude of Changes	3: High	PM_{10} and $PM_{2.5}$ concentrations from construction activities are estimated to exceed 50% of the respective SAAQT (conservative approach).
A2.3: Impact Extent	2: Tengah	Fugitive dust emissions are anticipated to extend beyond Project footprint.
B1: Permanence	2: Short Term	Fugitive dust emissions will cease when dust-generating construction activities stop.
B2: Impact Pathway	3: Direct	Fugitive dust emissions are a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fugitive dust emissions are reversible when dust-generating construction activities stop.
B4: Cumulative	3: Cumulative	Fugitive dust emissions from other construction projects are expected cause cumulative impacts to the local ambient air quality when happen concurrently.
Environmental Score (ES)	**(-12) x (10) = -120**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

9.4.3 Exhaust Emission from Fuel Burning Equipment/ Machinery/ Vehicle

Exhaust emissions from fuel-burning equipment and heavy vehicle/ machinery can impact local ambient air quality by potentially increasing air pollutant concentrations. PM_{10}, $PM_{2.5}$ and NO_2 emissions will mainly depend on the type of fuel and the quantity of fuel-burning equipment and heavy vehicle/ machinery used on site.

Table 9.8: Impact Significance for Fuel Burning Equipment/ Machinery/ Vehicle

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Fuel burning equipment/ machinery/ vehicle exhaust emissions are expected to have impact on the ambient air quality at the ASR locations.
A2.1: Impact Nature	-1: Negative	Local ambient air quality is expected to degrade due to fuel burning equipment/ machinery/ vehicle exhaust emissions from construction activities.
A2.2: Magnitude of Changes	2: Medium	PM_{10}, $PM_{2.5}$ and NO_2 concentrations from fuel burning equipment/ machinery/ vehicle exhaust emissions are estimated to exceed 10% - 50% of the respective SAAQT.
A2.3: Impact Extent	2: Tengah	Fuel burning equipment/ machinery/ vehicle exhaust emissions is anticipated to extend beyond Project footprint.
B1: Permanence	2: Short Term	Fuel burning equipment/ machinery/ vehicle exhaust emissions will cease when construction activities stop.
B2: Impact Pathway	3: Direct	Fuel burning equipment/ machinery/ vehicle exhaust emissions is a direct impact on the ambient air quality at the ASR locations.
B3: Reversibility	2: Reversible	The ambient air quality impacts due to fuel burning equipment/ machinery/ vehicle exhaust emissions is reversible when dust-generating construction activities stop.
B4: Cumulative	3: Cumulative	Fuel burning equipment/ machinery/ vehicle exhaust emissions from other construction projects are expected cause cumulative impacts to the local ambient air quality when happen concurrently.
Environmental Score (ES)	**(-8) x 10 = -80**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	

9.5 Applicable Prevention and Mitigation/ Enhancement Measures

Recommended mitigation measures to eliminate, minimise or reduce the potential impacts on ambient air quality during construction of the Project development are summarised and discussed below:

- Contractor shall engage an Environmental Control Officer (ECO) as stipulated in Section 3 of Code of Practice for Environmental Control Officers (COP for ECO).
- ECO to prepare the Site Environmental Control Program in accordance with the format in Appendix 4 of COP for ECO, which is to be submitted by Contractor to the Director-General of Public Health of NEA two weeks before the commencement of construction. Contractor should implement Environmental Control Programme specific to the construction works undertaken by the contractor.
- ECO to prepare and submit bi-weekly Site Environmental Control Report to Contractor in accordance to the format in Appendix 5 of COP for ECO.
- Contractor should engage Public Relation Officer (PRO) to establish good rapport with the community, handle and feedback complaints from the community.
- Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeter to reduce dust deposition at adjacent areas.
- The tree felling activity shall be in a way that minimise dust generation, e.g. using dust screen/ dust suppression and do not oversize the root ball trenching.
- Construction site perimeters and adjacent roads or lands shall be regularly inspected to check for dust and if necessary, remove dust deposition.
- Contractor should keep extent of excavation and soil exposure areas to minimum required for construction.
- Exposed soil and dusty material at the construction site and its boundary shall be dampened with water regularly, with the misting frequency increased during dry periods.
- Exposed site shall be properly treated by compaction, turfing, vegetation planting or sealing with bituminous materials, concrete or other suitable materials as soon as practicable after Project completion. Treat exposed earth by compaction, hydro seeding, vegetation planting, or cover with impermeable sheeting.
- Stockpiles and excavations shall be removed, backfilled or reinstated (as appropriate) by contractor as soon as practicable following excavation or unloading. If contractor needs to store excavated material on site, it will be entirely covered with impervious sheeting and the stockpile shall be removed as soon as practicable.
- Load of dusty materials on a vehicle leaving a construction site shall be covered entirely with impervious sheeting by contractor. Vehicle should not be overloaded and shall be cleaned prior to leaving the site.
- Proper cover for vehicle (e.g. tipper lorry) to avoid falling of soil debris. Any skip hoist used to transport dusty materials shall be completely enclosed by impervious sheeting.
- Vehicle washing facilities with high pressure water jets shall be provided by contractor at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point shall be paved.
- If roadways are contaminated with dusty materials from construction site, clean-up shall be conducted without delay.
- Vehicle on-site speed restrictions shall be imposed by contractor to prevent dust being whipped up by vehicle movements.
- All fuel-burning machinery or transport vehicles shall be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke.
- Reduce vehicle idling and traffic congestion, and minimise distance travelled for delivery of material.

- Ambient air quality parameters SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ at location A1, A2 and A3 are recommended to be measured prior to and during construction period under the southwest monsoon season (June to September) where the downwind receptors are likely to be impacted. However, if the construction schedule does not permit this, monitoring shall be carried out during the inter-monsoon period (late March-May). As the earthworks are planned to commence in Dec 2022, the pre-construction measurement is expected to be conducted prior to that. Should the construction schedule does not allow the pre-construction measurement during southwest monsoon season or inter-monsoon period, NEA shall be informed and discussion shall be initiated by the contractor. If ambient air quality for pre-construction measurement and monitoring is conducted using monitoring device non-certified by USEPA as Federal Reference Methods (FRM) or Federal Equivalent Methods (FEMs) (e.g. air quality sensor), EMMP consultants shall conduct their own collocation testing and calibration with a USEPA FRM/FEM equipment, to verify the equipment's performance prior to deployment to the Project site.
- If the ambient air quality level during construction exceeds the SAAQT, contractor should investigate the cause and implement more stringent mitigation measure.
- If there be any complaints from the community with regards to air quality during construction, additional ambient air quality monitoring shall be conducted.



Cover lorry when carrying dusty materials



Fuel burning equipment/ machinery/ vehicle shall be regularly maintained to prevent dark smoke emission



Dampen construction site with water regularly



Vehicle washing facilities at exit point from construction site



Cover stockpile with canvas

Figure 9.7: Example of Mitigation Measures for Ambient Air Quality Impact

9.6 Residual Impact

The adoption of the mitigation measures recommended above will assist to mitigate and further reduce the ambient air quality impacts during construction of the Project. After implementation of these suggested mitigation measures, the residual significance of ambient air quality impacts is anticipated to be minor negative impact. A summary of the ambient air quality impact significance pre- and post- mitigation can be found in **Table 9.9**.

Table 9.9: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
A-I1	Ambient air quality deterioration due to fugitive dust emissions from construction activities	-120	**Moderate Negative Impact**	-80	**Minor Negative Impact**
A-I2	Ambient air quality deterioration due to exhaust emissions from construction fuel-burning equipment, machinery and vehicles	-80	**Minor Negative Impact**	-40	**Minor Negative Impact**

10. Visual and Landscape

This section assesses the potential landscape and visual impacts associated with the activities of the Project construction and the eventual development. It introduces the applicable legislation and standards and outlines the assessment methodology taken. It also lays out the potential landscape and visual impacts identified and recommends mitigation/ enhancement measures to eliminate/ minimise these impacts.

10.1 Applicable Legislation and Standards

In Singapore, the Planning Act by URA regulates land use plans and development. The provisions set out in the Planning Act support the development of the Concept Plan and the Master Plan. The Concept Plan provides broad long term strategies for Singapore's development while the Master Plan is a statutory land use plan which translates these strategies into detailed plans. The Master Plan guides the development of land and property and shows the permissible land use and density for development. The most recent Master Plan was gazetted on 27 Nov 2019 (URA, 2019) and the development plans in the EIS Study Area follow that.

10.2 Assessment Methodology

There is currently no legalisation in Singapore that guides landscape and visual impacts assessment. The following assessment methodology was guided by Jacobs' internal guidelines for Landscape and Visual Impact Assessment (LVIA), adapted to the site context.

10.2.1 Project Description

The description lays out the current visual context of the EIS Study Area as well as describes the future visual changes that will be brought about by the construction and development of the Project. It highlights the areas which have the greatest potential to contribute to a change in views and the landscape.

10.2.2 Visual Study Area

The visual study area defines the extent of the area to be considered by the landscape and visual impact assessment. It largely relies on the identification of the viewshed, which is the area and or distance from the EIS Study Area where key features within are a recognisable element and hence could potentially be visually significant. It is based on the height of landscape features within the EIS Study Area, height of potential viewpoints outside and of the parameters of human vision.

10.2.3 Identification of Landscape Character Units and Sensitivity

Landscape character units (LCUs) are based on the physical and natural attributes of the EIS Study Area and can be defined by the topography, vegetation and the land use amongst other characteristics. Landscape sensitivity refers to the sensitivity of the viewers towards change in the landscape. This is defined by the ability of the LCU's ability to accommodate further change and the visual value that viewers place on the current land use. Typically, a heavily modified landscape would be less sensitive than one which appears mostly natural.

10.2.4 Identification of Visually Sensitive Receptors

Visually sensitive receptors (VSRs) are receptors in the visual study area that are likely to be affected by the visual changes in the EIS Study Area.

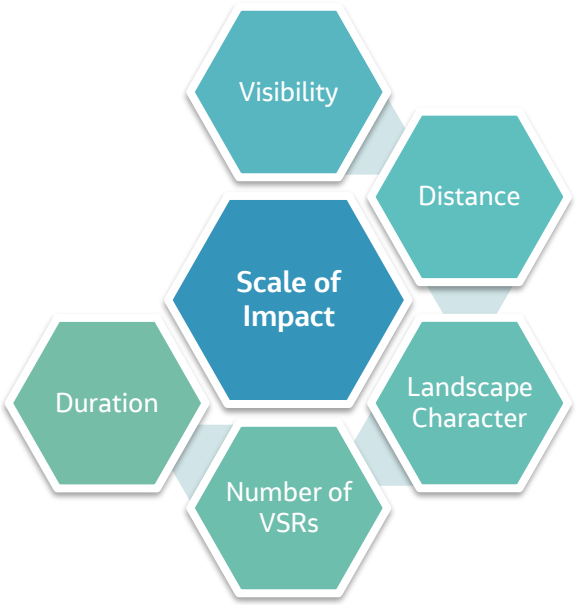
10.2.5 Selection of Representative and Accessible Viewpoints

Indicative viewpoints are selected to represent the range of VSRs identified as well as of area which have potentially significant views into the EIS Study Area. They should provide sufficient coverage to be representative of the visual impacts of the proposed construction activities of the Project within the EIS Study Area.

10.2.6 Assessment of Selected Viewpoints

The selected viewpoints are assessed using the RIAM method described in **Section 2** which assess the impacts based on its value, magnitude (impact nature, magnitude of visual changes and impact extent), permanence, impact pathway, reversibility and cumulative effects. In order to assess the magnitude of visual changes of the Project, five main criteria are used:

- **Visibility:** The visibility of the Project in the EIS Study Area is affected by the features within and surrounding including topography, vegetation and infrastructure.
- **Distance:** The visibility and dominance of the Project in the EIS Study Area decreases with distance, following the human field of vision.
- **Landscape Character:** The landscape character is based on visual features of LCUs present on site such as the land use, naturalness of the area and types of vegetation. Different features have different sensitivity where a modified landscape is likely to have less sensitive to changes than one that is largely natural or protected for ecological or cultural values.
- **Number of VSRs:** The overall scale of impact is correlated with the number of viewers of the proposed development, where viewpoints with greater number of viewers would have a greater impact.
- **Duration:** The likely duration spent at each location can often be hard to quantify as it is dependent on the individual and their purpose. However, the type of VSRs gives a relatively good gauge of the duration spent at the viewpoints. In general, residential areas where VSRs stay would have a longer viewing duration than passengers on a bus or pedestrians walking by.



These criteria are rated low to high and will guide the magnitude of visual change from negligible, minor, moderate and major:

- **Negligible Visual Change:** The visual change effect is barely discernible over the current baseline view. The EIS Study Area is at a considerable distance such that any features are a minute element or the view is predominately screened by intervening topography, vegetation, buildings or structures.
- **Minor Visual Change:** The visual change is noticeable but will not result in significant adverse impacts. It is where one or more of the criteria used to assess the visual change are rated low.
- **Moderate Visual Change:** The visual change is noticeable and may result in significant adverse impacts. It is where most of the criteria used to assess the visual change are rated higher than low.
- **Major Visual Change:** The visual change is highly noticeable and will result in significant adverse impacts. It is where all of the criteria used to assess the visual change are rated high.

10.3 Pre-construction Baseline

10.3.1 Project Description

This section describes the current visual context of the Project and the future visual changes that will result from the construction and development of the Project. It will also highlight areas which have the greatest potential to contribute to a change in view and the landscape.

10.3.1.1 Key Features of the Project

Tengah Town is Singapore's first smart and sustainable town, built to provide new homes and workspaces amidst nature features. It features a Forest Fringe at the north and south edges of the Project boundary and a larger Forest Corridor with a naturalised canal stream (Forest Stream) running through the centre. There is a mix of residential, commercial and educational buildings alongside health and medical centres and places of worship. Parks and greenery are planned to be spread out around the Project.



Figure 10.1: Artist Impression of Final Tengah Town Development

Source: HDB, 2020

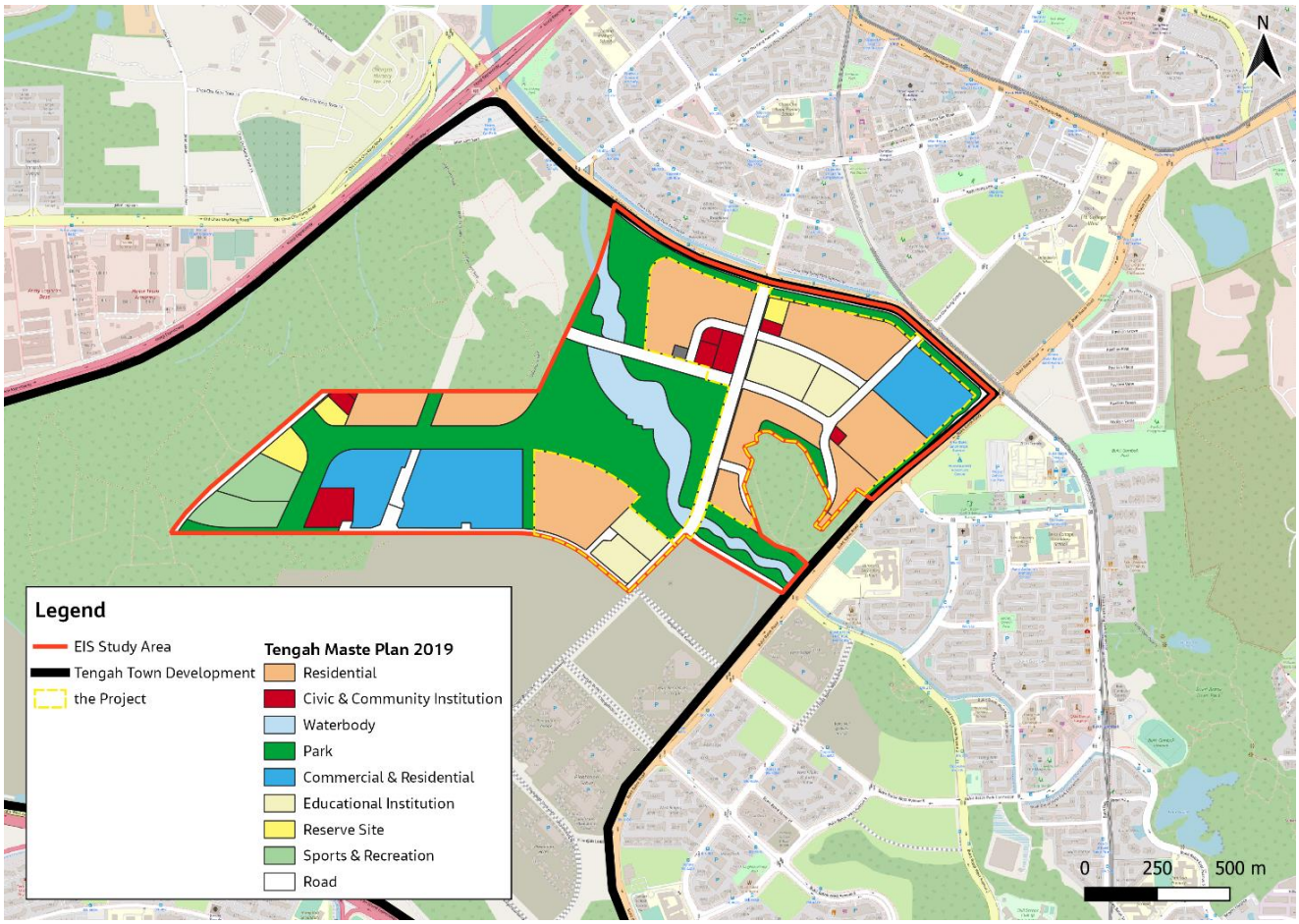


Figure 10.2: Land Use Plan of EIS Study Area

Base Map: OpenStreetMap, Source: Adapted from Tengah Master Plan 2019 gazetted by URA

10.3.1.2 Location of Proposed Buildings

Buildings are proposed to be built in the areas marked out for residential, place of worship, health and medical, educational, civic and community as well as commercial as seen in **Figure 10.2**. The heights of most of the buildings is expected to be of considerable heights similar to residential building heights in the vicinity which reach up to 17 floors (AMSL = approximately 60 m).

10.3.1.3 Vegetation Removal / Retention

All vegetation presently within the EIS Study Area, including those in the Project development area are to be cleared aside from those retained for the parks and the forest corridor following the concept of the Tengah Master Plan 2019. A vegetation buffer strip with width of about 20-25 m (which acts as Forest Fridge) along north (Brickland Land Road) and east (Bukit Batok Road) borders should screen a decent portion of views into the Project development area/ EIS Study Area, especially from those by the roadsides.

10.3.2 Internal Visual Context

10.3.2.1 Baseline

Majority of views within the EIS Study Area consist of forest and abandoned plantations which visually look of dense groups of trees of various heights. There are a couple of scrublands scattered throughout, which visually look of thick, overgrown grass with scattered shrubs. Several man-made structures which are not blocked by the

surrounding vegetation include a large concrete drain running through the centre of the EIS Study Area, smaller drains within and various internal dirt roads.

10.3.2.2 Constructions

It is expected that within the EIS Study Area, the Project development area and committed development areas by other stakeholders/ agencies (i.e. JRL, KJE and TSR) outside of the planned Forest Corridor/ Forest Stream will be cleared of the current trees to make way for construction activities. The visual views of the EIS Study Area during the construction phase are likely to consist of mostly cleared land with construction facilities and equipment such as temporary container offices, worker's dormitories, large vehicles and tractors. As the construction progresses, unfinished building infrastructures will be a common sight.

10.3.2.3 Operations

The final development plans will consist of a Forest Fringe at the north and south edges of the EIS Study Area with the larger Forest Corridor with a naturalised canal stream (Forest Stream) running through the centre. The visual views of the area would largely consist of a mix of tall residential and commercial buildings with various parks and roadside greenery throughout.

10.3.3 External Visual Context

The EIS Study Area is located in the Tengah Town development and is bounded by Brickland Road at the north, Bukit Batok Road in the east, forested areas at the west and by cleared land with ongoing construction activities at the south as part of HDB and LTA developments. The external visual context is examined up to 500 m from the boundaries of the EIS Study Area, as shown in **Figure 10.3**, which is the distance where views into the site are expected to be. As the Project forms part of a much larger Tengah development, the extent or external areas of visual context is limited to the urban areas to the east of Bukit Batok Road and north of Brickland Road.

10.3.3.1 Buildings

The large majority of buildings to the north and east of the EIS Study Area are high-rise buildings consisting of HDB estates and condominiums. There is also an elevated MRT track and several private landed properties to the northeast of the EIS Study Area. Educational institutes including Institute of Technical Education (ITE) College West, Dunearn Secondary School and Association for Persons with Special Needs (APSN) Delta Senior School can be found in the vicinity. There is also the presence of cultural sites including several temples and churches as well as recreational sites such as a golf driving range and entertainment centre under HomeTeamNS.

10.3.3.2 Roads

The Project is bordered by a 6-lane main road, Brickland Road to the north and another 6-lane main road Bukit Batok Road to the east. The main roads are flanked by pedestrian pavements which are lined with roadside trees. These trees screen a decent portion of views into the EIS Study Area where the Project development is located, especially those from the ground or of lower vantage points in the area.

Smaller 4-lane roads of Choa Chu Kang Avenue 6 and Choa Chu Kang Grove to the north and Bukit Batok West Avenue 7 and Bukit Batok West Avenue 2 to the east can be found as marked out in **Figure 10.3**. These roads are relatively straight and flat and are similarly flanked with pedestrian pavements, providing views towards the EIS Study Area. They form intersections when they meet Brickland Road and Bukit Batok Road.

10.3.3.3 Others

The area also has vegetated areas, mostly open flat grassy ground and a small forest fragment in front of Bukit Batok Driving Centre and at Bukit Batok Hillside park. There are also several construction sites in the area to the north, east and south of the EIS Study Area.

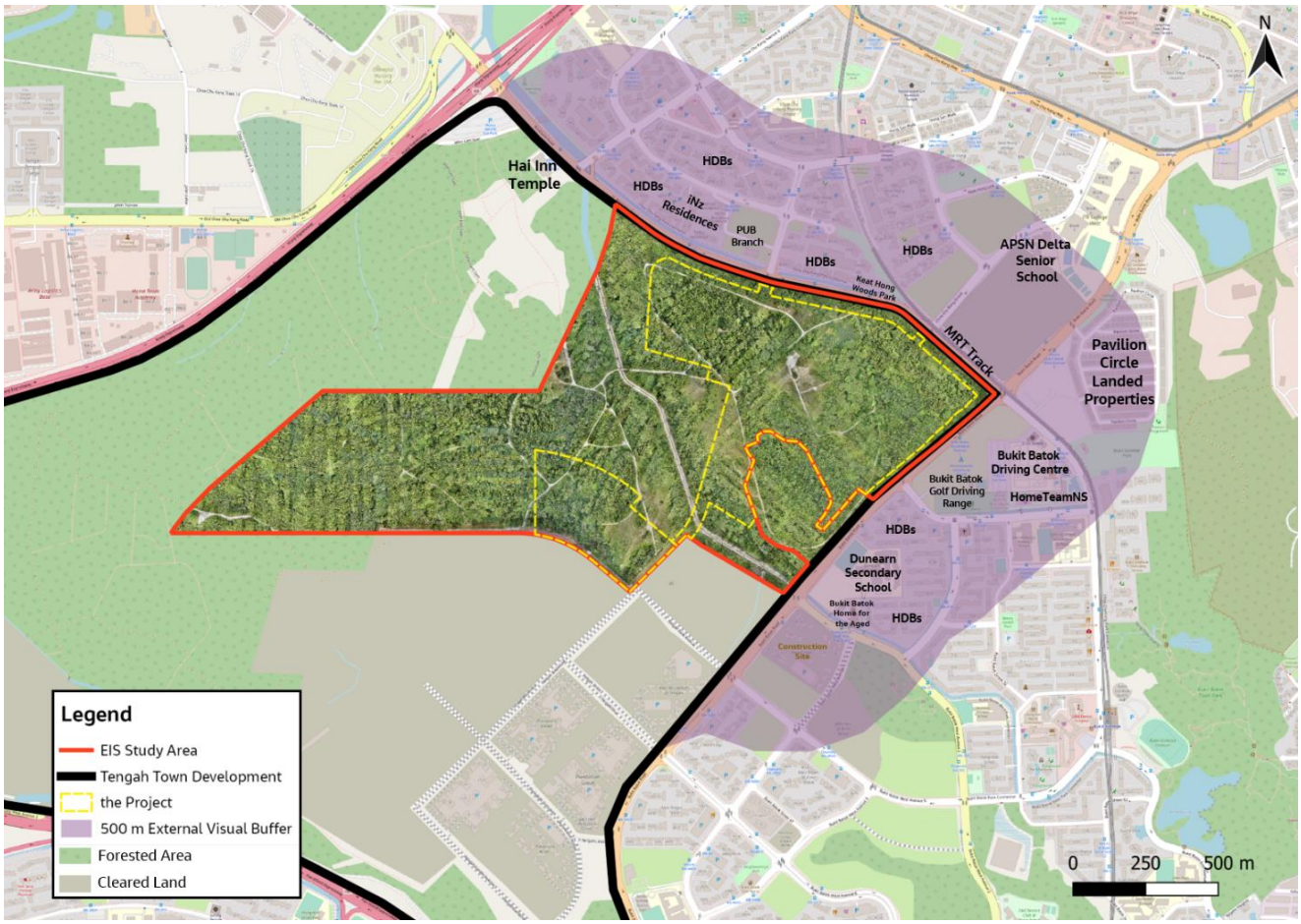


Figure 10.3: Map of External Visual Context

Base Map: OpenStreetMap, Source: Orthophoto from LiDAR survey

10.3.4 Visual Study Area

The visual study area defines the extent of the area, or viewshed, to be considered by the landscape and visual impact assessment. A viewshed analysis was conducted on Google Earth Pro (2020) to identify the views into the EIS Study Area. It was found that most of views are from the relatively tall buildings which surround the EIS Study Area. However, these buildings also screen a large proportion of views into the site from other buildings which are nearby. The viewshed analysis showed that, theoretically, views were mostly confined to 500 m away from the edge of the boundary site, with most of the views within 200 m.

The Zones of Visual Influence (ZVIs) is used to identify the visibility of the EIS Study Area based on vertical and horizontal field of vision as shown in **Figure 10.4**. The typical field of vision of a person is 10°, whereby 5% of the vertical or horizontal field of vision would be approximately 0.5°. Therefore, a greater the angle of the view, the greater the visibility and dominance of the EIS Study Area and hence a likely greater impact.

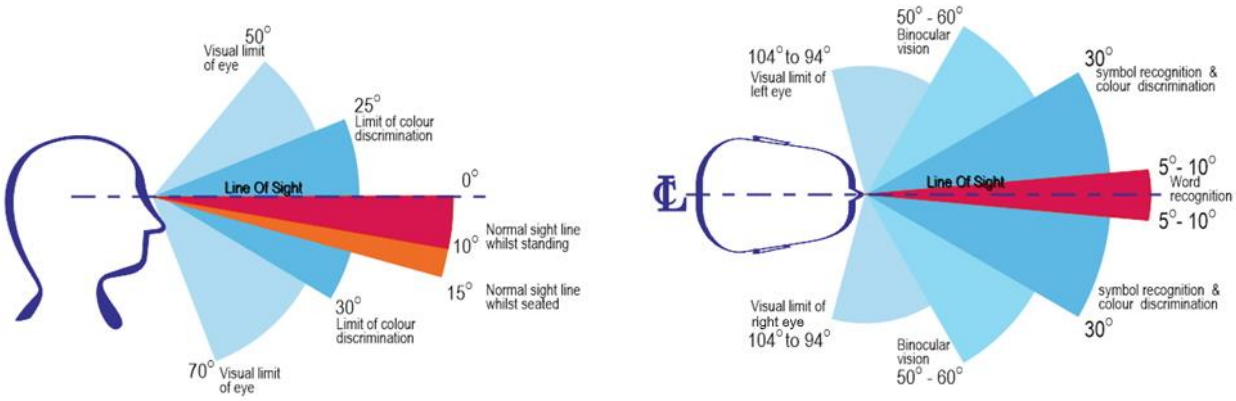


Figure 10.4: Vertical (Left) and Horizontal (Right) Field of View (Adapted from Panero & Zelnik, 1979)

Table 10.1: Zones of Visual Influence

Angle of view	Zones of Visual Influence
< 0.5 °	Visually insignificant, a very small element in the viewshed, which is difficult to discern and may not be visible in certain weather conditions.
0.5 ° -1.0 °	Noticeable, but will not dominate the landscape.
1.0 ° – 2.5 °	Noticeable and can dominate the landscape.
2.5 ° -5.0 °	Highly visible and will dominate the landscape.
> 5.0 °	Always visually dominant in the landscape.

10.3.5 Landscape Character Units and Sensitivity

10.3.5.1 Landscape Character Units (LCUs)

The following LCUs were identified and mapped out from our field surveys. These LCU's were validated during site inspections undertaken between Jan 31, 2020 and Aug 31, 2020.

Table 10.2: Landscape Character Units

Natural LCUs	Man-made Structures
• Abandoned-land forest with native regeneration • Abandoned-land forest • Waste woodlands • Farmland • Scrubland/herbaceous vegetation • Pond	• Military structures such as training sheds and grounds • Concrete drains • Internal roads and hiking trails

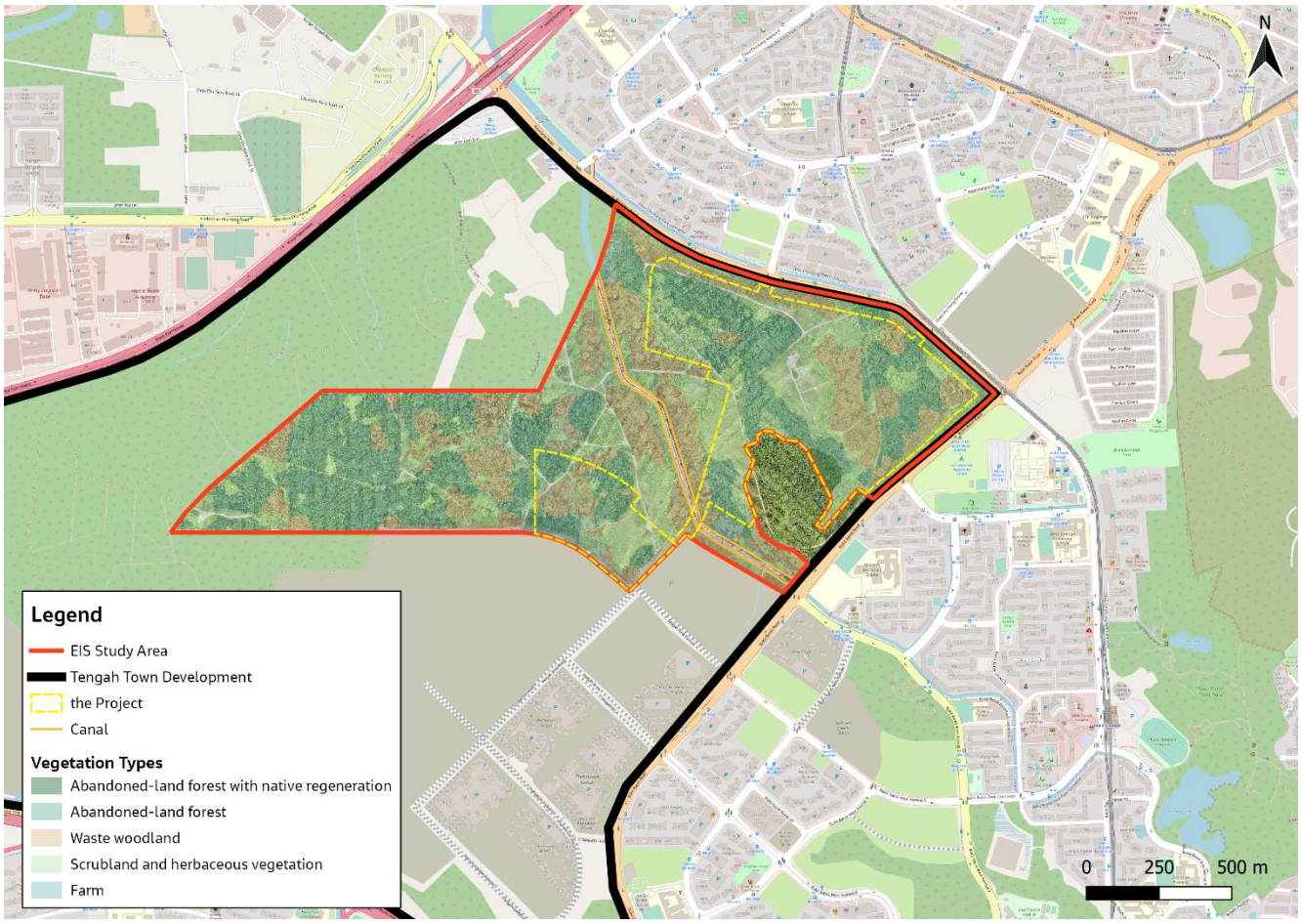


Figure 10.5: Map of Landscape Character Units in the EIS Study Area

Base Map: OpenStreetMap, Orthophoto from LiDAR survey

10.3.5.2 Landscape Sensitivity

Landscape sensitivity depends on a variety of attributes, namely the location, rarity and scene quality of the LCUs.

- **Location**: Viewers, where the landscape appears natural and pristine, will be more sensitive to the introduction of new and artificial elements within that landscape. A more modified landscape would result in a lower sensitivity to the introduction of a new modification.
- **Rarity**: Landscapes are likely to be valued more if they are considered rare or threatened.
- **Scenic qualities:** Landscapes that are considered scenic are those that have dramatic topographic changes, the presence of coastlines and water features and other comparable features. In Singapore, this also includes impressive infrastructures that have become recognisable features.

The field reconnaissance conducted found that the ponds, farm and military structures could not be seen from outside the EIS Study Area, having been screened by taller vegetation growing around them. As such, their landscape sensitivity were not assessed. In addition, the types of natural vegetation may not be easily differentiable to the average viewer. As such, the abandoned-land forest with native regeneration, abandoned-land forest and waste woodland have been grouped together as can be described visually in similar terms.

Table 10.3: Character Unit and their Sensitivity

Character Units	Sensitivity
Abandoned-land Forest with Native Regeneration	The LCUs visually consist of tall, large trees and take up the majority of views into the EIS Study Area. As such, they are surrounded by a natural untouched landscape to the west and by a mix of highly modified landscape for construction work and urban development on the other ends. Although secondary forest coverage in Singapore is approximately 20% of the land cover, they are relatively rare in Singapore outside of the central and western catchment (Yee et al., 2011). The presence of a large expanse of tall green trees can be considered relatively scenic. Overall, the sensitivity of the LCU is **high**.
Abandoned-land forest	
Waste woodland	
Scrubland/Herbaceous vegetation	The LCUs visually consist of shrubs and grasses of low to medium heights. It takes up the considerable amount of views into the EIS Study Area. As such, they are surrounded by a mix of natural untouched landscape and highly modified landscape for construction work and urban development depending on the viewpoint. Scrubland covers about 6% of Singapore's land cover but has over 8000 patches (Yee et al., 2011), resulting in a moderate level of rarity. They are not considered particularly scenic, as features are flat and may be considered to be unmanicured to several. However, its greenery may be appreciated by others. Overall, the sensitivity of the LCU is **medium**.

The areas where the drains, internal roads and hiking trails reduces the sensitivity of the forested areas it is present in. It is noted that the areas within the Woodlands/ Scrubland/ Forest are proposed to be modified overtime through the implementation of the broader site master plan shown in **Figure 10.2**.

10.3.6 Visually Sensitive Receptors

Based on the predicted viewshed and the ZVIs aligned with ground surveys of the view, the following VSRs were identified:

Table 10.4: Key Examples of VSRs

No.	Visually Sensitive Receptors	Key Examples
1	High-Rise Residents	• HDB estates (Various in Keat Hong, Bukit Batok, Choa Chu Kang) • Condominiums (iNz residences, Sol Acres)
2	Landed Property Residents	• Pavilion Circle
3	Students	• Dunearn Secondary School
4	Recreational	• HomeTeamNS Centre
5	Pedestrians/Joggers	• Along Brickland Road • Along Bukit Batok Road • Side road towards EIS Study Area
6	Drivers/Passengers/Bus Passengers	• Along Brickland Road • Along Bukit Batok Road • Side roads towards EIS Study Area
7	Park/Garden	• Keat Hong Woods Park
8	MRT Passengers	• Between NS3 Bukit Gombak and NS4 Choa Chu Kang

Notably, several locations which are close to the EIS Study Area and were within the visual study area were found to not have views into the EIS Study Area. These locations include educational institutions such as ITE College West, cultural centres such as Hai Inn Temple, multi-story car parks and recreational centres such as HomeTeam NS Golf Driving Range. These locations were often screened by roadside vegetation or by other buildings and infrastructure.

10.3.7 Representative and Accessible Viewpoints

Indicative viewpoints were selected to represent the range of VSRs identified as well as of area which have potentially significant views into the site. They had to be publicly accessible and the spread of selection should provide sufficient coverage to be representative of the visual impacts of the proposed construction activities of the Project around the EIS Study Area. The representative viewpoints selected for the impact assessment can be found in **Figure 10.6**, which shows the current view and **Figure 10.7**, which shows the potential future view using the Master Plan and **Table 10.5** which provides the location of these points. Ground-truthing and -assessment for these points was conducted on Aug 21, 2020. As described above, the majority of the area to the south and west are proposed to be redeveloped by the broader Tengah Town development. These areas are also not publicly accessible as they are currently under construction or are still restricted for military use. For this reason, no viewing locations have been captured from within this area.

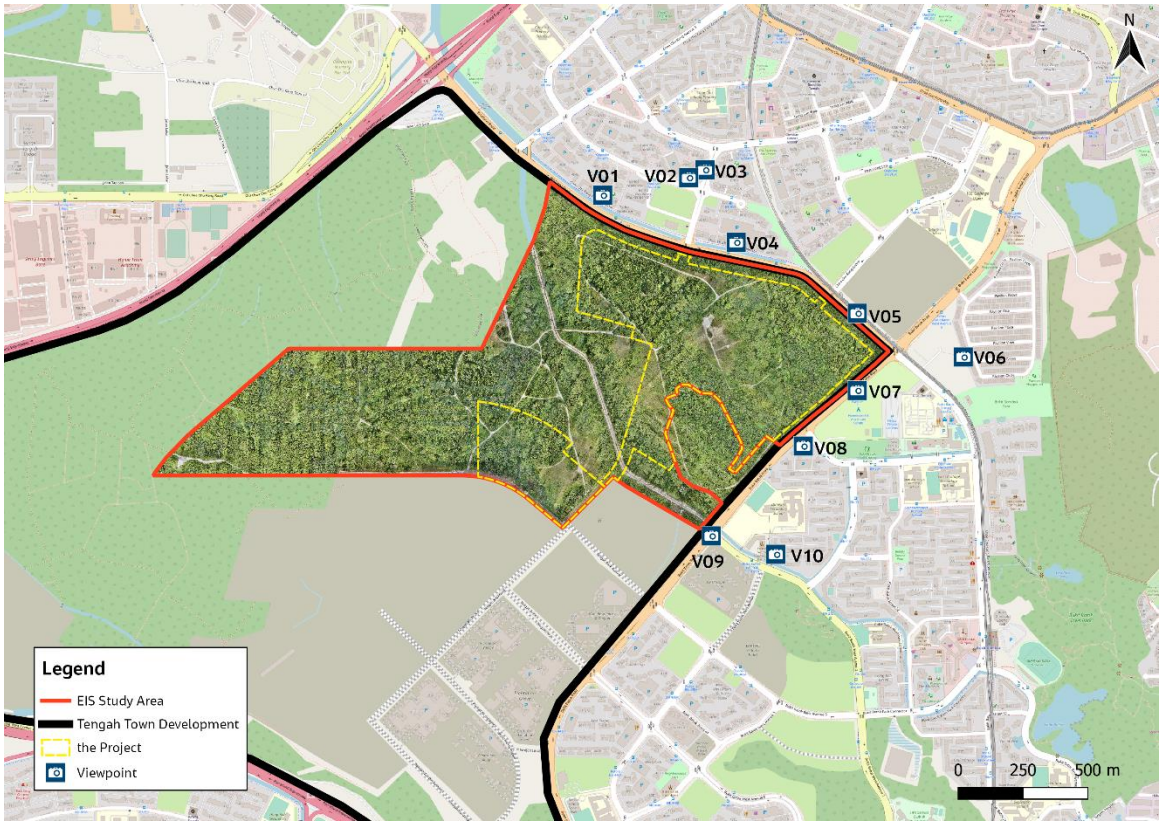


Figure 10.6 Selected Representative Viewpoints (Baseline)

Base Map: OpenStreetMap, Source: Orthophoto from LiDAR survey

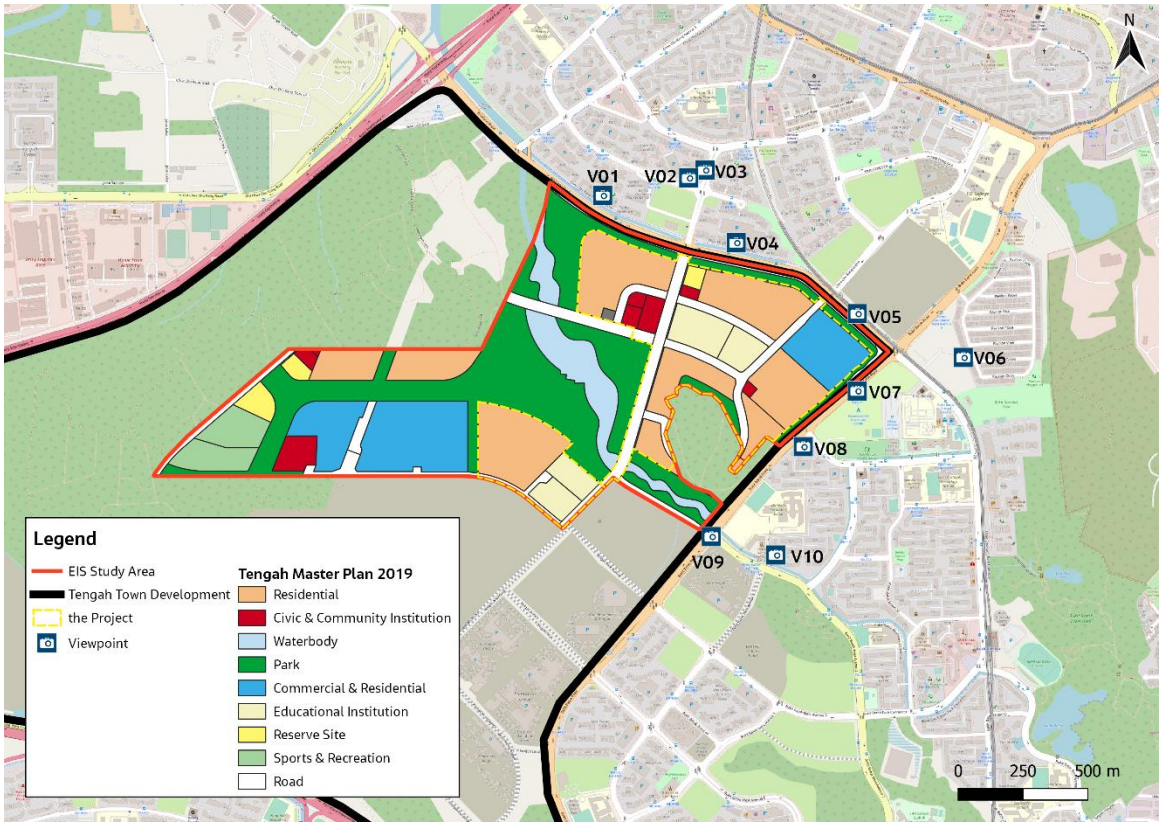
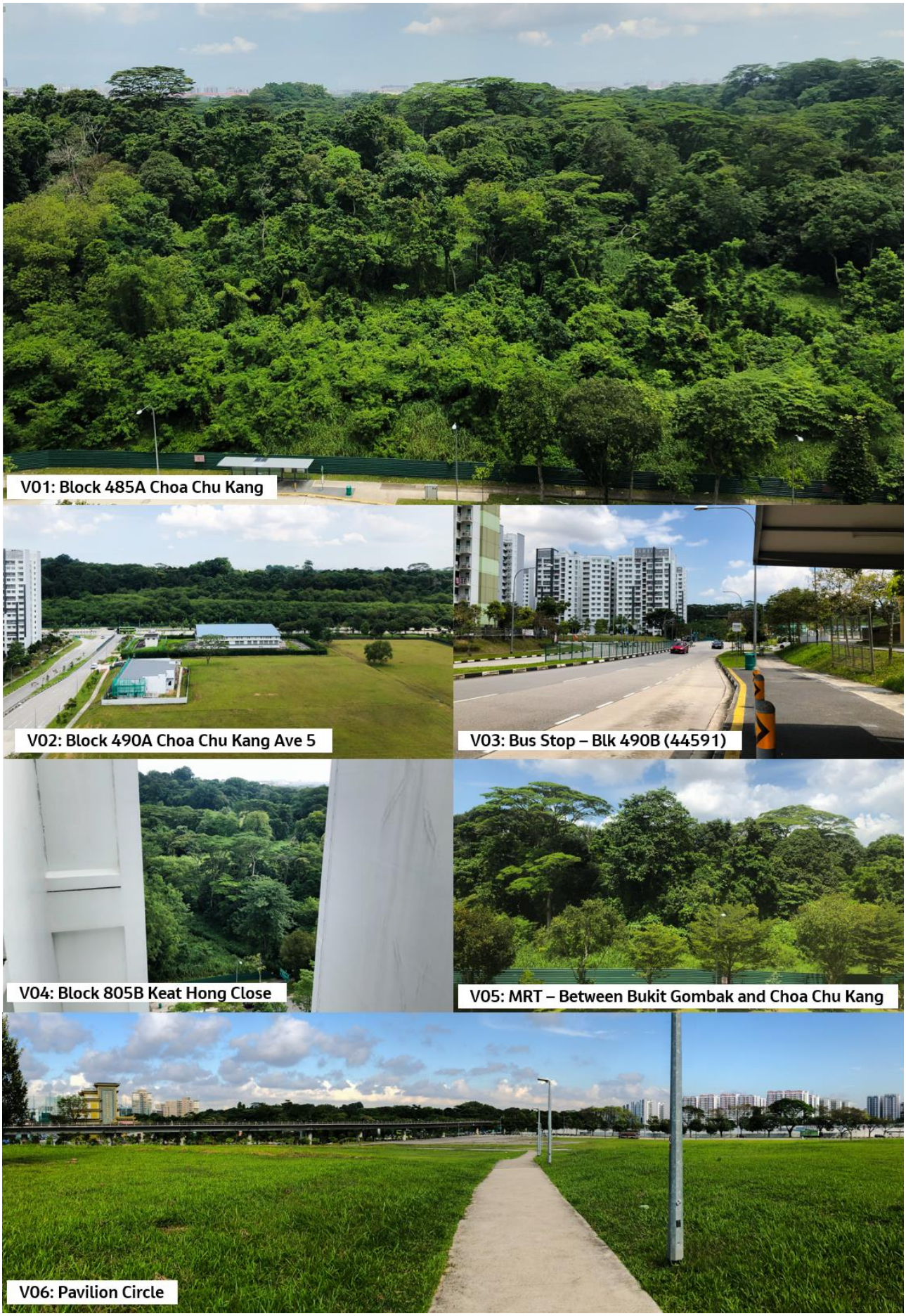


Figure 10.7: Selected Represented Viewpoints (with Tengah Master Plan 2019)

Base Map: OpenStreetMap, Source: Source: Adapted from Tengah Master Plan 2019 gazetted by URA


V01: Block 485A Choa Chu Kang
V02: Block 490A Choa Chu Kang Ave 5
V03: Bus Stop – Blk 490B (44591)
V04: Block 805B Keat Hong Close
V05: MRT – Between Bukit Gombak and Choa Chu Kang
V06: Pavilion Circle

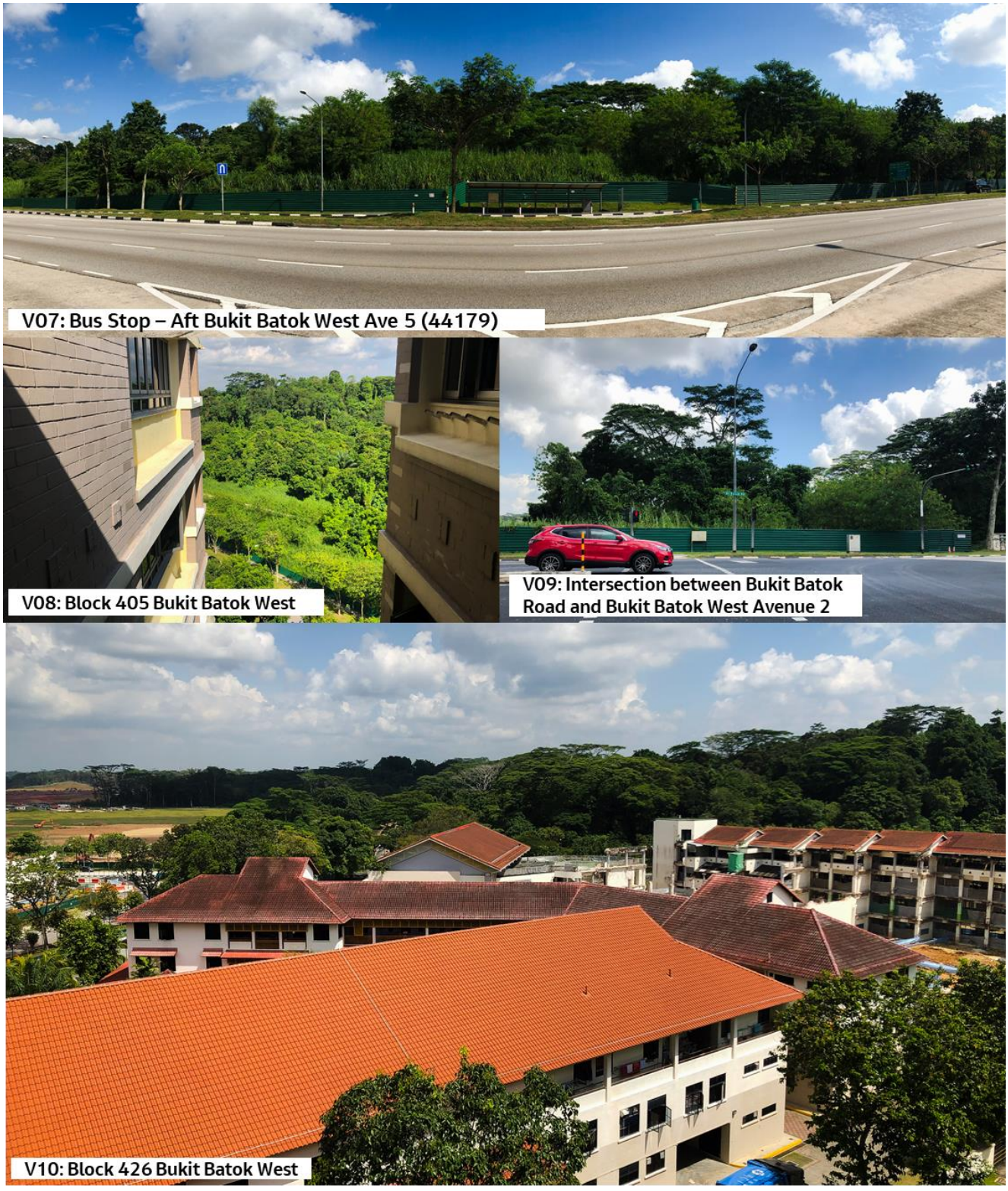


Figure 10.8: Views from Representative Viewpoints

10.4 Evaluation Potential Impact Before Mitigation Measures

The Project necessitates the removal of vegetation of which are medium and high in landscape character sensitivity. This would result in most viewpoints having a negative visual change. However, the retainment/ creation of a Forest Corridor has helped to mitigate some of the potential impacts by reducing the impact and with the conversion of the concrete canal into an "Active, Beautiful, Clean (ABC) designed stream which provides an improvement to the visual aesthetics. Based on the specific views and proposed changes to that view, the five criteria (i.e. visibility, distance, landscape characters, number of VSRs and duration of view) discussed in **Section 10.2** were used to assess the potential magnitude of visual changes from the proposed development and are as follows in **Table 10.5**. These visual impacts are limited to the visual study area and the visually sensitive receptors who are within that study area, and are hence considered of local importance with a local impact extent. Due to the nature of the Project, which it is to build a permanent infrastructure, the visual impact is considered to be of a long-term duration and irreversible. The following tables (**Table 10.7** to **Table 10.10**) are a summary of the impact significance for visual impact at the various viewpoints using the RIAM tool, where viewpoints with a negligible visual change are omitted from the assessment. A detailed assessment of the magnitude of visual changes can be found in **Appendix 10A**.

Table 10.5: Summary of Viewpoints and their Visual Changes from Proposed Development Activities of the Project

Viewpoint	Location	Overall Visual Change*
V01	Block 485A Choa Chu Kang (Higher floors – above 8th floor)	Major Negative
	Block 485A Choa Chu Kang (Lower floors – 8th floor and below)	Negligible
V02	Block 490A Choa Chu Kang Ave 5	Moderate Negative
V03	Bus Stop – Blk 490B	Minor Negative
V04	Block 805B Keat Hong Close (Higher floors – above 9th floor)	Major Negative
	Block 805B Keat Hong Close (Lower floors – 9th floor and below)	Negligible
V05	MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations	Minor Negative
V06	Pavilion Circle	Minor Negative
V07	Bus Stop – Aft Bukit Batok West Ave 5	Minor Negative
V08	Block 405 Bukit Batok West (Higher floors – above 8th floor)	Major Negative
	Block 405 Bukit Batok West (Lower floors – 8th floor and below)	Negligible
V09	Intersection between Bukit Batok Road and Bukit Batok West Avenue 2	Minor Positive
V10	Block 426 Bukit Batok West (Higher floors – above 5th floor)	Moderate Negative
	Block 426 Bukit Batok West (Lower floors – 5th floor and below)	Negligible

Note: *Results of overall visual change will be transpired to "A2.2 Magnitude of Change" in the RIAM impact evaluation

Table 10.6: Impact Significance for Viewpoints with Minor Negative Visual Changes (VO3, V05, V06, V07)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.
A2.1: Impact Nature	-1: Negative	Sensitive receivers perceive a loss in quality of view.
A2.2: Magnitude of Changes	1: Minor	The visual change is noticeable but will not result in significant adverse impacts. One or more of the criteria used to assess the visual changes are rated low.
A2.3: Impact Extent	2: Tengah	Visual impacts extend outside of the Project boundary to the viewers in Tengah.
B1: Permanence	4: Long Term	Infrastructure and other features constructed are meant to be a permanent fixture.
B2: Impact Pathway	3: Direct	Visual changes are a direct impact on the sensitive receivers.
B3: Reversibility	3: Irreversible	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.
Environmental Score (ES)	**(-4) x (13) = -52**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	

Table 10.7: Impact Significance Viewpoints with Moderate Negative Visual Changes (V02, V10)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.
A2.1: Impact Nature	-1: Negative	Sensitive receivers perceive a loss in quality of view.
A2.2: Magnitude of Changes	2: Moderate	The visual change is noticeable and may result in significant adverse impacts. Most of the criteria used to assess the visual changes are rated higher than low.
A2.3: Impact Extent	2: Tengah	Visual impacts extend outside of the Project boundary to the viewers in Tengah.
B1: Permanence	4: Long Term	Infrastructure and other features constructed are meant to be a permanent fixture.
B2: Impact Pathway	3: Direct	Visual changes are a direct impact on the sensitive receivers.
B3: Reversibility	3: Irreversible	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.
Environmental Score (ES)	**(-8) x (13) = -104**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

Table 10.8: Impact Significance Viewpoints with Major Negative Visual Changes (Higher Floors of V01, V04, and V08)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.
A2.1: Impact Nature	-1: Negative	Sensitive receivers perceive a loss in quality of view.
A2.2: Magnitude of Changes	3: Major	The visual change is highly noticeable and will result in significant adverse impacts. All of the criteria used to assess the visual changes are rated high.
A2.3: Impact Extent	2: Tengah	Visual impacts extend outside of the Project boundary to the viewers in Tengah.
B1: Permanence	4: Long Term	Infrastructure and other features constructed are meant to be a permanent fixture.
B2: Impact Pathway	3: Direct	Visual changes are a direct impact on the sensitive receivers.
B3: Reversibility	3: Irreversible	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.
Environmental Score (ES)	**(-12) x (13) = -156**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

Table 10.9: Impact Significance for Viewpoints with Minor Positive Visual Changes (V09)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: Tengah	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.
A2.1: Impact Nature	1: Positive	Sensitive receivers perceive a gain in quality of view.
A2.2: Magnitude of Changes	1: Minor	The visual change is noticeable but will not result in significant impacts. One or more of the criteria used to assess the visual changes are rated low.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	2: Tengah	Visual impacts extend outside of the Project boundary to the viewers in Tengah.
B1: Permanence	4: Long Term	Infrastructure and other features constructed are meant to be a permanent fixture.
B2: Impact Pathway	3: Direct	Visual changes are a direct impact on the sensitive receivers.
B3: Reversibility	3: Irreversible	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.
Environmental Score (ES)	**(4) x (13) = 52**	
Range Bands ES/ Impact Severity Significance	**Minor Positive Impact**	

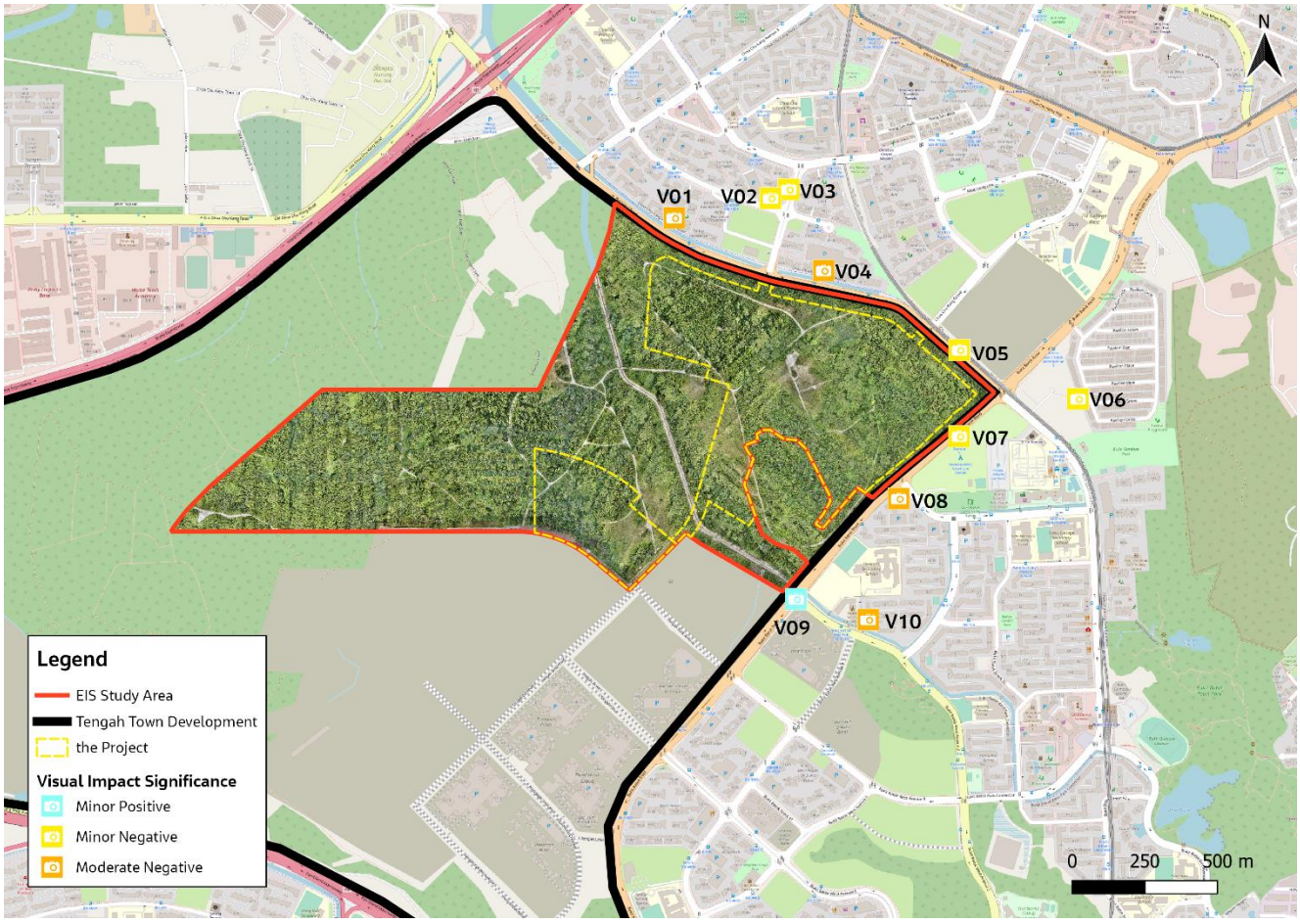


Figure 10.9: Representive Viewpoints with Visual Impact Significance Rating

Base Map: OpenStreetMap, Orthophoto from LiDAR survey

10.5 Applicable Prevention and Mitigation/ Enhancement Measures

The design of the Project/ Tengah Development follows Tengah Master Plan 2019, which limits changes to land use. In order to mitigate the visual impact of the Project, the following mitigation measures are recommended to reduce the contrast from current views:

- Selective thinning of perimeter vegetation should be done to continue to screen views into the Project development within the EIS Study Area.
- Strategic retention and protection of key cluster of trees of aesthetic value, which can be designed into overall Tengah Town Development plans.
- Conservation of the areas of high ecological conservation value, in particular, the southern corridor which will screen views from the southern side into the EIS Study Area as shown in **Figure 10.10**. The rehabilitation of these sites into more well-forested areas could also provide positive visual influence.
- Phased felling should be undertaken to spread out the impact from the reduction of forest and vegetation which have high landscape character sensitivity.
- Construction perimeter hoardings along Brickland Road and Bukit Batok Road should be built higher, potentially following the height of the noise barrier at 6 m, to block out roadside and lower floor views into the EIS Study Area where the Project is located during the construction phase. This will reduce a portion of views into strikingly contrasting sights such as construction works.
- Construction perimeter hoarding could display visuals of the new town development or use green walls in order to create a more visually pleasant outer boundary and to ease VSRs in the area into the final view.

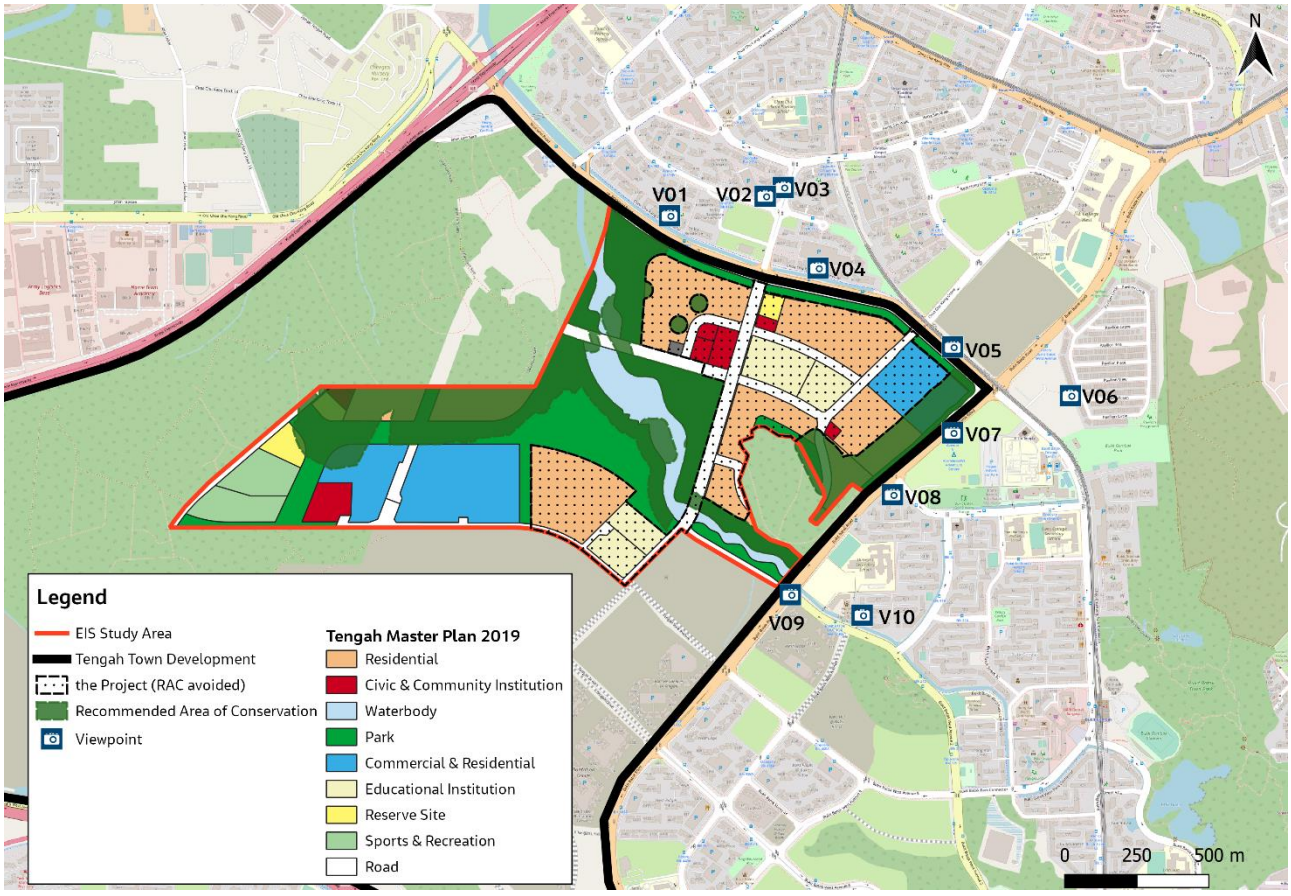


Figure 10.10: Map of EIS Study Area with Recommended Area of Conservation (RAC)

Base Map: OpenStreetMap, Source: Adapted from Tengah Master Plan 2019 gazetted by URA

Note: For the purposes of this study, the figure shows an indicative revised boundary assuming that agencies will avoid the Recommended Area of Conservation (RAC). Agencies are studying possible changes to the land use plan to balance conservation and development in response to the RAC.

10.6 Residual Impact

The adoption of the mitigation measures proposed above will assist to mitigate the visual impacts of the project during construction and promote mature landscape setting from start of the development. In addition, the retention and rehabilitation of the areas of high conservation value will screen views into the EIS Study area, rendering viewpoints in the southern side to reduce the magnitude of the impact and or result in no visual impact.

In particular, V06 and VO7 would have largely no visual change from their current views instead of a negative impact resulting in a negligible visual impact for these two viewpoints. V08 may see a minor positive visual impact if the area has views of is rehabilitated into a more ecologically sensitive habitat by revegetating the dirt paths seen in that area as seen in **Figure 10.8** resulting in a minor positive visual impact. A summary of the visual impact significance pre- and post- mitigation can be found in **Table 10.10** below.

Although the internal visual assessment is not within the scope of the EIS, it should be noted that while the Project incurs negative visual impacts for several of the viewpoints and the receptors that reside or pass by there, visibility prior to the Project is largely limited to the margins of the entire Tengah plot. The Tengah Town development results in a greater amount of greenery that can be enjoyed by more visual receptors in the future as they travel through the area or even reside there. It is therefore acknowledged that there could potentially be positive visual benefits from the opening up of the site and retention of the natural vegetation present.

Table 10.10: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
V01	Major negative visual change at higher floors, above 8th floor, of Block 485A Choa Chu Kang	-156	Moderate Negative Impact	-156	Moderate Negative Impact
V02	Moderate negative visual change at Block 490A Choa Chu Kang Ave 5	-104	Minor Negative Impact	-104	Minor Negative Impact
V03	Minor negative visual change at Bus Stop – Blk 490B	-52	Minor Negative Impact	-52	Minor Negative Impact
V04	Major negative visual change at higher floors, above 9th floor, of Block 805B Keat Hong Close	-52	Moderate Negative Impact	-156	Moderate Negative Impact
V05	Minor negative visual change at MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations	-52	Minor Negative Impact	-52	Minor Negative Impact
V06	Minor negative visual change at Pavilion Circle	-52	Minor Negative Impact	0	Negligible

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
V07	Minor negative visual change at Bus Stop – Aft Bukit Batok West Ave 5	-52	Minor Negative Impact	0	Negligible
V08	Major negative visual change at higher floors, above 8th floor, Block 405 Bukit Batok West	-156	Moderate Negative Impact	52	Minor Positive Impact
V09	Minor positive visual change at Intersection between Bukit Batok Road and Bukit Batok West Avenue 2	52	Minor Positive Impact	52	Minor Positive Impact
V10	Moderate negative visual change at higher floors, above 5th floor, Block 426 Bukit Batok West	-104	Moderate Negative Impact	-104	Moderate Negative Impact

11. Waste Management

This section assesses the potential waste impacts related to the existing baseline conditions and the construction and operational phases of the Project. It introduces the applicable legislation and standards and outlines the various waste streams and their preliminary impacts. It also recommends preliminary measures for the mitigation of the impacts.

11.1 Applicable Legislation and Standards

In Singapore, the management of solid and hazardous wastes is legislated by the following:

- *Environmental Public Health Act (EPHA)*
- *Environmental Public Health (General Waste Collection) Regulations*
- *Environmental Public Health (General Waste Disposal Facilities) Regulations*
- *Environmental Public Health (Toxic Industrial Waste) Regulations*

The management of construction waste is also supported by the following standards:

- SS 557: 2010. Code of Practice for Demolition
- Code of Practice for Environmental Control Officer (ECO)

11.1.1 Singapore Waste Management Scene

In Singapore, the general and hazardous waste management systems is planned, developed and administered by the NEA. In 2019, Singapore produced a total of 7.23 million tonnes of waste, of which 4.25 million tonnes (58.8%) was recycled. The following strategies are used to guide a more sustainable waste management system.



Figure 11.1: Singapore's General Waste Management Strategy (NEA, 2020)

In Singapore, there are three main types of wastes, i.e. non-hazardous waste, hazardous waste, and sewage waste, which have their own particular management systems as discussed below:

11.1.1.1 Non-hazardous Waste

According to *Code of Practice for Licensed General Waste Collectors*, non-hazardous waste, also called general waste, is waste that falls into three main categories as given below:

Table 11.1: Categories of Waste

Categories	Types of Waste
Type A	• Waste such as unwanted furniture, electrical appliances, construction and renovation debris, and cut tree trunks and branches • Bulky waste • Non-putrefiable waste • Recyclable waste (excluding food waste) • Digested sludge that has been dewatered from water reclamation plants
Type B	• Domestic refuse, food waste (excluding used cooking oil) and market waste • Waste with a high organic content and which is putrefiable • Used cooking oil (Type B.1)
Type C	• Sludge and other waste from grease interceptors • Sewage, sludge and other waste from water-seal latrines, sewage treatment plants (other than water reclamation plants), septic tanks or other types of sewerage systems • Waste from sanitary conveniences not part of a sewerage system, including waste from sanitary conveniences which are mobile or on ships or aircraft

All general wastes are collected and transported for disposal by collectors with valid General Waste Collectors' Licences issued by NEA according to the waste categories as given above. General waste is separated for recycling and disposal often at source point and go through the waste management system as shown in **Figure 11.2**. Recyclables are sent to the Materials Recovery Facilities (MRFs) to be sorted into the categories of paper, plastic, metal and glass. These recyclables are then compacted into bales to be sent to specialised recycling facilities locally and abroad for processing into new materials.

General waste for disposal falls into two categories, incinerable and non-incinerable waste. Incinerable waste are sent to waste-to-energy (WTE) plants, of which there are currently four in Singapore; Tuas, Senoko, Tuas South and Keppel Seghers Tuas. The incineration process reduces the volume of waste by 90% and produces steam which runs turbine-generators and generates electricity. The WTE plants are also equipped with an efficient flue gas cleaning system which remove dust and pollutants from the flue gas to allow the emissions to meet the air quality standards in the EPMA. Non-incinerable general waste include a range of items such as bulky waste, carbon fibres, fire retardants, electronic waste and construction waste amongst others listed in Appendix 1 of the *Code of Practice for Licensed General Waste Collectors*. These wastes have to be broken down to fit incineration size requirements, treated before incineration or otherwise landfilled as-is. Incinerated ash alongside any non-incinerable waste are then sent to the Marine Transfer Station where it is collected and transported to Semakau Landfill.

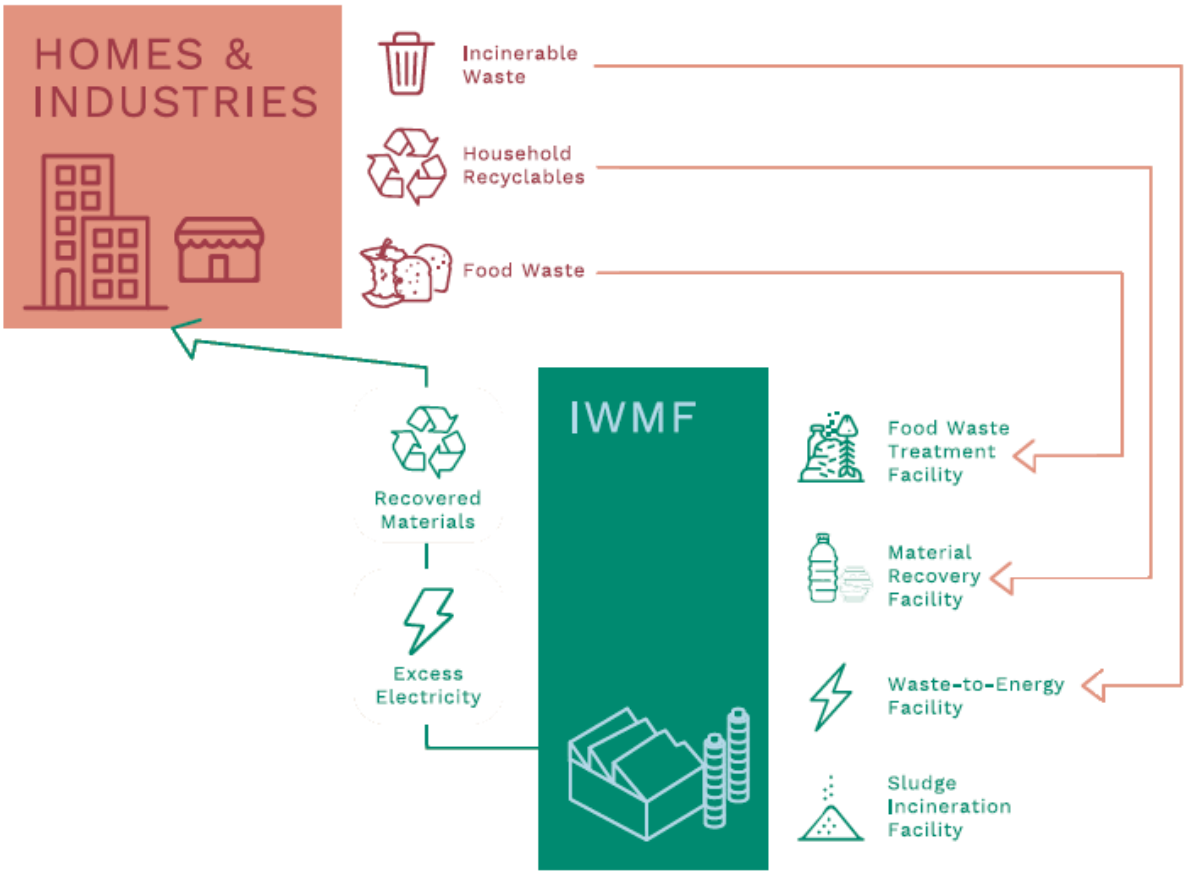


Figure 11.2: General Waste Management System in Singapore (Adapted from MEWR & NEA, 2019)

11.1.1.2 Hazardous Waste

Hazardous waste are often termed as toxic industrial waste and include a range of waste such as chemicals, lead-tainted products, polyvinyl chloride (PVC), used oil and pathogenic waste amongst others listed in the *Environmental Public Health (Toxic Industrial Waste) Regulations*. Hazardous waste is collected and treated by NEA licensed toxic industrial waste collectors who have specialised approved storage, process, treatment and disposal facilities related to the specific hazardous waste. The residues will have to comply with stringent standards before they can be incinerated and or disposed at the landfill.

11.1.1.3 Sewage Waste

Sewage waste in Singapore is usually collected via the existing networks of public sewers. Sewage is sent to the water reclamation plants where it is treated for non-potable use for industrial and cooling purposes or indirect potable use by introduction into the reservoirs to be blended with the raw water which will be treated for tap water. Sludge that remains after the treatment process is dewatered and incinerated, with the ash being disposed at Semakau Landfill.

11.1.2 Tengah Town's Waste Management Scene

The concept of Tengah Town general waste management system differs from the conventional system in Singapore as it is one of the few HDB estates in Singapore where a district-level pneumatic waste conveyance system will be implemented for household waste. It is an automated enclosed waste and recycling collection system where waste is conveyed via air suction from individual buildings through a network of pipes to a central collection location. This reduces the need for manual and multiple collections as well as odour and pest issues associated with exposed waste (HDB, 2016; MEWR & NEA, 2019).

11.2 Assessment Methodology

There is currently no legislation in Singapore that guides waste management impact assessments. The assessment methodology taken in this section include:

Identification of Waste Streams and Management Method

- Identify the different types of waste streams arising from the baseline conditions, construction and operations activities by combination of visual observation field survey and desktop assessment with reference to client-held data and publicly available sources as listed below:
  - National Environment Agency (NEA). (2020, May 26). *Waste Management*. National Environment Agency. https://www.nea.gov.sg/our-services/waste-management/overview
  - Building Construction Authority (BCA). (2020). *Guidelines for Pre-Demolition Audit, Sequential Demolition and Site Waste Management Plan*. https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/sc_demoprotocol.pdf
  - Housing and Development Board (HDB). (2020, August 1). *Tengah—Housing & Development Board (HDB)*. https://www.hdb.gov.sg/cs/infoweb/about-us/history/hdb-towns-your-home/tengah
- Semi-qualitatively identify/ estimate the volume of waste that may be generated in terms of high, medium and low based on available literature review:
  - **Low:** Minimal and barely noticeable volume; less than 50 tonnes/month
  - **Medium:** Moderate and noticeable volume; 50-500 tonnes/month
  - **High**: Large and very noticeable volume; more than 500 tonnes/month
- Identify the current waste management methods for each waste stream including disposal, handling, storage and recycling facilities.

Assessment of Environmental Impacts

- Assess the environmental impacts of waste generation from the construction activities, i.e. air and odour emissions, land, groundwater and surface water contamination due to wastewater (leachate) discharges, and introduction of non-native species such as pests and vector.
- Assess the significance of construction waste environmental impacts in terms of minor, moderate and major based on the volume of the waste generated and the severity of the environmental impacts.
- Qualitatively assess the environmental impacts of waste generation from the operations activities
- Recommend and outline measures to mitigate against the environmental impacts.

11.3 Pre-construction Baseline Conditions

The EIS Study Area is currently used as a military training area by the MINDEF. Although officially a restricted military area and hoarded up, there are occasional incursions by members of the public who use unofficial hiking trails that exist within Tengah Forest. The EIS Study Area also contains remnant waste from its previous land uses as a village and plantation grounds where housings and temples were present.

11.3.1 Identification of Waste Streams

The following waste streams have been identified to be currently present on site:

- Military waste from training activities including spent or training munitions
- General waste such as food and packaging as well as waste paper left behind after military training activities
- General waste such as food and packaging littered by trespassers known to hike in the area
- Remnant general waste from previous land uses such as plastic, piping and glass



Figure 11.3: Examples of Waste identified in the EIS Study Area (Clockwise from Left: Glass Bottles, Equipment Parts, Plastic Bottle)

11.3.2 Waste Generation and Waste Management Facility

Military waste is produced periodically when there are training exercises in the area. Such waste is likely to be accidental and hence minor in volume. It is handled by the military and is disposed following the protocols set out in their organisation for the removal and disposal of spent or training munitions.

General waste from the military such as food, packaging and wastepaper are brought back to camp to be disposed by conventional waste management services. Such waste is likely to be accidental and hence limited as well. General waste from trespassers are not handled or cleared and are often left there or picked up during military exercises whilst clearing the waste generated from their military exercises. Remnant general waste are also not handled or cleared. General waste can be handled via conventional waste disposal services and incinerated although care should be taken if any remnant waste might require special considerations.

11.4 Evaluation Potential Impact Before Mitigation Measures

The large amount of area being developed in Tengah similarly results in a large amount of waste that will be produced. Impacts of the waste can arise when waste is insufficiently managed, which can easily happen when large volumes are produced without a waste management system to match. The two main types of waste produced are non-hazardous and hazardous waste. Non-hazardous waste's impact significance would likely be correlated with its volume produced while hazardous waste's impact would depend largely on the nature of the

waste and its possible environmental impacts. These impacts have a range of minor to major impacts on the waste generation site and the surrounding areas. In general, the waste management system of Singapore is quite thorough in the day-to-day activities and there are fewer impacts expected from the operational activities of the project. These impacts are therefore not assessed for this EIS although recommendations to mitigate against potential waste-related issues are shared. The bulk of impacts is therefore likely to arise from the construction activities of the Project development in conjunction with other development within the EIS Study Area.

11.4.1 Potential Source of Impact

11.4.2 Volume Quantification of Waste Streams for the Project

In order to quantify the volume of waste streams in this Project, certain assumptions were made in order to reasonably estimate the volumes that would be expected and hence the impacts and management methods that would follow. In general, the characteristics of the area were assumed to be similar to other confirmed projects in Tengah Town and in the surrounding areas, including building height and residential density.

The following key assumptions were taken to estimate and quantify the amount of waste that would be produced by this project:

Table 11.2: Key Unit Volume Estimation and Assumptions

Type of Waste	Unit Volume Assumption
Wood (Deforestation)	209.4 tonnes/ ha[1]
Construction & Demolition	400 tonnes/ ha (per gross area)[2]
Hazardous	5 % of C&D Waste[3]
Municipal	0.024 tonnes/ person/ month[4]
Sewage	6.9 tonnes/ person/ month[5]
Commercial	20.1 tonnes/ ha (per gross area)/ month[6]
Persons	**Number of Persons**
Residents in the Project	Approximately 16, 000[7]
Workers on-site (Daily)	Approximately 4, 500[8]

[1] **Ngo et al., 2013** [2] Bergsdal et al., 2007; Cochran et al., 2007; Li et al., 2013; Seo & Hwang, 1999

[3] **Llatas, 2011**

[4] **MEWR & NEA, 2019**

[5] **COP on Sewerage and Sanitary Works**

[6] **WALGA, 2013**

[7] **Statistics Singapore, 2019; HDB 2020g**

[8] **BCA, 2019 (Project Productivity)**

The estimation of wood waste volume assumes that the forested area (40 ha) in the Project (66 ha) follows the aboveground biomass (AGB) of a Singaporean secondary forest. However, the species make-up and the associated tree architecture of secondary forests differs from that which is found in Tengah forest **Section 7.3.3.7** and is likely to be an overestimation rather than underestimation as the tree community is slowly shifting towards being a secondary forest, which should have higher carbon storage.

11.4.2.1 Waste Streams from Construction Phase

The construction activities (i.e. land clearance during advance works, earthworks and building construction) take place over the span of approximately 9-10 years, producing different waste streams of varying amounts. The following activities have been proposed in relation to the waste context:

- **Advance Works:** The EIS Study Area is currently largely vegetated and advance works that could potentially produce waste are from the erections of temporary hoarding, vegetation clearance and machinery maintenance. The vegetation present include a distribution of exotic-dominated secondary forest, abandoned plantations woodlands and scrublands.
- **Earthworks:** Earthworks include soil and geotechnical investigation work and demolition of existing structures. There is also the presence of a concrete canal, a farm and military structures within the EIS Study Area which will need to be demolished and removed.
- **Infrastructure and Building Activities:** The infrastructure and building activities include layering, concrete casting, material maintenance, foundation casting, prefabrication structure installation and architectural works.

The following types of waste are therefore expected to be produced during the construction phase:

Table 11.3: Waste Streams from Construction Activities of the Project

Type of Waste	Source	Estimated Volume	Project Planned Waste Management
Wood (i.e. Tree Trunks and Branches) **(Type A Waste)**	Produced during advance works from tree felling/ vegetation clearance including grass shrubs and tree trunks/ branches which are not retained. Wastes in the form of cleared trees, pruning from trees and dried leaves will continue to be produced in subsequent phases for maintenance of the vegetation related to safety.	700 tonnes/ month	Cleared off-site for treatment and disposal.
Construction and Demolition (C&D) Debris **(Type A Waste)**	Produced throughout the construction phase from the demolition of existing structures including concrete and metal frames. It also includes damaged/ surplus construction materials, equipment wrapping and packaging produced from the construction works.	2300 tonnes/ month	Sorted on site for on-site recovery and sent to approved disposal facility or accredited recycling facilities.
Hazardous/ Toxic Industrial Waste	Produced throughout the construction phase from the use of machineries within the site including used engine oils, hydraulic fluids, waste fuel, contaminated soil and spent chemicals from machinery and equipment maintenance activities. Toxic waste could also include materials contaminated by chemicals such as containers and packaging materials used to hold the chemicals.	120 tonnes/ month	Collected and treated by NEA licensed toxic industrial waste collectors to stringent standards before incineration and disposal at Semakau Landfill.

Type of Waste	Source	Estimated Volume	Project Planned Waste Management
Domestic Refuse and Food Waste (Type B Waste)	Produced throughout the construction phase from canteen, site office, worker's dormitories.	110 tonnes/ month	Sorted on site into recyclable and non-recyclables and encompassed into the national waste management system for recyclables and non-recyclables described in **Section 11.1.1.1.**
Recyclable Waste (Type A Waste)	Cardboard, paper packaging, papers, e-waste, plastics products, glass products produced from site office/ workers' dormitories.		
Sewage (Type C Waste)	Produced throughout the construction phase from mobile toilet facilities including wastewater and excrements.	30, 430 tonnes/ month	Collected and disposed of via temporary sanitary facilities by tinkering by a NEA's Licensed Waste Collector or be discharged into the existing public sewers with PUB approval.

11.4.2.2 Waste Streams from Operation Phase

The large proportion of the Project development is used for residential activities, with several blocks of HDBs. A section of the area is reserved for a mix of commercial and business purposes. It also includes other amenities such as places of worship, civic and community institutions, sports and recreation facilities, and health and medical care facilities. The Jurong Region MRT Line is an overhead track MRT and runs through part of the EIS Study Area with a sole station, Tengah MRT Station, which is within the boundaries of the EIS study area. A large proportion of the EIS Study Area contains parks, valuable retained trees and other managed vegetation. The forest corridor also runs through the area.

The following waste streams have been identified to be potentially present during operation phase:

Table 11.4: Waste Stream from Operation Activities of the Project

Type of Waste	Source	Estimated Volume	Project Planned Waste Management
Municipal Refuse and Food Waste (Type B Waste)	Produced from residential/ households, various other facilities and in the streets.	410 tonnes/ month	Collected via a district-level pneumatic waste conveyance and encompassed into the national waste management system.
Recyclable Waste (Type A Waste)			
Sewage (Type C Waste)		115,800 tonnes/ month	Connected to and collected via the public sewage network.
General Wastes from Commercial/ Business (Type A Waste)	Produced from the various businesses on site which could include a range of waste such as recyclable wastes and non-recyclables wastes	115 tonnes/ month	Sorted on site into recyclable and non-recyclables and encompassed into the national waste management system for recyclables and non-recyclables described in **Section 11.1.1.1**.

11.4.3 Impact from Construction Activities Waste Generation

The following sections evaluates the waste impacts from construction activities waste generation using the RIAM tool and assesses the impact severity significance.

11.4.3.1 Wood (i.e. Tree Trunks/ Branches)

There are two main hazards associated with wood waste. Firstly, the sight of large amounts of felled trees and vegetation could be visually unpleasant. Felled wood produces dust which could contaminate waterbodies and irritate human and wildlife in the vicinity.

Table 11.5: Impact Significance for Impact of Wood Waste Generation (Direct Impact)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	Environmental receivers include waterbodies connected to the larger national network of water channels and dust which can spread with the wind.
A2.1: Impact Nature	-1: Negative	Environmental receivers receive a reduction in quality.
A2.2: Magnitude of Changes	3: Medium	A large amount of wood is produced but is planned for removal from the site to off-site recycling facilities. The wood residues and dust from the tree felling, decomposition process during temporary stockpiling activities prior to disposal are expected be of medium magnitude.
A2.3: Impact Extent	3: National	Impact can extend pass the boundary of the local site via water and air.
B1: Permanence	2: Short Term	Felling of trees is expected to take place during the advance work stage which takes place over two years.
B2: Impact Pathway	3: Direct	Hazards directly affect the environment.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling.
Environmental Score (ES)	**(-12) x (10) = -120**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

For indirect impact, the felling of trees and removal of vegetation results in the release of the carbon that was originally stored within. The carbon is released into the atmosphere as carbon dioxide or methane immediately when burnt and slowly if it undergoes the process of decomposition (Houghton, 2005). Carbon dioxide and methane are both greenhouse gases which contribute towards global warming as they trap heat within the atmosphere. Greenhouse gases have transboundary impacts and contributes to global climate changes. The amount of carbon that will be released from the clearance of the vegetation in the EIS Study Area depends on the amount of biomass, which relates to their carbon content, that is removed. As the current area is largely vegetated with a small portion set aside for conservation, a significantly major amount of forest material is slated to be removed. As a gauge, it was reported that pristine forest in Malaysia and Indonesia could release between 316 to 474 tonnes CO_2-eq per hectare of wood removal (Croezen & van Valkengoed, 2009). However, pristine

forests are noted to have a higher biomass and carbon content that regenerated forest like those in Tengah forest and the amount of carbon release per hectare of wood removal is likely to be lower than that range.

Table 11.6: Impact Significance for Impact of Wood Waste Generation (Indirect Impact)

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	4: International	Environmental receivers include the environment and humans spread across the globe which are affected by climate change.
A2.1: Impact Nature	-1: Negative	The quality of the environment decreases while humans receive a reduction in quality of life.
A2.2: Magnitude of Changes	3: High	High volume of wood is produced from the mass felling of trees.
A2.3: Impact Extent	4: Transboundary	Greenhouse gases enter the atmosphere which undergo global circulation.
B1: Permanence	4: Long Term	Climate changes have long term impacts including changes in global temperatures and increases in sea level.
B2: Impact Pathway	2: Indirect	Contributes to climate change which indirectly affects the environment and humans
B3: Reversibility	3: Irreversible	Carbon sequestration from the atmosphere is not economical with current day technology.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling.
Environmental Score (ES)	**(-48) x (12) = -576**	
Range Bands ES/ Impact Severity Significance	**Critically Negative Impact**	

11.4.3.2 Construction and Demolition (C&D) Debris

C&D waste is non-hazardous in nature but the dust and debris that is produced from it could potentially cause health hazards for the wildlife and humans who breathe it in. The dust and debris could also settle into the natural open streams and water canal resulting in contamination of the water sources. C&D waste could be a fire hazard as it includes flammable materials such as plastic wrappings. Damaged or surplus construction materials could, depending on the size and shape, be choking or trapping hazards to wildlife. It is also visually unpleasant to look at.

Table 11.7: Impact Significance for Impact of C&D Debris Generation

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	2: National/ Regional	Environmental receivers include waterbodies connected to the larger national network of water channels and dust which can spread with the wind.
A2.1: Impact Nature	-1: Negative	Environmental receivers receive a reduction in quality.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.2: Magnitude of Changes	2: Medium	Although a high amount of C&D waste is produced from construction works, a larger proportion of waste are planned to be sorted and sent off-site for re-use and recovery of materials. The volume of dust and debris from the sorting, storage, transportation process are expected to be medium.
A2.3: Impact Extent	2: Tengah	Impact can extend to the air and water sensitive receivers identified.
B1: Permanence	3: Medium Term	Construction period is to take place over the next ten years.
B2: Impact Pathway	3: Direct	Hazards directly affect the environment.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction work.
Environmental Score (ES)	**(-12) x (11) = -132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

11.4.3.3 Hazardous/ Toxic Industrial Waste

There is a range of possible toxic waste that could be discharged during construction activities, each having their own forms of specific impacts. In general, most chemical waste are fire hazards and could cause fire to start especially if other flammable waste are present on site. Toxic waste could also infiltrate into the ground soil causing ecological shifts in the soil, resulting in issues with vegetation growth and soil erosion (Ashraf et al., 2014). Chemicals could also seep into water sources directly or through contaminated soil, polluting the water. Exposure to wildlife and humans could also prove to be harmful, via corrosive means during direct contact or poisoning leading to associated health issues (NRC (US) Committee on Environmental Epidemiology, 1991).

Table 11.8: Impact Significance for Impact of Hazardous/Toxic Industrial Waste Generation

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	Environmental receivers include waterbodies connected to the larger national network of water channels.
A2.1: Impact Nature	-1: Negative	Environmental receivers receive a reduction in quality.
A2.2: Magnitude of Changes	2: Medium	Toxic waste produced on site is planned to be collected and treated by NEA licensed toxic industrial waste collectors. The remnant of waste that could be arising from accidentally leakage during the management process would potentially have medium impacts due to its hazardous nature.
A2.3: Impact Extent	2: Tengah	Impact can extend to the air and water sensitive receivers identified.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B1: Permanence	3: Medium Term	Construction period is to take place over the next ten years.
B2: Impact Pathway	3: Direct	Hazards directly affect the environment.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time although it may take great effort to do so.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction work.
Environmental Score (ES)	**(-12) x (11) = - 132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

11.4.3.4 Municipal Waste (Refuse, Food Waste and Recyclables)

Municipal waste is non-hazardous in nature but could pose choking hazards to wildlife, may be visually unpleasant and produce unpleasant odours. As the construction is done in an area in close proximity to untouched forested areas known to be inhabited by wildlife, such waste especially those of food origin could attract wildlife and pests if not disposed correctly. This would then result in human-wildlife conflicts and pest-related health concerns for those on site.

Table 11.9: Impact Significance for Impact of Municipal Waste Generation

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local (EIS Study Area)	Environmental receivers are largely limited to the environment, humans and fauna on site.
A2.1: Impact Nature	-1: Negative	Environmental receivers receive a reduction in quality.
A2.2: Magnitude of Changes	1: Medium	As waste is planned to be collected, transported out for treatment/ disposal according to applicable COP, the remnant of waste due to improper management on-site is expected to be moderate despite the large number of workers on site
A2.3: Impact Extent	1: Local	Impact are unlikely to extend pass the local site boundaries.
B1: Permanence	3: Medium Term	Construction period is to take place over the next ten years.
B2: Impact Pathway	3: Direct	Hazards directly affect the environmental receivers.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction work with the presence of workers across.
Environmental Score (ES)	**(-2) x (11) = -22**	
Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	

11.4.3.5 Sewage Waste

Untreated sewage waste is biohazardous as it may contain bacteria and diseases that can cause environmental and health issues if exposed into the environment. As the construction is done in an area with natural open streams and connection to the water canal system, there is a potential water contamination issue.

Table 11.10: Impact Significance for Impact of Sewage Generation

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/Regional	Environmental receivers include waterbodies connected to the larger national network of water channels.
A2.1: Impact Nature	-1: Negative	Environmental receivers receive a reduction in quality.
A2.2: Magnitude of Changes	2: Medium	High volume of sewage produced but with only medium volume expected to impact from leakage/ insufficient capacity.
A2.3: Impact Extent	2: Tengah	Impact can extend to the water sensitive receivers identified.
B1: Permanence	3: Medium Term	Construction period is to take place over the next ten years.
B2: Impact Pathway	3: Direct	Hazards directly affect the environment.
B3: Reversibility	2: Reversible	Quality can be restored either through remediation efforts or over time although it may take great effort to do so.
B4: Cumulative	3: Cumulative	Part of a larger Tengah development which is similarly undergoing construction work with the presence of workers across.
Environmental Score (ES)	**(-12) x (11) = - 132**	
Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	

11.4.4 Impact from Operations Activities Waste Generation

The following sections qualitatively evaluates the waste impacts from operations activities waste generation. As the impacts of the operational phase are expected to be negligible, the RIAM tool is not used for this section.

11.4.4.1 Municipal Waste (Refuse, Food Waste and Recyclables)

Municipal waste is non-hazardous in nature. Such waste may be visually unpleasant, produce unpleasant odours and cause pest-related health issues. The waste management system used in town estates in Singapore is well-developed and rarely result in mismanagement. However, unlike other estates, the proposed development features a forest corridor where such waste would be placed in closer proximity to wildlife. Municipal waste, especially those of food origin could attract wildlife if not disposed correctly. This may result in human-wildlife conflicts.

11.4.4.2 Sewage Waste

Sewage waste is biohazardous as it may contain bacteria and diseases that can cause environmental and health issues if exposed to the community. As Tengah Town contains water features which are connected to the larger public water system, there is a potential water contamination issue should the sewage system be affected.

11.4.4.3 Commercial General Waste

General wastes from commercial entities are non-hazardous in nature but could be a fire hazard as it includes flammable materials such as plastic wrappings and wooden boxes. Fauna could also find themselves trapped in this waste or it could be choking hazards for them. It is also visually unpleasant to look at.

11.5 Applicable Prevention and Mitigation/ Enhancement Measures

There are standard legislation and regulations which are imposed by the various authorities in both construction and operations projects. They should be strictly adhered to confirm that the basic standards are met. This includes implementing waste handling, storage, collection and disposal good practices and contracting licensed general and toxic waste contractors to collect, transport and dispose of the various forms of waste produced during the project, as outlined in the applicable legislations as indicated in **Section 11.1**.

The following preliminary recommendations are made in alignment to Singapore's waste management strategies for sustainable waste and resource management. It follows a hierarchy of management decisions designed to reduce the amount of waste that is produced and disposed to the landfill.

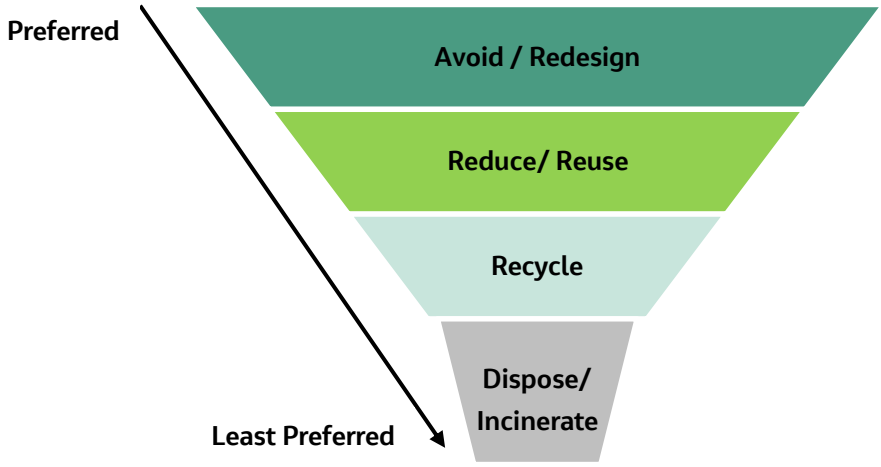


Figure 11.4: Hierarchy of Waste Management

Due to the largely natural landscape of the environment, several impacts have been heightened to be of greater significance. Mitigation methods therefore have to take into consideration, the proximity to the forest reserves and the forest features within.

11.5.1 Construction Activities Waste Prevention and Mitigation Measures

The following management measures have been identified to be applied to during different stages of the project development, i.e. project planning and throughout construction stage:

11.5.1.1 Project Planning/ Pre-construction

a) Overall

- Develop a waste management strategy to focus on waste elimination and to identify and communicate responsibilities for waste minimisation between developer; designer; project manager; contractors and suppliers.
- Conduct an analysis of the project waste profile.
- Establish a waste management and monitoring procedures and system for the Project to include waste stream and source identification, handling, storage, disposal tracking and monitoring, progress modification, evaluation as well as compliance audits.
- A review and reporting protocol for waste generated during construction should be developed that of which includes the amount of recycling and disposal done. Recycling targets should be aligned to match or be better than Singapore's current recycling rate for C&D, ferrous metal, paper/cardboard, plastics, food, wood and horticultural. This report should be reviewed monthly to examine areas of improvement in waste reduction and management.

b) Wood Waste

- Examine the possibilities of using materials from the removal of woody trees in the EIS Study Area. This could include leaving natural stumps or producing park furnishing from the felled trees.
- Examine the possibility of retaining larger sections of the woody trees in line with ecological conservation suggestions and to reduce the amount of wood felling.
- A routine schedule and recycling plan can be set up for horticultural waste based on the various volume produced at different construction stages.

c) C&D Waste

- Build for deconstruction and design to standard material sizes to allow future modification or decommissioning occurs, the entire structure can be taken apart and reused with ease and minimal waste.
- Careful planning in material estimation and procurement process to minimise wastes generation.
- The naturalisation of the concrete canal in the EIS Study Area could follow other ABC water features such as the Kallang River @ Bishan-Ang Mo Kio Park where concrete from the old canal was reused at various parts of the park (Schaefer & Spirn, 2014). This will reduce the amount of construction waste produced and showcase a small portion of sustainability and history from Tengah.

d) Hazardous/ Toxic Industrial Waste

- Review the hazardous/ toxic elements being used and examine the more environmentally friendly substitutes available.

11.5.1.2 Construction Stage

a) Overall

- Form an on-site waste management team to work with the appointed Environmental Control Officer (ECO) to implement daily waste management/ housekeeping works according to the established Waste Management Plan.
- Applying waste minimisation techniques and good practices on site following waste management hierarchy, i.e. source reduction, waste exchange, recycling, reuse and waste segregation.
- Plan for timely on-site separation and collection of materials with waste stream specific schedules in place.

b) Wood Waste

- All horticultural waste should be transported off-site to specialised horticultural recycling facilities where they can be grinded into wood chips which can be turned into mulch or compost. Where possible, wood recycling as wood chips into new wood products by mixing it with binders should be prioritised.
- Horticultural waste which is not suitable to be recycled should be used as fuel in biomass power plants.

c) C&D Waste

- Waste concrete from demolition could also be recycled into recycled concrete aggregate which is made up of 70% demolition concrete waste with natural aggregates and used in buildings and roads in Tengah.
- Construction waste should be properly segregated and have set storage locations to extract recoverable and recyclable materials which can then be reused or recycled.

d) Hazardous/ Toxic Industrial Waste

- Separate the different forms of hazardous waste, provide treatment on site if applicable and set up protocols for spillage.
- Implement strict waste handling, storage, collection and disposal practices to prevent leakages.

e) Municipal Waste

- Biodigesters or composting stations could be introduced onsite to deal with food waste generated by workers, converting it into grey water or compost which can then be reused onsite. These stations are usually well sealed which also reduces the hazard of wildlife being attracted to the area.
- Provide adequate garbage/ trash bins with tight lid (animal-proof bin) to prevent animals from getting into it.
- Recycling bins should be provided alongside every trash bins with well-labelled signs and examples of common recyclables items to help workers sort their waste.

f) Sewage

- Provide sufficient and maintain proper sanitary facilities at the worksite and connect discharge points to septic tanks and or the public sewage for disposal.
- Sewage not connected to the main sewage system has should have sufficient storage capacity and a clearance schedule that matches the volume being produced.

11.5.2 Operations Activities Waste Prevention and Mitigation Measures

In addition to the measures outlined in legislation and regulations, the following management measures for operations activities waste have been identified:

- Municipal and commercial waste should be sorted for recycling and disposal at the waste generation points. Relevant authoritative bodies (i.e. town council, real estate management) should engage with the residents and visitor to encourage sorting, including via awareness building and or design of bins.
- Any hazardous waste should be stored in specialised storage before collection by NEA licensed toxic industrial waste collectors.
- Public trash and recycling cans have to be wildlife-proof so that wildlife are unable to have access to the bin, whether to retrieve items from within or be trapped.
- A routine schedule and recycling plan can be set up for horticultural waste, including engaging a routine contractor to ensure that amounts do not build up.

11.6 Residual Impact

The adoption of the regulatory and mitigation measures proposed above will assist to reduce the magnitude of the waste impact by reducing the amount of waste being produced and ensuring that the waste is properly segregated, treated and or managed. This will allow minimal leakage out of the system. It also seeks upcycling opportunities for certain forms of waste to extract maximum value.

Table 11.11: Summary of Evaluation of Residual Impacts

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
Construction Phase					
W-I1	Impact of generation of wood waste (Direct)	-120	**Moderate Negative**	-60	**Minor Negative**
W-I2	Impact of generation of wood waste (Indirect)	-576	**Critically Negative**	-384	**Major Negative**
W-I3	Impact of generation of C&D waste	-132	**Moderate Negative**	-66	**Minor Negative**
W-I4	Impact of generation of hazardous/ toxic Industrial waste	-132	**Moderate Negative**	-66	**Minor Negative**
W-I5	Impact of generation of municipal waste	-22	**Minor Negative**	-11	**Slight Negative**
W-I6	Impact of generation of sewage waste	-132	**Moderate Negative**	-66	**Minor Negative**

12. Environmental Management and Monitoring Plan

This Section outlines an Environmental Management and Monitoring Plan (EMMP) specification which include the objective/ purpose of an EMMP, requirement of policy statement, organisational structure with assigned roles, responsibility, reporting and communication plans that will be put in place during construction phase of the Project for implementation of all the identified prevention and mitigation measures in the preceding sections. The section includes a Wildlife Management Plan which was developed as part of the mitigation measures recommended from ecology and biodiversity impacts (**Section 7**). The section also includes recommended performance indicators, monitoring and auditing regimes against applicable standards/ regulations. An EMMP register and reporting system will be given for implementation.

12.1 Purpose of EMMP

An EMMP for specific project for implementation during construction phase has the following purposes:

- For commitment of compliance with mitigation/ enhancement measures identified in this EIS and relevant environmental legislation by responsible parties during the various stages of project construction
- For basis of guidance to the selected Engineering, Procurement, Construction and Commissioning (EPCC)/ Project Consultant/ Main Contractor in developing a Contract Specific EMMP with specification for implementing appropriate environmental controls and monitoring procedures
- For basis of guidance to the developing agency of the Project (HDB) in developing impact registers and management protocols to safeguard identified environmental impacts during construction phase
- For performance monitoring and auditing of the project's actual environmental impacts during different stages, as EMMP services as a "live document", if there are any updates in project information/ planning activities, corrective actions to be taken and modifications that can be made to reduce/ mitigate the impacts to as low as reasonably practicable (ALARP)

12.2 Management of Change/Future Review of EMMP

As the EIS has been prepared based on information available at the conceptual planning stage of the Project, the EMMP will need to be reviewed once the detailed engineering design is finalised, after the appointment of the EPCC/ Project Consultant and Contractors for the construction works. In particular, the recommended mitigation measures in this EIS will need to be revised in detail in parallel with the detailed land use planning and engineering design for the Project.

12.3 Specification for A Contract Specific EMMP

A Contract Specific EMMP is required to be developed by the appointed EPCC/ Project Consultant and Contractors (this shall be referred to all contractors for various stages of construction phase). The Contract Specific EMMP shall include but not be limited to the following scopes where their respective specifications are described in the following sections.

- Project environmental policy and objectives
- EMMP organization structures
- EMMP roles and responsibilities
- Reporting and communication plans (e.g. response framework and reporting timeframes)
- Training programme
- Specific management plans that include a Wildlife Management Plan and Flora and Arboriculture Management Plan
- Mitigation/ enhancement measures to be implemented

- Environmental performance monitoring regime
- Environmental audit programme
- Contingency plan that includes a Wildlife Incident Plan
- Stakeholder engagement and management recommendations

12.3.1 Project Environmental Policy and Objectives

The Contractor is required to establish a project specific environmental policy that affirms their commitment to EMMP implementation and is aligned with the Developing Agencies' Environmental Policy (HDB, 2020f). The project specific environmental policy should cover the following:

- Commitment from the company's management with authorised name and signature
- Compliance with all applicable environmental legislation and relevant requirements including mitigation measures from this EIS and industry best practices
- Commitment to prevent pollution
- Commitment to continually improve environmental performance by setting and reviewing environmental objectives and targets
- Communication and education plans with all associated persons/ affected communities/ stakeholder to achieve environmental goals

12.3.2 EMMP Organization Structure

HDB as the developing agency has the ultimate responsibility over the implementation of the EMMP by the Contractor and its subcontractor or any third party during the construction period of the Project. The Tengah Working Committee refers to the relevant agencies (i.e. URA, NParks, NEA, LTA and PUB) where HDB is also a member of it and whom all have working roles in the overall Tengah development. This working committee consists of regulatory agencies and other stakeholders that will be responsible for providing guidance for requirements and sharing responsibilities with HDB for issues related to interfacing works where cumulative impacts are identified. A recommended organization structure for EMMP implementation during construction phase is presented in **Figure 12.1**.

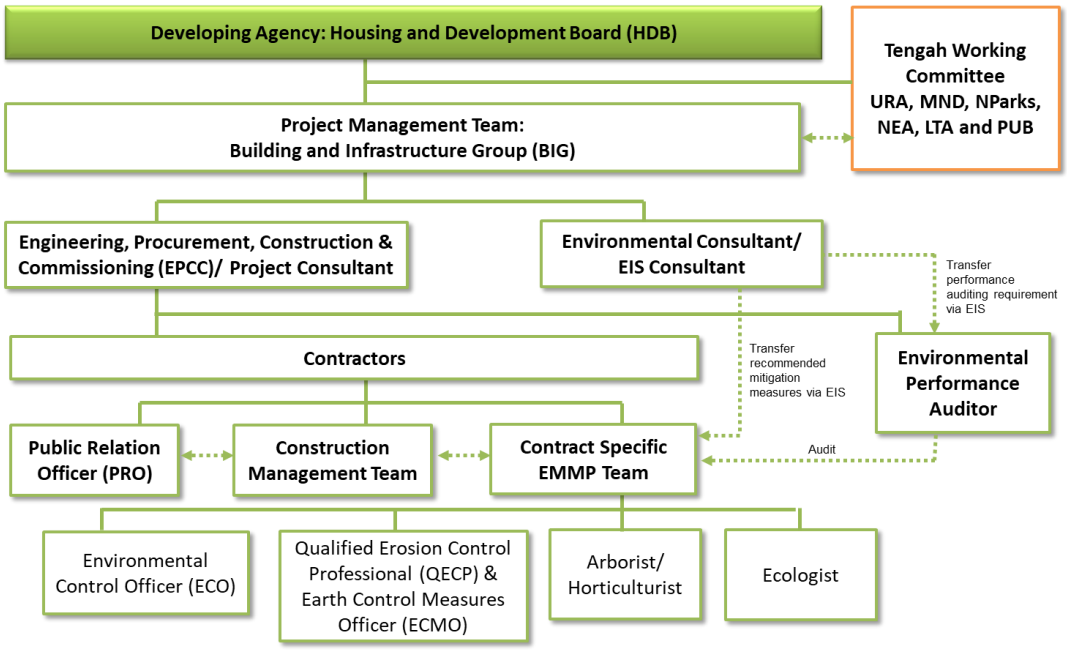


Figure 12.1: Organisation Chart for EMMP Implementation

12.3.3 EMMP Roles and Responsibilities

The roles and responsibilities for each key party in the recommended EMMP Organization Structure during construction phase is given in **Table 12.1**.

Table 12.1: Roles and Responsibilities of Key Parties in Recommended EMMP Organization Structure

Role	Party	Key Responsibilities
Developing Agency/ Project Owner	HDB	• Accountable for the overall environmental performance throughout the Project lifecycle. • Assume ultimate ownership of the Project compliance and commitment with relevant environmental legislation, guidelines and best practices.
Project Management Team	HDB's BIG or HDB's BQG	• Responsible for the overall management of the project development with full commitment to environmental policy and EMMP implementation. • Review internal and external audit reports relating to environmental management for the respective developments. • Liaise with the Tengah Working Committee and any relevant stakeholders/ authorities on specific requirements for the development or raise issues that require attention. • Communicate requirements from agencies/EIS to the EPC/ Project Consultant, Environmental Consultant and the Contractors.
EPCC/ Project Consultant	TBD	• Supervise and oversee construction works undertaken by Contractor according to contracts requirement, engineering, construction and EMMP specifications set by Developing Agency/ Authorities. • Monitor compliance of the implementation of the EMMP against the Contract specification and relevant environmental legislation requirement. • Appoint third party environmental auditor to check and audit the environmental performance monitoring. • Activate relevant response plans in the event of any exceedances or incidents. • Carry out complaint investigations, where applicable.
EIS Consultant/ Environmental Consultant	CH2M/ TBD	• Recommend environmental parameters to be managed and monitored in the EMMP. • Recommend environmental performance monitoring and auditing scheme to be transform as part of Contract specification requirement.
Contractors	TBD	• Responsible to execute the contract in compliance to applicable environmental legislation, environmental policy, mitigation/ enhancement measures recommended in the EIS, etc., set by relevant authorities and the Developing Agency. • Form a Contract Specific EMMP Team which consists of ECO, ECMO, Arborist/ Horticulturist and Ecologist to implement the environmental mitigation and monitoring measures relevant to construction works to achieve compliance to relevant regulations and requirements of the EMMP. • Establish method statements according to recommended mitigation measures, provide relevant information to Contract Specific EMMP Team on potential activities that create adverse environmental conditions.

Role	Party	Key Responsibilities
		• Participate in the site audits undertaken by the third party independent Environmental Performance Auditor and undertake corrective actions instructed by the Environmental Performance Auditor. • Submit periodic environmental performance monitoring reports to EPC for review. • Submit proposal for mitigation measures should there be an exceedances or incidents. • Implement approved mitigation measures to reduce the potential impacts from exceedances or incidents. • Appoint a Public Relation Officer (PRO) to support the EPCC/ Project Consultant in carrying out complaint investigation.

12.3.4 Reporting and Communication Plan

All documentation throughout the construction contract period should exist in a written format and be filed in a traceable and systematically manner. The Contractor is to establish templates for reporting for approval by the Developing Agency prior to commencement of contract works. All documentation templates/ formats should be clearly communicated to potential users (i.e. Project Management Team, Project Consultants and Contract Specific EMMP Team). The documents shall include the following at a minimum:

- Minutes of records and attendance records for all meetings and trainings related to the environment.
- Special management plan and/ or technical records.
- Method statement for construction approved by Developing Agency/ EPCC.
- Social, Health and Environment (SHE) inspection report.
- Environmental performance monitoring reports.
- Environmental audit reports.
- Non-compliance and remedial action plans.

All documents should be kept throughout the construction contract and defects-liability periods.

Minutes of records of trainings and meetings shall be reported within five working days to EPCC/ Developing Agency. Reporting timeframe for environmental performance monitoring and audit reports shall follow the recommended monitoring and audit regime (i.e. monthly/ quarterly) as indicated in **Section 12.3.8** and **Section 12.3.9**.

In the event of non-compliance by the Contractor against the requirements of the EMMP, the following process of reporting and communication is recommended:

1) Contractors via Contract Specific EMMP Team to notify the Project Manager/ Construction Manager from EPCC/ Developing Agency upon a finding of non-compliance.
2) EPCC/ Developing Agency to issue a notice of non-compliance to the Contractors, stating the nature and magnitude of the contravention.
3) The Contractors to provide the EPCC/ Developing Agency with a written statement describing remedial actions to be taken to rectify the non-compliance and expected results of the actions.
4) The Contractors to correct the non-compliance within a period that is stipulated by the EPCC/ Developing Agency, to provide the EPCC/ Developing Agency with documented evidence of the completed remedial actions and obtain the EPCC/ Developing Agency'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 EPCC/ Developing Agency may act (e.g. impose a penalty, require specific remedial action to be undertaken or stop work) based on the conditions of contract.

12.3.5 Specific Management Plan

12.3.5.1 Flora and Arboriculture Management and Monitoring Programme

a) During Construction Phase

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

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

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

- Conducting of monthly inspections at the construction sites to confirm tree conditions have not deteriorated; checking that integrity of the TPZs has not been compromised; verification that no mechanical damage to trees has occurred; and monitoring for edge effects at new forest edge.
- Provision of a brief monthly report with recommendations of mitigating measure(s) if any. Reports shall include photos of tree and condition of TPZs.
- Assessment to determine the need for additional tree removal due to construction constraints and liaison with NParks for permission to remove roots where necessary.
- Review of method statements from builders for construction at proximity to trees.
- Liaison and coordination with selected tree works contractor to carry out tree pruning works and carry out inspection to comply with NParks' standards.
- Work with architects and structural engineers on design changes and structural solutions at proximity to the trees that will meet NParks' guidelines and help justify the works within the TPZ if necessary.

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

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

Contractor to perform tree climbing and chainsaw work shall possess a valid basic tree climbing certification based upon demonstrated competence in the Workforce Skills Qualifications (WSQ) module conducted by Centre for Urban Greenery and Ecology (CUGE) or an equivalent WSQ-approved training organisation.

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

Additionally, the Contractor should fulfil the following:

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

b) Post-construction/ Operational Phase

Contractor is required to monitor trees, flora and fauna for at least two months after reinstatement to review the effectiveness of the implemented mitigation measures and rectify problems identified.

The flora monitoring aims to assess the impacts of operational works to surrounding vegetation and/or adjacent forest, and rectify issues when identified. The programme should include the following:

- Assess impact of operational on the physiological health and structural stability of vegetation and trees at proximity to the development.
- Identify excessive and/ or unauthorized removal of vegetation and trees beyond the development boundary.
- Monitor and assess potential edge effects (e.g. predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to the development.
- Identify unauthorized dumping of rubbish (e.g. food materials), construction debris and materials, oil/ chemical leakage that may contaminate soil and waterbodies after construction.

12.3.5.2 Wildlife Management Plan

Contractor shall develop a specific Wildlife Management Plan to manage movement of the wildlife out from the disturbance construction zone according to the Method Statement of Wildlife Shepherding in this EIS (refer to **Appendix 7E**).

12.3.5.3 Fauna Monitoring and Management Programme

a) Pre-Construction Phase/ Advance Works Stage

Faunistic surveys may include fauna surveys and site inspection within and outside of hoarded areas, and should be conducted on a monthly basis. The surveys may begin one month prior to construction and extend to two months after reinstatement.

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

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

b) Construction Phase

Faunistic Surveys

The methodology for the faunistic surveys should follow closely that which was implemented for this EIS, so as to allow the data collected can be used to compare against the baseline data. Comparison of species presence may be made with the baseline studies where appropriate, to provide an indication of the changes in faunal diversity. Further details of the surveys should be determined in consultation with NParks and should take into account construction phases, final construction footprint, final development hoarding plan, and baseline studies.

Site Inspections

Monthly fauna site inspection is recommended to be carried out by ecologist(s) appointed by the Contractor. The following shall be inspected for during monthly fauna site inspections (**Figure 12.2**).

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



Figure 12.2: Examples Photographs of Monthly Fauna Monitoring and Inspection On-site

Source: CH2M/ Camphora, 2020

Pre-site Clearance Inspection

Pre-site clearance inspection involves planning for directional vegetation clearance to passively shepherd animals out of the site, as well as pre-felling tree inspections for fauna before a tree is felled. This minimises fauna injury and mortality during tree felling and vegetation clearance. In addition, site clearance shall be executed outside of the key bird breeding season (March to July) where possible. The protocol for pre-felling tree inspection for fauna is shown in **Figure 12.3**.

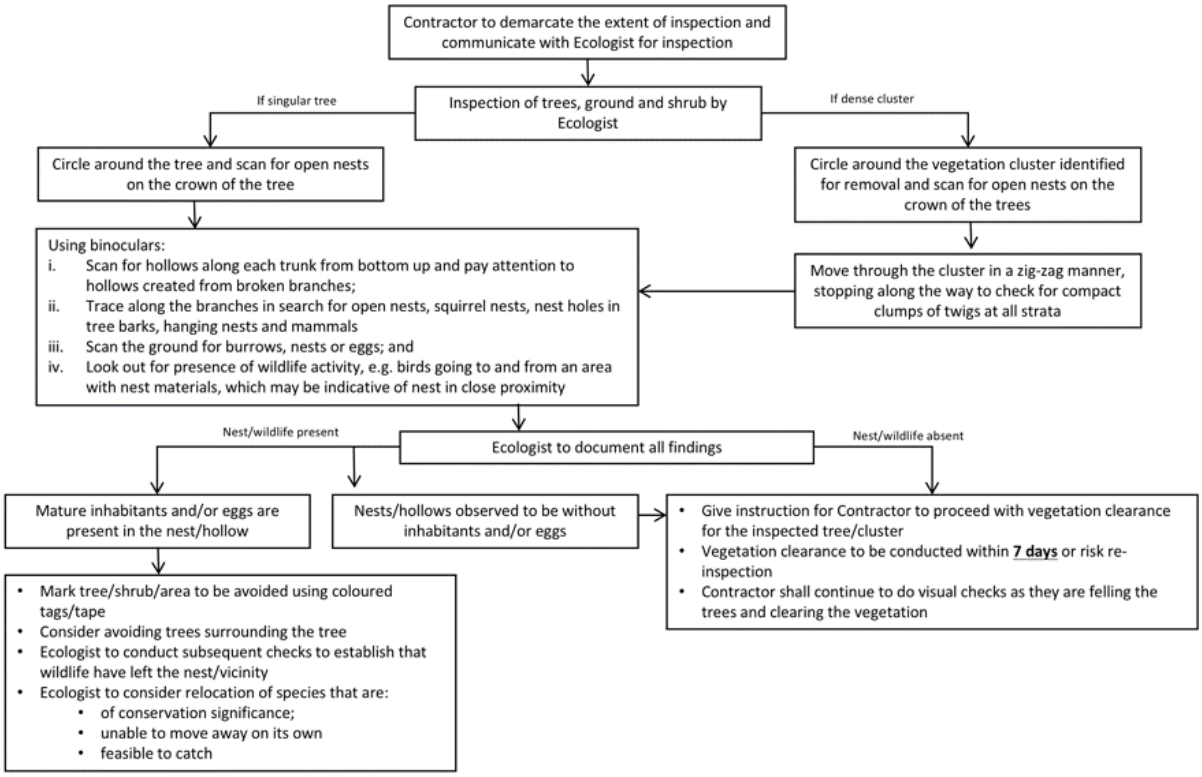


Figure 12.3: Pre-felling Inspection Protocol

Wildlife Response Plan

The Wildlife Response Plan shall be executed when a trapped/ injured/ dead/ dangerous animal is encountered around or within the worksite. The objective of the wildlife response plan is to minimise animal injury and mortality by responding appropriately to the different scenarios in **Figure 12.4**. This should be emphasized during the toolbox briefings. All wildlife encounters are to be documented within 24 hours using a Wildlife Incident Form.

Where species of conservation significance are affected by the Project development, relocation works shall be planned (e.g. bamboo bats). Where fauna is trapped on-site, options shall be explored to remove them from site (e.g. partitioning worksite, use of one-way exit door) (**Figure 12.5**).

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

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

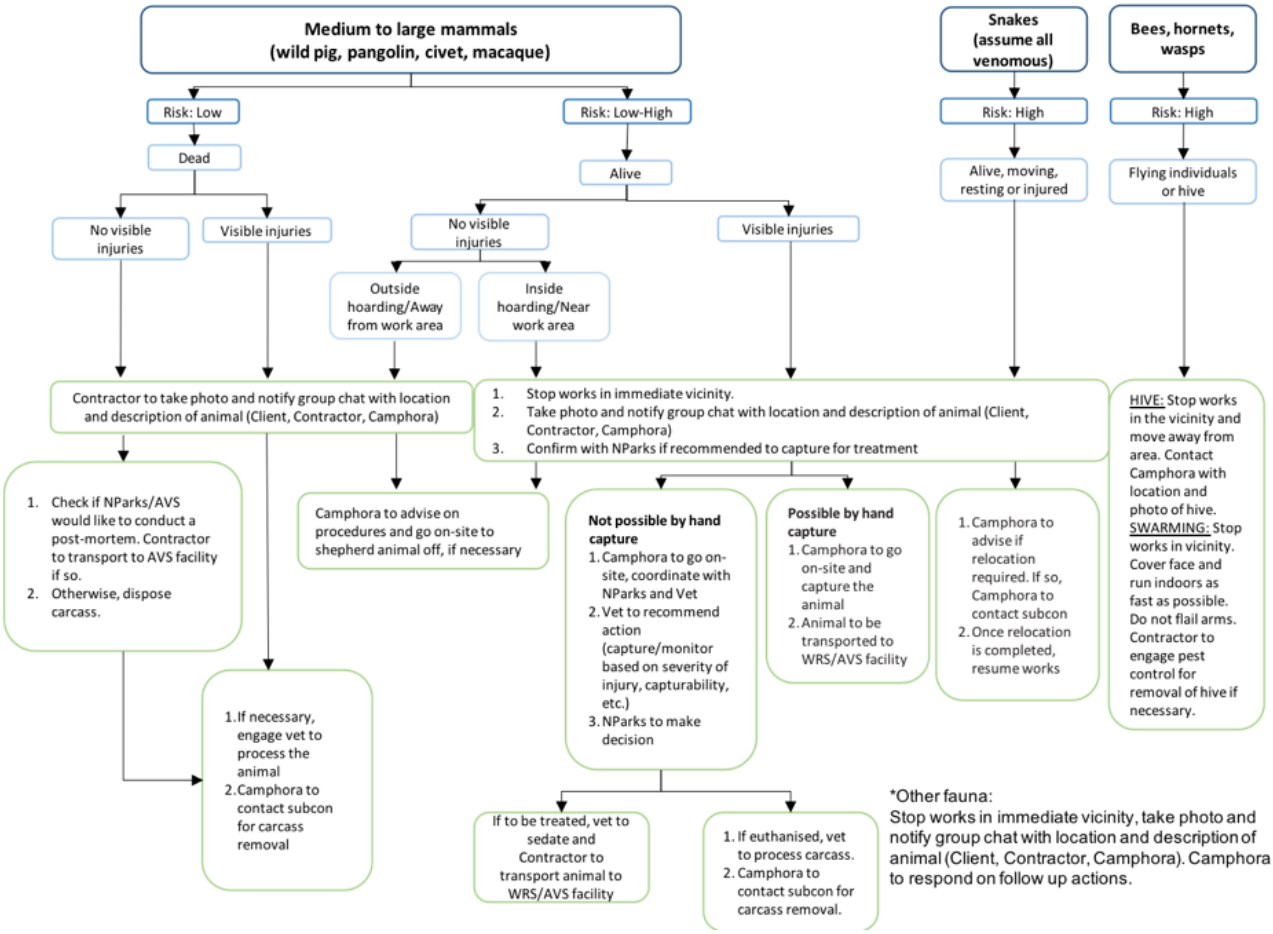


Figure 12.4: A Flowchart of the Wildlife Response Plan



Figure 12.5: Example of one-way flap door to allow fauna to exit independently

Biodiversity Awareness Trainings

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

c) Post-construction/Operational Phase

The fauna monitoring aims to assess the impacts of operational works to fauna residing within adjacent forest, and rectify possible issues identified. The methodology for the faunistic surveys shall follow closely that which was implemented for this EIS, during data collection during the baseline or construction phase, to provide an indication of the changes in faunal diversity. Contractor is required to monitor trees, flora and fauna for at least two months after reinstatement to review the effectiveness of the implemented mitigation measures and rectify problems identified.

12.3.5.4 Waste Management Plan

The purpose of a waste management plan is to provide an overview of the waste generated, treatment options and outline the responsibilities between the developer, designer, project manager and suppliers in minimising the waste produced. Prior to construction, the appointed Contractors should submit a waste strategy and management plan prior to execution with the aim of waste minimisation and mapping of waste types, volume and treatment methods. The plan shall provide a framework for the following:

- Specific types and projected volume of waste expected to be produced throughout the construction period.
- Recycling targets aligned with the Singapore's 2030 Recycling Target for each type of waste.
- Storage location and capacity of each type of waste/ recyclables and the specific precautions taken to prevent spillage/ contamination.
- List of licensed waste collector contracted and schedule of collection for each waste type.
- Treatment methods for each type of waste (i.e. recycled, incinerated) on-site and off-site.

A monitoring, review and reporting protocol for waste generated during construction should be developed to track the amount of recycling and disposal done with a monthly report to be submitted within the periodic environmental performance monitoring reports. The report shall be used to identify gaps in standards and targets and areas of improvement and highlight waste generations areas which may have been overlooked or were more serious than expected.

12.3.6 Training Programme

The appointed Contractors are responsible for induction and appropriate trainings related to environment topics of all workers employed on the construction site. The main purposes are to translate/ communicate EMMP requirements, to promote environmental awareness on responsibilities and to build capacity in mitigation measures implementation. The recommended training programmes are listed but not limited to:

- Tree protection management plan.
- Wildlife awareness and response procedures.
- Earth control measures management plan.
- Water quality management plan and procedures.
- Noise and air quality management plan.
- Environmental incident response and reporting procedures.

HDB as the developing agency should conduct periodic reviews and update training programme requirement to align with any project information changes.

12.3.7 Mitigation/ Enhancement Measures to be Implemented

Table 12.2 and **Table 12.3** outline the identified potential environmental impacts associated with construction activities identified from **Sections 4 – 11** of this EIS to potentially be of significance and the mitigation/ enhancement measures to be implemented throughout various stages of construction phase as indicated in Section 3 (i.e. Stage 1 – Advance Works, Stage 2 – Earthworks; Stage 3 – Infrastructure; and Stage 4 – Building).

For each environmental impact, mitigation/ enhancement measures are presented along with specific actions required to implement these measures, timing and means of verification. This table matrix forms the basis of EMMP for the Developing Agency and Contractors to follow. The following shall be noted when interpreting the table:

- The significance rating of the residual impacts assumes that the recommended mitigation/ enhancement measures have been fully implemented, and that they have been effective. Thus, regardless of the significance rating presented, mitigation measures are required. Any additional measures, if identified along with new information/ method statement shall be included to reduce the significance of residual impacts to ALARP.
- Each impact has been named with their specific impact ID and their corresponding actions and timeframe for implementation and verification of performance.

Table 12.2: Implementation Matrix for Recommended Mitigation/ Enhancement Measures over Construction Contract Period for Physical and Human Environmental Aspects

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
Environmental Aspect: Geomorphology, Soil and Hydrogeology						
G-I1	Changes to soil Infiltration capacity	**Minor Negative (ES: -22)**	• Minimise areas of disturbance with designation of non-disturbance areas/ buffer areas with vegetation cover within construction site boundary to compensate for the loss of open surface areas where permanent infrastructures will be built.	• Undertake a programmatic Excavation, Cut and fill and Earthmoving Plan to include zoning of buffer/non-disturbance areas following the final land use plan/ parcellation. • Prepare Operational Manual for Final Cut and Fill/ Excavation plan • Carry out construction works according to stages and programmed segments to minimise the area disturbed at any given time. • Implement of cut and fill/ excavation plan according to the Operation Manual.	Pre-Construction Phase/ Construction Phase	**Slight Negative (ES: -11)**
G-I2	Soil loss and erodibility	**Minor Negative (ES: -33)**	• Identify slope stability and soil compaction details in areas of concern (i.e. with slope more than 15 degree.) according to Slope Map generated. • Control soil erosion with placement of Erosion and Sediment Control (ESC) structure.	• Engage a Qualified Person (QP)/Professional Engineer to conduct a slope stability and soil compaction study in areas of concern, the resulting detailed assessment will serve as part of the operational manual during earth-moving and excavation activities. • Engage a Qualified Erosion Control Professional (QECP) to design, endorse an Earth Control Measure (ECM) Plan • Submit the endorsed ECM Plan to PUB for approval prior to construction commencement	Pre-construction Phase	**Minor Negative (ES: -22)**
			• Reduce soil erosion at various stages of construction phase • Rehabilitation of disturbed areas where applicable (i.e. temporary construction areas such as staging and stockpiling zones) can be rehabilitated into additional buffer zones that can be revegetated. • Removed topsoil will be stockpiled in a designated area and covered as necessary to prevent soil loss from secondary erosion. • Spoil materials will be separately stockpiled and can be used as backfill materials within the development areas as necessary or outside where it can be of use.	• Place ECM structure and implement ECM following the approved ECM • Engage a qualified ECMO to conduct performance monitoring throughout the construction phase • Prepare Soil and Spoil Stockpile Management Plan • Stockpile removed topsoil in designated area following Soil and Spoil Stockpile Management Plan. • Segregate spoil material stockpile area with topsoil, to be used as backfill materials within the development areas as necessary or outside where it can be of use.	Construction Phase	
G-I3	Changes to hydrogeology	**Moderate Negative (ES: -144)**	• Identify the extent of the aquifer characteristics beneath the "Spring Area" and the probable recharge zones located within the forested area. • Identify alternative buffer zone in development areas where groundwater hydrostatic pressure is potentially high. • Designate alternative in-situ recharge zones within the remaining conservation areas or green-belts to compensate for permanent loss of recharge areas that will be disturbed by the placement of at-grade and subsurface infrastructures. • Undertake shoring and dewatering with pumps as needed during construction activities where increased hydrostatic pressure is expected to cause leaching into construction areas. Automatic pumps may be installed which will operate when critical piezometric levels are exceeded. • Minimise disturbance of aquifer-hosting rock units during cut-and-fill activities.	• Carry out geo-resistivity survey to complement the information from the standpipes and assess the subsurface for aquifer characteristics beneath the "Spring Area" and the probable recharge zones located within the forested area with minimal disturbance. Develop a conservation programme based on the results. • Install piezometers and monitoring wells in areas where groundwater hydrostatic pressure potentially high. • Install reinjection wells where feasible. • Install dewatering pumps as needed. • Provide artificial recharge through installation of groundwater or diversion reinjection wells to replace the loss of surface water infiltration.	Pre-Construction Phase/ Construction Phase	**Minor Negative (ES: -96)**

[13] Required Action include recommended equipment/ resources/ procedures required to implement the recommended mitigation measures

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
Environmental Aspect: Surface Hydrology						
H-I1	Changes in surface water flow direction	**Moderate Negative (ES: -198)**	• The execution of construction work should follow the planned stages and programmed segments to avoid formation of uneven slopes or terrain that can influence surface flow direction and to avoid creation of conditions that can cause unchecked increase in surface water flow rate on temporary or permanent water features or drains. • Minimise the disturbance area affected by excavation and earthworks to what is only necessary in accordance with the Site Development Plan. The Site Development Plan must consider allocation of some of the available land resource for buffer zones acting as recharge zones which can naturally accommodate excess surface runoff and thereby reduce the surface water flow rates entering flood control drains and waterways and reducing the need for auxiliary equipment during peak rainfall regimes. These includes the existing wetlands, ponds, feeder canals as well as minor watercourses which help to naturally accommodate the runoff. Such buffer areas shall be maintained in their undisturbed condition where practicable, or retained where feasible, with appropriate modifications that can be integrated in the project plan. The RAC can also be considered as buffer zones for this purpose. • Placement of temporary diversion channels strategically placed within construction or work areas to manage and direct surface flows. • Waterways and drains designated as recipients of increased surface water flow rates may need to be designed with consideration of allowance of 5-10% above the design flood capacity. Alternatively, auxiliary equipment such as sluice gates and pumps shall be installed to provide operational support when excessive runoff enters these systems.	• Undertake a programmatic Excavation, Cut and fill and Earthmoving Plan to include zoning of buffer/non-disturbance areas following the final land use plan/ parcellation. Execute construction work according the specific Excavation, Cut and Fill and Earthmoving Plan. • Carry out excavation and earthworks according to Site Development Plan. • ECM plan to include sufficient and strategy temporary diversion channels within the construction/ work areas. • Design of waterways and drain to include 5-10% above the design flood capacity. Alternatively, install auxiliary equipment (i.e. sluice gates and pumps) to provide operational support when excessive runoff enters these systems.	Pre-Construction Phase/ Construction Phase	**Minor Negative (ES: -99)**
H-I2	Changes in Surface Water Flowrate	**Moderate Negative (ES: -198)**				**Minor Negative (ES: -99)**
Environmental Aspect: Water Quality						
WQ-I1	Water quality deterioration due to soil erosion and surface runoff from construction site	**Moderate Negative (ES: -180)**	• Implementation of good site practices in line with the COPs and guidebooks. • Provide storage tanks or reservoirs with additional 20% capacity and number to temporarily store/ contain muddy surface runoff before treatment. • Whenever possible, segregate clean water flow from silty water flow to maximize the sedimentation tank holding capacity • Provide sufficient treatment units or coagulant units to treat silty water before discharging into public drain within 10 hours of rain event. • Concrete and demolition debris, water used for dust control, and groundwater should not be allowed to cause erosion within the work area or to run offsite.	• QECP to plan a site-specific work sequence and schedule of earthworks or construction works in stages and progressively to avoid exposure of large bare/ erodible surfaces for long durations, including setting a standard for bare earth surface areas allowable at a point of time. • As outlined in the COP, the site operator/ contractor should monitor the TSS and turbidity of the treated water in concentrations within the prescribed limits before the discharge enters the surface water drainage system. A discharge bypass pipe with valve connected to the sedimentation tank is recommended to be installed at the treated holding tank. If the prescribed limit for TSS in the discharge is exceeded, the bypass pipe should be opened to return the water to the sedimentation tank. This will prevent silty water discharge. In the event of uncontrolled release of high TSS due to abnormal weather conditions, water quality sampling in the canals should be undertaken at the same locations that were sampled in this study. This will help to determine the impact of the discharge on water quality. The contractor should have incident response plan, identified in their Environmental Management Plan, to follow in case of exceedance of the prescribed TSS limits. These may include stopping construction activities during periods of excessive rainfall.	Pre-Construction Phase/ Construction Phase	**Moderate Negative (ES: -120)**

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
WQ-I2	Water quality deterioration due to sewage discharge	**Moderate Negative (ES: -132)**	• Provide sufficient numbers of and maintain proper sanitary facilities. It is recommended that there be one portable toilet per 10 pax and serviced 3 times per week. Appoint a NEA's Licensed Waste Collector (LWC) to conduct regular collection of sewage discharges for disposal. • Portable toilets are recommended to be installed on paved ground and bunded. • On-site dormitories are recommended to install container toilets and secure written approval from PUB to connect into public sewers.	• Provide sanitary facilities in accordance with number of workers on site and NEA and BCA requirement at different stages of the construction. • Install container toilet at on-site dormitories (if any) and managed according to regulatory requirement. • Establish a regular maintenance work schedule to check and maintenance cleanliness and functionality of sanitary facilities on site, at least once a week, depending on the amount of sanitary facilities. • Implement recommended mitigation measures.	Construction Phase	**Minor Negative (ES: -66)**
WQ-I3	Water quality deterioration due to use, storage and handling of diesel, oil and other pollutive substances on construction site	**Moderate Negative (ES: -132)**	• Suitable containers shall be used to hold the chemical wastes to avoid leakage or spillage during storage, handling and transport. • Chemical waste containers shall be labelled following the Globally Harmonised System of Classification and Labelling of Chemicals in the four national languages (i.e. English, Chinese, Malay and Tamil) and other commonly used languages on site to avoid accidents. There shall also be clear instructions showing what action to take in the event of an accident. • Chemical storage areas should be adequate, on paved ground, bunded, sheltered and located away from waterways and drains. Safety data sheets (SDS) should be kept together with the stored chemicals • Any construction equipment which causes pollution to the water system due to leakage of oil or fuel should be maintained or removed off-site immediately. • Spillage or leakage of chemical waste to be controlled using suitable absorbent materials. Used absorbent materials should be disposed through a licensed third-party toxic industrial waste disposal contractor. • Secondary containment with capacity of more than 10% volume for single large container and 25% of the total volume of multiple containers should be used for all chemical stores and diesel generators to minimise spillages and contamination of soil and surface water. Care should be taken around water channels to avoid toxic chemicals such as petrol/ diesel/ oil/ paint/ thinner leak from equipment. • Emergency response procedures shall be developed and implemented. • Good housekeeping practices shall be implemented to minimise 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. • Any soil contaminated with chemicals or oils shall be removed from site and sent to a licensed third-party toxic industrial waste collector for offsite disposal. The void created shall be filled with suitable materials.	• Develop waste register, handling, storage and disposal procedures for the Project. • Develop and implement emergency response procedures for the Project. • Implement recommended mitigation measures.	Construction	**Minor Negative (ES: -66)**

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
WQ-I4	Water quality deterioration due to discharge of trade effluent from construction activities	**Moderate Negative (ES: -132)**	• A temporary drainage channel and associated facilities shall be provided to collect the runoff generated and prevent concrete-contaminated water from entering watercourses. The trade effluent must be isolated and collected and may be treated offsite before being discharged if there are space constraints. Adjustment of pH can be achieved by adding a suitable neutralising reagent to wastewater prior to discharge. The treated water from construction activities be treated to levels prescribed by NEA/ PUB and must have written approval from NEA/ PUB if it will be discharged into public drains/ sewer. • Appropriate concrete wash out areas should be provided and should not be performed in or near any of the streams. • If on-site treatment is not feasible, wastewater must be stored separately and collected by licensed third-party toxic industrial waste collector for offsite treatment.	• Provide temporary drainage channel and associated facilities to collect runoff generated. • Provide concrete wash out areas that are near any of the streams. • Treat wastewater in accordance with Waste Management Plan established for the Project. • Implement recommended mitigation measures.	Construction Phase	**Minor Negative (ES: -66)**
Environmental Aspect: Airborne Noise						
N-I1	Noise emission from construction activities to NSR 1, NSR 2 and NSR 3	**Minor Negative (ES: -40 to -80)**	1. Use engineering methodology to control noise at source, such as: Noise enclosure, noise screen/ noise panel, portable noise barrier, quieter construction methodology 2. Implement industry best practices: ▪ Only well-maintained PME should be operated on-site and should be serviced regularly during the construction. ▪ The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the NSRs. ▪ Use of alternative equipment with less noise emission such as use of rubber mallets instead of metal hammer ▪ Care shall be taken during loading or unloading, dismantling or moving materials to reduce impact noise. ▪ Silencers or mufflers on PME (e.g. generator sets) should be utilized and should be properly maintained during the construction. ▪ Mobile PME, if any, should be sited as far from NSRs as possible. ▪ PME (such as trucks and cranes) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum possible. ▪ PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the nearby NSRs. ▪ Noisy construction activities shall be avoided at nights and Sundays and public holidays when the noise limits are more stringent. 3. (Fauna) Consider limiting heavy construction working hours to 8am to 6pm where possible to avoid the timings when crespular species may be active. Toolbox meetings and winding down of work can be done outside of these hours. 4. (Fauna) Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense.	• Contractor to engage ECO and public relations officer (PRO) as stipulated in Section 3 of Code of Practice for Environmental Control Officers (COP for ECO). • ECO to prepare the Site Environmental Control Program in accordance with the format in Appendix 4 of COP for ECO, which is to be submitted by Contractor to Director-General of Public Health of NEA two weeks before the commencement of construction. Contractor should implement Environmental Control Programme specific to the construction works undertaken by the contractor. • ECO to prepare and submit bi-weekly Site Environmental Control Report to Contractor in accordance to the format in Appendix 5 of COP for ECO. • Contractor should engage Public Relation Officer (PRO) to establish good rapport with the community, handle and feedback complaints from the community. • Establish a noise management plan (NMP) to help to implement noise mitigation measure. The suggested NMP template is indicted in Annex H of SS 602: 2014. • Install Noise Barrier (6 m high, actual height of noise barriers subject to site constraints and further noise construction assessment during EMMP stage once method statements and equipment inventory are available) along the site boundary facing affected NSRs following the specification as indicate in this EIS. • Noise enclosure. • Noise screen/ noise panel. • Portable noise barrier. • Conduct continuous real time noise monitoring using Type 1 sound level meter with data logging following the recommended performance monitoring programme.	Construction Phase	**Minor Negative (ES: -40)**
N-I2	Noise emission from construction activities to Fauna of priority/ sensitivity level - high	**Minor to Major Negative (ES: -99 to -297)**				**Minor to Major Negative (ES: -99 to -297)**
N-I3	Noise emission from construction activities to Fauna of priority/ sensitivity level - medium	**Minor to Moderate Negative (ES: -66 to 198)**				**Minor to Moderate Negative (ES: -66 to -198)**
N-I4	Noise emission from construction activities to Fauna of priority/ sensitivity level - low	**Minor Negative (ES: -20 to -60)**				**Minor Negative (ES: -20 to -60)**

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
Environmental Aspect: Ambient Air Quality						
A-I1	Ambient air quality deterioration due to fugitive dust emissions from construction activities	**Moderate Negative (ES: -120)**	• Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeter to reduce dust deposition at adjacent areas. • Tree felling activity shall be in a way that minimise dust generation, e.g. using dust suppression and do not oversize the root ball trenching. • Construction site perimeters and adjacent roads or lands shall be regularly inspected to check for dust and if necessary, remove dust deposition. • Keep extent of excavation and soil exposure areas to minimum required for construction. • Exposed soil and dusty material at the construction site and its boundary shall be dampened with water regularly, with the misting frequency increased during dry periods. • Exposed site shall be properly treated by compaction, turfing, vegetation planting or sealing with bituminous materials, concrete or other suitable materials as soon as practicable after project completion. Treat exposed earth by compaction, hydro seeding, vegetation planting, or cover with impermeable sheeting. • Stockpiles and excavations shall be removed, backfilled or reinstated (as appropriate) by contractor as soon as practicable following excavation or unloading. If contractor needs to store excavated material on site, it will be entirely covered with impervious sheeting and the stockpile shall be removed as soon as practicable. • Load of dusty materials on a vehicle leaving a construction site shall be covered entirely with impervious sheeting by contractor. Vehicle should not be overloaded and shall be cleaned prior to leaving the site. • Proper cover for vehicle to avoid falling of soil debris. Any skip hoist used to transport dusty materials shall be completely enclosed by impervious sheeting. • Vehicle washing facilities with high pressure water jets shall be provided by contractor at every discernible or designated vehicle exit point from construction site. Vehicle washing area and road section between washing facilities and exit point shall be paved. • If roadways are contaminated with dusty materials from construction site, clean-up shall be conducted without delay. • Vehicle on-site speed restrictions shall be imposed by contractor to prevent dust being whipped up by vehicle movements. • All fuel-burning machinery or transport vehicles shall be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke. • Reduce vehicle idling and traffic congestion, and minimise distance travelled for delivery of material.	• Ambient air quality parameters SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ at location A1, A2 and A3 shall be sampled under the southwest monsoon (June to September) period prior to construction commencement. • Alternatively, carry out the pre-construction measurement during inter-monsoon period (late March to May). • Contractor to inform and initiate discussion with NEA should the construction schedule does not allow the pre-construction measurement during southwest monsoon season or inter-monsoon period. • If ambient air quality for pre-construction measurement and monitoring is conducted using monitoring device non-certified by USEPA as FRM or FEMs (e.g. air quality sensor), EMMP consultants shall conduct their own collocation testing and calibration with a USEPA FRM/FEM equipment, to verify the equipment's performance prior to deployment to the Project site. • Conduct performance monitoring of ambient air quality following the recommended Performance Monitoring Regime in this specification. • Engage ECO as stipulated in Section 3 of Code of Practice for Environmental Control Officers (COP for ECO). • ECO to prepare the Site Environmental Control Program in accordance with the format in Appendix 4 of COP for ECO, which is to be submitted by Contractor to Director-General of Public Health of NEA two weeks before the commencement of construction. Contractor should implement Environmental Control Programme specific to the construction works undertaken by the contractor. • ECO to prepare and submit bi-weekly Site Environmental Control Report to Contractor in accordance with the format in Appendix 5 of COP for ECO. • Implement recommended mitigation measures.	Pre-Construction Phase/ Construction Phase	**Minor Negative (ES: -80)**

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
A-I2	Ambient air quality deterioration due to exhaust emissions from construction fuel-burning equipment, machinery and vehicles	**Minor Negative (ES: -80)**	• All fuel-burning machinery or transport vehicles should be regularly maintained according to manufacturer's maintenance recommendation, and use clean fuel if possible, and must not emit dark smoke. • Exhaust emitted from vehicle and equipment should be controlled by good practice procedures, such as turning off equipment when not in use.	• ECO to prepare and submit to Director-General of Public Health of NEA the Site Environmental Control Programme in accordance to the format in Appendix 4 of COP for ECO two weeks before the commencement of construction. • ECO to prepare and submit bi-weekly Site Environmental Control Report to the Occupier of Construction Site (e.g. Project Manager and Project Director) in accordance to the format in Appendix 5 of COP for ECO.	Monthly, during all stages Construction Phase	**Minor Negative (ES: -40)**
Environmental Aspect: Visual and Landscape						
V01	Major negative visual change at higher floors, > 8th floor, of Block 485A Choa Chu Kang	**Moderate Negative (ES: -156)**	• Selective thinning of perimeter vegetation should be done to continue to screen views into the EIS Study Area. • Phased felling should be undertaken to spread out the impact from the reduction of forest extent which is sensitive to viewers. • Construction perimeter hoarding could be built higher and display visuals of the new town development or use green walls.	• Mitigation techniques to be passed on as part of Contractor's tender requirements. • Selection and design of construction perimeter hoarding to be discussed and decided on prior to construction.	Pre-construction and Construction Phase	**Moderate Negative (ES: -156)**
V02	Moderate negative visual change at Block 490A Choa Chu Kang Ave 5	**Moderate Negative (ES: -104)**				**Moderate Negative (ES: -104)**
V03	Minor negative visual change at Bus Stop – Blk 490B	**Minor Negative (ES: -52)**				**Minor Negative (ES: -52)**
V04	Major negative visual change at higher floors, > 9th floor, of Block 805B Keat Hong Close	**Moderate Negative (ES: -156)**				**Moderate Negative (ES: -156)**
V05	Minor negative visual change at MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations	**Minor Negative (ES: -52)**				**Minor Negative (ES: -52)**
V09	Minor positive visual change at Intersection between Bukit Batok Road and Bukit Batok West Avenue 2	**Minor Positive (ES: 52)**				**Minor Positive (ES: 52)**
V10	Moderate negative visual change at higher floors, above 5th floor, Block 426 Bukit Batok West	**Moderate Negative (ES: -104)**				**Moderate Negative (ES: -104)**
V06	Minor negative visual change at Pavilion Circle	**Minor Negative (ES: -52)**	• Strategic retention and protection key cluster of trees of aesthetic value which can be designed into Tengah Town Development plans.	• Re-parcelling of land use to incorporate selected features. • Design consideration for smaller features to be passed on to designers.	Planning/ Pre-construction Phase	**Negligible (ES: 0)**

ID	Impact Register	Impact Significance/ ES	Recommended Mitigation/ Enhancement Measure	Required Action[13]	Timing of Action	Residual Impact Significance
V07	Minor negative visual change at Bus Stop – Aft Bukit Batok West Ave 5	**Minor Negative (ES: -52)**	• Areas of high ecological conservation value in the southern side should be preserved and rehabilitated to screen views.			**Negligible (ES: 0)**
V08	Major negative visual change at higher floors, above 8th floor, Block 405 Bukit Batok West	**Moderate Negative (ES: -156)**				**Minor Positive (ES: 52)**
Environmental Aspect: Waste						
W-I1	Impact of generation of wood waste (Direct)	**Moderate Negative (ES: -120)**	• Examine the possibilities of using woody waste material as park furnishing or for upcycling into other materials. • Examine the possibility of retaining larger sections of the woody trees in line with ecological conservation suggestions and to reduce the amount of wood felling • A routine schedule and recycling plan can be set up for horticultural waste based on the various volume produced at different construction stages. • All horticultural waste should be transported off-site to specialised horticultural recycling facilities where they can be grinded into wood chips which can be turned into mulch or compost. Where possible, wood recycling as wood chips into new wood products by mixing it with binders should be prioritised. • Horticultural waste which is not suitable to be recycled should be used as fuel in biomass power plants.	• Design consideration for retainment of natural features and reuse of woody materials to be passed on to designers and design contractors. • Mitigation techniques to be passed on as part of Contractor's tender requirements	Planning/ Pre-construction / Construction	**Minor Negative (ES: -60)**
W-I2	Impact of generation of wood waste (Indirect)	**Critically Negative (ES: -576)**				**Major Negative (ES: -384)**
W-I3	Impact of generation of C&D waste	**Moderate Negative (ES: -132)**	• Build for deconstruction and design to standard material sizes to allow future modification or decommissioning occurs, the entire structure can be taken apart and reused with ease and minimal waste. • To have proper segregation and storage of construction waste to extract recoverable and recyclable materials. • Waste concrete from demolition could also be recycled into recycled concrete aggregate and used in buildings and roads in Tengah.	• Mitigation techniques to be passed on as part of Contractor's tender requirements.	Planning/ Pre-construction / Construction	**Minor Negative (ES: -66)**
W-I4	Impact of generation of hazardous/ toxic Industrial waste	**Moderate Negative (ES: -132)**	• Separate the different forms of hazardous waste, provide treatment on site if applicable and set up protocols for spillage. • Implement strict waste handling, storage, on-site treatment, and disposal practices to prevent leakages. • Review the hazardous/ toxic elements being used and examine the more environmentally friendly substitutes available.	• Mitigation techniques to be passed on as part of Contractor's tender requirements.	Planning/ Pre-construction / Construction	**Minor Negative (ES: -66)**
W-I5	Impact of generation of municipal waste	**Minor Negative (ES: -22)**	• Provision of well-labelled recycling bins alongside every trash bins. • Provide adequate garbage/ trash bins with tight lid (animal-proof bin) to prevent animals from getting into it. • Biodigesters or composting stations could be introduced onsite to deal with food waste generated by workers, converting it into grey water or compost which can then be reused onsite.	• Mitigation techniques to be passed on as part of Contractor's tender requirements.	Construction	**Slight Negative (ES: -11)**
W-I6	Impact of generation of sewage waste	**Moderate Negative (ES: -132)**	• Provide sufficient and maintain proper sanitary facilities at the worksite and connect discharge points to septic tanks and or the public sewage for disposal. • Sewage not connected to the main sewage system has should have sufficient storage capacity and a clearance schedule that matches the volume being produced.	• Sewage capacity modelling should be done prior to construction and can be passed on as part of Contractor's tender requirements.	Planning/ Pre-construction / Construction	**Minor Negative (ES: -66)**

Table 12.3: Implementation Matrix for Recommended Mitigation/ Enhancement Measures over Construction Contract Period for Ecology and Biodiversity Aspects

Potential Ecological Impact	Biodiversity-sensitive Habitat Receiver	ES (Pre-mitigation)	Impact Significance	Mitigation Measures	ES (Post Mitigation)	Residual Impact Significance
Loss of vegetation/habitat	Abandoned-land Forest with Native Regeneration	-351	Major Negative	Without mitigation, 1 ha (100%) of abandoned-land forest with native regeneration, 31.3 ha (54.7%) of abandoned-land forest, 18.1 ha (49.9%) of scrubland/herbaceous vegetation and 12.6 ha (45.5%) of waste woodland will be affected. Mitigation measures: ▪ **Avoid**: Complete retention of the abandoned-land forest with native regeneration & its 30-m buffer by redesigning the road alignment. ▪ **Minimise**: Retention of 2.5 ha (4.3%) of abandoned-land forest (vegetation corridor along north-eastern boundary). ▪ **Minimise**: Retention of 1.9 ha (4.9%) of scrubland/herbaceous vegetation (vegetation corridor along north-eastern boundary). ▪ **Minimise**: Retention of 2.2 ha (3.7%) of waste woodland (vegetation corridor along north-eastern boundary). ▪ **Minimise**: Keep sensitive habitats affected by works as long as possible before clearance. ▪ **Compensate**: Creation of open-country pond (Pond1, Pond2) as an ABC Water Feature. ▪ **Enhance**: Enhancement of vegetation corridor along the north-eastern boundary	0	Not Impacted
	Abandoned-land Forest	-351	Major Negative		-234	Major Negative
	Waste Woodland	-234	Major Negative		-234	Major Negative
	Scrubland and Herbaceous Vegetation	-234	Major Negative		-156	Moderate Negative
	Closed-canopy Stream (ED2)	-324	Major Negative		-324	Major Negative
	Closed-canopy Stream (ED7)	-324	Major Negative		0	Not Impacted
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	Major Negative		-234	Major Negative
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	Moderate Negative		-216	Moderate Negative
	Open-country Ponds (Pond1 and Pond2)	-216	Moderate Negative		-216	Moderate Negative
	Main Canal	-44	Minor Negative		Since only minimal impacts are expected, no residual impacts are presented.	
Loss of ecological connectivity	Abandoned-land Forest with Native Regeneration	-351	Major Negative	The loss of ecological connectivity is largely associated with habitat loss and fragmentation. As such, it includes the mitigation measures for habitat loss listed above. Additional considerations/measures for ecological connectivity are: ▪ **Minimise**: Vegetation corridor along north-eastern boundary provides a stepping stone habitat for fauna to disperse to Bukit Batok/Gombak forest in the north-east. ▪ **Compensate**: Provision of grade-separated wildlife crossings within site (including use of drains and streams). ▪ **Compensate**: Provision of wildlife crossings to surrounding green spaces (i.e. Bukit Batok/Gombak forest through Bukit Batok Avenue 5 and Bukit Batok Hillside Park through Bukit Batok Avenue 2). ▪ **Compensate**: Connect planted vegetation to retained habitats or corridors to maximise connectivity throughout the site. ▪ **Enhance**: Enhancement of habitats along wildlife crossings. ▪ **Enhance**: Enhancement of habitats to surrounding green spaces (i.e. along Bukit Batok Avenue 2 and 5).	0	Not Impacted
	Abandoned-land Forest	-351	Major Negative		-234	Major Negative
	Waste Woodland	-234	Major Negative		-156	Moderate Negative
	Scrubland and Herbaceous Vegetation	-234	Major Negative		-156	Moderate Negative
	Closed-canopy Stream (ED2)	-324	Major Negative		-324	Major Negative
	Closed-canopy Stream (ED7)	-324	Major Negative		0	Not Impacted
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-234	Major Negative		-234	Major Negative
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-216	Moderate Negative		-216	Moderate Negative
	Open-country Ponds (Pond1 and Pond2)	-216	Moderate Negative		-216	Moderate Negative
	Main Canal	-72	Minor Negative		Since only minimal impacts are expected, no residual impacts are presented.	

Potential Ecological Impact	Biodiversity-sensitive Habitat Receiver	ES (Pre-mitigation)	Impact Significance	Mitigation Measures	ES (Post Mitigation)	Residual Impact Significance
Habitat pollution	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Habitat pollution may occur to retained habitats within and outside the Project works, including the abandoned-land forest with native regeneration and closed-canopy streams (ED2 and ED7). Key mitigation measures are: ▪ **Avoid**: Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise**: Adhere strictly to working space and practise good housekeeping to minimise unnecessary and unauthorised clearance of retained habitats within and outside the Project. ▪ **Minimise**: Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. ▪ **Minimise**: Retain ground cover for as long as possible. When ground cover is removed, erosion control measures (e.g. erosion control blankets, silt fence and sandbags) are to be in place. ▪ **Minimise**: Engage a qualified erosion control professional to formulate and implement ECM plan in accordance with pub requirements. ▪ **Minimise**: Monitor the water quality and aquatic faunal community in retained streams and vegetation adjacent to the Project works. ▪ **Minimise**: Conduct regular inspections for compliance and identify any impacts/unnecessary clearance in adjacent forest areas and retained habitats.	-216	**Moderate Negative**
	Abandoned-land Forest	-198	**Moderate Negative**		-66	**Minor Negative**
	Waste Woodland	-88	**Minor Negative**		Since only minimal impacts are expected, no residual impacts are presented.	
	Scrubland and Herbaceous Vegetation	-88	**Minor Negative**		Since only minimal impacts are expected, no residual impacts are presented.	
	Closed-canopy Stream (ED2)	-180	**Moderate Negative**		-60	**Minor Negative**
	Closed-canopy Stream (ED7)	-180	**Moderate Negative**		-60	**Minor Negative**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-132	**Moderate Negative**		-44	**Minor Negative**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-132	**Moderate Negative**		-44	**Minor Negative**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	
Habitat degradation	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Habitat degradation may occur to retained habitats within and vegetation on the boundary of the Project works. Key mitigation measures are: ▪ **Avoid**: Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise**: Provide sufficient hydrological flow within retained waterbodies. ▪ **Minimise**: Conduct regular inspections for compliance and identify any impacts/unnecessary clearance in adjacent forest areas and retained habitats. ▪ **Enhance**: Enhancement of conserved habitats and its buffer.	-216	**Moderate Negative**
	Abandoned-land Forest	-234	**Major Negative**		-156	**Moderate Negative**
	Waste Woodland	-104	**Moderate Negative**		-52	**Minor Negative**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative**		-52	**Minor Negative**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative**		-72	**Minor Negative**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative**		-72	**Minor Negative**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-156	**Moderate Negative**		-52	**Minor Negative**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-156	**Moderate Negative**		-52	**Minor Negative**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	

Potential Ecological Impact	Biodiversity-sensitive Habitat Receiver	ES (Pre-mitigation)	Impact Significance	Mitigation Measures	ES (Post Mitigation)	Residual Impact Significance
Change in species composition	Abandoned-land Forest with Native Regeneration	N.A. (cleared during construction phase)		Change in species composition may occur from forest edge effects, hence mitigation measures from habitat degradation would also apply. Additional mitigation measures are: ▪ **Avoid**: Clear demarcation of conserved areas. Do not encroach into the conserved habitats and its 30-m buffer. Review development plans and construction methods to minimise impacts. ▪ **Minimise**: Quarantine plant materials at external nursery before transferring to site.	-234	**Major Negative**
	Abandoned-land Forest	-234	**Major Negative**		-156	**Moderate Negative**
	Waste Woodland	-104	**Moderate Negative**		-52	**Minor Negative**
	Scrubland and Herbaceous Vegetation	-104	**Moderate Negative**		-52	**Minor Negative**
	Closed-canopy Stream (ED2)	-216	**Moderate Negative**		-72	**Minor Negative**
	Closed-canopy Stream (ED7)	-216	**Moderate Negative**		-72	**Minor Negative**
	Open-country Streams (Spring, ED1, ED6 and ED8_01)	-104	**Moderate Negative**		-52	**Minor Negative**
	Closed-canopy & Semi Open-Country Ponds (Pond6, Pond3, Pond4, Pond5 and ED8_02)	-104	**Moderate Negative**		-52	**Minor Negative**
	Open-country Ponds (Pond1 and Pond2)	N.A. (cleared during construction phase)			N.A. (cleared during construction phase)	
	Main Canal	N.A. (transformed into Forest Stream)			N.A. (transformed into Forest Stream)	

12.3.8 Environmental Performance Monitoring Regime

The objective of environmental performance monitoring is to check for compliance with the EMMP by monitoring the construction activities of the Project. This will include monitoring of the actual impacts of the proposed activities on selected sensitive receptors so that impacts that have not been anticipated in the EIS or impacts which exceed the levels anticipated in the EIS can be identified and appropriate mitigation measures can be adopted promptly.

As required by Environmental Public Health Act (EPHA) (Registration of Environmental Control Officers) Regulations, there will be inspection and reporting scheme required to be performed by the appointed ECO and ECMO for the following environmental aspects:

- **Hydrology and water quality** – recommendations from this EIS have been made on best management practices as well as erosion and sedimentation control measures that required an ECM plan which is under the purview of the Contractors (via engagement of the QECP) in compliance with applicable legislation enacted by PUB.
- **Ambient air quality** – there is currently no construction dust standard in Singapore for compliance, mitigation/ enhancement measures recommended in this EIS (refer to **Table 12.2**) would be sufficient to control the impacts with daily visual inspection by ECO for verification of effectiveness of control measures. Ambient air quality should be measured prior to construction under the southwest monsoon season/ inter-monsoon period and during construction phase for full parameters (i.e. PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO) to have a full representation of the construction area. If ambient air quality for pre-construction measurement and monitoring is conducted using monitoring device non-certified by USEPA as FRM or FEMs, EMMP consultants shall conduct their own collocation testing and calibration with a USEPA FRM/FEM equipment, to verify the equipment's performance prior to deployment to the Project site
- **Landscape and visual** – there are currently no standards for performance tracking of landscape and visual impacts in Singapore. With implementation of mitigation measures, grievance mechanism to be established as part of the stakeholder engagement plan is recommended (refer to **Section 12.3.11**).
- **Waste** – daily visual inspection by ECO on compliance and verification of EMMP implementation is recommended. Waste Management Plan during construction recommended in **Section 12.3.6.4** forms the basis of Contract Specific EMMP for the Contractors.

For flora/trees and fauna that are typically not included in inspection regime of ECO/ECMO, the specification recommended for performance monitoring is given in sections below:

12.3.8.1 Performance Monitoring for Airborne Noise

Environmental Objectives	To monitor the noise levels at affected community and at affected fauna receptors and check the noise level against the stipulated standard and required key performance indicators.
Standards/ Regulations	For affected community: EPM (Control of Noise at Construction Sites) Regulations, Second Schedule For affected fauna: within 5 dBA increment from baseline noise level
Parameters	L_{Aeq} 12 hours and L_{Aeq} 5 mins
Monitoring Specification	NEA's Approved Class 1 Integrating Sound Level Meter (real time)
Monitoring Frequency	During construction
Monitoring Duration	Continuous
Monitoring Location	• For Affected community (NSR 1, NSR 2 and NSR 3) at the same locations (N1 – N3) as baseline noise monitoring at all stages

	• Additional locations for NSR 1, NSR 2 and NSR 3 at building rooftop only during Stage 4 – Building. • For Affected fauna (NSR 4 and NSR 5) at all stages: at the site boundary adjacent to forested area.
Reporting Frequency	Monthly
Qualification of Monitoring Personnel	-

12.3.8.2 Performance Monitoring for Ambient Air Quality

Environmental Objectives	To monitor the ambient air quality at affected community (before and during construction) and check against the stipulated standard and required key performance indicators.
Standards/ Regulations	SAAQT
Parameters	24-hour mean PM_{10} and $PM_{2.5}$ 24-hour mean SO_2 1-hour mean NO_2 8-hour mean O_3 1-hour mean CO and 8-hour mean CO
Monitoring Specification	Portable air quality sensor
Monitoring Frequency	Before construction: • One time (during southwest monsoon season/ inter-monsoon period) During construction: • One time per construction stage (i.e. Advance, Earthworks, Infrastructure and Building) • One time per complaint event (if any)
Monitoring Duration	Before construction: • One week (7 consecutive days, including one weekend) During construction: • One week (7 consecutive days, including one weekend)
Monitoring Location	Identified three ASRs during EIS stage: • A1 (Block 484B Choa Chu Kang Avenue 5 • A2 (Block 805C Kean Hong Close) • A3 (Block 405 Bukit Batok West Ave 7)
Reporting Frequency	Each sampling/ monitoring event
Qualification of Monitoring Personnel	Laboratory accredited by the Singapore Accreditation Council, supervised by contractor's ECO

12.3.9 Environmental Audit Monitoring Regime

The purpose of environmental auditing is to provide an independent check that appropriate environmental management is taking place in accordance with statutory requirements and the EMMP. The environmental audit

will also review the results of monitoring undertaken during the construction phase to identify the need for any additional environmental management or mitigation measures to be implemented.

The scope of the Environmental Audit shall cover all the environmental issues relating to construction that are addressed in this EIS report and by this EMMP. The Environmental Audit shall be undertaken by the Developing Agency appointed third party consultant. The activities to be undertaken as part of an environmental audit include:

- Examination of the environmental incidents and complaints log.
- Examination of the environmental register, including results of monitoring.
- Interviews with the Contractor's Project Manager, Contract Specific EMMP representative(s) and ECO and other site staff as required.
- Consultation with relevant statutory authorities, where appropriate.
- Visual examination of the site, to examine working practices, environmental effects, mitigation measures and monitoring activities.

It is recommended the environmental auditing to be carried out on quarterly (i.e. every three months) basis throughout the construction phase.

12.3.10 Contingency Plan

In order to safeguard the environment and workers health and safety, the construction contract specification should include the requirement for Contractors to develop an Emergency Preparedness and Response Plan for any emergency/ incidents/ accidents happen during construction according to the regulations/ guidelines (e.g. Environmental Protection and Management Act, Environmental Public Health Act, Building Control Act, Control of Vectors and Pesticides Act, Code of Practice on Surface Water Drainage, National Heritage Board Act, Parks and Trees Act and Sewerage and Drainage Act).

The plan should include environmental related emergency/ incidents (i.e. spillage, wildlife incident) which should cover the following recommended specifications:

- Emergency contact personnel and contact detail (internal and external contact).
- Emergency contact organisation, include first and second point of contact.
- Incident response notification procedures and action flow chart.
- Response reporting timeframe.
- Reporting requirement (date, time, location, incident encounter, reporting person and witness) and reporting timeframe (i.e. within 24 hours of an incident happen).
- Reporting flow, i.e. report should be prepared by Contractor's appointed Ecologist/ EMMP Team and ultimately reporting to Developing Agency.

12.3.11 Stakeholder Engagement and Communication Plan

A specific Stakeholder Engagement Plan and Grievance Mechanism procedures should be established as part of the Contract Specific EMMP with the following specifications:

- Stakeholder identifications and analysis.
- Information disclosure. The type of information should be on environmental impacts and public safety concerns.
- Stakeholder consultation requirement.

- Communication channel where project information can be shared and communicated to affected communities and public to provide greater transparency and help in allaying uncertainty or misconceptions about the project.
- A grievance mechanism/ procedure to handle feedback and complaints to incorporate input from various stakeholders and public.
- Organization chart with roles and responsibilities for stakeholder engagement and grievance mechanism.
- Documentation and investigation procedures.
- Performance monitoring and evaluation of effectiveness of plan.

13. Conclusion

The Project is located in an area of ecological and hydrological importance and is a part of the largest remaining patch of forest within the Kranji Reservoir Catchment that serves as critical wildlife connection pathway between nature reserves (i.e. Central Catchment Nature Reserve (CCNR), Bukit Timah Nature Reserve and Western Water Catchment Area). Therefore, the Project development (i.e. land use changes and construction activities) in conjunction with other planned developments in the vicinity potentially bring significant cumulative impacts to the ecological and non-ecological aspects/ sensitive receivers in the area that are classified as important to the local and regional context.

Following the establishment of baseline conditions, the EIS has assessed and evaluated the impact significance qualitatively and quantitatively with Environmental Scores (ES) given for each impact register according to the modified Rapid Impact Assessment Matrix (RIAM) tool. The impact assessment has found the impact significance of the Project's construction activities to non-ecological aspects mostly ranged from minor to moderate negative impacts. While for ecology and biodiversity aspects, habitat loss, wildlife connectivity and noise impacts were found with critically and major negative effects. The EIS had identified 30% of the EIS Study Area that carries significant biodiversity value worth for conservation, this area termed as the Recommended Area of Conservation (RAC) has been demarcated for careful land use planning.

Mitigation measures are recommended according to the mitigation hierarchy (avoidance, minimisation, enhancement and compensation) and designed to reduce the residual impact resulting from direct and/or indirect cumulative impacts to as low as reasonably practical (ALARP). The recommended mitigation measures together with the embedded measures required by the applicable regulations and Code of Practice (COP) have been incorporated into an Environmental Management and Monitoring Plan (EMMP), which has been formulated as an implementation tool for contractors to adopt during the construction phase of the Project.

The EIS has assumed that the Project development would be designed and undertaken in accordance with gazetted Tengah Master Plan, regulatory requirements and the recommended mitigation measures from this EIS.

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Appendix 4A: Factual Report

Report Reference: GIE/ INS20004

FACTUAL REPORT ON
INSTRUMENTATION & MONITORING WORKS AT
TENGAH FOREST AREA

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SINGAPORE ACCREDITATION COUNCIL
Cert No: IB-2016-142-F

Certification by Professional Engineer for Site Investigation Report

1. I, Kevin Quan Chee Nurn the Professional Engineer, PE Registration No. 4102 certify that **"Factual Report on Instrumentation & Monitoring Works at Tengah Forest Area"** comprising all field and/or laboratory data, tests and results therein has been carried out by me or under my supervision or direction and I have verified the accuracy of the information given in the site investigation report and to the best of my knowledge and belief, all have been prepared in compliance in all respects with the provisions of the Building Control Act and Regulations, relevant Codes of Practice and Standards.

2. I further certify that I have the appropriate qualifications and experience, and I am familiar with the purpose of the investigation for which this Site Investigation Report is prepared in reference to Project Ref. No:_____

3. Total number of pages in the Site Investigation Report of is **175** (excluding cover page).



Kevin Quan Chee Nurn
Professional Engineer for Site Investigation

Date: 16 June 2020

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Figure 01 Borehole Location Plan

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Terms and Symbols Used on Borehole Logs

Final Borehole Logs

Water Standpipe Installation and Monitoring Data

Field Borehole Logs

This report has been submitted on a confidential basis and is not for use by any other persons, nor may it be reproduced. By accepting delivery of this report, the recipient agrees not to divulge the contents to any other parties without the prior agreement from Ground Instrumentation & Engineering Pte Ltd.

1.0 INTRODUCTION

M/s Ground Instrumentation & Engineering Pte. Ltd. (GIE Pte Ltd) has been awarded the works of “Instrumentation & Monitoring Works at Tengah Forest Area” for Jacobs Singapore Pte Ltd, Singapore.

The investigation includes drilling of Eight (08) boreholes with excavation of trial pits and Eight (08) Water Standpipes, with associated in-situ testing as well as laboratory testing on selected retrieved soil samples.

The purpose of the investigation was to obtain geotechnical information on the subsoil conditions at the proposed site.

The Borehole Location Plan is presented in Figure 1.

The field investigation was conducted between 3 March 2020 & 13 March 2020. The Lab testing for Samples were conducted thereafter in SAC-SINGLAS accredited GIE in-house Laboratory.

This Report presents the results of the field investigation and laboratory tests conducted for the investigation.

2.0 SCOPE OF WORKS

The scope of works as stipulated in Contract Specification is detailed as follows:

1. Obtaining all the permits, access and permission from all the relevant authorities prior to commencement of any works at the site.
2. Obtaining all the Cable and pipeline drawings from the relevant Authority to verify the presence of any services and utility lines along the soil investigation locations.
3. Mobilisation and demobilisation of in-situ test equipment, rotary drilling rigs, necessary equipment and personnel to the project site.
4. Excavation of Eight (08) numbers of Trial Pits

5. Drilling and sampling boreholes with undisturbed sampling as specified by the project consultant.
6. Installing and monitoring of Eight (08) water standpipes
7. Full time field supervision by geologist during the course of the fieldwork.
8. Conducting laboratory testing for selected soil samples to evaluate the pertinent physical and engineering characteristics of the soil underlying the project site.
9. Preparing factual report summarizing our findings of field and laboratory investigations and conclusion based on the subsurface condition revealed through the investigation.

3.0 REFERENCES / CODE OF PRACTICES

Soil investigation was carried out in compliance with Euro Code 7. The soil description and geological classification is described with relevant EC standards (EN ISO 14688, EN ISO 14689).

The standard followed for the entire investigation are:

a) Eurocode 7 SS EN 1997 – 2:2010
b) Singapore National Annex to SS EN 1997 – 2:2010
c) Geotechnical Investigation and Testing – Identification and Classification of Soils BS EN ISO 14688; 2018
d) BS 1377-1:1990: Methods of test for soils for civil engineering purposes. General requirements and sample preparation

In compliance to the requirement of Field testing, SPTs, all SPT hammers were calibrated and Calibration Certificate of the hammers are appended in Appendix A.

4.0 EQUIPMENT

TOHO rotary drilling rig was used for drilling the boreholes. Hand auger and manual excavation were conducted for trial excavation for top 3.0m of subsoil. Thin Walled/ Mazier Sampler were used for collecting undisturbed samples. Laboratory testing was

conducted using standard equipment for the respective laboratory testing in a SAC-SINGLAS accredited GIE in-house laboratory.

5.0 METHODS OF FIELD INVESTIGATION

5.1 General

The fieldworks for this project were started after obtaining all the necessary approvals. Drilling of the boreholes was commenced on 14 March 2020.

5.2 Setting Out

Setting out of instruments location was carried out by the client.

5.3 Exploratory Boreholes

TOHO rotary drilling rig utilizing rotary wash techniques was used to drill the boreholes into the underlying hard layer. Flush jointed casings with nominal diameters of 100 mm were used to stabilize and prevent collapse of the borehole walls. A tricone roller bit/drag bit was used to advance the borehole and water was used as the flushing medium.

Sampling was performed at different depth intervals over the depth drilled and the interval was varied in order to suit the ground strata encountered. Undisturbed soil samples were recovered by means of a thin-walled/thick walled sampler.

Thin-walled undisturbed push samples are collected from the soft to firm cohesive soil layers by pushing a 76 mm-diameter thin-walled sampling tube into the soil by the static thrust of the drilling rig. Undisturbed samples were collected or attempted by Mazier core barrel sampler with brass lined inner barrel protrusion. The inner barrel collects the cored samples for further testing. The cutting shoe of the bottom inner barrel is substantial, making it less likely to be damaged but does introduce disturbance when high area ratio shoe travels ahead of the core bit.

The logging of boreholes was carried out by geologist with wide experience on subsoil and geological condition of the site. The logging was carried out in accordance with Eurocode 7.

5.4 Water Standpipe Installation & Monitoring

Water Standpipes are installed in the following boreholes locations.

Borehole No	Installation Depth, m (bgl)
BH 01/WSP-01	8.50
BH 02/WSP-02	10.50
BH 03/WSP-03	8.00
BH 04/WSP-04	6.00
BH 05/WSP-05	6.00
BH 06/WSP-06	6.00
BH 07/WSP-07	8.50
BH 09/WSP-08	9.00

Installation and monitoring record sheets are attached in Appendix A.

6.0 LABORATORY TESTING

On the basis of the borehole logs, a programme of laboratory testing was to be developed by Project Geotechnical Engineer to obtain the relevant material properties of the soil strata at the project site for engineering design.

The laboratory testing program was formulated to obtain:

- Sufficient data such that the different soil strata can be adequately identified and classified.
- The relevant strength and deformation properties of the subsurface soils required for foundation design.

The undisturbed samples were extruded from their sampling tubes, examined and visually classified. Selected undisturbed samples recovered were tested to determine index properties undrained shear strengths, drained strength parameters via

classification tests, Triaxial compression tests. All samples were examined by a soil technician and checked against the laboratory test results before final description.

Lab test results are attached in Appendix B.

Prepared By	***Checked By***
Jamil Un Nabi	**Mohiuddin Ahamad**
Geotechnical Engineer	General Manager

GROUND INSTRUMENTATION AND ENGINEERING PTE LTD

FIGURES

Figure 01 Borehole Location Plan



Station	Longitude	Latitude
WSP1	103.742	1.371
WSP2	103.738	1.373
WSP3	103.745	1.369
WSP4	103.74	1.369
WSP5	103.736	1.368
WSP6	103.738	1.364
WSP7	103.731	1.366
WSP8	103.726	1.367
WSPA	103.735	1.37

APPENDIX A

FIELD TEST RESULTS

Terms and Symbols Used on Borehole Logs

Final Borehole Logs

Water Standpipe Installation & Monitoring Data

Field Borehole Logs

Terms and Symbols Used on Borehole Logs

HATCHING PATTERNS FOR SOIL PROFILE (GEOLOGICAL CLASSIFICATION)

 *Fill*

KALLANG FORMATION

 *F1*

 *F2*

 *E*

 *M*

OLD ALLUVIUM

 O(A)

 O(D)

 O(B)

 O(E)

 O(C)

JURONG FORMATION

 S(0)

 S(3)

 S(1)

 S(4)

 S(2)

 S(5)

BUKIT TIMAH GRANITE

 G(0)

 G(3)

 G(1)

 G(4)

 G(2)

 G(5)

HATCHING PATTERNS FOR BORELOGS (EN CLASSIFICATION)

 *Mg (asphalt)*

 *Mg*

 *Be*

 *Mg (brick)*

 *Bo*

 *Cl*

 *siCl*

 *orCl, saorCl*

 *saCl, sisaCl*

 *MuSt*

 *saSi, clsaSi*

 *orSi*

 *Pt*

 *saPt*

 *grPt*

 *siPt*

 *clPt*

 *grCl, sigrCl, sagrCl*

 *ptCl*

 *Cng*

 *Mg (concrete)*

 *siGr*

 *Gr*

 *saGr, clsaGr, sisaGr*

 *ptGr*

 *Sa*

 *grSa, clgrSa, sigrSa*

 *orSa*

 *siSa*

 *clSa*

 *ptSa*

 *SaSt*

 *clGr*

 *GrSt*

 *orGr*

 *LiSt*

 *Si*

 *clSi*

 *ptSi*

 *grSi, sagrSi*

 *SiSt*

 *Sh*

 *Sch*

 *Tb*

Final Borehole Logs

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area		BORING LOG: BH 01/WSP 01
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**	
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**	
DRILLING STARTED ON: 10-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**	
DRILLING COMPLETED ON: 11-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**	
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water	**NORTHING:**
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole	**EASTING:**
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Sattar	**REDUCED LEVEL:**
DRILLED BY:	**CHECKED BY:** Jamil	**WL*:** 5.5 m dated 03-10-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	Undrained Shear Strength kN/m²	SPT N blows/30cm	Rock TCR (%)	Rock RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)	PL	WC	LL	Bulk Density Mg/m³
		(0.80) 0.80				Firm reddish brown to grey Sandy SILT with gravel (Made Ground)						Mg	saSi							
1						Firm yellowish to reddish brown Sandy SILT															
2																				
3		(4.70)											saSi							
4					4.00 UD1 4.50															
5	▽	5.50																		
6						Firm to stiff reddish to whitish grey fine Sandy SILT															
7		(3.00)											saSi							
8					7.50 UD2 8.00															
		8.50																		
9						*WSP installed up to 8.50 m* Borehole terminated at 8.5m															
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				

RQD/TCR(%)

REMARKS:

Ground Instrumentation & Engineering

LEGEND:

- Pressuremeter Test (PMT)
- Vane Shear Test (VST)
- Permeability Test (PBT)
- Packer Test (PKT)
- Standard Penetration Test (SPT)
- Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- Mazier Sample (MZ) Denison Sample (DS)
- Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- Piston Sample (PS)
- Core Run (CR)
- TCR
- RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area		BORING LOG: BH 02/WSP 02
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**	
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**	
DRILLING STARTED ON: 13-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**	
DRILLING COMPLETED ON: 13-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**	
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water	**NORTHING:**
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole	**EASTING:**
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Pandiyan	**REDUCED LEVEL:**
DRILLED BY:	**CHECKED BY:** Jamil	▽ **WL*:** 8 m dated 13-03-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	TCR (%)	RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)
1		(2.00)				Firm reddish brown and light grey fine-coarse sandy SILT with gravel and hardcores (Made Ground)				Mg	saSi			
2		2.00												
3						Firm reddish brown and yellow fine sandy SILT (Residual Soil, Jurong Formation)								
4					3.50 UD1 4.00									
5		(5.00)								S(5)	saSi			
6														
7		7.00												
8	▽					Stiff light grey to grey fine sandy SILT (Residual Soil, Jurong Formation)								
9		(3.50)			8.00 UD2 8.50					S(5)	saSi			
10														
11		10.50				*WSP installed up to 10.50 m* Borehole terminated at 10.5m								
12														
13														
14														
15														
16														
17														
18														
19														
20														

● SPT N blows/30cm (20 40 60 80)
× Undrained Shear Strength kN/m² (20 40 60 80)
RQD/TCR(%)

Shear Strength
PL ○ WC △ LL ● (20 40 60 80)
■ Bulk Density Mg/m³ (1.4 1.8 2.2 2.6)

REMARKS:

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▯ – Core Run (CR)
- ▩ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**
DRILLING STARTED ON: 12-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**
DRILLING COMPLETED ON: 12-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Pandiyan
DRILLED BY:	**CHECKED BY:** Jamil

BORING LOG: BH 03/WSP 03

NORTHING:
EASTING:
REDUCED LEVEL:
WL*: 7 m dated 03-12-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	TCR (%)	RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)
1		(1.30) 1.30				Firm reddish brown fine sandy SILT (Made Ground)				Mg	saSi			
2						Firm reddish brown to yellow slightly fine-coarse sandy SILT (Residual Soil, Jurong Formation)								
3														
4					3.50 UD2 4.00									
5		(6.70)								S(5)	saSi			
6														
7	▽													
8		8.00			7.50 UD2 8.00	*WSP installed up to 8.00 m* Borehole terminated at 8m								
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

● SPT N blows/30cm (20 40 60 80)
× Undrained Shear Strength kN/m² (20 40 60 80)
RQD/TCR(%)

PL ○ WC △ LL ● (20 40 60 80)
■ Bulk Density Mg/m³ (1.4 1.8 2.2 2.6)

REMARKS:

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- ▩ – TCR
- ▩ – RQD

Ground Instrumentation & Engineering

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**
DRILLING STARTED ON: 09-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**
DRILLING COMPLETED ON: 09-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Pandiyan
DRILLED BY:	**CHECKED BY:** Jamil

BORING LOG: BH 04/WSP 04

NORTHING:
EASTING:
REDUCED LEVEL:
WL*: 2 m dated 03-09-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	TCR (%)	RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)
1						Loose light grey and brown silty fine-coarse SAND with gravel (Made Ground)								
2	▽	(3.00)			1.50 UD2 2.00					Mg	siSa			
3		3.00												
4						Firm reddish brown slightly fine-coarse sandy SILT with trace of gravel (Residual Soil, Jurong Formation)									
5		(3.00)								S(5)	saSi			
6		6.00			5.50 UD2 6.00									
7						*WSP installed up to 6.00 m* Borehole terminated at 6m									
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

SPT N blows/30cm (20 40 60 80)
Undrained Shear Strength kN/m² (20 40 60 80)
PL ○ WC △ LL ● (20 40 60 80)
Bulk Density Mg/m³ (1.4 1.8 2.2 2.6)

REMARKS:

RQD/TCR(%)

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▨ – Core Run (CR)
- ▨ – TCR
- ▨ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

BORING LOG: BH 05/WSP 05

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**
DRILLING STARTED ON: 04-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**
DRILLING COMPLETED ON: 04-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Helal
DRILLED BY:	**CHECKED BY:** Jamil

NORTHING:
EASTING:
REDUCED LEVEL:
WL*: 2.5 m dated 03-04-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	TCR (%)	RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)	PL WC LL / Bulk Density Mg/m³
1		(1.20) 1.20				Firm brown and yellowish brown sandy SILT with gravel (Made Ground)				Mg	saSi				
2	▽				2.00 UD1 2.50	Soft brown and yellowish brown sandy SILT (Residual Soil, Jurong Formation)									
3		(3.30)								S(5)	saSi				
4		4.50													
5		(1.50)			5.00 UD2 5.50	Very soft reddish brown and yellowish brown sandy SILT (Completely Weathered)				S(4)	saSi				
6		6.00													
7						*WSP installed up to 6.00 m* Borehole terminated at 6m										
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

● SPT N blows/30cm (20 40 60 80)
× Undrained Shear Strength kN/m² (20 40 60 80)
RQD/TCR(%)
PL ○ WC △ LL ● (20 40 60 80)
■ Bulk Density Mg/m³ (1.4 1.8 2.2 2.6)

REMARKS:

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▨ – Core Run (CR)
- ▨ – TCR
- ▨ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area		BORING LOG: BH 06/WSP 06
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**	
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**	
DRILLING STARTED ON: 05-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**	
DRILLING COMPLETED ON: 05-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**	
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water	**NORTHING:**
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole	**EASTING:**
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Helal	**REDUCED LEVEL:**
DRILLED BY:	**CHECKED BY:** Jamil	**WL*:** 2.5 m dated 03-05-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	Undrained Shear Strength kN/m²	SPT N blows/30cm	TCR (%)	RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)	PL	WC	LL	Bulk Density Mg/m³
1		(1.00) 1.00				Firm brown and yellowish brown sandy SILT with gravel (Made Ground)						Mg	saSi							
2	▽				2.00 UD1 2.50	Firm to very stiff brownish grey, reddish brown and yellowish brown sandy SILT with gravel (Residual Soil, Jurong Formation)														
3																				
4		(5.50)										S(5)	saSi							
5																				
6																				
7		6.50				*WSP installed up to 6.00 m* Borehole terminated at 6.5m														
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				

REMARKS:

RQD/TCR(%)

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▨ – Core Run (CR)
- ▨ – TCR
- ▨ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

BORING LOG: BH 07/WSP 07

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**
DRILLING STARTED ON: 03-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**
DRILLING COMPLETED ON: 03-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Helal
DRILLED BY:	**CHECKED BY:** Jamil

NORTHING:
EASTING:
REDUCED LEVEL:
WL*: 4 m dated 03-03-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	Rock TCR (%)	Rock RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)
1		(0.50) 0.50				CONCRETE				FILL	CON			
2		(2.50)				Firm reddish brown and yellowish brown sandy SILT (Made Ground)				Mg	saSi			
3		3.00												
4	▽	(2.50)			3.50 UD1 4.00	Stiff brown and yellowish brown sandy SILT with gravel (Residual Soil, Jurong Formation)				S(5)	saSi			
5		5.50												
6		(3.00)			7.00 UD2 7.50	Soft brown and reddish brown sandy CLAY (Completely Weathered, Jurong Formation)				S(4)	saCl			
7														
8		8.50												
9						*WSP installed up to 8.50 m* Borehole terminated at 8.5m								
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

● SPT N blows/30cm (20 40 60 80)
× Undrained Shear Strength kN/m² (20 40 60 80)

PL ○ WC △ LL ● (20 40 60 80)
■ Bulk Density Mg/m³ (1.4 1.8 2.2 2.6)

REMARKS:

RQD/TCR(%)

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (VST)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▨ – Core Run (CR)
- ▨ – TCR
- ▨ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

EN BORING LOG (MRL) INS20004.GPJ GIE GENERAL TEMPLATE 2019 (BY MEHEDI).GDT 29-4-20

PROJECT ID: INS20004

PROJECT: Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT: Jacobs Singapore Pte Ltd	**SPT HAMMER TYPE:**
LOCATION: Jalan Lam Sam	**CALIBRATION CERT. NO:**
DRILLING STARTED ON: 07-03-2020	**ENERGY RATIO:** **SPT HAMMER S.NO:**
DRILLING COMPLETED ON: 07-03-2020	**CASING DIA:** 100 mm **CASING DEPTH:**
DRILLING RIG TYPE: TOHO **RIG NO:** 2	**FLUSHING MEDIUM:** Water
DRILLING ROD TYPE: BW **ROD SIZE:** 50 mm	**DRILLING METHOD:** Rotary open hole
BOREHOLE DIA: 100 mm **CORE DIA:**	**LOGGED BY:** Helal
DRILLED BY:	**CHECKED BY:** Jamil

BORING LOG: BH 08/WSP 08

NORTHING:
EASTING:
REDUCED LEVEL:
WL*: 7.5 m dated 03-07-2020

Scale	Reduced Level (m)	Depth (m) (Thickness)	Graphic Log	Legend	Type & No.	Description	SPT N blows/30cm	Rock TCR (%)	Rock RQD (%)	Geological Classification	EN Soil Classification	Grain Size Analysis G/SA/S/C	Shear Strength C (kN/m²)	Shear Strength (°)	PL WC LL / Bulk Density Mg/m³
1		(1.00) 1.00				Firm brown and yellowish brown sandy SILT with gravel (Made Ground)				Mg	saSi				
2						Soft reddish brown sandy CLAY with silt (Completely Weathered, Jurong Formation)									
3					3.00 UD1 3.50										
4		(5.00)								S(4)	saCl				
5															
6		6.00													
7						Stiff to very stiff reddish brown sandy SILT with gravel (Residual Soil, Jurong Formation)									
8	▽	(3.00)								S(5)	saSi				
9		9.00			9.00 UD*2 9.00	*WSP installed up to 9.00 m* Borehole terminated at 9m									
10															
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

SPT N blows/30cm (20 40 60 80)
Undrained Shear Strength kN/m² (20 40 60 80)
RQD/TCR(%)

REMARKS:

Ground Instrumentation & Engineering

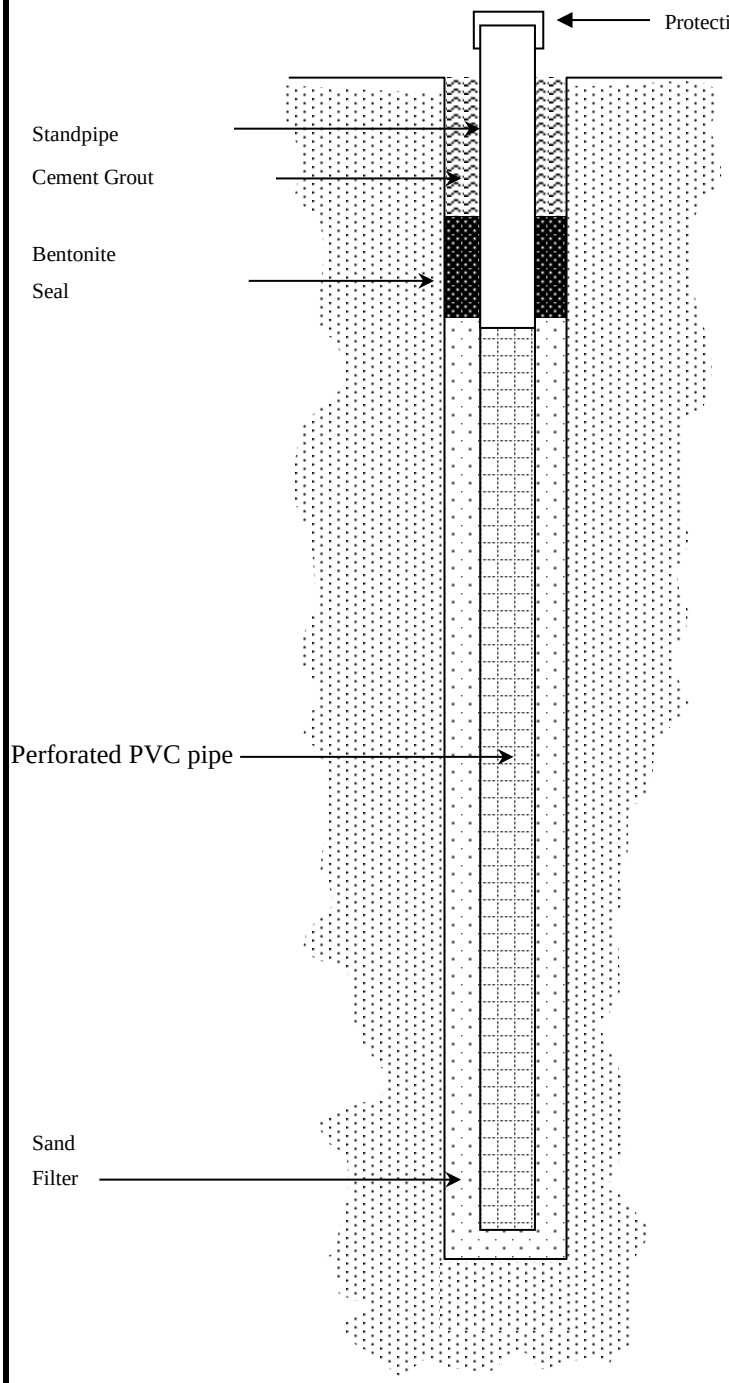
LEGEND:

- Pressuremeter Test (PMT)
- Vane Shear Test (VST)
- Permeability Test (PBT)
- Packer Test (PKT)
- Standard Penetration Test (SPT)
- Thin Wall Push In Sample (TW) Undisturbed Sample Open Drive (UD)
- Mazier Sample (MZ) Denison Sample (DS)
- Attempted (TW*), (UD*), (PS*), (MZ*) & (DS*)
- Piston Sample (PS)
- Core Run (CR)
- TCR
- RQD

*WL - Ground Water Level observed from Borehole (BGL)

Water Standpipe Installation & Monitoring Data

PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	11 Mar 2020	**INSTALLED BY:** Sattar



Depth (GL-m)	0.00
	2.50
	3.00
	8.50

REMARKS:

INSTALLED IN BH01/WSP-01

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/18/20 04:00:00 PM	17.586	81.090	3.03	12.36
03/18/20 05:00:00 PM	17.582	81.090	3.03	12.36
03/18/20 06:00:00 PM	17.586	81.090	3.01	12.38
03/18/20 07:00:00 PM	17.615	81.090	3.00	12.39
03/18/20 08:00:00 PM	17.619	80.911	3.00	12.39
03/18/20 09:00:00 PM	17.628	80.911	2.99	12.40
03/18/20 10:00:00 PM	17.633	80.911	2.99	12.40
03/18/20 11:00:00 PM	17.638	80.911	3.00	12.39
03/19/20 12:00:00 AM	17.628	80.911	3.00	12.39
03/19/20 01:00:00 AM	17.619	80.911	3.01	12.38
03/19/20 02:00:00 AM	17.614	80.911	3.02	12.37
03/19/20 03:00:00 AM	17.595	80.911	3.03	12.36
03/19/20 04:00:00 AM	17.586	80.911	3.03	12.36
03/19/20 05:00:00 AM	17.586	80.911	3.03	12.36
03/19/20 06:00:00 AM	17.581	80.911	3.03	12.36
03/19/20 07:00:00 AM	17.581	80.911	3.02	12.37
03/19/20 08:00:00 AM	17.590	80.911	3.02	12.37
03/19/20 09:00:00 AM	17.595	80.911	3.02	12.37
03/19/20 10:00:00 AM	17.600	80.911	3.02	12.37
03/19/20 11:00:00 AM	17.595	80.911	3.03	12.36
03/19/20 12:00:00 PM	17.586	80.911	3.03	12.36
03/19/20 01:00:00 PM	17.577	81.090	3.04	12.35
03/19/20 02:00:00 PM	17.571	80.911	3.04	12.35
03/19/20 03:00:00 PM	17.562	80.911	3.06	12.33
03/19/20 04:00:00 PM	17.538	80.911	3.07	12.32
03/19/20 05:00:00 PM	17.528	80.911	3.07	12.32
03/19/20 06:00:00 PM	17.524	80.911	3.07	12.32
03/19/20 07:00:00 PM	17.528	80.911	3.06	12.33
03/19/20 08:00:00 PM	17.543	80.911	3.05	12.34
03/19/20 09:00:00 PM	17.552	80.911	3.04	12.35
03/19/20 10:00:00 PM	17.562	80.911	3.04	12.35
03/19/20 11:00:00 PM	17.567	80.911	3.04	12.35
03/20/20 12:00:00 AM	17.571	80.911	3.05	12.34
03/20/20 01:00:00 AM	17.557	80.911	3.06	12.33
03/20/20 02:00:00 AM	17.543	80.911	3.07	12.32
03/20/20 03:00:00 AM	17.524	80.911	3.08	12.31
03/20/20 04:00:00 AM	17.514	80.911	3.08	12.31
03/20/20 05:00:00 AM	17.509	80.911	3.08	12.31
03/20/20 06:00:00 AM	17.509	80.911	3.08	12.31
03/20/20 07:00:00 AM	17.509	80.911	3.08	12.31
03/20/20 08:00:00 AM	17.514	80.911	3.07	12.32
03/20/20 09:00:00 AM	17.528	80.911	3.07	12.32
03/20/20 10:00:00 AM	17.528	80.911	3.07	12.32

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 11:00:00 AM	17.519	80.911	3.08	12.31
03/20/20 12:00:00 PM	17.509	80.911	3.09	12.30
03/20/20 01:00:00 PM	17.495	80.911	3.11	12.28
03/20/20 02:00:00 PM	17.467	80.911	3.12	12.27
03/20/20 03:00:00 PM	17.448	80.911	3.13	12.26
03/20/20 04:00:00 PM	17.443	80.911	3.14	12.25
03/20/20 05:00:00 PM	17.424	80.911	3.13	12.26
03/20/20 06:00:00 PM	17.433	80.911	3.14	12.25
03/20/20 07:00:00 PM	17.429	80.911	3.13	12.26
03/20/20 08:00:00 PM	17.433	80.911	3.12	12.27
03/20/20 09:00:00 PM	17.448	80.911	3.12	12.27
03/20/20 10:00:00 PM	17.448	80.911	3.13	12.26
03/20/20 11:00:00 PM	17.443	80.911	3.13	12.26
03/21/20 12:00:00 AM	17.438	80.911	3.14	12.25
03/21/20 01:00:00 AM	17.424	80.911	3.15	12.24
03/21/20 02:00:00 AM	17.405	80.911	3.16	12.23
03/21/20 03:00:00 AM	17.395	80.911	3.17	12.22
03/21/20 04:00:00 AM	17.386	80.911	3.17	12.22
03/21/20 05:00:00 AM	17.386	80.911	3.17	12.22
03/21/20 06:00:00 AM	17.386	80.911	3.17	12.22
03/21/20 07:00:00 AM	17.386	80.911	3.16	12.23
03/21/20 08:00:00 AM	17.390	80.911	3.16	12.23
03/21/20 09:00:00 AM	17.395	80.911	3.16	12.23
03/21/20 10:00:00 AM	17.395	80.911	3.17	12.22
03/21/20 11:00:00 AM	17.386	80.911	3.17	12.22
03/21/20 12:00:00 PM	17.381	80.911	3.19	12.20
03/21/20 01:00:00 PM	17.357	80.911	3.20	12.19
03/21/20 02:00:00 PM	17.338	80.911	3.21	12.18
03/21/20 03:00:00 PM	17.328	80.911	3.21	12.18
03/21/20 04:00:00 PM	17.324	80.911	3.21	12.18
03/21/20 05:00:00 PM	17.319	80.911	3.22	12.17
03/21/20 06:00:00 PM	17.314	80.911	3.21	12.18
03/21/20 07:00:00 PM	17.324	80.911	3.21	12.18
03/21/20 08:00:00 PM	17.319	80.911	3.20	12.19
03/21/20 09:00:00 PM	17.333	80.911	3.20	12.19
03/21/20 10:00:00 PM	17.343	80.911	3.20	12.19
03/21/20 11:00:00 PM	17.338	80.911	3.20	12.19
03/22/20 12:00:00 AM	17.338	80.911	3.21	12.18
03/22/20 01:00:00 AM	17.324	80.911	3.22	12.17
03/22/20 02:00:00 AM	17.314	80.911	3.23	12.16
03/22/20 03:00:00 AM	17.295	80.911	3.23	12.16
03/22/20 04:00:00 AM	17.290	80.911	3.24	12.15

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 05:00:00 AM	17.286	80.911	3.24	12.15
03/22/20 06:00:00 AM	17.281	80.911	3.24	12.15
03/22/20 07:00:00 AM	17.286	80.911	3.24	12.15
03/22/20 08:00:00 AM	17.286	80.911	3.22	12.17
03/22/20 09:00:00 AM	17.305	80.911	3.22	12.17
03/22/20 10:00:00 AM	17.305	80.911	3.23	12.16
03/22/20 11:00:00 AM	17.296	81.090	3.24	12.15
03/22/20 12:00:00 PM	17.281	80.911	3.25	12.14
03/22/20 01:00:00 PM	17.271	80.911	3.26	12.13
03/22/20 02:00:00 PM	17.258	81.090	3.27	12.12
03/22/20 03:00:00 PM	17.239	81.090	3.26	12.13
03/22/20 04:00:00 PM	17.253	81.090	3.26	12.13
03/22/20 05:00:00 PM	17.248	81.090	3.27	12.12
03/22/20 06:00:00 PM	17.244	81.090	3.28	12.11
03/22/20 07:00:00 PM	17.229	81.090	3.26	12.13
03/22/20 08:00:00 PM	17.248	80.911	3.26	12.13
03/22/20 09:00:00 PM	17.258	81.090	3.25	12.14
03/22/20 10:00:00 PM	17.267	81.090	3.24	12.15
03/22/20 11:00:00 PM	17.282	81.090	3.23	12.16
03/23/20 12:00:00 AM	17.290	80.911	3.22	12.17
03/23/20 01:00:00 AM	17.310	81.090	3.23	12.16
03/23/20 02:00:00 AM	17.301	81.090	3.23	12.16
03/23/20 03:00:00 AM	17.296	81.090	3.23	12.16
03/23/20 04:00:00 AM	17.301	81.090	3.22	12.17
03/23/20 05:00:00 AM	17.305	80.911	3.21	12.18
03/23/20 06:00:00 AM	17.324	80.911	3.20	12.19
03/23/20 07:00:00 AM	17.343	80.911	3.18	12.21
03/23/20 08:00:00 AM	17.362	80.911	3.17	12.22
03/23/20 09:00:00 AM	17.386	80.911	3.16	12.23
03/23/20 10:00:00 AM	17.395	80.911	3.16	12.23
03/23/20 11:00:00 AM	17.390	80.911	3.16	12.23
03/23/20 12:00:00 PM	17.400	80.911	3.16	12.23
03/23/20 01:00:00 PM	17.395	80.911	3.16	12.23
03/23/20 02:00:00 PM	17.395	80.911	3.17	12.22
03/23/20 03:00:00 PM	17.386	80.911	3.17	12.22
03/23/20 04:00:00 PM	17.386	80.911	3.16	12.23
03/23/20 05:00:00 PM	17.395	80.911	3.15	12.24
03/23/20 06:00:00 PM	17.409	80.911	3.14	12.25
03/23/20 07:00:00 PM	17.419	80.911	3.13	12.26
03/23/20 08:00:00 PM	17.433	80.911	3.13	12.26
03/23/20 09:00:00 PM	17.438	80.911	3.12	12.27
03/23/20 10:00:00 PM	17.448	80.911	3.11	12.28

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/23/20 11:00:00 PM	17.467	80.911	3.11	12.28
03/24/20 12:00:00 AM	17.467	80.911	3.11	12.28
03/24/20 01:00:00 AM	17.462	80.911	3.12	12.27
03/24/20 02:00:00 AM	17.457	80.911	3.12	12.27
03/24/20 03:00:00 AM	17.452	80.911	3.12	12.27
03/24/20 04:00:00 AM	17.452	80.911	3.12	12.27
03/24/20 05:00:00 AM	17.448	80.911	3.12	12.27
03/24/20 06:00:00 AM	17.452	80.911	3.11	12.28
03/24/20 07:00:00 AM	17.463	81.090	3.11	12.28
03/24/20 08:00:00 AM	17.467	81.090	3.10	12.29
03/24/20 09:00:00 AM	17.481	80.911	3.10	12.29
03/24/20 10:00:00 AM	17.486	80.911	3.09	12.30
03/24/20 11:00:00 AM	17.490	80.911	3.09	12.30
03/24/20 12:00:00 PM	17.490	80.911	3.10	12.29
03/24/20 01:00:00 PM	17.481	80.911	3.11	12.28
03/24/20 02:00:00 PM	17.462	80.911	3.12	12.27
03/24/20 03:00:00 PM	17.457	80.911	3.13	12.26
03/24/20 04:00:00 PM	17.443	80.911	3.13	12.26
03/24/20 05:00:00 PM	17.443	80.911	3.12	12.27
03/24/20 06:00:00 PM	17.452	80.911	3.11	12.28
03/24/20 07:00:00 PM	17.467	80.911	3.10	12.29
03/24/20 08:00:00 PM	17.476	80.911	3.10	12.29
03/24/20 09:00:00 PM	17.476	80.911	3.09	12.30
03/24/20 10:00:00 PM	17.490	80.911	3.08	12.31
03/24/20 11:00:00 PM	17.509	80.911	3.08	12.31
03/25/20 12:00:00 AM	17.505	80.911	3.09	12.30
03/25/20 01:00:00 AM	17.495	80.911	3.09	12.30
03/25/20 02:00:00 AM	17.490	80.911	3.10	12.29
03/25/20 03:00:00 AM	17.486	80.911	3.10	12.29
03/25/20 04:00:00 AM	17.476	80.911	3.10	12.29
03/25/20 05:00:00 AM	17.476	80.911	3.10	12.29
03/25/20 06:00:00 AM	17.481	80.911	3.10	12.29
03/25/20 07:00:00 AM	17.486	80.911	3.10	12.29
03/25/20 08:00:00 AM	17.486	80.911	3.09	12.30
03/25/20 09:00:00 AM	17.500	80.911	3.09	12.30
03/25/20 10:00:00 AM	17.501	81.090	3.07	12.32
03/25/20 11:00:00 AM	17.519	80.911	3.08	12.31
03/25/20 12:00:00 PM	17.505	80.911	3.09	12.30
03/25/20 01:00:00 PM	17.495	80.911	3.09	12.30
03/25/20 02:00:00 PM	17.490	80.911	3.10	12.29
03/25/20 03:00:00 PM	17.477	81.090	3.11	12.28
03/25/20 04:00:00 PM	17.467	81.090	3.11	12.28

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/25/20 05:00:00 PM	17.463	81.090	3.11	12.28
03/25/20 06:00:00 PM	17.467	81.090	3.11	12.28
03/25/20 07:00:00 PM	17.467	81.090	3.10	12.29
03/25/20 08:00:00 PM	17.481	80.911	3.09	12.30
03/25/20 09:00:00 PM	17.500	80.911	3.08	12.31
03/25/20 10:00:00 PM	17.514	80.911	3.07	12.32
03/25/20 11:00:00 PM	17.528	80.911	3.06	12.33
03/26/20 12:00:00 AM	17.533	80.911	3.06	12.33
03/26/20 01:00:00 AM	17.538	80.911	3.07	12.32
03/26/20 02:00:00 AM	17.524	80.911	3.07	12.32
03/26/20 03:00:00 AM	17.528	80.911	3.07	12.32
03/26/20 04:00:00 AM	17.524	80.911	3.07	12.32
03/26/20 05:00:00 AM	17.524	80.911	3.06	12.33
03/26/20 06:00:00 AM	17.533	80.911	3.05	12.34
03/26/20 07:00:00 AM	17.547	80.911	3.04	12.35
03/26/20 08:00:00 AM	17.563	81.090	3.03	12.36
03/26/20 09:00:00 AM	17.576	80.911	3.02	12.37
03/26/20 10:00:00 AM	17.590	80.911	3.02	12.37
03/26/20 11:00:00 AM	17.595	80.911	3.02	12.37
03/26/20 12:00:00 PM	17.590	80.911	3.02	12.37
03/26/20 01:00:00 PM	17.590	80.911	3.03	12.36
03/26/20 02:00:00 PM	17.581	80.911	3.04	12.35
03/26/20 03:00:00 PM	17.571	80.911	3.04	12.35
03/26/20 04:00:00 PM	17.567	80.911	3.04	12.35
03/26/20 05:00:00 PM	17.567	80.911	3.04	12.35
03/26/20 06:00:00 PM	17.571	80.911	3.02	12.37
03/26/20 07:00:00 PM	17.590	80.911	3.02	12.37
03/26/20 08:00:00 PM	17.595	80.911	3.01	12.38
03/26/20 09:00:00 PM	17.609	80.911	3.00	12.39
03/26/20 10:00:00 PM	17.624	80.911	2.99	12.40
03/26/20 11:00:00 PM	17.633	80.911	2.98	12.41
03/27/20 12:00:00 AM	17.648	80.911	2.98	12.41
03/27/20 01:00:00 AM	17.648	80.911	2.99	12.40
03/27/20 02:00:00 AM	17.638	80.911	3.00	12.39
03/27/20 03:00:00 AM	17.628	80.911	3.00	12.39
03/27/20 04:00:00 AM	17.619	80.911	3.00	12.39
03/27/20 05:00:00 AM	17.628	80.911	3.00	12.39
03/27/20 06:00:00 AM	17.619	80.911	3.00	12.39
03/27/20 07:00:00 AM	17.628	80.911	2.99	12.40
03/27/20 08:00:00 AM	17.643	80.911	2.98	12.41
03/27/20 09:00:00 AM	17.652	80.911	2.98	12.41
03/27/20 10:00:00 AM	17.657	80.911	2.97	12.42

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/27/20 11:00:00 AM	17.667	80.911	2.98	12.41
03/27/20 12:00:00 PM	17.657	80.911	2.98	12.41
03/27/20 01:00:00 PM	17.652	80.911	2.99	12.40
03/27/20 02:00:00 PM	17.643	80.911	3.00	12.39
03/27/20 03:00:00 PM	17.624	80.911	3.00	12.39
03/27/20 04:00:00 PM	17.628	80.911	3.00	12.39
03/27/20 05:00:00 PM	17.619	80.911	2.99	12.40
03/27/20 06:00:00 PM	17.633	80.911	2.99	12.40
03/27/20 07:00:00 PM	17.633	80.911	2.99	12.40
03/27/20 08:00:00 PM	17.643	80.911	2.98	12.41
03/27/20 09:00:00 PM	17.657	80.911	2.97	12.42
03/27/20 10:00:00 PM	17.662	80.911	2.96	12.43
03/27/20 11:00:00 PM	17.686	80.911	2.95	12.44
03/28/20 12:00:00 AM	17.690	80.911	2.95	12.44
03/28/20 01:00:00 AM	17.690	80.911	2.96	12.43
03/28/20 02:00:00 AM	17.676	80.911	2.96	12.43
03/28/20 03:00:00 AM	17.676	80.911	2.96	12.43
03/28/20 04:00:00 AM	17.676	80.911	2.96	12.43
03/28/20 05:00:00 AM	17.681	80.911	2.96	12.43
03/28/20 06:00:00 AM	17.686	80.911	2.94	12.45
03/28/20 07:00:00 AM	17.705	80.911	2.93	12.46
03/28/20 08:00:00 AM	17.728	80.911	2.92	12.47
03/28/20 09:00:00 AM	17.738	80.911	2.91	12.48
03/28/20 10:00:00 AM	17.752	80.911	2.91	12.48
03/28/20 11:00:00 AM	17.752	80.911	2.91	12.48
03/28/20 12:00:00 PM	17.757	80.911	2.91	12.48
03/28/20 01:00:00 PM	17.747	80.911	2.92	12.47
03/28/20 02:00:00 PM	17.738	80.911	2.93	12.46
03/28/20 03:00:00 PM	17.728	80.911	2.93	12.46
03/28/20 04:00:00 PM	17.724	80.911	2.93	12.46
03/28/20 05:00:00 PM	17.728	80.911	2.92	12.47
03/28/20 06:00:00 PM	17.733	80.911	2.92	12.47
03/28/20 07:00:00 PM	17.743	80.911	2.91	12.48
03/28/20 08:00:00 PM	17.757	80.911	2.89	12.50
03/28/20 09:00:00 PM	17.781	80.911	2.87	12.52
03/28/20 10:00:00 PM	17.805	80.911	2.87	12.52
03/28/20 11:00:00 PM	17.814	80.911	2.86	12.53
03/29/20 12:00:00 AM	17.824	80.911	2.86	12.53
03/29/20 01:00:00 AM	17.824	80.911	2.86	12.53
03/29/20 02:00:00 AM	17.828	80.911	2.86	12.53
03/29/20 03:00:00 AM	17.819	80.911	2.86	12.53
03/29/20 04:00:00 AM	17.819	80.911	2.86	12.53

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 05:00:00 AM	17.819	80.911	2.86	12.53
03/29/20 06:00:00 AM	17.824	80.911	2.86	12.53
03/29/20 07:00:00 AM	17.828	80.911	2.85	12.54
03/29/20 08:00:00 AM	17.833	80.911	2.84	12.55
03/29/20 09:00:00 AM	17.852	80.911	2.83	12.56
03/29/20 10:00:00 AM	17.862	80.911	2.83	12.56
03/29/20 11:00:00 AM	17.867	80.911	2.84	12.55
03/29/20 12:00:00 PM	17.857	80.911	2.84	12.55
03/29/20 01:00:00 PM	17.848	80.911	2.85	12.54
03/29/20 02:00:00 PM	17.838	80.911	2.85	12.54
03/29/20 03:00:00 PM	17.833	80.911	2.85	12.54
03/29/20 04:00:00 PM	17.833	80.911	2.86	12.53
03/29/20 05:00:00 PM	17.828	80.911	2.86	12.53
03/29/20 06:00:00 PM	17.824	80.911	2.86	12.53
03/29/20 07:00:00 PM	17.828	80.911	2.85	12.54
03/29/20 08:00:00 PM	17.843	80.911	2.83	12.56
03/29/20 09:00:00 PM	17.862	80.911	2.82	12.57
03/29/20 10:00:00 PM	17.876	80.911	2.81	12.58
03/29/20 11:00:00 PM	17.890	80.911	2.81	12.58
03/30/20 12:00:00 AM	17.895	80.911	2.82	12.57
03/30/20 01:00:00 AM	17.881	80.911	2.83	12.56
03/30/20 02:00:00 AM	17.871	80.911	2.83	12.56
03/30/20 03:00:00 AM	17.862	80.911	2.84	12.55
03/30/20 04:00:00 AM	17.852	80.911	2.84	12.55
03/30/20 05:00:00 AM	17.848	80.911	2.84	12.55
03/30/20 06:00:00 AM	17.857	80.911	2.84	12.55
03/30/20 07:00:00 AM	17.857	80.911	2.83	12.56
03/30/20 08:00:00 AM	17.862	80.911	2.82	12.57
03/30/20 09:00:00 AM	17.876	80.911	2.82	12.57
03/30/20 10:00:00 AM	17.881	80.911	2.82	12.57
03/30/20 11:00:00 AM	17.886	80.911	2.83	12.56
03/30/20 12:00:00 PM	17.867	80.911	2.84	12.55
03/30/20 01:00:00 PM	17.857	80.911	2.84	12.55
03/30/20 02:00:00 PM	17.848	80.911	2.85	12.54
03/30/20 03:00:00 PM	17.833	80.911	2.86	12.53
03/30/20 04:00:00 PM	17.819	80.911	2.87	12.52
03/30/20 05:00:00 PM	17.814	80.911	2.87	12.52
03/30/20 06:00:00 PM	17.814	80.911	2.85	12.54
03/30/20 07:00:00 PM	17.833	80.911	2.85	12.54
03/30/20 08:00:00 PM	17.838	80.911	2.84	12.55
03/30/20 09:00:00 PM	17.852	80.911	2.84	12.55
03/30/20 10:00:00 PM	17.852	80.911	2.83	12.56

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/30/20 11:00:00 PM	17.862	80.911	2.84	12.55
03/31/20 12:00:00 AM	17.857	80.911	2.84	12.55
03/31/20 01:00:00 AM	17.852	80.911	2.85	12.54
03/31/20 02:00:00 AM	17.833	80.911	2.85	12.54
03/31/20 03:00:00 AM	17.833	80.911	2.86	12.53
03/31/20 04:00:00 AM	17.824	80.911	2.86	12.53
03/31/20 05:00:00 AM	17.819	80.911	2.86	12.53
03/31/20 06:00:00 AM	17.819	80.911	2.86	12.53
03/31/20 07:00:00 AM	17.824	80.911	2.86	12.53
03/31/20 08:00:00 AM	17.828	80.911	2.85	12.54
03/31/20 09:00:00 AM	17.843	80.911	2.84	12.55
03/31/20 10:00:00 AM	17.848	80.911	2.84	12.55
03/31/20 11:00:00 AM	17.848	80.911	2.86	12.53
03/31/20 12:00:00 PM	17.828	80.911	2.86	12.53
03/31/20 01:00:00 PM	17.824	80.911	2.88	12.51
03/31/20 02:00:00 PM	17.800	80.911	2.89	12.50
03/31/20 03:00:00 PM	17.786	80.911	2.89	12.50
03/31/20 04:00:00 PM	17.776	80.911	2.90	12.49
03/31/20 05:00:00 PM	17.766	80.911	2.89	12.50
03/31/20 06:00:00 PM	17.776	80.911	2.89	12.50
03/31/20 07:00:00 PM	17.786	80.911	2.88	12.51
03/31/20 08:00:00 PM	17.795	80.911	2.88	12.51
03/31/20 09:00:00 PM	17.800	80.911	2.87	12.52
03/31/20 10:00:00 PM	17.814	80.911	2.87	12.52
03/31/20 11:00:00 PM	17.814	80.911	2.87	12.52
4/1/2020 12:00:00 AM	17.805	80.911	2.88	12.51
4/1/2020 1:00:00 AM	17.800	80.911	2.88	12.51
4/1/2020 2:00:00 AM	17.790	80.911	2.89	12.50
4/1/2020 3:00:00 AM	17.776	80.911	2.90	12.49
4/1/2020 4:00:00 AM	17.771	80.911	2.90	12.49
4/1/2020 5:00:00 AM	17.771	80.911	2.89	12.50
4/1/2020 6:00:00 AM	17.776	80.911	2.89	12.50
4/1/2020 7:00:00 AM	17.781	80.911	2.89	12.50
4/1/2020 8:00:00 AM	17.786	80.911	2.89	12.50
4/1/2020 9:00:00 AM	17.786	80.911	2.89	12.50
4/1/2020 10:00:00 AM	17.786	80.911	2.89	12.50
4/1/2020 11:00:00 AM	17.781	80.911	2.90	12.49
4/1/2020 12:00:00 PM	17.771	80.911	2.90	12.49
4/1/2020 1:00:00 PM	17.762	80.911	2.92	12.47
4/1/2020 2:00:00 PM	17.743	80.911	2.93	12.46
4/1/2020 3:00:00 PM	17.724	80.911	2.94	12.45
4/1/2020 4:00:00 PM	17.714	80.911	2.94	12.45

WATER STANDPIPE MONITORING

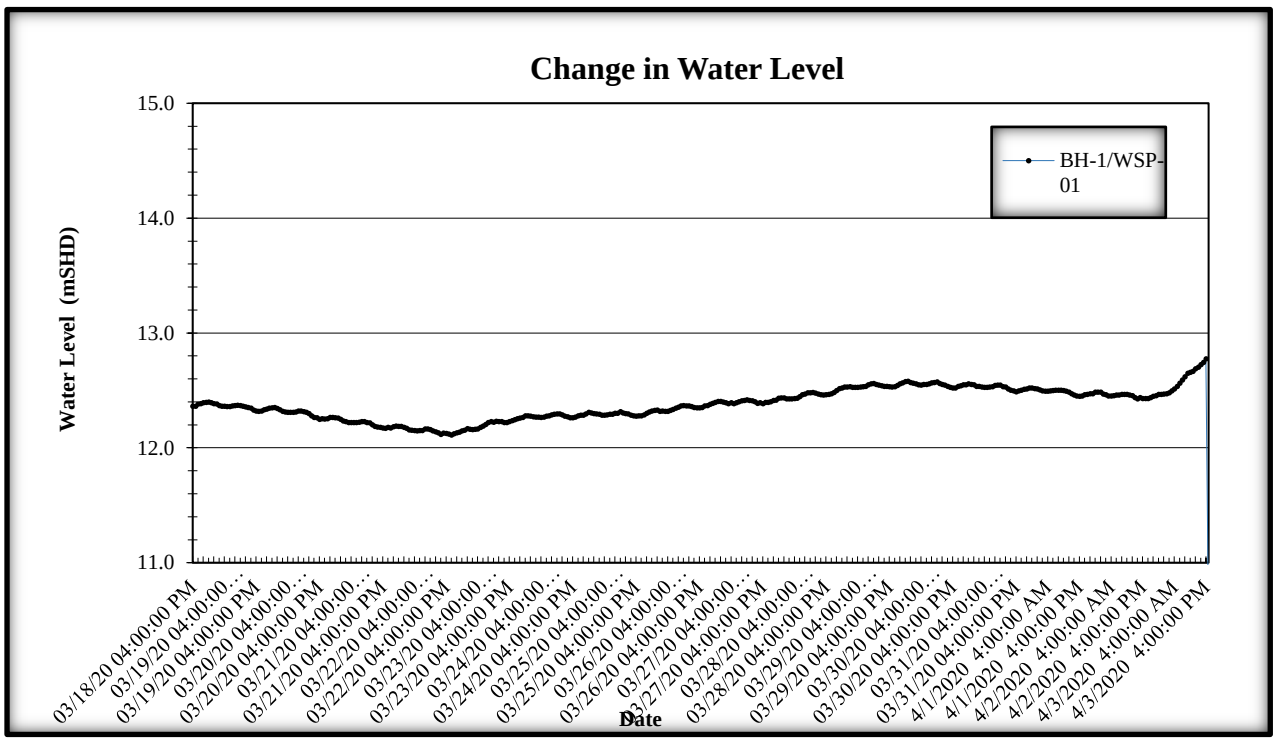
Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/1/2020 5:00:00 PM	17.709	80.911	2.94	12.45
4/1/2020 6:00:00 PM	17.714	80.911	2.93	12.46
4/1/2020 7:00:00 PM	17.728	80.911	2.92	12.47
4/1/2020 8:00:00 PM	17.733	80.911	2.92	12.47
4/1/2020 9:00:00 PM	17.743	80.911	2.92	12.47
4/1/2020 10:00:00 PM	17.743	80.911	2.90	12.49
4/1/2020 11:00:00 PM	17.762	80.911	2.90	12.49
4/2/2020 12:00:00 AM	17.762	80.911	2.90	12.49
4/2/2020 1:00:00 AM	17.762	80.911	2.92	12.47
4/2/2020 2:00:00 AM	17.738	80.911	2.93	12.46
4/2/2020 3:00:00 AM	17.728	80.911	2.94	12.45
4/2/2020 4:00:00 AM	17.714	80.911	2.94	12.45
4/2/2020 5:00:00 AM	17.714	80.911	2.93	12.46
4/2/2020 6:00:00 AM	17.719	80.911	2.93	12.46
4/2/2020 7:00:00 AM	17.724	80.911	2.93	12.46
4/2/2020 8:00:00 AM	17.724	80.911	2.92	12.47
4/2/2020 9:00:00 AM	17.733	80.911	2.92	12.47
4/2/2020 10:00:00 AM	17.733	80.911	2.92	12.47
4/2/2020 11:00:00 AM	17.733	80.911	2.93	12.46
4/2/2020 12:00:00 PM	17.724	80.911	2.93	12.46
4/2/2020 1:00:00 PM	17.719	80.911	2.95	12.44
4/2/2020 2:00:00 PM	17.695	80.911	2.96	12.43
4/2/2020 3:00:00 PM	17.676	80.911	2.95	12.44
4/2/2020 4:00:00 PM	17.695	80.911	2.96	12.43
4/2/2020 5:00:00 PM	17.681	80.911	2.96	12.43
4/2/2020 6:00:00 PM	17.681	80.911	2.96	12.43
4/2/2020 7:00:00 PM	17.681	80.911	2.95	12.44
4/2/2020 8:00:00 PM	17.695	80.911	2.94	12.45
4/2/2020 9:00:00 PM	17.709	80.911	2.93	12.46
4/2/2020 10:00:00 PM	17.719	80.911	2.92	12.47
4/2/2020 11:00:00 PM	17.733	80.911	2.92	12.47
4/3/2020 12:00:00 AM	17.733	80.911	2.92	12.47
4/3/2020 1:00:00 AM	17.738	80.911	2.92	12.47
4/3/2020 2:00:00 AM	17.743	80.911	2.91	12.48
4/3/2020 3:00:00 AM	17.752	80.911	2.89	12.50
4/3/2020 4:00:00 AM	17.776	80.911	2.88	12.51
4/3/2020 5:00:00 AM	17.800	80.911	2.85	12.54
4/3/2020 6:00:00 AM	17.833	80.911	2.83	12.56
4/3/2020 7:00:00 AM	17.871	80.911	2.80	12.59
4/3/2020 8:00:00 AM	17.909	80.911	2.77	12.62
4/3/2020 9:00:00 AM	17.952	80.911	2.74	12.65
4/3/2020 10:00:00 AM	17.995	80.911	2.73	12.66

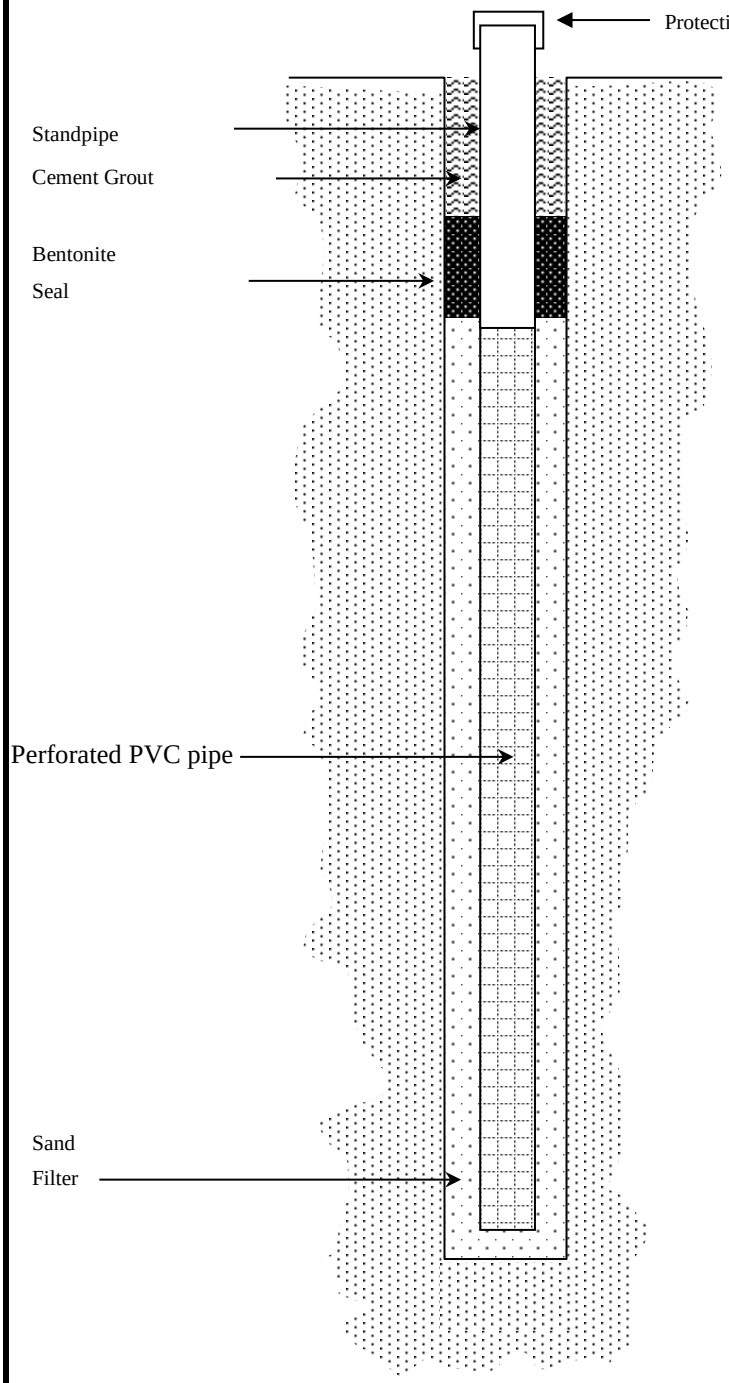
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-1/WSP-01**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.02
Location:	Tengah	**Pipe Top Level (mSHD)**	16.040
		Ground Level (mSHD)	15.390

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/3/2020 11:00:00 AM	18.005	80.911	2.72	12.67
4/3/2020 12:00:00 PM	18.019	80.911	2.70	12.69
4/3/2020 1:00:00 PM	18.048	81.090	2.69	12.70
4/3/2020 2:00:00 PM	18.071	80.911	2.66	12.73
4/3/2020 3:00:00 PM	18.101	81.090	2.65	12.74
4/3/2020 4:00:00 PM	18.128	80.911	2.61	12.78
4/3/2020 5:00:00 PM	18.171	80.911	5.03	10.36



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	13 Mar 2020	**INSTALLED BY:** M. Pandiyan



Depth (GL-m)	0.00
	2.50
	3.00
	10.50

REMARKS:

INSTALLED IN BH02/WSP-02

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/18/20 04:00:00 PM	19.172	81.090	3.06	15.09
03/18/20 05:00:00 PM	19.192	81.090	3.04	15.11
03/18/20 06:00:00 PM	19.206	81.090	3.03	15.12
03/18/20 07:00:00 PM	19.251	81.090	3.00	15.15
03/18/20 08:00:00 PM	19.265	81.090	2.99	15.16
03/18/20 09:00:00 PM	19.285	81.090	2.98	15.17
03/18/20 10:00:00 PM	19.295	81.090	2.97	15.18
03/18/20 11:00:00 PM	19.305	81.090	2.96	15.19
03/19/20 12:00:00 AM	19.320	81.090	2.95	15.20
03/19/20 01:00:00 AM	19.320	81.090	2.95	15.20
03/19/20 02:00:00 AM	19.324	81.090	2.95	15.20
03/19/20 03:00:00 AM	19.320	81.090	2.95	15.20
03/19/20 04:00:00 AM	19.310	81.090	2.96	15.19
03/19/20 05:00:00 AM	19.320	81.090	2.95	15.20
03/19/20 06:00:00 AM	19.315	81.090	2.96	15.19
03/19/20 07:00:00 AM	19.324	81.090	2.95	15.20
03/19/20 08:00:00 AM	19.344	81.090	2.94	15.21
03/19/20 09:00:00 AM	19.354	81.090	2.93	15.22
03/19/20 10:00:00 AM	19.364	81.090	2.92	15.23
03/19/20 11:00:00 AM	19.364	81.090	2.92	15.23
03/19/20 12:00:00 PM	19.359	81.090	2.92	15.23
03/19/20 01:00:00 PM	19.349	81.090	2.93	15.22
03/19/20 02:00:00 PM	19.334	81.090	2.94	15.21
03/19/20 03:00:00 PM	19.324	81.090	2.95	15.20
03/19/20 04:00:00 PM	19.309	80.911	2.96	15.19
03/19/20 05:00:00 PM	19.300	81.090	2.97	15.18
03/19/20 06:00:00 PM	19.300	81.090	2.97	15.18
03/19/20 07:00:00 PM	19.309	80.911	2.96	15.19
03/19/20 08:00:00 PM	19.329	80.911	2.95	15.20
03/19/20 09:00:00 PM	19.339	81.090	2.94	15.21
03/19/20 10:00:00 PM	19.348	80.911	2.93	15.22
03/19/20 11:00:00 PM	19.368	80.911	2.92	15.23
03/20/20 12:00:00 AM	19.368	80.911	2.92	15.23
03/20/20 01:00:00 AM	19.368	80.911	2.92	15.23
03/20/20 02:00:00 AM	19.353	80.911	2.93	15.22
03/20/20 03:00:00 AM	19.339	81.090	2.94	15.21
03/20/20 04:00:00 AM	19.334	80.911	2.94	15.21
03/20/20 05:00:00 AM	19.334	80.911	2.94	15.21
03/20/20 06:00:00 AM	19.339	80.911	2.94	15.21
03/20/20 07:00:00 AM	19.343	80.911	2.94	15.21
03/20/20 08:00:00 AM	19.353	80.911	2.93	15.22
03/20/20 09:00:00 AM	19.358	80.911	2.93	15.22

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 10:00:00 AM	19.368	80.911	2.92	15.23

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 11:00:00 AM	19.368	80.911	2.92	15.23
03/20/20 12:00:00 PM	19.358	80.911	2.93	15.22
03/20/20 01:00:00 PM	19.348	80.911	2.93	15.22
03/20/20 02:00:00 PM	19.324	80.911	2.95	15.20
03/20/20 03:00:00 PM	19.309	80.911	2.96	15.19
03/20/20 04:00:00 PM	19.299	80.911	2.97	15.18
03/20/20 05:00:00 PM	19.289	80.911	2.97	15.18
03/20/20 06:00:00 PM	19.294	80.911	2.97	15.18
03/20/20 07:00:00 PM	19.299	80.911	2.97	15.18
03/20/20 08:00:00 PM	19.314	80.911	2.96	15.19
03/20/20 09:00:00 PM	19.319	80.911	2.95	15.20
03/20/20 10:00:00 PM	19.324	80.911	2.95	15.20
03/20/20 11:00:00 PM	19.329	80.911	2.95	15.20
03/21/20 12:00:00 AM	19.334	80.911	2.94	15.21
03/21/20 01:00:00 AM	19.319	80.911	2.95	15.20
03/21/20 02:00:00 AM	19.309	80.911	2.96	15.19
03/21/20 03:00:00 AM	19.299	80.911	2.97	15.18
03/21/20 04:00:00 AM	19.294	80.911	2.97	15.18
03/21/20 05:00:00 AM	19.294	80.911	2.97	15.18
03/21/20 06:00:00 AM	19.294	80.911	2.97	15.18
03/21/20 07:00:00 AM	19.299	80.911	2.97	15.18
03/21/20 08:00:00 AM	19.314	80.911	2.96	15.19
03/21/20 09:00:00 AM	19.324	80.911	2.95	15.20
03/21/20 10:00:00 AM	19.324	80.911	2.95	15.20
03/21/20 11:00:00 AM	19.324	80.911	2.95	15.20
03/21/20 12:00:00 PM	19.309	80.911	2.96	15.19
03/21/20 01:00:00 PM	19.294	80.911	2.97	15.18
03/21/20 02:00:00 PM	19.275	80.911	2.98	15.17
03/21/20 03:00:00 PM	19.265	80.911	2.99	15.16
03/21/20 04:00:00 PM	19.265	80.911	2.99	15.16
03/21/20 05:00:00 PM	19.260	80.911	2.99	15.16
03/21/20 06:00:00 PM	19.250	80.911	3.00	15.15
03/21/20 07:00:00 PM	19.260	80.911	2.99	15.16
03/21/20 08:00:00 PM	19.270	80.911	2.99	15.16
03/21/20 09:00:00 PM	19.284	80.911	2.98	15.17
03/21/20 10:00:00 PM	19.289	80.911	2.97	15.18
03/21/20 11:00:00 PM	19.294	80.911	2.97	15.18
03/22/20 12:00:00 AM	19.294	80.911	2.97	15.18
03/22/20 01:00:00 AM	19.284	80.911	2.98	15.17
03/22/20 02:00:00 AM	19.275	80.911	2.98	15.17
03/22/20 03:00:00 AM	19.260	80.911	2.99	15.16

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 04:00:00 AM	19.250	80.911	3.00	15.15
03/22/20 05:00:00 AM	19.250	80.911	3.00	15.15
03/22/20 06:00:00 AM	19.245	80.911	3.01	15.14
03/22/20 07:00:00 AM	19.250	80.911	3.00	15.15
03/22/20 08:00:00 AM	19.250	80.911	3.00	15.15
03/22/20 09:00:00 AM	19.265	80.911	2.99	15.16
03/22/20 10:00:00 AM	19.270	80.911	2.99	15.16
03/22/20 11:00:00 AM	19.265	80.911	2.99	15.16
03/22/20 12:00:00 PM	19.245	80.911	3.01	15.14
03/22/20 01:00:00 PM	19.235	80.911	3.01	15.14
03/22/20 02:00:00 PM	19.216	80.911	3.03	15.12
03/22/20 03:00:00 PM	19.191	80.911	3.04	15.11
03/22/20 04:00:00 PM	19.201	80.911	3.04	15.11
03/22/20 05:00:00 PM	19.196	80.911	3.04	15.11
03/22/20 06:00:00 PM	19.201	80.911	3.04	15.11
03/22/20 07:00:00 PM	19.206	80.911	3.03	15.12
03/22/20 08:00:00 PM	19.216	80.911	3.03	15.12
03/22/20 09:00:00 PM	19.225	80.911	3.02	15.13
03/22/20 10:00:00 PM	19.220	80.911	3.02	15.13
03/22/20 11:00:00 PM	19.230	80.911	3.02	15.13
03/23/20 12:00:00 AM	19.230	80.911	3.02	15.13
03/23/20 01:00:00 AM	19.230	80.911	3.02	15.13
03/23/20 02:00:00 AM	19.206	80.911	3.03	15.12
03/23/20 03:00:00 AM	19.201	80.911	3.04	15.11
03/23/20 04:00:00 AM	19.191	80.911	3.04	15.11
03/23/20 05:00:00 AM	19.196	80.911	3.04	15.11
03/23/20 06:00:00 AM	19.196	80.911	3.04	15.11
03/23/20 07:00:00 AM	19.201	80.911	3.04	15.11
03/23/20 08:00:00 AM	19.216	80.911	3.03	15.12
03/23/20 09:00:00 AM	19.235	80.911	3.01	15.14
03/23/20 10:00:00 AM	19.240	80.911	3.01	15.14
03/23/20 11:00:00 AM	19.230	80.911	3.02	15.13
03/23/20 12:00:00 PM	19.240	80.911	3.01	15.14
03/23/20 01:00:00 PM	19.240	80.911	3.01	15.14
03/23/20 02:00:00 PM	19.225	80.911	3.02	15.13
03/23/20 03:00:00 PM	19.220	80.911	3.02	15.13
03/23/20 04:00:00 PM	19.220	80.911	3.02	15.13
03/23/20 05:00:00 PM	19.235	80.911	3.01	15.14
03/23/20 06:00:00 PM	19.250	80.911	3.00	15.15
03/23/20 07:00:00 PM	19.265	80.911	2.99	15.16
03/23/20 08:00:00 PM	19.284	80.911	2.98	15.17

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/23/20 09:00:00 PM	19.294	80.911	2.97	15.18
03/23/20 10:00:00 PM	19.309	80.911	2.96	15.19
03/23/20 11:00:00 PM	19.334	80.911	2.94	15.21
03/24/20 12:00:00 AM	19.348	80.911	2.93	15.22
03/24/20 01:00:00 AM	19.348	80.911	2.93	15.22
03/24/20 02:00:00 AM	19.348	80.911	2.93	15.22
03/24/20 03:00:00 AM	19.373	80.911	2.91	15.24
03/24/20 04:00:00 AM	19.393	80.911	2.90	15.25
03/24/20 05:00:00 AM	19.417	80.911	2.88	15.27
03/24/20 06:00:00 AM	19.457	80.911	2.86	15.29
03/24/20 07:00:00 AM	19.481	80.911	2.84	15.31
03/24/20 08:00:00 AM	19.506	80.911	2.82	15.33
03/24/20 09:00:00 AM	19.536	80.911	2.80	15.35
03/24/20 10:00:00 AM	19.565	80.911	2.78	15.37
03/24/20 11:00:00 AM	19.624	80.911	2.74	15.41
03/24/20 12:00:00 PM	19.634	80.911	2.73	15.42
03/24/20 01:00:00 PM	19.639	80.911	2.73	15.42
03/24/20 02:00:00 PM	19.634	80.911	2.73	15.42
03/24/20 03:00:00 PM	19.644	80.911	2.72	15.43
03/24/20 04:00:00 PM	19.654	80.911	2.72	15.43
03/24/20 05:00:00 PM	19.664	80.911	2.71	15.44
03/24/20 06:00:00 PM	19.688	80.911	2.69	15.46
03/24/20 07:00:00 PM	19.718	80.911	2.67	15.48
03/24/20 08:00:00 PM	19.752	80.911	2.65	15.50
03/24/20 09:00:00 PM	19.777	80.911	2.63	15.52
03/24/20 10:00:00 PM	19.875	80.911	2.56	15.59
03/24/20 11:00:00 PM	19.915	80.911	2.53	15.62
03/25/20 12:00:00 AM	19.920	80.911	2.53	15.62
03/25/20 01:00:00 AM	19.925	80.911	2.53	15.62
03/25/20 02:00:00 AM	19.915	80.911	2.53	15.62
03/25/20 03:00:00 AM	19.915	80.911	2.53	15.62
03/25/20 04:00:00 AM	19.905	80.911	2.54	15.61
03/25/20 05:00:00 AM	19.905	80.911	2.54	15.61
03/25/20 06:00:00 AM	19.905	80.911	2.54	15.61
03/25/20 07:00:00 AM	19.910	80.911	2.54	15.61
03/25/20 08:00:00 AM	19.915	80.911	2.53	15.62
03/25/20 09:00:00 AM	19.920	80.911	2.53	15.62
03/25/20 10:00:00 AM	19.930	80.911	2.52	15.63
03/25/20 11:00:00 AM	19.930	80.911	2.52	15.63
03/25/20 12:00:00 PM	19.925	80.911	2.53	15.62
03/25/20 01:00:00 PM	19.910	80.911	2.54	15.61

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/25/20 02:00:00 PM	19.900	80.911	2.54	15.61
03/25/20 03:00:00 PM	19.895	80.911	2.55	15.60
03/25/20 04:00:00 PM	19.875	80.911	2.56	15.59
03/25/20 05:00:00 PM	19.866	80.911	2.57	15.58
03/25/20 06:00:00 PM	19.871	80.911	2.56	15.59
03/25/20 07:00:00 PM	19.875	80.911	2.56	15.59
03/25/20 08:00:00 PM	19.890	80.911	2.55	15.60
03/25/20 09:00:00 PM	19.910	80.911	2.54	15.61
03/25/20 10:00:00 PM	19.930	80.911	2.52	15.63
03/25/20 11:00:00 PM	19.964	80.911	2.50	15.65
03/26/20 12:00:00 AM	19.974	80.911	2.49	15.66
03/26/20 01:00:00 AM	20.004	80.911	2.47	15.68
03/26/20 02:00:00 AM	20.013	80.911	2.46	15.69
03/26/20 03:00:00 AM	20.023	80.911	2.46	15.69
03/26/20 04:00:00 AM	20.033	80.911	2.45	15.70
03/26/20 05:00:00 AM	20.048	80.911	2.44	15.71
03/26/20 06:00:00 AM	20.053	80.911	2.44	15.71
03/26/20 07:00:00 AM	20.072	80.911	2.42	15.73
03/26/20 08:00:00 AM	20.102	80.911	2.40	15.75
03/26/20 09:00:00 AM	20.127	80.911	2.38	15.77
03/26/20 10:00:00 AM	20.156	80.911	2.36	15.79
03/26/20 11:00:00 AM	20.171	80.911	2.35	15.80
03/26/20 12:00:00 PM	20.191	80.911	2.34	15.81
03/26/20 01:00:00 PM	20.196	80.911	2.34	15.81
03/26/20 02:00:00 PM	20.200	80.911	2.33	15.82
03/26/20 03:00:00 PM	20.210	80.911	2.33	15.82
03/26/20 04:00:00 PM	20.230	80.911	2.31	15.84
03/26/20 05:00:00 PM	20.255	80.911	2.29	15.86
03/26/20 06:00:00 PM	20.269	80.911	2.28	15.87
03/26/20 07:00:00 PM	20.289	80.911	2.27	15.88
03/26/20 08:00:00 PM	20.309	80.911	2.26	15.89
03/26/20 09:00:00 PM	20.324	80.911	2.25	15.90
03/26/20 10:00:00 PM	20.333	80.911	2.24	15.91
03/26/20 11:00:00 PM	20.348	80.911	2.23	15.92
03/27/20 12:00:00 AM	20.348	80.911	2.23	15.92
03/27/20 01:00:00 AM	20.353	80.911	2.23	15.92
03/27/20 02:00:00 AM	20.333	80.911	2.24	15.91
03/27/20 03:00:00 AM	20.324	80.911	2.25	15.90
03/27/20 04:00:00 AM	20.319	80.911	2.25	15.90
03/27/20 05:00:00 AM	20.324	80.911	2.25	15.90
03/27/20 06:00:00 AM	20.319	80.911	2.25	15.90

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/27/20 07:00:00 AM	20.319	80.911	2.25	15.90
03/27/20 08:00:00 AM	20.319	80.911	2.25	15.90
03/27/20 09:00:00 AM	20.329	80.911	2.24	15.91
03/27/20 10:00:00 AM	20.338	80.911	2.24	15.91
03/27/20 11:00:00 AM	20.348	80.911	2.23	15.92
03/27/20 12:00:00 PM	20.343	80.911	2.23	15.92
03/27/20 01:00:00 PM	20.333	80.911	2.24	15.91
03/27/20 02:00:00 PM	20.314	80.911	2.25	15.90
03/27/20 03:00:00 PM	20.289	80.911	2.27	15.88
03/27/20 04:00:00 PM	20.284	80.911	2.27	15.88
03/27/20 05:00:00 PM	20.279	80.911	2.28	15.87
03/27/20 06:00:00 PM	20.284	80.911	2.27	15.88
03/27/20 07:00:00 PM	20.284	80.911	2.27	15.88
03/27/20 08:00:00 PM	20.289	80.911	2.27	15.88
03/27/20 09:00:00 PM	20.294	80.911	2.27	15.88
03/27/20 10:00:00 PM	20.304	80.911	2.26	15.89
03/27/20 11:00:00 PM	20.329	80.911	2.24	15.91
03/28/20 12:00:00 AM	20.338	80.911	2.24	15.91
03/28/20 01:00:00 AM	20.358	80.911	2.22	15.93
03/28/20 02:00:00 AM	20.383	80.911	2.20	15.95
03/28/20 03:00:00 AM	20.422	80.911	2.18	15.97
03/28/20 04:00:00 AM	20.471	80.911	2.14	16.01
03/28/20 05:00:00 AM	20.501	80.911	2.12	16.03
03/28/20 06:00:00 AM	20.535	80.911	2.10	16.05
03/28/20 07:00:00 AM	20.580	80.911	2.07	16.08
03/28/20 08:00:00 AM	20.614	80.911	2.04	16.11
03/28/20 09:00:00 AM	20.639	80.911	2.02	16.13
03/28/20 10:00:00 AM	20.654	80.911	2.01	16.14
03/28/20 11:00:00 AM	20.654	80.911	2.01	16.14
03/28/20 12:00:00 PM	20.668	80.911	2.00	16.15
03/28/20 01:00:00 PM	20.668	80.911	2.00	16.15
03/28/20 02:00:00 PM	20.663	80.911	2.01	16.14
03/28/20 03:00:00 PM	20.654	80.911	2.01	16.14
03/28/20 04:00:00 PM	20.649	80.911	2.02	16.13
03/28/20 05:00:00 PM	20.649	80.911	2.02	16.13
03/28/20 06:00:00 PM	20.654	80.911	2.01	16.14
03/28/20 07:00:00 PM	20.659	80.911	2.01	16.14
03/28/20 08:00:00 PM	20.668	80.911	2.00	16.15
03/28/20 09:00:00 PM	20.678	80.911	2.00	16.15
03/28/20 10:00:00 PM	20.688	80.911	1.99	16.16
03/28/20 11:00:00 PM	20.698	80.911	1.98	16.17

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 12:00:00 AM	20.693	80.911	1.99	16.16
03/29/20 01:00:00 AM	20.683	80.911	1.99	16.16
03/29/20 02:00:00 AM	20.668	80.911	2.00	16.15
03/29/20 03:00:00 AM	20.659	80.911	2.01	16.14
03/29/20 04:00:00 AM	20.654	80.911	2.01	16.14
03/29/20 05:00:00 AM	20.644	80.911	2.02	16.13
03/29/20 06:00:00 AM	20.639	80.911	2.02	16.13
03/29/20 07:00:00 AM	20.644	80.911	2.02	16.13
03/29/20 08:00:00 AM	20.644	80.911	2.02	16.13
03/29/20 09:00:00 AM	20.644	80.911	2.02	16.13
03/29/20 10:00:00 AM	20.639	80.911	2.02	16.13
03/29/20 11:00:00 AM	20.629	80.911	2.03	16.12
03/29/20 12:00:00 PM	20.619	80.911	2.04	16.11
03/29/20 01:00:00 PM	20.604	80.911	2.05	16.10
03/29/20 02:00:00 PM	20.585	80.911	2.06	16.09
03/29/20 03:00:00 PM	20.565	80.911	2.08	16.07
03/29/20 04:00:00 PM	20.550	80.911	2.09	16.06
03/29/20 05:00:00 PM	20.540	80.911	2.09	16.06
03/29/20 06:00:00 PM	20.535	80.911	2.10	16.05
03/29/20 07:00:00 PM	20.530	80.911	2.10	16.05
03/29/20 08:00:00 PM	20.540	80.911	2.09	16.06
03/29/20 09:00:00 PM	20.550	80.911	2.09	16.06
03/29/20 10:00:00 PM	20.550	80.911	2.09	16.06
03/29/20 11:00:00 PM	20.550	80.911	2.09	16.06
03/30/20 12:00:00 AM	20.540	80.911	2.09	16.06
03/30/20 01:00:00 AM	20.526	80.911	2.10	16.05
03/30/20 02:00:00 AM	20.506	80.911	2.12	16.03
03/30/20 03:00:00 AM	20.491	80.911	2.13	16.02
03/30/20 04:00:00 AM	20.476	80.911	2.14	16.01
03/30/20 05:00:00 AM	20.462	80.911	2.15	16.00
03/30/20 06:00:00 AM	20.462	80.911	2.15	16.00
03/30/20 07:00:00 AM	20.452	80.911	2.16	15.99
03/30/20 08:00:00 AM	20.452	80.911	2.16	15.99
03/30/20 09:00:00 AM	20.452	80.911	2.16	15.99
03/30/20 10:00:00 AM	20.447	80.911	2.16	15.99
03/30/20 11:00:00 AM	20.427	80.911	2.17	15.98
03/30/20 12:00:00 PM	20.402	80.911	2.19	15.96
03/30/20 01:00:00 PM	20.383	80.911	2.20	15.95
03/30/20 02:00:00 PM	20.358	80.911	2.22	15.93
03/30/20 03:00:00 PM	20.333	80.911	2.24	15.91
03/30/20 04:00:00 PM	20.314	80.911	2.25	15.90

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/30/20 05:00:00 PM	20.304	80.911	2.26	15.89
03/30/20 06:00:00 PM	20.304	80.911	2.26	15.89
03/30/20 07:00:00 PM	20.319	80.911	2.25	15.90
03/30/20 08:00:00 PM	20.324	80.911	2.25	15.90
03/30/20 09:00:00 PM	20.329	80.911	2.24	15.91
03/30/20 10:00:00 PM	20.333	80.911	2.24	15.91
03/30/20 11:00:00 PM	20.343	80.911	2.23	15.92
03/31/20 12:00:00 AM	20.329	80.911	2.24	15.91
03/31/20 01:00:00 AM	20.319	80.911	2.25	15.90
03/31/20 02:00:00 AM	20.304	80.911	2.26	15.89
03/31/20 03:00:00 AM	20.294	80.911	2.27	15.88
03/31/20 04:00:00 AM	20.274	80.911	2.28	15.87
03/31/20 05:00:00 AM	20.264	80.911	2.29	15.86
03/31/20 06:00:00 AM	20.260	80.911	2.29	15.86
03/31/20 07:00:00 AM	20.255	80.911	2.29	15.86
03/31/20 08:00:00 AM	20.260	80.911	2.29	15.86
03/31/20 09:00:00 AM	20.264	80.911	2.29	15.86
03/31/20 10:00:00 AM	20.260	80.911	2.29	15.86
03/31/20 11:00:00 AM	20.255	80.911	2.29	15.86
03/31/20 12:00:00 PM	20.240	80.911	2.31	15.84
03/31/20 01:00:00 PM	20.215	80.911	2.32	15.83
03/31/20 02:00:00 PM	20.186	80.911	2.34	15.81
03/31/20 03:00:00 PM	20.161	80.911	2.36	15.79
03/31/20 04:00:00 PM	20.151	80.911	2.37	15.78
03/31/20 05:00:00 PM	20.137	80.911	2.38	15.77
03/31/20 06:00:00 PM	20.132	80.911	2.38	15.77
03/31/20 07:00:00 PM	20.141	80.911	2.37	15.78
03/31/20 08:00:00 PM	20.146	80.911	2.37	15.78
03/31/20 09:00:00 PM	20.151	80.911	2.37	15.78
03/31/20 10:00:00 PM	20.156	80.911	2.36	15.79
03/31/20 11:00:00 PM	20.151	80.911	2.37	15.78
4/1/2020 12:00:00 AM	20.146	80.911	2.37	15.78
4/1/2020 1:00:00 AM	20.132	80.911	2.38	15.77
4/1/2020 2:00:00 AM	20.117	80.911	2.39	15.76
4/1/2020 3:00:00 AM	20.102	80.911	2.40	15.75
4/1/2020 4:00:00 AM	20.082	80.911	2.42	15.73
4/1/2020 5:00:00 AM	20.072	80.911	2.42	15.73
4/1/2020 6:00:00 AM	20.077	80.911	2.42	15.73
4/1/2020 7:00:00 AM	20.072	80.911	2.42	15.73
4/1/2020 8:00:00 AM	20.063	80.911	2.43	15.72
4/1/2020 9:00:00 AM	20.053	80.911	2.44	15.71

WATER STANDPIPE MONITORING

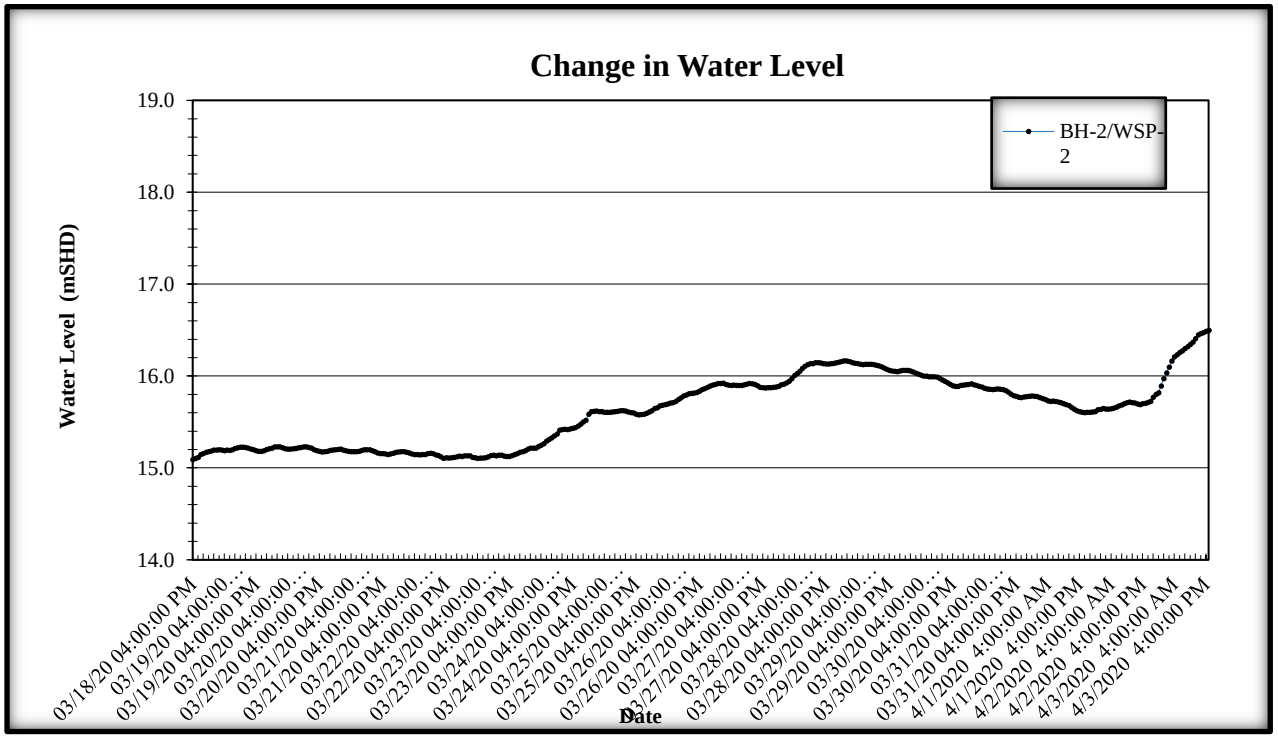
Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/1/2020 10:00:00 AM	20.038	80.911	2.45	15.70
4/1/2020 11:00:00 AM	20.023	80.911	2.46	15.69
4/1/2020 12:00:00 PM	20.008	80.911	2.47	15.68
4/1/2020 1:00:00 PM	19.979	80.911	2.49	15.66
4/1/2020 2:00:00 PM	19.954	80.911	2.51	15.64
4/1/2020 3:00:00 PM	19.930	80.911	2.52	15.63
4/1/2020 4:00:00 PM	19.915	80.911	2.53	15.62
4/1/2020 5:00:00 PM	19.905	80.911	2.54	15.61
4/1/2020 6:00:00 PM	19.900	80.911	2.54	15.61
4/1/2020 7:00:00 PM	19.905	80.911	2.54	15.61
4/1/2020 8:00:00 PM	19.905	80.911	2.54	15.61
4/1/2020 9:00:00 PM	19.910	80.911	2.54	15.61
4/1/2020 10:00:00 PM	19.915	80.911	2.53	15.62
4/1/2020 11:00:00 PM	19.944	80.911	2.51	15.64
4/2/2020 12:00:00 AM	19.949	80.911	2.51	15.64
4/2/2020 1:00:00 AM	19.964	80.911	2.50	15.65
4/2/2020 2:00:00 AM	19.954	80.911	2.51	15.64
4/2/2020 3:00:00 AM	19.954	80.911	2.51	15.64
4/2/2020 4:00:00 AM	19.959	80.911	2.50	15.65
4/2/2020 5:00:00 AM	19.969	80.911	2.50	15.65
4/2/2020 6:00:00 AM	19.984	80.911	2.49	15.66
4/2/2020 7:00:00 AM	20.004	80.911	2.47	15.68
4/2/2020 8:00:00 AM	20.018	80.911	2.46	15.69
4/2/2020 9:00:00 AM	20.038	80.911	2.45	15.70
4/2/2020 10:00:00 AM	20.053	80.911	2.44	15.71
4/2/2020 11:00:00 AM	20.063	80.911	2.43	15.72
4/2/2020 12:00:00 PM	20.053	80.911	2.44	15.71
4/2/2020 1:00:00 PM	20.048	80.911	2.44	15.71
4/2/2020 2:00:00 PM	20.033	80.911	2.45	15.70
4/2/2020 3:00:00 PM	20.023	80.911	2.46	15.69
4/2/2020 4:00:00 PM	20.038	80.911	2.45	15.70
4/2/2020 5:00:00 PM	20.043	80.911	2.44	15.71
4/2/2020 6:00:00 PM	20.058	80.911	2.43	15.72
4/2/2020 7:00:00 PM	20.072	80.911	2.42	15.73
4/2/2020 8:00:00 PM	20.137	80.911	2.38	15.77
4/2/2020 9:00:00 PM	20.181	80.911	2.35	15.80
4/2/2020 10:00:00 PM	20.205	80.911	2.33	15.82
4/2/2020 11:00:00 PM	20.309	80.911	2.26	15.89
4/3/2020 12:00:00 AM	20.422	80.911	2.18	15.97
4/3/2020 1:00:00 AM	20.511	80.911	2.11	16.04
4/3/2020 2:00:00 AM	20.599	80.911	2.05	16.10

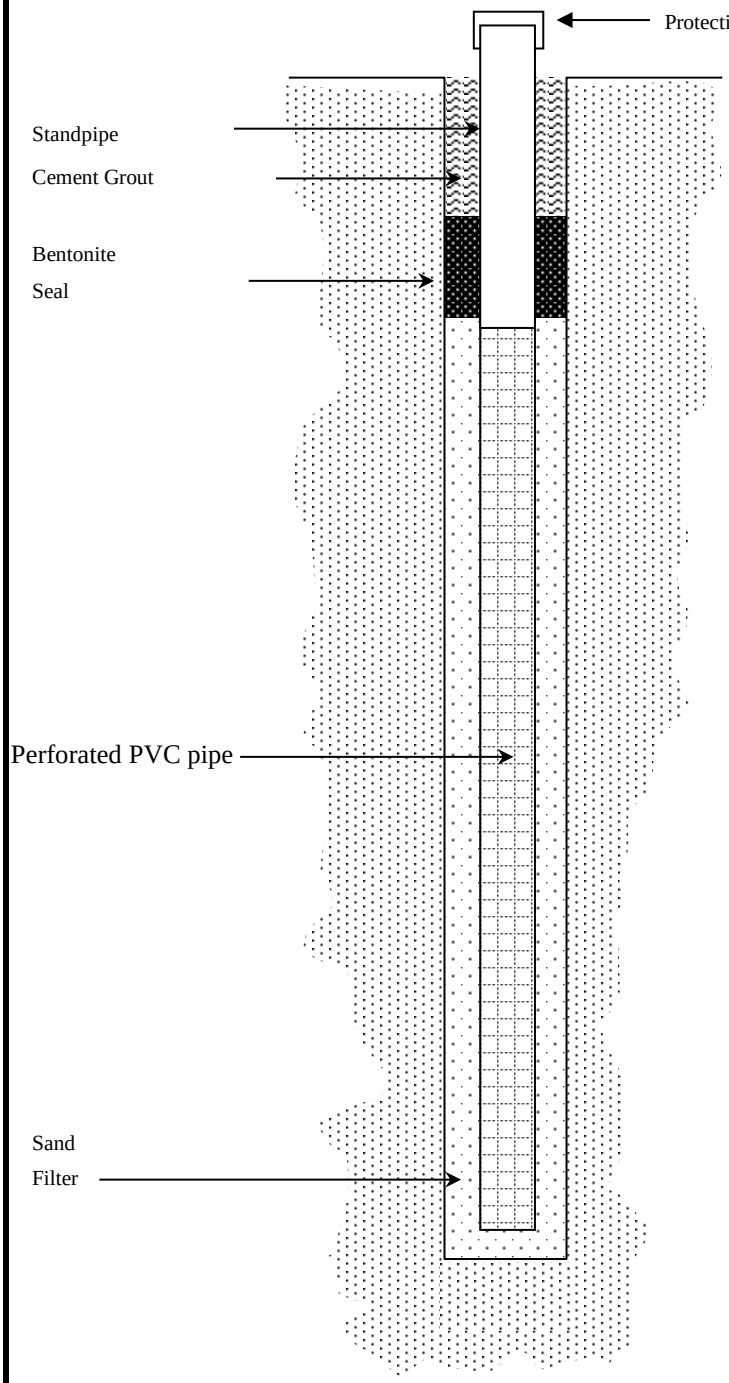
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-2/WSP-2**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.31
Location:	Tengah	**Pipe Top Level (mSHD)**	18.950
		Ground Level (mSHD)	18.150

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/3/2020 3:00:00 AM	20.693	80.911	1.99	16.16
4/3/2020 4:00:00 AM	20.757	80.911	1.94	16.21
4/3/2020 5:00:00 AM	20.796	80.911	1.91	16.24
4/3/2020 6:00:00 AM	20.831	80.911	1.89	16.26
4/3/2020 7:00:00 AM	20.855	80.911	1.87	16.28
4/3/2020 8:00:00 AM	20.890	80.911	1.85	16.30
4/3/2020 9:00:00 AM	20.919	80.911	1.83	16.32
4/3/2020 10:00:00 AM	20.954	80.911	1.80	16.35
4/3/2020 11:00:00 AM	20.988	80.911	1.78	16.37
4/3/2020 12:00:00 PM	21.043	80.911	1.74	16.41
4/3/2020 1:00:00 PM	21.102	80.911	1.70	16.45
4/3/2020 2:00:00 PM	21.121	80.911	1.68	16.47
4/3/2020 3:00:00 PM	21.136	80.911	1.67	16.48
4/3/2020 4:00:00 PM	21.156	80.911	1.66	16.49
4/3/2020 5:00:00 PM	21.171	80.911	1.65	16.50



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	12 Mar 2020	**INSTALLED BY:** M. Pandiyan



Depth (GL-m)	0.00
	2.50
	3.00
	8.00

REMARKS:

INSTALLED IN BH03/WSP-03

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/18/20 04:00:00 PM	17.030	80.382	4.55	17.34
03/18/20 05:00:00 PM	17.019	80.206	4.56	17.33
03/18/20 06:00:00 PM	17.019	80.206	4.56	17.33
03/18/20 07:00:00 PM	17.044	80.206	4.54	17.35
03/18/20 08:00:00 PM	17.044	80.206	4.54	17.35
03/18/20 09:00:00 PM	17.059	80.206	4.53	17.36
03/18/20 10:00:00 PM	17.064	80.206	4.53	17.36
03/18/20 11:00:00 PM	17.064	80.206	4.53	17.36
03/19/20 12:00:00 AM	17.059	80.206	4.53	17.36
03/19/20 01:00:00 AM	17.054	80.206	4.54	17.35
03/19/20 02:00:00 AM	17.059	80.206	4.53	17.36
03/19/20 03:00:00 AM	17.034	80.206	4.55	17.34
03/19/20 04:00:00 AM	17.029	80.206	4.55	17.34
03/19/20 05:00:00 AM	17.029	80.206	4.55	17.34
03/19/20 06:00:00 AM	17.019	80.206	4.56	17.33
03/19/20 07:00:00 AM	17.029	80.206	4.55	17.34
03/19/20 08:00:00 AM	17.044	80.206	4.54	17.35
03/19/20 09:00:00 AM	17.054	80.206	4.54	17.35
03/19/20 10:00:00 AM	17.054	80.206	4.54	17.35
03/19/20 11:00:00 AM	17.059	80.206	4.53	17.36
03/19/20 12:00:00 PM	17.044	80.206	4.54	17.35
03/19/20 01:00:00 PM	17.039	80.206	4.55	17.34
03/19/20 02:00:00 PM	17.009	80.206	4.57	17.32
03/19/20 03:00:00 PM	17.004	80.206	4.57	17.32
03/19/20 04:00:00 PM	16.989	80.206	4.58	17.31
03/19/20 05:00:00 PM	16.984	80.206	4.59	17.30
03/19/20 06:00:00 PM	16.979	80.206	4.59	17.30
03/19/20 07:00:00 PM	16.994	80.206	4.58	17.31
03/19/20 08:00:00 PM	16.999	80.206	4.58	17.31
03/19/20 09:00:00 PM	17.019	80.206	4.56	17.33
03/19/20 10:00:00 PM	17.024	80.206	4.56	17.33
03/19/20 11:00:00 PM	17.029	80.206	4.55	17.34
03/20/20 12:00:00 AM	17.039	80.206	4.55	17.34
03/20/20 01:00:00 AM	17.034	80.206	4.55	17.34
03/20/20 02:00:00 AM	17.019	80.206	4.56	17.33
03/20/20 03:00:00 AM	16.999	80.206	4.58	17.31
03/20/20 04:00:00 AM	16.994	80.206	4.58	17.31
03/20/20 05:00:00 AM	16.994	80.206	4.58	17.31
03/20/20 06:00:00 AM	17.004	80.206	4.57	17.32
03/20/20 07:00:00 AM	17.009	80.206	4.57	17.32
03/20/20 08:00:00 AM	17.014	80.206	4.56	17.33
03/20/20 09:00:00 AM	17.024	80.206	4.56	17.33

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 10:00:00 AM	17.029	80.206	4.55	17.34

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 11:00:00 AM	17.029	80.206	4.55	17.34
03/20/20 12:00:00 PM	17.014	80.206	4.56	17.33
03/20/20 01:00:00 PM	17.004	80.206	4.57	17.32
03/20/20 02:00:00 PM	16.984	80.206	4.59	17.30
03/20/20 03:00:00 PM	16.974	80.206	4.59	17.30
03/20/20 04:00:00 PM	16.959	80.206	4.60	17.29
03/20/20 05:00:00 PM	16.954	80.206	4.61	17.28
03/20/20 06:00:00 PM	16.959	80.206	4.60	17.29
03/20/20 07:00:00 PM	16.964	80.206	4.60	17.29
03/20/20 08:00:00 PM	16.974	80.206	4.59	17.30
03/20/20 09:00:00 PM	16.989	80.206	4.58	17.31
03/20/20 10:00:00 PM	16.989	80.206	4.58	17.31
03/20/20 11:00:00 PM	16.999	80.206	4.58	17.31
03/21/20 12:00:00 AM	16.999	80.206	4.58	17.31
03/21/20 01:00:00 AM	16.984	80.206	4.59	17.30
03/21/20 02:00:00 AM	16.969	80.206	4.60	17.29
03/21/20 03:00:00 AM	16.959	80.206	4.60	17.29
03/21/20 04:00:00 AM	16.949	80.206	4.61	17.28
03/21/20 05:00:00 AM	16.964	80.206	4.60	17.29
03/21/20 06:00:00 AM	16.959	80.206	4.60	17.29
03/21/20 07:00:00 AM	16.964	80.206	4.60	17.29
03/21/20 08:00:00 AM	16.979	80.206	4.59	17.30
03/21/20 09:00:00 AM	16.984	80.206	4.59	17.30
03/21/20 10:00:00 AM	16.984	80.206	4.59	17.30
03/21/20 11:00:00 AM	16.984	80.206	4.59	17.30
03/21/20 12:00:00 PM	16.974	80.206	4.59	17.30
03/21/20 01:00:00 PM	16.959	80.206	4.60	17.29
03/21/20 02:00:00 PM	16.944	80.206	4.61	17.28
03/21/20 03:00:00 PM	16.934	80.206	4.62	17.27
03/21/20 04:00:00 PM	16.929	80.206	4.62	17.27
03/21/20 05:00:00 PM	16.924	80.206	4.63	17.26
03/21/20 06:00:00 PM	16.924	80.206	4.63	17.26
03/21/20 07:00:00 PM	16.934	80.206	4.62	17.27
03/21/20 08:00:00 PM	16.934	80.206	4.62	17.27
03/21/20 09:00:00 PM	16.949	80.206	4.61	17.28
03/21/20 10:00:00 PM	16.964	80.206	4.60	17.29
03/21/20 11:00:00 PM	16.959	80.206	4.60	17.29
03/22/20 12:00:00 AM	16.969	80.206	4.60	17.29
03/22/20 01:00:00 AM	16.959	80.206	4.60	17.29
03/22/20 02:00:00 AM	16.944	80.206	4.61	17.28
03/22/20 03:00:00 AM	16.934	80.206	4.62	17.27

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 04:00:00 AM	16.929	80.206	4.62	17.27
03/22/20 05:00:00 AM	16.924	80.206	4.63	17.26
03/22/20 06:00:00 AM	16.939	80.206	4.62	17.27
03/22/20 07:00:00 AM	16.924	80.206	4.63	17.26
03/22/20 08:00:00 AM	16.934	80.206	4.62	17.27
03/22/20 09:00:00 AM	16.939	80.206	4.62	17.27
03/22/20 10:00:00 AM	16.949	80.206	4.61	17.28
03/22/20 11:00:00 AM	16.939	80.206	4.62	17.27
03/22/20 12:00:00 PM	16.924	80.206	4.63	17.26
03/22/20 01:00:00 PM	16.919	80.206	4.63	17.26
03/22/20 02:00:00 PM	16.904	80.206	4.64	17.25
03/22/20 03:00:00 PM	16.884	80.206	4.66	17.23
03/22/20 04:00:00 PM	16.894	80.206	4.65	17.24
03/22/20 05:00:00 PM	16.939	80.206	4.62	17.27
03/22/20 06:00:00 PM	16.989	80.206	4.58	17.31
03/22/20 07:00:00 PM	17.019	80.206	4.56	17.33
03/22/20 08:00:00 PM	17.054	80.206	4.54	17.35
03/22/20 09:00:00 PM	17.079	80.206	4.52	17.37
03/22/20 10:00:00 PM	17.089	80.206	4.51	17.38
03/22/20 11:00:00 PM	17.109	80.206	4.50	17.39
03/23/20 12:00:00 AM	17.114	80.206	4.49	17.40
03/23/20 01:00:00 AM	17.114	80.206	4.49	17.40
03/23/20 02:00:00 AM	17.099	80.206	4.50	17.39
03/23/20 03:00:00 AM	17.084	80.206	4.52	17.37
03/23/20 04:00:00 AM	17.069	80.206	4.53	17.36
03/23/20 05:00:00 AM	17.064	80.206	4.53	17.36
03/23/20 06:00:00 AM	17.064	80.206	4.53	17.36
03/23/20 07:00:00 AM	17.064	80.206	4.53	17.36
03/23/20 08:00:00 AM	17.079	80.206	4.52	17.37
03/23/20 09:00:00 AM	17.084	80.206	4.52	17.37
03/23/20 10:00:00 AM	17.089	80.206	4.51	17.38
03/23/20 11:00:00 AM	17.069	80.206	4.53	17.36
03/23/20 12:00:00 PM	17.074	80.206	4.52	17.37
03/23/20 01:00:00 PM	17.059	80.206	4.53	17.36
03/23/20 02:00:00 PM	17.044	80.206	4.54	17.35
03/23/20 03:00:00 PM	17.029	80.206	4.55	17.34
03/23/20 04:00:00 PM	17.024	80.206	4.56	17.33
03/23/20 05:00:00 PM	17.019	80.206	4.56	17.33
03/23/20 06:00:00 PM	17.019	80.206	4.56	17.33
03/23/20 07:00:00 PM	17.024	80.206	4.56	17.33
03/23/20 08:00:00 PM	17.029	80.206	4.55	17.34

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/23/20 09:00:00 PM	17.034	80.206	4.55	17.34
03/23/20 10:00:00 PM	17.024	80.206	4.56	17.33
03/23/20 11:00:00 PM	17.044	80.206	4.54	17.35
03/24/20 12:00:00 AM	17.049	80.206	4.54	17.35
03/24/20 01:00:00 AM	17.039	80.206	4.55	17.34
03/24/20 02:00:00 AM	17.029	80.206	4.55	17.34
03/24/20 03:00:00 AM	17.024	80.206	4.56	17.33
03/24/20 04:00:00 AM	17.009	80.206	4.57	17.32
03/24/20 05:00:00 AM	17.009	80.206	4.57	17.32
03/24/20 06:00:00 AM	17.009	80.206	4.57	17.32
03/24/20 07:00:00 AM	17.009	80.206	4.57	17.32
03/24/20 08:00:00 AM	17.014	80.206	4.56	17.33
03/24/20 09:00:00 AM	17.019	80.206	4.56	17.33
03/24/20 10:00:00 AM	17.029	80.206	4.55	17.34
03/24/20 11:00:00 AM	17.029	80.206	4.55	17.34
03/24/20 12:00:00 PM	17.014	80.206	4.56	17.33
03/24/20 01:00:00 PM	17.004	80.206	4.57	17.32
03/24/20 02:00:00 PM	16.984	80.206	4.59	17.30
03/24/20 03:00:00 PM	16.969	80.206	4.60	17.29
03/24/20 04:00:00 PM	16.954	80.206	4.61	17.28
03/24/20 05:00:00 PM	16.949	80.206	4.61	17.28
03/24/20 06:00:00 PM	16.949	80.206	4.61	17.28
03/24/20 07:00:00 PM	16.959	80.206	4.60	17.29
03/24/20 08:00:00 PM	16.969	80.206	4.60	17.29
03/24/20 09:00:00 PM	16.974	80.206	4.59	17.30
03/24/20 10:00:00 PM	16.984	80.206	4.59	17.30
03/24/20 11:00:00 PM	16.989	80.206	4.58	17.31
03/25/20 12:00:00 AM	16.989	80.206	4.58	17.31
03/25/20 01:00:00 AM	16.979	80.206	4.59	17.30
03/25/20 02:00:00 AM	16.974	80.206	4.59	17.30
03/25/20 03:00:00 AM	16.964	80.206	4.60	17.29
03/25/20 04:00:00 AM	16.954	80.206	4.61	17.28
03/25/20 05:00:00 AM	16.949	80.206	4.61	17.28
03/25/20 06:00:00 AM	16.954	80.206	4.61	17.28
03/25/20 07:00:00 AM	16.954	80.206	4.61	17.28
03/25/20 08:00:00 AM	16.959	80.206	4.60	17.29
03/25/20 09:00:00 AM	16.964	80.206	4.60	17.29
03/25/20 10:00:00 AM	16.969	80.206	4.60	17.29
03/25/20 11:00:00 AM	16.979	80.206	4.59	17.30
03/25/20 12:00:00 PM	16.969	80.206	4.60	17.29
03/25/20 01:00:00 PM	16.954	80.206	4.61	17.28

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/25/20 02:00:00 PM	16.944	80.206	4.61	17.28
03/25/20 03:00:00 PM	16.944	80.206	4.61	17.28
03/25/20 04:00:00 PM	16.984	80.206	4.59	17.30
03/25/20 05:00:00 PM	17.034	80.206	4.55	17.34
03/25/20 06:00:00 PM	17.079	80.206	4.52	17.37
03/25/20 07:00:00 PM	17.114	80.206	4.49	17.40
03/25/20 08:00:00 PM	17.155	80.206	4.47	17.42
03/25/20 09:00:00 PM	17.175	80.206	4.45	17.44
03/25/20 10:00:00 PM	17.205	80.206	4.43	17.46
03/25/20 11:00:00 PM	17.225	80.206	4.42	17.47
03/26/20 12:00:00 AM	17.225	80.206	4.42	17.47
03/26/20 01:00:00 AM	17.225	80.206	4.42	17.47
03/26/20 02:00:00 AM	17.225	80.206	4.42	17.47
03/26/20 03:00:00 AM	17.210	80.206	4.43	17.46
03/26/20 04:00:00 AM	17.210	80.206	4.43	17.46
03/26/20 05:00:00 AM	17.200	80.206	4.43	17.46
03/26/20 06:00:00 AM	17.195	80.206	4.44	17.45
03/26/20 07:00:00 AM	17.200	80.206	4.43	17.46
03/26/20 08:00:00 AM	17.210	80.206	4.43	17.46
03/26/20 09:00:00 AM	17.215	80.206	4.42	17.47
03/26/20 10:00:00 AM	17.215	80.206	4.42	17.47
03/26/20 11:00:00 AM	17.215	80.206	4.42	17.47
03/26/20 12:00:00 PM	17.210	80.206	4.43	17.46
03/26/20 01:00:00 PM	17.195	80.206	4.44	17.45
03/26/20 02:00:00 PM	17.175	80.206	4.45	17.44
03/26/20 03:00:00 PM	17.155	80.206	4.47	17.42
03/26/20 04:00:00 PM	17.139	80.206	4.48	17.41
03/26/20 05:00:00 PM	17.135	80.206	4.48	17.41
03/26/20 06:00:00 PM	17.129	80.206	4.48	17.41
03/26/20 07:00:00 PM	17.135	80.206	4.48	17.41
03/26/20 08:00:00 PM	17.145	80.206	4.47	17.42
03/26/20 09:00:00 PM	17.149	80.206	4.47	17.42
03/26/20 10:00:00 PM	17.149	80.206	4.47	17.42
03/26/20 11:00:00 PM	17.160	80.206	4.46	17.43
03/27/20 12:00:00 AM	17.165	80.206	4.46	17.43
03/27/20 01:00:00 AM	17.155	80.206	4.47	17.42
03/27/20 02:00:00 AM	17.149	80.206	4.47	17.42
03/27/20 03:00:00 AM	17.124	80.206	4.49	17.40
03/27/20 04:00:00 AM	17.109	80.206	4.50	17.39
03/27/20 05:00:00 AM	17.109	80.206	4.50	17.39
03/27/20 06:00:00 AM	17.099	80.206	4.50	17.39

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/27/20 07:00:00 AM	17.104	80.206	4.50	17.39
03/27/20 08:00:00 AM	17.114	80.206	4.49	17.40
03/27/20 09:00:00 AM	17.119	80.206	4.49	17.40
03/27/20 10:00:00 AM	17.119	80.206	4.49	17.40
03/27/20 11:00:00 AM	17.119	80.206	4.49	17.40
03/27/20 12:00:00 PM	17.109	80.206	4.50	17.39
03/27/20 01:00:00 PM	17.099	80.206	4.50	17.39
03/27/20 02:00:00 PM	17.074	80.206	4.52	17.37
03/27/20 03:00:00 PM	17.064	80.206	4.53	17.36
03/27/20 04:00:00 PM	17.059	80.206	4.53	17.36
03/27/20 05:00:00 PM	17.049	80.206	4.54	17.35
03/27/20 06:00:00 PM	17.059	80.206	4.53	17.36
03/27/20 07:00:00 PM	17.089	80.206	4.51	17.38
03/27/20 08:00:00 PM	17.135	80.206	4.48	17.41
03/27/20 09:00:00 PM	17.175	80.206	4.45	17.44
03/27/20 10:00:00 PM	17.210	80.206	4.43	17.46
03/27/20 11:00:00 PM	17.250	80.206	4.40	17.49
03/28/20 12:00:00 AM	17.280	80.206	4.38	17.51
03/28/20 01:00:00 AM	17.300	80.206	4.36	17.53
03/28/20 02:00:00 AM	17.300	80.206	4.36	17.53
03/28/20 03:00:00 AM	17.310	80.206	4.36	17.53
03/28/20 04:00:00 AM	17.310	80.206	4.36	17.53
03/28/20 05:00:00 AM	17.310	80.206	4.36	17.53
03/28/20 06:00:00 AM	17.310	80.206	4.36	17.53
03/28/20 07:00:00 AM	17.320	80.206	4.35	17.54
03/28/20 08:00:00 AM	17.340	80.206	4.34	17.55
03/28/20 09:00:00 AM	17.340	80.206	4.34	17.55
03/28/20 10:00:00 AM	17.335	80.206	4.34	17.55
03/28/20 11:00:00 AM	17.325	80.206	4.35	17.54
03/28/20 12:00:00 PM	17.315	80.206	4.35	17.54
03/28/20 01:00:00 PM	17.300	80.206	4.36	17.53
03/28/20 02:00:00 PM	17.280	80.206	4.38	17.51
03/28/20 03:00:00 PM	17.250	80.206	4.40	17.49
03/28/20 04:00:00 PM	17.245	80.206	4.40	17.49
03/28/20 05:00:00 PM	17.225	80.206	4.42	17.47
03/28/20 06:00:00 PM	17.225	80.206	4.42	17.47
03/28/20 07:00:00 PM	17.225	80.206	4.42	17.47
03/28/20 08:00:00 PM	17.225	80.206	4.42	17.47
03/28/20 09:00:00 PM	17.230	80.206	4.41	17.48
03/28/20 10:00:00 PM	17.245	80.206	4.40	17.49
03/28/20 11:00:00 PM	17.250	80.206	4.40	17.49

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 12:00:00 AM	17.250	80.206	4.40	17.49
03/29/20 01:00:00 AM	17.245	80.206	4.40	17.49
03/29/20 02:00:00 AM	17.230	80.206	4.41	17.48
03/29/20 03:00:00 AM	17.220	80.206	4.42	17.47
03/29/20 04:00:00 AM	17.205	80.206	4.43	17.46
03/29/20 05:00:00 AM	17.200	80.206	4.43	17.46
03/29/20 06:00:00 AM	17.200	80.206	4.43	17.46
03/29/20 07:00:00 AM	17.195	80.206	4.44	17.45
03/29/20 08:00:00 AM	17.190	80.206	4.44	17.45
03/29/20 09:00:00 AM	17.205	80.206	4.43	17.46
03/29/20 10:00:00 AM	17.205	80.206	4.43	17.46
03/29/20 11:00:00 AM	17.190	80.206	4.44	17.45
03/29/20 12:00:00 PM	17.190	80.206	4.44	17.45
03/29/20 01:00:00 PM	17.170	80.206	4.46	17.43
03/29/20 02:00:00 PM	17.155	80.206	4.47	17.42
03/29/20 03:00:00 PM	17.135	80.206	4.48	17.41
03/29/20 04:00:00 PM	17.124	80.206	4.49	17.40
03/29/20 05:00:00 PM	17.114	80.206	4.49	17.40
03/29/20 06:00:00 PM	17.109	80.206	4.50	17.39
03/29/20 07:00:00 PM	17.114	80.206	4.49	17.40
03/29/20 08:00:00 PM	17.119	80.206	4.49	17.40
03/29/20 09:00:00 PM	17.139	80.206	4.48	17.41
03/29/20 10:00:00 PM	17.149	80.206	4.47	17.42
03/29/20 11:00:00 PM	17.155	80.206	4.47	17.42
03/30/20 12:00:00 AM	17.160	80.206	4.46	17.43
03/30/20 01:00:00 AM	17.149	80.206	4.47	17.42
03/30/20 02:00:00 AM	17.135	80.206	4.48	17.41
03/30/20 03:00:00 AM	17.124	80.206	4.49	17.40
03/30/20 04:00:00 AM	17.109	80.206	4.50	17.39
03/30/20 05:00:00 AM	17.104	80.206	4.50	17.39
03/30/20 06:00:00 AM	17.109	80.206	4.50	17.39
03/30/20 07:00:00 AM	17.104	80.206	4.50	17.39
03/30/20 08:00:00 AM	17.109	80.206	4.50	17.39
03/30/20 09:00:00 AM	17.114	80.206	4.49	17.40
03/30/20 10:00:00 AM	17.129	80.206	4.48	17.41
03/30/20 11:00:00 AM	17.124	80.206	4.49	17.40
03/30/20 12:00:00 PM	17.109	80.206	4.50	17.39
03/30/20 01:00:00 PM	17.099	80.206	4.50	17.39
03/30/20 02:00:00 PM	17.079	80.206	4.52	17.37
03/30/20 03:00:00 PM	17.059	80.206	4.53	17.36
03/30/20 04:00:00 PM	17.044	80.206	4.54	17.35

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/30/20 05:00:00 PM	17.029	80.206	4.55	17.34
03/30/20 06:00:00 PM	17.029	80.206	4.55	17.34
03/30/20 07:00:00 PM	17.044	80.206	4.54	17.35
03/30/20 08:00:00 PM	17.044	80.206	4.54	17.35
03/30/20 09:00:00 PM	17.054	80.206	4.54	17.35
03/30/20 10:00:00 PM	17.059	80.206	4.53	17.36
03/30/20 11:00:00 PM	17.064	80.206	4.53	17.36
03/31/20 12:00:00 AM	17.064	80.206	4.53	17.36
03/31/20 01:00:00 AM	17.059	80.206	4.53	17.36
03/31/20 02:00:00 AM	17.044	80.206	4.54	17.35
03/31/20 03:00:00 AM	17.034	80.206	4.55	17.34
03/31/20 04:00:00 AM	17.024	80.206	4.56	17.33
03/31/20 05:00:00 AM	17.019	80.206	4.56	17.33
03/31/20 06:00:00 AM	17.014	80.206	4.56	17.33
03/31/20 07:00:00 AM	17.019	80.206	4.56	17.33
03/31/20 08:00:00 AM	17.024	80.206	4.56	17.33
03/31/20 09:00:00 AM	17.044	80.206	4.54	17.35
03/31/20 10:00:00 AM	17.044	80.206	4.54	17.35
03/31/20 11:00:00 AM	17.034	80.206	4.55	17.34
03/31/20 12:00:00 PM	17.029	80.206	4.55	17.34
03/31/20 01:00:00 PM	17.009	80.206	4.57	17.32
03/31/20 02:00:00 PM	16.989	80.206	4.58	17.31
03/31/20 03:00:00 PM	16.974	80.206	4.59	17.30
03/31/20 04:00:00 PM	16.959	80.206	4.60	17.29
03/31/20 05:00:00 PM	16.949	80.206	4.61	17.28
03/31/20 06:00:00 PM	16.949	80.206	4.61	17.28
03/31/20 07:00:00 PM	16.959	80.206	4.60	17.29
03/31/20 08:00:00 PM	16.964	80.206	4.60	17.29
03/31/20 09:00:00 PM	16.989	80.206	4.58	17.31
03/31/20 10:00:00 PM	16.994	80.206	4.58	17.31
03/31/20 11:00:00 PM	16.989	80.206	4.58	17.31
4/1/2020 12:00:00 AM	16.989	80.206	4.58	17.31
4/1/2020 1:00:00 AM	16.979	80.206	4.59	17.30
4/1/2020 2:00:00 AM	16.974	80.206	4.59	17.30
4/1/2020 3:00:00 AM	16.959	80.206	4.60	17.29
4/1/2020 4:00:00 AM	16.954	80.206	4.61	17.28
4/1/2020 5:00:00 AM	16.949	80.206	4.61	17.28
4/1/2020 6:00:00 AM	16.954	80.206	4.61	17.28
4/1/2020 7:00:00 AM	16.964	80.206	4.60	17.29
4/1/2020 8:00:00 AM	16.964	80.206	4.60	17.29
4/1/2020 9:00:00 AM	16.974	80.206	4.59	17.30

WATER STANDPIPE MONITORING

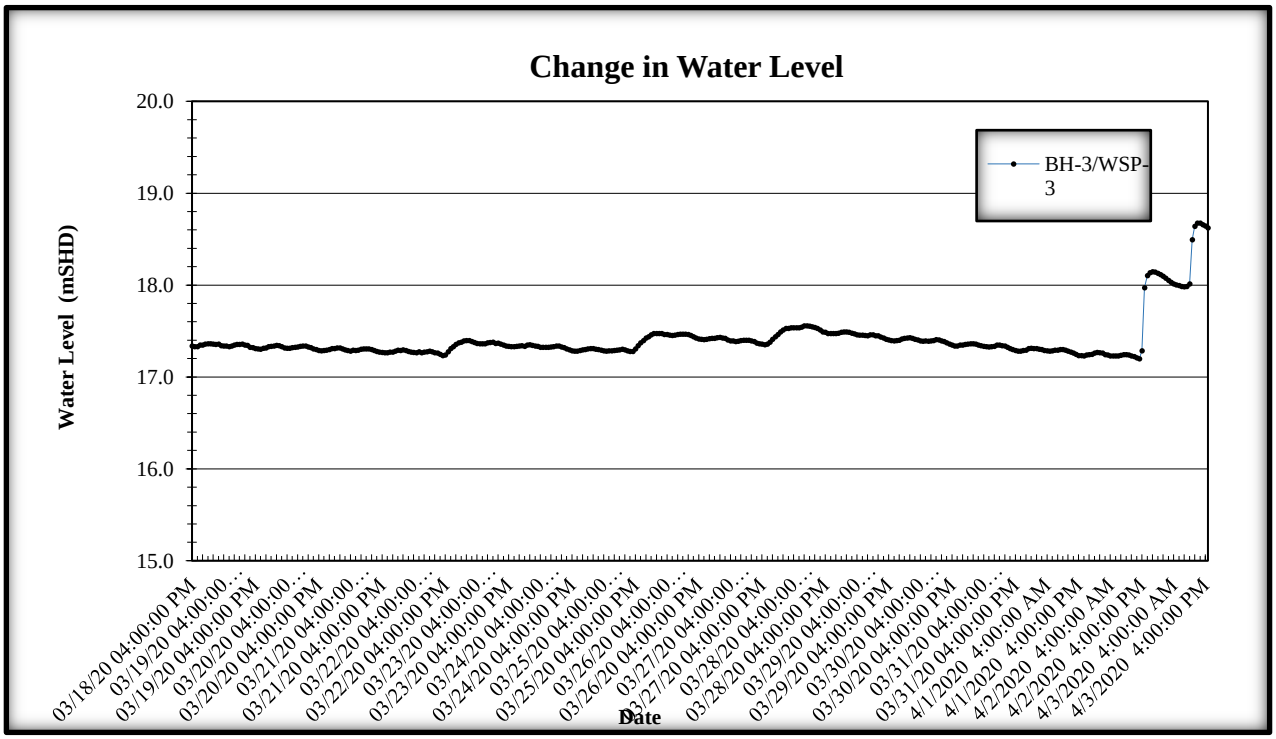
Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/1/2020 10:00:00 AM	16.974	80.206	4.59	17.30
4/1/2020 11:00:00 AM	16.964	80.206	4.60	17.29
4/1/2020 12:00:00 PM	16.949	80.206	4.61	17.28
4/1/2020 1:00:00 PM	16.934	80.206	4.62	17.27
4/1/2020 2:00:00 PM	16.919	80.206	4.63	17.26
4/1/2020 3:00:00 PM	16.904	80.206	4.64	17.25
4/1/2020 4:00:00 PM	16.884	80.206	4.66	17.23
4/1/2020 5:00:00 PM	16.884	80.206	4.66	17.23
4/1/2020 6:00:00 PM	16.879	80.206	4.66	17.23
4/1/2020 7:00:00 PM	16.894	80.206	4.65	17.24
4/1/2020 8:00:00 PM	16.899	80.206	4.65	17.24
4/1/2020 9:00:00 PM	16.904	80.206	4.64	17.25
4/1/2020 10:00:00 PM	16.919	80.206	4.63	17.26
4/1/2020 11:00:00 PM	16.929	80.206	4.62	17.27
4/2/2020 12:00:00 AM	16.924	80.206	4.63	17.26
4/2/2020 1:00:00 AM	16.919	80.206	4.63	17.26
4/2/2020 2:00:00 AM	16.899	80.206	4.65	17.24
4/2/2020 3:00:00 AM	16.894	80.206	4.65	17.24
4/2/2020 4:00:00 AM	16.879	80.206	4.66	17.23
4/2/2020 5:00:00 AM	16.879	80.206	4.66	17.23
4/2/2020 6:00:00 AM	16.879	80.206	4.66	17.23
4/2/2020 7:00:00 AM	16.879	80.206	4.66	17.23
4/2/2020 8:00:00 AM	16.889	80.206	4.65	17.24
4/2/2020 9:00:00 AM	16.899	80.206	4.65	17.24
4/2/2020 10:00:00 AM	16.899	80.206	4.65	17.24
4/2/2020 11:00:00 AM	16.894	80.206	4.65	17.24
4/2/2020 12:00:00 PM	16.879	80.206	4.66	17.23
4/2/2020 1:00:00 PM	16.869	80.206	4.67	17.22
4/2/2020 2:00:00 PM	16.849	80.206	4.68	17.21
4/2/2020 3:00:00 PM	16.833	80.206	4.69	17.20
4/2/2020 4:00:00 PM	16.954	80.206	4.61	17.28
4/2/2020 5:00:00 PM	17.932	80.206	3.92	17.97
4/2/2020 6:00:00 PM	18.117	80.206	3.79	18.10
4/2/2020 7:00:00 PM	18.163	80.206	3.76	18.13
4/2/2020 8:00:00 PM	18.178	80.206	3.75	18.14
4/2/2020 9:00:00 PM	18.173	80.206	3.75	18.14
4/2/2020 10:00:00 PM	18.153	80.206	3.76	18.13
4/2/2020 11:00:00 PM	18.133	80.206	3.78	18.11
4/3/2020 12:00:00 AM	18.107	80.206	3.80	18.09
4/3/2020 1:00:00 AM	18.077	80.206	3.82	18.07
4/3/2020 2:00:00 AM	18.047	80.206	3.84	18.05

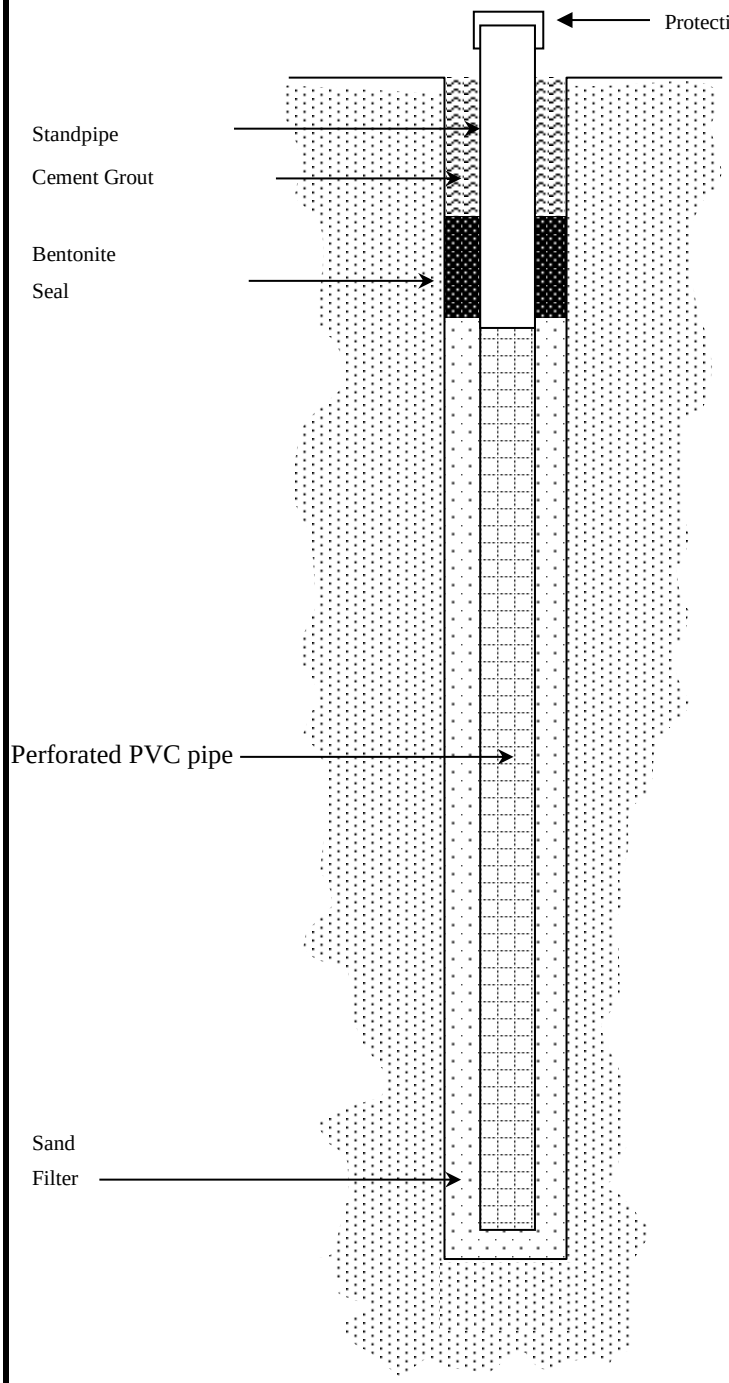
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-3/WSP-3**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.20
Location:	Tengah	**Pipe Top Level (mSHD)**	22.740
		Ground Level (mSHD)	21.890

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/3/2020 3:00:00 AM	18.017	80.206	3.86	18.03
4/3/2020 4:00:00 AM	17.992	80.206	3.88	18.01
4/3/2020 5:00:00 AM	17.977	80.206	3.89	18.00
4/3/2020 6:00:00 AM	17.967	80.206	3.89	18.00
4/3/2020 7:00:00 AM	17.952	80.206	3.90	17.99
4/3/2020 8:00:00 AM	17.947	80.206	3.91	17.98
4/3/2020 9:00:00 AM	17.952	80.206	3.90	17.99
4/3/2020 10:00:00 AM	17.992	80.206	3.88	18.01
4/3/2020 11:00:00 AM	18.674	80.206	3.40	18.49
4/3/2020 12:00:00 PM	18.880	80.206	3.25	18.64
4/3/2020 1:00:00 PM	18.930	80.206	3.22	18.67
4/3/2020 2:00:00 PM	18.930	80.206	3.22	18.67
4/3/2020 3:00:00 PM	18.905	80.206	3.23	18.66
4/3/2020 4:00:00 PM	18.885	80.206	3.25	18.64
4/3/2020 5:00:00 PM	18.860	80.206	3.27	18.62



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	9 Mar 2020	**INSTALLED BY:** M. Pandiyan



Depth (GL-m)	0.00
	1.50
	2.00
	6.00

REMARKS:

INSTALLED IN BH04/WSP-04

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/18/20 03:00:00 PM	17.028	84.295	2.23	13.02
03/18/20 04:00:00 PM	16.959	82.152	2.28	12.97
03/18/20 05:00:00 PM	16.938	82.152	2.29	12.96
03/18/20 06:00:00 PM	16.928	82.152	2.30	12.95
03/18/20 07:00:00 PM	16.943	82.152	2.29	12.96
03/18/20 08:00:00 PM	16.943	82.152	2.29	12.96
03/18/20 09:00:00 PM	16.959	82.152	2.28	12.97
03/18/20 10:00:00 PM	16.959	82.152	2.28	12.97
03/18/20 11:00:00 PM	16.964	82.152	2.27	12.98
03/19/20 12:00:00 AM	16.954	82.152	2.28	12.97
03/19/20 01:00:00 AM	16.948	82.152	2.28	12.97
03/19/20 02:00:00 AM	16.948	82.152	2.28	12.97
03/19/20 03:00:00 AM	16.933	82.152	2.29	12.96
03/19/20 04:00:00 AM	16.928	82.152	2.30	12.95
03/19/20 05:00:00 AM	16.923	82.152	2.30	12.95
03/19/20 06:00:00 AM	16.928	82.152	2.30	12.95
03/19/20 07:00:00 AM	16.933	82.152	2.29	12.96
03/19/20 08:00:00 AM	16.943	82.152	2.29	12.96
03/19/20 09:00:00 AM	16.954	82.152	2.28	12.97
03/19/20 10:00:00 AM	16.959	82.152	2.28	12.97
03/19/20 11:00:00 AM	16.959	82.152	2.28	12.97
03/19/20 12:00:00 PM	16.948	82.152	2.28	12.97
03/19/20 01:00:00 PM	16.938	82.152	2.29	12.96
03/19/20 02:00:00 PM	16.923	82.152	2.30	12.95
03/19/20 03:00:00 PM	16.912	82.152	2.31	12.94
03/19/20 04:00:00 PM	16.897	82.152	2.32	12.93
03/19/20 05:00:00 PM	16.891	82.152	2.32	12.93
03/19/20 06:00:00 PM	16.891	82.152	2.32	12.93
03/19/20 07:00:00 PM	16.902	82.152	2.32	12.93
03/19/20 08:00:00 PM	16.917	82.152	2.31	12.94
03/19/20 09:00:00 PM	16.923	82.152	2.30	12.95
03/19/20 10:00:00 PM	16.933	82.152	2.29	12.96
03/19/20 11:00:00 PM	16.943	82.152	2.29	12.96
03/20/20 12:00:00 AM	16.948	82.152	2.28	12.97
03/20/20 01:00:00 AM	16.938	82.152	2.29	12.96
03/20/20 02:00:00 AM	16.928	82.152	2.30	12.95
03/20/20 03:00:00 AM	16.917	82.152	2.31	12.94
03/20/20 04:00:00 AM	16.912	82.152	2.31	12.94
03/20/20 05:00:00 AM	16.907	82.152	2.31	12.94
03/20/20 06:00:00 AM	16.907	82.152	2.31	12.94
03/20/20 07:00:00 AM	16.923	82.152	2.30	12.95
03/20/20 08:00:00 AM	16.923	82.152	2.30	12.95

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 09:00:00 AM	16.943	82.152	2.29	12.96

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 10:00:00 AM	16.943	82.152	2.29	12.96
03/20/20 11:00:00 AM	16.948	82.152	2.28	12.97
03/20/20 12:00:00 PM	16.933	82.152	2.29	12.96
03/20/20 01:00:00 PM	16.928	82.152	2.30	12.95
03/20/20 02:00:00 PM	16.907	82.152	2.31	12.94
03/20/20 03:00:00 PM	16.891	82.152	2.32	12.93
03/20/20 04:00:00 PM	16.881	82.152	2.33	12.92
03/20/20 05:00:00 PM	16.881	82.152	2.33	12.92
03/20/20 06:00:00 PM	16.886	82.152	2.33	12.92
03/20/20 07:00:00 PM	16.891	82.152	2.32	12.93
03/20/20 08:00:00 PM	16.897	82.152	2.32	12.93
03/20/20 09:00:00 PM	16.907	82.152	2.31	12.94
03/20/20 10:00:00 PM	16.917	82.152	2.31	12.94
03/20/20 11:00:00 PM	16.923	82.152	2.30	12.95
03/21/20 12:00:00 AM	16.923	82.152	2.30	12.95
03/21/20 01:00:00 AM	16.907	82.152	2.31	12.94
03/21/20 02:00:00 AM	16.902	82.152	2.32	12.93
03/21/20 03:00:00 AM	16.897	82.152	2.32	12.93
03/21/20 04:00:00 AM	16.886	82.152	2.33	12.92
03/21/20 05:00:00 AM	16.886	82.152	2.33	12.92
03/21/20 06:00:00 AM	16.891	82.152	2.32	12.93
03/21/20 07:00:00 AM	16.891	82.152	2.32	12.93
03/21/20 08:00:00 AM	16.902	82.152	2.32	12.93
03/21/20 09:00:00 AM	16.912	82.152	2.31	12.94
03/21/20 10:00:00 AM	16.917	82.152	2.31	12.94
03/21/20 11:00:00 AM	16.912	82.152	2.31	12.94
03/21/20 12:00:00 PM	16.902	82.152	2.32	12.93
03/21/20 01:00:00 PM	16.891	82.152	2.32	12.93
03/21/20 02:00:00 PM	16.881	82.152	2.33	12.92
03/21/20 03:00:00 PM	16.860	82.152	2.35	12.90
03/21/20 04:00:00 PM	16.871	82.152	2.34	12.91
03/21/20 05:00:00 PM	16.866	82.152	2.34	12.91
03/21/20 06:00:00 PM	16.866	82.152	2.34	12.91
03/21/20 07:00:00 PM	16.876	82.152	2.33	12.92
03/21/20 08:00:00 PM	16.886	82.152	2.33	12.92
03/21/20 09:00:00 PM	16.886	82.152	2.33	12.92
03/21/20 10:00:00 PM	16.902	82.152	2.32	12.93
03/21/20 11:00:00 PM	16.897	82.152	2.32	12.93
03/22/20 12:00:00 AM	16.907	82.152	2.31	12.94
03/22/20 01:00:00 AM	16.897	82.152	2.32	12.93
03/22/20 02:00:00 AM	16.881	82.152	2.33	12.92

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 03:00:00 AM	16.876	82.152	2.33	12.92
03/22/20 04:00:00 AM	16.871	82.152	2.34	12.91
03/22/20 05:00:00 AM	16.871	82.152	2.34	12.91
03/22/20 06:00:00 AM	16.871	82.152	2.34	12.91
03/22/20 07:00:00 AM	16.871	82.152	2.34	12.91
03/22/20 08:00:00 AM	16.876	82.152	2.33	12.92
03/22/20 09:00:00 AM	16.886	82.152	2.33	12.92
03/22/20 10:00:00 AM	16.886	82.152	2.33	12.92
03/22/20 11:00:00 AM	16.886	82.152	2.33	12.92
03/22/20 12:00:00 PM	16.876	82.152	2.33	12.92
03/22/20 01:00:00 PM	16.866	82.152	2.34	12.91
03/22/20 02:00:00 PM	16.845	82.152	2.36	12.89
03/22/20 03:00:00 PM	16.824	82.152	2.37	12.88
03/22/20 04:00:00 PM	16.840	82.152	2.36	12.89
03/22/20 05:00:00 PM	16.840	82.152	2.36	12.89
03/22/20 06:00:00 PM	16.840	82.152	2.36	12.89
03/22/20 07:00:00 PM	16.845	82.152	2.36	12.89
03/22/20 08:00:00 PM	16.855	82.152	2.35	12.90
03/22/20 09:00:00 PM	16.866	82.152	2.34	12.91
03/22/20 10:00:00 PM	16.871	82.152	2.34	12.91
03/22/20 11:00:00 PM	16.871	82.152	2.34	12.91
03/23/20 12:00:00 AM	16.876	82.152	2.33	12.92
03/23/20 01:00:00 AM	16.881	82.152	2.33	12.92
03/23/20 02:00:00 AM	16.860	82.152	2.35	12.90
03/23/20 03:00:00 AM	16.850	82.152	2.35	12.90
03/23/20 04:00:00 AM	16.845	82.152	2.36	12.89
03/23/20 05:00:00 AM	16.840	82.152	2.36	12.89
03/23/20 06:00:00 AM	16.845	82.152	2.36	12.89
03/23/20 07:00:00 AM	16.850	82.152	2.35	12.90
03/23/20 08:00:00 AM	16.866	82.152	2.34	12.91
03/23/20 09:00:00 AM	16.876	82.152	2.33	12.92
03/23/20 10:00:00 AM	16.876	82.152	2.33	12.92
03/23/20 11:00:00 AM	16.871	82.152	2.34	12.91
03/23/20 12:00:00 PM	16.871	82.152	2.34	12.91
03/23/20 01:00:00 PM	16.860	82.152	2.35	12.90
03/23/20 02:00:00 PM	16.850	82.152	2.35	12.90
03/23/20 03:00:00 PM	16.840	82.152	2.36	12.89
03/23/20 04:00:00 PM	16.840	82.152	2.36	12.89
03/23/20 05:00:00 PM	16.834	82.152	2.36	12.89
03/23/20 06:00:00 PM	16.834	82.152	2.36	12.89
03/23/20 07:00:00 PM	16.840	82.152	2.36	12.89

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/23/20 08:00:00 PM	16.834	82.152	2.36	12.89
03/23/20 09:00:00 PM	16.850	82.152	2.35	12.90
03/23/20 10:00:00 PM	16.850	82.152	2.35	12.90
03/23/20 11:00:00 PM	16.860	82.152	2.35	12.90
03/24/20 12:00:00 AM	16.860	82.152	2.35	12.90
03/24/20 01:00:00 AM	16.845	82.152	2.36	12.89
03/24/20 02:00:00 AM	16.850	82.152	2.35	12.90
03/24/20 03:00:00 AM	16.840	82.152	2.36	12.89
03/24/20 04:00:00 AM	16.829	82.152	2.37	12.88
03/24/20 05:00:00 AM	16.829	82.152	2.37	12.88
03/24/20 06:00:00 AM	16.819	82.152	2.37	12.88
03/24/20 07:00:00 AM	16.829	82.152	2.37	12.88
03/24/20 08:00:00 AM	16.834	82.152	2.36	12.89
03/24/20 09:00:00 AM	16.840	82.152	2.36	12.89
03/24/20 10:00:00 AM	16.850	82.152	2.35	12.90
03/24/20 11:00:00 AM	16.840	82.152	2.36	12.89
03/24/20 12:00:00 PM	16.840	82.152	2.36	12.89
03/24/20 01:00:00 PM	16.824	82.152	2.37	12.88
03/24/20 02:00:00 PM	16.809	82.152	2.38	12.87
03/24/20 03:00:00 PM	16.798	82.152	2.39	12.86
03/24/20 04:00:00 PM	16.788	82.152	2.40	12.85
03/24/20 05:00:00 PM	16.783	82.152	2.40	12.85
03/24/20 06:00:00 PM	16.788	82.152	2.40	12.85
03/24/20 07:00:00 PM	16.798	82.152	2.39	12.86
03/24/20 08:00:00 PM	16.809	82.152	2.38	12.87
03/24/20 09:00:00 PM	16.809	82.152	2.38	12.87
03/24/20 10:00:00 PM	16.824	82.152	2.37	12.88
03/24/20 11:00:00 PM	16.829	82.152	2.37	12.88
03/25/20 12:00:00 AM	16.829	82.152	2.37	12.88
03/25/20 01:00:00 AM	16.824	82.152	2.37	12.88
03/25/20 02:00:00 AM	16.824	82.152	2.37	12.88
03/25/20 03:00:00 AM	16.814	82.152	2.38	12.87
03/25/20 04:00:00 AM	16.803	82.152	2.39	12.86
03/25/20 05:00:00 AM	16.798	82.152	2.39	12.86
03/25/20 06:00:00 AM	16.803	82.152	2.39	12.86
03/25/20 07:00:00 AM	16.803	82.152	2.39	12.86
03/25/20 08:00:00 AM	16.809	82.152	2.38	12.87
03/25/20 09:00:00 AM	16.814	82.152	2.38	12.87
03/25/20 10:00:00 AM	16.819	82.152	2.37	12.88
03/25/20 11:00:00 AM	16.829	82.152	2.37	12.88
03/25/20 12:00:00 PM	16.819	82.152	2.37	12.88

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/25/20 01:00:00 PM	16.803	82.152	2.39	12.86
03/25/20 02:00:00 PM	16.803	82.152	2.39	12.86
03/25/20 03:00:00 PM	16.793	82.152	2.39	12.86
03/25/20 04:00:00 PM	16.777	82.152	2.40	12.85
03/25/20 05:00:00 PM	16.772	82.152	2.41	12.84
03/25/20 06:00:00 PM	16.772	82.152	2.41	12.84
03/25/20 07:00:00 PM	16.777	82.152	2.40	12.85
03/25/20 08:00:00 PM	16.777	82.152	2.40	12.85
03/25/20 09:00:00 PM	16.793	82.152	2.39	12.86
03/25/20 10:00:00 PM	16.803	82.152	2.39	12.86
03/25/20 11:00:00 PM	16.814	82.152	2.38	12.87
03/26/20 12:00:00 AM	16.819	82.152	2.37	12.88
03/26/20 01:00:00 AM	16.814	82.152	2.38	12.87
03/26/20 02:00:00 AM	16.803	82.152	2.39	12.86
03/26/20 03:00:00 AM	16.803	82.152	2.39	12.86
03/26/20 04:00:00 AM	16.798	82.152	2.39	12.86
03/26/20 05:00:00 AM	16.798	82.152	2.39	12.86
03/26/20 06:00:00 AM	16.793	82.152	2.39	12.86
03/26/20 07:00:00 AM	16.809	82.152	2.38	12.87
03/26/20 08:00:00 AM	16.809	82.152	2.38	12.87
03/26/20 09:00:00 AM	16.829	82.152	2.37	12.88
03/26/20 10:00:00 AM	16.834	82.152	2.36	12.89
03/26/20 11:00:00 AM	16.834	82.152	2.36	12.89
03/26/20 12:00:00 PM	16.834	82.152	2.36	12.89
03/26/20 01:00:00 PM	16.819	82.152	2.37	12.88
03/26/20 02:00:00 PM	16.809	82.152	2.38	12.87
03/26/20 03:00:00 PM	16.798	82.152	2.39	12.86
03/26/20 04:00:00 PM	16.783	82.152	2.40	12.85
03/26/20 05:00:00 PM	16.793	82.152	2.39	12.86
03/26/20 06:00:00 PM	16.788	82.152	2.40	12.85
03/26/20 07:00:00 PM	16.798	82.152	2.39	12.86
03/26/20 08:00:00 PM	16.814	82.152	2.38	12.87
03/26/20 09:00:00 PM	16.814	82.152	2.38	12.87
03/26/20 10:00:00 PM	16.819	82.152	2.37	12.88
03/26/20 11:00:00 PM	16.834	82.152	2.36	12.89
03/27/20 12:00:00 AM	16.840	82.152	2.36	12.89
03/27/20 01:00:00 AM	16.834	82.152	2.36	12.89
03/27/20 02:00:00 AM	16.834	82.152	2.36	12.89
03/27/20 03:00:00 AM	16.819	82.152	2.37	12.88
03/27/20 04:00:00 AM	16.814	82.152	2.38	12.87
03/27/20 05:00:00 AM	16.809	82.152	2.38	12.87

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/27/20 06:00:00 AM	16.814	82.152	2.38	12.87
03/27/20 07:00:00 AM	16.814	82.152	2.38	12.87
03/27/20 08:00:00 AM	16.824	82.152	2.37	12.88
03/27/20 09:00:00 AM	16.834	82.152	2.36	12.89
03/27/20 10:00:00 AM	16.824	82.152	2.37	12.88
03/27/20 11:00:00 AM	16.834	82.152	2.36	12.89
03/27/20 12:00:00 PM	16.840	82.152	2.36	12.89
03/27/20 01:00:00 PM	16.824	82.152	2.37	12.88
03/27/20 02:00:00 PM	16.814	82.152	2.38	12.87
03/27/20 03:00:00 PM	16.798	82.152	2.39	12.86
03/27/20 04:00:00 PM	16.798	82.152	2.39	12.86
03/27/20 05:00:00 PM	16.798	82.152	2.39	12.86
03/27/20 06:00:00 PM	16.793	82.152	2.39	12.86
03/27/20 07:00:00 PM	16.798	82.152	2.39	12.86
03/27/20 08:00:00 PM	16.803	82.152	2.39	12.86
03/27/20 09:00:00 PM	16.814	82.152	2.38	12.87
03/27/20 10:00:00 PM	16.819	82.152	2.37	12.88
03/27/20 11:00:00 PM	16.829	82.152	2.37	12.88
03/28/20 12:00:00 AM	16.829	82.152	2.37	12.88
03/28/20 01:00:00 AM	16.834	82.152	2.36	12.89
03/28/20 02:00:00 AM	16.819	82.152	2.37	12.88
03/28/20 03:00:00 AM	16.814	82.152	2.38	12.87
03/28/20 04:00:00 AM	16.809	82.152	2.38	12.87
03/28/20 05:00:00 AM	16.814	82.152	2.38	12.87
03/28/20 06:00:00 AM	16.814	82.152	2.38	12.87
03/28/20 07:00:00 AM	16.829	82.152	2.37	12.88
03/28/20 08:00:00 AM	16.845	82.152	2.36	12.89
03/28/20 09:00:00 AM	16.850	82.152	2.35	12.90
03/28/20 10:00:00 AM	16.840	82.152	2.36	12.89
03/28/20 11:00:00 AM	16.834	82.152	2.36	12.89
03/28/20 12:00:00 PM	16.834	82.152	2.36	12.89
03/28/20 01:00:00 PM	16.824	82.152	2.37	12.88
03/28/20 02:00:00 PM	16.819	82.152	2.37	12.88
03/28/20 03:00:00 PM	16.793	82.152	2.39	12.86
03/28/20 04:00:00 PM	16.783	82.152	2.40	12.85
03/28/20 05:00:00 PM	16.783	82.152	2.40	12.85
03/28/20 06:00:00 PM	16.783	82.152	2.40	12.85
03/28/20 07:00:00 PM	16.793	82.152	2.39	12.86
03/28/20 08:00:00 PM	16.803	82.152	2.39	12.86
03/28/20 09:00:00 PM	16.809	82.152	2.38	12.87
03/28/20 10:00:00 PM	16.824	82.152	2.37	12.88

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/28/20 11:00:00 PM	16.829	82.152	2.37	12.88
03/29/20 12:00:00 AM	16.840	82.152	2.36	12.89
03/29/20 01:00:00 AM	16.829	82.152	2.37	12.88
03/29/20 02:00:00 AM	16.824	82.152	2.37	12.88
03/29/20 03:00:00 AM	16.819	82.152	2.37	12.88
03/29/20 04:00:00 AM	16.814	82.152	2.38	12.87
03/29/20 05:00:00 AM	16.809	82.152	2.38	12.87
03/29/20 06:00:00 AM	16.809	82.152	2.38	12.87
03/29/20 07:00:00 AM	16.819	82.152	2.37	12.88
03/29/20 08:00:00 AM	16.819	82.152	2.37	12.88
03/29/20 09:00:00 AM	16.829	82.152	2.37	12.88
03/29/20 10:00:00 AM	16.829	82.152	2.37	12.88
03/29/20 11:00:00 AM	16.829	82.152	2.37	12.88
03/29/20 12:00:00 PM	16.829	82.152	2.37	12.88
03/29/20 01:00:00 PM	16.814	82.152	2.38	12.87
03/29/20 02:00:00 PM	16.803	82.152	2.39	12.86
03/29/20 03:00:00 PM	16.788	82.152	2.40	12.85
03/29/20 04:00:00 PM	16.777	82.152	2.40	12.85
03/29/20 05:00:00 PM	16.777	82.152	2.40	12.85
03/29/20 06:00:00 PM	16.777	82.152	2.40	12.85
03/29/20 07:00:00 PM	16.777	82.152	2.40	12.85
03/29/20 08:00:00 PM	16.793	82.152	2.39	12.86
03/29/20 09:00:00 PM	16.814	82.152	2.38	12.87
03/29/20 10:00:00 PM	16.824	82.152	2.37	12.88
03/29/20 11:00:00 PM	16.834	82.152	2.36	12.89
03/30/20 12:00:00 AM	16.840	82.152	2.36	12.89
03/30/20 01:00:00 AM	16.829	82.152	2.37	12.88
03/30/20 02:00:00 AM	16.819	82.152	2.37	12.88
03/30/20 03:00:00 AM	16.814	82.152	2.38	12.87
03/30/20 04:00:00 AM	16.814	82.152	2.38	12.87
03/30/20 05:00:00 AM	16.809	82.152	2.38	12.87
03/30/20 06:00:00 AM	16.809	82.152	2.38	12.87
03/30/20 07:00:00 AM	16.814	82.152	2.38	12.87
03/30/20 08:00:00 AM	16.819	82.152	2.37	12.88
03/30/20 09:00:00 AM	16.829	82.152	2.37	12.88
03/30/20 10:00:00 AM	16.840	82.152	2.36	12.89
03/30/20 11:00:00 AM	16.829	82.152	2.37	12.88
03/30/20 12:00:00 PM	16.824	82.152	2.37	12.88
03/30/20 01:00:00 PM	16.814	82.152	2.38	12.87
03/30/20 02:00:00 PM	16.803	82.152	2.39	12.86
03/30/20 03:00:00 PM	16.788	82.152	2.40	12.85

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/30/20 04:00:00 PM	16.777	82.152	2.40	12.85
03/30/20 05:00:00 PM	16.772	82.152	2.41	12.84
03/30/20 06:00:00 PM	16.772	82.152	2.41	12.84
03/30/20 07:00:00 PM	16.777	82.152	2.40	12.85
03/30/20 08:00:00 PM	16.793	82.152	2.39	12.86
03/30/20 09:00:00 PM	16.803	82.152	2.39	12.86
03/30/20 10:00:00 PM	16.814	82.152	2.38	12.87
03/30/20 11:00:00 PM	16.819	82.152	2.37	12.88
03/31/20 12:00:00 AM	16.819	82.152	2.37	12.88
03/31/20 01:00:00 AM	16.819	82.152	2.37	12.88
03/31/20 02:00:00 AM	16.809	82.152	2.38	12.87
03/31/20 03:00:00 AM	16.798	82.152	2.39	12.86
03/31/20 04:00:00 AM	16.793	82.152	2.39	12.86
03/31/20 05:00:00 AM	16.793	82.152	2.39	12.86
03/31/20 06:00:00 AM	16.798	82.152	2.39	12.86
03/31/20 07:00:00 AM	16.803	82.152	2.39	12.86
03/31/20 08:00:00 AM	16.809	82.152	2.38	12.87
03/31/20 09:00:00 AM	16.824	82.152	2.37	12.88
03/31/20 10:00:00 AM	16.819	82.152	2.37	12.88
03/31/20 11:00:00 AM	16.819	82.152	2.37	12.88
03/31/20 12:00:00 PM	16.814	82.152	2.38	12.87
03/31/20 01:00:00 PM	16.803	82.152	2.39	12.86
03/31/20 02:00:00 PM	16.783	82.152	2.40	12.85
03/31/20 03:00:00 PM	16.767	82.152	2.41	12.84
03/31/20 04:00:00 PM	16.757	82.152	2.42	12.83
03/31/20 05:00:00 PM	16.752	82.152	2.42	12.83
03/31/20 06:00:00 PM	16.752	82.152	2.42	12.83
03/31/20 07:00:00 PM	16.772	82.152	2.41	12.84
03/31/20 08:00:00 PM	16.777	82.152	2.40	12.85
03/31/20 09:00:00 PM	16.793	82.152	2.39	12.86
03/31/20 10:00:00 PM	16.798	82.152	2.39	12.86
03/31/20 11:00:00 PM	16.809	82.152	2.38	12.87
4/1/2020 12:00:00 AM	16.803	82.152	2.39	12.86
4/1/2020 1:00:00 AM	16.798	82.152	2.39	12.86
4/1/2020 2:00:00 AM	16.788	82.152	2.40	12.85
4/1/2020 3:00:00 AM	16.783	82.152	2.40	12.85
4/1/2020 4:00:00 AM	16.777	82.152	2.40	12.85
4/1/2020 5:00:00 AM	16.777	82.152	2.40	12.85
4/1/2020 6:00:00 AM	16.788	82.152	2.40	12.85
4/1/2020 7:00:00 AM	16.798	82.152	2.39	12.86
4/1/2020 8:00:00 AM	16.803	82.152	2.39	12.86

WATER STANDPIPE MONITORING

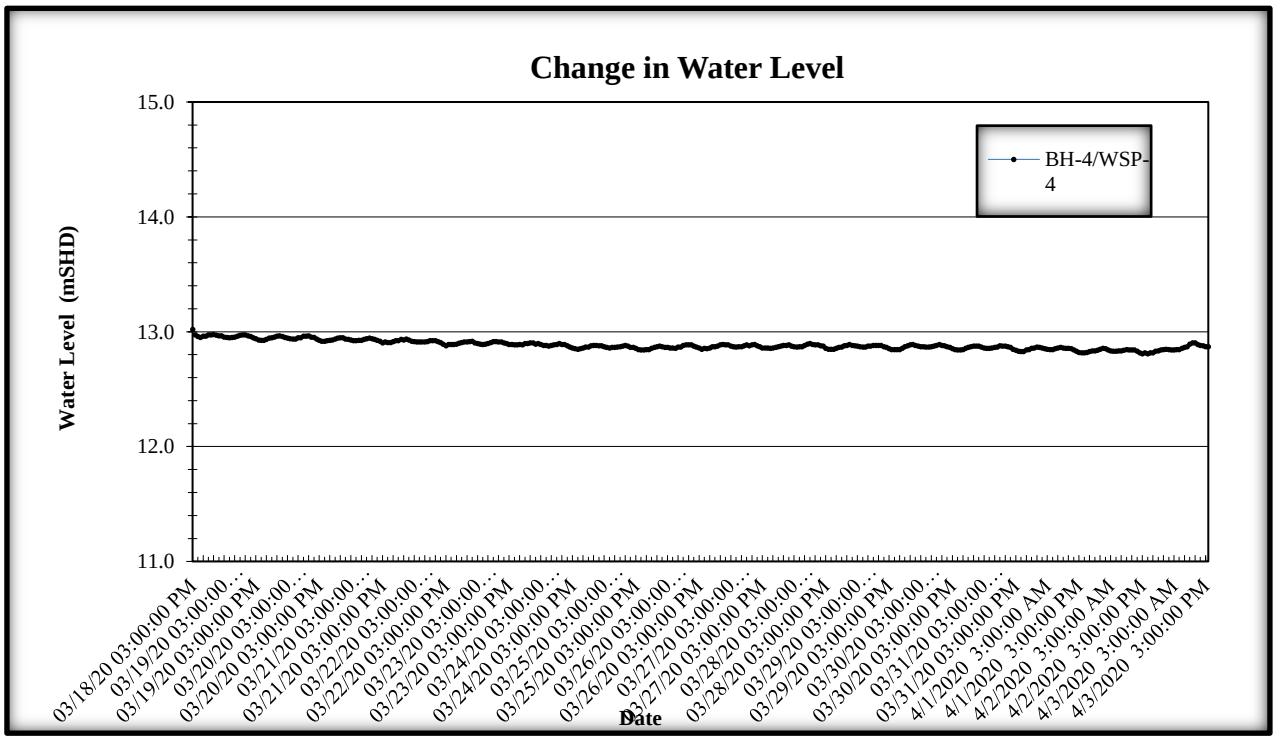
Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/1/2020 9:00:00 AM	16.798	82.152	2.39	12.86
4/1/2020 10:00:00 AM	16.793	82.152	2.39	12.86
4/1/2020 11:00:00 AM	16.793	82.152	2.39	12.86
4/1/2020 12:00:00 PM	16.788	82.152	2.40	12.85
4/1/2020 1:00:00 PM	16.772	82.152	2.41	12.84
4/1/2020 2:00:00 PM	16.757	82.152	2.42	12.83
4/1/2020 3:00:00 PM	16.741	82.152	2.43	12.82
4/1/2020 4:00:00 PM	16.736	82.152	2.43	12.82
4/1/2020 5:00:00 PM	16.736	82.152	2.43	12.82
4/1/2020 6:00:00 PM	16.741	82.152	2.43	12.82
4/1/2020 7:00:00 PM	16.752	82.152	2.42	12.83
4/1/2020 8:00:00 PM	16.762	82.152	2.41	12.84
4/1/2020 9:00:00 PM	16.762	82.152	2.41	12.84
4/1/2020 10:00:00 PM	16.767	82.152	2.41	12.84
4/1/2020 11:00:00 PM	16.783	82.152	2.40	12.85
4/2/2020 12:00:00 AM	16.793	82.152	2.39	12.86
4/2/2020 1:00:00 AM	16.788	82.152	2.40	12.85
4/2/2020 2:00:00 AM	16.772	82.152	2.41	12.84
4/2/2020 3:00:00 AM	16.762	82.152	2.41	12.84
4/2/2020 4:00:00 AM	16.757	82.152	2.42	12.83
4/2/2020 5:00:00 AM	16.757	82.152	2.42	12.83
4/2/2020 6:00:00 AM	16.762	82.152	2.41	12.84
4/2/2020 7:00:00 AM	16.762	82.152	2.41	12.84
4/2/2020 8:00:00 AM	16.767	82.152	2.41	12.84
4/2/2020 9:00:00 AM	16.777	82.152	2.40	12.85
4/2/2020 10:00:00 AM	16.772	82.152	2.41	12.84
4/2/2020 11:00:00 AM	16.772	82.152	2.41	12.84
4/2/2020 12:00:00 PM	16.772	82.152	2.41	12.84
4/2/2020 1:00:00 PM	16.757	82.152	2.42	12.83
4/2/2020 2:00:00 PM	16.736	82.152	2.43	12.82
4/2/2020 3:00:00 PM	16.726	82.152	2.44	12.81
4/2/2020 4:00:00 PM	16.736	82.152	2.43	12.82
4/2/2020 5:00:00 PM	16.726	82.152	2.44	12.81
4/2/2020 6:00:00 PM	16.736	82.152	2.43	12.82
4/2/2020 7:00:00 PM	16.736	82.152	2.43	12.82
4/2/2020 8:00:00 PM	16.757	82.152	2.42	12.83
4/2/2020 9:00:00 PM	16.762	82.152	2.41	12.84
4/2/2020 10:00:00 PM	16.772	82.152	2.41	12.84
4/2/2020 11:00:00 PM	16.777	82.152	2.40	12.85
4/3/2020 12:00:00 AM	16.783	82.152	2.40	12.85
4/3/2020 1:00:00 AM	16.777	82.152	2.40	12.85

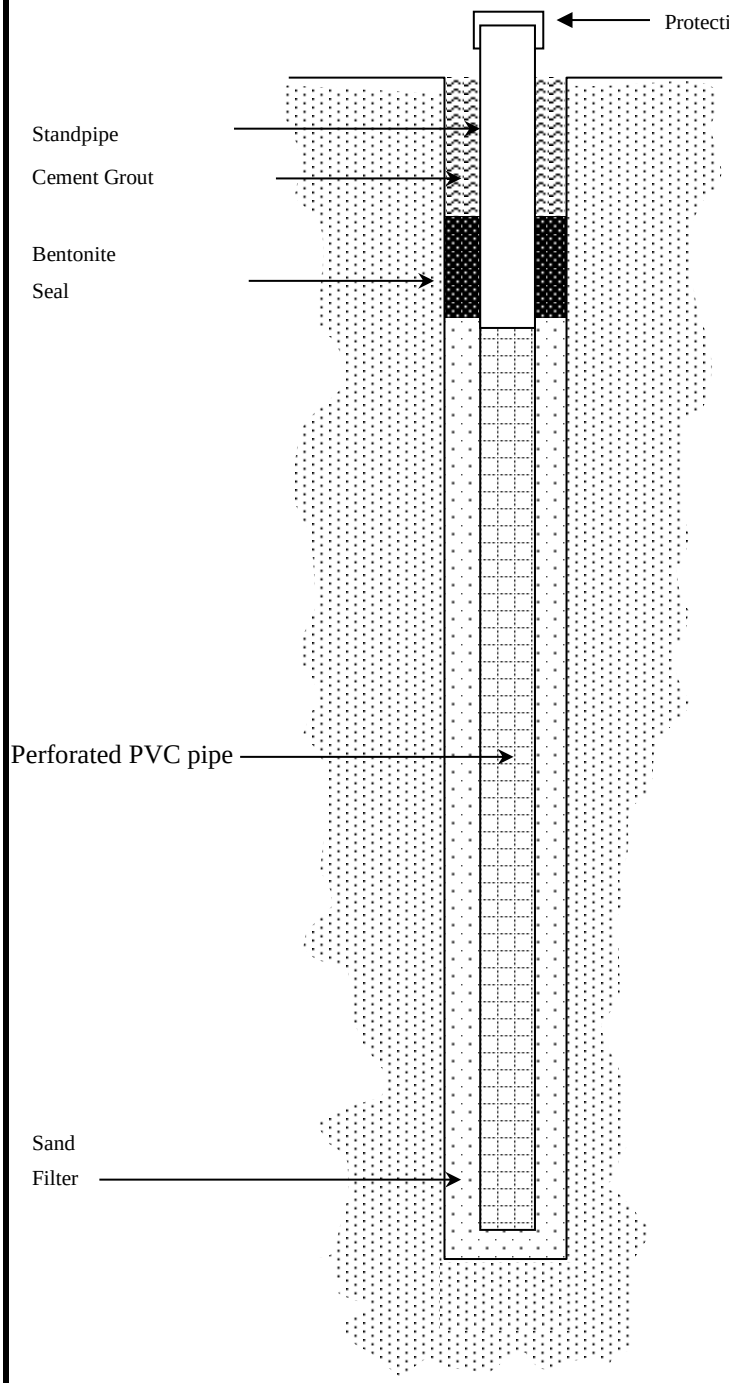
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-4/WSP-4**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	4.05
Location:	Tengah	**Pipe Top Level (mSHD)**	16.250
		Ground Level (mSHD)	15.250

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/3/2020 2:00:00 AM	16.772	82.152	2.41	12.84
4/3/2020 3:00:00 AM	16.772	82.152	2.41	12.84
4/3/2020 4:00:00 AM	16.777	82.152	2.40	12.85
4/3/2020 5:00:00 AM	16.777	82.152	2.40	12.85
4/3/2020 6:00:00 AM	16.793	82.152	2.39	12.86
4/3/2020 7:00:00 AM	16.803	82.152	2.39	12.86
4/3/2020 8:00:00 AM	16.814	82.152	2.38	12.87
4/3/2020 9:00:00 AM	16.845	82.152	2.36	12.89
4/3/2020 10:00:00 AM	16.860	82.152	2.35	12.90
4/3/2020 11:00:00 AM	16.860	82.152	2.35	12.90
4/3/2020 12:00:00 PM	16.840	82.152	2.36	12.89
4/3/2020 1:00:00 PM	16.829	82.152	2.37	12.88
4/3/2020 2:00:00 PM	16.824	82.152	2.37	12.88
4/3/2020 3:00:00 PM	16.814	82.152	2.38	12.87
4/3/2020 4:00:00 PM	16.814	82.152	2.38	12.87



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	4 Mar 2020	**INSTALLED BY:** Helal



Depth (GL-m)	0.00
	1.50
	2.00
	6.00

REMARKS:

INSTALLED IN BH05/WSP-05

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/17/20 06:00:00 PM	16.937	81.442	1.62	15.62
03/17/20 07:00:00 PM	16.952	81.442	1.61	15.63
03/17/20 08:00:00 PM	16.957	81.442	1.61	15.64
03/17/20 09:00:00 PM	16.957	81.442	1.61	15.64
03/17/20 10:00:00 PM	16.962	81.442	1.60	15.64
03/17/20 11:00:00 PM	16.972	81.442	1.60	15.65
03/18/20 12:00:00 AM	16.967	81.442	1.60	15.64
03/18/20 01:00:00 AM	16.962	81.442	1.60	15.64
03/18/20 02:00:00 AM	16.952	81.442	1.61	15.63
03/18/20 03:00:00 AM	16.942	81.442	1.62	15.62
03/18/20 04:00:00 AM	16.937	81.442	1.62	15.62
03/18/20 05:00:00 AM	16.932	81.442	1.63	15.62
03/18/20 06:00:00 AM	16.932	81.442	1.63	15.62
03/18/20 07:00:00 AM	16.932	81.442	1.63	15.62
03/18/20 08:00:00 AM	16.937	81.442	1.62	15.62
03/18/20 09:00:00 AM	16.942	81.442	1.62	15.62
03/18/20 10:00:00 AM	16.942	81.442	1.62	15.62
03/18/20 11:00:00 AM	16.947	81.442	1.61	15.63
03/18/20 12:00:00 PM	16.937	81.442	1.62	15.62
03/18/20 01:00:00 PM	16.927	81.442	1.63	15.61
03/18/20 02:00:00 PM	16.916	81.442	1.64	15.61
03/18/20 03:00:00 PM	16.906	81.442	1.64	15.60
03/18/20 04:00:00 PM	16.886	81.442	1.66	15.59
03/18/20 05:00:00 PM	16.891	81.442	1.65	15.59
03/18/20 06:00:00 PM	16.896	81.442	1.65	15.59
03/18/20 07:00:00 PM	16.911	81.442	1.64	15.60
03/18/20 08:00:00 PM	16.911	81.442	1.64	15.60
03/18/20 09:00:00 PM	16.921	81.442	1.63	15.61
03/18/20 10:00:00 PM	16.927	81.442	1.63	15.61
03/18/20 11:00:00 PM	16.927	81.442	1.63	15.61
03/19/20 12:00:00 AM	16.927	81.442	1.63	15.61
03/19/20 01:00:00 AM	16.911	81.442	1.64	15.60
03/19/20 02:00:00 AM	16.911	81.442	1.64	15.60
03/19/20 03:00:00 AM	16.901	81.442	1.65	15.60
03/19/20 04:00:00 AM	16.891	81.442	1.65	15.59
03/19/20 05:00:00 AM	16.896	81.442	1.65	15.59
03/19/20 06:00:00 AM	16.891	81.442	1.65	15.59
03/19/20 07:00:00 AM	16.896	81.442	1.65	15.59
03/19/20 08:00:00 AM	16.906	81.442	1.64	15.60
03/19/20 09:00:00 AM	16.921	81.442	1.63	15.61
03/19/20 10:00:00 AM	16.921	81.442	1.63	15.61
03/19/20 11:00:00 AM	16.916	81.442	1.64	15.61

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 12:00:00 PM	16.906	81.442	1.64	15.60

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 01:00:00 PM	16.901	81.442	1.65	15.60
03/19/20 02:00:00 PM	16.881	81.442	1.66	15.58
03/19/20 03:00:00 PM	16.876	81.442	1.66	15.58
03/19/20 04:00:00 PM	16.861	81.442	1.68	15.57
03/19/20 05:00:00 PM	16.855	81.442	1.68	15.56
03/19/20 06:00:00 PM	16.855	81.442	1.68	15.56
03/19/20 07:00:00 PM	16.855	81.442	1.68	15.56
03/19/20 08:00:00 PM	16.871	81.442	1.67	15.57
03/19/20 09:00:00 PM	16.876	81.442	1.66	15.58
03/19/20 10:00:00 PM	16.886	81.442	1.66	15.59
03/19/20 11:00:00 PM	16.891	81.442	1.65	15.59
03/20/20 12:00:00 AM	16.891	81.442	1.65	15.59
03/20/20 01:00:00 AM	16.891	81.442	1.65	15.59
03/20/20 02:00:00 AM	16.886	81.442	1.66	15.59
03/20/20 03:00:00 AM	16.876	81.442	1.66	15.58
03/20/20 04:00:00 AM	16.861	81.442	1.68	15.57
03/20/20 05:00:00 AM	16.866	81.442	1.67	15.57
03/20/20 06:00:00 AM	16.866	81.442	1.67	15.57
03/20/20 07:00:00 AM	16.871	81.442	1.67	15.57
03/20/20 08:00:00 AM	16.876	81.442	1.66	15.58
03/20/20 09:00:00 AM	16.881	81.442	1.66	15.58
03/20/20 10:00:00 AM	16.886	81.442	1.66	15.59
03/20/20 11:00:00 AM	16.881	81.442	1.66	15.58
03/20/20 12:00:00 PM	16.871	81.442	1.67	15.57
03/20/20 01:00:00 PM	16.861	81.442	1.68	15.57
03/20/20 02:00:00 PM	16.855	81.442	1.68	15.56
03/20/20 03:00:00 PM	16.840	81.442	1.69	15.55
03/20/20 04:00:00 PM	16.835	81.442	1.69	15.55
03/20/20 05:00:00 PM	16.825	81.442	1.70	15.54
03/20/20 06:00:00 PM	16.825	81.442	1.70	15.54
03/20/20 07:00:00 PM	16.835	81.442	1.69	15.55
03/20/20 08:00:00 PM	16.845	81.442	1.69	15.56
03/20/20 09:00:00 PM	16.850	81.442	1.68	15.56
03/20/20 10:00:00 PM	16.850	81.442	1.68	15.56
03/20/20 11:00:00 PM	16.861	81.442	1.68	15.57
03/21/20 12:00:00 AM	16.855	81.442	1.68	15.56
03/21/20 01:00:00 AM	16.840	81.442	1.69	15.55
03/21/20 02:00:00 AM	16.835	81.442	1.69	15.55
03/21/20 03:00:00 AM	16.830	81.442	1.70	15.55
03/21/20 04:00:00 AM	16.820	81.442	1.70	15.54
03/21/20 05:00:00 AM	16.825	81.442	1.70	15.54

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/21/20 06:00:00 AM	16.825	81.442	1.70	15.54
03/21/20 07:00:00 AM	16.825	81.442	1.70	15.54
03/21/20 08:00:00 AM	16.835	81.442	1.69	15.55
03/21/20 09:00:00 AM	16.840	81.442	1.69	15.55
03/21/20 10:00:00 AM	16.840	81.442	1.69	15.55
03/21/20 11:00:00 AM	16.845	81.442	1.69	15.56
03/21/20 12:00:00 PM	16.825	81.442	1.70	15.54
03/21/20 01:00:00 PM	16.815	81.442	1.71	15.54
03/21/20 02:00:00 PM	16.805	81.442	1.71	15.53
03/21/20 03:00:00 PM	16.800	81.442	1.72	15.52
03/21/20 04:00:00 PM	16.800	81.442	1.72	15.52
03/21/20 05:00:00 PM	16.800	81.442	1.72	15.52
03/21/20 06:00:00 PM	16.789	81.442	1.73	15.52
03/21/20 07:00:00 PM	16.800	81.442	1.72	15.52
03/21/20 08:00:00 PM	16.810	81.442	1.71	15.53
03/21/20 09:00:00 PM	16.820	81.442	1.70	15.54
03/21/20 10:00:00 PM	16.830	81.442	1.70	15.55
03/21/20 11:00:00 PM	16.825	81.442	1.70	15.54
03/22/20 12:00:00 AM	16.825	81.442	1.70	15.54
03/22/20 01:00:00 AM	16.820	81.442	1.70	15.54
03/22/20 02:00:00 AM	16.810	81.442	1.71	15.53
03/22/20 03:00:00 AM	16.800	81.442	1.72	15.52
03/22/20 04:00:00 AM	16.795	81.442	1.72	15.52
03/22/20 05:00:00 AM	16.789	81.442	1.73	15.52
03/22/20 06:00:00 AM	16.789	81.442	1.73	15.52
03/22/20 07:00:00 AM	16.789	81.442	1.73	15.52
03/22/20 08:00:00 AM	16.795	81.442	1.72	15.52
03/22/20 09:00:00 AM	16.805	81.442	1.71	15.53
03/22/20 10:00:00 AM	16.810	81.442	1.71	15.53
03/22/20 11:00:00 AM	16.805	81.442	1.71	15.53
03/22/20 12:00:00 PM	16.784	81.442	1.73	15.51
03/22/20 01:00:00 PM	16.779	81.442	1.73	15.51
03/22/20 02:00:00 PM	16.764	81.442	1.74	15.50
03/22/20 03:00:00 PM	16.744	81.442	1.76	15.49
03/22/20 04:00:00 PM	16.754	81.442	1.75	15.49
03/22/20 05:00:00 PM	16.779	81.442	1.73	15.51
03/22/20 06:00:00 PM	16.784	81.442	1.73	15.51
03/22/20 07:00:00 PM	16.795	81.442	1.72	15.52
03/22/20 08:00:00 PM	16.815	81.442	1.71	15.54
03/22/20 09:00:00 PM	16.830	81.442	1.70	15.55
03/22/20 10:00:00 PM	16.835	81.442	1.69	15.55

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 11:00:00 PM	16.840	81.442	1.69	15.55
03/23/20 12:00:00 AM	16.850	81.442	1.68	15.56
03/23/20 01:00:00 AM	16.850	81.442	1.68	15.56
03/23/20 02:00:00 AM	16.840	81.442	1.69	15.55
03/23/20 03:00:00 AM	16.830	81.442	1.70	15.55
03/23/20 04:00:00 AM	16.820	81.442	1.70	15.54
03/23/20 05:00:00 AM	16.820	81.442	1.70	15.54
03/23/20 06:00:00 AM	16.825	81.442	1.70	15.54
03/23/20 07:00:00 AM	16.825	81.442	1.70	15.54
03/23/20 08:00:00 AM	16.835	81.442	1.69	15.55
03/23/20 09:00:00 AM	16.845	81.442	1.69	15.56
03/23/20 10:00:00 AM	16.845	81.442	1.69	15.56
03/23/20 11:00:00 AM	16.835	81.442	1.69	15.55
03/23/20 12:00:00 PM	16.835	81.442	1.69	15.55
03/23/20 01:00:00 PM	16.825	81.442	1.70	15.54
03/23/20 02:00:00 PM	16.810	81.442	1.71	15.53
03/23/20 03:00:00 PM	16.805	81.442	1.71	15.53
03/23/20 04:00:00 PM	16.795	81.442	1.72	15.52
03/23/20 05:00:00 PM	16.789	81.442	1.73	15.52
03/23/20 06:00:00 PM	16.800	81.442	1.72	15.52
03/23/20 07:00:00 PM	16.805	81.442	1.71	15.53
03/23/20 08:00:00 PM	16.805	81.442	1.71	15.53
03/23/20 09:00:00 PM	16.810	81.442	1.71	15.53
03/23/20 10:00:00 PM	16.810	81.442	1.71	15.53
03/23/20 11:00:00 PM	16.825	81.442	1.70	15.54
03/24/20 12:00:00 AM	16.830	81.442	1.70	15.55
03/24/20 01:00:00 AM	16.815	81.442	1.71	15.54
03/24/20 02:00:00 AM	16.815	81.442	1.71	15.54
03/24/20 03:00:00 AM	16.805	81.442	1.71	15.53
03/24/20 04:00:00 AM	16.805	81.442	1.71	15.53
03/24/20 05:00:00 AM	16.800	81.442	1.72	15.52
03/24/20 06:00:00 AM	16.795	81.442	1.72	15.52
03/24/20 07:00:00 AM	16.795	81.442	1.72	15.52
03/24/20 08:00:00 AM	16.800	81.442	1.72	15.52
03/24/20 09:00:00 AM	16.805	81.442	1.71	15.53
03/24/20 10:00:00 AM	16.815	81.442	1.71	15.54
03/24/20 11:00:00 AM	16.815	81.442	1.71	15.54
03/24/20 12:00:00 PM	16.810	81.442	1.71	15.53
03/24/20 01:00:00 PM	16.795	81.442	1.72	15.52
03/24/20 02:00:00 PM	16.774	81.442	1.74	15.51
03/24/20 03:00:00 PM	16.759	81.442	1.75	15.50

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/24/20 04:00:00 PM	16.749	81.442	1.75	15.49
03/24/20 05:00:00 PM	16.749	81.442	1.75	15.49
03/24/20 06:00:00 PM	16.749	81.442	1.75	15.49
03/24/20 07:00:00 PM	16.754	81.442	1.75	15.49
03/24/20 08:00:00 PM	16.764	81.442	1.74	15.50
03/24/20 09:00:00 PM	16.769	81.442	1.74	15.50
03/24/20 10:00:00 PM	16.774	81.442	1.74	15.51
03/24/20 11:00:00 PM	16.774	81.442	1.74	15.51
03/25/20 12:00:00 AM	16.779	81.442	1.73	15.51
03/25/20 01:00:00 AM	16.769	81.442	1.74	15.50
03/25/20 02:00:00 AM	16.759	81.442	1.75	15.50
03/25/20 03:00:00 AM	16.754	81.442	1.75	15.49
03/25/20 04:00:00 AM	16.744	81.442	1.76	15.49
03/25/20 05:00:00 AM	16.739	81.442	1.76	15.48
03/25/20 06:00:00 AM	16.749	81.442	1.75	15.49
03/25/20 07:00:00 AM	16.744	81.442	1.76	15.49
03/25/20 08:00:00 AM	16.744	81.442	1.76	15.49
03/25/20 09:00:00 AM	16.749	81.442	1.75	15.49
03/25/20 10:00:00 AM	16.759	81.442	1.75	15.50
03/25/20 11:00:00 AM	16.759	81.442	1.75	15.50
03/25/20 12:00:00 PM	16.744	81.442	1.76	15.49
03/25/20 01:00:00 PM	16.739	81.442	1.76	15.48
03/25/20 02:00:00 PM	16.734	81.442	1.76	15.48
03/25/20 03:00:00 PM	16.723	81.442	1.77	15.47
03/25/20 04:00:00 PM	16.718	81.442	1.78	15.47
03/25/20 05:00:00 PM	16.723	81.442	1.77	15.47
03/25/20 06:00:00 PM	16.734	81.442	1.76	15.48
03/25/20 07:00:00 PM	16.744	81.442	1.76	15.49
03/25/20 08:00:00 PM	16.764	81.442	1.74	15.50
03/25/20 09:00:00 PM	16.779	81.442	1.73	15.51
03/25/20 10:00:00 PM	16.795	81.442	1.72	15.52
03/25/20 11:00:00 PM	16.810	81.442	1.71	15.53
03/26/20 12:00:00 AM	16.810	81.442	1.71	15.53
03/26/20 01:00:00 AM	16.810	81.442	1.71	15.53
03/26/20 02:00:00 AM	16.800	81.442	1.72	15.52
03/26/20 03:00:00 AM	16.795	81.442	1.72	15.52
03/26/20 04:00:00 AM	16.795	81.442	1.72	15.52
03/26/20 05:00:00 AM	16.789	81.442	1.73	15.52
03/26/20 06:00:00 AM	16.789	81.442	1.73	15.52
03/26/20 07:00:00 AM	16.795	81.442	1.72	15.52
03/26/20 08:00:00 AM	16.805	81.442	1.71	15.53

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/26/20 09:00:00 AM	16.815	81.442	1.71	15.54
03/26/20 10:00:00 AM	16.815	81.442	1.71	15.54
03/26/20 11:00:00 AM	16.815	81.442	1.71	15.54
03/26/20 12:00:00 PM	16.815	81.442	1.71	15.54
03/26/20 01:00:00 PM	16.800	81.442	1.72	15.52
03/26/20 02:00:00 PM	16.789	81.442	1.73	15.52
03/26/20 03:00:00 PM	16.774	81.442	1.74	15.51
03/26/20 04:00:00 PM	16.769	81.442	1.74	15.50
03/26/20 05:00:00 PM	16.764	81.442	1.74	15.50
03/26/20 06:00:00 PM	16.759	81.442	1.75	15.50
03/26/20 07:00:00 PM	16.769	81.442	1.74	15.50
03/26/20 08:00:00 PM	16.774	81.442	1.74	15.51
03/26/20 09:00:00 PM	16.779	81.442	1.73	15.51
03/26/20 10:00:00 PM	16.779	81.442	1.73	15.51
03/26/20 11:00:00 PM	16.784	81.442	1.73	15.51
03/27/20 12:00:00 AM	16.789	81.442	1.73	15.52
03/27/20 01:00:00 AM	16.789	81.442	1.73	15.52
03/27/20 02:00:00 AM	16.779	81.442	1.73	15.51
03/27/20 03:00:00 AM	16.769	81.442	1.74	15.50
03/27/20 04:00:00 AM	16.754	81.442	1.75	15.49
03/27/20 05:00:00 AM	16.749	81.442	1.75	15.49
03/27/20 06:00:00 AM	16.749	81.442	1.75	15.49
03/27/20 07:00:00 AM	16.759	81.442	1.75	15.50
03/27/20 08:00:00 AM	16.769	81.442	1.74	15.50
03/27/20 09:00:00 AM	16.774	81.442	1.74	15.51
03/27/20 10:00:00 AM	16.774	81.442	1.74	15.51
03/27/20 11:00:00 AM	16.779	81.442	1.73	15.51
03/27/20 12:00:00 PM	16.774	81.442	1.74	15.51
03/27/20 01:00:00 PM	16.759	81.442	1.75	15.50
03/27/20 02:00:00 PM	16.744	81.442	1.76	15.49
03/27/20 03:00:00 PM	16.729	81.442	1.77	15.47
03/27/20 04:00:00 PM	16.723	81.442	1.77	15.47
03/27/20 05:00:00 PM	16.723	81.442	1.77	15.47
03/27/20 06:00:00 PM	16.723	81.442	1.77	15.47
03/27/20 07:00:00 PM	16.729	81.442	1.77	15.47
03/27/20 08:00:00 PM	16.754	81.442	1.75	15.49
03/27/20 09:00:00 PM	16.779	81.442	1.73	15.51
03/27/20 10:00:00 PM	16.800	81.442	1.72	15.52
03/27/20 11:00:00 PM	16.830	81.442	1.70	15.55
03/28/20 12:00:00 AM	16.840	81.442	1.69	15.55
03/28/20 01:00:00 AM	16.850	81.442	1.68	15.56

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/28/20 02:00:00 AM	16.850	81.442	1.68	15.56
03/28/20 03:00:00 AM	16.855	81.442	1.68	15.56
03/28/20 04:00:00 AM	16.866	81.442	1.67	15.57
03/28/20 05:00:00 AM	16.866	81.442	1.67	15.57
03/28/20 06:00:00 AM	16.876	81.442	1.66	15.58
03/28/20 07:00:00 AM	16.886	81.442	1.66	15.59
03/28/20 08:00:00 AM	16.901	81.442	1.65	15.60
03/28/20 09:00:00 AM	16.911	81.442	1.64	15.60
03/28/20 10:00:00 AM	16.916	81.442	1.64	15.61
03/28/20 11:00:00 AM	16.911	81.442	1.64	15.60
03/28/20 12:00:00 PM	16.911	81.442	1.64	15.60
03/28/20 01:00:00 PM	16.901	81.442	1.65	15.60
03/28/20 02:00:00 PM	16.886	81.442	1.66	15.59
03/28/20 03:00:00 PM	16.871	81.442	1.67	15.57
03/28/20 04:00:00 PM	16.861	81.442	1.68	15.57
03/28/20 05:00:00 PM	16.855	81.442	1.68	15.56
03/28/20 06:00:00 PM	16.850	81.442	1.68	15.56
03/28/20 07:00:00 PM	16.850	81.442	1.68	15.56
03/28/20 08:00:00 PM	16.855	81.442	1.68	15.56
03/28/20 09:00:00 PM	16.861	81.442	1.68	15.57
03/28/20 10:00:00 PM	16.876	81.442	1.66	15.58
03/28/20 11:00:00 PM	16.881	81.442	1.66	15.58
03/29/20 12:00:00 AM	16.886	81.442	1.66	15.59
03/29/20 01:00:00 AM	16.881	81.442	1.66	15.58
03/29/20 02:00:00 AM	16.866	81.442	1.67	15.57
03/29/20 03:00:00 AM	16.861	81.442	1.68	15.57
03/29/20 04:00:00 AM	16.850	81.442	1.68	15.56
03/29/20 05:00:00 AM	16.845	81.442	1.69	15.56
03/29/20 06:00:00 AM	16.845	81.442	1.69	15.56
03/29/20 07:00:00 AM	16.840	81.442	1.69	15.55
03/29/20 08:00:00 AM	16.845	81.442	1.69	15.56
03/29/20 09:00:00 AM	16.855	81.442	1.68	15.56
03/29/20 10:00:00 AM	16.850	81.442	1.68	15.56
03/29/20 11:00:00 AM	16.840	81.442	1.69	15.55
03/29/20 12:00:00 PM	16.835	81.442	1.69	15.55
03/29/20 01:00:00 PM	16.820	81.442	1.70	15.54
03/29/20 02:00:00 PM	16.810	81.442	1.71	15.53
03/29/20 03:00:00 PM	16.800	81.442	1.72	15.52
03/29/20 04:00:00 PM	16.795	81.442	1.72	15.52
03/29/20 05:00:00 PM	16.784	81.442	1.73	15.51
03/29/20 06:00:00 PM	16.779	81.442	1.73	15.51

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 07:00:00 PM	16.779	81.442	1.73	15.51
03/29/20 08:00:00 PM	16.784	81.442	1.73	15.51
03/29/20 09:00:00 PM	16.800	81.442	1.72	15.52
03/29/20 10:00:00 PM	16.815	81.442	1.71	15.54
03/29/20 11:00:00 PM	16.820	81.442	1.70	15.54
03/30/20 12:00:00 AM	16.820	81.442	1.70	15.54
03/30/20 01:00:00 AM	16.815	81.442	1.71	15.54
03/30/20 02:00:00 AM	16.795	81.442	1.72	15.52
03/30/20 03:00:00 AM	16.784	81.442	1.73	15.51
03/30/20 04:00:00 AM	16.784	81.442	1.73	15.51
03/30/20 05:00:00 AM	16.774	81.442	1.74	15.51
03/30/20 06:00:00 AM	16.779	81.442	1.73	15.51
03/30/20 07:00:00 AM	16.779	81.442	1.73	15.51
03/30/20 08:00:00 AM	16.784	81.442	1.73	15.51
03/30/20 09:00:00 AM	16.789	81.442	1.73	15.52
03/30/20 10:00:00 AM	16.795	81.442	1.72	15.52
03/30/20 11:00:00 AM	16.789	81.442	1.73	15.52
03/30/20 12:00:00 PM	16.779	81.442	1.73	15.51
03/30/20 01:00:00 PM	16.769	81.442	1.74	15.50
03/30/20 02:00:00 PM	16.759	81.442	1.75	15.50
03/30/20 03:00:00 PM	16.739	81.442	1.76	15.48
03/30/20 04:00:00 PM	16.718	81.442	1.78	15.47
03/30/20 05:00:00 PM	16.713	81.442	1.78	15.46
03/30/20 06:00:00 PM	16.708	81.442	1.78	15.46
03/30/20 07:00:00 PM	16.729	81.442	1.77	15.47
03/30/20 08:00:00 PM	16.734	81.442	1.76	15.48
03/30/20 09:00:00 PM	16.734	81.442	1.76	15.48
03/30/20 10:00:00 PM	16.739	81.442	1.76	15.48
03/30/20 11:00:00 PM	16.749	81.442	1.75	15.49
03/31/20 12:00:00 AM	16.749	81.442	1.75	15.49
03/31/20 01:00:00 AM	16.739	81.442	1.76	15.48
03/31/20 02:00:00 AM	16.734	81.442	1.76	15.48
03/31/20 03:00:00 AM	16.723	81.442	1.77	15.47
03/31/20 04:00:00 AM	16.718	81.442	1.78	15.47
03/31/20 05:00:00 AM	16.723	81.442	1.77	15.47
03/31/20 06:00:00 AM	16.713	81.442	1.78	15.46
03/31/20 07:00:00 AM	16.718	81.442	1.78	15.47
03/31/20 08:00:00 AM	16.723	81.442	1.77	15.47
03/31/20 09:00:00 AM	16.739	81.442	1.76	15.48
03/31/20 10:00:00 AM	16.739	81.442	1.76	15.48
03/31/20 11:00:00 AM	16.729	81.442	1.77	15.47

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

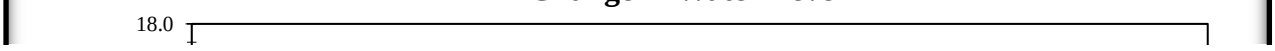
Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/31/20 12:00:00 PM	16.718	81.442	1.78	15.47
03/31/20 01:00:00 PM	16.708	81.442	1.78	15.46
03/31/20 02:00:00 PM	16.693	81.442	1.79	15.45
03/31/20 03:00:00 PM	16.673	81.442	1.81	15.44
03/31/20 04:00:00 PM	16.668	81.442	1.81	15.43
03/31/20 05:00:00 PM	16.657	81.442	1.82	15.42
03/31/20 06:00:00 PM	16.657	81.442	1.82	15.42
03/31/20 07:00:00 PM	16.668	81.442	1.81	15.43
03/31/20 08:00:00 PM	16.673	81.442	1.81	15.44
03/31/20 09:00:00 PM	16.688	81.442	1.80	15.45
03/31/20 10:00:00 PM	16.698	81.442	1.79	15.45
03/31/20 11:00:00 PM	16.703	81.442	1.79	15.46
4/1/2020 12:00:00 AM	16.698	81.442	1.79	15.45
4/1/2020 1:00:00 AM	16.688	81.442	1.80	15.45
4/1/2020 2:00:00 AM	16.673	81.442	1.81	15.44
4/1/2020 3:00:00 AM	16.668	81.442	1.81	15.43
4/1/2020 4:00:00 AM	16.668	81.442	1.81	15.43
4/1/2020 5:00:00 AM	16.663	81.442	1.81	15.43
4/1/2020 6:00:00 AM	16.668	81.442	1.81	15.43
4/1/2020 7:00:00 AM	16.678	81.442	1.80	15.44
4/1/2020 8:00:00 AM	16.683	81.442	1.80	15.44
4/1/2020 9:00:00 AM	16.683	81.442	1.80	15.44
4/1/2020 10:00:00 AM	16.688	81.442	1.80	15.45
4/1/2020 11:00:00 AM	16.683	81.442	1.80	15.44
4/1/2020 12:00:00 PM	16.668	81.442	1.81	15.43
4/1/2020 1:00:00 PM	16.657	81.442	1.82	15.42
4/1/2020 2:00:00 PM	16.637	81.442	1.83	15.41
4/1/2020 3:00:00 PM	16.622	81.442	1.84	15.40
4/1/2020 4:00:00 PM	16.607	81.442	1.85	15.39
4/1/2020 5:00:00 PM	16.602	81.442	1.86	15.39
4/1/2020 6:00:00 PM	16.607	81.442	1.85	15.39
4/1/2020 7:00:00 PM	16.652	81.442	1.82	15.42
4/1/2020 8:00:00 PM	16.673	81.442	1.81	15.44
4/1/2020 9:00:00 PM	16.698	81.442	1.79	15.45
4/1/2020 10:00:00 PM	16.723	81.442	1.77	15.47
4/1/2020 11:00:00 PM	16.749	81.442	1.75	15.49
4/2/2020 12:00:00 AM	16.769	81.442	1.74	15.50
4/2/2020 1:00:00 AM	16.779	81.442	1.73	15.51
4/2/2020 2:00:00 AM	16.774	81.442	1.74	15.51
4/2/2020 3:00:00 AM	16.779	81.442	1.73	15.51
4/2/2020 4:00:00 AM	16.779	81.442	1.73	15.51

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/2/2020 5:00:00 AM	16.784	81.442	1.73	15.51
4/2/2020 6:00:00 AM	16.784	81.442	1.73	15.51
4/2/2020 7:00:00 AM	16.784	81.442	1.73	15.51
4/2/2020 8:00:00 AM	16.795	81.442	1.72	15.52
4/2/2020 9:00:00 AM	16.805	81.442	1.71	15.53
4/2/2020 10:00:00 AM	16.810	81.442	1.71	15.53
4/2/2020 11:00:00 AM	16.810	81.442	1.71	15.53
4/2/2020 12:00:00 PM	16.805	81.442	1.71	15.53
4/2/2020 1:00:00 PM	16.789	81.442	1.73	15.52
4/2/2020 2:00:00 PM	16.774	81.442	1.74	15.51
4/2/2020 3:00:00 PM	16.764	81.442	1.74	15.50
4/2/2020 4:00:00 PM	16.845	81.442	1.69	15.56
4/2/2020 5:00:00 PM	16.891	81.442	1.65	15.59
4/2/2020 6:00:00 PM	16.927	81.442	1.63	15.61
4/2/2020 7:00:00 PM	16.977	81.442	1.59	15.65
4/2/2020 8:00:00 PM	17.038	81.442	1.55	15.69
4/2/2020 9:00:00 PM	17.104	81.442	1.50	15.74
4/2/2020 10:00:00 PM	17.155	81.442	1.47	15.77
4/2/2020 11:00:00 PM	17.211	81.442	1.43	15.81
4/3/2020 12:00:00 AM	17.256	81.442	1.40	15.85
4/3/2020 1:00:00 AM	17.297	81.442	1.37	15.87
4/3/2020 2:00:00 AM	17.328	81.442	1.35	15.90
4/3/2020 3:00:00 AM	17.353	81.442	1.33	15.91
4/3/2020 4:00:00 AM	17.383	81.442	1.31	15.94
4/3/2020 5:00:00 AM	17.404	81.442	1.29	15.95
4/3/2020 6:00:00 AM	17.429	81.442	1.28	15.97
4/3/2020 7:00:00 AM	17.454	81.442	1.26	15.99
4/3/2020 8:00:00 AM	17.470	81.442	1.25	16.00
4/3/2020 9:00:00 AM	17.495	81.442	1.23	16.01
4/3/2020 10:00:00 AM	17.525	81.442	1.21	16.04
4/3/2020 11:00:00 AM	17.647	81.442	1.12	16.12
4/3/2020 12:00:00 PM	17.723	81.442	1.07	16.17
4/3/2020 1:00:00 PM	17.784	81.442	1.03	16.22
4/3/2020 2:00:00 PM	17.830	81.442	0.99	16.25
4/3/2020 3:00:00 PM	17.866	81.442	0.97	16.27
4/3/2020 4:00:00 PM	17.896	81.442	0.95	16.30

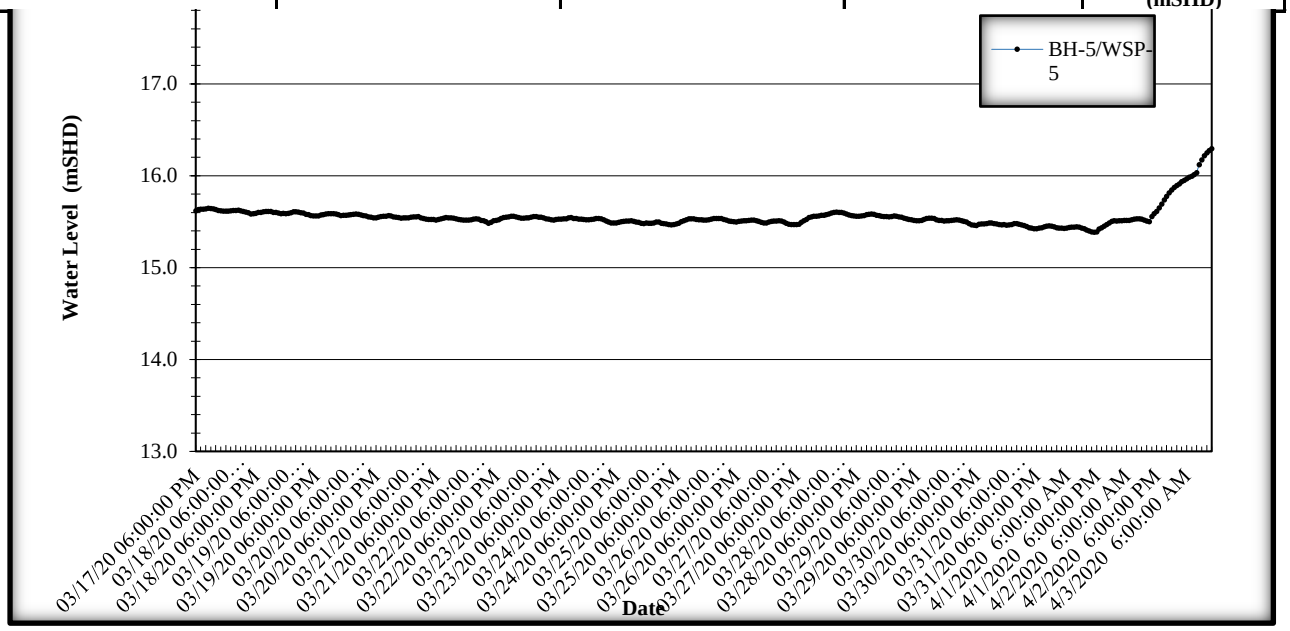
Change in Water Level



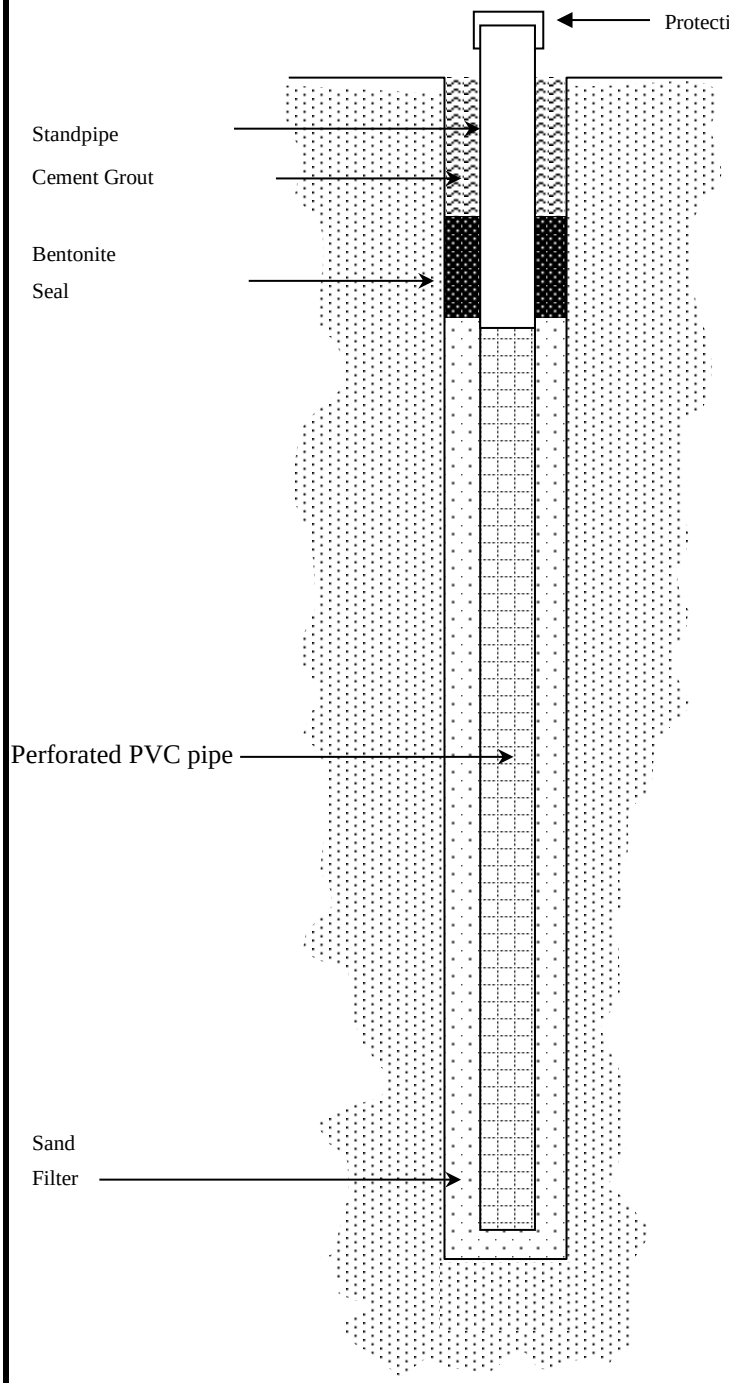
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-5/WSP-5**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.27
Location:	Tengah	**Pipe Top Level (mSHD)**	18.093
		Ground Level (mSHD)	17.243

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area		
CLIENT:	Jacobs Singapore Pte Ltd		
LOCATION:	Tengah		
DATE OF INSTALLATION:	5 Mar 2020	**INSTALLED BY:**	Helal



Depth (GL-m)	0.00
	1.50
	2.00
	6.00

REMARKS:

INSTALLED IN BH06/WSP-06

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/18/20 03:00:00 PM	17.459	82.508	1.25	11.63
03/18/20 04:00:00 PM	17.439	82.508	1.26	11.62
03/18/20 05:00:00 PM	17.439	82.508	1.26	11.62
03/18/20 06:00:00 PM	17.444	82.508	1.26	11.62
03/18/20 07:00:00 PM	17.454	82.508	1.25	11.63
03/18/20 08:00:00 PM	17.449	82.508	1.25	11.63
03/18/20 09:00:00 PM	17.459	82.508	1.25	11.63
03/18/20 10:00:00 PM	17.464	82.508	1.24	11.64
03/18/20 11:00:00 PM	17.464	82.508	1.24	11.64
03/19/20 12:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 01:00:00 AM	17.449	82.508	1.25	11.63
03/19/20 02:00:00 AM	17.459	82.508	1.25	11.63
03/19/20 03:00:00 AM	17.449	82.508	1.25	11.63
03/19/20 04:00:00 AM	17.444	82.508	1.26	11.62
03/19/20 05:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 06:00:00 AM	17.439	82.508	1.26	11.62
03/19/20 07:00:00 AM	17.449	82.508	1.25	11.63
03/19/20 08:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 09:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 10:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 11:00:00 AM	17.454	82.508	1.25	11.63
03/19/20 12:00:00 PM	17.444	82.508	1.26	11.62
03/19/20 01:00:00 PM	17.439	82.508	1.26	11.62
03/19/20 02:00:00 PM	17.424	82.508	1.27	11.61
03/19/20 03:00:00 PM	17.419	82.508	1.27	11.61
03/19/20 04:00:00 PM	17.409	82.508	1.28	11.60
03/19/20 05:00:00 PM	17.399	82.508	1.29	11.59
03/19/20 06:00:00 PM	17.394	82.508	1.29	11.59
03/19/20 07:00:00 PM	17.399	82.508	1.29	11.59
03/19/20 08:00:00 PM	17.409	82.508	1.28	11.60
03/19/20 09:00:00 PM	17.414	82.508	1.28	11.60
03/19/20 10:00:00 PM	17.414	82.508	1.28	11.60
03/19/20 11:00:00 PM	17.414	82.508	1.28	11.60
03/20/20 12:00:00 AM	17.419	82.508	1.27	11.61
03/20/20 01:00:00 AM	17.414	82.508	1.28	11.60
03/20/20 02:00:00 AM	17.409	82.508	1.28	11.60
03/20/20 03:00:00 AM	17.399	82.508	1.29	11.59
03/20/20 04:00:00 AM	17.399	82.508	1.29	11.59
03/20/20 05:00:00 AM	17.404	82.508	1.28	11.60
03/20/20 06:00:00 AM	17.404	82.508	1.28	11.60
03/20/20 07:00:00 AM	17.404	82.508	1.28	11.60

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/20/20 08:00:00 AM	17.404	82.508	1.28	11.60
03/20/20 09:00:00 AM	17.414	82.508	1.28	11.60
03/20/20 10:00:00 AM	17.409	82.508	1.28	11.60
03/20/20 11:00:00 AM	17.409	82.508	1.28	11.60
03/20/20 12:00:00 PM	17.399	82.508	1.29	11.59
03/20/20 01:00:00 PM	17.394	82.508	1.29	11.59
03/20/20 02:00:00 PM	17.379	82.508	1.30	11.58
03/20/20 03:00:00 PM	17.379	82.508	1.30	11.58
03/20/20 04:00:00 PM	17.374	82.508	1.31	11.57
03/20/20 05:00:00 PM	17.363	82.508	1.31	11.57
03/20/20 06:00:00 PM	17.374	82.508	1.31	11.57
03/20/20 07:00:00 PM	17.368	82.508	1.31	11.57
03/20/20 08:00:00 PM	17.374	82.508	1.31	11.57
03/20/20 09:00:00 PM	17.374	82.508	1.31	11.57
03/20/20 10:00:00 PM	17.374	82.508	1.31	11.57
03/20/20 11:00:00 PM	17.379	82.508	1.30	11.58
03/21/20 12:00:00 AM	17.379	82.508	1.30	11.58
03/21/20 01:00:00 AM	17.374	82.508	1.31	11.57
03/21/20 02:00:00 AM	17.363	82.508	1.31	11.57
03/21/20 03:00:00 AM	17.358	82.508	1.32	11.56
03/21/20 04:00:00 AM	17.363	82.508	1.31	11.57
03/21/20 05:00:00 AM	17.363	82.508	1.31	11.57
03/21/20 06:00:00 AM	17.363	82.508	1.31	11.57
03/21/20 07:00:00 AM	17.363	82.508	1.31	11.57
03/21/20 08:00:00 AM	17.374	82.508	1.31	11.57
03/21/20 09:00:00 AM	17.374	82.508	1.31	11.57
03/21/20 10:00:00 AM	17.368	82.508	1.31	11.57
03/21/20 11:00:00 AM	17.368	82.508	1.31	11.57
03/21/20 12:00:00 PM	17.363	82.508	1.31	11.57
03/21/20 01:00:00 PM	17.358	82.508	1.32	11.56
03/21/20 02:00:00 PM	17.348	82.508	1.32	11.56
03/21/20 03:00:00 PM	17.338	82.508	1.33	11.55
03/21/20 04:00:00 PM	17.338	82.508	1.33	11.55
03/21/20 05:00:00 PM	17.333	82.508	1.33	11.55
03/21/20 06:00:00 PM	17.333	82.508	1.33	11.55
03/21/20 07:00:00 PM	17.338	82.508	1.33	11.55
03/21/20 08:00:00 PM	17.348	82.508	1.32	11.56
03/21/20 09:00:00 PM	17.348	82.508	1.32	11.56
03/21/20 10:00:00 PM	17.353	82.508	1.32	11.56
03/21/20 11:00:00 PM	17.358	82.508	1.32	11.56
03/22/20 12:00:00 AM	17.358	82.508	1.32	11.56

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 01:00:00 AM	17.358	82.508	1.32	11.56
03/22/20 02:00:00 AM	17.358	82.508	1.32	11.56
03/22/20 03:00:00 AM	17.353	82.508	1.32	11.56
03/22/20 04:00:00 AM	17.348	82.508	1.32	11.56
03/22/20 05:00:00 AM	17.348	82.508	1.32	11.56
03/22/20 06:00:00 AM	17.353	82.508	1.32	11.56
03/22/20 07:00:00 AM	17.348	82.508	1.32	11.56
03/22/20 08:00:00 AM	17.348	82.508	1.32	11.56
03/22/20 09:00:00 AM	17.358	82.508	1.32	11.56
03/22/20 10:00:00 AM	17.358	82.508	1.32	11.56
03/22/20 11:00:00 AM	17.348	82.508	1.32	11.56
03/22/20 12:00:00 PM	17.343	82.508	1.33	11.55
03/22/20 01:00:00 PM	17.333	82.508	1.33	11.55
03/22/20 02:00:00 PM	17.328	82.508	1.34	11.54
03/22/20 03:00:00 PM	17.313	82.508	1.35	11.53
03/22/20 04:00:00 PM	17.313	82.508	1.35	11.53
03/22/20 05:00:00 PM	17.318	82.508	1.35	11.53
03/22/20 06:00:00 PM	17.379	82.508	1.30	11.58
03/22/20 07:00:00 PM	17.474	82.508	1.24	11.64
03/22/20 08:00:00 PM	17.515	82.508	1.21	11.67
03/22/20 09:00:00 PM	17.530	82.508	1.20	11.68
03/22/20 10:00:00 PM	17.530	82.508	1.20	11.68
03/22/20 11:00:00 PM	17.525	82.508	1.20	11.68
03/23/20 12:00:00 AM	17.535	82.508	1.19	11.69
03/23/20 01:00:00 AM	17.530	82.508	1.20	11.68
03/23/20 02:00:00 AM	17.525	82.508	1.20	11.68
03/23/20 03:00:00 AM	17.520	82.508	1.20	11.68
03/23/20 04:00:00 AM	17.510	82.508	1.21	11.67
03/23/20 05:00:00 AM	17.510	82.508	1.21	11.67
03/23/20 06:00:00 AM	17.510	82.508	1.21	11.67
03/23/20 07:00:00 AM	17.505	82.508	1.21	11.67
03/23/20 08:00:00 AM	17.510	82.508	1.21	11.67
03/23/20 09:00:00 AM	17.515	82.508	1.21	11.67
03/23/20 10:00:00 AM	17.510	82.508	1.21	11.67
03/23/20 11:00:00 AM	17.500	82.508	1.22	11.66
03/23/20 12:00:00 PM	17.500	82.508	1.22	11.66
03/23/20 01:00:00 PM	17.495	82.508	1.22	11.66
03/23/20 02:00:00 PM	17.484	82.508	1.23	11.65
03/23/20 03:00:00 PM	17.469	82.508	1.24	11.64
03/23/20 04:00:00 PM	17.469	82.508	1.24	11.64
03/23/20 05:00:00 PM	17.459	82.508	1.25	11.63

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/23/20 06:00:00 PM	17.459	82.508	1.25	11.63
03/23/20 07:00:00 PM	17.464	82.508	1.24	11.64
03/23/20 08:00:00 PM	17.474	82.508	1.24	11.64
03/23/20 09:00:00 PM	17.474	82.508	1.24	11.64
03/23/20 10:00:00 PM	17.484	82.508	1.23	11.65
03/23/20 11:00:00 PM	17.505	82.508	1.21	11.67
03/24/20 12:00:00 AM	17.510	82.508	1.21	11.67
03/24/20 01:00:00 AM	17.510	82.508	1.21	11.67
03/24/20 02:00:00 AM	17.510	82.508	1.21	11.67
03/24/20 03:00:00 AM	17.505	82.508	1.21	11.67
03/24/20 04:00:00 AM	17.505	82.508	1.21	11.67
03/24/20 05:00:00 AM	17.505	82.508	1.21	11.67
03/24/20 06:00:00 AM	17.510	82.508	1.21	11.67
03/24/20 07:00:00 AM	17.505	82.508	1.21	11.67
03/24/20 08:00:00 AM	17.515	82.508	1.21	11.67
03/24/20 09:00:00 AM	17.515	82.508	1.21	11.67
03/24/20 10:00:00 AM	17.520	82.508	1.20	11.68
03/24/20 11:00:00 AM	17.510	82.508	1.21	11.67
03/24/20 12:00:00 PM	17.510	82.508	1.21	11.67
03/24/20 01:00:00 PM	17.489	82.508	1.22	11.66
03/24/20 02:00:00 PM	17.479	82.508	1.23	11.65
03/24/20 03:00:00 PM	17.469	82.508	1.24	11.64
03/24/20 04:00:00 PM	17.459	82.508	1.25	11.63
03/24/20 05:00:00 PM	17.449	82.508	1.25	11.63
03/24/20 06:00:00 PM	17.449	82.508	1.25	11.63
03/24/20 07:00:00 PM	17.444	82.508	1.26	11.62
03/24/20 08:00:00 PM	17.449	82.508	1.25	11.63
03/24/20 09:00:00 PM	17.449	82.508	1.25	11.63
03/24/20 10:00:00 PM	17.449	82.508	1.25	11.63
03/24/20 11:00:00 PM	17.444	82.508	1.26	11.62
03/25/20 12:00:00 AM	17.444	82.508	1.26	11.62
03/25/20 01:00:00 AM	17.444	82.508	1.26	11.62
03/25/20 02:00:00 AM	17.439	82.508	1.26	11.62
03/25/20 03:00:00 AM	17.434	82.508	1.26	11.62
03/25/20 04:00:00 AM	17.434	82.508	1.26	11.62
03/25/20 05:00:00 AM	17.424	82.508	1.27	11.61
03/25/20 06:00:00 AM	17.429	82.508	1.27	11.61
03/25/20 07:00:00 AM	17.424	82.508	1.27	11.61
03/25/20 08:00:00 AM	17.424	82.508	1.27	11.61
03/25/20 09:00:00 AM	17.429	82.508	1.27	11.61
03/25/20 10:00:00 AM	17.429	82.508	1.27	11.61

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/25/20 11:00:00 AM	17.434	82.508	1.26	11.62
03/25/20 12:00:00 PM	17.424	82.508	1.27	11.61
03/25/20 01:00:00 PM	17.419	82.508	1.27	11.61
03/25/20 02:00:00 PM	17.419	82.508	1.27	11.61
03/25/20 03:00:00 PM	17.409	82.508	1.28	11.60
03/25/20 04:00:00 PM	17.449	82.508	1.25	11.63
03/25/20 05:00:00 PM	17.570	82.508	1.17	11.71
03/25/20 06:00:00 PM	17.615	82.508	1.14	11.74
03/25/20 07:00:00 PM	17.646	82.508	1.11	11.77
03/25/20 08:00:00 PM	17.666	82.508	1.10	11.78
03/25/20 09:00:00 PM	17.686	82.508	1.09	11.79
03/25/20 10:00:00 PM	17.701	82.508	1.08	11.80
03/25/20 11:00:00 PM	17.706	82.508	1.07	11.81
03/26/20 12:00:00 AM	17.721	82.508	1.06	11.82
03/26/20 01:00:00 AM	17.726	82.508	1.06	11.82
03/26/20 02:00:00 AM	17.726	82.508	1.06	11.82
03/26/20 03:00:00 AM	17.731	82.508	1.05	11.83
03/26/20 04:00:00 AM	17.736	82.508	1.05	11.83
03/26/20 05:00:00 AM	17.736	82.508	1.05	11.83
03/26/20 06:00:00 AM	17.736	82.508	1.05	11.83
03/26/20 07:00:00 AM	17.742	82.508	1.05	11.83
03/26/20 08:00:00 AM	17.742	82.508	1.05	11.83
03/26/20 09:00:00 AM	17.701	82.508	1.08	11.80
03/26/20 10:00:00 AM	17.742	82.508	1.05	11.83
03/26/20 11:00:00 AM	17.726	82.508	1.06	11.82
03/26/20 12:00:00 PM	17.711	82.508	1.07	11.81
03/26/20 01:00:00 PM	17.716	82.508	1.07	11.81
03/26/20 02:00:00 PM	17.696	82.508	1.08	11.80
03/26/20 03:00:00 PM	17.681	82.508	1.09	11.79
03/26/20 04:00:00 PM	17.671	82.508	1.10	11.78
03/26/20 05:00:00 PM	17.661	82.508	1.10	11.78
03/26/20 06:00:00 PM	17.651	82.508	1.11	11.77
03/26/20 07:00:00 PM	17.646	82.508	1.11	11.77
03/26/20 08:00:00 PM	17.646	82.508	1.11	11.77
03/26/20 09:00:00 PM	17.641	82.508	1.12	11.76
03/26/20 10:00:00 PM	17.636	82.508	1.12	11.76
03/26/20 11:00:00 PM	17.636	82.508	1.12	11.76
03/27/20 12:00:00 AM	17.636	82.508	1.12	11.76
03/27/20 01:00:00 AM	17.626	82.508	1.13	11.75
03/27/20 02:00:00 AM	17.621	82.508	1.13	11.75
03/27/20 03:00:00 AM	17.621	82.508	1.13	11.75

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/27/20 04:00:00 AM	17.605	82.508	1.14	11.74
03/27/20 05:00:00 AM	17.605	82.508	1.14	11.74
03/27/20 06:00:00 AM	17.600	82.508	1.15	11.73
03/27/20 07:00:00 AM	17.600	82.508	1.15	11.73
03/27/20 08:00:00 AM	17.605	82.508	1.14	11.74
03/27/20 09:00:00 AM	17.605	82.508	1.14	11.74
03/27/20 10:00:00 AM	17.595	82.508	1.15	11.73
03/27/20 11:00:00 AM	17.595	82.508	1.15	11.73
03/27/20 12:00:00 PM	17.585	82.508	1.16	11.72
03/27/20 01:00:00 PM	17.585	82.508	1.16	11.72
03/27/20 02:00:00 PM	17.565	82.508	1.17	11.71
03/27/20 03:00:00 PM	17.560	82.508	1.18	11.70
03/27/20 04:00:00 PM	17.560	82.508	1.18	11.70
03/27/20 05:00:00 PM	17.540	82.508	1.19	11.69
03/27/20 06:00:00 PM	17.560	82.508	1.18	11.70
03/27/20 07:00:00 PM	17.676	82.508	1.09	11.79
03/27/20 08:00:00 PM	17.878	82.508	0.95	11.93
03/27/20 09:00:00 PM	18.009	82.508	0.86	12.02
03/27/20 10:00:00 PM	18.099	82.508	0.80	12.08
03/27/20 11:00:00 PM	18.165	82.508	0.75	12.13
03/28/20 12:00:00 AM	18.205	82.508	0.72	12.16
03/28/20 01:00:00 AM	18.235	82.508	0.70	12.18
03/28/20 02:00:00 AM	18.256	82.508	0.69	12.19
03/28/20 03:00:00 AM	18.251	82.508	0.69	12.19
03/28/20 04:00:00 AM	18.261	82.508	0.68	12.20
03/28/20 05:00:00 AM	18.261	82.508	0.68	12.20
03/28/20 06:00:00 AM	18.261	82.508	0.68	12.20
03/28/20 07:00:00 AM	18.266	82.508	0.68	12.20
03/28/20 08:00:00 AM	18.271	82.508	0.68	12.20
03/28/20 09:00:00 AM	18.266	82.508	0.68	12.20
03/28/20 10:00:00 AM	18.256	82.508	0.69	12.19
03/28/20 11:00:00 AM	18.246	82.508	0.69	12.19
03/28/20 12:00:00 PM	18.230	82.508	0.70	12.18
03/28/20 01:00:00 PM	18.205	82.508	0.72	12.16
03/28/20 02:00:00 PM	18.185	82.508	0.74	12.14
03/28/20 03:00:00 PM	18.160	82.508	0.75	12.13
03/28/20 04:00:00 PM	18.079	82.508	0.81	12.07
03/28/20 05:00:00 PM	18.119	82.508	0.78	12.10
03/28/20 06:00:00 PM	18.074	82.508	0.81	12.07
03/28/20 07:00:00 PM	18.069	82.508	0.82	12.06
03/28/20 08:00:00 PM	18.059	82.508	0.82	12.06

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/28/20 09:00:00 PM	18.079	82.508	0.81	12.07
03/28/20 10:00:00 PM	18.074	82.508	0.81	12.07
03/28/20 11:00:00 PM	18.074	82.508	0.81	12.07
03/29/20 12:00:00 AM	18.064	82.508	0.82	12.06
03/29/20 01:00:00 AM	18.054	82.508	0.83	12.05
03/29/20 02:00:00 AM	18.049	82.508	0.83	12.05
03/29/20 03:00:00 AM	18.039	82.508	0.84	12.04
03/29/20 04:00:00 AM	18.034	82.508	0.84	12.04
03/29/20 05:00:00 AM	18.024	82.508	0.85	12.03
03/29/20 06:00:00 AM	18.014	82.508	0.86	12.02
03/29/20 07:00:00 AM	18.009	82.508	0.86	12.02
03/29/20 08:00:00 AM	18.004	82.508	0.86	12.02
03/29/20 09:00:00 AM	17.999	82.508	0.87	12.01
03/29/20 10:00:00 AM	17.989	82.508	0.87	12.01
03/29/20 11:00:00 AM	17.978	82.508	0.88	12.00
03/29/20 12:00:00 PM	17.968	82.508	0.89	11.99
03/29/20 01:00:00 PM	17.953	82.508	0.90	11.98
03/29/20 02:00:00 PM	17.933	82.508	0.91	11.97
03/29/20 03:00:00 PM	17.913	82.508	0.93	11.95
03/29/20 04:00:00 PM	17.893	82.508	0.94	11.94
03/29/20 05:00:00 PM	17.878	82.508	0.95	11.93
03/29/20 06:00:00 PM	17.868	82.508	0.96	11.92
03/29/20 07:00:00 PM	17.862	82.508	0.96	11.92
03/29/20 08:00:00 PM	17.857	82.508	0.97	11.91
03/29/20 09:00:00 PM	17.857	82.508	0.97	11.91
03/29/20 10:00:00 PM	17.857	82.508	0.97	11.91
03/29/20 11:00:00 PM	17.857	82.508	0.97	11.91
03/30/20 12:00:00 AM	17.852	82.508	0.97	11.91
03/30/20 01:00:00 AM	17.847	82.508	0.97	11.91
03/30/20 02:00:00 AM	17.837	82.508	0.98	11.90
03/30/20 03:00:00 AM	17.832	82.508	0.98	11.90
03/30/20 04:00:00 AM	17.827	82.508	0.99	11.89
03/30/20 05:00:00 AM	17.822	82.508	0.99	11.89
03/30/20 06:00:00 AM	17.822	82.508	0.99	11.89
03/30/20 07:00:00 AM	17.817	82.508	0.99	11.89
03/30/20 08:00:00 AM	17.812	82.508	1.00	11.88
03/30/20 09:00:00 AM	17.812	82.508	1.00	11.88
03/30/20 10:00:00 AM	17.812	82.508	1.00	11.88
03/30/20 11:00:00 AM	17.812	82.508	1.00	11.88
03/30/20 12:00:00 PM	17.792	82.508	1.01	11.87
03/30/20 01:00:00 PM	17.782	82.508	1.02	11.86

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/30/20 02:00:00 PM	17.772	82.508	1.03	11.85
03/30/20 03:00:00 PM	17.757	82.508	1.04	11.84
03/30/20 04:00:00 PM	17.747	82.508	1.04	11.84
03/30/20 05:00:00 PM	17.736	82.508	1.05	11.83
03/30/20 06:00:00 PM	17.731	82.508	1.05	11.83
03/30/20 07:00:00 PM	17.726	82.508	1.06	11.82
03/30/20 08:00:00 PM	17.721	82.508	1.06	11.82
03/30/20 09:00:00 PM	17.721	82.508	1.06	11.82
03/30/20 10:00:00 PM	17.721	82.508	1.06	11.82
03/30/20 11:00:00 PM	17.726	82.508	1.06	11.82
03/31/20 12:00:00 AM	17.726	82.508	1.06	11.82
03/31/20 01:00:00 AM	17.716	82.508	1.07	11.81
03/31/20 02:00:00 AM	17.711	82.508	1.07	11.81
03/31/20 03:00:00 AM	17.706	82.508	1.07	11.81
03/31/20 04:00:00 AM	17.701	82.508	1.08	11.80
03/31/20 05:00:00 AM	17.696	82.508	1.08	11.80
03/31/20 06:00:00 AM	17.696	82.508	1.08	11.80
03/31/20 07:00:00 AM	17.696	82.508	1.08	11.80
03/31/20 08:00:00 AM	17.701	82.508	1.08	11.80
03/31/20 09:00:00 AM	17.701	82.508	1.08	11.80
03/31/20 10:00:00 AM	17.696	82.508	1.08	11.80
03/31/20 11:00:00 AM	17.696	82.508	1.08	11.80
03/31/20 12:00:00 PM	17.686	82.508	1.09	11.79
03/31/20 01:00:00 PM	17.671	82.508	1.10	11.78
03/31/20 02:00:00 PM	17.661	82.508	1.10	11.78
03/31/20 03:00:00 PM	17.646	82.508	1.11	11.77
03/31/20 04:00:00 PM	17.646	82.508	1.11	11.77
03/31/20 05:00:00 PM	17.626	82.508	1.13	11.75
03/31/20 06:00:00 PM	17.626	82.508	1.13	11.75
03/31/20 07:00:00 PM	17.631	82.508	1.13	11.75
03/31/20 08:00:00 PM	17.626	82.508	1.13	11.75
03/31/20 09:00:00 PM	17.626	82.508	1.13	11.75
03/31/20 10:00:00 PM	17.631	82.508	1.13	11.75
03/31/20 11:00:00 PM	17.631	82.508	1.13	11.75
4/1/2020 12:00:00 AM	17.626	82.508	1.13	11.75
4/1/2020 1:00:00 AM	17.621	82.508	1.13	11.75
4/1/2020 2:00:00 AM	17.615	82.508	1.14	11.74
4/1/2020 3:00:00 AM	17.610	82.508	1.14	11.74
4/1/2020 4:00:00 AM	17.605	82.508	1.14	11.74
4/1/2020 5:00:00 AM	17.600	82.508	1.15	11.73
4/1/2020 6:00:00 AM	17.605	82.508	1.14	11.74

WATER STANDPIPE MONITORING

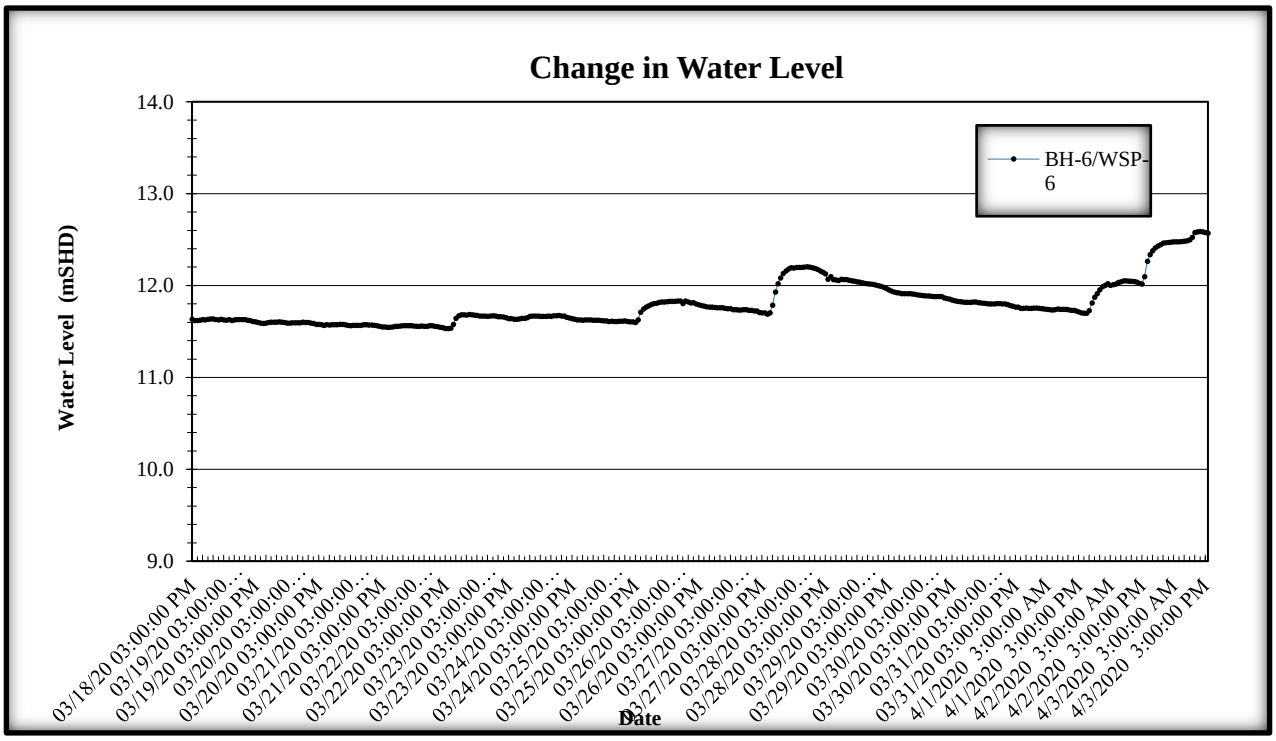
Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/1/2020 7:00:00 AM	17.615	82.508	1.14	11.74
4/1/2020 8:00:00 AM	17.610	82.508	1.14	11.74
4/1/2020 9:00:00 AM	17.610	82.508	1.14	11.74
4/1/2020 10:00:00 AM	17.610	82.508	1.14	11.74
4/1/2020 11:00:00 AM	17.605	82.508	1.14	11.74
4/1/2020 12:00:00 PM	17.595	82.508	1.15	11.73
4/1/2020 1:00:00 PM	17.595	82.508	1.15	11.73
4/1/2020 2:00:00 PM	17.585	82.508	1.16	11.72
4/1/2020 3:00:00 PM	17.575	82.508	1.16	11.72
4/1/2020 4:00:00 PM	17.560	82.508	1.18	11.70
4/1/2020 5:00:00 PM	17.555	82.508	1.18	11.70
4/1/2020 6:00:00 PM	17.555	82.508	1.18	11.70
4/1/2020 7:00:00 PM	17.590	82.508	1.15	11.73
4/1/2020 8:00:00 PM	17.711	82.508	1.07	11.81
4/1/2020 9:00:00 PM	17.802	82.508	1.00	11.88
4/1/2020 10:00:00 PM	17.857	82.508	0.97	11.91
4/1/2020 11:00:00 PM	17.913	82.508	0.93	11.95
4/2/2020 12:00:00 AM	17.963	82.508	0.89	11.99
4/2/2020 1:00:00 AM	17.983	82.508	0.88	12.00
4/2/2020 2:00:00 AM	18.009	82.508	0.86	12.02
4/2/2020 3:00:00 AM	17.983	82.508	0.88	12.00
4/2/2020 4:00:00 AM	17.994	82.508	0.87	12.01
4/2/2020 5:00:00 AM	18.004	82.508	0.86	12.02
4/2/2020 6:00:00 AM	18.029	82.508	0.85	12.03
4/2/2020 7:00:00 AM	18.039	82.508	0.84	12.04
4/2/2020 8:00:00 AM	18.054	82.508	0.83	12.05
4/2/2020 9:00:00 AM	18.054	82.508	0.83	12.05
4/2/2020 10:00:00 AM	18.049	82.508	0.83	12.05
4/2/2020 11:00:00 AM	18.049	82.508	0.83	12.05
4/2/2020 12:00:00 PM	18.044	82.508	0.83	12.05
4/2/2020 1:00:00 PM	18.034	82.508	0.84	12.04
4/2/2020 2:00:00 PM	18.014	82.508	0.86	12.02
4/2/2020 3:00:00 PM	18.004	82.508	0.86	12.02
4/2/2020 4:00:00 PM	18.119	82.508	0.78	12.10
4/2/2020 5:00:00 PM	18.356	82.508	0.61	12.27
4/2/2020 6:00:00 PM	18.457	82.508	0.54	12.34
4/2/2020 7:00:00 PM	18.518	82.508	0.50	12.38
4/2/2020 8:00:00 PM	18.563	82.508	0.47	12.41
4/2/2020 9:00:00 PM	18.593	82.508	0.45	12.43
4/2/2020 10:00:00 PM	18.613	82.508	0.43	12.45
4/2/2020 11:00:00 PM	18.639	82.508	0.42	12.46

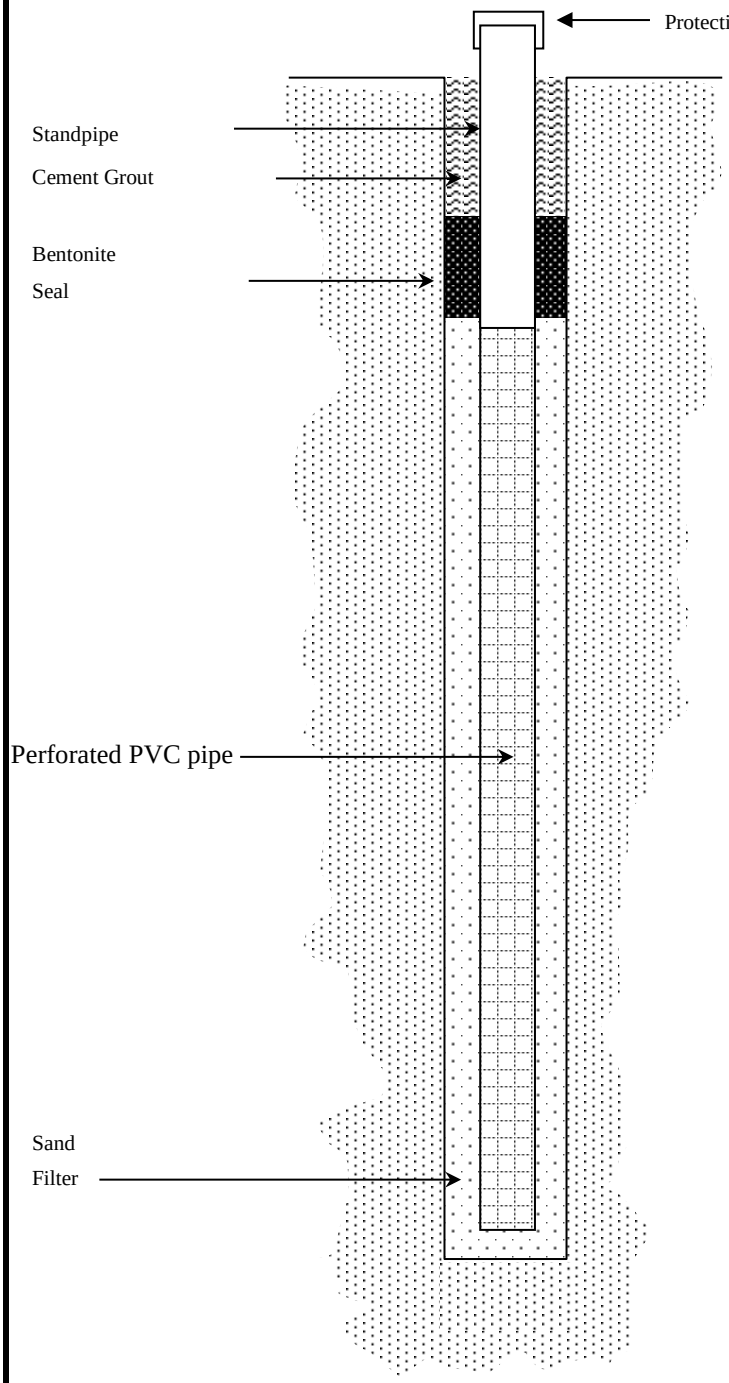
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-6/WSP-6**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	3.45
Location:	Tengah	**Pipe Top Level (mSHD)**	13.730
		Ground Level (mSHD)	12.880

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/3/2020 12:00:00 AM	18.644	82.508	0.41	12.47
4/3/2020 1:00:00 AM	18.649	82.508	0.41	12.47
4/3/2020 2:00:00 AM	18.654	82.508	0.41	12.47
4/3/2020 3:00:00 AM	18.659	82.508	0.40	12.48
4/3/2020 4:00:00 AM	18.659	82.508	0.40	12.48
4/3/2020 5:00:00 AM	18.659	82.508	0.40	12.48
4/3/2020 6:00:00 AM	18.664	82.508	0.40	12.48
4/3/2020 7:00:00 AM	18.669	82.508	0.39	12.49
4/3/2020 8:00:00 AM	18.674	82.508	0.39	12.49
4/3/2020 9:00:00 AM	18.689	82.508	0.38	12.50
4/3/2020 10:00:00 AM	18.724	82.508	0.36	12.52
4/3/2020 11:00:00 AM	18.800	82.508	0.30	12.58
4/3/2020 12:00:00 PM	18.810	82.508	0.30	12.58
4/3/2020 1:00:00 PM	18.815	82.508	0.29	12.59
4/3/2020 2:00:00 PM	18.810	82.508	0.30	12.58
4/3/2020 3:00:00 PM	18.800	82.508	0.30	12.58
4/3/2020 4:00:00 PM	18.790	82.508	0.31	12.57



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	3 Mar 2020	**INSTALLED BY:** Helal



Depth (GL-m)	0.00
	2.50
	3.00
	8.50

REMARKS:

INSTALLED IN BH07/WSP-07

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/17/20 06:00:00 PM	16.422	80.911	4.47	14.19
03/17/20 07:00:00 PM	16.436	80.911	4.47	14.19
03/17/20 08:00:00 PM	16.444	80.735	4.46	14.20
03/17/20 09:00:00 PM	16.453	80.735	4.45	14.21
03/17/20 10:00:00 PM	16.457	80.735	4.45	14.21
03/17/20 11:00:00 PM	16.468	80.911	4.44	14.22
03/18/20 12:00:00 AM	16.466	80.735	4.44	14.22
03/18/20 01:00:00 AM	16.457	80.735	4.45	14.21
03/18/20 02:00:00 AM	16.448	80.735	4.46	14.20
03/18/20 03:00:00 AM	16.434	80.735	4.47	14.19
03/18/20 04:00:00 AM	16.431	80.911	4.47	14.19
03/18/20 05:00:00 AM	16.434	80.735	4.47	14.19
03/18/20 06:00:00 AM	16.430	80.735	4.47	14.19
03/18/20 07:00:00 AM	16.431	80.911	4.47	14.19
03/18/20 08:00:00 AM	16.444	80.735	4.46	14.20
03/18/20 09:00:00 AM	16.457	80.735	4.45	14.21
03/18/20 10:00:00 AM	16.457	80.735	4.45	14.21
03/18/20 11:00:00 AM	16.462	80.735	4.45	14.21
03/18/20 12:00:00 PM	16.453	80.735	4.45	14.21
03/18/20 01:00:00 PM	16.448	80.735	4.46	14.20
03/18/20 02:00:00 PM	16.434	80.735	4.47	14.19
03/18/20 03:00:00 PM	16.420	80.735	4.48	14.18
03/18/20 04:00:00 PM	16.407	80.735	4.49	14.17
03/18/20 05:00:00 PM	16.407	80.735	4.49	14.17
03/18/20 06:00:00 PM	16.411	80.735	4.48	14.18
03/18/20 07:00:00 PM	16.439	80.735	4.46	14.20
03/18/20 08:00:00 PM	16.439	80.735	4.46	14.20
03/18/20 09:00:00 PM	16.457	80.735	4.45	14.21
03/18/20 10:00:00 PM	16.466	80.735	4.44	14.22
03/18/20 11:00:00 PM	16.471	80.735	4.44	14.22
03/19/20 12:00:00 AM	16.466	80.735	4.44	14.22
03/19/20 01:00:00 AM	16.453	80.735	4.45	14.21
03/19/20 02:00:00 AM	16.453	80.735	4.45	14.21
03/19/20 03:00:00 AM	16.448	80.735	4.46	14.20
03/19/20 04:00:00 AM	16.439	80.735	4.46	14.20
03/19/20 05:00:00 AM	16.439	80.735	4.46	14.20
03/19/20 06:00:00 AM	16.434	80.735	4.47	14.19
03/19/20 07:00:00 AM	16.444	80.735	4.46	14.20
03/19/20 08:00:00 AM	16.457	80.735	4.45	14.21
03/19/20 09:00:00 AM	16.466	80.735	4.44	14.22
03/19/20 10:00:00 AM	16.466	80.735	4.44	14.22
03/19/20 11:00:00 AM	16.476	80.735	4.44	14.22

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 12:00:00 PM	16.466	80.735	4.44	14.22

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 01:00:00 PM	16.457	80.735	4.45	14.21
03/19/20 02:00:00 PM	16.439	80.735	4.46	14.20
03/19/20 03:00:00 PM	16.434	80.735	4.47	14.19
03/19/20 04:00:00 PM	16.417	80.911	4.48	14.18
03/19/20 05:00:00 PM	16.411	80.735	4.48	14.18
03/19/20 06:00:00 PM	16.411	80.735	4.48	14.18
03/19/20 07:00:00 PM	16.420	80.735	4.48	14.18
03/19/20 08:00:00 PM	16.439	80.735	4.46	14.20
03/19/20 09:00:00 PM	16.444	80.735	4.46	14.20
03/19/20 10:00:00 PM	16.462	80.735	4.45	14.21
03/19/20 11:00:00 PM	16.466	80.735	4.44	14.22
03/20/20 12:00:00 AM	16.476	80.735	4.44	14.22
03/20/20 01:00:00 AM	16.466	80.735	4.44	14.22
03/20/20 02:00:00 AM	16.457	80.735	4.45	14.21
03/20/20 03:00:00 AM	16.448	80.735	4.46	14.20
03/20/20 04:00:00 AM	16.439	80.735	4.46	14.20
03/20/20 05:00:00 AM	16.434	80.735	4.47	14.19
03/20/20 06:00:00 AM	16.444	80.735	4.46	14.20
03/20/20 07:00:00 AM	16.450	80.911	4.46	14.20
03/20/20 08:00:00 AM	16.459	80.911	4.45	14.21
03/20/20 09:00:00 AM	16.466	80.735	4.44	14.22
03/20/20 10:00:00 AM	16.476	80.735	4.44	14.22
03/20/20 11:00:00 AM	16.471	80.735	4.44	14.22
03/20/20 12:00:00 PM	16.466	80.735	4.44	14.22
03/20/20 01:00:00 PM	16.453	80.735	4.45	14.21
03/20/20 02:00:00 PM	16.439	80.735	4.46	14.20
03/20/20 03:00:00 PM	16.430	80.735	4.47	14.19
03/20/20 04:00:00 PM	16.417	80.911	4.48	14.18
03/20/20 05:00:00 PM	16.416	80.735	4.48	14.18
03/20/20 06:00:00 PM	16.420	80.735	4.48	14.18
03/20/20 07:00:00 PM	16.430	80.735	4.47	14.19
03/20/20 08:00:00 PM	16.444	80.735	4.46	14.20
03/20/20 09:00:00 PM	16.453	80.735	4.45	14.21
03/20/20 10:00:00 PM	16.457	80.735	4.45	14.21
03/20/20 11:00:00 PM	16.466	80.735	4.44	14.22
03/21/20 12:00:00 AM	16.466	80.735	4.44	14.22
03/21/20 01:00:00 AM	16.453	80.735	4.45	14.21
03/21/20 02:00:00 AM	16.444	80.735	4.46	14.20
03/21/20 03:00:00 AM	16.434	80.735	4.47	14.19
03/21/20 04:00:00 AM	16.430	80.735	4.47	14.19
03/21/20 05:00:00 AM	16.434	80.735	4.47	14.19

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/21/20 06:00:00 AM	16.434	80.735	4.47	14.19
03/21/20 07:00:00 AM	16.444	80.735	4.46	14.20
03/21/20 08:00:00 AM	16.457	80.735	4.45	14.21
03/21/20 09:00:00 AM	16.462	80.735	4.45	14.21
03/21/20 10:00:00 AM	16.466	80.735	4.44	14.22
03/21/20 11:00:00 AM	16.466	80.735	4.44	14.22
03/21/20 12:00:00 PM	16.453	80.735	4.45	14.21
03/21/20 01:00:00 PM	16.439	80.735	4.46	14.20
03/21/20 02:00:00 PM	16.430	80.735	4.47	14.19
03/21/20 03:00:00 PM	16.420	80.735	4.48	14.18
03/21/20 04:00:00 PM	16.425	80.735	4.47	14.19
03/21/20 05:00:00 PM	16.420	80.735	4.48	14.18
03/21/20 06:00:00 PM	16.420	80.735	4.48	14.18
03/21/20 07:00:00 PM	16.434	80.735	4.47	14.19
03/21/20 08:00:00 PM	16.439	80.735	4.46	14.20
03/21/20 09:00:00 PM	16.453	80.735	4.45	14.21
03/21/20 10:00:00 PM	16.457	80.735	4.45	14.21
03/21/20 11:00:00 PM	16.462	80.735	4.45	14.21
03/22/20 12:00:00 AM	16.471	80.735	4.44	14.22
03/22/20 01:00:00 AM	16.462	80.735	4.45	14.21
03/22/20 02:00:00 AM	16.453	80.735	4.45	14.21
03/22/20 03:00:00 AM	16.444	80.735	4.46	14.20
03/22/20 04:00:00 AM	16.439	80.735	4.46	14.20
03/22/20 05:00:00 AM	16.439	80.735	4.46	14.20
03/22/20 06:00:00 AM	16.444	80.735	4.46	14.20
03/22/20 07:00:00 AM	16.448	80.735	4.46	14.20
03/22/20 08:00:00 AM	16.453	80.735	4.45	14.21
03/22/20 09:00:00 AM	16.466	80.735	4.44	14.22
03/22/20 10:00:00 AM	16.480	80.735	4.43	14.23
03/22/20 11:00:00 AM	16.471	80.735	4.44	14.22
03/22/20 12:00:00 PM	16.462	80.735	4.45	14.21
03/22/20 01:00:00 PM	16.453	80.735	4.45	14.21
03/22/20 02:00:00 PM	16.439	80.735	4.46	14.20
03/22/20 03:00:00 PM	16.416	80.735	4.48	14.18
03/22/20 04:00:00 PM	16.430	80.735	4.47	14.19
03/22/20 05:00:00 PM	16.430	80.735	4.47	14.19
03/22/20 06:00:00 PM	16.444	80.735	4.46	14.20
03/22/20 07:00:00 PM	16.444	80.735	4.46	14.20
03/22/20 08:00:00 PM	16.476	80.735	4.44	14.22
03/22/20 09:00:00 PM	16.508	80.735	4.41	14.25
03/22/20 10:00:00 PM	16.517	80.735	4.41	14.25

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 11:00:00 PM	16.535	80.735	4.40	14.26
03/23/20 12:00:00 AM	16.541	80.911	4.39	14.27
03/23/20 01:00:00 AM	16.545	80.735	4.39	14.27
03/23/20 02:00:00 AM	16.526	80.735	4.40	14.26
03/23/20 03:00:00 AM	16.512	80.735	4.41	14.25
03/23/20 04:00:00 AM	16.499	80.735	4.42	14.24
03/23/20 05:00:00 AM	16.499	80.735	4.42	14.24
03/23/20 06:00:00 AM	16.503	80.735	4.42	14.24
03/23/20 07:00:00 AM	16.503	80.735	4.42	14.24
03/23/20 08:00:00 AM	16.517	80.735	4.41	14.25
03/23/20 09:00:00 AM	16.526	80.735	4.40	14.26
03/23/20 10:00:00 AM	16.535	80.735	4.40	14.26
03/23/20 11:00:00 AM	16.526	80.735	4.40	14.26
03/23/20 12:00:00 PM	16.517	80.735	4.41	14.25
03/23/20 01:00:00 PM	16.512	80.735	4.41	14.25
03/23/20 02:00:00 PM	16.503	80.735	4.42	14.24
03/23/20 03:00:00 PM	16.490	80.735	4.43	14.23
03/23/20 04:00:00 PM	16.485	80.735	4.43	14.23
03/23/20 05:00:00 PM	16.490	80.735	4.43	14.23
03/23/20 06:00:00 PM	16.494	80.735	4.42	14.24
03/23/20 07:00:00 PM	16.499	80.735	4.42	14.24
03/23/20 08:00:00 PM	16.503	80.735	4.42	14.24
03/23/20 09:00:00 PM	16.503	80.735	4.42	14.24
03/23/20 10:00:00 PM	16.503	80.735	4.42	14.24
03/23/20 11:00:00 PM	16.512	80.735	4.41	14.25
03/24/20 12:00:00 AM	16.526	80.735	4.40	14.26
03/24/20 01:00:00 AM	16.532	80.911	4.40	14.26
03/24/20 02:00:00 AM	16.531	80.735	4.40	14.26
03/24/20 03:00:00 AM	16.526	80.735	4.40	14.26
03/24/20 04:00:00 AM	16.522	80.735	4.40	14.26
03/24/20 05:00:00 AM	16.517	80.735	4.41	14.25
03/24/20 06:00:00 AM	16.517	80.735	4.41	14.25
03/24/20 07:00:00 AM	16.517	80.735	4.41	14.25
03/24/20 08:00:00 AM	16.522	80.735	4.40	14.26
03/24/20 09:00:00 AM	16.526	80.735	4.40	14.26
03/24/20 10:00:00 AM	16.531	80.735	4.40	14.26
03/24/20 11:00:00 AM	16.531	80.735	4.40	14.26
03/24/20 12:00:00 PM	16.522	80.735	4.40	14.26
03/24/20 01:00:00 PM	16.512	80.735	4.41	14.25
03/24/20 02:00:00 PM	16.495	80.911	4.42	14.24
03/24/20 03:00:00 PM	16.480	80.735	4.43	14.23

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/24/20 04:00:00 PM	16.471	80.735	4.44	14.22
03/24/20 05:00:00 PM	16.471	80.735	4.44	14.22
03/24/20 06:00:00 PM	16.476	80.735	4.44	14.22
03/24/20 07:00:00 PM	16.485	80.735	4.43	14.23
03/24/20 08:00:00 PM	16.503	80.735	4.42	14.24
03/24/20 09:00:00 PM	16.503	80.735	4.42	14.24
03/24/20 10:00:00 PM	16.508	80.735	4.41	14.25
03/24/20 11:00:00 PM	16.517	80.735	4.41	14.25
03/25/20 12:00:00 AM	16.517	80.735	4.41	14.25
03/25/20 01:00:00 AM	16.512	80.735	4.41	14.25
03/25/20 02:00:00 AM	16.512	80.735	4.41	14.25
03/25/20 03:00:00 AM	16.499	80.735	4.42	14.24
03/25/20 04:00:00 AM	16.494	80.735	4.42	14.24
03/25/20 05:00:00 AM	16.490	80.735	4.43	14.23
03/25/20 06:00:00 AM	16.494	80.735	4.42	14.24
03/25/20 07:00:00 AM	16.495	80.911	4.42	14.24
03/25/20 08:00:00 AM	16.494	80.735	4.42	14.24
03/25/20 09:00:00 AM	16.499	80.735	4.42	14.24
03/25/20 10:00:00 AM	16.508	80.735	4.41	14.25
03/25/20 11:00:00 AM	16.517	80.735	4.41	14.25
03/25/20 12:00:00 PM	16.503	80.735	4.42	14.24
03/25/20 01:00:00 PM	16.494	80.735	4.42	14.24
03/25/20 02:00:00 PM	16.499	80.735	4.42	14.24
03/25/20 03:00:00 PM	16.480	80.735	4.43	14.23
03/25/20 04:00:00 PM	16.463	80.911	4.45	14.21
03/25/20 05:00:00 PM	16.453	80.735	4.45	14.21
03/25/20 06:00:00 PM	16.480	80.735	4.43	14.23
03/25/20 07:00:00 PM	16.503	80.735	4.42	14.24
03/25/20 08:00:00 PM	16.522	80.735	4.40	14.26
03/25/20 09:00:00 PM	16.540	80.735	4.39	14.27
03/25/20 10:00:00 PM	16.554	80.735	4.38	14.28
03/25/20 11:00:00 PM	16.563	80.735	4.38	14.28
03/26/20 12:00:00 AM	16.568	80.735	4.37	14.29
03/26/20 01:00:00 AM	16.558	80.735	4.38	14.28
03/26/20 02:00:00 AM	16.549	80.735	4.39	14.27
03/26/20 03:00:00 AM	16.540	80.735	4.39	14.27
03/26/20 04:00:00 AM	16.540	80.735	4.39	14.27
03/26/20 05:00:00 AM	16.535	80.735	4.40	14.26
03/26/20 06:00:00 AM	16.535	80.735	4.40	14.26
03/26/20 07:00:00 AM	16.535	80.735	4.40	14.26
03/26/20 08:00:00 AM	16.545	80.735	4.39	14.27

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/26/20 09:00:00 AM	16.549	80.735	4.39	14.27
03/26/20 10:00:00 AM	16.558	80.735	4.38	14.28
03/26/20 11:00:00 AM	16.554	80.735	4.38	14.28
03/26/20 12:00:00 PM	16.554	80.735	4.38	14.28
03/26/20 01:00:00 PM	16.545	80.735	4.39	14.27
03/26/20 02:00:00 PM	16.531	80.735	4.40	14.26
03/26/20 03:00:00 PM	16.517	80.735	4.41	14.25
03/26/20 04:00:00 PM	16.503	80.735	4.42	14.24
03/26/20 05:00:00 PM	16.499	80.735	4.42	14.24
03/26/20 06:00:00 PM	16.499	80.735	4.42	14.24
03/26/20 07:00:00 PM	16.503	80.735	4.42	14.24
03/26/20 08:00:00 PM	16.517	80.735	4.41	14.25
03/26/20 09:00:00 PM	16.522	80.735	4.40	14.26
03/26/20 10:00:00 PM	16.526	80.735	4.40	14.26
03/26/20 11:00:00 PM	16.535	80.735	4.40	14.26
03/27/20 12:00:00 AM	16.545	80.735	4.39	14.27
03/27/20 01:00:00 AM	16.545	80.735	4.39	14.27
03/27/20 02:00:00 AM	16.535	80.735	4.40	14.26
03/27/20 03:00:00 AM	16.526	80.735	4.40	14.26
03/27/20 04:00:00 AM	16.522	80.735	4.40	14.26
03/27/20 05:00:00 AM	16.517	80.735	4.41	14.25
03/27/20 06:00:00 AM	16.517	80.735	4.41	14.25
03/27/20 07:00:00 AM	16.526	80.735	4.40	14.26
03/27/20 08:00:00 AM	16.531	80.735	4.40	14.26
03/27/20 09:00:00 AM	16.531	80.735	4.40	14.26
03/27/20 10:00:00 AM	16.535	80.735	4.40	14.26
03/27/20 11:00:00 AM	16.540	80.735	4.39	14.27
03/27/20 12:00:00 PM	16.540	80.735	4.39	14.27
03/27/20 01:00:00 PM	16.526	80.735	4.40	14.26
03/27/20 02:00:00 PM	16.508	80.735	4.41	14.25
03/27/20 03:00:00 PM	16.494	80.735	4.42	14.24
03/27/20 04:00:00 PM	16.499	80.735	4.42	14.24
03/27/20 05:00:00 PM	16.490	80.735	4.43	14.23
03/27/20 06:00:00 PM	16.490	80.735	4.43	14.23
03/27/20 07:00:00 PM	16.494	80.735	4.42	14.24
03/27/20 08:00:00 PM	16.503	80.735	4.42	14.24
03/27/20 09:00:00 PM	16.512	80.735	4.41	14.25
03/27/20 10:00:00 PM	16.546	80.911	4.39	14.27
03/27/20 11:00:00 PM	16.583	80.911	4.36	14.30
03/28/20 12:00:00 AM	16.581	80.735	4.36	14.30
03/28/20 01:00:00 AM	16.595	80.735	4.35	14.31

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/28/20 02:00:00 AM	16.586	80.735	4.36	14.30
03/28/20 03:00:00 AM	16.572	80.735	4.37	14.29
03/28/20 04:00:00 AM	16.572	80.735	4.37	14.29
03/28/20 05:00:00 AM	16.568	80.735	4.37	14.29
03/28/20 06:00:00 AM	16.563	80.735	4.38	14.28
03/28/20 07:00:00 AM	16.577	80.735	4.37	14.29
03/28/20 08:00:00 AM	16.581	80.735	4.36	14.30
03/28/20 09:00:00 AM	16.590	80.735	4.36	14.30
03/28/20 10:00:00 AM	16.590	80.735	4.36	14.30
03/28/20 11:00:00 AM	16.581	80.735	4.36	14.30
03/28/20 12:00:00 PM	16.577	80.735	4.37	14.29
03/28/20 01:00:00 PM	16.568	80.735	4.37	14.29
03/28/20 02:00:00 PM	16.554	80.735	4.38	14.28
03/28/20 03:00:00 PM	16.531	80.735	4.40	14.26
03/28/20 04:00:00 PM	16.522	80.735	4.40	14.26
03/28/20 05:00:00 PM	16.512	80.735	4.41	14.25
03/28/20 06:00:00 PM	16.512	80.735	4.41	14.25
03/28/20 07:00:00 PM	16.512	80.735	4.41	14.25
03/28/20 08:00:00 PM	16.526	80.735	4.40	14.26
03/28/20 09:00:00 PM	16.531	80.735	4.40	14.26
03/28/20 10:00:00 PM	16.545	80.735	4.39	14.27
03/28/20 11:00:00 PM	16.554	80.735	4.38	14.28
03/29/20 12:00:00 AM	16.558	80.735	4.38	14.28
03/29/20 01:00:00 AM	16.555	80.911	4.38	14.28
03/29/20 02:00:00 AM	16.545	80.735	4.39	14.27
03/29/20 03:00:00 AM	16.535	80.735	4.40	14.26
03/29/20 04:00:00 AM	16.526	80.735	4.40	14.26
03/29/20 05:00:00 AM	16.512	80.735	4.41	14.25
03/29/20 06:00:00 AM	16.522	80.735	4.40	14.26
03/29/20 07:00:00 AM	16.526	80.735	4.40	14.26
03/29/20 08:00:00 AM	16.532	80.911	4.40	14.26
03/29/20 09:00:00 AM	16.540	80.735	4.39	14.27
03/29/20 10:00:00 AM	16.541	80.911	4.39	14.27
03/29/20 11:00:00 AM	16.541	80.911	4.39	14.27
03/29/20 12:00:00 PM	16.537	80.911	4.39	14.27
03/29/20 01:00:00 PM	16.519	80.911	4.41	14.25
03/29/20 02:00:00 PM	16.500	80.911	4.42	14.24
03/29/20 03:00:00 PM	16.490	80.735	4.43	14.23
03/29/20 04:00:00 PM	16.480	80.735	4.43	14.23
03/29/20 05:00:00 PM	16.480	80.735	4.43	14.23
03/29/20 06:00:00 PM	16.471	80.735	4.44	14.22

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 07:00:00 PM	16.480	80.735	4.43	14.23
03/29/20 08:00:00 PM	16.494	80.735	4.42	14.24
03/29/20 09:00:00 PM	16.514	80.911	4.41	14.25
03/29/20 10:00:00 PM	16.531	80.735	4.40	14.26
03/29/20 11:00:00 PM	16.545	80.735	4.39	14.27
03/30/20 12:00:00 AM	16.549	80.735	4.39	14.27
03/30/20 01:00:00 AM	16.540	80.735	4.39	14.27
03/30/20 02:00:00 AM	16.541	80.911	4.39	14.27
03/30/20 03:00:00 AM	16.523	80.911	4.40	14.26
03/30/20 04:00:00 AM	16.523	80.911	4.40	14.26
03/30/20 05:00:00 AM	16.528	80.911	4.40	14.26
03/30/20 06:00:00 AM	16.517	80.735	4.41	14.25
03/30/20 07:00:00 AM	16.522	80.735	4.40	14.26
03/30/20 08:00:00 AM	16.540	80.735	4.39	14.27
03/30/20 09:00:00 AM	16.549	80.735	4.39	14.27
03/30/20 10:00:00 AM	16.558	80.735	4.38	14.28
03/30/20 11:00:00 AM	16.554	80.735	4.38	14.28
03/30/20 12:00:00 PM	16.535	80.735	4.40	14.26
03/30/20 01:00:00 PM	16.532	80.911	4.40	14.26
03/30/20 02:00:00 PM	16.517	80.735	4.41	14.25
03/30/20 03:00:00 PM	16.512	80.735	4.41	14.25
03/30/20 04:00:00 PM	16.499	80.735	4.42	14.24
03/30/20 05:00:00 PM	16.495	80.911	4.42	14.24
03/30/20 06:00:00 PM	16.494	80.735	4.42	14.24
03/30/20 07:00:00 PM	16.512	80.735	4.41	14.25
03/30/20 08:00:00 PM	16.526	80.735	4.40	14.26
03/30/20 09:00:00 PM	16.535	80.735	4.40	14.26
03/30/20 10:00:00 PM	16.545	80.735	4.39	14.27
03/30/20 11:00:00 PM	16.551	80.911	4.38	14.28
03/31/20 12:00:00 AM	16.560	80.911	4.38	14.28
03/31/20 01:00:00 AM	16.555	80.911	4.38	14.28
03/31/20 02:00:00 AM	16.545	80.735	4.39	14.27
03/31/20 03:00:00 AM	16.545	80.735	4.39	14.27
03/31/20 04:00:00 AM	16.535	80.735	4.40	14.26
03/31/20 05:00:00 AM	16.535	80.735	4.40	14.26
03/31/20 06:00:00 AM	16.531	80.735	4.40	14.26
03/31/20 07:00:00 AM	16.531	80.735	4.40	14.26
03/31/20 08:00:00 AM	16.549	80.735	4.39	14.27
03/31/20 09:00:00 AM	16.563	80.735	4.38	14.28
03/31/20 10:00:00 AM	16.558	80.735	4.38	14.28
03/31/20 11:00:00 AM	16.558	80.735	4.38	14.28

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/31/20 12:00:00 PM	16.554	80.735	4.38	14.28
03/31/20 01:00:00 PM	16.545	80.735	4.39	14.27
03/31/20 02:00:00 PM	16.535	80.735	4.40	14.26
03/31/20 03:00:00 PM	16.517	80.735	4.41	14.25
03/31/20 04:00:00 PM	16.509	80.911	4.41	14.25
03/31/20 05:00:00 PM	16.505	80.911	4.42	14.24
03/31/20 06:00:00 PM	16.512	80.735	4.41	14.25
03/31/20 07:00:00 PM	16.519	80.911	4.41	14.25
03/31/20 08:00:00 PM	16.531	80.735	4.40	14.26
03/31/20 09:00:00 PM	16.545	80.735	4.39	14.27
03/31/20 10:00:00 PM	16.549	80.735	4.39	14.27
03/31/20 11:00:00 PM	16.563	80.735	4.38	14.28
4/1/2020 12:00:00 AM	16.558	80.735	4.38	14.28
4/1/2020 1:00:00 AM	16.560	80.911	4.38	14.28
4/1/2020 2:00:00 AM	16.551	80.911	4.38	14.28
4/1/2020 3:00:00 AM	16.537	80.911	4.39	14.27
4/1/2020 4:00:00 AM	16.535	80.735	4.40	14.26
4/1/2020 5:00:00 AM	16.531	80.735	4.40	14.26
4/1/2020 6:00:00 AM	16.545	80.735	4.39	14.27
4/1/2020 7:00:00 AM	16.554	80.735	4.38	14.28
4/1/2020 8:00:00 AM	16.563	80.735	4.38	14.28
4/1/2020 9:00:00 AM	16.563	80.735	4.38	14.28
4/1/2020 10:00:00 AM	16.563	80.735	4.38	14.28
4/1/2020 11:00:00 AM	16.568	80.735	4.37	14.29
4/1/2020 12:00:00 PM	16.549	80.735	4.39	14.27
4/1/2020 1:00:00 PM	16.540	80.735	4.39	14.27
4/1/2020 2:00:00 PM	16.531	80.735	4.40	14.26
4/1/2020 3:00:00 PM	16.517	80.735	4.41	14.25
4/1/2020 4:00:00 PM	16.508	80.735	4.41	14.25
4/1/2020 5:00:00 PM	16.503	80.735	4.42	14.24
4/1/2020 6:00:00 PM	16.508	80.735	4.41	14.25
4/1/2020 7:00:00 PM	16.517	80.735	4.41	14.25
4/1/2020 8:00:00 PM	16.537	80.911	4.39	14.27
4/1/2020 9:00:00 PM	16.545	80.735	4.39	14.27
4/1/2020 10:00:00 PM	16.568	80.735	4.37	14.29
4/1/2020 11:00:00 PM	16.609	80.735	4.34	14.32
4/2/2020 12:00:00 AM	16.627	80.735	4.33	14.33
4/2/2020 1:00:00 AM	16.623	80.735	4.33	14.33
4/2/2020 2:00:00 AM	16.614	80.735	4.34	14.32
4/2/2020 3:00:00 AM	16.600	80.735	4.35	14.31
4/2/2020 4:00:00 AM	16.601	80.911	4.35	14.31

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/2/2020 5:00:00 AM	16.592	80.911	4.36	14.30
4/2/2020 6:00:00 AM	16.590	80.735	4.36	14.30
4/2/2020 7:00:00 AM	16.600	80.735	4.35	14.31
4/2/2020 8:00:00 AM	16.606	80.911	4.35	14.31
4/2/2020 9:00:00 AM	16.615	80.911	4.34	14.32
4/2/2020 10:00:00 AM	16.609	80.735	4.34	14.32
4/2/2020 11:00:00 AM	16.614	80.735	4.34	14.32
4/2/2020 12:00:00 PM	16.606	80.911	4.35	14.31
4/2/2020 1:00:00 PM	16.590	80.735	4.36	14.30
4/2/2020 2:00:00 PM	16.577	80.735	4.37	14.29
4/2/2020 3:00:00 PM	16.563	80.735	4.38	14.28
4/2/2020 4:00:00 PM	16.572	80.735	4.37	14.29
4/2/2020 5:00:00 PM	16.563	80.735	4.38	14.28
4/2/2020 6:00:00 PM	16.577	80.735	4.37	14.29
4/2/2020 7:00:00 PM	16.604	80.735	4.35	14.31
4/2/2020 8:00:00 PM	16.623	80.735	4.33	14.33
4/2/2020 9:00:00 PM	16.646	80.735	4.32	14.34
4/2/2020 10:00:00 PM	16.659	80.735	4.31	14.35
4/2/2020 11:00:00 PM	16.664	80.735	4.30	14.36
4/3/2020 12:00:00 AM	16.664	80.735	4.30	14.36
4/3/2020 1:00:00 AM	16.664	80.735	4.30	14.36
4/3/2020 2:00:00 AM	16.655	80.735	4.31	14.35
4/3/2020 3:00:00 AM	16.655	80.735	4.31	14.35
4/3/2020 4:00:00 AM	16.655	80.735	4.31	14.35
4/3/2020 5:00:00 AM	16.655	80.735	4.31	14.35
4/3/2020 6:00:00 AM	16.664	80.735	4.30	14.36
4/3/2020 7:00:00 AM	16.669	80.735	4.30	14.36
4/3/2020 8:00:00 AM	16.682	80.735	4.29	14.37
4/3/2020 9:00:00 AM	16.696	80.735	4.28	14.38
4/3/2020 10:00:00 AM	16.715	80.735	4.27	14.39
4/3/2020 11:00:00 AM	16.705	80.735	4.28	14.38
4/3/2020 12:00:00 PM	16.696	80.735	4.28	14.38
4/3/2020 1:00:00 PM	16.701	80.735	4.28	14.38
4/3/2020 2:00:00 PM	16.692	80.735	4.29	14.37
4/3/2020 3:00:00 PM	16.692	80.735	4.29	14.37

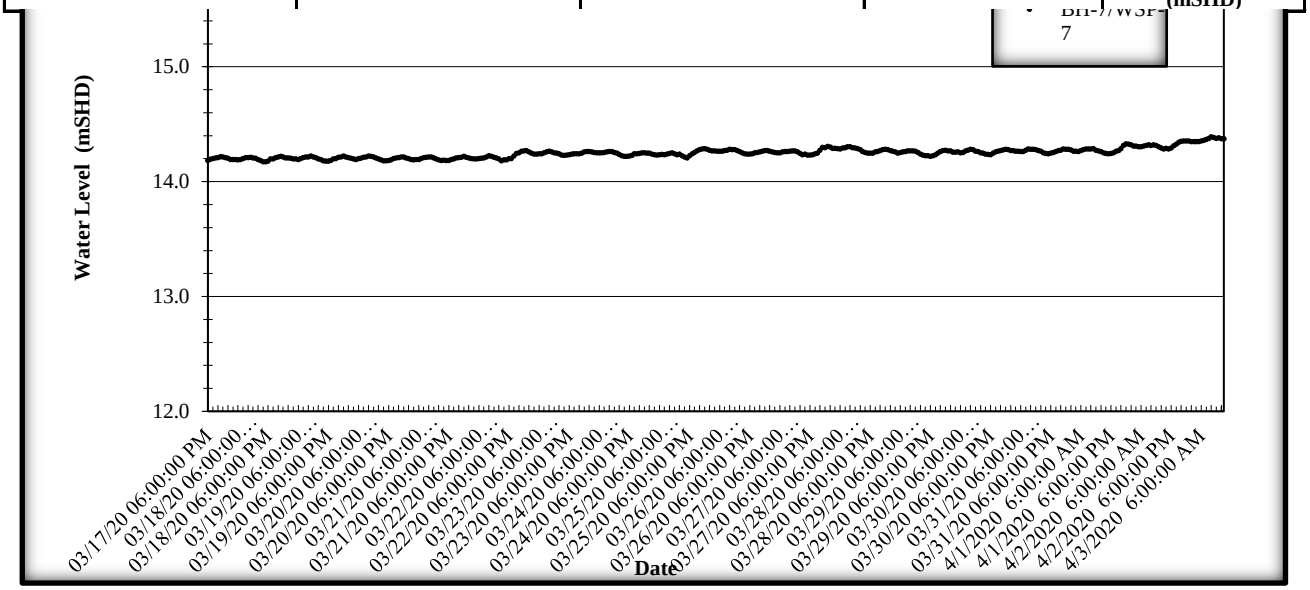
Change in Water Level



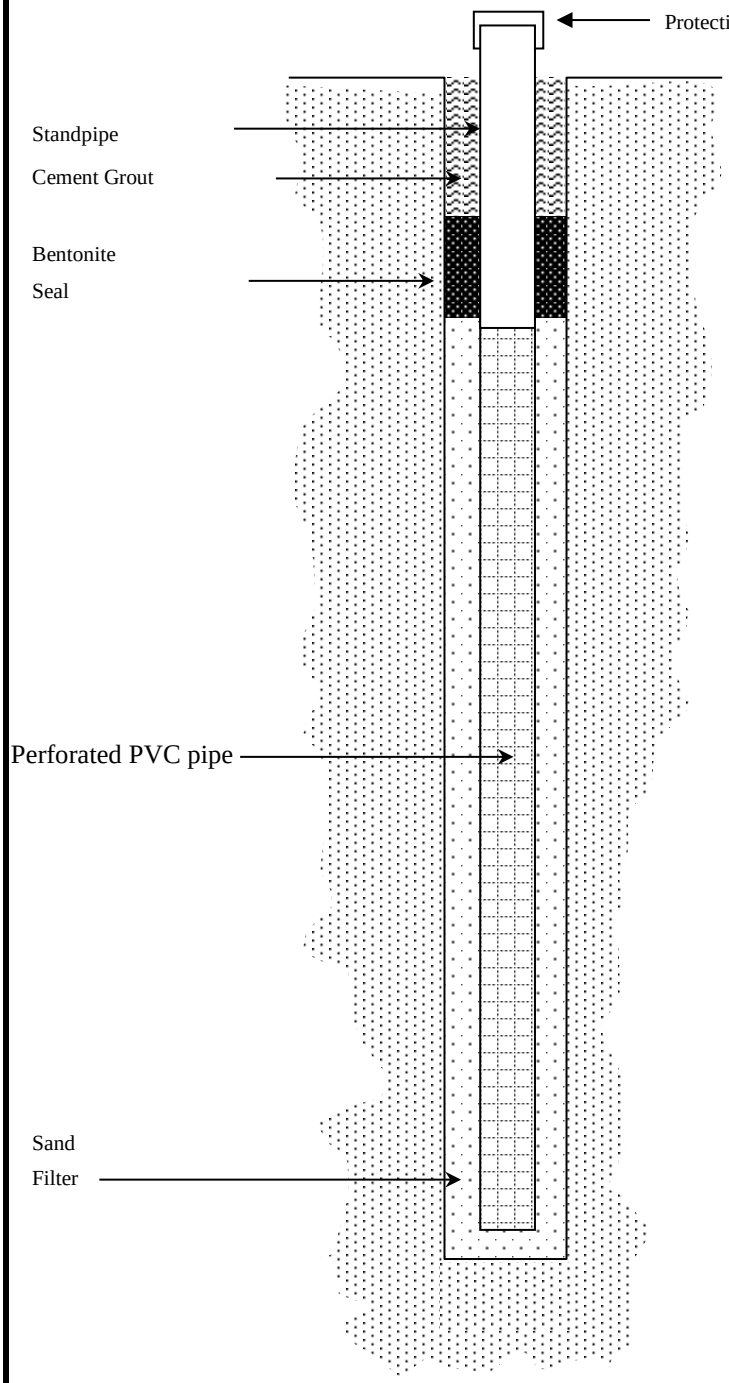
WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-7/WSP-7**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	5.85
Location:	Tengah	**Pipe Top Level (mSHD)**	19.510
		Ground Level (mSHD)	18.660

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)



PROJECT:	Instrumentation & Monitoring Works at Tengah Forest Area	
CLIENT:	Jacobs Singapore Pte Ltd	
LOCATION:	Tengah	
DATE OF INSTALLATION:	7 Mar 2020	**INSTALLED BY:** Helal



Depth (GL-m)	0.00
	2.50
	3.00
	9.00

REMARKS:

INSTALLED IN BH08/WSP-08

Note: NTS

INSTALLATION RECORD FOR

WATER STANDPIPE

GROUND INSTRUMENTATION & ENGINEERING PTE LTD

62 Ubi Road 1, #01-32 Oxley Bizhub 2 Singapore 408734

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/17/20 05:00:00 PM	17.466	80.735	3.98	12.81
03/17/20 06:00:00 PM	17.475	80.559	3.97	12.82
03/17/20 07:00:00 PM	17.485	80.559	3.96	12.82
03/17/20 08:00:00 PM	17.495	80.559	3.96	12.83
03/17/20 09:00:00 PM	17.500	80.559	3.95	12.83
03/17/20 10:00:00 PM	17.510	80.559	3.95	12.84
03/17/20 11:00:00 PM	17.515	80.559	3.94	12.84
03/18/20 12:00:00 AM	17.510	80.559	3.95	12.84
03/18/20 01:00:00 AM	17.500	80.559	3.95	12.83
03/18/20 02:00:00 AM	17.495	80.559	3.96	12.83
03/18/20 03:00:00 AM	17.475	80.559	3.97	12.82
03/18/20 04:00:00 AM	17.470	80.559	3.98	12.81
03/18/20 05:00:00 AM	17.465	80.559	3.98	12.81
03/18/20 06:00:00 AM	17.470	80.559	3.98	12.81
03/18/20 07:00:00 AM	17.470	80.559	3.98	12.81
03/18/20 08:00:00 AM	17.480	80.559	3.97	12.82
03/18/20 09:00:00 AM	17.485	80.559	3.96	12.82
03/18/20 10:00:00 AM	17.485	80.559	3.96	12.82
03/18/20 11:00:00 AM	17.490	80.559	3.96	12.83
03/18/20 12:00:00 PM	17.480	80.559	3.97	12.82
03/18/20 01:00:00 PM	17.465	80.559	3.98	12.81
03/18/20 02:00:00 PM	17.445	80.559	3.99	12.80
03/18/20 03:00:00 PM	17.435	80.559	4.00	12.79
03/18/20 04:00:00 PM	17.410	80.559	4.02	12.77
03/18/20 05:00:00 PM	17.410	80.559	4.02	12.77
03/18/20 06:00:00 PM	17.410	80.559	4.02	12.77
03/18/20 07:00:00 PM	17.440	80.559	4.00	12.79
03/18/20 08:00:00 PM	17.445	80.559	3.99	12.80
03/18/20 09:00:00 PM	17.460	80.559	3.98	12.81
03/18/20 10:00:00 PM	17.460	80.559	3.98	12.81
03/18/20 11:00:00 PM	17.465	80.559	3.98	12.81
03/19/20 12:00:00 AM	17.460	80.559	3.98	12.81
03/19/20 01:00:00 AM	17.450	80.559	3.99	12.80
03/19/20 02:00:00 AM	17.450	80.559	3.99	12.80
03/19/20 03:00:00 AM	17.435	80.559	4.00	12.79
03/19/20 04:00:00 AM	17.430	80.559	4.00	12.78
03/19/20 05:00:00 AM	17.425	80.559	4.01	12.78
03/19/20 06:00:00 AM	17.430	80.559	4.00	12.78
03/19/20 07:00:00 AM	17.435	80.559	4.00	12.79
03/19/20 08:00:00 AM	17.440	80.559	4.00	12.79
03/19/20 09:00:00 AM	17.455	80.559	3.99	12.80
03/19/20 10:00:00 AM	17.455	80.559	3.99	12.80

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 11:00:00 AM	17.450	80.559	3.99	12.80

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/19/20 12:00:00 PM	17.440	80.559	4.00	12.79
03/19/20 01:00:00 PM	17.425	80.559	4.01	12.78
03/19/20 02:00:00 PM	17.405	80.559	4.02	12.77
03/19/20 03:00:00 PM	17.395	80.559	4.03	12.76
03/19/20 04:00:00 PM	17.385	80.559	4.04	12.75
03/19/20 05:00:00 PM	17.375	80.559	4.04	12.75
03/19/20 06:00:00 PM	17.375	80.559	4.04	12.75
03/19/20 07:00:00 PM	17.380	80.559	4.04	12.75
03/19/20 08:00:00 PM	17.400	80.559	4.02	12.76
03/19/20 09:00:00 PM	17.405	80.559	4.02	12.77
03/19/20 10:00:00 PM	17.415	80.559	4.01	12.77
03/19/20 11:00:00 PM	17.415	80.559	4.01	12.77
03/20/20 12:00:00 AM	17.425	80.559	4.01	12.78
03/20/20 01:00:00 AM	17.420	80.559	4.01	12.78
03/20/20 02:00:00 AM	17.405	80.559	4.02	12.77
03/20/20 03:00:00 AM	17.390	80.559	4.03	12.76
03/20/20 04:00:00 AM	17.385	80.559	4.04	12.75
03/20/20 05:00:00 AM	17.385	80.559	4.04	12.75
03/20/20 06:00:00 AM	17.390	80.559	4.03	12.76
03/20/20 07:00:00 AM	17.400	80.559	4.02	12.76
03/20/20 08:00:00 AM	17.405	80.559	4.02	12.77
03/20/20 09:00:00 AM	17.415	80.559	4.01	12.77
03/20/20 10:00:00 AM	17.415	80.559	4.01	12.77
03/20/20 11:00:00 AM	17.410	80.559	4.02	12.77
03/20/20 12:00:00 PM	17.400	80.559	4.02	12.76
03/20/20 01:00:00 PM	17.380	80.559	4.04	12.75
03/20/20 02:00:00 PM	17.365	80.559	4.05	12.74
03/20/20 03:00:00 PM	17.350	80.559	4.06	12.73
03/20/20 04:00:00 PM	17.345	80.559	4.06	12.72
03/20/20 05:00:00 PM	17.345	80.559	4.06	12.72
03/20/20 06:00:00 PM	17.350	80.559	4.06	12.73
03/20/20 07:00:00 PM	17.355	80.559	4.06	12.73
03/20/20 08:00:00 PM	17.370	80.559	4.05	12.74
03/20/20 09:00:00 PM	17.375	80.559	4.04	12.75
03/20/20 10:00:00 PM	17.375	80.559	4.04	12.75
03/20/20 11:00:00 PM	17.380	80.559	4.04	12.75
03/21/20 12:00:00 AM	17.370	80.559	4.05	12.74
03/21/20 01:00:00 AM	17.365	80.559	4.05	12.74
03/21/20 02:00:00 AM	17.350	80.559	4.06	12.73
03/21/20 03:00:00 AM	17.345	80.559	4.06	12.72
03/21/20 04:00:00 AM	17.350	80.559	4.06	12.73

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/21/20 05:00:00 AM	17.355	80.559	4.06	12.73
03/21/20 06:00:00 AM	17.360	80.559	4.05	12.74
03/21/20 07:00:00 AM	17.365	80.559	4.05	12.74
03/21/20 08:00:00 AM	17.375	80.559	4.04	12.75
03/21/20 09:00:00 AM	17.375	80.559	4.04	12.75
03/21/20 10:00:00 AM	17.370	80.559	4.05	12.74
03/21/20 11:00:00 AM	17.375	80.559	4.04	12.75
03/21/20 12:00:00 PM	17.355	80.559	4.06	12.73
03/21/20 01:00:00 PM	17.340	80.559	4.07	12.72
03/21/20 02:00:00 PM	17.315	80.559	4.08	12.70
03/21/20 03:00:00 PM	17.320	80.559	4.08	12.71
03/21/20 04:00:00 PM	17.325	80.559	4.08	12.71
03/21/20 05:00:00 PM	17.320	80.559	4.08	12.71
03/21/20 06:00:00 PM	17.330	80.559	4.07	12.71
03/21/20 07:00:00 PM	17.345	80.559	4.06	12.72
03/21/20 08:00:00 PM	17.350	80.559	4.06	12.73
03/21/20 09:00:00 PM	17.365	80.559	4.05	12.74
03/21/20 10:00:00 PM	17.370	80.559	4.05	12.74
03/21/20 11:00:00 PM	17.360	80.559	4.05	12.74
03/22/20 12:00:00 AM	17.365	80.559	4.05	12.74
03/22/20 01:00:00 AM	17.360	80.559	4.05	12.74
03/22/20 02:00:00 AM	17.340	80.559	4.07	12.72
03/22/20 03:00:00 AM	17.340	80.559	4.07	12.72
03/22/20 04:00:00 AM	17.335	80.559	4.07	12.72
03/22/20 05:00:00 AM	17.345	80.559	4.06	12.72
03/22/20 06:00:00 AM	17.345	80.559	4.06	12.72
03/22/20 07:00:00 AM	17.350	80.559	4.06	12.73
03/22/20 08:00:00 AM	17.355	80.559	4.06	12.73
03/22/20 09:00:00 AM	17.360	80.559	4.05	12.74
03/22/20 10:00:00 AM	17.365	80.559	4.05	12.74
03/22/20 11:00:00 AM	17.350	80.559	4.06	12.73
03/22/20 12:00:00 PM	17.330	80.559	4.07	12.71
03/22/20 01:00:00 PM	17.315	80.559	4.08	12.70
03/22/20 02:00:00 PM	17.300	80.559	4.10	12.69
03/22/20 03:00:00 PM	17.285	80.559	4.11	12.68
03/22/20 04:00:00 PM	17.300	80.559	4.10	12.69
03/22/20 05:00:00 PM	17.320	80.559	4.08	12.71
03/22/20 06:00:00 PM	17.365	80.559	4.05	12.74
03/22/20 07:00:00 PM	17.440	80.559	4.00	12.79
03/22/20 08:00:00 PM	17.500	80.559	3.95	12.83
03/22/20 09:00:00 PM	17.555	80.559	3.92	12.87

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/22/20 10:00:00 PM	17.601	80.559	3.88	12.90
03/22/20 11:00:00 PM	17.646	80.559	3.85	12.94
03/23/20 12:00:00 AM	17.691	80.559	3.82	12.97
03/23/20 01:00:00 AM	17.741	80.559	3.79	13.00
03/23/20 02:00:00 AM	17.771	80.559	3.76	13.02
03/23/20 03:00:00 AM	17.806	80.559	3.74	13.05
03/23/20 04:00:00 AM	17.836	80.559	3.72	13.07
03/23/20 05:00:00 AM	17.866	80.559	3.70	13.09
03/23/20 06:00:00 AM	17.896	80.559	3.68	13.11
03/23/20 07:00:00 AM	17.921	80.559	3.66	13.13
03/23/20 08:00:00 AM	17.946	80.559	3.64	13.15
03/23/20 09:00:00 AM	17.967	80.559	3.63	13.16
03/23/20 10:00:00 AM	17.972	80.559	3.62	13.17
03/23/20 11:00:00 AM	17.956	80.559	3.63	13.16
03/23/20 12:00:00 PM	17.952	80.559	3.64	13.15
03/23/20 01:00:00 PM	17.936	80.559	3.65	13.14
03/23/20 02:00:00 PM	17.921	80.559	3.66	13.13
03/23/20 03:00:00 PM	17.906	80.559	3.67	13.12
03/23/20 04:00:00 PM	17.906	80.559	3.67	13.12
03/23/20 05:00:00 PM	17.906	80.559	3.67	13.12
03/23/20 06:00:00 PM	17.906	80.559	3.67	13.12
03/23/20 07:00:00 PM	17.921	80.559	3.66	13.13
03/23/20 08:00:00 PM	17.926	80.559	3.65	13.13
03/23/20 09:00:00 PM	17.932	80.559	3.65	13.14
03/23/20 10:00:00 PM	17.942	80.559	3.64	13.14
03/23/20 11:00:00 PM	17.956	80.559	3.63	13.16
03/24/20 12:00:00 AM	17.972	80.559	3.62	13.17
03/24/20 01:00:00 AM	17.972	80.559	3.62	13.17
03/24/20 02:00:00 AM	17.977	80.559	3.62	13.17
03/24/20 03:00:00 AM	17.977	80.559	3.62	13.17
03/24/20 04:00:00 AM	17.987	80.559	3.61	13.18
03/24/20 05:00:00 AM	17.992	80.559	3.61	13.18
03/24/20 06:00:00 AM	18.002	80.559	3.60	13.19
03/24/20 07:00:00 AM	18.012	80.559	3.59	13.19
03/24/20 08:00:00 AM	18.022	80.559	3.59	13.20
03/24/20 09:00:00 AM	18.037	80.559	3.58	13.21
03/24/20 10:00:00 AM	18.042	80.559	3.57	13.22
03/24/20 11:00:00 AM	18.037	80.559	3.58	13.21
03/24/20 12:00:00 PM	18.022	80.559	3.59	13.20
03/24/20 01:00:00 PM	18.002	80.559	3.60	13.19
03/24/20 02:00:00 PM	17.977	80.559	3.62	13.17

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/24/20 03:00:00 PM	17.962	80.559	3.63	13.16
03/24/20 04:00:00 PM	17.946	80.559	3.64	13.15
03/24/20 05:00:00 PM	17.946	80.559	3.64	13.15
03/24/20 06:00:00 PM	17.956	80.559	3.63	13.16
03/24/20 07:00:00 PM	17.967	80.559	3.63	13.16
03/24/20 08:00:00 PM	17.977	80.559	3.62	13.17
03/24/20 09:00:00 PM	17.977	80.559	3.62	13.17
03/24/20 10:00:00 PM	17.977	80.559	3.62	13.17
03/24/20 11:00:00 PM	17.977	80.559	3.62	13.17
03/25/20 12:00:00 AM	17.962	80.559	3.63	13.16
03/25/20 01:00:00 AM	17.946	80.559	3.64	13.15
03/25/20 02:00:00 AM	17.936	80.559	3.65	13.14
03/25/20 03:00:00 AM	17.921	80.559	3.66	13.13
03/25/20 04:00:00 AM	17.906	80.559	3.67	13.12
03/25/20 05:00:00 AM	17.901	80.559	3.67	13.12
03/25/20 06:00:00 AM	17.896	80.559	3.68	13.11
03/25/20 07:00:00 AM	17.896	80.559	3.68	13.11
03/25/20 08:00:00 AM	17.896	80.559	3.68	13.11
03/25/20 09:00:00 AM	17.901	80.559	3.67	13.12
03/25/20 10:00:00 AM	17.901	80.559	3.67	13.12
03/25/20 11:00:00 AM	17.901	80.559	3.67	13.12
03/25/20 12:00:00 PM	17.881	80.559	3.69	13.10
03/25/20 01:00:00 PM	17.851	80.559	3.71	13.08
03/25/20 02:00:00 PM	17.841	80.559	3.71	13.07
03/25/20 03:00:00 PM	17.816	80.559	3.73	13.06
03/25/20 04:00:00 PM	17.801	80.559	3.74	13.05
03/25/20 05:00:00 PM	17.806	80.559	3.74	13.05
03/25/20 06:00:00 PM	17.826	80.559	3.73	13.06
03/25/20 07:00:00 PM	17.856	80.559	3.70	13.08
03/25/20 08:00:00 PM	17.891	80.559	3.68	13.11
03/25/20 09:00:00 PM	17.926	80.559	3.65	13.13
03/25/20 10:00:00 PM	17.956	80.559	3.63	13.16
03/25/20 11:00:00 PM	17.972	80.559	3.62	13.17
03/26/20 12:00:00 AM	17.982	80.559	3.62	13.17
03/26/20 01:00:00 AM	17.982	80.559	3.62	13.17
03/26/20 02:00:00 AM	17.977	80.559	3.62	13.17
03/26/20 03:00:00 AM	17.972	80.559	3.62	13.17
03/26/20 04:00:00 AM	17.977	80.559	3.62	13.17
03/26/20 05:00:00 AM	17.977	80.559	3.62	13.17
03/26/20 06:00:00 AM	17.982	80.559	3.62	13.17
03/26/20 07:00:00 AM	17.992	80.559	3.61	13.18

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/26/20 08:00:00 AM	18.012	80.559	3.59	13.19
03/26/20 09:00:00 AM	18.017	80.559	3.59	13.20
03/26/20 10:00:00 AM	18.022	80.559	3.59	13.20
03/26/20 11:00:00 AM	18.017	80.559	3.59	13.20
03/26/20 12:00:00 PM	18.007	80.559	3.60	13.19
03/26/20 01:00:00 PM	17.982	80.559	3.62	13.17
03/26/20 02:00:00 PM	17.956	80.559	3.63	13.16
03/26/20 03:00:00 PM	17.932	80.559	3.65	13.14
03/26/20 04:00:00 PM	17.916	80.559	3.66	13.13
03/26/20 05:00:00 PM	17.921	80.559	3.66	13.13
03/26/20 06:00:00 PM	17.921	80.559	3.66	13.13
03/26/20 07:00:00 PM	17.926	80.559	3.65	13.13
03/26/20 08:00:00 PM	17.942	80.559	3.64	13.14
03/26/20 09:00:00 PM	17.942	80.559	3.64	13.14
03/26/20 10:00:00 PM	17.942	80.559	3.64	13.14
03/26/20 11:00:00 PM	17.942	80.559	3.64	13.14
03/27/20 12:00:00 AM	17.942	80.559	3.64	13.14
03/27/20 01:00:00 AM	17.926	80.559	3.65	13.13
03/27/20 02:00:00 AM	17.906	80.559	3.67	13.12
03/27/20 03:00:00 AM	17.891	80.559	3.68	13.11
03/27/20 04:00:00 AM	17.876	80.559	3.69	13.10
03/27/20 05:00:00 AM	17.871	80.559	3.69	13.10
03/27/20 06:00:00 AM	17.866	80.559	3.70	13.09
03/27/20 07:00:00 AM	17.866	80.559	3.70	13.09
03/27/20 08:00:00 AM	17.876	80.559	3.69	13.10
03/27/20 09:00:00 AM	17.881	80.559	3.69	13.10
03/27/20 10:00:00 AM	17.876	80.559	3.69	13.10
03/27/20 11:00:00 AM	17.871	80.559	3.69	13.10
03/27/20 12:00:00 PM	17.851	80.559	3.71	13.08
03/27/20 01:00:00 PM	17.836	80.559	3.72	13.07
03/27/20 02:00:00 PM	17.801	80.559	3.74	13.05
03/27/20 03:00:00 PM	17.776	80.559	3.76	13.03
03/27/20 04:00:00 PM	17.776	80.559	3.76	13.03
03/27/20 05:00:00 PM	17.766	80.559	3.77	13.02
03/27/20 06:00:00 PM	17.766	80.559	3.77	13.02
03/27/20 07:00:00 PM	17.776	80.559	3.76	13.03
03/27/20 08:00:00 PM	17.821	80.559	3.73	13.06
03/27/20 09:00:00 PM	17.911	80.559	3.67	13.12
03/27/20 10:00:00 PM	18.007	80.559	3.60	13.19
03/27/20 11:00:00 PM	18.112	80.559	3.52	13.26
03/28/20 12:00:00 AM	18.187	80.559	3.47	13.32

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/28/20 01:00:00 AM	18.237	80.559	3.44	13.35
03/28/20 02:00:00 AM	18.272	80.559	3.41	13.38
03/28/20 03:00:00 AM	18.307	80.559	3.39	13.40
03/28/20 04:00:00 AM	18.333	80.559	3.37	13.42
03/28/20 05:00:00 AM	18.353	80.559	3.35	13.43
03/28/20 06:00:00 AM	18.373	80.559	3.34	13.45
03/28/20 07:00:00 AM	18.408	80.559	3.32	13.47
03/28/20 08:00:00 AM	18.438	80.559	3.29	13.49
03/28/20 09:00:00 AM	18.463	80.559	3.28	13.51
03/28/20 10:00:00 AM	18.463	80.559	3.28	13.51
03/28/20 11:00:00 AM	18.463	80.559	3.28	13.51
03/28/20 12:00:00 PM	18.448	80.559	3.29	13.50
03/28/20 01:00:00 PM	18.433	80.559	3.30	13.49
03/28/20 02:00:00 PM	18.413	80.559	3.31	13.48
03/28/20 03:00:00 PM	18.398	80.559	3.32	13.47
03/28/20 04:00:00 PM	18.383	80.559	3.33	13.46
03/28/20 05:00:00 PM	18.378	80.559	3.34	13.45
03/28/20 06:00:00 PM	18.373	80.559	3.34	13.45
03/28/20 07:00:00 PM	18.383	80.559	3.33	13.46
03/28/20 08:00:00 PM	18.383	80.559	3.33	13.46
03/28/20 09:00:00 PM	18.398	80.559	3.32	13.47
03/28/20 10:00:00 PM	18.408	80.559	3.32	13.47
03/28/20 11:00:00 PM	18.413	80.559	3.31	13.48
03/29/20 12:00:00 AM	18.408	80.559	3.32	13.47
03/29/20 01:00:00 AM	18.398	80.559	3.32	13.47
03/29/20 02:00:00 AM	18.378	80.559	3.34	13.45
03/29/20 03:00:00 AM	18.358	80.559	3.35	13.44
03/29/20 04:00:00 AM	18.343	80.559	3.36	13.43
03/29/20 05:00:00 AM	18.333	80.559	3.37	13.42
03/29/20 06:00:00 AM	18.327	80.559	3.37	13.42
03/29/20 07:00:00 AM	18.333	80.559	3.37	13.42
03/29/20 08:00:00 AM	18.333	80.559	3.37	13.42
03/29/20 09:00:00 AM	18.333	80.559	3.37	13.42
03/29/20 10:00:00 AM	18.333	80.559	3.37	13.42
03/29/20 11:00:00 AM	18.323	80.559	3.38	13.41
03/29/20 12:00:00 PM	18.307	80.559	3.39	13.40
03/29/20 01:00:00 PM	18.282	80.559	3.40	13.38
03/29/20 02:00:00 PM	18.262	80.559	3.42	13.37
03/29/20 03:00:00 PM	18.237	80.559	3.44	13.35
03/29/20 04:00:00 PM	18.222	80.559	3.45	13.34
03/29/20 05:00:00 PM	18.212	80.559	3.45	13.34

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/29/20 06:00:00 PM	18.202	80.559	3.46	13.33
03/29/20 07:00:00 PM	18.197	80.559	3.46	13.32
03/29/20 08:00:00 PM	18.212	80.559	3.45	13.34
03/29/20 09:00:00 PM	18.227	80.559	3.44	13.35
03/29/20 10:00:00 PM	18.232	80.559	3.44	13.35
03/29/20 11:00:00 PM	18.237	80.559	3.44	13.35
03/30/20 12:00:00 AM	18.237	80.559	3.44	13.35
03/30/20 01:00:00 AM	18.222	80.559	3.45	13.34
03/30/20 02:00:00 AM	18.202	80.559	3.46	13.33
03/30/20 03:00:00 AM	18.182	80.559	3.47	13.31
03/30/20 04:00:00 AM	18.162	80.559	3.49	13.30
03/30/20 05:00:00 AM	18.152	80.559	3.50	13.29
03/30/20 06:00:00 AM	18.157	80.559	3.49	13.30
03/30/20 07:00:00 AM	18.152	80.559	3.50	13.29
03/30/20 08:00:00 AM	18.157	80.559	3.49	13.30
03/30/20 09:00:00 AM	18.162	80.559	3.49	13.30
03/30/20 10:00:00 AM	18.167	80.559	3.49	13.30
03/30/20 11:00:00 AM	18.152	80.559	3.50	13.29
03/30/20 12:00:00 PM	18.127	80.559	3.51	13.28
03/30/20 01:00:00 PM	18.107	80.559	3.53	13.26
03/30/20 02:00:00 PM	18.077	80.559	3.55	13.24
03/30/20 03:00:00 PM	18.052	80.559	3.57	13.22
03/30/20 04:00:00 PM	18.032	80.559	3.58	13.21
03/30/20 05:00:00 PM	18.017	80.559	3.59	13.20
03/30/20 06:00:00 PM	18.012	80.559	3.59	13.19
03/30/20 07:00:00 PM	18.022	80.559	3.59	13.20
03/30/20 08:00:00 PM	18.027	80.559	3.58	13.20
03/30/20 09:00:00 PM	18.037	80.559	3.58	13.21
03/30/20 10:00:00 PM	18.042	80.559	3.57	13.22
03/30/20 11:00:00 PM	18.042	80.559	3.57	13.22
03/31/20 12:00:00 AM	18.037	80.559	3.58	13.21
03/31/20 01:00:00 AM	18.027	80.559	3.58	13.20
03/31/20 02:00:00 AM	18.007	80.559	3.60	13.19
03/31/20 03:00:00 AM	17.997	80.559	3.61	13.18
03/31/20 04:00:00 AM	17.982	80.559	3.62	13.17
03/31/20 05:00:00 AM	17.977	80.559	3.62	13.17
03/31/20 06:00:00 AM	17.972	80.559	3.62	13.17
03/31/20 07:00:00 AM	17.972	80.559	3.62	13.17
03/31/20 08:00:00 AM	17.982	80.559	3.62	13.17
03/31/20 09:00:00 AM	17.992	80.559	3.61	13.18
03/31/20 10:00:00 AM	17.987	80.559	3.61	13.18

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

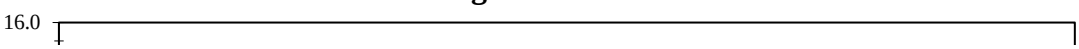
Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
03/31/20 11:00:00 AM	17.982	80.559	3.62	13.17
03/31/20 12:00:00 PM	17.967	80.559	3.63	13.16
03/31/20 01:00:00 PM	17.936	80.559	3.65	13.14
03/31/20 02:00:00 PM	17.911	80.559	3.67	13.12
03/31/20 03:00:00 PM	17.886	80.559	3.68	13.11
03/31/20 04:00:00 PM	17.871	80.559	3.69	13.10
03/31/20 05:00:00 PM	17.856	80.559	3.70	13.08
03/31/20 06:00:00 PM	17.856	80.559	3.70	13.08
03/31/20 07:00:00 PM	17.871	80.559	3.69	13.10
03/31/20 08:00:00 PM	17.881	80.559	3.69	13.10
03/31/20 09:00:00 PM	17.886	80.559	3.68	13.11
03/31/20 10:00:00 PM	17.891	80.559	3.68	13.11
03/31/20 11:00:00 PM	17.891	80.559	3.68	13.11
4/1/2020 12:00:00 AM	17.891	80.559	3.68	13.11
4/1/2020 1:00:00 AM	17.876	80.559	3.69	13.10
4/1/2020 2:00:00 AM	17.861	80.559	3.70	13.09
4/1/2020 3:00:00 AM	17.846	80.559	3.71	13.08
4/1/2020 4:00:00 AM	17.836	80.559	3.72	13.07
4/1/2020 5:00:00 AM	17.831	80.559	3.72	13.07
4/1/2020 6:00:00 AM	17.831	80.559	3.72	13.07
4/1/2020 7:00:00 AM	17.836	80.559	3.72	13.07
4/1/2020 8:00:00 AM	17.841	80.559	3.71	13.07
4/1/2020 9:00:00 AM	17.836	80.559	3.72	13.07
4/1/2020 10:00:00 AM	17.841	80.559	3.71	13.07
4/1/2020 11:00:00 AM	17.826	80.559	3.73	13.06
4/1/2020 12:00:00 PM	17.806	80.559	3.74	13.05
4/1/2020 1:00:00 PM	17.791	80.559	3.75	13.04
4/1/2020 2:00:00 PM	17.771	80.559	3.76	13.02
4/1/2020 3:00:00 PM	17.751	80.559	3.78	13.01
4/1/2020 4:00:00 PM	17.731	80.559	3.79	13.00
4/1/2020 5:00:00 PM	17.726	80.559	3.80	12.99
4/1/2020 6:00:00 PM	17.731	80.559	3.79	13.00
4/1/2020 7:00:00 PM	17.756	80.559	3.77	13.01
4/1/2020 8:00:00 PM	17.826	80.559	3.73	13.06
4/1/2020 9:00:00 PM	17.932	80.559	3.65	13.14
4/1/2020 10:00:00 PM	18.042	80.559	3.57	13.22
4/1/2020 11:00:00 PM	18.142	80.559	3.50	13.29
4/2/2020 12:00:00 AM	18.222	80.559	3.45	13.34
4/2/2020 1:00:00 AM	18.272	80.559	3.41	13.38
4/2/2020 2:00:00 AM	18.307	80.559	3.39	13.40
4/2/2020 3:00:00 AM	18.343	80.559	3.36	13.43

WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)
4/2/2020 4:00:00 AM	18.368	80.559	3.34	13.44
4/2/2020 5:00:00 AM	18.388	80.559	3.33	13.46
4/2/2020 6:00:00 AM	18.413	80.559	3.31	13.48
4/2/2020 7:00:00 AM	18.433	80.559	3.30	13.49
4/2/2020 8:00:00 AM	18.448	80.559	3.29	13.50
4/2/2020 9:00:00 AM	18.468	80.559	3.27	13.52
4/2/2020 10:00:00 AM	18.478	80.559	3.27	13.52
4/2/2020 11:00:00 AM	18.473	80.559	3.27	13.52
4/2/2020 12:00:00 PM	18.473	80.559	3.27	13.52
4/2/2020 1:00:00 PM	18.458	80.559	3.28	13.51
4/2/2020 2:00:00 PM	18.443	80.559	3.29	13.50
4/2/2020 3:00:00 PM	18.428	80.559	3.30	13.49
4/2/2020 4:00:00 PM	18.453	80.559	3.28	13.50
4/2/2020 5:00:00 PM	18.528	80.559	3.23	13.56
4/2/2020 6:00:00 PM	18.764	80.559	3.07	13.72
4/2/2020 7:00:00 PM	18.919	80.559	2.96	13.83
4/2/2020 8:00:00 PM	19.029	80.559	2.88	13.91
4/2/2020 9:00:00 PM	19.089	80.559	2.84	13.95
4/2/2020 10:00:00 PM	19.175	80.559	2.78	14.01
4/2/2020 11:00:00 PM	19.240	80.559	2.73	14.06
4/3/2020 12:00:00 AM	19.210	80.559	2.75	14.04
4/3/2020 1:00:00 AM	19.280	80.559	2.70	14.09
4/3/2020 2:00:00 AM	19.330	80.559	2.67	14.12
4/3/2020 3:00:00 AM	19.365	80.559	2.64	14.15
4/3/2020 4:00:00 AM	19.400	80.559	2.62	14.17
4/3/2020 5:00:00 AM	19.425	80.559	2.60	14.19
4/3/2020 6:00:00 AM	19.450	80.559	2.58	14.21
4/3/2020 7:00:00 AM	19.470	80.559	2.57	14.22
4/3/2020 8:00:00 AM	19.490	80.559	2.55	14.23
4/3/2020 9:00:00 AM	19.525	80.559	2.53	14.26
4/3/2020 10:00:00 AM	19.551	80.559	2.51	14.28
4/3/2020 11:00:00 AM	19.555	80.559	2.51	14.28
4/3/2020 12:00:00 PM	19.716	80.559	2.40	14.39
4/3/2020 1:00:00 PM	19.816	80.559	2.33	14.46
4/3/2020 2:00:00 PM	19.881	80.559	2.28	14.51
4/3/2020 3:00:00 PM	19.916	80.559	2.25	14.53
4/3/2020 4:00:00 PM	19.936	80.559	2.24	14.55

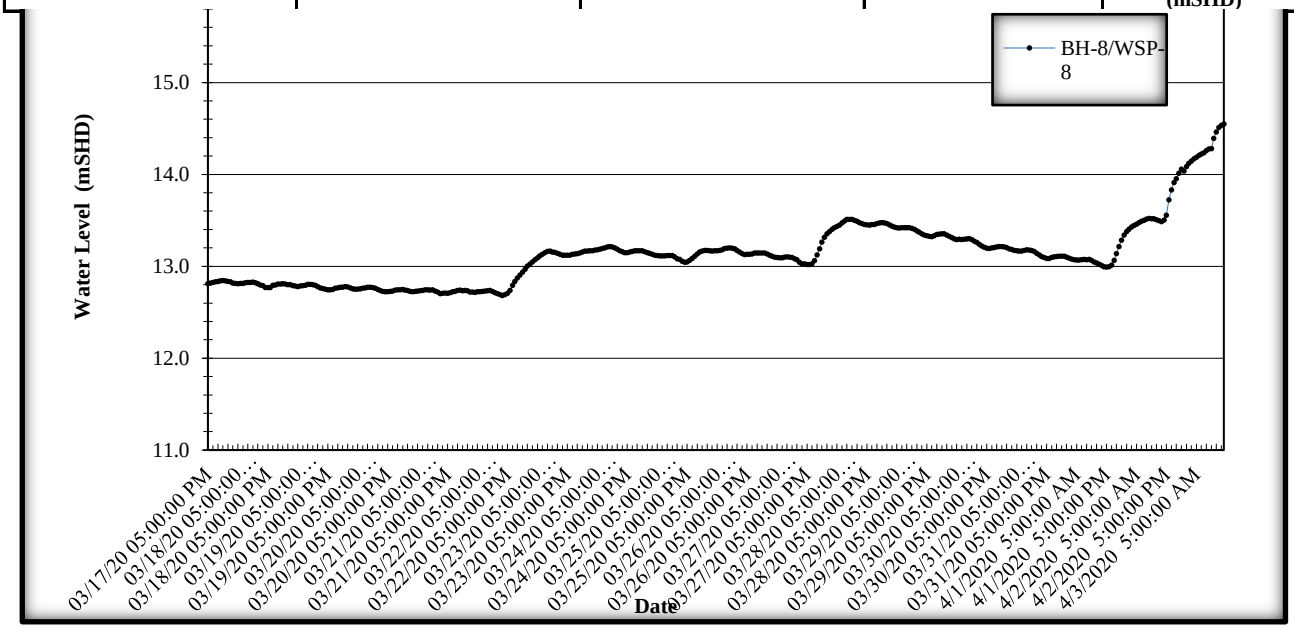
Change in Water Level



WATER STANDPIPE MONITORING

Project:	Instrumentation & Monitoring Works at Tengah Forest Area	**Reference**	**BH-8/WSP-8**
Client:	Jacobs Singapore Pte Ltd	**Data logger Installation Depth (m)**	6.00
Location:	Tengah	**Pipe Top Level (mSHD)**	17.589
		Ground Level (mSHD)	16.789

Date Time, GMT+08:00	Abs Pres, psi	Temp, °F	WL, m BGL	Water Level (mSHD)



Field Borehole Log

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: SINS-20004

Sheet _____ of _____

PROJECT: Instrumentation work at Jalan Lam Sam		BORING LOG: BH-01 / WSP-01
CLIENT:	DRILL RIG MODEL: TOHO RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: Jalan Lam Sam / Tengah	CORE DIA: -	
DRILLING DATE: 10.03.20 to 11.03.20	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 50mm	FLUSHING MEDIUM: -	EASTING:
HAMMER TYPE / S/NO: -	CASING DIA / LENGTH: - mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE: -	SUPERVISOR NAME: Sattar SIGNATURE:	▽ WL*: 5.50m

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
0m				- Firm - Reddish Brown to grey - Sandy SILT with gravels - Made Ground 0.8m									Trial pit & Handaugering
1m													
2m													
3m				- Firm - yellowish to reddish brown - Sand SILT									
4m	4.50 – 4.50		UD 01										MZ-01 Rec - 45 cm
5m				5.50m									
6m				- Firm to stiff - Reddish to whitish grey - Fine sandy SILT									
7m													
8m	7.50 – 8.00		UD 02										MZ-02 Rec - 25cm
9m				* WSP installed 8.50m									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◐ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▭ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- ▭ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ▮ – Piston Sample (PS)
- ▮ – Core Run (CR)
- ▭ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: SI INS - 2004

Sheet _____ of _____

PROJECT: INSTALLATION WORK AT JALAN LAM SAM		**BORING LOG:**
CLIENT: JACOB	DRILL RIG MODEL: JOHO RIG NO: 02	BH NO: 02/WSP-02
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: JALAN LAM SAM	CORE DIA: -	
DRILLING DATE: 13.03.20	DRILLING METHOD: ROTARY	NORTHING:
DRILLING ROD TYPE / SIZE: BW/50mm	FLUSHING MEDIUM:	EASTING:
HAMMER TYPE / S/NO: SELF TRIPPING	CASING DIA / LENGTH: _____ mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE:	SUPERVISOR NAME: U. Pandiyan SIGNATURE:	▽ WL*: 8.00 m

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
1				- Firm - Redish brown light grey - Sandy SILT - Fine to Coarse grained Sand with gravel - mixed with hard core - Made ground									Trial pit and hand auger upto 3.00m
2													
3													
4	3.50 4.00		UP 1	2.00m									UD : 1 Rec : 30cm
5				- Firm - Redish brown and yellow - Sandy SILT - Fine grained sand - Residual Soil - JURONG FORMATION									
6													
7													
8	8.00 8.50		UD 2	- Stiff - Light grey to grey - Sandy SILT - Fine grained sand - Residual Soil - JURONG FORMATION									UD : 2 Rec : 30cm
9													
10													

10.50m Installed WSP upto 10.50m

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◐ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- □ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: ~~SI~~ INS 20004 Sheet _____ of _____

PROJECT: INSTALLATION WORK AT JALAN LAM SAM		**BORING LOG:** BH NO 03/WSP-03
CLIENT: JACOB	DRILL RIG MODEL: TOHO RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100mm	
LOCATION: JALAN LAM SAM	CORE DIA: -	
DRILLING DATE: 12.03.20	DRILLING METHOD: ROTARY	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 50 mm	FLUSHING MEDIUM: -	EASTING:
HAMMER TYPE / S/NO: SELF TRIPPING	CASING DIA / LENGTH: 100 mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE:	SUPERVISOR NAME: M. Pandiyan SIGNATURE:	▽ WL*: 7.00m

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
1				- Firm - Redish brown - Sandy SILT									Trial pit and hand auger up to 3.00m
2				- Fine graine Sand - Mode ground									
				1.30									
3				- Firm - Redish brown to yellow - Slightly Sandy SILT									
4	3.50 4.00		UD 1	- Fine to coarse Grained Sand - Residual Soil - JURONG FORMATION									UD : 1 Rec : 50cm
5													
6													
7													
8	7.50 8.00		UD 2										UD: 2 Rec : 30cm
				Installed WSP upto 8.00m									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ⊕ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- □ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: SI INS 20004

Sheet _____ of _____

PROJECT: Installation work at Jalan Lam Sam		**BORING LOG:** BH 04 / WSP 04
CLIENT: JACOB	DRILL RIG MODEL: TOHO RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: Jalan Lam Sam	CORE DIA: –	
DRILLING DATE: 09-03-20	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 50mm	FLUSHING MEDIUM:	EASTING:
HAMMER TYPE / S/NO:	CASING DIA / LENGTH: _____ mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE:	SUPERVISOR NAME: SIGNATURE:	▽ WL*: 2.00 m

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
1				- Loose - Light grey brown - Silty SAND									Trail pit and hand auger
2	1.5 2.00		UD 1	- Fine to Coarse grained Sand - with gravel - Made ground									UD: 1 Rec: 30cm
3				3.00 m									
4				- Firm - Redish brown - Slightly Sandy SILT									
5				- Fine to coarse grained sand									UD: 2 Rec: 40cm
6	5.50 6.00m		UD 2	- with trace gravel - Residual soil - JURONG FORMATION									
				Installed WSP upto 6.00 m									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◕ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- □ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: ~~SI~~ INS-20004

Sheet _____ of _____

PROJECT: Instrumentation Works		**BORING LOG:** WSP-05
CLIENT: JACOB	DRILL RIG MODEL: Toho RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100mm	
LOCATION: Jalan Lam Sam	CORE DIA: -	
DRILLING DATE: 04.03.20	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 53mm	FLUSHING MEDIUM: -	EASTING:
HAMMER TYPE / S/NO: -	CASING DIA / LENGTH: _____ mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE: -	SUPERVISOR NAME: Helal SIGNATURE:	▽ WL*: 2.5m.

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
0				- Fiirm - Brown and Yellowish brown. - Sandy SILT with gravels MADE GROUND (1.20m)									Trialpit and Hand Auger 2.100m.
1													
2	2.00 to 2.50 m		UD-1	- Soft - Brown and Yellowish brown. - Sandy SILT - Residual Soil JURONG FORMATION (4.5m)									UD-1 Rec. - 35Cm.
3													
4													
5	5.00 to 5.50 m		UD-2	- Very Soft - Reddish brown and Yellowish brown. - Sandy SILT - Completly weathered. JURONG FORMATION (6.00m)									UD-2 Rec. - Full
6													
7				* WSP Installation depth 6.00m.									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◐ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▩ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- □ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: ~~SI~~ INS-20004

Sheet _____ of _____

PROJECT: Instrumentation Works		**BORING LOG:** WSP NO 6
CLIENT: JACOB	DRILL RIG MODEL: Tolto RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: Jalan Lor Sawi/Tengah	CORE DIA: -	
DRILLING DATE: 05/03/20	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 53.2mm	FLUSHING MEDIUM: -	EASTING:
HAMMER TYPE / S/NO: -	CASING DIA / LENGTH: - mm / - m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE: -	SUPERVISOR NAME: Helal SIGNATURE:	▽ WL*: 2.50m.

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
0				- Firm Brown and Yellowish brown. - Sandy SILT with gravels MADE GROUND (1.00m)									Trialpit and Hand Auger depth 2.00m.
1													
2	2.00 to 2.50		UD - 1	- Firm - Brownish grey and Yellowish brown. - Sandy SILT with gravels - Residual Soil JURONG FORMATION									UD - 1 Rec. - FULL
3													UD - 2 Rec. - 30 Cm.
4				- Firm to Very Stiff - Reddish brown - Sandy SILT with gravels - Residual Soil. JURONG FORMATION. (6.50m)									
5													
6													
7				* WSP Installation depth 6.00m.									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▭ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- ▭ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ▮ – Piston Sample (PS)
- ▮ – Core Run (CR)
- ▭ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: ~~SI~~ INS-20004

Sheet 1 of 1

PROJECT: Instrumentation Works		**BORING LOG:** WSP-07
CLIENT: JACOB	DRILL RIG MODEL: TOHO RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: Jalan Lam Sam	CORE DIA: -	
DRILLING DATE: 03.03.20	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE: BW / 53 mm	FLUSHING MEDIUM: -	EASTING:
HAMMER TYPE / S/NO: -	CASING DIA / LENGTH: - mm / - m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE: -	SUPERVISOR NAME: Helal SIGNATURE:	▽ WL*: 4.00 m.

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	2nd 15cm	3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	SCR (%)	RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
0				- Fiom - Reddish brown and Yellowish brown. - Sandy SILT [GL to 0.50m Concrete] - MADE GROUND									Trialpit and Hand auger
1													
2				(3.00m.)									
3				- Stiff - Brown and Yellowish brown									UD - 1 ~~3.50m~~ Rec. - 40 Cm
4	3.50 m. 4.00 m.		UD - 1	- Sandy SILT with gravels. - Residual Soil. JURONG FORMATION									
5				(5.50m.)									
6				- Soft - Brown and Reddish brown - Sandy CLAY - Completly weathered JURONG FORMATION.									UD-2 Rec - 45 Cm.
7	7.00 7.50 m.		UD - 2										
8				(8.50m)									
9				* Installation WSP depth 8.50m.									

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◍ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▤ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- □ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ■ – Piston Sample (PS)
- ▮ – Core Run (CR)
- □ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

FIELD LOG
(ISO 22475-1:2006)

GIE Project ID: SI INS-20004

Sheet _____ of _____

PROJECT: Instrumentation works		**BORING LOG:** WSP-08
CLIENT: JACOB	DRILL RIG MODEL: Totto RIG NO: 02	
CONTRACTOR: GIE	BOREHOLE DIA: 100 mm	
LOCATION: Jalan Lam Sam/Tengah	CORE DIA: -	
DRILLING DATE:	DRILLING METHOD: Rotary	NORTHING:
DRILLING ROD TYPE / SIZE:	FLUSHING MEDIUM:	EASTING:
HAMMER TYPE / S/NO: 07.03.20	CASING DIA / LENGTH: _____ mm / _____ m	REDUCED LEVEL:
CALIBRATION CERT NO / DATE:	SUPERVISOR NAME: Helal SIGNATURE:	▽ WL*: 7.50m.

Scale	Depth (m) (Thickness)	Legend	Type & No	Description	Standard Penetration Test 1st 15cm	Standard Penetration Test 2nd 15cm	Standard Penetration Test 3rd 15cm	SPT N blows / 30cm	Rock TCR (%)	Rock SCR (%)	Rock RQD (%)	Geological Classification	Remarks (Always Record Water level during SPT, SPT Recovery, Straightness of end after every 20 SPT, UD Recovery)
0				- Fiom.									Tpialpit and Hand Auger
1				- Brown and Yellowish brown.									
				- Sandy SILT with gravels MADE GROUND (1.00 m)									
2				- Soft - Reddish brown									3.00 m.
3	3.00 To 3.50 m.		UD-1	- Sandy CLAY with Silty - Completly weathered. - JURONG FORMATION (6.00m)									UD-1 Rec. - FULL
4				Stiff to very stiff.									
5				- Reddish brown - Sandy SILT with gravels - Residual Soil									
6				JURONG FORMATION (9.00 m)									UD-2 NO Recovery
7				* WSP Installation 9.00m.									
8													
9	9.00		UD-2										
10													

Ground Instrumentation & Engineering

LEGEND:

- ▼ – Pressuremeter Test (PMT)
- ◔ – Vane Shear Test (V)
- ⊗ – Permeability Test (PBT)
- ▭ – Packer Test (PKT)
- ▨ – Standard Penetration Test (SPT)
- ▨ – Undisturbed Sample (UD) Open Drive Thickwall Sample (OD)
- ▨ – Mazier Sample (MZ) Denison Sample (DS)
- ▭ – Attempted (UD*), (OD*), (PS*), (MZ*) & (DS*)
- ▮ – Piston Sample (PS)
- ▮ – Core Run (CR)
- ▭ – TCR
- ▩ – RQD

*WL - Ground Water Level observed from Borehole (BGL)

APPENDIX B

LABORATORY TEST RESULTS

LABORATORY TEST RESULTS

BOREHOLE NO: BH-01/WSP-01

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**										
Project No. :	**INS20004**										
Borehole No. :			**BH-01/WSP-01**								
Sample No.			UD1	UD2							
Depth, m		from	4.00	7.50							
		to	4.50	8.00							
Soil			saCl	saSi							
Moisture Content:		%	17	14							
Bulk Density		Mg/m^3	2.02	2.05							
Dry Density		Mg/m^3	1.73	1.80							
Atterberg Limits	Liquid Limit	%									
	Plastic Limit	%									
	Plasticity Index	%									
Grain Size Distribution	Gravel	%	7	0							
	Sand	%	32	22							
	Silt	%	25	40							
	Clay	%	36	38							
Particle Density											
Unconfined Compression	Shear Strength	kPa									
	Compressive Strength	kPa									
Triaxial Comp. (UU)	Cohesion	kPa									
	Phi angle	°									
Triaxial Comp. (CIU)	Cohesion	kPa									
	Phi angle	°									
Triaxial Comp. (CID)	Cohesion	kPa									
	Phi angle	°									
Consolidation	Initial Void Ratio										
	Degree of Saturation	%									
	Preconsol, Pressure, Pc	kPa									
	Compression Index, Cc										
Direct Shear	Cohesion	kPa									
	Phi angle	°									
Compaction	Maximum Dry Density	Mg/m^3									
	Optimum MC	%									
Rock											
Point Load	Strength Index	MPa									
UCT	Compressive Strength	MPa									
Slake Durability	Index ID_2	%									
Cerchar	Corrected CAI	HRC55									
Constant Head Txl Permeability											
	Kv @ 20 °C	m/s									

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &
Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-01/WSP-01	UD1	4.00 - 4.50	Reddish brown sandy CLAY
	UD2	7.50 - 8.00	Greyish brown sandy SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-01/WSP-01	UD1	4.00 - 4.50	17	2.02	1.73
	UD2	7.50 - 8.00	14	2.05	1.80

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

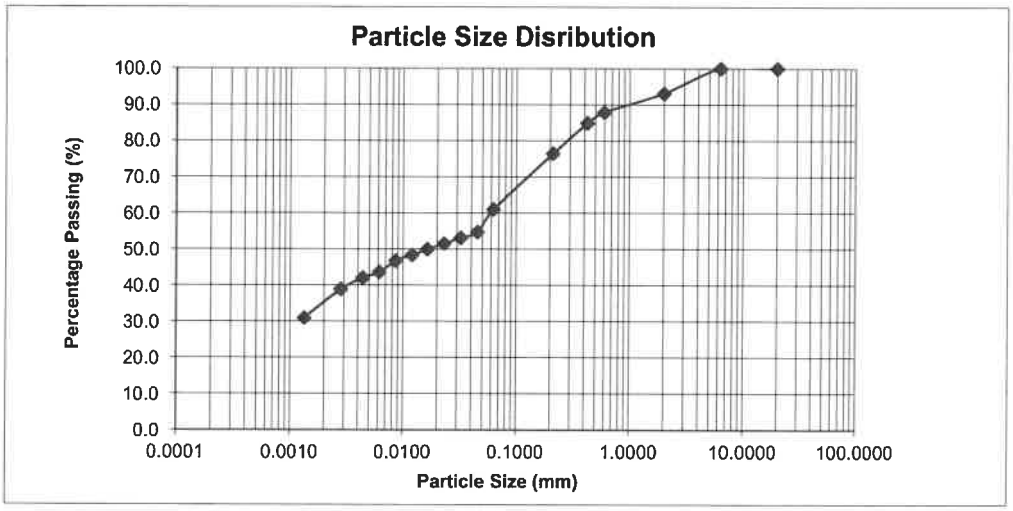
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	93.1
0.600	87.9
0.425	84.8
0.212	76.4
0.063	61.0
0.0455	54.7
0.0324	53.1
0.0231	51.5
0.0165	49.9
0.0121	48.3
0.0086	46.8
0.0062	43.6
0.0044	42.0
0.0028	38.8
0.0013	30.9



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
7%	32%	25%	36%

Description: Reddish brown sandy CLAY

Project/Location :	Instrumentation & Monitoring Works At Tengah Forest Area
Project No. :	INS20004
BH :	BH-01/WSP-01
Sample No. :	UD1
Depth (m) :	4.00-4.50

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	13/6/20

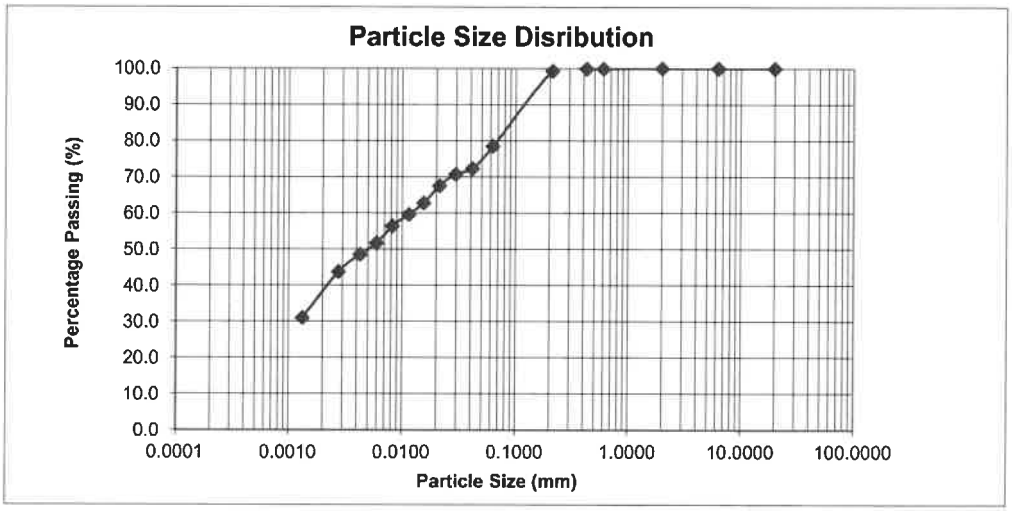
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	99.9
0.425	99.9
0.212	99.3
0.063	78.5
0.0415	72.3
0.0296	70.7
0.0213	67.5
0.0155	62.7
0.0115	59.6
0.0082	56.4
0.0060	51.6
0.0043	48.5
0.0028	43.7
0.0013	31.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	22%	40%	38%

Description: Greyish brown sandy SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-01/WSP-01

Sample No. : UD2

Depth (m) : 7.50-8.00

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	17/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-02/WSP-02

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-02/WSP-02**							
Sample No.			UD1	UD2						
Depth, m		from	3.50	8.00						
		to	4.00	8.50						
Soil			saSi	saSi						
Moisture Content:		%	26	22						
Bulk Density		Mg/m^3	1.84	2.07						
Dry Density		Mg/m^3	1.46	1.70						
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	0	0						
	Sand	%	17	34						
	Silt	%	58	45						
	Clay	%	25	21						
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM Date: 13/6/2020

Approved by: MC Date: 13/6/2020

Ground Instrumentation & Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-02/WSP-02	UD1	3.50 - 4.00	Reddish brown sandy SILT
	UD2	8.00 - 8.50	Light grey sandy SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-02/WSP-02	UD1	3.50 - 4.00	26	1.84	1.46
	UD2	8.00 - 8.50	22	2.07	1.70

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

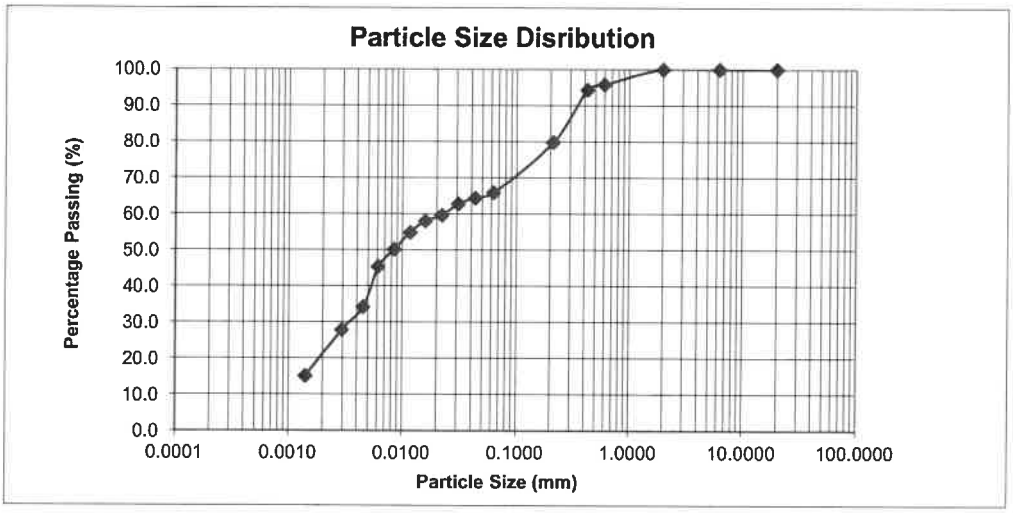
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	95.8
0.425	94.3
0.212	79.8
0.063	65.8
0.0434	64.3
0.0309	62.7
0.0222	59.6
0.0158	58.0
0.0118	54.8
0.0085	50.0
0.0061	45.3
0.0046	34.2
0.0030	27.8
0.0014	15.1



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	34%	45%	21%

Description: Light grey sandy SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-02/WSP-02

Sample No. : UD2

Depth (m) : 8.00-8.50

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	13/6/20

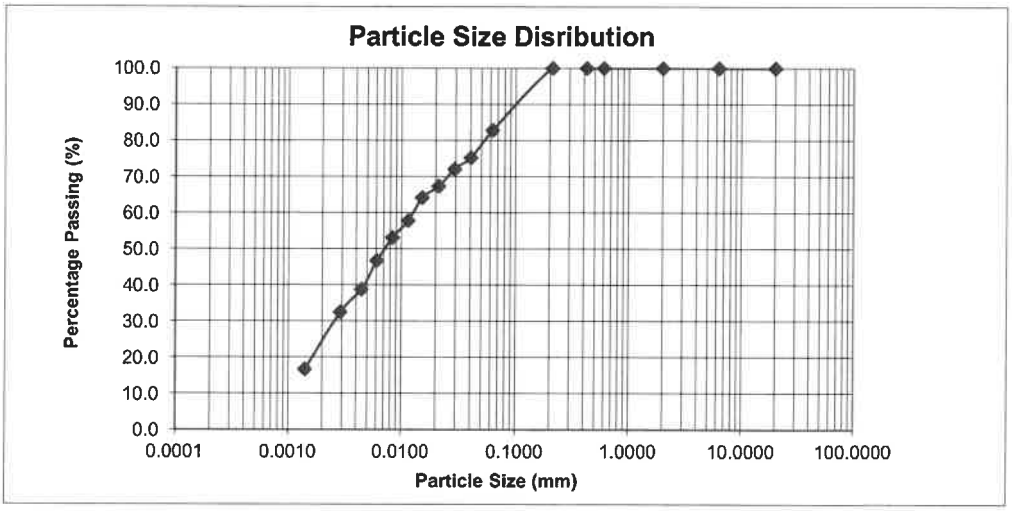
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	100.0
0.425	100.0
0.212	100.0
0.063	82.8
0.0407	75.2
0.0293	72.1
0.0213	67.3
0.0153	64.1
0.0116	57.8
0.0084	53.0
0.0061	46.7
0.0045	38.8
0.0029	32.5
0.0014	16.6



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	17%	58%	25%

Description: Reddish brown sandy SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-02/WSP-02

Sample No. : UD1

Depth (m) : 3.50-4.00

Tested by Faysal Checked by MM Approved by MC

Date : 10/06/20 Date : 13/6/20 Date 13/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-03/WSP-03

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-03/WSP-03**							
Sample No.			UD1	UD2						
Depth, m		from	3.50	7.50						
		to	4.00	8.00						
Soil			siSa	Si						
Moisture Content:		%	17	40						
Bulk Density		Mg/m^3	2.01	1.94						
Dry Density		Mg/m^3	1.72	1.39						
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	0	0						
	Sand	%	57	9						
	Silt	%	24	70						
	Clay	%	19	21						
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM
Date: 13/6/2020

Approved by: MC
Date: 13/6/2020

Ground Instrumentation &
Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-03/WSP-03	UD1	3.50 - 4.00	Reddish grey silty SAND
	UD2	7.50 - 8.00	Reddish yellow SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-03/WSP-03	UD1	3.50 - 4.00	17	2.01	1.72
	UD2	7.50 - 8.00	40	1.94	1.39

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

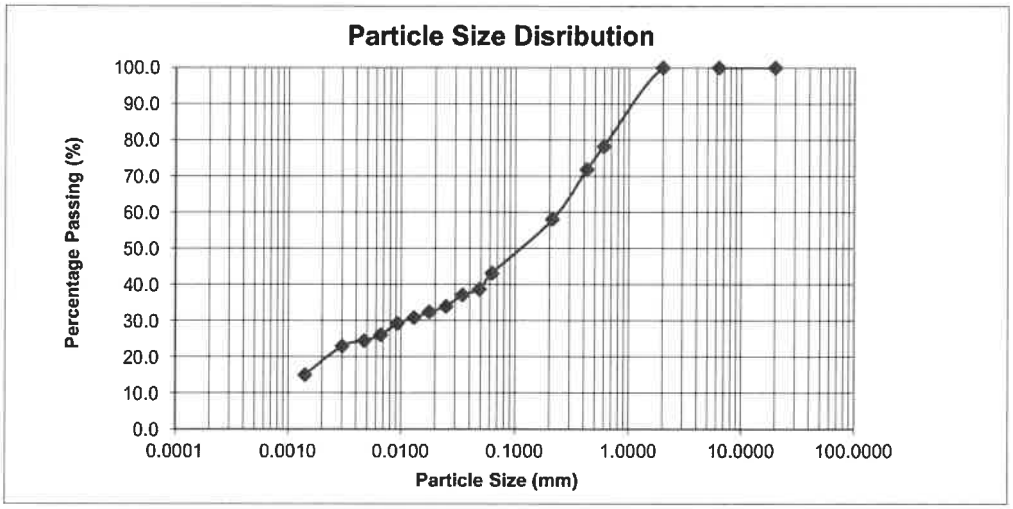
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	78.2
0.425	71.8
0.212	58.0
0.063	43.1
0.0489	38.7
0.0348	37.1
0.0250	33.9
0.0178	32.4
0.0131	30.8
0.0093	29.2
0.0066	26.0
0.0047	24.5
0.0030	22.9
0.0014	15.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	57%	24%	19%

Description: Reddish grey silty SAND

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-03/WSP-03

Sample No. : UD1

Depth (m) : 3.50-4.00

Tested by Faysal Checked by MM Approved by MC

Date : 10/06/20 Date : 13/6/20 Date 13/6/20

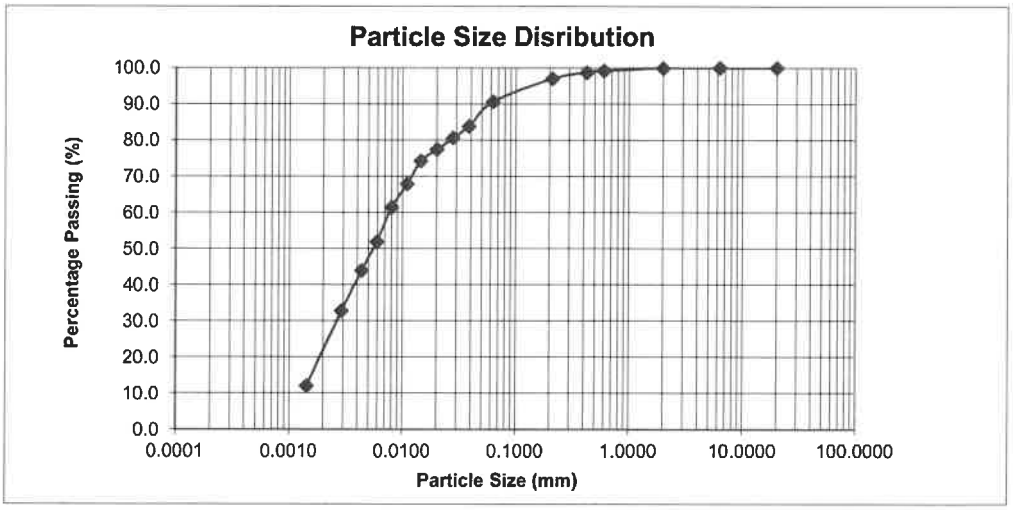
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	99.9
0.600	99.1
0.425	98.7
0.212	97.0
0.063	90.6
0.0387	83.8
0.0279	80.6
0.0201	77.4
0.0145	74.2
0.0110	67.8
0.0081	61.4
0.0060	51.9
0.0044	43.9
0.0029	32.7
0.0014	12.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	9%	70%	21%

Description: Reddish yellow SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-03/WSP-03

Sample No. : UD2

Depth (m) : 7.50-8.00

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	13/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-04/WSP-04

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-04/WSP-04**							
Sample No.			UD1	UD2						
Depth, m		from	1.50	5.50						
		to	2.00	6.00						
Soil			siSa	clSa						
Moisture Content:		%	21	27						
Bulk Density		Mg/m^3	1.93	2.11						
Dry Density		Mg/m^3	1.60	1.66						
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	0	0						
	Sand	%	76	55						
	Silt	%	18	11						
	Clay	%	6	34						
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &
Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-04/WSP-04	UD1	1.50 - 2.00	Dark grey silty SAND
	UD2	5.50 - 6.00	Reddish brown clayey SAND

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-04/WSP-04	UD1	1.50 - 2.00	21	1.93	1.60
	UD2	5.50 - 6.00	27	2.11	1.66

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

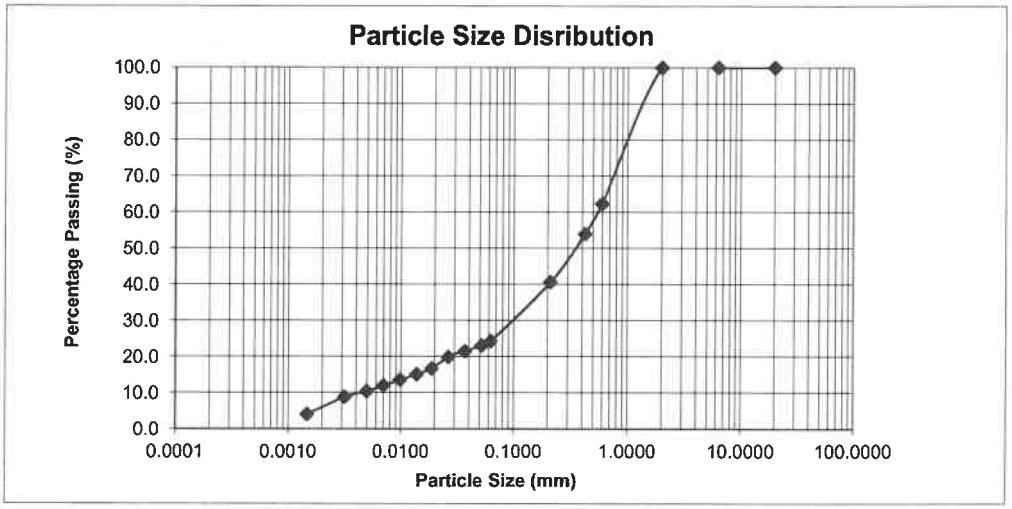
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	62.3
0.425	53.9
0.212	40.6
0.063	24.2
0.0521	23.0
0.0371	21.5
0.0264	19.9
0.0189	16.7
0.0138	15.1
0.0098	13.5
0.0070	11.9
0.0050	10.3
0.0032	8.7
0.0015	4.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	76%	18%	6%

Description: Dark grey silty SAND

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-04/WSP-04

Sample No. : UD1

Depth (m) : 1.50-2.00

Tested by Faysal Checked by MM Approved by MC

Date : 10/06/20 Date : 13/6/20 Date 13/6/20

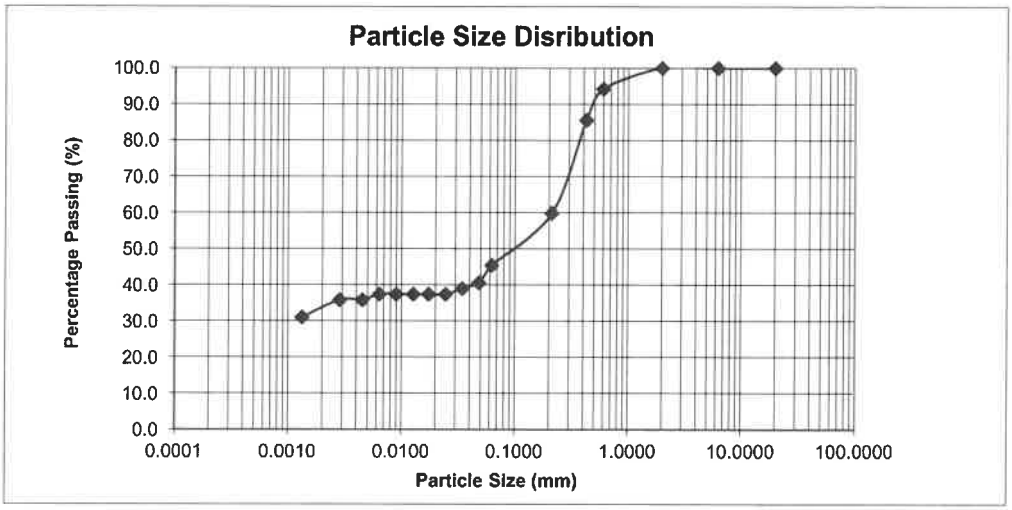
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	94.2
0.425	85.6
0.212	59.8
0.063	45.3
0.0486	40.5
0.0346	38.9
0.0246	37.4
0.0174	37.4
0.0127	37.4
0.0090	37.4
0.0064	37.4
0.0045	35.8
0.0029	35.8
0.0013	31.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	55%	11%	34%

Description: Reddish brown clayey SAND

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-04/WSP-04

Sample No. : UD2

Depth (m) : 5.50-6.00

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	13/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-05/WSP-05

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-05/WSP-05**							
Sample No.			UD1	UD2						
Depth, m		from	2.00	5.00						
		to	2.50	5.50						
Soil			saCl	saSi						
Moisture Content:		%	11	14						
Bulk Density		Mg/m^3	2.19	1.88						
Dry Density		Mg/m^3	1.97	1.65						
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	0	0						
	Sand	%	45	46						
	Silt	%	25	34						
	Clay	%	30	20						
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation & Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-05/WSP-05	UD1	2.00 - 2.50	Dark yellowish brown sandy CLAY
	UD2	5.00 - 5.50	Yellowish brown sandy SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-05/WSP-05	UD1	2.00 - 2.50	11	2.19	1.97
	UD2	5.00 - 5.50	14	1.88	1.65

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

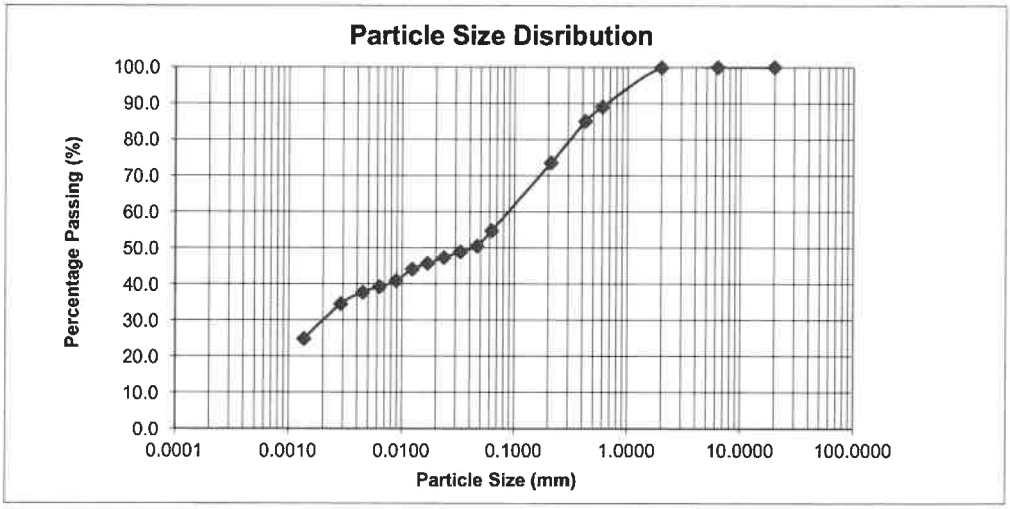
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	99.9
0.600	89.0
0.425	85.0
0.212	73.6
0.063	54.7
0.0466	50.4
0.0332	48.8
0.0236	47.2
0.0168	45.6
0.0124	44.0
0.0089	40.8
0.0063	39.2
0.0045	37.6
0.0029	34.4
0.0014	24.8



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	45%	25%	30%

Description: Dark yellowish brown sandy CLAY

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-05/WSP-05

Sample No. : UD1

Depth (m) : 2.00-2.50

Tested by Faysal Checked by MM 13/6/20 Approved by MC 13/6/20

Date : 10/06/20 Date : Date

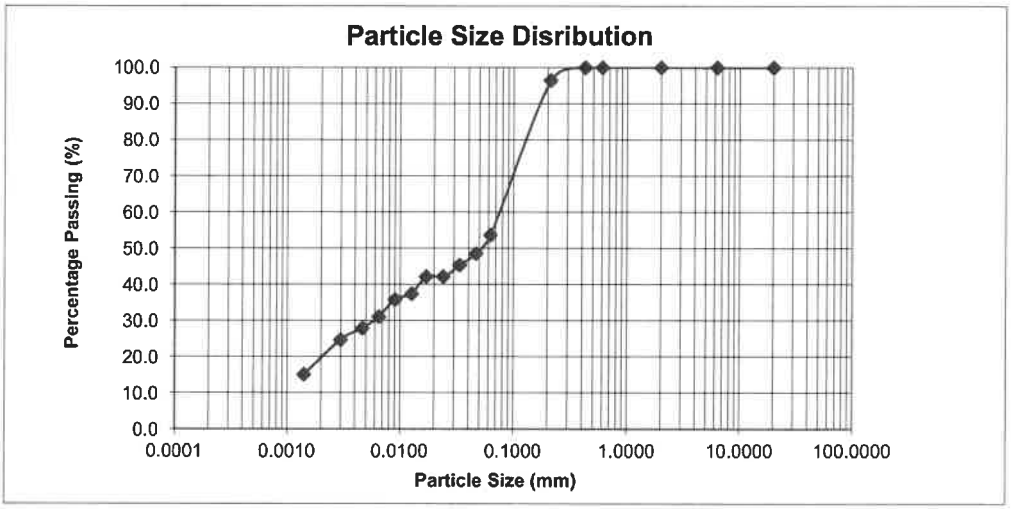
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	100.0
0.425	100.0
0.212	96.4
0.063	53.7
0.0469	48.5
0.0337	45.3
0.0241	42.1
0.0171	42.1
0.0127	37.3
0.0091	35.8
0.0065	31.0
0.0047	27.8
0.0030	24.6
0.0014	15.1



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	46%	34%	20%

Description: Yellowish brown sandy SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-05/WSP-05

Sample No. : UD2

Depth (m) : 5.00-5.50

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	13/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-06/WSP-06

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-06/WSP-06**							
Sample No.			UD1	UD2						
Depth, m		from	2.00	5.50						
		to	2.50	6.00						
Soil			siSa	saSi						
Moisture Content:		%	24	18						
Bulk Density		Mg/m^3	1.97	2.17						
Dry Density		Mg/m^3	1.59	1.84						
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	0	0						
	Sand	%	55	16						
	Silt	%	25	44						
	Clay	%	20	40						
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &
Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-06/WSP-06	UD1	2.00 - 2.50	Reddish brown gravelly silty SAND
	UD2	5.50 - 6.00	Reddish brown sandy SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-06/WSP-06	UD1	2.00 - 2.50	24	1.97	1.59
	UD2	5.50 - 6.00	18	2.17	1.84

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

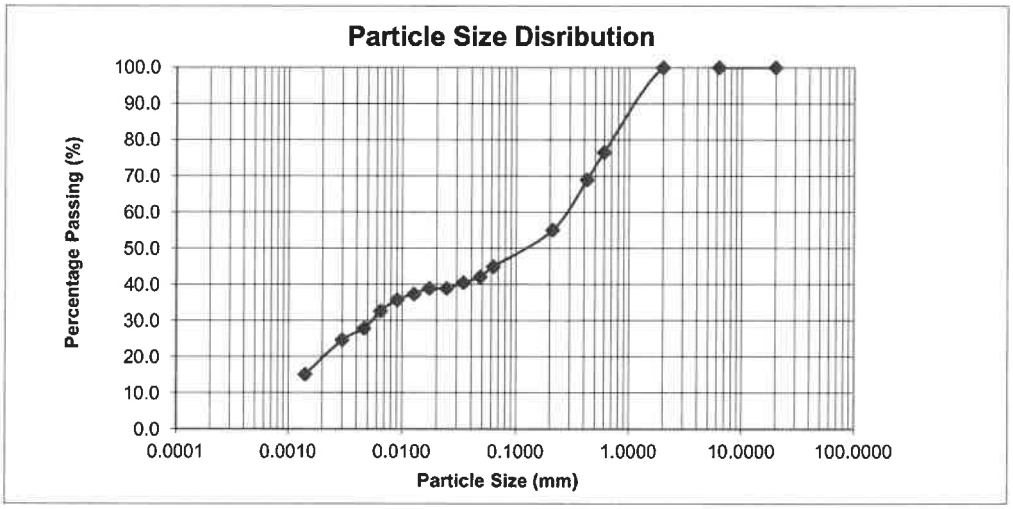
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	76.5
0.425	68.9
0.212	55.0
0.063	44.9
0.0483	42.0
0.0344	40.5
0.0245	38.9
0.0173	38.9
0.0127	37.3
0.0091	35.7
0.0065	32.5
0.0047	27.8
0.0030	24.6
0.0014	15.1



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	55%	25%	20%

Description: Reddish brown gravelly silty SAND

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-06/WSP-06

Sample No. : UD1

Depth (m) : 2.00-2.50

Tested by Faysal Checked by MM Approved by MC

Date : 10/06/20 Date : 13/6/20 Date 13/6/20

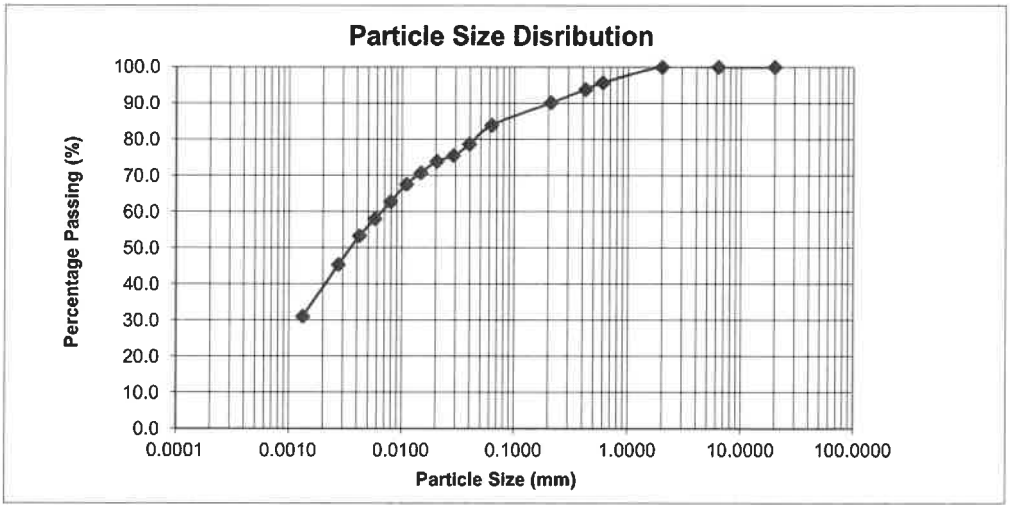
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	95.6
0.425	93.8
0.212	90.1
0.063	83.9
0.0399	78.6
0.0288	75.5
0.0205	73.9
0.0148	70.7
0.0110	67.5
0.0080	62.7
0.0058	58.0
0.0042	53.2
0.0027	45.3
0.0013	31.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	16%	44%	40%

Description: Reddish brown sandy SILT

Project/Location :	Instrumentation & Monitoring Works At Tengah Forest Area
Project No. :	INS20004
BH :	BH-06/WSP-06
Sample No. :	UD2
Depth (m) :	5.50-6.00

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	16/6/20

LABORATORY TEST RESULTS

BOREHOLE NO: BH-07/WSP-07

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**										
Project No. :	**INS20004**										
Borehole No. :			**BH-07/WSP-07**								
Sample No.			UD1	UD2							
Depth, m		from	3.50	7.00							
		to	4.00	7.50							
Soil			siSa	saSi							
Moisture Content:		%	21	*							
Bulk Density		Mg/m^3	1.99	*							
Dry Density		Mg/m^3	1.64	*							
Atterberg Limits	Liquid Limit	%									
	Plastic Limit	%									
	Plasticity Index	%									
Grain Size Distribution	Gravel	%	0	0							
	Sand	%	54	25							
	Silt	%	31	47							
	Clay	%	15	28							
Particle Density											
Unconfined Compression	Shear Strength	kPa									
	Compressive Strength	kPa									
Triaxial Comp. (UU)	Cohesion	kPa									
	Phi angle	°									
Triaxial Comp. (CIU)	Cohesion	kPa									
	Phi angle	°									
Triaxial Comp. (CID)	Cohesion	kPa									
	Phi angle	°									
Consolidation	Initial Void Ratio										
	Degree of Saturation	%									
	Preconsol, Pressure, Pc	kPa									
	Compression Index, Cc										
Direct Shear	Cohesion	kPa									
	Phi angle	°									
Compaction	Maximum Dry Density	Mg/m^3									
	Optimum MC	%									
Rock											
Point Load	Strength Index	MPa									
UCT	Compressive Strength	MPa									
Slake Durability	Index ID_2	%									
Cerchar	Corrected CAI	HRC55									
Constant Head Txl Permeability											
	Kv @ 20 °C	m/s									

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:
* Test is not possible due to sample being slurry.

Prepared by: MM
Date: 13/6/2020

Approved by: MC
Date: 13/6/2020

Ground Instrumentation & Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-07/WSP-07	UD1	3.50 - 4.00	Reddish brown silty SAND
	UD2	7.00 - 7.50	Reddish brown sandy SILT

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-07/WSP-07	UD1	3.50 - 4.00	21	1.99	1.64
	UD2	7.00 - 7.50	*	*	*

* Test is not possible due to sample being slurry.

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

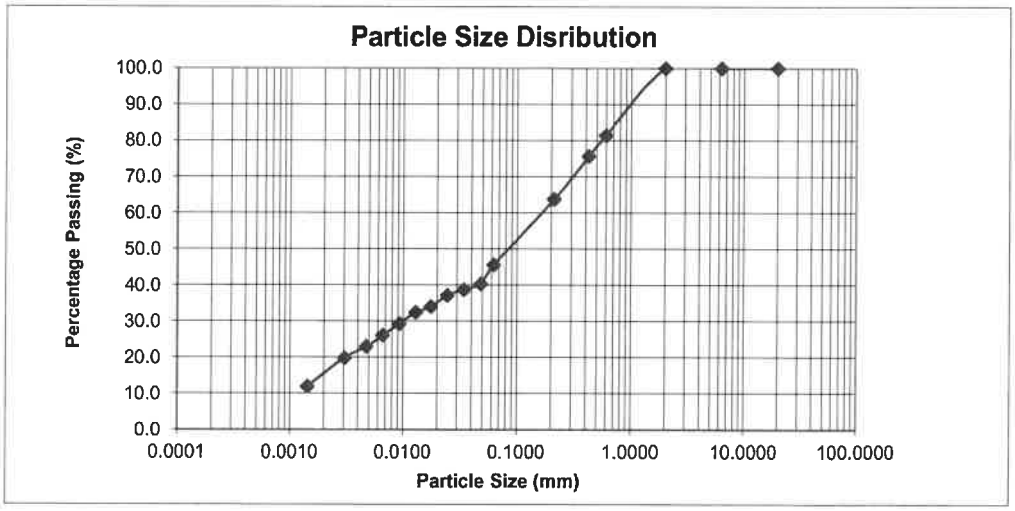
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	81.4
0.425	75.6
0.212	63.7
0.063	45.5
0.0486	40.3
0.0346	38.7
0.0246	37.1
0.0176	34.0
0.0130	32.4
0.0093	29.2
0.0066	26.1
0.0048	22.9
0.0030	19.7
0.0014	11.8



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	54%	31%	15%

Description: Reddish brown silty SAND

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-07/WSP-07

Sample No. : UD1

Depth (m) : 3.50-4.00

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	

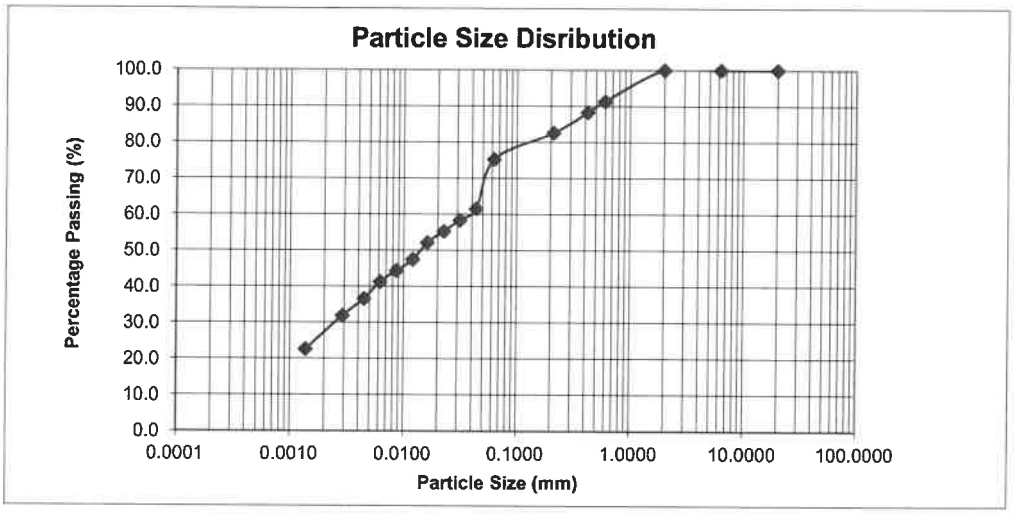
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	100.0
0.600	91.3
0.425	88.2
0.212	82.5
0.063	75.2
0.0437	61.4
0.0314	58.3
0.0226	55.2
0.0162	52.1
0.0121	47.4
0.0087	44.3
0.0062	41.2
0.0045	36.6
0.0029	31.9
0.0014	22.6



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
0%	25%	47%	28%

Description: Reddish brown sandy SILT

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-07/WSP-07

Sample No. : UD2

Depth (m) : 7.00-7.50

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	

LABORATORY TEST RESULTS

BOREHOLE NO: BH-08/WSP-08

Ground Instrumentation & Engineering Pte Ltd

SUMMARY OF TEST RESULTS

Project/Location :	**Instrumentation & Monitoring Works At Tengah Forest Area**									
Project No. :	**INS20004**									
Borehole No. :			**BH-08/WSP-08**							
Sample No.			UD1							
Depth, m		from	3.00							
		to	3.50							
Soil			CI							
Moisture Content:		%	37							
Bulk Density		Mg/m^3	1.93							
Dry Density		Mg/m^3	1.41							
Atterberg Limits	Liquid Limit	%								
	Plastic Limit	%								
	Plasticity Index	%								
Grain Size Distribution	Gravel	%	9							
	Sand	%	8							
	Silt	%	31							
	Clay	%	52							
Particle Density										
Unconfined Compression	Shear Strength	kPa								
	Compressive Strength	kPa								
Triaxial Comp. (UU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CIU)	Cohesion	kPa								
	Phi angle	°								
Triaxial Comp. (CID)	Cohesion	kPa								
	Phi angle	°								
Consolidation	Initial Void Ratio									
	Degree of Saturation	%								
	Preconsol, Pressure, Pc	kPa								
	Compression Index, Cc									
Direct Shear	Cohesion	kPa								
	Phi angle	°								
Compaction	Maximum Dry Density	Mg/m^3								
	Optimum MC	%								
Rock										
Point Load	Strength Index	MPa								
UCT	Compressive Strength	MPa								
Slake Durability	Index ID_2	%								
Cerchar	Corrected CAI	HRC55								
Constant Head Txl Permeability										
	Kv @ 20 °C	m/s								

Legend:
UC - Unconfined Compression
UU - Unconsolidated Undrained
CIU - Consolidated Isotropic Undrained
CID - Consolidated Isotropic Drained
QD - Direct Shear
OED - Oedometer

Remarks:

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &
Engineering Pte Ltd

SOIL DESCRIPTION

ACCREDITED LABORATORY SAC-SINGLAS

Project : **Instrumentation & Monitoring Works At Tengah Forest Area**

Job No. : **INS20004**

Borehole Number	Sample Number	Depth (m)	Soil Description
BH-08/WSP-08	UD1	3.00 - 3.50	Reddish brown CLAY

The results reported herein have been performed in accordance with the terms of accreditation under the Singapore Accreditation Council - Singapore Laboratory Accreditation Scheme (SAC-SINGLAS).

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

Ground Instrumentation &

MOISTURE CONTENT & BULK DENSITY

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Project : Instrumentation & Monitoring Works At Tengah Forest Area

Job No. : INS20004

Borehole Number	Sample Number	Depth (m)	Moisture Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)
BH-08/WSP-08	UD1	3.00 - 3.50	37	1.93	1.41

Prepared by: MM

Date: 13/6/2020

Approved by: MC

Date: 13/6/2020

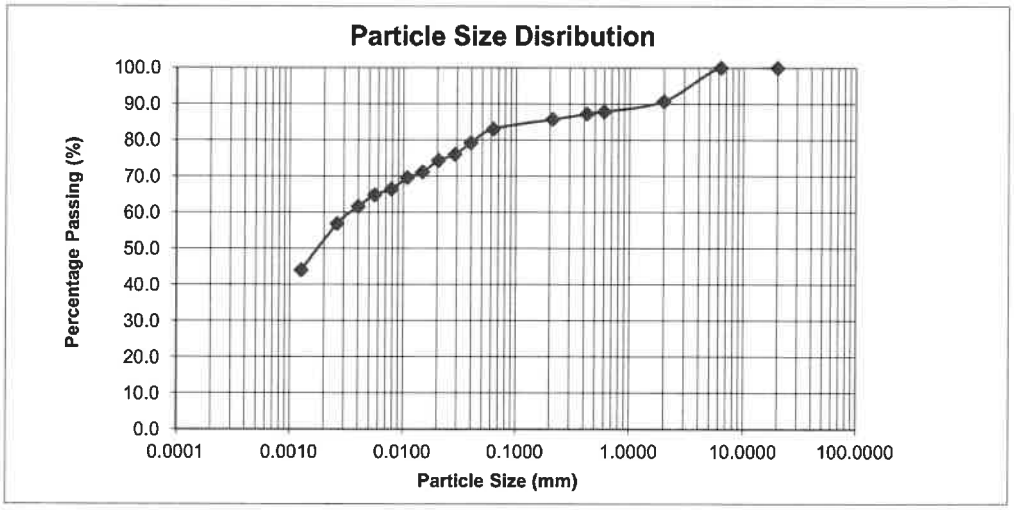
Ground Instrumentation & Engineering Pte Ltd

PARTICLE SIZE DISTRIBUTION

BS 1377 : Part 2 : 1990

ACCREDITED LABORATORY SAC-SINGLAS

Particle Size (mm)	Percentage Passing (%)
20.000	100.0
6.300	100.0
2.000	90.7
0.600	87.8
0.425	87.2
0.212	85.7
0.063	83.0
0.0399	79.2
0.0288	76.0
0.0205	74.4
0.0148	71.2
0.0109	69.6
0.0079	66.4
0.0056	64.8
0.0040	61.6
0.0026	56.8
0.0013	44.0



	CLAY	SILT	SAND	GRAVEL	C	

GRAVEL	SAND	SILT	CLAY
9%	8%	31%	52%

Description: Reddish brown CLAY

Project/Location : Instrumentation & Monitoring Works At Tengah Forest Area

Project No. : INS20004

BH : BH-08/WSP-08

Sample No. : UD1

Depth (m) : 3.00-3.50

Tested by	Faysal	Checked by	MM	Approved by	MC
Date :	10/06/20	Date :	13/6/20	Date	

Certification by Professional Engineer for Site Investigation Report

1. I, Kevin Quan Chee Nurn the Professional Engineer, PE Registration No. 4102 certify that **"Factual Report on Instrumentation & Monitoring Works at Tengah Forest Area"** comprising all field and/or laboratory data, tests and results therein has been carried out by me or under my supervision or direction and I have verified the accuracy of the information given in the site investigation report and to the best of my knowledge and belief, all have been prepared in compliance in all respects with the provisions of the Building Control Act and Regulations, relevant Codes of Practice and Standards.

2. I further certify that I have the appropriate qualifications and experience, and I am familiar with the purpose of the investigation for which this Site Investigation Report is prepared in reference to Project Ref. No:_____

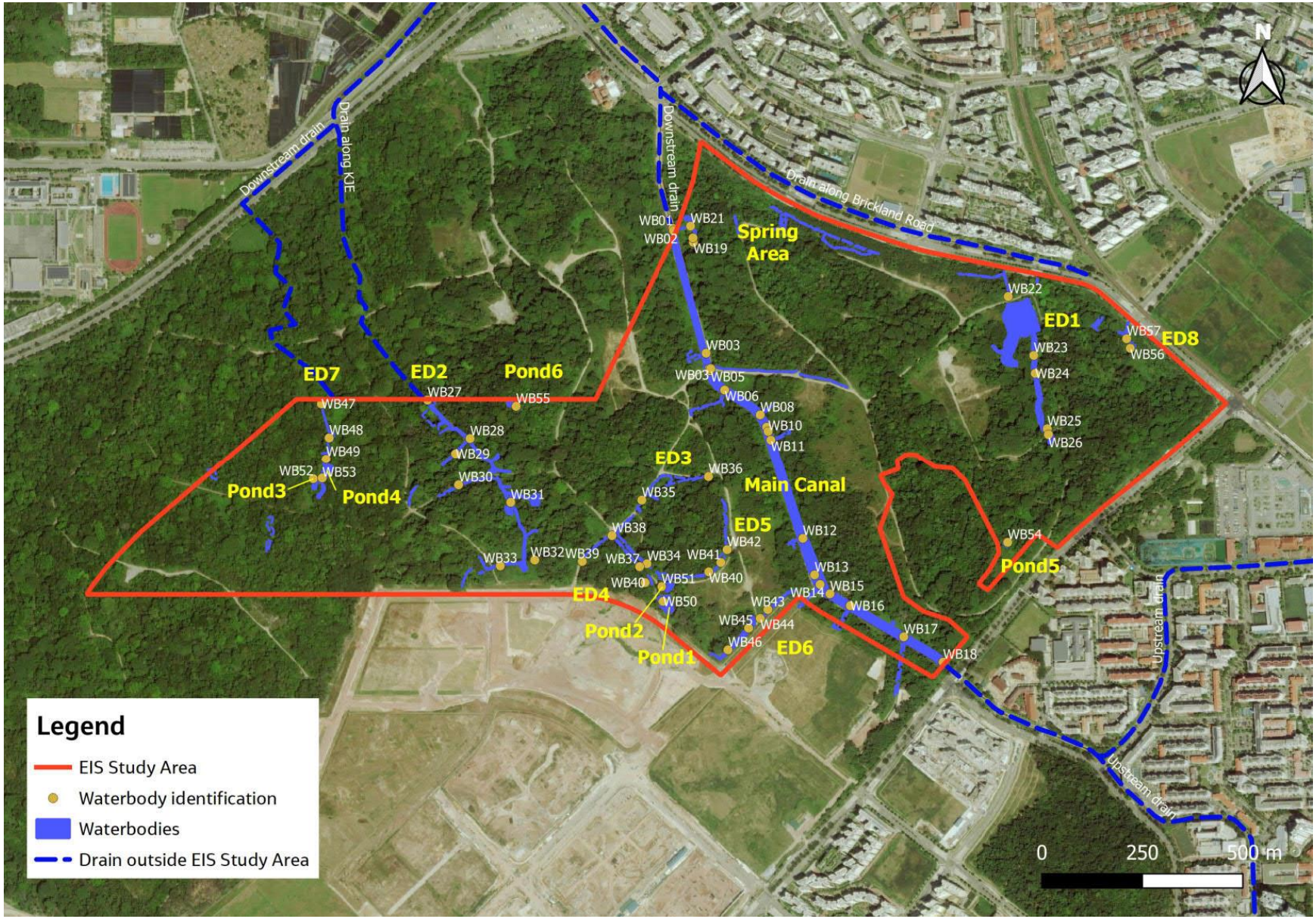
3. Total number of pages in the Site Investigation Report of is **175** (excluding cover page).



Kevin Quan Chee Nurn
Professional Engineer for Site Investigation

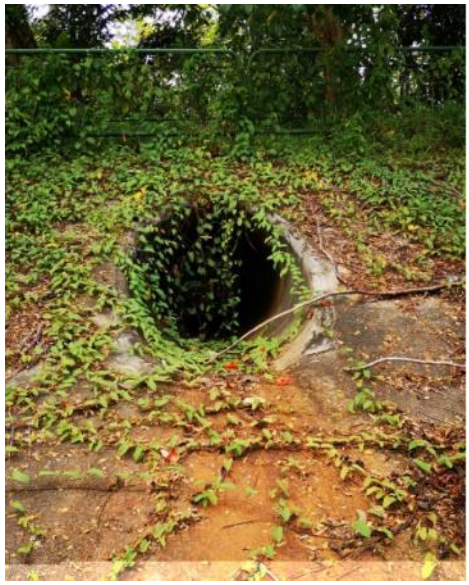
Date: 16 June 2020

Appendix 5A: Photographic Log of Surface Hydrology


N
Downstream drain
Drain along KJE
Downstream drain
Drain along Brickland Road
Spring Area
ED1
ED8
ED7
ED2
Pond6
Pond3
Pond4
ED3
Main Canal
ED5
ED4
Pond2
Pond1
ED6
Pond5
Upstream drain
Upstream drain
WB01
WB02
WB21
WB19
WB22
WB57
WB56
WB23
WB24
WB25
WB26
WB03
WB03
WB05
WB06
WB08
WB10
WB11
WB27
WB47
WB55
WB48
WB28
WB49
WB29
WB52
WB53
WB30
WB31
WB36
WB35
WB38
WB42
WB12
WB54
WB33
WB32
WB39
WB37
WB34
WB41
WB13
WB40
WB51
WB40
WB14
WB15
WB50
WB43
WB16
WB45
WB44
WB17
WB46
WB18
Legend
EIS Study Area
Waterbody identification
Waterbodies
Drain outside EIS Study Area
0
250
500 m

Details	Photograph
Photograph ID: WB01 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Overview of Main Canal. Lined trapezoidal drain. Photo was taken during dry weather flow at the most downstream point of Main canal within EIS Study Area, looking upstream.	
Photograph ID: WB02 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Pipe drain from Spring Area.	
Photograph ID: WB03 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Box culvert for flow from western area of Main Canal	

Details	Photograph
Photograph ID: WB04 **Photo Location:** Main Canal (bridge) **Survey Date:** Jan 7, 2020 **Field Observation:** Overview of midstream of Main Canal, a lined trapezoidal drain. Photo was taken from bridge, looking downstream. Dry weather flow.	
Photograph ID: WB05 **Photo Location:** Main Canal (bridge) **Survey Date:** Jan 7, 2020 **Field Observation:** Overview of midstream of Main canal, a lined trapezoidal drain. Photo was taken from bridge, looking upstream.	
Photograph ID: WB06 **Photo Location:** Main Canal (bridge) **Survey Date:** Jan 7, 2020 **Field Observation:** Pipe drain for flow from eastern area of Main Canal.	

Details	Photograph
Photograph ID: WB07 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation :** Pipe drain for flow from western area of Main Canal.	
Photograph ID: WB08 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Pipe drain for flow from eastern area of Main Canal.	
Photograph ID: WB09 **Photo Location:** Main Canal **Survey Date:** Jun 16, 2020 **Field Observation:** Bending at Main Canal. Photo was taken looking upstream (southerly direction). Photo was taken after a rainfall. Fast flowing water were observed.	

Details	Photograph
Photograph ID: WB10 **Photo Location:** Main Canal **Survey Date:** Jun 16, 2020 **Field Observation:** Overview of midstream of Main Canal, looking upstream. Photo was taken after a rainfall. Fast flowing water were observed.	
Photograph ID: WB11 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Pipe drain for flow from eastern area of Main Canal.	
Photograph ID: WB12 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Pipe drain for flow from western area of Main Canal.	

Details	Photograph
Photograph ID: WB13 **Photo Location:** Main Canal **Survey Date:** Jun 16, 2020 **Field Observation:** Bending at Main Canal. Photo was taken after a rainfall. Fast flowing water were observed.	
Photograph ID: WB14 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Lined trapezoidal drain flowing from the western area to Main Canal.	
Photograph ID: WB15 **Photo Location:** Main Canal **Survey Date:** Jun 16, 2020 **Field Observation:** Overview of midstream of Main Canal, looking upstream. Photo was taken after a rainfall. Fast flowing water were observed.	

Details	Photograph
Photograph ID: WB16 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Box culvert and lined drain flowing from western area to Main Canal.	
Photograph ID: WB17 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Lined drain flowing from western area to Main Canal.	
Photograph ID: WB18 **Photo Location:** Main Canal **Survey Date:** Mar 16, 2020 **Field Observation:** Overview of upstream of Main Canal. Photo was taken at the most upstream point of Main Canal within EIS Study Area, looking downstream.	

Details	Photograph
Photograph ID: WB19 **Photo Location:** Spring Area **Survey Date:** Jun 16, 2020 **Field Observation:** Slow-flowing open-country streams characterised by low canopy cover. Situated within a patch of farmland.	
Photograph ID: WB20 **Photo Location:** Spring Area **Survey Date:** Jun 16, 2020 **Field Observation:** Slow-flowing open-country streams with soft bank and riparian vegetation with low-canopy cover. Situated within a patch of farmland.	
Photograph ID: WB21 **Photo Location:** Spring Area **Survey Date:** Jun 16, 2020 **Field Observation:** Slow-flowing open-country streams with soft bank and riparian vegetation with low-canopy cover. Situated within a patch of farmland.	

Details	Photograph
Photograph ID: WB22 **Photo Location:** Earth Drain 1 **Survey Date:** Mar 1, 2020 **Field Observation:** Downstream of Earth Drain 1, looking downstream. The downstream part of Earth Drain 1 is lined.	
Photograph ID: WB23 **Photo Location:** Earth Drain 1 **Survey Date:** Feb 5, 2020 **Field Observation:** Midstream of Earth Drain 1 was noted wet but very low flow or semi-stagnant, looking upstream. Semi open-country stream, soft bank covered with sparse riparian vegetation.	
Photograph ID: WB24 **Photo Location:** Earth Drain1 **Survey Date:** Feb 5, 2020 **Field Observation:** Midstream of Earth Drain 1 was noted dry, looking upstream. Soft bank with high accumulation of leaf litter.	

Details	Photograph
Photograph ID: WB25 **Photo Location:** Earth Drain 1 **Survey Date:** Mar 1, 2020 **Field Observation:** Culvert connecting Earth Drain 1 to a pond (next photo), looking upstream.	
Photograph ID: WB26 **Photo Location:** Earth Drain 1 **Survey Date:** April 3, 2020 **Field Observation:** Pond was noted at upstream point of Earth Drain 1. Well shaded.	
Photograph ID: WB27 **Photo Location:** Earth Drain 2 **Survey Date:** Mar Sep 3, 2020 **Field Observation:** Downstream part of Earth Drain 2, near the boundary of EIS Study Area, looking downstream. Soft bank stream with riparian vegetation. Slow flowing water towards northerly direction.	

Details	Photograph
Photograph ID: WB28 **Photo Location:** Earth Drain 2 **Survey Date:** 3 Sep 2020 **Field Observation:** Midstream of Earth Drain 2 with inflow from western earth drain (Photograph ID WB29). Soft bank stream with riparian vegetation. Slow flowing water towards northerly direction.	
Photograph ID: WB29 **Photo Location:** Earth Drain 2 **Survey Date:** 3 Sep 2020 **Field Observation:** Earth drain flowing to main Earth Drain 2. Soft bank stream with riparian vegetation. Slow flowing water towards northerly direction.	
Photograph ID: WB30 **Photo Location:** Earth Drain 2 **Survey Date:** Jan 7, 2020; Sep 3, 2020 **Field Observation:** Earth drain along the internal track. Dried with no water observed. Soft bank stream with riparian vegetation.	

Details	Photograph
Photograph ID: WB31 **Photo Location:** Earth Drain 2 **Survey Date:** Jan 7, 2020; Sep 9, 2020 **Field Observation:** Midstream of Earth Drain 2 , looking upstream. Slow-flowing with vegetation at the bank of stream. Soft bank stream with riparian vegetation. Slow flowing water towards northerly direction.	
Photograph ID: WB32 **Photo Location:** Earth Drain 2 **Survey Date:** Jan 7, 2020; Sep 9, 2020 **Field Observation:** Upstream of Earth Drain 2 was noted covered with grass, looking upstream. Slow-flowing towards northerly direction.	
Photograph ID: WB33 **Photo Location:** Earth Drain 2 **Survey Date:** Jan 7, 2020; Sep 14, 2020 **Field Observation:** Earth drain flowing to main Earth Drain 2, looking downstream. Slow-flowing soft bank stream with riparian vegetation.	

Details	Photograph
Photograph ID: WB34 **Photo Location:** Earth Drain 3 **Survey Date:** Oct 13, 2020 **Field Observation:** The downstream point of Earth Drain 3.	
Photograph ID: WB35 **Photo Location:** Earth Drain 3 **Survey Date:** Oct 13, 2020 **Field Observation:** Midstream of Earth Drain 3.	
Photograph ID: WB36 **Photo Location:** Earth Drain 3 **Survey Date:** Oct 13, 2020 **Field Observation:** The upstream point of Earth Drain 3.	

Details	Photograph
Photograph ID: WB37 **Photo Location:** Earth Drain 4 **Survey Date:** Sep 14, 2020 **Field Observation:** Downstream of Earth Drain 4.	
Photograph ID: WB38 **Photo Location:** Earth Drain 4 **Survey Date:** Sep 14, 2020 **Field Observation:** Midstream of Earth Drain 4.	
Photograph ID: WB39 **Photo Location:** Earth Drain 4 **Survey Date:** Sep 14, 2020 **Field Observation:** Upstream of Earth Drain 4.	

Details	Photograph
Photograph ID: WB40 **Photo Location:** Earth Drain 5 **Survey Date:** Aug 26, 2020 **Field Observation:** Downstream of Earth Drain 5.	
Photograph ID: WB41 **Photo Location:** Earth Drain 5 **Survey Date:** Aug 26, 2020 **Field Observation:** Midstream of Earth Drain 5.	
Photograph ID: WB42 **Photo Location:** Earth Drain 5 **Survey Date:** Aug 26, 2020 **Field Observation:** Midstream of Earth Drain 5 was noted dry.	

Details	Photograph
Photograph ID: WB43 **Photo Location:** Earth Drain 6 **Survey Date:** Aug 26, 2020 **Field Observation:** Downstream of Earth Drain 6 is lined. Further downstream of Earth Drain 6 is non-accessible with dense vegetation/ shrubs/ branches of trees.	
Photograph ID: WB44 **Photo Location:** Earth Drain 6 **Survey Date:** Aug 26, 2020 **Field Observation:** Midstream of Earth Drain 6, looking upstream. Soft high and steep bank stream. One bank is partially shaded by trees.	
Photograph ID: WB45 **Photo Location:** Earth Drain 6 **Survey Date:** Aug 26, 2020 **Field Observation:** Midstream of Earth Drain 6.	

Details	Photograph
Photograph ID: WB46 **Photo Location:** Earth Drain 6 **Survey Date:** Aug 26, 2020 **Field Observation:** Upstream of Earth Drain 6, looking downstream.	
Photograph ID: WB47 **Photo Location:** Earth Drain 7 **Survey Date:** Aug 27, 2020; Sep 1, 2020 **Field Observation:** Downstream of Earth Drain 7 was dried. Soft bank stream with closed-canopy at both sides. Slow flowing water towards northerly direction were observed on Aug 27, 2020.	
Photograph ID: WB48 **Photo Location:** Earth Drain 7 **Survey Date:** Aug 27, 2020; Sep 1, 2020; Oct 13, 2020 **Field Observation:** Midstream. Puddle of water was noted. Soft bank stream with slightly open-canopy at both sides. Slow flowing water towards northerly direction were observed on Aug 27, 2020.	

Details	Photograph
Photograph ID: WB49 **Photo Location:** Earth Drain 7 **Survey Date:** Aug 27, 2020; Sep 1, 2020	
Field Observation: Upstream was noted dried during water quality sampling on Sep 1, 2020. Soft bank stream with slightly open-canopy at both sides. Slow flowing water towards northerly direction were observed on Aug 27, 2020.	
Photograph ID: WB50 **Photo Location:** Pond1 **Survey Date:** Sep 14, 2020 **Field Observation:** Overview of Pond1. A large open-country pond that is situated in an area of scrubland and herbaceous vegetation. The vegetation on the edge of the pond is very lush, and most of the water surface is covered by floating plants.	
Photograph ID: WB51 **Photo Location:** Pond2 **Survey Date:** Sep 14, 2020 **Field Observation:** Overview of Pond2. Large open-country pond in an area of scrubland and herbaceous vegetation. Pond is covered vegetation and marshy soft land.	

Details	Photograph
Photograph ID: WB52 **Photo Location:** Pond3 **Survey Date:** Aug 27, 2020; Sep 1, 2020 **Field Observation:** Overview of Pond3. Surrounded by trees canopy with centre expose to sunlight. Pond covered floating aquatic plants/ algae.	
Photograph ID: WB53 **Photo Location:** Pond4 **Survey Date:** Aug 27, 2020; Sep 1, 2020 **Field Observation:** Overview of Pond4. Surrounded by trees canopy with centre expose to sunlight. Pond covered floating aquatic plants/ algae.	
Photograph ID: WB54 **Photo Location:** Pond5 **Survey Date:** Jun 30, 2020 **Field Observation:** Overview of Pond5	

Details	Photograph
Photograph ID: WB55 **Photo Location:** Pond6 **Survey Date:** Jun 9, 2020 **Field Observation:** Overview of Pond6. The vegetation along the edges of the ponds is sparse. Pond was littered with significant amounts of trash during the time of visit.	
Photograph ID: WB56 **Photo Location:** Earth Drain 8 **Survey Date:** Jul 14, 2020 **Field Observation:** Overview of upstream of Earth Drain 8. Surrounded by vegetation and trees.	
Photograph ID: WB57 **Photo Location:** Earth Drain 8 **Survey Date:** Oct 13, 2020 **Field Observation:** Overview of midstream of Earth Drain 8.	

Appendix 6A: Photographic Log of Water Quality Baseline Sampling

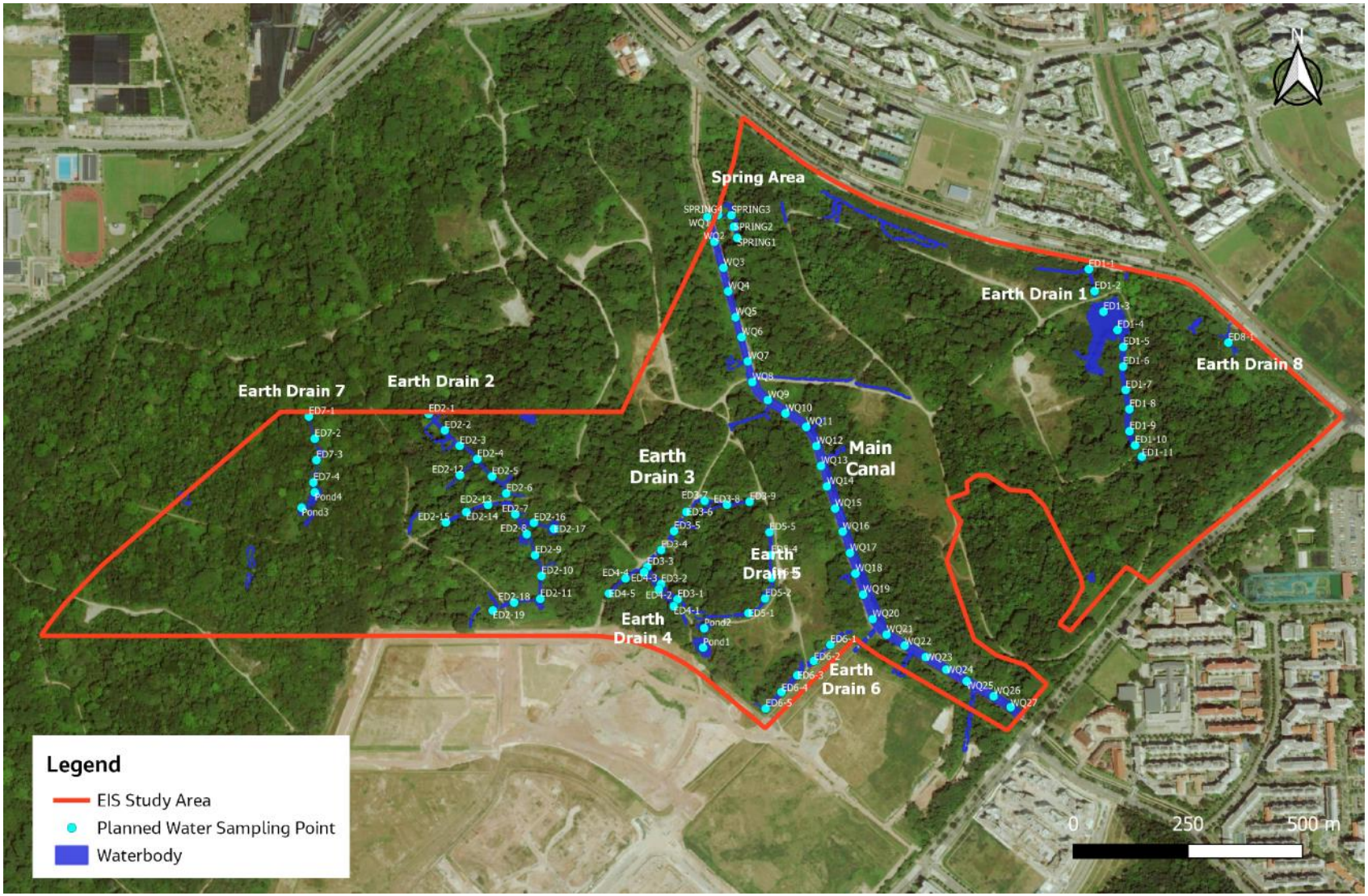


Figure 6A.1: Locations of Identified Water Quality Points of Every 50 m Interval for Dry and Wet Event Sampling

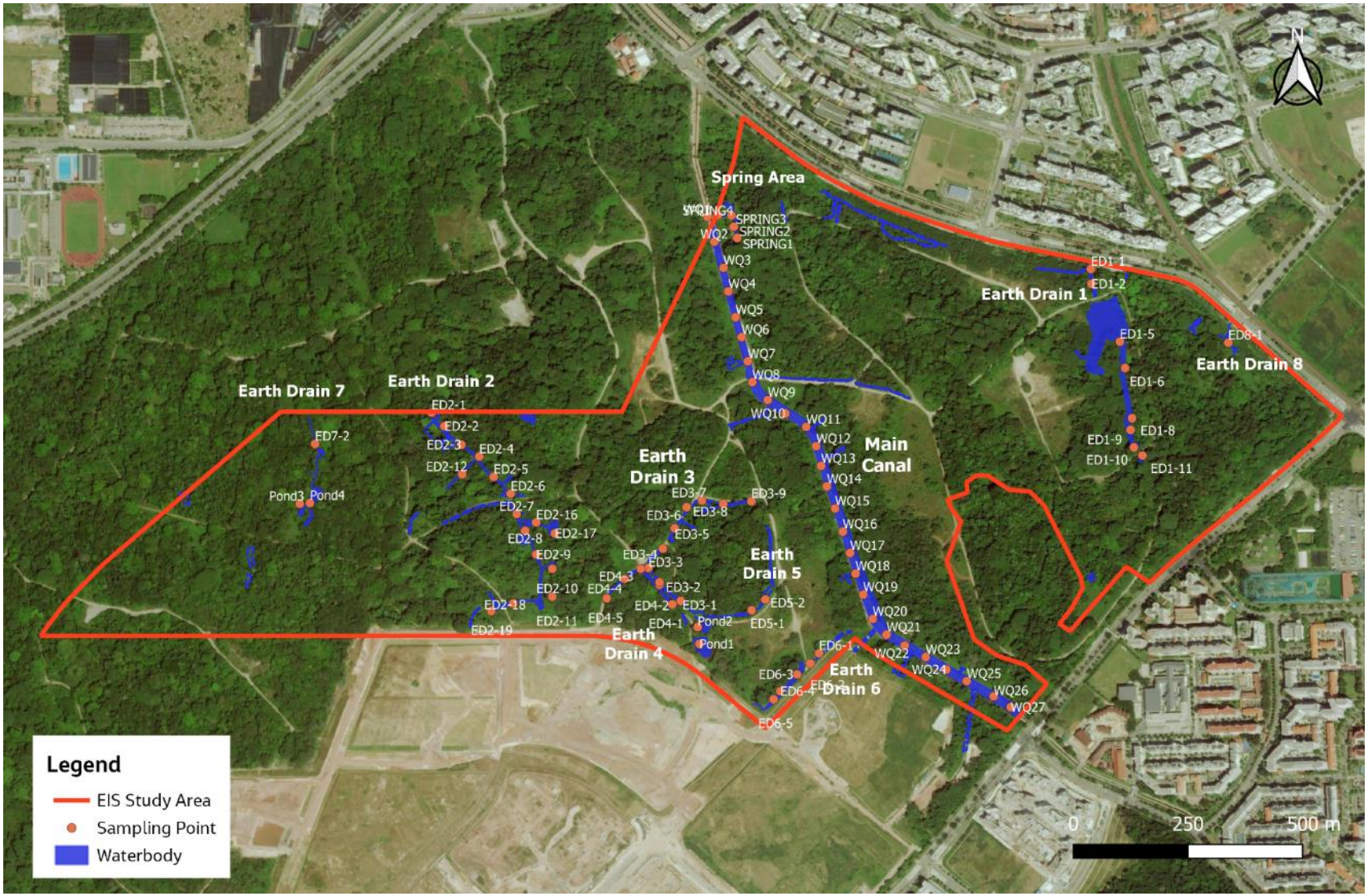


Figure 6A.2: Locations of Water Quality Sampling during Wet Event

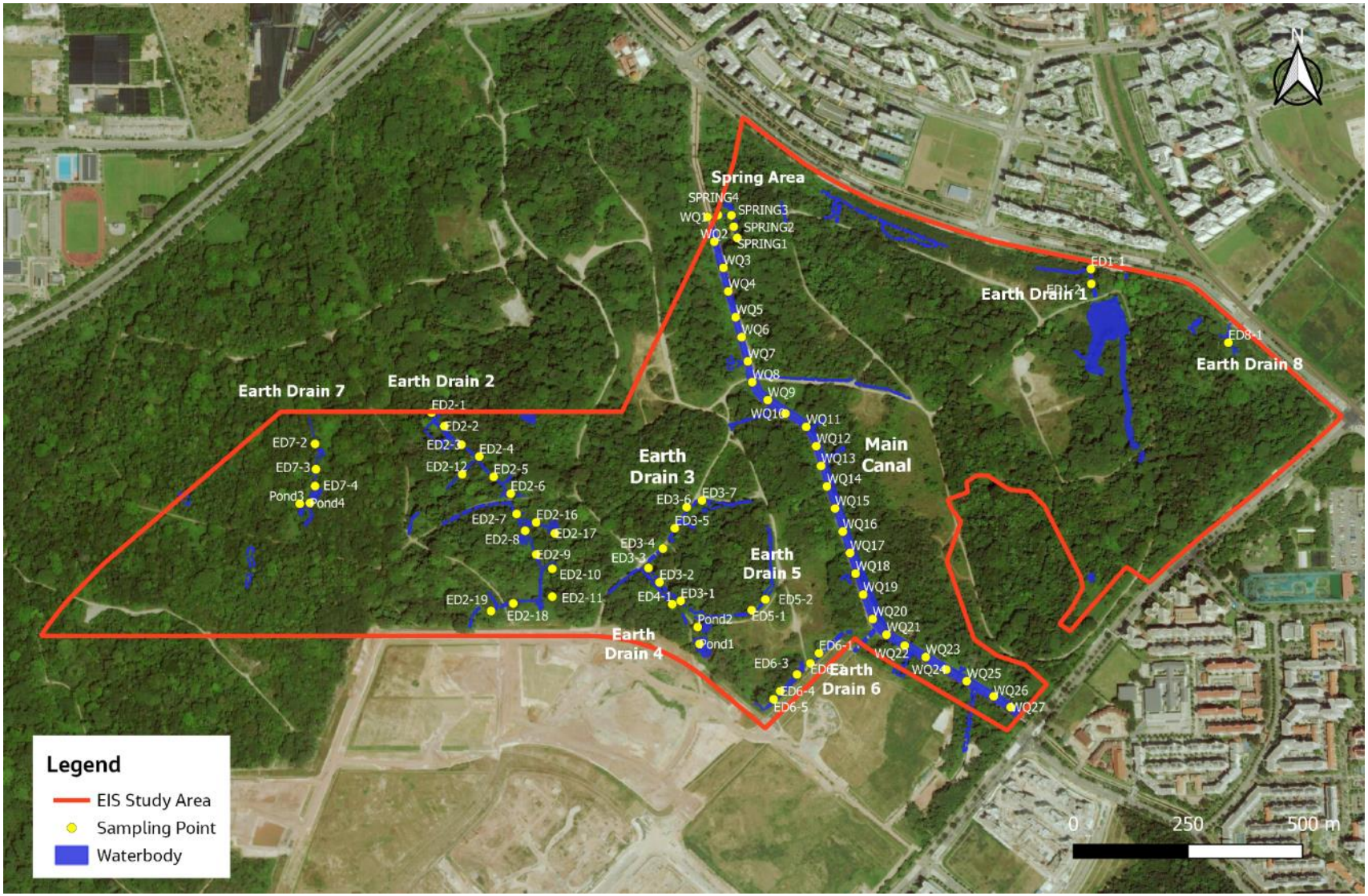


Figure 6A.3: Locations of Water Quality Sampling during Dry Event

Details	Photograph	
Photograph ID: 1 **Coordinates:** 01°22'22.80"N 103°44'09.24"E **Sampling Location:** Main Canal WQ1	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 
Photograph ID: 2 **Coordinates:** 01°22'21.00"N 103°44'09.96"E **Sampling Location:** Main Canal WQ2	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 

Details	Photograph	
Photograph ID: 3 **Coordinates:** 01°22'19.20"N 103°44'10.32"E **Sampling Location:** Main Canal WQ3	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 
Photograph ID: 4 **Coordinates:** 01°22'17.40"N 103°44'10.68"E **Sampling Location:** Main Canal WQ4	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 

Details	Photograph	
Photograph ID: 5 **Coordinates:** 01°22'15.60"N 103°44'11.40"E **Sampling Location:** Main Canal WQ5	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 
Photograph ID: 6 **Coordinates:** 01°22'14.16"N 103°44'11.76"E **Sampling Location:** Main Canal WQ6	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 

Details	Photograph	
Photograph ID: 7 **Coordinates:** 01°22'12.72"N 103°44'12.12"E **Sampling Location:** Main Canal WQ7	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 02 Apr 2020 
Photograph ID: 8 **Coordinates:** 01°22'11.28"N 103°44'12.48"E **Sampling Location:** Main Canal WQ8	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 9 **Coordinates:** 01°22'09.84"N 103°44'13.56"E **Sampling Location:** Main Canal WQ9	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 10 **Coordinates:** 01°22'08.76"N 103°44'15.00"E **Sampling Location:** Main Canal WQ10	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 11 **Coordinates:** 01°22'08.04"N 103°44'16.44"E **Sampling Location:** Main Canal WQ11	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 12 **Coordinates:** 01°22'06.60"N 103°44'17.16"E **Sampling Location:** Main Canal WQ12	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 13 **Coordinates:** 01°22'05.16"N 103°44'17.52"E **Sampling Location:** Main Canal WQ13	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 14 **Coordinates:** 01°22'03.72"N 103°44'17.88"E **Sampling Location:** Main Canal WQ14	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 15 **Coordinates:** 01°22'02.28"N 103°44'18.24"E **Sampling Location:** Main Canal WQ15	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 16 **Coordinates:** 01°22'00.48"N 103°44'18.96"E **Sampling Location:** Main Canal WQ16	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 17 **Coordinates:** 01°21'59.04"N 103°44'19.32"E **Sampling Location:** Main Canal WQ17	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 18 **Coordinates:** 01°21'57.60"N 103°44'19.68"E **Sampling Location:** Main Canal WQ18	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 19 **Coordinates:** 01°21'56.16"N 103°44'20.40"E **Sampling Location:** Main Canal WQ19	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 20 **Coordinates:** 01°21'54.36"N 103°44'21.12"E **Sampling Location:** Main Canal WQ20	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

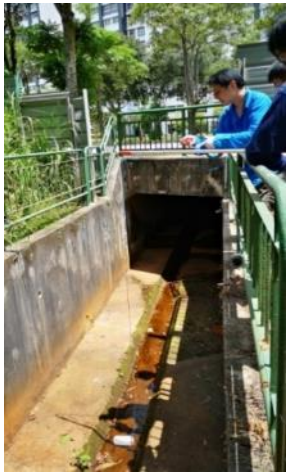
Details	Photograph	
Photograph ID: 21 **Coordinates:** 01°21'53.16"N 103°44'21.96"E **Sampling Location:** Main Canal WQ21	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 22 **Coordinates:** 01°21'52.56"N 103°44'23.28"E **Sampling Location:** Main Canal WQ22	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 23 **Coordinates:** 01°21'51.48"N 103°44'24.72"E **Sampling Location:** Main Canal WQ23	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 24 **Coordinates:** 01°21'50.76"N 103°44'26.16"E **Sampling Location:** Main Canal WQ24	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 25 **Coordinates:** 01°21'49.68"N 103°44'27.60"E **Sampling Location:** Main Canal WQ25	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 26 **Coordinates** 01°21'48.60"N 103°44'29.40"E **Sampling Location:** Main Canal WQ26	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 27 **Coordinates:** 01°21'47.88"N 103°44'30.84"E **Sampling Location:** Main Canal WQ27	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 28 **Coordinates:** 01°22'21.36"N 103°44'11.40"E **Sampling Location:** Spring Area SPRING1	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 29 **Coordinates:** 01°22'22.08"N 103°44'11.04"E **Sampling Location:** Spring Area SPRING2	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 30 **Coordinates:** 01°22'22.97"N 103°44'11.01"E **Sampling Location:** Spring Area SPRING3	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 

Details	Photograph	
Photograph ID: 31 **Coordinates:** 01°22'23.16"N 103°44'09.96"E **Sampling Location:** Spring Area SPRING4	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 16 Jun 2020 
Photograph ID: 32 **Coordinates:** 01°22'19.20"N 103°44'36.24"E **Sampling Location:** Earth Drain 1 ED1-1	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 03 Apr 2020 

Details	Photograph	
Photograph ID: 33 **Coordinates:** 01°22'18.12"N 103°44'36.24"E **Sampling Location:** Earth Drain 1 ED1-2	**Dry Event Sampling Date:** 16 Mar 2020 	**Wet Event Sampling Date:** 03 Apr 2020 
Photograph ID: 34 **Coordinates:** 01°22'13.99"N 103°44'38.43"E **Sampling Location:** Earth Drain 1 ED1-5	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 

Details	Photograph	
Photograph ID: 35 **Coordinates:** 01°22'12.12"N 103°44'38.79"E **Sampling Location:** Earth Drain 1 ED1-6	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 
Photograph ID: 36 **Coordinates:** 01°22'08.55"N 103°44'39.29"E **Sampling Location:** Earth Drain 1 ED1-8	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 

Details	Photograph	
Photograph ID: 37 **Coordinates:** 01°22'07.72"N 103°44'39.18"E **Sampling Location:** Earth Drain 1 ED1-9	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 
Photograph ID: 38 **Coordinates:** 01°22'06.47"N 103°44'39.42"E **Sampling Location:** Earth Drain 1 ED1-10	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 

Details	Photograph	
Photograph ID: 39 **Coordinates:** 01°22'05.90"N 103°44'40.02"E **Sampling Location:** Earth Drain 1 ED1-11	**Dry Event Sampling Date:** 16 Mar 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 03 Apr 2020 
Photograph ID: 40 **Coordinates:** 01°22'8.94"N 103°43'49.86"E **Sampling Location:** Earth Drain 2 ED2-1	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 

Details	Photograph	
Photograph ID: 41 **Coordinates:** 01°22'7.98"N 103°43'50.76"E **Sampling Location:** Earth Drain 2 ED2-2	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 
Photograph ID: 42 **Coordinates:** 01°22'6.66"N 103°43'51.96"E **Sampling Location:** Earth Drain 2 ED2-3	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 

Details	Photograph	
Photograph ID: 43 **Coordinates:** 01°22'5.82"N 103°43'53.22"E **Sampling Location:** Earth Drain 2 ED2-4	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 
Photograph ID: 44 **Coordinates:** 01°22'4.38"N 103°43'54.24"E **Sampling Location:** Earth Drain 2 ED2-5	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 

Details	Photograph	
Photograph ID: 45 **Coordinates:** 01°22'3.18"N 103°43'55.44"E **Sampling Location:** Earth Drain 2 ED2-6	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 
Photograph ID: 46 **Coordinates:** 01°22'1.74"N 103°43'55.86"E **Sampling Location:** Earth Drain 2 ED2-7	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 

Details	Photograph	
Photograph ID: 47 **Coordinates:** 01°22'0.54"N 103°43'56.46"E **Sampling Location:** Earth Drain 2 ED2-8	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 
Photograph ID: 48 **Coordinates:** 01°21'58.86"N 103°43'57.24"E **Sampling Location:** Earth Drain 2 ED2-9	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 

Details	Photograph	
Photograph ID: 49 **Coordinates:** 01°21'57.84"N 103°43'58.38"E **Sampling Location:** Earth Drain 2 ED2-10	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 
Photograph ID: 50 **Coordinates:** 01°21'55.86"N 103°43'58.38"E **Sampling Location:** Earth Drain 2 ED2-11	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 

Details	Photograph	
Photograph ID: 51 **Coordinates:** 01°22'4.56"N 103°43'52.02"E **Sampling Location:** Earth Drain 2 ED2-12	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 03 Sep 2020 
Photograph ID: 52 **Coordinates:** 01°22'1.14"N 103°43'57.24"E **Sampling Location:** Earth Drain 2 ED2-16	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 

Details	Photograph	
Photograph ID: 53 **Coordinates:** 01°22'0.36"N 103°43'58.56"E **Sampling Location:** Earth Drain 2 ED2-17	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 10 Sep 2020 
Photograph ID: 54 **Coordinates:** 01°21'55.38"N 103°43'55.62"E **Sampling Location:** Earth Drain 2 ED2-18	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 55 **Coordinates:** 01°21'54.84"N 103°43'54.06"E **Sampling Location:** Earth Drain 2 ED2-19	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 56 **Coordinates:** 01°21'55.56"N 103°44'7.44"E **Sampling Location:** Earth Drain 3 ED3-1	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 57 **Coordinates:** 01°21'56.88"N 103°44'5.94"E **Sampling Location:** Earth Drain 3 ED3-2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 58 **Coordinates:** 01°21'57.9"N 103°44'5.16"E **Sampling Location:** Earth Drain 3 ED3-3	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 59 **Coordinates:** 01°21'59.28"N 103°44'06.18"E **Sampling Location:** Earth Drain 3 ED3-4	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 29 Sep 2020 
Photograph ID: 60 **Coordinates:** 01°22'00.72"N 103°44'07.02"E **Sampling Location:** Earth Drain 3 ED3-5	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 29 Sep 2020 

Details	Photograph	
Photograph ID: 61 **Coordinates:** 01°22'02.22"N 103°44'07.86"E **Sampling Location:** Earth Drain 3 ED3-6	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 29 Sep 2020 
Photograph ID: 62 **Coordinates:** 01°22'02.70"N 103°44'08.94"E **Sampling Location:** Earth Drain 3 ED3-7	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 29 Sep 2020 

Details	Photograph	
Photograph ID: 63 **Coordinates:** 01°22'02.46"N 103°44'10.44"E **Sampling Location:** Earth Drain 3 ED3-8	**Dry Event Sampling Date:** 13 Oct 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 29 Sep 2020 
Photograph ID: 64 **Coordinates:** 01°22'02.64"N 103°44'12.42"E **Sampling Location:** Earth Drain 3 ED3-9	**Dry Event Sampling Date:** 13 Oct 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 29 Sep 2020 

Details	Photograph	
Photograph ID: 65 **Coordinates:** 01°21'55.32"N 103°44'6.84"E **Sampling Location:** Earth Drain 4 ED4-1	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 66 **Coordinates:** 01°21'56.7"N 103°44'5.94"E **Sampling Location:** Earth Drain 4 ED4-2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 67 **Coordinates:** 01°21'57.84"N 103°44'4.62"E **Sampling Location:** Earth Drain 4 ED4-3	**Dry Event Sampling Date:** 13 Oct 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 68 **Coordinates:** 01°21'57.12"N 103°44'3.48"E **Sampling Location:** Earth Drain 4 ED4-4	**Dry Event Sampling Date:** 13 Oct 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 69 **Coordinates:** 01°21'55.74"N 103°44'2.22"E **Sampling Location:** Earth Drain 4 ED4-5	**Dry Event Sampling Date:** 13 Oct 2020  **Note:** No sample was taken as sampling point was dry	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 70 **Coordinates:** 1°21'54.9"N 103°44'12.5"E **Sampling Location:** Earth Drain 5 ED5-1	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 

Details	Photograph	
Photograph ID: 71 **Coordinates:** 1°21'55.7"N 103°44'13.4"E **Sampling Location:** Earth Drain 5 ED5-2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 
Photograph ID: 72 **Coordinates:** 01°21'51.8"N 103°44'17.2"E **Sampling Location:** Earth Drain 6 ED6-1	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 

Details	Photograph	
Photograph ID: 73 **Coordinates:** 01°21'51.1"N 103°44'16.6"E **Sampling Location:** Earth Drain 6 ED6-2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 
Photograph ID: 74 **Coordinates:** 1°21'50.4"N 103°44'15.7"E **Sampling Location:** Earth Drain 6 ED6-3	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 

Details	Photograph	
Photograph ID: 75 **Coordinates:** 01°21'49.2"N 103°44'14.4"E **Sampling Location:** Earth Drain 6 ED6-4	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 
Photograph ID: 76 **Coordinates:** 01°21'48.6"N 103°44'14.0"E **Sampling Location:** Earth Drain 6 ED6-5	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 26 Aug 2020 

Details	Photograph	
Photograph ID: 77 **Coordinates:** 01°22'6.72"N 103°43'41.64"E **Sampling Location:** Earth Drain 7 ED7-2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 01 Sep 2020 
Photograph ID: 78 **Coordinates:** 01°22'4.92"N 103°43'41.7"E **Sampling Location:** Earth Drain 7 ED7-3	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 01 Sep 2020  **Note:** No sample was taken as sampling point was dry

Details	Photograph	
Photograph ID: 79 **Coordinates:** 01°22'3.72"N 103°43'41.64"E **Sampling Location:** Earth Drain 7 ED7-4	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 01 Sep 2020  **Note:** No sample was taken as sampling point was dry
Photograph ID: 80 **Coordinates:** 01°22'13.92"N 103°44'46.08"E **Sampling Location:** Earth Drain 8 ED8-1	**Dry Event Sampling Date:** 14 Oct 2020 	**Wet Event Sampling Date:** 22 Oct 2020 

Details	Photograph	
Photograph ID: 81 **Coordinates:** 01°21'52.5"N 103°44'8.76"E **Sampling Location:** Pond 1	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 
Photograph ID: 82 **Coordinates:** 01°21'53.7"N 103°44'8.64"E **Sampling Location:** Pond 2	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 14 Sep 2020 

Details	Photograph	
Photograph ID: 83 **Coordinates:** 01°22'2.46"N 103°43'40.56"E **Sampling Location:** Pond 3	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 01 Sep 2020 
Photograph ID: 84 **Coordinates:** 01°22'2.52"N 103°43'41.28"E **Sampling Location:** Pond 4	**Dry Event Sampling Date:** 13 Oct 2020 	**Wet Event Sampling Date:** 01 Sep 2020 

Appendix 6B: Water Quality Laboratory Test Report

TEST REPORT

Our Reference No.	:	**R201325** **R201545**	Date Received	: 16/03/2020 & 27/03/2020
Project Code / Ref.	:	Tengah Dry Weather Sampling	Date Commenced	: 16/03/2020
			Date Reported	: 02/04/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 33 Sampling Points		
RESULTS:		Refer to Page 2 to 3		

Tan Thuan Piang
Technical Manager

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1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

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Website:	www.mls.sg		

R201325

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Controlled Watercourse**
			WQ1	WQ2	WQ3	WQ4	WQ5	
			16/03/2020, 0925hrs	16/03/2020, 0931hrs	16/03/2020, 0934hrs	16/03/2020, 0936hrs	16/03/2020, 0938hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	324	321	319	314	316	-
pH value	-		8.5	8.7	8.8	8.9	8.9	6-9
Turbidity	NTU		3.5	3.7	3.7	3.5	3.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	215	209	210	200	203	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.11	0.10	0.11	0.12	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.55	0.48	0.43	0.40	0.38	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.081	0.082	0.083	0.086	0.085	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.16	0.16	0.17	0.17	0.17	20

Test Parameter	Unit	Test Method	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Controlled Watercourse**
			WQ6	WQ7	WQ8	WQ9	WQ10	
			16/03/2020, 0941hrs	16/03/2020, 0944hrs	16/03/2020, 1029hrs	16/03/2020, 1032hrs	16/03/2020, 1034hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	319	322	302	266	290	-
pH value	-		8.8	8.8	9.0	9.1	9.2	6-9
Turbidity	NTU		3.7	3.6	4.1	5.0	4.3	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	16.7	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	203	206	188	182	182	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.13	0.097	0.080	0.081	0.098	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.48	0.46	0.56	0.60	0.67	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.087	0.085	0.070	0.067	0.066	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.18	0.19	0.22	0.28	0.30	20

Test Parameter	Unit	Test Method	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Controlled Watercourse**
			WQ11	WQ12	WQ13	WQ14	WQ15	
			16/03/2020, 1036hrs	16/03/2020, 1038hrs	16/03/2020, 1040hrs	16/03/2020, 1043hrs	16/03/2020, 1045hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	291	291	289	283	282	-
pH value	-		9.2	9.2	9.2	9.2	9.3	6-9
Turbidity	NTU		4.1	4.0	4.0	3.9	3.9	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	181	177	179	175	175	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.084	0.083	0.078	0.086	0.082	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.75	0.70	0.62	0.82	0.80	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.065	0.065	0.067	0.067	0.065	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.31	0.32	0.33	0.33	0.33	20

Note:
1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

R201325 & R201545

RESULTS

Test Parameter	Unit	Test Method	Sample 16 WQ16	Sample 17 WQ17	Sample 18 WQ18	Sample 19 WQ19	Sample 20 WQ20	Sample 21 WQ22	Controlled Watercourse**
			16/03/2020, 1047hrs	16/03/2020, 1049hrs	16/03/2020, 1052hrs	16/03/2020, 1054hrs	16/03/2020, 1056hrs	16/03/2020, 1059hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	253	282	300	311	334	352	-
pH value	-		9.3	9.3	9.3	9.3	9.2	9.2	6-9
Turbidity	NTU		3.9	4.1	4.2	4.4	4.7	5.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	172	176	181	182	199	210	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.096	0.085	0.083	0.090	0.091	0.092	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.73	0.67	0.68	0.68	0.79	0.86	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.067	0.069	0.068	0.069	0.072	0.077	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.31	0.30	0.30	0.29	0.29	0.29	20

Test Parameter	Unit	Test Method	Sample 22 WQ23	Sample 23 WQ24	Sample 24 WQ25	Sample 25 WQ26	Sample 26 WQ27	Sample 27 Earth Drain 1-1	Controlled Watercourse**
			16/03/2020, 1102hrs	16/03/2020, 1106hrs	16/03/2020, 1109hrs	16/03/2020, 1111hrs	16/03/2020, 1114hrs	16/03/2020, 1158hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	343	300	387	244	251	506	-
pH value	-		9.2	9.1	9.1	9.1	9.1	7.6	6-9
Turbidity	NTU		5.7	4.6	7.4	3.70	3.70	34.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	19.9	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	83	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	376	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	200	192	216	160	156	318	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.099	0.10	0.11	0.12	0.13	0.21	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.85	0.74	0.88	0.64	0.63	2.08	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.081	0.085	0.086	0.090	0.094	0.064	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.28	0.26	0.24	0.24	0.18	0.83	20

Test Parameter	Unit	Test Method	Sample 28 Earth Drain 1-2	Sample 29 Spring 1	Sample 30 Spring 2	Sample 31 Spring 3	Sample 32 Spring 4	Sample 33 WQ21	Controlled Watercourse**
			16/03/2020, 1153hrs	16/03/2020, 0956hrs	16/03/2020, 1001hrs	16/03/2020, 1004hrs	16/03/2020, 1009hrs	27/03/2020,1510hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	522	322	305	142	182	319	-
pH value	-		7.3	7.5	7.0	6.6	6.6	9.7	6-9
Turbidity	NTU		161	126	30.6	47.0	31.2	4.6	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	20.2	80.4	6.61	8.02	4.91	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	56	246	47	58	41	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	143	28.0	65.0	41.0	29.7	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	340	213	210	128	125	162	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.13	0.81	0.10	0.20	0.15	0.30	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.69	11.8	1.05	2.15	1.62	1.46	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.076	0.087	0.052	0.057	0.055	0.12	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.82	<0.015	<0.015	<0.015	<0.015	0.80	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R201325**	Date Received	:	16/03/2020
Project Code / Ref.	:	Tengah Dry Weather Sampling	Date Commenced	:	16/03/2020
			Date Reported	:	23/03/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 32 Sampling Points			
RESULTS:		Refer to Page 2 to 3			

Tan Thuan Piang
Technical Manager

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Website:	www.mls.sg		

R201325

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Controlled Watercourse**
			WQ1	WQ2	WQ3	WQ4	WQ5	
			16/03/2020, 0925hrs	16/03/2020, 0931hrs	16/03/2020, 0934hrs	16/03/2020, 0936hrs	16/03/2020, 0938hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	324	321	319	314	316	-
pH value	-		8.5	8.7	8.8	8.9	8.9	6-9
Turbidity	NTU		3.5	3.7	3.7	3.5	3.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	215	209	210	200	203	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.11	0.10	0.11	0.12	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.55	0.48	0.43	0.40	0.38	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.081	0.082	0.083	0.086	0.085	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.16	0.16	0.17	0.17	0.17	20

Test Parameter	Unit	Test Method	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Controlled Watercourse**
			WQ6	WQ7	WQ8	WQ9	WQ10	
			16/03/2020, 0941hrs	16/03/2020, 0944hrs	16/03/2020, 1029hrs	16/03/2020, 1032hrs	16/03/2020, 1034hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	319	322	302	266	290	-
pH value	-		8.8	8.8	9.0	9.1	9.2	6-9
Turbidity	NTU		3.7	3.6	4.1	5.0	4.3	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	16.7	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	203	206	188	182	182	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.13	0.097	0.080	0.081	0.098	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.48	0.46	0.56	0.60	0.67	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.087	0.085	0.070	0.067	0.066	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.18	0.19	0.22	0.28	0.30	20

Test Parameter	Unit	Test Method	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Controlled Watercourse**
			WQ11	WQ12	WQ13	WQ14	WQ15	
			16/03/2020, 1036hrs	16/03/2020, 1038hrs	16/03/2020, 1040hrs	16/03/2020, 1043hrs	16/03/2020, 1045hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	291	291	289	283	282	-
pH value	-		9.2	9.2	9.2	9.2	9.3	6-9
Turbidity	NTU		4.1	4.0	4.0	3.9	3.9	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	181	177	179	175	175	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.084	0.083	0.078	0.086	0.082	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.75	0.70	0.62	0.82	0.80	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.065	0.065	0.067	0.067	0.065	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.31	0.32	0.33	0.33	0.33	20

Note:
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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

R201325

RESULTS

Test Parameter	Unit	Test Method	Sample 16	Sample 17	Sample 18	Sample 19	Sample 20	Sample 21	Controlled Watercourse**
			WQ16	WQ17	WQ18	WQ19	WQ20	WQ21	
			16/03/2020, 1047hrs	16/03/2020, 1049hrs	16/03/2020, 1052hrs	16/03/2020, 1054hrs	16/03/2020, 1056hrs	16/03/2020, 1059hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	253	282	300	311	334	352	-
pH value	-		9.3	9.3	9.3	9.3	9.2	9.2	6-9
Turbidity	NTU		3.9	4.1	4.2	4.4	4.7	5.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	172	176	181	182	199	210	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.096	0.085	0.083	0.090	0.091	0.092	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.73	0.67	0.68	0.68	0.79	0.86	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.067	0.069	0.068	0.069	0.072	0.077	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.31	0.30	0.30	0.29	0.29	0.29	20

Test Parameter	Unit	Test Method	Sample 22	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27	Controlled Watercourse**
			WQ22	WQ23	WQ24	WQ25	WQ26	Earth Drain 1-1	
			16/03/2020, 1102hrs	16/03/2020, 1106hrs	16/03/2020, 1109hrs	16/03/2020, 1111hrs	16/03/2020, 1114hrs	16/03/2020, 1158hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	343	300	387	244	251	506	-
pH value	-		9.2	9.1	9.1	9.1	9.1	7.6	6-9
Turbidity	NTU		5.7	4.6	7.4	3.70	3.70	34.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	19.9	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	<20	83	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	376	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	200	192	216	160	156	318	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.099	0.10	0.11	0.12	0.13	0.21	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.85	0.74	0.88	0.64	0.63	2.08	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.081	0.085	0.086	0.090	0.094	0.064	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.28	0.26	0.24	0.24	0.18	0.83	20

Test Parameter	Unit	Test Method	Sample 28	Sample 29	Sample 30	Sample 31	Sample 32	Controlled Watercourse**
			Earth Drain 1-2	Spring 1	Spring 2	Spring 3	Spring 4	
			16/03/2020, 1153hrs	16/03/2020, 0956hrs	16/03/2020, 1001hrs	16/03/2020, 1004hrs	16/03/2020, 1009hrs	
Conductivity	µS/cm	MLS-SOP-ES-004 using Multi-parameter	522	322	305	142	182	-
pH value	-		7.3	7.5	7.0	6.6	6.6	6-9
Turbidity	NTU		161	126	30.6	47.0	31.2	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	20.2	80.4	6.61	8.02	4.91	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	56	246	47	58	41	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	143	28.0	65.0	41.0	29.7	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	340	213	210	128	125	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.13	0.81	0.10	0.20	0.15	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.69	11.8	1.05	2.15	1.62	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.076	0.087	0.052	0.057	0.055	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.82	<0.015	<0.015	<0.015	<0.015	20

Note:
1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R201657**	Date Received	:	02/04/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	:	02/04/2020
			Date Reported	:	13/04/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 7 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Technical Manager

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R201657

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Controlled Watercourse**
			WQ1	WQ2	WQ3	WQ4	
			02/04/2020,1732hrs	02/04/2020,1736hrs	02/04/2020,1740hrs	02/04/2020,1742hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	290	306	319	327	-
pH value (In-situ)	-		8.1	8.1	8.1	8.1	6-9
Turbidity (In-situ)	NTU		202	188	186	244	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	2.76	2.50	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	25	32	30	22	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	82.7	86.5	85.0	91.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	156	163	168	177	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.075	0.075	0.081	0.083	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.74	1.93	1.72	1.90	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.057	0.058	0.059	0.060	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	1.10	1.12	1.11	1.12	20

Test Parameter	Unit	Test Method	Sample 5	Sample 6	Sample 7	Controlled Watercourse**
			WQ5	WQ6	WQ7	
			02/04/2020,1745hrs	02/04/2020,1748hrs	02/04/2020,1749hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	334	340	342	-
pH value (In-situ)	-		8.1	8.1	8.1	6-9
Turbidity (In-situ)	NTU		190	197	201	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.86	2.74	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	32	32	34	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	82.0	84.0	89.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	182	184	185	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.084	0.083	0.076	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.90	1.78	1.88	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.060	0.059	0.057	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	1.11	1.10	1.1	20

Note:

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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R201665**	Date Received	:	03/04/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	:	03/04/2020
			Date Reported	:	13/04/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 8 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Technical Manager

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R201665

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Controlled Watercourse**
			Earth Drain 1-1	Earth Drain 1-2	Earth Drain 1-5	Earth Drain 1-6	
			03/04/2020,1103hrs	03/04/2020,1107hrs	03/04/2020,1124hrs	03/04/2020,1134hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	317	407	409	340	-
pH value (In-situ)	-		6.5	6.9	6.2	6.1	6-9
Turbidity (In-situ)	NTU		58.9	19.7	206	104	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.82	3.34	2.92	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	32	35	40	40	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	28.3	13.3	98.0	64.3	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	187	250	258	200	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.13	0.15	0.085	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.81	1.39	4.61	3.33	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.082	0.097	0.047	0.049	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	1.28	0.82	4.46	2.90	20

Test Parameter	Unit	Test Method	Sample 5	Sample 6	Sample 7	Sample 8	Controlled Watercourse**
			Earth Drain 1-8	Earth Drain 1-9	Earth Drain 1-10	Earth Drain 1-11	
			03/04/2020,1142hrs	03/04/2020,1146hrs	03/04/2020,1159hrs	03/04/2020,1204hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	170	180	155	149	-
pH value (In-situ)	-		6.6	6.6	6.6	7.2	6-9
Turbidity (In-situ)	NTU		49.6	41.2	39.9	53.4	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.52	2.98	3.08	3.04	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	50	43	39	42	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	38.7	21.0	10.7	25.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	93.0	99.0	186	80.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.14	0.13	0.13	0.11	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.64	1.36	1.72	1.32	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.10	0.11	0.095	0.075	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.65	0.57	0.91	0.44	20

Note:

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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R203644**	Date Received	:	16/06/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	:	16/06/2020
			Date Reported	:	23/06/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 24 Sampling Points			
RESULTS:		Refer to Page 2 to 3			

Tan Thuan Piang
Technical Manager

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R203644

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Controlled Watercourse**
			WQ8	WQ9	WQ10	WQ11	WQ12	WQ13	
			16/06/2020,1339hrs	16/06/2020,1342hrs	16/06/2020,1344hrs	16/06/2020,1346hrs	16/06/2020,1349hrs	16/06/2020,1351hrs	
Conductivity	µS/cm	APHA 2510B	130	134	136	137	139	139	-
pH value (In-situ)	-	MLS-SOP-ES-004 using Multi-parameter	8.5	8.6	8.7	8.7	8.7	8.7	6-9
Turbidity (In-situ)	NTU		58.0	60.2	51.5	46.0	74.4	84.0	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	23	<20	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	23.0	22.7	20.7	19.7	25.7	36.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	83.0	86.0	87.0	88.0	89.0	89.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.099	0.083	0.081	0.089	0.082	0.11	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.21	1.12	1.17	1.24	1.17	1.17	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	<0.025	0.025	0.026	0.027	0.028	0.027	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.59	0.59	0.59	0.59	0.60	0.59	20

Test Parameter	Unit	Test Method	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Controlled Watercourse**
			WQ14	WQ15	WQ16	WQ17	WQ18	WQ19	
			16/06/2020,1353hrs	16/06/2020,1355hrs	16/06/2020,1358hrs	16/06/2020,1400hrs	16/06/2020,1402hrs	16/06/2020,1404hrs	
Conductivity	µS/cm	APHA 2510B	143	139	137	135	132	135	-
pH value (In-situ)	-	MLS-SOP-ES-004 using Multi-parameter	8.7	8.7	8.7	8.8	8.8	8.8	6-9
Turbidity (In-situ)	NTU		71.8	67.2	62.2	52.1	45.4	43.2	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	2.21	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	21	<20	<20	50	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	30.0	25.7	21.7	18.7	15.3	15.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	92.0	89.0	88.0	88.0	85.0	86.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.12	0.11	0.12	0.15	0.10	0.084	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.18	1.25	1.15	1.11	1.16	1.07	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.028	0.029	0.028	0.028	0.028	0.028	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.59	0.58	0.58	0.54	0.58	0.57	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

R203644

RESULTS

Test Parameter	Unit	Test Method	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Controlled Watercourse**
			WQ20	WQ21	WQ22	WQ23	WQ24	WQ25	
			16/06/2020,1406hrs	16/06/2020,1408hrs	16/06/2020,1411hrs	16/06/2020,1413hrs	16/06/2020,1415hrs	16/06/2020,1417hrs	
Conductivity	µS/cm	APHA 2510B	136	136	137	140	140	138	-
pH value (In-situ)	-	MLS-SOP-ES-004 using Multi-parameter	8.8	8.8	8.9	8.9	8.9	8.9	6-9
Turbidity (In-situ)	NTU		40.7	42.4	43.2	38.6	37.0	39.1	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	23	<20	<20	21	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	15.7	15.3	16.0	12.3	12.7	11.7	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	87.0	87.0	88.0	89.0	90.0	88.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.092	0.087	0.12	0.12	0.11	0.11	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.08	1.07	1.10	1.11	1.07	1.09	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.029	0.030	0.030	0.030	0.030	0.031	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.58	0.57	0.57	0.55	0.56	0.56	20

Test Parameter	Unit	Test Method	Sample 19	Sample 20	Sample 21	Sample 22	Sample 23	Sample 24	Controlled Watercourse**
			WQ26	WQ27	Spring 1	Spring 2	Spring 3	Spring 4	
			16/06/2020,1420hrs	16/06/2020,1422hrs	16/06/2020,1513hrs	16/06/2020,1517hrs	16/06/2020,1522hrs	16/06/2020,1528hrs	
Conductivity	µS/cm	APHA 2510B	116	120	308	279	140	106	-
pH value (In-situ)	-	MLS-SOP-ES-004 using Multi-parameter	9.0	9.0	6.8	6.7	6.5	6.5	6-9
Turbidity (In-situ)	NTU		7.51	7.09	37.1	65.6	57.0	56.0	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	4.31	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	20	20	25	32	<20	49	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	19.7	15.3	15.0	34.3	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	74.0	76.0	203	179	90.0	69.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.088	0.12	0.10	0.057	0.26	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.06	1.11	1.41	1.39	0.89	1.74	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.031	0.031	0.042	0.040	0.034	0.032	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.59	0.58	0.073	0.050	0.070	0.054	20

Note:

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2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R204911**	Date Received	:	26/08/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	:	26/08/2020
			Date Reported	:	02/09/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 7 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Technical Manager

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Website: www.mls.sg

R204911

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Controlled Watercourse**
			ED6-1	ED6-2	ED6-3	ED6-4	
			26/08/2020,1602hrs	26/08/2020,1606hrs	26/08/2020,1612hrs	26/08/2020,1617hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	242	237	237	245	-
pH value (In-situ)	-		6.7	7.2	7.3	7.2	6-9
Turbidity (In-situ)	NTU		174	174	171	162	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	2.30	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	21	22	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	29.7	47.7	41.0	38.7	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	168	162	161	164	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.12	0.12	0.11	0.12	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.47	0.45	0.41	0.53	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.048	0.049	0.047	0.047	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.15	0.12	0.13	0.14	20

Test Parameter	Unit	Test Method	Sample 5	Sample 6	Sample 7	Controlled Watercourse**
			ED6-5	ED5-1	ED5-2	
			26/08/2020,1626hrs	26/08/2020,1647hrs	26/08/2020,1654hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	242	301	359	-
pH value (In-situ)	-		7.3	6.8	6.7	6-9
Turbidity (In-situ)	NTU		183	18.2	13.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	2.12	3.16	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	25	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	41.3	11.7	26.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	165	201	230	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.12	0.12	0.18	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.44	0.95	0.53	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.048	0.062	0.064	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.12	0.18	0.095	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205038**	Date Received	: 01/09/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	: 01/09/2020
			Date Reported	: 08/09/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 3 Sampling Points		
RESULTS:		Refer to Page 2		

Tan Thuan Piang
Technical Manager

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R205038

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Controlled Watercourse**
			ED7-2	Pond 4	Pond 3	
			01/09/2020, 1630hrs	01/09/2020, 1642hrs	01/09/2020, 1650hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	54.1	63.7	104	-
pH value (In-situ)	-		5.5	5.6	5.8	6-9
Turbidity (In-situ)	NTU		19.3	10.6	8.38	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	17.0	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	35.0	44.0	73.0	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.076	0.071	0.12	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.36	0.39	0.35	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.031	0.030	0.057	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.045	0.020	0.012	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205086**	Date Received	: 03/09/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	: 03/09/2020
			Date Reported	: 10/09/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 7 Sampling Points		
RESULTS:		Refer to Page 2		

Tan Thuan Piang
Technical Manager

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R205086

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Controlled Watercourse**
			ED 2-1	ED 2-2	ED 2-3	ED 2-4	
			03/09/2020,1445hrs	03/09/2020,1451hrs	03/09/2020,1504hrs	03/09/2020,1508hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	230	243	261	278	-
pH value (In-situ)	-		6.8	6.8	6.7	6.7	6-9
Turbidity (In-situ)	NTU		54.6	159	39.9	43.9	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	23.7	14.0	10.3	18.7	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	160	164	179	185	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.16	0.13	0.13	0.16	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.84	0.83	0.86	0.93	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.059	0.063	0.065	0.067	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.12	0.13	0.11	0.10	20

Test Parameter	Unit	Test Method	Sample 5	Sample 6	Sample 7	Controlled Watercourse**
			ED 2-5	ED 2-6	ED 2-12	
			03/09/2020,1519hrs	03/09/2020,1524hrs	03/09/2020,1514hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	287	270	244	-
pH value (In-situ)	-		6.7	6.7	6.8	6-9
Turbidity (In-situ)	NTU		45.0	53.7	27.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	20	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	14.0	18.3	15.3	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	195	184	164	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.15	0.18	0.080	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.90	0.83	0.37	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.065	0.069	0.065	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.067	0.032	<0.015	20

Note:

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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205203**	Date Received	:	10/09/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	:	10/09/2020
			Date Reported	:	17/09/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 8 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Technical Manager

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R205203

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Controlled Watercourse**
			ED 2-7	ED 2-8	ED 2-16	ED 2-17	
			10/09/2020, 1240hrs	10/09/2020, 1249hrs	10/09/2020, 1303hrs	10/09/2020, 1312hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	228	290	148	153	-
pH value (In-situ)	-		6.5	6.7	6.8	6.5	6-9
Turbidity (In-situ)	NTU		145	31.1	24.0	89.9	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.96	<2	2.91	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	64	42	37	39	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	184	165	49.0	35.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	170	211	113	117	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.27	0.15	0.085	0.058	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.99	0.76	0.62	0.59	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.048	0.054	0.038	0.035	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.048	0.047	<0.015	<0.015	20

Test Parameter	Unit	Test Method	Sample 5	Sample 6	Sample 7	Sample 8	Controlled Watercourse**
			ED 2-9	ED 2-10	ED2-10B	ED2-11	
			10/09/2020, 1322hrs	10/09/2020, 1329hrs	10/09/2020, 1358hrs	10/09/2020, 1413hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	314	547	143	472	-
pH value (In-situ)	-		6.8	6.9	6.3	6.7	6-9
Turbidity (In-situ)	NTU		82.3	85.1	198	33.4	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	7.91	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	57	56	31	68	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	31.0	32.0	88.0	21.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	239	392	93.0	329	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.15	0.085	0.59	0.20	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.89	2.96	0.74	2.16	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.055	0.067	0.036	0.054	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.053	0.015	<0.015	<0.015	20

Note:

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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205259**	Date Received	: 14/09/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	: 14/09/2020
			Date Reported	: 21/09/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 12 Sampling Points		
RESULTS:		Refer to Page 2		

Tan Thuan Piang
Technical Manager

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R205259

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Controlled Watercourse**
			ED2-18	ED2-19	Pond 2	Pond 1	ED4-1	ED4-2	
			14/09/2020,1447hrs	14/09/2020,1453hrs	14/09/2020,1517hrs	14/09/2020,1524hrs	14/09/2020,1529hrs	14/09/2020,1534hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	320	279	288	190	294	401	-
pH value (In-situ)	-		7.5	7.0	7.2	7.0	6.9	7.2	6-9
Turbidity (In-situ)	NTU		61.3	43.9	33.9	167	16.9	20.0	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	2.58	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	20	20	29	<20	20	25	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	15.0	32.7	26.7	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	226	192	202	130	206	284	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.19	0.16	0.19	0.13	0.18	0.30	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.14	1.00	0.79	0.27	0.57	0.50	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.082	0.072	0.088	0.049	0.10	0.14	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.11	0.092	0.074	0.026	0.064	0.016	20

Test Parameter	Unit	Test Method	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Controlled Watercourse**
			ED4-3	ED4-4	ED4-5	ED3-1	ED3-2	ED3-3	
			14/09/2020,1541hrs	14/09/2020,1545hrs	14/09/2020,1549hrs	14/09/2020,1556hrs	14/09/2020,1601rs	14/09/2020,1619hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	314	273	232	293	295	254	-
pH value (In-situ)	-		7.4	7.5	7.3	7.2	7.0	7.1	6-9
Turbidity (In-situ)	NTU		25.4	23.5	113	22.5	14.7	13.8	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	29	27	42	33	35	32	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	11.0	<10	54.0	12.7	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	213	185	156	203	220	176	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.29	0.26	0.26	0.17	0.21	0.20	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.51	0.67	0.78	0.79	0.58	0.59	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.15	0.14	0.13	0.10	0.11	0.10	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.015	<0.015	<0.015	0.075	0.052	0.064	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205527**	Date Received	: 29/09/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	: 29/09/2020
			Date Reported	: 06/10/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 6 Sampling Points		
RESULTS:		Refer to Page 2		

Tan Thuan Piang
Technical Manager

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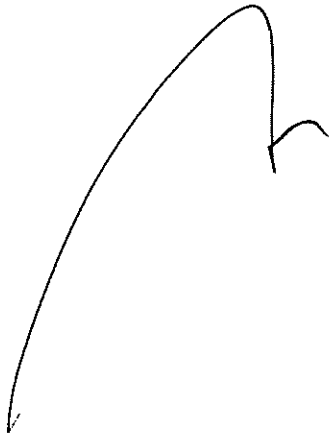
R205527

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Controlled Watercourse**
			ED 3-4	ED 3-5	ED 3-6	ED 3-7	ED 3-8	ED 3-9	
			29/09/2020,1607hrs	29/09/2020,1611hrs	29/09/2020,1617hrs	29/09/2020,1622hrs	29/09/2020,1627hrs	29/09/2020,1631hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	398	407	505	357	322	297	-
pH value (In-situ)	-		6.2	6.7	7.2	7.2	7.2	6.9	6-9
Turbidity (In-situ)	NTU		49.6	47.5	26.2	132	172	100	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	2.66	8.20	4.35	7.30	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	34	43	49	115	73	79	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	22.7	25.3	41.7	193	208	35.0	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	276	271	340	237	227	176	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.26	0.31	0.23	0.30	0.35	0.11	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.08	1.17	1.00	1.41	1.97	1.50	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.099	0.12	0.13	0.12	0.18	0.072	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.46	0.071	0.050	0.086	0.17	0.028	20

Note:

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TEST REPORT

Our Reference No.	:	**R205789**	Date Received	: 13/10/2020
Project Code / Ref.	:	Tengah Wet Weather Sampling	Date Commenced	: 13/10/2020
			Date Reported	: 20/10/2020
Customer Ref. No.	:	-		
Customer Name	:	CH2M (Jacobs)		
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720		
Attention To	:	Ms. Catherine Baldedara		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 24 Sampling Points		
RESULTS:		Refer to Page 2 to 3		

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R205789

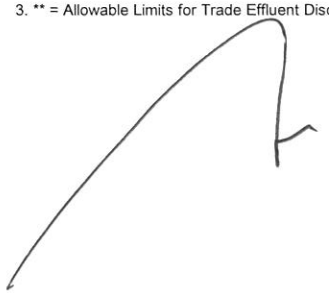
RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Controlled Watercourse**
			ED 7-2	ED 7-3	ED 7-4	Pond 4	Pond 3	ED 2-18	
			13/10/2020,1030hrs	13/10/2020,1035hrs	13/10/2020,1040hrs	13/10/2020,1046hrs	13/10/2020,1051hrs	13/10/2020,1117hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	61.9	60.9	57.1	70.2	107	374	-
pH value (In-situ)	-		6.2	6.0	5.8	5.6	5.6	6.6	6-9
Turbidity (In-situ)	NTU		13.8	13.8	18.8	19.3	29.3	20.6	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	2.48	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	<20	<20	30	29	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	<10	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	41.0	39.0	37.0	45.0	71.0	247	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.12	0.12	0.14	0.17	0.24	0.098	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.25	0.27	0.34	0.31	0.47	1.18	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.028	0.026	0.028	0.035	0.10	0.065	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.021	0.015	<0.015	<0.015	0.019	0.039	20

Test Parameter	Unit	Test Method	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Controlled Watercourse**
			ED 2-19	ED 6-1	ED 6-2	ED 6-3	ED 6-4	ED 6-5	
			13/10/2020,1125hrs	13/10/2020,1333hrs	13/10/2020,1338hrs	13/10/2020,1355hrs	13/10/2020,1404hrs	13/10/2020,1416hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	332	230	226	228	236	239	-
pH value (In-situ)	-		6.7	7.0	7.1	7.2	7.1	7.2	6-9
Turbidity (In-situ)	NTU		14.8	46.4	57.3	48.3	39.5	39.2	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	23	24	20	<20	23	62	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	10.7	12.7	<10	<10	12.0	11.3	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	202	150	144	143	146	147	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.13	0.14	0.12	0.13	0.10	0.13	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.93	0.53	0.51	0.48	0.47	0.46	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.061	0.049	0.048	0.048	0.049	0.049	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	<0.015	0.087	0.068	0.069	0.079	0.077	20

Note:

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R205789

RESULTS

Test Parameter	Unit	Test Method	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Controlled Watercourse**
			ED 5-1	ED 5-2	Pond 2	Pond 1	ED 4-1	ED 3-1	
			13/10/2020,1438hrs	13/10/2020,1445hrs	13/10/2020,1511hrs	13/10/2020,1517hrs	13/10/2020,1524hrs	13/10/2020,1529hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	336	376	353	164	301	395	-
pH value (In-situ)	-		6.8	6.6	6.9	7.0	6.8	6.7	6-9
Turbidity (In-situ)	NTU		110	7.9	18.3	70.6	10.3	30.5	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.50	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	21	<20	<20	20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	44.7	13.0	10.7	26.3	<10	13.3	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	206	231	223	102	194	251	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.072	0.12	0.10	0.13	0.085	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.06	0.59	0.51	0.26	0.45	0.93	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.063	0.066	0.065	0.028	0.061	0.072	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.21	0.13	<0.015	<0.015	0.056	0.028	20

Test Parameter	Unit	Test Method	Sample 19	Sample 20	Sample 21	Sample 22	Sample 23	Sample 24	Controlled Watercourse**
			ED 3-2	ED 3-3	ED 3-4	ED 3-5	ED 3-6	ED 3-7	
			13/10/2020,1534hrs	13/10/2020,1542hrs	13/10/2020,1551hrs	13/10/2020,1557hrs	13/10/2020,1601hrs	13/10/2020,1610hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	279	257	413	424	615	600	-
pH value (In-situ)	-		6.8	6.6	7.0	6.8	7.1	7.2	6-9
Turbidity (In-situ)	NTU		23.7	12.6	24.4	9.9	31.8	138	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	2.84	<2	<2	<2	<2	3.42	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20	<20	26	29	47	79	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	10.0	<10	12.0	<10	13.3	134	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	177	157	273	269	409	364	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.11	0.096	0.11	0.10	0.23	0.23	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.59	0.41	1.05	1.04	1.38	2.09	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.067	0.069	0.10	0.094	0.15	0.17	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.022	0.027	0.24	0.027	<0.015	<0.015	20

Note:

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3. ** = Allowable Limits for Trade Effident Discharge to Controlled Watercourse.

TEST REPORT

Our Reference No.	:	**R205803**	Date Received	:	14/10/2020
Project Code / Ref.	:	Tengah Dry Weather Sampling	Date Commenced	:	14/10/2020
			Date Reported	:	21/10/2020
Customer Ref. No.	:	-			
Customer Name	:	CH2M (Jacobs)			
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720			
Attention To	:	Ms. Catherine Baldedara			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 15 Sampling Points			
RESULTS:		Refer to Page 2 to 3			

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R205803

RESULTS

Test Parameter	Unit	Test Method	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Controlled Watercourse**
			ED 2-1	ED 2-2	ED 2-3	ED 2-4	ED 2-12	
			14/10/2020,1118hrs	14/10/2020,1124hrs	14/10/2020,1129hrs	14/10/2020,1133hrs	14/10/2020,1138hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	206	222	245	272	232	-
pH value (In-situ)	-		6.6	6.6	6.7	6.7	6.7	6-9
Turbidity (In-situ)	NTU		24.2	31.9	15.5	14.3	28.3	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	38	23	21	26	20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	12.3	<10	<10	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	131	142	154	178	151	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.14	0.14	0.075	0.091	0.10	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.54	0.58	0.75	0.74	0.32	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.051	0.053	0.054	0.057	0.055	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.036	0.044	0.053	0.059	<0.015	20

Test Parameter	Unit	Test Method	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Controlled Watercourse**
			ED 2-5	ED 2-6	ED 2-7	ED 2-8	ED 2-9	
			14/10/2020,1142hrs	14/10/2020,1147hrs	14/10/2020,1155hrs	14/10/2020,1159hrs	14/10/2020,1212hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	286	271	262	285	330	-
pH value (In-situ)	-		6.7	6.7	6.7	6.7	6.8	6-9
Turbidity (In-situ)	NTU		13.8	14.7	31.2	14.6	31.4	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	24	26	27	29	32	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	<10	<10	16.3	<10	14.7	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	185	175	173	185	212	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.10	0.12	0.098	0.089	0.092	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.80	0.67	0.71	0.71	0.78	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.059	0.063	0.065	0.072	0.068	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.049	0.034	0.022	0.017	<0.015	20

Note:

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3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.

R205803

RESULTS

Test Parameter	Unit	Test Method	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Controlled Watercourse**
			ED 2-10	ED 2-11	ED 2-16	ED 2-17	ED 8-1	
			14/10/2020,1221hrs	14/10/2020,1228hrs	14/10/2020,1242hrs	14/10/2020,1245hrs	14/10/2020,1319hrs	
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	168	545	165	207	211	-
pH value (In-situ)	-		5.9	6.6	6.4	6.0	6.0	6-9
Turbidity (In-situ)	NTU		52.1	30.3	79.4	21.3	7.30	-
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2	<2	<2	<2	<2	20
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	35	46	24	25	<20	60
Total Suspended Solids, TSS	mg/L	APHA 2540D	48.3	18.3	43.3	23.3	<10	30
Total Dissolved Solids, TDS	mg/L	APHA 2540C	85.0	356	101	125	128	1,000
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.51	0.081	0.15	0.081	0.076	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.63	0.99	0.97	0.52	0.58	-
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.055	0.072	0.048	0.038	0.030	2
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	<0.015	<0.015	<0.015	<0.015	0.040	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.
3. ** = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse.



TEST REPORT

Our Reference No. : **R205937**
Project Code / Ref. : Tengah Wet Weather Sampling

Date Received : 22/10/2020
Date Commenced : 22/10/2020
Date Reported : 29/10/2020

Customer Ref. No. : -
Customer Name : CH2M (Jacobs)
Customer Address : 150 Beach Road
Gateway West 34th Floor
Singapore 189720

Attention To : Ms. Catherine Baldedara
Sample Description : Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 for 1 Sampling Point

RESULTS:

Test Parameter	Unit	Test Method	ED 8-1
			22/10/2020,0947hrs
Conductivity (In-situ)	µS/cm	MLS-SOP-ES-004 using Multi-parameter	216
pH value (In-situ)	-		6.4
Turbidity (In-situ)	NTU		29.7
Biochemical Oxygen Demand, BOD_5	mg/L	APHA 5210B	<2
Chemical Oxygen Demand, COD	mg O_2/L	HACH Method 8000	<20
Total Suspended Solids, TSS	mg/L	APHA 2540D	16.3
Total Dissolved Solids, TDS	mg/L	APHA 2540C	149
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.037
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	0.56
Phosphate as PO_4-P	mg/L	APHA 4500-P (G)	0.027
Nitrate as NO_3-N	mg/L	APHA 4500-NO_3 (H)	0.035

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 23rd Edition, 2017)
2. "<" = Less than. The data reported is less than Detection Limit of the test.

Tan Thuan Piang
Technical Manager

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Appendix 6C: Key Code of Practice Measures for Water Quality

Appendix 6C: Key Code of Practice Measures for Water Quality

The following are key code of practice measures that are assumed to be embedded as part of basic project measures.

COP for Environmental Control Officer (ECO) issued by NEA

- A part-time or full-time, depending on the contract sum of construction works, ECO should be employed to oversee on-site compliance with environmental regulations, provide advice for environmental remediation measures and carry out site inspections and engagements to maintain good environment healthy standards on site.
- Earth Control Measures
  - The site operator/owner shall submit a detailed Earth Control Measures (ECM) proposal, endorsed by a Qualified Erosion Control Professional (QECP) to the relevant authorities for an approval.
  - A system of ECM including silty water treatment plant, holding pond, temporary perimeter lined cut-off drains, silt fences and silt traps is to be implemented within the worksite in accordance with the approved ECM plan before commencement of any earthworks or construction works to prevent the wash down of silt, earth, and debris from the worksite into the public drains and adjacent premises.
  - Water run-off from the worksite is to be channeled to the holding pond and silty water treatment plant for treatment and is not to be discharged directly into the public drains.
  - Earth control measures including the silty water treatment plants, holding pond, temporary perimeter lined cut-off drains, silt fences and silt traps are to be maintained and desilted regularly.
  - Earth surfaces or slopes adjacent to any drain shall be closed turfed, paved or covered with appropriate materials.
  - Minimise the extent and duration of any exposed bare erodible surface in construction site by adopting proper construction staging and work sequencing. Bare surfaces shall be covered up with appropriate materials before rain and daily works should be halted to reduce the volume of silty water to be contained and treated. As a good practice, all bare surfaces should also be covered up at the end of each work day in anticipation of any rain event after working hours.
  - The treatment of silty water shall be closely monitored, and the treatment shall be stopped immediately if silty water is being discharged to the public drain.
  - Drains in the vicinity of the worksite shall not be silted, altered or obstructed due to the construction works.
  - The discharge from any construction sites into public drains shall not contain Total Suspended Solids (TSS) in concentration greater than the prescribed legal limits.
  - The ECM shall not be removed before the completion of work. The site operator/owner shall inform the relevant authority prior to removal of the ECM on completion of the project.
- Prevention of Water Pollution
  - All wastewater generated at the construction site must be properly treated and disposed of. No discharge of sewage or other untreated wastewater into drain or land is allowed.
  - Oil and chemical in drums, carboys, containers, etc. shall be stored in a designated storage area within a building or covered shed with concrete floors and facilities to contain any leak or spillage.
  - Waste oil and chemicals generated from site activities shall only be sent to a licensed toxic industrial waste collector for proper disposal.

- 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.
- Any repair or servicing of vehicle, which requires waste oil to be disposed of should only be carried out if there are facilities to contain the waste oil.
- Soil treatment is to be carried out only by trained operators of registered pest control companies. The operators shall comply fully with the water pollution control requirements for the use of termiticides in anti-termite soil treatment issued to the companies by the Pollution Control 1 Division, National Environment Agency.

COP on Surface Water Drainage (revised 2007) issued by PUB

- The execution of any work shall not change, disrupt, fill, block, divert or disturb the existing overland flow or the existing system of drains unless an alternative drainage system has been approved by the Board.
- The runoff within, upstream of and adjacent to the worksite shall be effectively drained away without causing drainage problems within the worksite or in areas outside the worksite.
- All earth slopes shall be set outside the drainage reserve.
- No obstruction of any kind shall be placed, laid or erected within drainage reserves and drains unless authorised by the Board. If so, the drainage reserves and drains shall remain accessible at all times to workers and plant/equipment of, or authorised by the Board.
- No temporary structures such as cofferdams, crossings, stagings etc. shall be constructed in or over an existing drain without the approval of the Board.
- Any temporary structure if approved within a drain or drainage reserve shall be removed immediately on completion of the construction works or as directed.
- Drainage inlets such as drop-inlet chambers and scupper drains shall not be blocked by any material or debris.
- Drains shall not be covered without the approval of the Board.
- Bunds of stockpiled materials such as earth from trench work shall not be longer than 10 m and gaps of at least 1 m width shall be provided between the bunds to allow the free flow of surface runoff.
- Material from any stockpile shall not be allowed to fall or be washed into the drain. Adequate preventive measures, including the provision of proper and stable barricades or screens where necessary, shall be provided.
- Any damage to existing drain/drainage facilities arising out of any work shall be immediately reported to the Board. Any obstruction to flow arising from the damage shall be immediately and completely cleared. The damaged drain shall be repaired or reinstated to the requirements of the Board.
- No services shall be laid or left (in conjunction with development works) within a drainage reserve. Where the services have to cross a drainage reserve, approval of the Board shall be obtained.
- The discharge from any construction / earthwork sites into storm water drainage system shall not contain Total Suspended Solids (TSS) in concentrations greater than, the prescribed limits under Regulation 4 (1) of the Sewerage and Drainage (Surface Water Drainage) Regulations.
- Developers / owners and Qualified Persons should include the earth control measures (ECM) specifications and schematic or conceptual ECM plans in the tender documents and allow for the cost of ECM in the tenders.
- The site operator/contractor shall obtain a written permission (or a clearance certificate) from the Board and implement adequate ECM before the commencement of any earthwork.
- The site operator/owner shall submit the detailed ECM proposal, endorsed by a QECP, to the Board to apply for an approval. The ECM proposals (with calculations) shall include a plan.

- The ECM shall be designed to cope with at least a storm of return period of 5 years.
- Installation of ECM on site The ECM shall be installed by the site operator/contractor according to the endorsed plans and the completed ECM at site shall be approved by the QECP before commencement of earthworks and construction works.
- An effective ECM requires 2 components which shall include, but is not limited to, the following minimum measures in order to meet the legal requirements cited under Regulation 4(1) of the Sewerage and Drainage (Surface Water Drainage) Regulations:
  - Erosion Control Measures, which shall minimise the extent and duration of any exposed/bare/erodible surfaces by:
    a) Proper Work Sequencing - Proper construction staging and work sequencing shall be adopted to ensure that no large bare/ erodible surfaces are exposed for long duration.
    b) Covering up of all bare / erodible surfaces - Bare surfaces (including earth stockpiles) shall be covered by concrete-lining, concrete-paving, milled waste, erosion control blankets, close turfing or other suitable materials. Access roads within the site and at exit/entrance as well as the surfaces around the site facilities (such as office, fabrication and storage yards) shall be covered or paved. Work areas shall be covered with canvas sheets, tarpaulin sheeting or other suitable materials during rain or before work stops every day. Minimizing of the bare erodible surfaces as mentioned above will reduce the volume of silty water to be contained and treated. For areas which have been paved/ covered, the clean surface runoff could be channeled directly into the drains.
    c) Progressive and timely revegetation and stabilization – All bare surfaces shall be restored immediately upon completion of work at every stage.
  - Sediment Control Measures, which shall trap, contain and treat the silty discharges from within a construction/earthworks site (including rain, runoff, water from wash bay, underground water at basement, etc.) by providing:
    a) The sediment control measures shall a. Perimeter Cut-off Drain – Perimeter cut-off drains shall be concrete-lined and adequate to capture all runoff from the site. For sites located above slope, a boundary wall of at least 600 mm high shall be provided along the entire perimeter of the site to prevent overflow onto adjacent properties.
    b) Perimeter Silt Fence – Silt fences shall be erected along the perimeter cutoff drain (between the construction site and perimeter cut-off drain). The silt fence is to be embedded firmly into the ground and made from an approved geotextile filter fabric or equivalents to capture the sediment from stormwater runoff. The sediment built-up behind the silt fence must be regularly removed.
    c) Intermediate Silt Trap – Intermediate silt traps of suitable size shall be installed at regular intervals along the perimeter lined cut-off drain. Within the intermediate silt traps, suitable geotextile filter fabric or equivalents shall be installed across the full depth and width and /or coagulation assistance materials shall be placed. Silt traps relying primarily on hardcore, granite chips or sands for filtration, are not acceptable.
    d) Holding pond/sump – All silty runoff shall be collected and channelled to ground holding pond/sump for treatment to the required water quality standard before discharging the runoff into the drain. All silty water shall be treated and discharged within 10 hours after the rainstorm so as to prepare the pond/sump for the next rainfall event.
      i. No processed/used water, such as slurry water and sullage water shall be discharged to or kept in the holding pond/sump.
      ii. The holding pond/sump shall be located near the drainage outlet.
      iii. Water level markings shall be provided within the holding pond/sump to indicate the level of water in the holding pond/sump and the depth of the holding pond/sump.
      iv. The holding pond/sump shall have a storage capacity to cope with a storm of return period of 5 years.

v. Cut-off drains could be used as part of the holding pond/sump. The capacity of the cut-off drains available to hold the silty runoff should be clearly tabulated, taking into consideration the site terrain. The wash bay sump shall not be included in the calculation for storage.

e) Treatment System – Adequately-sized treatment system shall be installed to treat all silty surface runoff before it is discharged into the drains. The treatment system shall be sized to treat and empty the rain runoff water in the holding pond/sump within 10 hours after the rainstorm so as that to prepare the pond/sump for the next rainfall event. Any other water shall be handled separately and shall not be channelled to the holding pond/sump for treatment. The treatment system shall be calibrated regularly according to the manufacturer's specification. The quality of discharge shall be monitored continuously by a Total Suspended Solids (TSS) meter or by other means.

i. The treatment plant treats the silty water at a prescribed flow rate and there is no holding capacity within the treatment plant. Treatment plants shall not be included as part of the total holding pond/sump capacity.

ii. For above ground holding tank design proposal, contractor shall provide justifications that the system is able to function at all times, in particular, during heavy rain in the middle of the night. The justifications shall include detailed calculations of number of pumps and pump size, provision of redundancy to cater for maintenance and breakdown, positive suction head at the sump pit, provision of power supply for the automated system throughout the entire operation, and configuration of the automated system and the standby manpower as necessary.

iii. The above information, schematics and technical drawings shall be clearly enclosed in the ECM plan for contractor to strictly adhere to. Contractor shall engage a QP (mechanical) to design and endorse the pumping system and monitor the performance and revise the ECM design accordingly.

f) Turbidity Curtains - For works that are within or adjacent to the water bodies, such as canals, rivers, sea or reclamation works, turbidity curtain(s) shall be installed along all the exposed slopes/riverbanks. The silt within the turbidity curtain(s) shall be removed regularly and disposed off accordingly to the relevant regulations.

g) Wheel wash – Used water from wheel wash shall not be discharged directly to the drain. The silty water within the wash bay could be channelled into the holding pond/ sump. 24

h) Minimal or No Discharge - Recycling of water should be practised at construction/earthwork sites. The recycled water could be used for nonportable purposes in order to minimize discharge into the drain.

- The site operator/contractor shall inspect the conditions of the ECM regularly and during/after every rain event. The site operator/contractor shall arrange for his QECP to carry out regular audit/review for every stage of the earthworks and construction works, and also revise/amend the ECM at site according to the advice of the QECP. All inspection/audit/review reports shall be kept on site and made available to the Board upon request.
- The ECM implemented on site shall be checked and maintained regularly to ensure that the ECM remains effective throughout the whole duration of works. This shall include:
  - Replacing of silt fences and erosion control blankets
  - Re-paving of worn-out concrete surfaces
  - Replacing of membrane modules
  - Calibration of silty water treatment plant according to the manufacturer's specification
  - Removal of silt accumulated in the holding sump
  - Removal of silt accumulated at the silt fence and beside the boundary wall

- The site operator/contractor shall monitor the discharge water quality and ensure it meets prescribed limits before it enters the roadside/ outlet drain(s). The site operator/contractor shall for this purpose, provide a continuous monitoring system which include the necessary monitoring instrument and CCTV system upon requested by the Board. The CCTV system shall be positioned at the drain so that it is able to view the discharge outlet(s) along with the upstream of the drain clearly. The CCTV image quality shall be able to distinguish the clear water and the silty water clearly. The site operator/contractor shall keep the CCTV in operations at all times. The site operator/contractor shall submit regular reports (including photographic and monitoring records) of the site ECM as well as those for discharge quality upon requested by the Board.
- The ECM shall not be removed before the completion of work. The site operator/ owner shall inform the Board prior to removal of the ECM on completion of the project.
- The approval of the Board shall be sought for all earthworks affecting the existing drainage system or the flow pattern of surface runoff. In the event that earthworks are to be carried out adjacent to major drains and canals, the developer/owner shall engage a Qualified Person to carry out soil investigation works and slope stability analysis to ensure that the earthworks will not cause any damage to the drainage structures.
- The developer/ owner shall take all necessary steps and measures, such as implementing suitable soil stabilisation methods and temporary protection works to ensure the stability and structural integrity of the existing drainage structures.
- A temporary drainage system shall be provided for all roadworks to prevent flooding or water ponding on the road. Where the road is being raised and the new road drainage outlets are at a higher level than the existing ones, the existing outlets shall not be blocked unless temporary alternative drainage system has been provided. The developer/owner and the Qualified Person shall be responsible for implementing all necessary measures to ensure that the site is kept flood free at all times. Where necessary, the Board may require the submission of hydraulic calculations, programme of works, temporary drainage arrangements at various stages of the roadworks, etc. by the Qualified Person.

COP of Practice on Sewage and Sanitary Works (2nd Edition, Jan 2019) issued by PUB

General Requirements for Temporary Sanitary Facilities for Construction Site

- All used water discharged from temporary toilets, sanitary appliances and washing facilities at the construction site must be collected and disposed of via the temporary sanitary facilities. No used water shall be discharged into drains, soil and surrounding environment.
- Approval from PUB (WRN) on the design of the temporary sanitary facilities must be obtained prior to its construction and operation at the construction site. The design shall be in accordance with the General Requirements for temporary sanitary facilities for Construction Site. The design submission to PUB (WRN) shall include the detailed design and layout plans of the temporary sanitary facilities and NEA's Clearance Certificate on Environmental Health.
- The used water from the temporary toilets, sanitary appliances and washing facilities shall be either collected in holding tank(s) and be disposed of by tankering by a NEA's Licensed Waste Collector (LWC) or be discharged into the existing public sewers if available via a pumped system or other means subject to the site condition and approval of WRN (PUB).
- A dedicated and competent contractor shall be engaged to carry out regular preventive and breakdown maintenance of all parts of the temporary sanitary facilities designed for the construction site such as used water pipes, fittings, supports, tanks, pumps, level sensor system M&E equipment etc to ensure proper functionality to prevent used water overflow.
- All parts of the temporary sanitary facilities design for the construction site such as used water pipes, fittings, supports, tanks, pumps, level sensor system M&E equipment shall not be installed inside the drains.
- Where public sewer is available at or near the construction site, the temporary sanitary facilities shall be connected to the public sewer. The sewer connection works shall be carried out in compliance with the detailed plans/drawings approved by PUB, the Code of Practice on Sewerage and Sanitary Works, Sewerage and Drainage Act and the Sewerage and Drainage (Sanitary Works) Regulations.

- No structure/piling/retaining structure (whether temporary or permanent) shall be sited over or close to the existing sewer/manhole within the construction site. All manholes shall be properly and adequately covered to ensure that safety is not compromised. The Builder/Contractor shall ensure that no debris/building material such as sand, earth, gravel, cement, cement grout, timber, wood or any other materials are disposed of or accidentally get into the inspection chambers/manholes/sewerage system.
- If there would be any proposed change in the site condition / access to the holding tank, types of activities or increase in the number of users which may result in an increase of the used water discharging to the temporary sanitary facilities, the Builder/Contractor shall consult PUB (WRN) for approval before making any such changes. In such a case, the Builder/Contractor shall review and upgrade/amend the temporary sanitary facilities including the holding tank to ensure the pipe size and holding capacity are adequate to meet the used water discharge volume/flow rate and incorporate any additional requirements as imposed by PUB (WRN). Amended design for the temporary sanitary facilities shall be resubmitted to PUB (WRN) for approval. Approval from PUB (WRN) on the design of the temporary sanitary facilities must be obtained prior to putting the temporary sanitary facilities into use or operation.

Sewerage and Drainage (Trade Effluent) Regulations, issued by PUB

- Any person who discharges trade effluent into any sewerage system shall install a pre-treatment plant if the Board so requires and shall use and operate the plant to treat trade effluent before discharging the trade effluent into the sewerage system and maintain the plant in an efficient condition at all times.
- Any person who discharges trade effluent into any sewerage system shall install a grease trap, if required.
- A person must not discharge or caused to be discharged into any public sewer any trade effluent - (a) which is not of a nature or type approved by the Board; (b) the temperature of which exceeds 45° Celsius at the point of its entry into the public sewer; (c) the pH value of which is less than 6 or more than 9 at the point of its entry into the public sewer; or (d) the caustic alkalinity of which is more than 2,000 milligrams of calcium carbonate per litre at the point of its entry into the public sewer.
- Any person who seeks to discharge any trade effluent into any public sewer to treat the trade effluent before discharging the trade effluent into the public sewer.
- A person must not discharge or caused to be discharged any trade effluent which contains any of the following substances: (a) any toxic industrial waste specified in the first column of the Schedule to the Environmental Public Health (Toxic Industrial Waste) Regulations (Cap. 95, Rg 11); (b) calcium carbide; (c) petroleum spirit or other inflammable substance; (d) any organic compound specified in the First Schedule; (e) any substance that either by itself or in combination or by reaction with other waste or refuse may give rise to any gas, fume, odour or substance which is or is likely to be a hazard to human life, a public nuisance, injurious or otherwise objectionable, or which prevents or is likely to prevent entry into the public sewer by workmen maintaining or repairing it; (f) yeast, spent or unspent yeast, spent or unspent molasses, crude tar, tar oil, crude oil, carbon disulphide, hydro-sulphide and poly-sulphide; (g) any radioactive material; (h) any waste or refuse liable to form a viscous or solid coating or deposit on any part of the public sewer or sewerage system; (i) any excessively discolouring substance; (j) any pesticide, fungicide, herbicide, insecticide, rodenticide or fumigant; (k) blood waste; (l) infectious waste.
- A person must not discharge or cause to be discharged into a public sewer any trade effluent which - (a) contains any substance listed in the Second or Third Schedule in a concentration greater than that specified therein for the substance; (b) has a 5-day Biochemical Oxygen Demand at 20° Celsius greater than 400 milligrams per litre of the trade effluent; (c) has a Chemical Oxygen Demand greater than 600 milligrams per litre of the trade effluent; (d) has Total Suspended Solids greater than 400 milligrams per litre of the trade effluent; or (e) has Grease or Oil, which is not hydrocarbon in nature, greater than 100 milligrams per litre of the trade effluent.

Appendix 7A: List of Flora Species

List of Flora Species

Species	Family	Origin	Status	Habit	Common name
Acacia auriculiformis	Fabaceae	Exotic	Naturalised	Tree	Acacia-Tree, Earleaf Acacia, Black Wattle, Wattle, Bunga Siam, Akasia Kuning, Yellow Wattle, Ear-Pod Wattle, Northern Black Wattle, Papua Wattle
Acacia mangium	Fabaceae	Exotic	Naturalised	Tree	Silver Wattle, Brown Salwood, Sabah Salwood, Mangge Hutan, Tongke Hutan, Lancewood, Mangium, Mangium Wattle, Forest Mangrove, Mange, Hickory Wattle, Black Wattle, Sally Wattle, Broadleaf Salwood
Acacia sp.	Fabaceae	Cryptogenic	-	Climber	-
Acalypha hispida	Euphorbiaceae	Exotic	Cultivated only	Shrub	Chenille Plant, Red Hot Cat's Tail, Red Cattail, Ekur Kuching, Buntut Kucing, Cat's Tail
Acalypha siamensis	Euphorbiaceae	Exotic	Casual	Shrub	Tumput, Teh Kampong
Adenanthera pavonina	Fabaceae	Exotic	Naturalised	Tree	Saga, Coral Bean Tree, Daun Tumpul, Suga, Redwood, Red Sandalwood Tree, Peacock Flower Fence, Barbados Pride, Coral Pea, Red Bead Tree, Circassian Bean, Coralwood
Adiantum latifolium	Adiantaceae	Exotic	Naturalised	Herb	-
Aeschynomene americana	Fabaceae	Exotic	Naturalised	Herb	Shyleaf, Forage Aeschynomene, American Joint Vetch, Thornless Mimosa, Bastard Sensitive Plant
Ageratum conyzoides	Asteraceae	Exotic	Naturalised	Herb	Billygoat-Weed, Chick Weed, Goatweed, Whiteweed
Aglaonema commutatum	Araceae	Exotic	Casual	Herb	Painted Drop-Tongue, Chinese Evergreen, Silver Evergreen, Pewter
Allamanda cathartica	Apocynaceae	Exotic	Casual	Climber	Allamanda, Golden-Trumpet, Common Allamanda, Yellow Allamanda, Akar Cempaka Hutan, Bunga Akar Kuning, Akar Chempaka Kuning, Allamada Trumpet Vine, Golden Trumpet Vine
Alpinia mutica	Zingiberaceae	Native	Extinct	Herb	-
Alsophila latebrosa	Cyatheaceae	Native	Vulnerable	Tree	Tree Fern, Paku
Alstonia angustifolia	Apocynaceae	Native	Common	Tree	Pulai Penipu Paya, Red-Leaved Pulai, Hard Alstonia
Alstonia scholaris	Apocynaceae	Exotic	Cultivated only	Shrub	Indian Pulai, White Cheesewood, Devil Tree, Blackboard Tree, Milkwood Pine, Dita Bark, Bitter Bark
Amphineuron opulentum	Thelypteridaceae	Native	Endangered	Climber	-
Andira inermis	Fabaceae	Exotic	Casual	Shrub	Brown Heart, Cabbage Tree, Bastard Mahogany, Bay Seed, Cabbage Bark, Crown Heart, Partridge Wood, Pig's Turd, Angelin, River Almond
Angiopteris evecta	Marattiaceae	Native	Vulnerable	Herb	Elephant Fern, Paku Gajah, Turnip Fern, Duku
Annona muricata	Annonaceae	Exotic	Cultivated only	Tree	Soursop, Guanabana, Prickly Custard Apple, Durian Belanda, Graviola, Durian Europa, Durian Makkah, Durian Benggala
Antidesma bunius	Phyllanthaceae	Exotic	Casual	Tree	Chinese Laurel, Currantwood, Buni, Berunai, Bignay
Aphanamixis polystachya	Meliaceae	Native	Endangered	Tree	Pasak Lingga, Amoora, Cikih, Kasai Paya, Kulim Burung, Pithraj Tree
Aporosa benthamiana	Phyllanthaceae	Native	Vulnerable	Tree	Crescent Tree

Species	Family	Origin	Status	Habit	Common name
Ardisia elliptica	Primulaceae	Native	Endangered	Shrub	Seashore Ardisia, Mata Pelandok, Mempenai, Rempenai, Shoebutton Ardisia, Mata Pelanduk, Penah, Periah, Buah Letus, Cempenai, Daun Bisa Hati, Mata Ayam, Mata Itek
Ardisia gigantifolia	Primulaceae	Exotic	Cultivated only	Shrub	-
Areca catechu	Arecaceae	Exotic	Casual	Tree	Areca, Betel-Nut Palm, Pinang, Betel Palm, Areca-Nut, Pinang Siri
Aristolochia acuminata	Aristolochiaceae	Exotic	Cultivated only	Climber	Indian Birthwort, Dutchman's Pipe, Native Dutchman's Pipe, Akar Ketola Hutan
Artabotrys suaveolens	Annonaceae	Native	Endangered	Climber	-
Arthrophyllum diversifolium	Araliaceae	Native	Common	Tree	Ivy Palm, Tumbuh Kelapa, Common Ivy Palm, Tumbuh Nyior
Artocarpus altilis	Moraceae	Exotic	Casual	Tree	Breadfruit, Sukun, Suku, Kulur, Kelor
Artocarpus elasticus	Moraceae	Native	Common	Tree	Terap, Getah Terup
Arundina graminifolia	Orchidaceae	Native	Common	Shrub	Bamboo Orchid
Artocarpus heterophyllus	Moraceae	Exotic	Casual	Tree	Jackfruit, Nangka, Jack, Jak, Jake Tree
Artocarpus integer	Moraceae	Exotic	Casual	Tree	Cempedak, Champedah, Chempedak, Chempedak Utan, Bangkong, Baroh
Aspidopterys concava	Malpighiaceae	Native	Endangered	Climber	-
Asplenium longissimum	Aspleniaceae	Native	Common	Epiphyte	Spleenwort
Asplenium nidus	Aspleniaceae	Native	Common	Epiphyte	Bird's Nest Fern, Rumah Langsuyar, Paku Pandan
Asystasia gangetica	Acanthaceae	Exotic	Naturalised	Herb	-
Averrhoa bilimbi	Oxalidaceae	Exotic	Casual	Tree	Belimbing Besi, Bilimbi, Cucumber Tree, Belimbing, Belimbing Buloh
Averrhoa carambola	Oxalidaceae	Exotic	Casual	Tree	Star Fruit, Belimbing Manis, Kembola, Carambola, Caramba, Country Gooseberry, Belimbing Sagi, Kamrak
Axonopus compressus	Poaceae	Exotic	Naturalised	Herb	Tropical Carpet Grass, Wide-Leaved Carpet Grass, Cow Grass, Rumput Parit
Baccaurea motleyana	Phyllanthaceae	Native	Critically Endangered	Tree	Rambai, Common Rambai, Jelintik, Buah Jentik, Asam Lambun, Tampoi
Bambusa heterostachya	Poaceae	Exotic	Casual	Shrub	-
Bambusa multiplex	Poaceae	Exotic	Cultivated only	Shrub	Hedge Bamboo, Buluh Pagar, Chinese Dwarf Bamboo
Bambusa ventricosa	Poaceae	Exotic	Cultivated only	Shrub	Buddha Bamboo, Buddha's-Belly Bamboo
Bambusa vulgaris	Poaceae	Exotic	Casual	Shrub	Common Bamboo, Golden Bamboo
Baphia nitida	Fabaceae	Exotic	Casual	Shrub	Camwood, African Sandlewood, Barwood
Bidens alba	Asteraceae	Exotic	Cultivated only	Herb	Shepherd's Needles, Butterfly Needles, Hairy Beggarticks, Spanish Needles
Bignonia magnifica	Bignoniaceae	Exotic	Cultivated only	Climber	Purple Bignonia

Species	Family	Origin	Status	Habit	Common name
Blumea balsamifera	Asteraceae	Cryptogenic	-	Herb	-
Bouea oppositifolia	Anacardiaceae	Native	Vulnerable	Tree	Plum Mango, Marian Plum, Rumenia
Bougainvillea glabra	Nyctaginaceae	Exotic	Cultivated only	Shrub	Paper Flower
Bridelia stipularis	Phyllanthaceae	Native	Vulnerable	climber	Kenidai, Kernam
Bridelia tomentosa	Phyllanthaceae	Native	Common	Tree	Kenidai, Kernong, Kernam
Callicarpa longifolia	Lamiaceae	Native	Endangered	Shrub	Long Leaved Beauty Berry, Nasi-Nasi, White-Berried Malayan Lilac, Capal, Capal Kecil, Karat Besi, Tampah Besi, Tampal Besi, Tampung Besi, Tampung Besi Putih
Calophyllum inophyllum	Calophyllacaeae	Native	Critically Endangered	Tree	Penaga Laut, Bintangor Laut, Borneo Mahogany, Alexandrine Laurel, Alexandrian Laurel, Alexandra Laurel, Indian Laurel, Laurel Wood, Beauty Leaf, Nyamplung, Penaga, Bodek Laut, Paku Achu, Bintangur Bunga
Calopogonium mucunoides	Fabaceae	Exotic	Naturalised	Climber	Calopo, Calapo, Wild Ground Nut
Campnosperma auriculatum	Anacardiaceae	Native	Common	Tree	Terentang, Serentang, Terentang Daun Besar, Napan
Cananga odorata	Annonaceae	Exotic	Cultivated only	Tree	Kenanga, Nerian, Ilang Ilang, Ylang Ylang, Kenanga Hutan, Perfume Tree, Cananga, Kenanga Utan, Chenanga, Nyai
Capsicum annuum	Solanaceae	Exotic	Cultivated only	Shrub	Capsicum
Carallia brachiata	Rhizophoraceae	Native	Endangered	Tree	Corkwood, Corky Bark, False Kelat, Maniawiga, Bongbong, Bongkok, Gandang, Ganding, Janggut Keli, Kesinga, Mesinga, Merpoi, Mersinga, Merpuing, Tengkawa
Carica papaya	Caricaceae	Exotic	Casual	Tree	Papaya, Betik, Pawpaw, Betek, Melon Tree, Ketalah
Carmona retusa	Boraginaceae	Exotic	Naturalised	Shrub	Tsaang-Gubat, Fukien Tea Tree, Wild Tea, Scorpion Bush
Caryota mitis	Arecaceae	Native	Common	Tree	Fishtail Palm, Common Fishtail Palm, Burmese Fishtail Palm, Clustered Fishtail Palm, Rabok, Rebuk, Meridin, Dudok, Tukas
Cayratia mollissima	Vitaceae	Native	Endangered	Climber	-
Cayratia trifolia	Vitaceae	Native	Vulnerable	Climber	Three-Leaved Wild Vine
Cecropia pachystachya	Urticaceae	Exotic	Naturalised	Tree	-
Ceiba pentandra	Malvaceae	Exotic	Casual	Tree	Kapok Tree, Silk Cotton Tree, White Silk Cotton Tree, Kabu-Kabu, Kapok, Kapuk, Kekabu, P.W.D. Tree
Centotheca lappacea	Poaceae	Native	Critically Endangered	Herb	Rumput Lilit Kain, Rumput Darah
Centrosema molle	Fabaceae	Exotic	Naturalised	Herb	-
Cerbera odollam	Apocynaceae	Native	Vulnerable	Tree	Pong Pong, Pong-Pong, Sea Pong Pong, Yellow-Eyed Cerbera, Buta Buta
Chassalia curviflora	Rubiaceae	Native	Endangered	Shrub	-
Christella dentata	Thelypteridaceae	Cryptogenic	-	Herb	Binung

Species	Family	Origin	Status	Habit	Common name
Christella parasitica	Thelypteridaceae	Cryptogenic	-	Herb	
Christella subpubescens	Thelypteridaceae	Native	Common	Herb	-
Cinnamomum iners	Lauraceae	Native	Common	Tree	Wild Cinnamon, Clove Cinnamon, Kayu Manis, Kayu Manis Hutan, Medang Teja, Teja Lawang
Cissus hastata	Vitaceae	Cryptogenic	-	Climber	-
Cissus repens	Vitaceae	Native	Critically Endangered	Climber	Malayan Wild Vine, Carik Merah, Lakum, Pokok Riang Hutan
Citrus hystrix	Rutaceae	Exotic	Cultivated only	Shrub	Kaffir Lime
Claoxylon indicum	Euphorbiaceae	Native	Common	Tree	Laping Budak, Jarak Kayu, Lampin Budak
Claoxylon longifolium	Euphorbiaceae	Native	Extinct	Tree	-
Clausena excavata	Rutaceae	Native	Common	Shrub	Pink Lime-Berry, Cama, Cemama, Cemamar, Cerek, Cerek Hitam, Kemantu Hitam, Secerek, Semeru, Suntang Hitam
Clerodendrum deflexum	Lamiaceae	Native	Vulnerable	Shrub	Nodding Witch's Tongue, Setawar Bukit, Balong Ayam, Kayu Sampu, Kayu Sampu Kelau, Lemak Berok, Lidah Kerbau, Lidah Kerbau Betina, Setawar Hutan, Sumbong Hutan
Clerodendrum laevifolium	Lamiaceae	Native	Common	Shrub	Swaddling Flower, Celeguri, Guriam, Kecolam, Keculun, Lampin Badak, Lampin Budak, Lelampang Badak, Pencolam, Puding, Seleguri, Seleguri Betina, Selulang Bukit, Sempayan Pitu, Tudung Roman, Uluh Ulai, Unting-Unting
Clerodendrum paniculatum	Lamiaceae	Exotic	Casual	Shrub	Pagoda Flower
Clerodendrum villosum	Lamiaceae	Native	Vulnerable	Shrub	-
Clidemia hirta	Melastomataceae	Exotic	Naturalised	Herb	Koster's Curse
Clinacanthus nutans	Acanthaceae	Exotic	Cultivated only	Herb	Sabah Snake Grass
Cocos nucifera	Arecaceae	Exotic	Naturalised	Tree	Coconut, Coconut Palm, Kelapa, Niyor
Coffea liberica	Rubiaceae	Exotic	Cultivated only	Tree	Liberian Coffee, Liberica Coffee
Commelina diffusa	Commelinaceae	Cryptogenic	-	Herb	Spreading Dayflower, Climbing Dayflower, Scurvy Weed
Connarus semidecandrus	Connaraceae	Native	Critically Endangered	Climber	-
Cordyline fruticosa	Asparagaceae	Exotic	Casual	Shrub	Red Dracaena, Cabbage Tree
Cratoxylum formosum	Hypericaceae	Native	Endangered	Tree	Pink Mempat, Derum, Mempat, Entemu, Geronggang Biabas, Gerunggung, Kemutul, Kemutun, Mempitis
Crinum asiaticum	Amaryllidaceae	Native	Critically Endangered	Shrub	Seashore Lily, Poison Bulb, Bakung, Crinum Lily, Asiatic Poison Lily, Spider Lily, Seashore Crinum, Bawang Hutan
Crotalaria retusa	Fabaceae	Cryptogenic	-	Shrub	Rattleweed, Shak-Shak, Rattlebox, Wedge-Leaf
Crytococcum patens	Poaceae	Native	Critically endangered	Herb	Bowgrass
Cucumis maderaspatanus	Cucurbitaceae	Exotic	Naturalised	Climber	Madras Pea Pumpkin

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Cuphea carthagenesis	Lythraceae	Exotic	Naturalised	Herb	Colombian Waxweed
Cuscuta australis	Convolvulaceae	Cryptogenic	-	Climber	Australian Dodder
Cyathula prostrata	Amaranthaceae	Native	Common	Herb	Hookweed, Pastureweed, Nyarang
Cyclosorus interruptus	Thelypteridaceae	Native	Common	Herb	Swamp Shield-Fern
Cyclosorus polycarpus	Thelypteridaceae	Native	Vulnerable	Herb	-
Cyclosorus triphyllus	Thelypteridaceae	Native	Common	Herb	-
Cynometra cauliflora	Fabaceae	Exotic	Cultivated only	Tree	Nam Nam, Katak Puru, Puki Anjing, Namu Namu
Cyperus compactus	Cyperaceae	Native	Common	Herb	-
Davallia denticulata	Davalliaceae	Native	Common	Climber	Rabbit's Foot Fern, Paku Tertutup
Dendrobium crumenatum	Orchidaceae	Native	Common	Epiphyte	Pigeon Orchid, White Dove Orchid, Pigeon Flower, Sparrow Orchid, Bag-Shaped Dendrobium, Anggerek Merpati, Daun Sepulih Tulang
Derris elliptica	Fabaceae	Native	Common	Climber	Tuba, Poison Vine
Desmodium heterophyllum	Fabaceae	Cryptogenic	-	Herb	Variable-Leaf Tick Trefoil, Spanish Clover, Greater Clover-Leaved Desmodium, Hetero, Rumput Sisek Naga
Desmodium triflorum	Fabaceae	Cryptogenic	-	Herb	Creeping Tick Trefoil, Three-Flower Beggarweed
Dieffenbachia amoena	Araceae	Exotic	Cultivated only	Shrub	-
Dieffenbachia seguine var. *seguine*	Araceae	Exotic	Casual	Herb	-
Digitaria longiflora	Poaceae	Native	Common	Herb	False Couch Grass
Dillenia suffruticosa	Dilleniaceae	Native	Common	Shrub	Simpuh Air, Simpoh Air, Shrubby Simpoh, Simpoh Ayer, White Simpoh, Yellow Simpoh
Dimocarpus longan	Sapindaceae	Exotic	Casual	Tree	Longan, Mata Kuching, Lungen, Dragon's Eye
Dimocarpus longan ssp. *malesianus*	Sapindaceae	Exotic	Casual	Tree	Mata Kuching
Diospyros blancoi	Ebenaceae	Exotic	Cultivated only	Tree	Butter Fruit, Velvet Persimmon, Velvet Apple, Mabolo, Buah Lemak, Buah Mentega
Dischidia nummularia	Apocynaceae	Native	Common	Epiphyte	Button Orchid, Daun Pitis Kecil
Dischidia oiantha	Apocynaceae	Exotic	Cultivated only	Climber	-
Dracaena aubryana	Asparagaceae	Exotic	Cultivated only	Shrub	Lance Dracaena
Dracaena fragrans	Asparagaceae	Exotic	Casual	Shrub	Corn Palm, Palmillo, Fortune Plant, Corn Plant, Senjuang Wangi, Dragon Plant, Iron Plant
Dracaena reflexa	Asparagaceae	Exotic	Cultivated only	Shrub	-
Dracaena surculosa	Asparagaceae	Exotic	Cultivated only	Shrub	Gold Dust Dracaena, Spotted Dracaena, Japanese Bamboo
Dracaena braunii	Asparagaceae	Exotic	Cultivated only	Shrub	Ribbon Dracaena, Lucky Bamboo, Belgian Evergreen, Ribbon Plant
Drynaria sp.	Polypodiaceae	Native	Common	Epiphyte	-

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Durio sp.	Malvaceae	Exotic	Cultivated only	Tree	-
Durio zibethinus	Malvaceae	Exotic	Casual	Tree	Durian, Durian Kampong
Eichhornia crassipes	Pontederiaceae	Exotic	Naturalised	Shrub	Lilac Devil, Water Hyacinth, Kemeling Telur, Common Water Hyacinth
Elaeis guineensis	Arecaceae	Exotic	Cultivated only	Tree	African Oil Palm
Elaeocarpus mastersii	Elaeocarpaceae	Native	Common	Tree	-
Eleocharis geniculata	Cyperaceae	Cryptogenic	-	Herb	Bent Spikerush, Canada Spikesedge
Embelia ribes	Myrsinaceae	Native	Common	Climber	False Black Pepper, White-Flowered Embelia
Entada spiralis	Fabaceae	Native	Common	Climber	Sea Bean, Akar Beluru
Epipremnum aureum	Araceae	Exotic	Casual	Climber	Ivy Arum, Golden Pothos, Money Plant, Devil's Ivy
Epipremnum pinnatum	Araceae	Native	Critically Endangered	Climber	Dragon-Tail Plant, Taro Vine, Silver Vine
Erycibe tomentosa	Convolvulaceae	Native	Common	Climber	Akar Pelandok
Etlingera elatior	Zingiberaceae	Exotic	Cultivated only	Herb	Painted Net Leaf, Torch Ginger, Philippine Waxflower, Nerve Plant, Bunga Kantan, Bunga Siantan
Eulophia graminea	Orchidaceae	Native	Common	Herb	Grass Orchid, Bawang Hantu
Falcataria moluccana	Fabaceae	Exotic	Naturalised	Tree	Albizia, Kayu Machis, Batai, Peacocksplume
Ficus apiocarpa	Moraceae	Native	Endangered	Climber	Ara Akar, Akar Tangisan Burung
Ficus aurata var. aurata	Moraceae	Native	Vulnerable	Shrub	Yellow Hairy Fig
Ficus benjamina	Moraceae	Cryptogenic	-	Tree	Weeping Fig, Benjamin's Fig, Malayan Banyan, Java Fig, Tropical Laurel, Weeping Laurel, Waringin, Ara Waringin, Jejawi, Java Willow, Java Tree, Beringin, Benjamin Tree, Small-Leaved Fig, Small-Leaved Rubber Plant
Ficus binnendijkii	Moraceae	Native	Critically Endangered	Strangler	-
Ficus caulocarpa	Moraceae	Native	Common	Tree	Stem-Fruited Fig
Ficus elastica	Moraceae	Exotic	Casual	Tree	Rubber Plant, Rubber Tree
Ficus fistulosa	Moraceae	Native	Common	Tree	Common Yellow Stem-Fig, Ara Serapat, Kelampung Bukit
Ficus grossularioides var. grossularioides	Moraceae	Native	Common	Tree	Ara Putih, White-Leafed Fig
Ficus heteropleura	Moraceae	Native	Common	climber	Sandy-Leafed Fig
Ficus hispida	Moraceae	Exotic	Naturalised	Tree	-
Ficus microcarpa	Moraceae	Native	Common	Tree	Malayan Banyan, Jejawi, Curtain Fig, Chinese Banyan, Glossy-Leaf Fig, Jawi Jawi, Small-Fruited Fig, Indian Laurel Fig, Laurel Fig
Ficus pumila var. *awkeotsang*	Moraceae	Exotic	Casual	Climber	Jelly Fig

Species	Family	Origin	Status	Habit	Common name
Ficus religiosa	Moraceae	Exotic	Naturalised	Tree	Sacred Fig Tree, Bodhi Tree, Pipul Tree, Budi, Pipal Tree, Pepul Tree, Bo Tree, Bodi, Ara Budi, Peepul Tree
Ficus variegata	Moraceae	Native	Common	Tree	Common Red-Stem Fig, Variegated Fig, Variegated Rubber Plant, Ara Kelumpang
Ficus vasculosa	Moraceae	Native	Endangered	Tree	White Fig, Ara Nasi, Pulut-Pulut, Sepedih, Tampang Burung
Fimbristylis cymosa ssp. *cymosa*	Cyperaceae	Native	Common	Herb	-
Fimbristylis dichotoma	Cyperaceae	Cryptogenic	-	Herb	-
Fimbristylis littoralis	Cyperaceae	Cryptogenic	-	Herb	Lesser Fimbry
Flagellaria indica	Flagellariaceae	Native	Common	climber	Common Flagellaria, Rotan Dini, False Rattan
Flemingia macrophylla	Fabaceae	Cryptogenic	-	Shrub	-
Garcinia mangostana	Clusiaceae	Exotic	Casual	Tree	Mangosteen, Manggis, Mesetor, Sementah, Semetah
Gliricidia sepium	Fabaceae	Exotic	Casual	Tree	Mexican Lilac, Madre De Cacao, Nicaraguan Cacao-Shade, Madre, Gliricidia, Mother Of Cocoa, Quick Stick
Glochidion zeylanicum var. *zeylanicum*	Phyllanthaceae	Native	Vulnerable	Tree	-
Gnetum gnemon var. *gnemon*	Gnetaceae	Native	Critically Endangered	Tree	Belinjau, Meninjau, Bago, Gnemon Tree, Maninjau, Minjau, Songkok, Spanish Joint Fir
Goniophlebium percussum	Polypodiaceae	Native	Vulnerable	Epiphyte	-
Guioa cf. *pubescens*	Sapindaceae	Native	Vulnerable	Tree	-
Gynochthodes sublanceolata	Rubiaceae	Native	Common	Climber	Akar Lampai Hitam
Hedyotis auricularia	Rubiaceae	Native	Common	Herb	-
Heliconia psittacorum	Heliconiaceae	Exotic	Casual	Shrub	Parakeet Flower
Hetaeria oblongifolia	Orchidaceae	Native	Presumed Extinct; Recently re-discovered	Herb	Jewel Orchid
Hevea brasiliensis	Euphorbiaceae	Exotic	Naturalised	Tree	Para Rubber, Rubber Tree, Pokok Getah, Hevea, Pokok Getah Para, Brazilian Rubber Tree
Hibiscus rosa-sinensis	Malvaceae	Exotic	Casual	Shrub	-
Hoya diversifolia	Apocynaceae	Native	Critically endangered	Climber	Akar Kekapal, Akar Serapat, Akar Sesapat, Akar Sedudu Bukit, Caping
Hoya latifolia	Apocynaceae	Native	Endangered	Climber	-
Hoya verticillata var. *verticillata*	Apocynaceae	Native	Common	Climber	Ridley's Hoya
Hypolytrum nemorum	Cyperaceae	Native	Common	Herb	-
Hyptis capitata	Lamiaceae	Exotic	Naturalised	Herb	-
Imperata conferta	Poaceae	Native	Common	Herb	-
Imperata cylindrica	Poaceae	Cryptogenic	-	Herb	Lalang, Cogon Grass, Alang-Alang, Blady Grass, Speargrass

Species	Family	Origin	Status	Habit	Common name
Indorouchera griffithiana	Linaceae	Native	Common	Climber	Akar Biji, Akar Kait Putih, Akar Putih, Akar Tenggadin, Akar Tuai, Garam-Garam
Ipomoea cairica	Convolvulaceae	Exotic	Naturalised	Climber	Messina Creeper, Mile A Minute Vine, Railway Creeper
Ipomoea pes-caprae	Convolvulaceae	Native	Common	Climber	Beach Morning Glory, Railroad Vine, Sea Morning Glory, Tapak Kuda, , Goat's Foot, Attukkal
Isachne globosa	Poaceae	Cryptogenic	-	Herb	-
Ischaemum muticum	Poaceae	Native	Common	Herb	Seashore Centipede Grass, Rumput Tembaga Jantan, Rumput Kemarau
Ischaemum rugosum	Poaceae	Cryptogenic	-	Herb	-
Ixonanthes reticulata	Ixonanthaceae	Native	Common	Tree	Pagar Anak, Ten Men Tree, Inggir Burong, Nyiran Burong
Ixora congesta	Rubiaceae	Native	Common	Shrub	Malayan Ixora, Jarum-Jarum, Khem Deang
Justicia gendarussa	Acanthaceae	Exotic	Cultivated only	Shrub	Willow-Leaved Justicia, Warer Willow, Daun Rusa, Gardarusa, Ganda Rusa
Kyllinga polyphylla	Cyperaceae	Exotic	Naturalised	Herb	Navua Sedge
Lagerstroemia speciosa	Lythraceae	Exotic	Cultivated only	Shrub	Pride Of India, Rose Of India, Queen's Crape Myrtle, Crepe Myrtle, Crepe Flower, Queen Flower, Banaba, Pyinma, Bungur Raya, Bungor Raya, Bungor
Lansium domesticum	Meliaceae	Exotic	Cultivated only	Tree	Langsat, Duku, Langsat Hutan
Lantana camara	Verbenaceae	Exotic	Naturalised	Shrub	Big-Sage, Wild-Sage, Red-Sage, White-Sage, Tickberry, West Indian Lantana
Leea angulata	Vitaceae	Native	Critically Endangered	Tree	Memali, Thorny Tree-Vine, Mali Berduri, Mali-Mali, Toi
Leea indica	Vitaceae	Native	Common	Tree	Common Tree-Vine, Jolok-Jolok, Merbati Padang
Lemna minor	Araceae	Cryptogenic	-	Herb	-
Lepisanthes rubiginosa	Sapindaceae	Native	Common	Tree	-
Leucaena leucocephala	Fabaceae	Exotic	Naturalised	Tree	Lead Tree, Reuse Wattel, White Popinac, Horse Tamarind, Wild Tamarind, Leucaena, Jumbie Bean, Jumbay, Ipil-Ipil, Petai Jawa
Limacia scandens	Menispermaceae	Native	Vulnerable	Climber	-
Lindera lucida	Lauraceae	Native	Vulnerable	Tree	-
Litchi chinensis	Sapindaceae	Exotic	Cultivated only	Tree	Lychee, Litchee, Litchi
Litsea cf. *cordata*	Lauraceae	Native	Critically Endangered	Tree	Medang
Litsea elliptica	Lauraceae	Native	Common	Tree	-
Litsea firma	Lauraceae	Native	Vulnerable	Tree	Blue Laurel, Medang
Ludwigia octovalvis	Onagraceae	Cryptogenic	-	Herb	Mexican Primrose Willow, Primrose Willow
Lygodium flexuosum	Schizaeaceae	Native	Common	Climber	-

Species	Family	Origin	Status	Habit	Common name
Macaranga bancana	Euphorbiaceae	Native	Common	Tree	-
Macaranga conifera	Euphorbiaceae	Native	Common	Tree	-
Macaranga gigantea	Euphorbiaceae	Native	Common	Tree	-
Macaranga griffithiana	Euphorbiaceae	Native	Vulnerable	Tree	Mahang Bulan, Mahang Tutup
Macaranga heynei	Euphorbiaceae	Native	Common	Tree	-
Macaranga hypoleuca	Euphorbiaceae	Native	Common	Tree	-
Macrosolen cochinchinensis	Loranthaceae	Native	Common	Epiphyte	Common Chinese Mistletoe
Mallotus paniculatus	Euphorbiaceae	Native	Common	Tree	-
Mangifera foetida	Anacardiaceae	Native	Vulnerable	Tree	Horse Mango, Bacang, Bachang, Machang, Machai, Membacang
Mangifera indica	Anacardiaceae	Exotic	Casual	Tree	Mango, Mangas, Mangga, Mempalam, Puah, Mempelam
Mangifera odorata	Anacardiaceae	Native	Vulnerable	Tree	Saipan Mango, Fragrant Mango, Kuini, Kweni, Kuweni, Kuwini, Wani
Manihot carthagenensis ssp. *glaziovii*	Euphorbiaceae	Exotic	Naturalised	Tree	Tree Cassava, Ceara Rubber Tree
Manihot esculenta	Euphorbiaceae	Exotic	Naturalised	Herb	Manihot, Tapioca, Bitter Cassava, Manioc, Mandioca, Ubi Kayu, Gari
Manilkara zapota	Sapotaceae	Exotic	Cultivated only	Tree	Chiku, Sapodilla, Sauh Menila, Naseberry, Nispero, Chicle, Chicle Gum, Ciku
Megathyrsus maximus	Poaceae	Exotic	Naturalised	Herb	Guinea Grass, Green Panic Grass
Melastoma malabathricum	Melastomataceae	Native	Common	Shrub	Common Sendudok, Singapore Rhododendron, Indian Rhododendron, Sesenduk, Malabar Gooseberry, Straits Rhododendron, Sendudok, Senduduk
Melicope lunu-ankenda	Rutaceae	Native	Critically Endangered	Tree	-
Melothria pendula	Cucurbitaceae	Exotic	Naturalised	Climber	Guadeloupe Cucumber
Merremia umbellata	Convolvulaceae	Cryptogenic	-	Climber	-
Microlepia speluncae	Dennstaedtiaceae	Native	Common	Herb	-
Mikania micrantha	Asteraceae	Exotic	Naturalised	Climber	American Rope, Mile-A-Minute Weed, Bittervine, Chinese Creeper, Climbing Hempvine
Mimosa pigra	Fabaceae	Exotic	Naturalised	Shrub	Giant Sensitive Tree, Bashful Plant, Catclaw Mimosa, Black Mimosa
Mimosa pudica	Fabaceae	Exotic	Naturalised	Herb	Sensitive Plant, Sleepy Plant, Action Plant, Dormilones, Touch-Me-Not, Shameplant, Shy Plant
Morella esculenta	Myricaceae	Native	Common	Tree	Malay Gale, Telur Cicak, Geliche, Telur Chichak
Morinda citrifolia	Rubiaceae	Cryptogenic	-	Tree	Mengkudu Besar, Inda, Menkudu, Indian Mulberry, Noni, Great Morinda, Cheese Fruit, Mengkudu, Awl Tree, Brimstone Tree
Mucuna biplicata	Leguminosae	Native	Not Assessed; Recently discovered	Climber	-

Species	Family	Origin	Status	Habit	Common name
Muntingia calabura	Malvaceae	Exotic	Naturalised	Tree	Buah Cheri, Malayan Cherry, Singapore Cherry, Calabura, Cherry Tree, Japanese Cherry, Jamaican Cherry, West Indian Cherry Tree, Kerukup-Siam, Buah Ceri, Capulin, Panama Berry
Murraya koenigii	Rutaceae	Exotic	Casual	Shrub	Curry Tree
Nephelium lappaceum	Sapindaceae	Native	Critically Endangered	Tree	Rambutan, Hairy Lychee
Nephelium ramboutan-ake	Sapindaceae	Native	Extinct	Tree	Pulasan, Kapoelasan, Rambutan Paroh, Rambutan-Kafri, Pening-Pening Ramboutan, Bulala
Nephrolepis biserrata	Oleandraceae	Native	Common	Herb	Broad Sword Fern, Paku Larat, Giant Sword Fern, Sword Fern
Nephrolepis falcata	Oleandraceae	Native	Common	Epiphyte	Fish-Tail Fern, Fishtail Sword Fern, Weeping Sword Fern
Neptunia plena	Fabaceae	Exotic	Naturalised	Shrub	Aquatic Sensitive Plant, Water Sensitive Plant, Water Dead-And-Awake, Water Mimosa
Ochna kirkii	Ochnaceae	Exotic	Cultivated only	Shrub	Mickey Mouse Plant, Bird's Eye Bush
Oncosperma tigillarium	Arecaceae	Native	Vulnerable	Tree	Nibung, Nibong, Nibung Palm
Ottochloa nodosa	Poaceae	Native	Common	Herb	-
Oxalis barrelieri	Oxalidaceae	Exotic	Naturalised	Shrub	Lavender Sorrel
Oxyceros longiflorus	Rubiaceae	Native	Vulnerable	Climber	Akar Berdara Laut
Paederia foetida	Rubiaceae	Native	Common	Climber	Lesser Malayan Stinkwort, Akar Sekentut, Daun Kentut-Kentut
Pandanus amaryllifolius	Pandanaceae	Exotic	Casual	Shrub	Pandan, Fragrant Pandan, Scented Pandan, Screwpine, Fragrant Screwpine, Indonesian Screwpine, Pandan Rampeh, Pandan Wangi, Daun Pandan
Pandanus odorifer	Pandanaceae	Native	Common	Shrub	Screw-Pine, Kewda, Fragrant Screw Pine, Umbrella Tree, Screw Tree
Panicum repens	Poaceae	Native	Common	Herb	Torpedograss, Creeping Panic, Panic Rampant, Couch Panicum, Wainaku Grass, Quack Grass, Dog-Tooth Grass, Bullet Grass
Pellionia repens	Urticaceae	Native	Extinct	Climber	Trailing Watermelon Begonia, Wavy Watermelon Begonia, Satin Creeper, Rainbow Vine, Sisek Naga
Pennisetum setaceum	Poaceae	Exotic	Cultivated only	Herb	Variegated Purple Fountain Grass
Peperomia pellucida	Piperaceae	Exotic	Naturalised	Herb	Shiny Bush, Pepper Elder
Pereskia bleo	Cactaceae	Exotic	Cultivated only	Shrub	Wax Rose, Rose Cactus, Jarum Tujuh Bilah, Leaf Cactus, Perescia
Peristrophe roxburghiana	Acanthaceae	Cryptogenic	-	Herb	Peristrophe, Magenta Plant, Noja
Persicaria chinensis var. *chinensis*	Polygonaceae	Exotic	Naturalised	Shrub	Chinese Knotweed, Sembuluh
Phaleria macrocarpa	Thymelaeaceae	Exotic	Cultivated only	Tree	Mahkota Dewa,God's Crown, Tree of Life
Philodendron erubescens	Araceae	Exotic	Cultivated only	Climber	Blushing Philodendron, Red-Leaf Philodendron
Phyllanthus urinaria	Phyllanthaceae	Exotic	Naturalised	Herb	Shatterstone, Leafflower, Chamber Bitter
Phytocrene bracteata	Icacinaceae	Native	Vulnerable	Climber	-

Species	Family	Origin	Status	Habit	Common name
Pilea nummulariifolia	Urticaceae	Exotic	Cultivated only	Herb	Creeping Charlie
Pinus sp.	Pinaceae	Exotic	Cultivated only	Tree	-
Piper aduncum	Piperaceae	Exotic	Naturalised	tree	Spiked Pepper, Matico, Higuillo De Hoja Menuda
Piper betle	Piperaceae	Exotic	Casual	Herb	Betel, Betel Vine, Betel Pepper, Betle Pepper, Pan, Sireh
Piper sarmentosum	Piperaceae	Native	Common	Herb	Wild Pepper, Wild Betel, Kadok, Kaduk, Daun Kaduk, Chabei, Sri Tanah, Chaa Phluu, La Lot, Akar Bugu, Sirih Duduk
Pipturus argenteus	Urticaceae	Exotic	Naturalised	Tree	False Stinger, Native Mulberry, White Mulberry, White Nettle
Pithecellobium dulce	Fabaceae	Exotic	Casual	Tree	Madras Thorn, Bread-And-Cheese, Manila Tamarind, Huamuchil, Opiuma, Asam Keranji, Blackhead, Asam Kranji, Asam Tjina
Planchonella obovata	Sapotaceae	Native	Vulnerable	Tree	Sea Gutta, Menasi, Northern Yellow Boxwood, Yellow Teak, Black Ash, Pulau Dammar, Misi, Nyatoh Laut
Plectranthus monostachyus	Lamiaceae	Exotic	Naturalised	Herb	Monkey's Potato
Pleocnemia irregularis	Dryopteridaceae	Native	Common	Herb	-
Pluchea indica	Asteraceae	Native	Common	Shrub	Indian Camphorweed, Indian Fleabane, Indian Pluchea
Polyalthia longifolia	Annonaceae	Exotic	Cultivated only	Tree	Indian Mast Tree, Mast Tree, Sorrowless Tree, False Ashok Tree, Cemetery Tree, Asoka Tree
Polyscias fruticosa	Araliaceae	Exotic	Cultivated only	Shrub	Ming Aralia
Pometia pinnata	Sapindaceae	Native	Endangered	Tree	Island Lychee, Lansir, Pacific Lychee, Fijian Longan, Kasai Daun Besar, Kasai Langsir, Kelisar, Obahu, Kawa, Tawa
Premna serratifolia	Lamiaceae	Native	Vulnerable	Climber	Buas-Buas, Bastard Guelder, Bangkung Kayu, Sarunai, Singkel
Pteris ensiformis 'Victoriae'	Pteridaceae	Cryptogenic	-	Herb	Sword Brake, Slender Brake, Paku Padang
Pteris vittata	Pteridaceae	Cryptogenic	-	Herb	Chinese Brake Fern, Brake Fern, Chinese Ladder Fern
Pterocarpus indicus	Fabaceae	Exotic	Casual	Tree	Angsana, Sena, Burmese Rosewood, Philippine Mahogany, Andaman Redwood, Red Sandalwood, Padouk, Padauk, Narra, Pokok Sena
Ptychosperma macarthurii	Arecaceae	Exotic	Naturalised	Tree	Macarthur Palm, Hurricane Palm, Macarthur Feather Palm, Cluster Palm
Pyrrosia piloselloides	Polypodiaceae	Native	Common	Epiphyte	Dragon Scales, Sakat Ribu-Ribu, Sisek Naga, Pakis Duitan, Dragon's Scale Fern
Quisqualis indica	Combretaceae	Exotic	Casual	Climber	Rangoon Creeper, Drunken Sailor, Akar Dani, Akar Suloh, Dani, Ara Dani, Akar Pontianak, Red Jasmine
Rhapis excelsa	Arecaceae	Exotic	Cultivated only	Shrub	Ground Rattan, Bamboo Palm, Lady Palm, Miniature Fan Palm, Fern Rhapis
Rhodamnia cinerea	Myrtaceae	Native	Common	Tree	Silver Back Tree, Mempoyan, Poyan, Empoyan, Tempoyai, Mengkoyan
Rubus moluccanus var. *moluccanus*	Rosaceae	Native	Vulnerable	climber	-
Salvinia minima	Salviniaceae	Exotic	Naturalised	Herb	-

Species	Family	Origin	Status	Habit	Common name
Salvinia molesta	Salviniaceae	Exotic	Naturalised	Herb	Giant Salvinia, Kariba Weed
Samanea saman	Fabaceae	Exotic	Casual	Tree	Rain Tree, Pukul Lima, Cow Tamarind, Hujan-Hujan, East Indian Walnut, Monkey-Pod, Saman
Sanchezia speciosa	Acanthaceae	Exotic	Cultivated only	Shrub	Zebra Plant, Yellow Sanchezia, Shrubby Whitevein, Gold Vein Plant
Sandoricum koetjape	Meliaceae	Native	Endangered	Tree	Sentul, Santol, Sentol, Kechapi, Kecapi, Kelampu, Ketjape, Ketuat, Lolly Fruit, Ranggu, Red Santol, Yellow Sentol
Schefflera actinophylla	Araliaceae	Exotic	Casual	Tree	Umbrella Tree, Octopus Tree, Australian Ivy - Palm, Queensland, Ivy Palm, Brassaia
Schefflera elliptica	Araliaceae	Native	Vulnerable	Shrub	Ara Bebari, Bunga Kuku Langsuir, Cenama Gajah
Scindapsus hederaceus	Araceae	Native	Common	Climber	Akar Lebang Aleh, Akar Ular, Lowland Scindapsus
Scleria ciliaris	Cyperaceae	Native	Common	Herb	-
Scurrula ferruginea	Loranthaceae	Native	Common	Epiphyte	-
Selaginella willdenowii	Selaginellaceae	Native	Vulnerable	Herb	Willdenow's Spikemoss, Peacock Fern, Blue Spike Moss, Blue Club Moss, Vine Spike Moss, Paku Selemah
Senna alata	Fabaceae	Exotic	Naturalised	Tree	Candle Bush, Empress Candle Plant, Seven Golden Candlesticks, Candlestick Cassia, Candlestick Senna, Christmas Candle, Ringworm Cassia, Ringworm Bush, Gelenggang, Daun Kurap
Setaria barbata	Poaceae	Exotic	Naturalised	Herb	-
Sida acuta	Malvaceae	Cryptogenic	-	Shrub	Spiny-head Sida, Common Wireweed
Smilax setosa	Smilacaceae	Native	Common	Climber	Bearded Smilax, Akar Banar, Akar Keranting Jantan
Solanum torvum	Solanaceae	Exotic	Naturalised	Shrub	Turkey Berry, Devil's Fig, Terung Pipit
Spathodea campanulata	Bignoniaceae	Exotic	Naturalised	Tree	African Tulip Tree, Flame Of The Forest, Fountain Tree, Fire Tree, Fire Bell, Nandi Flame, Gabon Tulip Tree, Syringe Tree, Pancut-Pancut, Panchot
Spathoglottis plicata	Orchidaceae	Native	Common	Shrub	Spathoglottis Orchid, Common Spathoglottis, Philippine Ground Orchid, Lumbah Tikus, Pleated Leaf Spathoglottis, Malayan Ground Orchid
Spondias pinnata	Anacardiaceae	Exotic	Cultivated only	Tree	-
Sporobolus indicus	Poaceae	Native	Common	Herb	-
Stachytarpheta indica	Verbenaceae	Exotic	Naturalised	Herb	Indian Snakeweed, Blue Snakeweed, Nettle-Leaved Vervain
Stenochlaena palustris	Blechnaceae	Native	Common	Climber	Climbing Fern, Akar Paku, Paku Ranu, Paku Miding
Stenotaphrum secundatum	Poaceae	Exotic	Naturalised	Herb	Variegated Saint Augustine Grass
Sterculia rubiginosa	Malvaceae	Native	Vulnerable	Tree	Rusty Sterculia, Kelumpang, Kelumpang Bukit, Kelumpang Gajah, Kayu Amplas, Bayur Betina, Dedamak Hitam, Pokok Sakhlat, Tangisan Burung, Unting-Unting Besar
Strobilanthes crispa	Acanthaceae	Exotic	Cultivated only	Herb	Bayam Karang, Pecah Batu, Batu Jin, Keci Beling

Species	Family	Origin	Status	Habit	Common name
Symplocos fasciculata	Symplocaceae	Native	Vulnerable	Tree	-
Syngonium podophyllum	Araceae	Exotic	Naturalised	Herb	Arrowhead Vine
Syzygium aqueum	Myrtaceae	Exotic	Cultivated only	Tree	Water Apple, Jambu Air Mawar, Water Rose Apple, Watery Rose Apple, Water Cherry, Java Apple, Bell Fruit, Jambu Ayer, Jambu Chili, Jambu Air
Syzygium borneense	Myrtaceae	Native	Common	Tree	Bullate Eugenia
Syzygium grande	Myrtaceae	Native	Common	Tree	Sea Apple, Jambu Laut, Kilat Jambu, Jambu Air Laut, Jambu Ayer Laut, Jambu Jembah, Jembah, Kerian Acheh, Kerian Ayer, Keriang Batu, Ubah
Syzygium jambos	Myrtaceae	Exotic	Casual	Tree	Rose Apple, Malabar Plum, Jambu Air Mawar, Jambu Mawar, Jambu Kraton, Jambu Kelampok, Jambu Mawer
Syzygium lineatum	Myrtaceae	Native	Common	Tree	Common Kelat, Gelam Tikus, Ubah, Benitan Putih, Kecam, Kelat Lapis, Kelat Merah, Kelat Nasi-Nasi, Kelat Paya, Kelat Putih, Sekujah
Syzygium malaccense	Myrtaceae	Exotic	Casual	Tree	Malay Apple, Pomerac, Jambu Bol, Jambu Merah
Syzygium myrtifolium	Myrtaceae	Native	Extinct	Tree	Kelat Oil, Kelat Paya, Red Lip
Syzygium polyanthum	Myrtaceae	Native	Vulnerable	Tree	Indonesian Bayleaf, Salam, Samak, Indian Bayleaf, Buah Salam, Kelat Samak, Serah
Syzygium zeylanicum	Myrtaceae	Native	Common	Tree	Spicate Eugenia, Kelat Nasi Nasi, Kelat Nenasi, Gelam Tikus, Gelam Paya, Gelam Tikus Laut, Kelat Merah
Tabebuia rosea	Bignoniaceae	Exotic	Casual	Tree	Trumpet Tree, Pink Poui, New World Trumpet, Rosy Trumpet Tree, Pink Tecoma
Tabernaemontana corymbosa	Apocynaceae	Native	Endangered	Shrub	Great Rosebay, Flower Of Love, Jelutong Badak
Taenitis blechnoides	Pteridaceae	Native	Common	Climber	Ribbon Fern
Talipariti tiliaceum	Malvaceae	Native	Common	Tree	Sea Hibiscus, Beach Hibiscus, Linden Hibiscus, Cotton Tree, Baru Baru, Bebaru, Mahoe
Tamarindus indica	Fabaceae	Exotic	Casual	Tree	Tamarind, Asam, Asam Jawa, Tamarindo, Indian Date
Tecoma stans	Bignoniaceae	Exotic	Cultivated only	Tree	Golden Bells, Yellow Bells, Yellow Bignonia, Trumpet Tree, Ramat Emas, Yellow Trumpet Flowers, Yellow Elder
Terminalia catappa	Combretaceae	Native	Common	Tree	Sea Almond, Ketapang, Tropical Almond Tree, Pacific Almond, Singapore Almond, Indian Almond, Lingtak, Bastard Almond, Telisai, Jelawai Ketapang
Tetracera indica	Dilleniaceae	Native	Common	Climber	Fireweed, Tetracera, Hedge Row Tetracera, Puson Dumarun, Akar Pulas Duyio, Akar Mempelas, Empelas
Theobroma cacao	Malvaceae	Exotic	Cultivated only	Tree	Cocoa, Cacao, Chocolate Nut Tree
Thunbergia grandiflora	Acanthaceae	Exotic	Casual	Climber	-
Tinospora crispa	Menispermaceae	Exotic	Casual	Climber	Petawali, Makabuhai, Liane-Quinine
Tradescantia spathacea	Commelinaceae	Exotic	Cultivated only	Herb	Boat Lily, Oyster Plant, Cradle Lily, Moses-In-The-Cradle, Moses In His Cradle, Moses On A Raft, Moses In The Bulrushes, Men In A Boat

Species	Family	Origin	Status	Habit	Common name
Triadica cochinchinensis	Euphorbiaceae	Native	Common	Tree	Mouse Deer's Delight
Triphasia trifolia	Rutaceae	Exotic	Cultivated only	Tree	Limeberry, Limau Keah, Limau Kiah, Limau Kikir, Kelingket
Unknown Pteridophyte	-	-	-	-	-
Utricularia aurea	Lentibulariaceae	Cryptogenic	-	Herb	Bladderwort
Vigna reflexopilosa	Fabaceae	Exotic	Naturalised	Climber	-
Vitex pinnata	Lamiaceae	Native	Common	Tree	Leban, Malayan Teak, Vitex, Halban, Leban Buas, Leban Papa, Leban Tandok
Vittaria ensiformis	Vittariaceae	Native	Common	Epiphyte	-
Wrightia religiosa	Apocynaceae	Exotic	Casual	Shrub	Wild Water Plum, Water Jasmine, Sacred Buddhist
Xanthophyllum flavescens	Polygalaceae	Native	Endangered	Tree	-
Zingiber officinale	Zingiberaceae	Exotic	Cultivated only	Herb	Halia, Common Ginger, Canton Ginger, Stem Ginger, Ginger
Zingiber ottensii	Zingiberaceae	Exotic	Casual	Herb	-

Appendix 7B: List of Probable and Recorded Faunal Species

List of Probable and Recorded Faunal Species

Faunal group	No. of probable species		No. of recorded species		No. of recorded species not on probable list	
	All species	CS species	All species	CS species	All species	CS species
Aculeate hymenopterans	78	0	43	1	0	0
Bees	38	0	18	0	0	0
Stinging wasps	40	0	25	1	0	0
Odonates	54	1	40	3	2	2
Dragonflies	44	0	32	1	1	1
Damselflies	10	1	8	2	1	1
Butterflies	201	24	72	4	0	0
Freshwater decapod crustaceans	3	0	0	0	0	0
Freshwater fish	22	1	9	1	1	0
Herpetofauna	49	7	29	2	0	0
Amphibians	13	0	12	0	0	0
Reptiles	36	7	17	2	0	0
Birds	177	24	86	15	0	0
Mammals	28	7	17	5	0	0
Non-volant mammals	17	4	9	3	0	0
Bats	11	3	8	2	0	0
Total	**612**	**64**	**296**	**31**	**3**	**1**

List of Probable and Recorded Faunal Species - Aculeate hymenopterans

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Ascher et al. (in prep); JXQ Lee, pers comm)	Species of Conservation Significance	Native Status (The Biodiversity of Singapore, 2020; JXQ Lee, pers comm)	Probable Species	Recorded Species	Remarks
1	Bee	Apidae	*Amegilla andrewsi*	Andrew's blue-banded digger bee	Not Assessed	Least Concern	No	Native	Yes	No	
2	Bee	Apidae	*Amegilla korotonensis*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
3	Bee	Apidae	*Apis andreniformis*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
4	Bee	Apidae	*Apis cerana*	Eastern honey bee	Not Assessed	Not Assessed	No	Native	Yes	Yes	
5	Bee	Apidae	*Apis dorsata*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
6	Bee	Apidae	*Apis florea*	NA	Not Assessed	Not Assessed	No	Non-native	Yes	Yes	
7	Bee	Apidae	*Braunsapis clarihirta*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
8	Bee	Apidae	*Braunsapis cupulifera**	NA	Not Assessed	Least Concern	No	Native	Yes	No	
9	Bee	Apidae	*Braunsapis hewitti**	NA	Not Assessed	Least Concern	No	Native	Yes	No	
10	Bee	Apidae	*Braunsapis puangensis*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
11	Bee	Apidae	*Ceratina collusor*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
12	Bee	Apidae	*Ceratina dentipes*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
13	Bee	Apidae	*Ceratina lieftincki*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
14	Bee	Apidae	*Ceratina smaragdula*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
15	Bee	Apidae	*Ceratina unimaculata*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
16	Bee	Apidae	*Ceratini nigrolateralis*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
17	Bee	Apidae	*Tetragonula valdezi*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
18	Bee	Apidae	*Thyreus ceylonicus*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
19	Bee	Apidae	*Thyreus himalayensis*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
20	Bee	Apidae	*Xylocopa aestuans*	White-cheeked carpenter bee	Not Assessed	Not Assessed	No	Native	Yes	Yes	
21	Bee	Apidae	*Xylocopa caerulea*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
22	Bee	Apidae	*Xylocopa flavonigrescens*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
23	Bee	Apidae	*Xylocopa latipes*	Broad-handed carpenter bee	Not Assessed	Not Assessed	No	Native	Yes	Yes	
24	Bee	Colletidae	*Hylaeus penangensis*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
25	Bee	Halictidae	*Lasioglossum adonidiae*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
26	Bee	Halictidae	*Lasioglossum deliense*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
27	Bee	Halictidae	*Lasioglossum vagans*	NA	Not Assessed	Least Concern	No	Native	Yes	No	

List of Probable and Recorded Faunal Species - Aculeate hymenopterans

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Ascher et al. (in prep); JXQ Lee, pers comm)	Species of Conservation Significance	Native Status (The Biodiversity of Singapore, 2020; JXQ Lee, pers comm)	Probable Species	Recorded Species	Remarks
28	Bee	Halictidae	*Lipotriches ceratina*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
29	Bee	Halictidae	*Nomia strigata*	Pearly-banded bee	Not Assessed	Not Assessed	No	Native	Yes	Yes	
30	Bee	Halictidae	*Pseudapis siamensis*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
31	Bee	Megachilidae	*Euaspis polynesia*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
32	Bee	Megachilidae	*Megachile conjuncta*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
33	Bee	Megachilidae	*Megachile disjuncta*	NA	Not Assessed	Not Assessed	No	Non-native	Yes	No	
34	Bee	Megachilidae	*Megachile umbripennis*	NA	Not Assessed	Not Assessed	No	Non-native	Yes	No	
35	Bee	Megachilidae	*Coelioxys confusus*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
36	Bee	Megachilidae	*Heriades sp.*	NA	NA	NA	No	NA	Yes	Yes	
37	Bee	Megachilidae	*Megachile laticeps*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
38	Bee	Megachilidae	*Megachile subrixator*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
39	Wasp	Crabronidae	*Liris subtessellatus*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
40	Wasp	Crabronidae	*Trypoxylon sp.*	NA	NA	NA	No	NA	Yes	Yes	
41	Wasp	Crabronidae	*Unidentified Larrinae*	NA	NA	NA	No	NA	Yes	Yes	
42	Wasp	Pompilidae	*Auplopus sp. (grey)*	NA	NA	NA	No	NA	Yes	Yes	
43	Wasp	Pompilidae	*Tachypompilus analis*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
44	Wasp	Scoliidae	*Campsomeriella collaris*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
45	Wasp	Scoliidae	*Phalerimeris phalerata*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
46	Wasp	Sphecidae	*Chalybion bengalense*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
47	Wasp	Sphecidae	*Isodontia diodon*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
48	Wasp	Sphecidae	*Sceliphron javanum*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
49	Wasp	Sphecidae	*Sphex diabolicus*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
50	Wasp	Sphecidae	*Sphex sericeus*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
51	Wasp	Sphecidae	*Sphex subtruncatus*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
52	Wasp	Vespidae	*Allorhynchium argentatum*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
53	Wasp	Vespidae	*Antepipona sp. nr. bipustulata*	NA	NA	NA	No	NA	Yes	Yes	
54	Wasp	Vespidae	*Delta campaniforme*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	

List of Probable and Recorded Faunal Species - Aculeate hymenopterans

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Ascher et al. (in prep); JXQ Lee, pers comm)	Species of Conservation Significance	Native Status (The Biodiversity of Singapore, 2020; JXQ Lee, pers comm)	Probable Species	Recorded Species	Remarks
55	Wasp	Vespidae	*Delta pyriforme*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
56	Wasp	Vespidae	*Elimus sp.*	NA	NA	NA	No	Native	Yes	No	
57	Wasp	Vespidae	*Eumenes sp.*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
58	Wasp	Vespidae	*Liostenogaster nitidipennis*	NA	Not Assessed	Near Threatened	No	Native	Yes	No	
59	Wasp	Vespidae	*Liostenogaster varipicta*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
60	Wasp	Vespidae	*Parapolybia varia*	Lesser paper wasp	Not Assessed	Near Threatened	No	Native	Yes	No	
61	Wasp	Vespidae	*Parischnogaster mellyi*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
62	Wasp	Vespidae	*Parischnogaster nigricans*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
63	Wasp	Vespidae	*Phimenes flavopictus*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
64	Wasp	Vespidae	*Polistes sagittarius*	Banded paper wasp	Not Assessed	Least Concern	No	Native	Yes	No	
65	Wasp	Vespidae	*Polistes stigma*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
66	Wasp	Vespidae	*Polistes tenebris*	NA	Not Assessed	Data Deficient	No	Native	Yes	No	
67	Wasp	Vespidae	*Rhynchium haemorrhoidale*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
68	Wasp	Vespidae	*Ropalidia erythrospila*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
69	Wasp	Vespidae	*Ropalidia jacobsoni*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
70	Wasp	Vespidae	*Ropalidia marginata*	NA	Not Assessed	Near Threatened	Yes	Native	Yes	Yes	
71	Wasp	Vespidae	*Ropalidia stigma*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
72	Wasp	Vespidae	*Ropalidia sumatrae*	NA	Not Assessed	Not Assessed	No	Native	Yes	Yes	
73	Wasp	Vespidae	*Ropalidia timida*	NA	Not Assessed	Not Assessed	No	NA	Yes	Yes	
74	Wasp	Vespidae	*Stenodyneriellus guttulatus*	NA	Not Assessed	Least Concern	No	Native	Yes	Yes	
75	Wasp	Vespidae	*Subancistrocerus sichelii*	NA	Not Assessed	Least Concern	No	Native	Yes	No	
76	Wasp	Vespidae	*Vespa affinis*	Lesser banded hornet	Not Assessed	Not Assessed	No	Native	Yes	Yes	
77	Wasp	Vespidae	*Vespa analis*	Yellow vented hornet	Not Assessed	Not Assessed	No	Native	Yes	Yes	
78	Wasp	Vespidae	*Vespa tropica*	Greater banded hornet	Not Assessed	Not Assessed	No	Native	Yes	Yes	
-	Bee	Halictidae	*Lasioglossum sp.*	NA	NA	NA	No	NA	Yes	Yes	

List of Probable and Recorded Faunal Species - Aculeate hymenopterans

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Ascher et al. (in prep); JXQ Lee, pers comm)	Species of Conservation Significance	Native Status (The Biodiversity of Singapore, 2020; JXQ Lee, pers comm)	Probable Species	Recorded Species	Remarks
*Both the taxonomic revision of *Braunsapis* and preliminary DNA barcoding results from Singapore suggests that both *B. cupulifera* and *B. hewitti* may be species complexes. Both size and colour variation are evident but neither could be readily associated with barcode clusters. Available data suggests that bees from mangrove sites may differ specifically from that of other sites in Singapore. Integrative taxonomic studies are needed before potential cryptic taxa can be delimited and named reliably, including studies of DNA and male genitalia from across the wide ranges of these species. From Ascher et al (in prep)											

List of Probable and Recorded Faunal Species - Odonates

No.	Type	Family Name	Scientific Name	Common Name	Global Status (IUCN, 2012)	National Status (Soh et al., 2019)	Species of Conservation Significance	Distribution/Rarity (Soh et al. 2019)	Probable Species	Recorded Species	Remarks
1	Damselfly	Coenagrionidae	*Agriocnemis femina*	Variable wisp	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
2	Damselfly	Coenagrionidae	*Agriocnemis nana*	Dwarf wisp	Least Concern	Endangered	Yes	Restricted and Very Rare	No	Yes	
3	Damselfly	Coenagrionidae	*Agriocnemis rubescens*	Variable sprite	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
4	Damselfly	Coenagrionidae	*Archibasis viola*	Violet sprite	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
5	Damselfly	Coenagrionidae	*Ceriagrion cerinorubellum*	Ornate coraltail	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
6	Damselfly	Coenagrionidae	*Ischnura senegalensis*	Common bluetail	Least Concern	Least Concern	No	Widespread and Common	Yes	No	Recorded in J1002 EIA (2016); Tengah EBS (2017)
7	Damselfly	Coenagrionidae	*Pseudagrion microcephalum*	Blue sprite	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
8	Damselfly	Coenagrionidae	*Teinobasis ruficollis*	Red-tailed sprite	Not Assessed	Near Threatened	No	Widespread but Rare	Yes	No	Recorded in J1001 EIA (2017)
9	Damselfly	Platycnemididae	*Copera marginipes*	Yellow featherlegs	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
10	Damselfly	Platycnemididae	*Copera vittata*	Variable featherlegs	Least Concern	Vulnerable	Yes	Restricted and Rare	Yes	Yes	
11	Damselfly	Platycnemididae	*Onychargia atrocyana*	Shorttail	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	No	
12	Dragonfly	Aeshnidae	*Anax guttatus*	Emperor	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
13	Dragonfly	Aeshnidae	*Gynacantha dohrni*	Spear-tail duskhawker	Not Assessed	Least Concern	No	Widespread but Uncommon	Yes	Yes	
14	Dragonfly	Aeshnidae	*Gynacantha subinterrupta*	Dingy duskhawker	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
15	Dragonfly	Gomphidae	*Ictinogomphus decoratus*	Common flangetail	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
16	Dragonfly	Libellulidae	*Acisoma panorpoides*	Trumpet tail	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
17	Dragonfly	Libellulidae	*Aethriamanta aethra*	Blue adjudant	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
18	Dragonfly	Libellulidae	*Aethriamanta brevipennis*	Scarlet adjudant	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
19	Dragonfly	Libellulidae	*Aethriamanta gracilis*	Pond adjudant	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
20	Dragonfly	Libellulidae	*Agrionoptera insignis*	Grenadier	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
21	Dragonfly	Libellulidae	*Brachydiplax chalybea*	Blue dasher	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
22	Dragonfly	Libellulidae	*Brachythemis contaminata*	Common amberwing	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
23	Dragonfly	Libellulidae	*Camacinia gigantea*	Sultan	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
24	Dragonfly	Libellulidae	*Cratilla lineata*	Lined forest skimmer	Least Concern	Near Threatened	Yes	Widespread but Rare	No	Yes	
25	Dragonfly	Libellulidae	*Cratilla metallica*	Dark-tipped forest skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
26	Dragonfly	Libellulidae	*Crocothemis servilia*	Common scarlet	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	

List of Probable and Recorded Faunal Species - Odonates

No.	Type	Family Name	Scientific Name	Common Name	Global Status (IUCN, 2012)	National Status (Soh et al., 2019)	Species of Conservation Significance	Distribution/Rarity (Soh et al. 2019)	Probable Species	Recorded Species	Remarks
27	Dragonfly	Libellulidae	*Diplacodes nebulosa*	Black-tipped percher	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	No	
28	Dragonfly	Libellulidae	*Diplacodes trivialis*	Blue percher	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
29	Dragonfly	Libellulidae	*Hydrobasileus croceus*	Water monarch	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
30	Dragonfly	Libellulidae	*Lathrecista asiatica*	Scarlet grenadier	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
31	Dragonfly	Libellulidae	*Macrodiplax cora*	Coastal glider	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
32	Dragonfly	Libellulidae	*Nannophya pygmaea*	Scarlet pygmy	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
33	Dragonfly	Libellulidae	*Neurothemis fluctuans*	Common parasol	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
34	Dragonfly	Libellulidae	*Orchithemis pulcherrima*	Variable sentinel	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
35	Dragonfly	Libellulidae	*Orthetrum chrysis*	Spine-tufted skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
36	Dragonfly	Libellulidae	*Orthetrum glaucum*	Common blue skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
37	Dragonfly	Libellulidae	*Orthetrum luzonicum*	Slender blue skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
38	Dragonfly	Libellulidae	*Orthetrum sabina*	Variegated green skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
39	Dragonfly	Libellulidae	*Orthetrum testaceum*	Scarlet skimmer	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
40	Dragonfly	Libellulidae	*Pantala flavescens*	Wandering glider	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
41	Dragonfly	Libellulidae	*Potamarcha congener*	Common chaser	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
42	Dragonfly	Libellulidae	*Pseudothemis jorina*	Banded skimmer	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	No	
43	Dragonfly	Libellulidae	*Rhodothemis rufa*	Common redbolt	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
44	Dragonfly	Libellulidae	*Rhyothemis obsolescens*	Bronze flutterer	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	Yes	
45	Dragonfly	Libellulidae	*Rhyothemis phyllis*	Yellow-barred flutterer	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
46	Dragonfly	Libellulidae	*Rhyothemis triangularis*	Sapphire flutterer	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	No	
47	Dragonfly	Libellulidae	*Tholymis tillarga*	White-barred duskhawk	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
48	Dragonfly	Libellulidae	*Tramea transmarina*	Saddlebag glider	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
49	Dragonfly	Libellulidae	*Trithemis aurora*	Crimson dropwing	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
50	Dragonfly	Libellulidae	*Trithemis festiva*	Indigo dropwing	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	
51	Dragonfly	Libellulidae	*Trithemis pallidinervis*	Dancing dropwing	Least Concern	Least Concern	No	Widespread but Uncommon	Yes	No	Recorded in J1002 EIS (2016)
52	Dragonfly	Libellulidae	*Tyriobapta torrida*	Treehugger	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
53	Dragonfly	Libellulidae	*Urothemis signata*	Scarlet basker	Not Assessed	Least Concern	No	Widespread and Common	Yes	Yes	
54	Dragonfly	Libellulidae	*Zyxomma petiolatum*	Slender duskdarter	Least Concern	Least Concern	No	Widespread and Common	Yes	Yes	

List of Probable and Recorded Faunal Species - Odonates

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55	Dragonfly	Macromiidae	*Epophthalmia vittigera*	Pond cruiser	Least Concern	Least Concern	No	Widespread and Common	Yes	No	
56	Dragonfly	Synthemistidae	*Idionyx yolanda*	Shadowdancer	Not Assessed	Least Concern	No	Widespread but Uncommon	Yes	Yes	

List of Probable and Recorded Faunal Species - Butterflies

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1	Hesperiidae	*Ampittia dioscorides camertes*	Bush hopper	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
2	Hesperiidae	*Ancistroides nigrita maura*	Chocolate demon	Not Assessed	Not Assessed	No	Common	Yes	Yes	Recorded in Tengah EBS (2017)
3	Hesperiidae	*Astictopterus jama jama*	Forest hopper	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
4	Hesperiidae	*Baoris farri farri*	Bamboo paintbrush swift	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
5	Hesperiidae	*Baoris oceia*	Paintbrush swift	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
6	Hesperiidae	*Borbo cinnara*	Formosan swift	Not Assessed	Endangered	Yes	Moderately common	Yes	No	Recorded in Tengah EBS (2017)
7	Hesperiidae	*Burara harisa consobrina*	Orange awlet	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
8	Hesperiidae	*Caltoris cormasa*	Full stop swift	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
9	Hesperiidae	*Caltoris malaya*	Malayan swift	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	No	
10	Hesperiidae	*Caltoris philippina philippina*	Philippine swift	Not Assessed	Not Assessed	No	Rare	Yes	No	
11	Hesperiidae	*Cephrenes acalle niasicus*	Plain palm dart	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	No	
12	Hesperiidae	*Cephrenes trichopepla*	Yellow palm dart	Not Assessed	Not assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017)
13	Hesperiidae	*Erionota hiraca apicalis*	White tipped skipper	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
14	Hesperiidae	*Erionota thrax thrax*	Banana skipper	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
15	Hesperiidae	*Erionota torus*	Torus skipper	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
16	Hesperiidae	*Halpe ormenes vilasina*	Dark banded ace	Not Assessed	Not Assessed	No	Rare	Yes	No	
17	Hesperiidae	*Hasora badra badra*	Common awl	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
18	Hesperiidae	*Hidari irava*	Coconut skipper	Not Assessed	Not Assessed	No	Common	Yes	No	
19	Hesperiidae	*Iambrix salsala salsala*	Chestnut bob	Not Assessed	Not Assessed	No	Common	Yes	Yes	
20	Hesperiidae	*Iambrix stellifer*	Starry bob	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
21	Hesperiidae	*Matapa aria*	Common redeye	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
22	Hesperiidae	*Mooreana trichoneura trichoneura*	Yellow flat	Not Assessed	Not assessed	No	Rare	Yes	No	
23	Hesperiidae	*Notocrypta paralysos varians*	Banded demon	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	Recorded in J1001 EIS (2017)
24	Hesperiidae	*Odina hieroglyphica ortina*	Hieroglyphic flat	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
25	Hesperiidae	*Odontoptilum angulatum angulatum*	Chestnut angle	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in J1001 EIS (2017)
26	Hesperiidae	*Oriens gola pseudolus*	Common dartlet	Not Assessed	Not Assessed	No	Moderately common	Yes	No	

List of Probable and Recorded Faunal Species - Butterflies

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27	Hesperiidae	*Pelopidas agna agna*	Bengal swift	Not Assessed	Endangered	Yes	Moderately common	Yes	No	
28	Hesperiidae	*Pelopidas assamensis*	Great swift	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
29	Hesperiidae	*Pelopidas conjunctus conjunctus*	Conjoined swift	Not Assessed	Not assessed	No	Moderately rare	Yes	No	
30	Hesperiidae	*Pelopidas mathias mathias*	Small branded swift	Not Assessed	Not Assessed	No	Common	Yes	Yes	
31	Hesperiidae	*Pemara pugnans*	Pugnacious lancer	Not Assessed	Not Assessed	No	Very rare	Yes	No	
32	Hesperiidae	*Plastingia naga*	Chequered lancer	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
33	Hesperiidae	*Polytremis lubricans lubricans*	Contiguous swift	Not Assessed	Not Assessed	No	Common	Yes	Yes	
34	Hesperiidae	*Potanthus ganda*	NA	Not Assessed	Not Assessed	No	N/A	Yes	No	
35	Hesperiidae	*Potanthus omaha omaha*	Lesser dart	Not Assessed	Not Assessed	No	Common	Yes	Yes	
36	Hesperiidae	*Potanthus serina*	Large dart	Not Assessed	Not assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
37	Hesperiidae	*Potanthus trachala tytleri*	Detached dart	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	Yes	
38	Hesperiidae	*Pseudocoladenia dan dhyana*	Fulvous pied flat	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
39	Hesperiidae	*Pyroneura latoia latoia*	Yellow vein lancer	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
40	Hesperiidae	*Suastus gremius gremius*	Palm bob	Not Assessed	Not Assessed	No	Common	Yes	No	
41	Hesperiidae	*Tagiades japetus atticus*	Common snow flat	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
42	Hesperiidae	*Taractrocera archias quinta*	Yellow grass dart	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017)
43	Hesperiidae	*Taractrocera ardonia lamia*	Spotted grass dart	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
44	Hesperiidae	*Telicota augias augias*	Pale palm dart	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
45	Hesperiidae	*Telicota besta bina*	Besta palm dart	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
46	Hesperiidae	*Telicota colon stinga*	Common palm dart	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately common	Yes	No	
47	Hesperiidae	*Telicota linna*	Linna palm dart	Not Assessed	Not assessed	No	Moderately rare	Yes	No	
48	Hesperiidae	*Udaspes folus*	Grass demon	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
49	Hesperiidae	*Unkana ambasa batara*	Hoary palmer	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
50	Hesperiidae	*Zographetus doxus*	Spotted flitter	Not Assessed	Not Assessed	No	Rare	Yes	No	Recorded in J1001 EIS (2017)
51	Lycaenidae	*Acytolepis puspa lambi*	Common hedge blue	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
52	Lycaenidae	*Allotinus unicolor unicolor*	Lesser darkwing	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
53	Lycaenidae	*Anthene emolus goberus*	Ciliate blue	Not Assessed	Not Assessed	No	Common	Yes	Yes	

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54	Lycaenidae	*Anthene lycaenina miya*	Pointed ciliate blue	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in J1001 EIS (2017)
55	Lycaenidae	*Arhopala amphimuta amphimuta*	NA	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately common	Yes	No	
56	Lycaenidae	*Arhopala antimuta antimuta*	Small tailless oakblue	Not Assessed	Nationally Extinct	Yes	Rare	Yes	No	
57	Lycaenidae	*Arhopala centaurus nakula*	Centaur oakblue	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
58	Lycaenidae	*Arhopala major major*	NA	Not Assessed	Data Deficient	No	Common	Yes	No	
59	Lycaenidae	*Arhopala silhetensis adorea*	Sylhet oakblue	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Rare	Yes	No	
60	Lycaenidae	*Catochrysops panormus exiguus*	Silver forget-me-not	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in J1001 EIS (2017)
61	Lycaenidae	*Catochrysops strabo strabo*	Forget-me-not	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
62	Lycaenidae	*Catopyrops ancyra*	Ancyra blue	Not Assessed	Vulnerable	Yes	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
63	Lycaenidae	*Cheritra freja frigga*	Common imperial	Least Concern	Not Assessed	No	Moderately rare	Yes	No	
64	Lycaenidae	*Chilades pandava pandava*	Cycad blue	Not Assessed	Not Assessed	No	Common	Yes	No	
65	Lycaenidae	*Curetis saronis sumatrana*	Sumatran sunbeam	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
66	Lycaenidae	*Deudorix epijarbas cinnabarus*	Cornelian	Not Assessed	Not Assessed	No	Rare	Yes	No	
67	Lycaenidae	*Eooxylides tharis distanti*	Branded imperial	Not Assessed	Not Assessed	No	Common	Yes	Yes	Recorded in J1001 EIS (2017)
68	Lycaenidae	*Euchrysops cnejus cnejus*	Gram blue	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
69	Lycaenidae	*Everes lacturnus rileyi*	Indian cupid	Not Assessed	Not Assessed	No	Rare	Yes	No	
70	Lycaenidae	*Flos apidanus saturatus*	Plain plushblue	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
71	Lycaenidae	*Horaga syrinx maenala*	Ambon onyx	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
72	Lycaenidae	*Hypolycaena erylus teatus*	Common tit	Not Assessed	Not Assessed	No	Common	Yes	No	
73	Lycaenidae	*Hypolycaena thecloides thecloides*	Dark tit	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
74	Lycaenidae	*Ionolyce helicon merguiana*	Pointed line blue	Not Assessed	Not Assessed	No	Common	Yes	Yes	
75	Lycaenidae	*Iraota rochana boswelliana*	Scarce silverstreak	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
76	Lycaenidae	*Jacoona anasuja anasuja*	Great imperial	Not Assessed	Data Deficient	No	Rare	Yes	No	
77	Lycaenidae	*Jamides alecto ageladas*	Metallic caerulean	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
78	Lycaenidae	*Jamides bochus nabonassar*	Dark caerulean	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
79	Lycaenidae	*Jamides celeno aelianus*	Common caerulean	Not Assessed	Not Assessed	No	Common	Yes	Yes	
80	Lycaenidae	*Lampides boeticus*	Pea blue	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017)

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81	Lycaenidae	*Liphyra brassolis abbreviata*	Moth butterfly	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Very rare	Yes	No	
82	Lycaenidae	*Logania marmorata damis*	Pale mottle	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
83	Lycaenidae	*Loxura atymnus fuconius*	Yamfly	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
84	Lycaenidae	*Megisba malaya sikkima*	Malayan	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
85	Lycaenidae	*Miletus biggsii biggsii*	Bigg's brownwing	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
86	Lycaenidae	*Miletus gopara gopara*	NA	Not Assessed	Nationally Extinct	Yes	Very rare	Yes	No	
87	Lycaenidae	*Miletus symethus petronius*	Blue brownwing/ great brownie	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
88	Lycaenidae	*Nacaduba berenice icena*	Rounded sixline blue	Not Assessed	Not Assessed	No	Common	Yes	No	
89	Lycaenidae	*Nacaduba beroe neon*	Opaque sixline blue	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017)
90	Lycaenidae	*Nacaduba biocellata*	Two spotted line blue	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
91	Lycaenidae	*Nacaduba calauria malayica*	Dark malayan sixline blue	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
92	Lycaenidae	*Nacaduba kurava nemana*	Transparent sixline blue	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately common	Yes	No	
93	Lycaenidae	*Nacaduba pactolus odon*	Large fourline blue	Not Assessed	Nationally Extinct (Rediscovered)	Yes	Moderately rare	Yes	No	
94	Lycaenidae	*Petrelaea dana*	Dingy line blue	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
95	Lycaenidae	*Poritia sumatrae sumatrae*	Sumatran gem	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
96	Lycaenidae	*Prosotas aluta nanda*	Barred line blue	Not Assessed	Not assessed	No	Rare	Yes	No	
97	Lycaenidae	*Prosotas dubiosa lumpura*	Tailless line blue	Not Assessed	Not Assessed	No	Common	Yes	Yes	
98	Lycaenidae	*Prosotas nora superdates*	Common line blue	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
99	Lycaenidae	*Rachana jalindra burbona*	Banded royal	Not Assessed	Critically Endangered	Yes	Very rare	Yes	No	
100	Lycaenidae	*Rapala dieneces dieneces*	Scarlet flash	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
101	Lycaenidae	*Rapala iarbus iarbus*	Common red flash	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
102	Lycaenidae	*Rapala manea chozeba*	Slate flash	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
103	Lycaenidae	*Rapala pheretima sequeira*	Copper flash	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017)
104	Lycaenidae	*Rapala suffusa barthema*	Suffused flash	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
105	Lycaenidae	*Rapala varuna orseis*	Indigo flash	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
106	Lycaenidae	*Remelana jangala travana*	Chocolate royal	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
107	Lycaenidae	*Semanga superba deliciosa*	NA	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	

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108	Lycaenidae	*Spalgis epius epius*	Apefly	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
109	Lycaenidae	*Spindasis lohita senama*	Long banded silverline	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
110	Lycaenidae	*Spindasis syama terana*	Club silverline	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
111	Lycaenidae	*Surendra vivarna amisena*	Acacia blue	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
112	Lycaenidae	*Tajuria cippus maxentius*	Peacock royal	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
113	Lycaenidae	*Tajuria dominus dominus*	NA	Not Assessed	Not Assessed	No	Very rare	Yes	No	
114	Lycaenidae	*Zeltus amasa maximinianus*	Fluffy tit	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
115	Lycaenidae	*Zizeeria maha serica*	Pale grass blue	Not Assessed	Not Assessed	No	Common	Yes	No	
116	Lycaenidae	*Zizina otis lampa*	Lesser grass blue	Not Assessed	Not Assessed	No	Common	Yes	Yes	
117	Lycaenidae	*Zizula hylax pygmaea*	Pygmy grass blue	Not Assessed	Not Assessed	No	Common	Yes	Yes	
118	Nymphalidae (Brush Foots)	*Acraea terpsicore*	Tawny coster	Not Assessed	Not assessed	No	Common	Yes	Yes	
119	Nymphalidae (Brush Foots)	*Amathusia phidippus phidippus*	Palm king	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
120	Nymphalidae (Brush Foots)	*Athyma nefte subrata*	Colour sergeant	Not Assessed	Not Assessed	Yes	Common	Yes	No	Recorded in J1001 EIS (2017)
121	Nymphalidae (Brush Foots)	*Athyma reta moorei*	Malay staff sergeant	Not Assessed	Not Assessed	Yes	Very rare	Yes	Yes	
122	Nymphalidae (Brush Foots)	*Cethosia cyane*	Leopard lacewing	Not Assessed	Not assessed	No	Common	Yes	No	Recorded in J1001 EIS (2017)
123	Nymphalidae (Brush Foots)	*Cupha erymanthis lotis*	Rustic	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
124	Nymphalidae (Brush Foots)	*Danaus chrysippus chrysippus*	Plain tiger	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017); J1001 EIS (2017)
125	Nymphalidae (Brush Foots)	*Danaus genutia genutia*	Common tiger	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
126	Nymphalidae (Brush Foots)	*Danaus melanippus hegesippus*	Black veined tiger	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
127	Nymphalidae (Brush Foots)	*Discophora sondaica despoliata*	Common duffer	Not Assessed	Critically Endangered	Yes	Rare	Yes	No	Recorded in J1001 EIS (2017)
128	Nymphalidae (Brush Foots)	*Doleschallia bisaltide bisaltide*	Autumn leaf	Not Assessed	Not assessed	No	Common	Yes	No	Recorded in J1001 EIS (2017)
129	Nymphalidae (Brush Foots)	*Doleschallia bisaltide pratipa*	Autumn leaf	Not Assessed	Not assessed	No	Very rare	Yes	No	
130	Nymphalidae (Brush Foots)	*Elymnias hypermnestra agina*	Common palmfly	Not Assessed	Not Assessed	No	Common	Yes	Yes	
131	Nymphalidae (Brush Foots)	*Elymnias panthera panthera*	Tawny palmfly	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
132	Nymphalidae (Brush Foots)	*Euploea eyndhovii gardineri*	Striped black crow	Not Assessed	Not Assessed	No	Rare	Yes	No	Recorded in Tengah EBS (2017)

List of Probable and Recorded Faunal Species - Butterflies

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008; Jain et al, 2018)	Species of Conservation Significance	Distribution/ Abundance /Rarity (Khew, 2015)	Probable Species	Recorded Species	Remarks
133	Nymphalidae (Brush Foots)	*Euploea crameri bremeri*	Spotted black crow	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	Recorded in Tengah EBS (2017)
134	Nymphalidae (Brush Foots)	*Euploea midamus singapura*	Blue spotted crow	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017)
135	Nymphalidae (Brush Foots)	*Euploea mulciber mulciber*	Striped blue crow	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017)
136	Nymphalidae (Brush Foots)	*Euploea radamanthus radamanthus*	Magpie crow	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
137	Nymphalidae (Brush Foots)	*Euthalia aconthea gurda*	Baron	Not Assessed	Not Assessed	No	Common	Yes	Yes	
138	Nymphalidae (Brush Foots)	*Euthalia adonia pinwilli*	Green baron	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
139	Nymphalidae (Brush Foots)	*Euthalia monina monina*	Malay baron	Not Assessed	Not Assessed	No	Common	Yes	Yes	
140	Nymphalidae (Brush Foots)	*Hypolimnas anomala anomala*	Malayan eggfly	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017): J1001 EIS (2017)
141	Nymphalidae (Brush Foots)	*Hypolimnas bolina bolina*	Great eggfly	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017): J1001 EIS (2017)
142	Nymphalidae (Brush Foots)	*Hypolimnas bolina jacintha*	Jacintha eggfly	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017)
143	Nymphalidae (Brush Foots)	*Ideopsis vulgaris macrina*	Blue glassy tiger	Not Assessed	Not Assessed	No	Common	Yes	Yes	
144	Nymphalidae (Brush Foots)	*Junonia almana javana*	Peacock pansy	Least Concern	Not Assessed	No	Common	Yes	Yes	
145	Nymphalidae (Brush Foots)	*Junonia atlites atlites*	Grey pansy	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
146	Nymphalidae (Brush Foots)	*Junonia hedonia ida*	Chocolate pansy	Not Assessed	Not Assessed	No	Common	Yes	Yes	
147	Nymphalidae (Brush Foots)	*Junonia orithya wallacei*	Blue pansy	Not Assessed	Not Assessed	No	Common	Yes	Yes	
148	Nymphalidae (Brush Foots)	*Lasippa tiga siaka*	Malayan lascar	Not Assessed	Not Assessed	No	Common	Yes	Yes	
149	Nymphalidae (Brush Foots)	*Lebadea martha parkeri*	Knight	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017)
150	Nymphalidae (Brush Foots)	*Lethe europa malaya*	Bamboo tree brown	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
151	Nymphalidae (Brush Foots)	*Melanitis leda leda*	Common evening brown	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
152	Nymphalidae (Brush Foots)	*Moduza procris milonia*	Commander	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
153	Nymphalidae (Brush Foots)	*Mycalesis mineus macromalavana*	Dark brand bush brown	Not Assessed	Not Assessed	No	Common	Yes	Yes	
154	Nymphalidae (Brush Foots)	*Mycalesis orseis nautilus*	Purple bush brown	Not Assessed	Not Assessed	No	Rare	Yes	No	
155	Nymphalidae (Brush Foots)	*Mycalesis perseoides perseoides*	Burmese bush brown	Not Assessed	Data Deficient	No	Common	Yes	Yes	
156	Nymphalidae (Brush Foots)	*Mycalesis perseus cepheus*	Dingy bush brown	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017)

List of Probable and Recorded Faunal Species - Butterflies

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008; Jain et al, 2018)	Species of Conservation Significance	Distribution/ Abundance /Rarity (Khew, 2015)	Probable Species	Recorded Species	Remarks
157	Nymphalidae (Brush Foots)	*Mycalesis visala phamis*	Long brand bush brown	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
158	Nymphalidae (Brush Foots)	*Neptis hylas papaja*	Common sailor	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
159	Nymphalidae (Brush Foots)	*Neptis leucoporos cresina*	Burmese sailor	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017); J1001 EIS (2017)
160	Nymphalidae (Brush Foots)	*Orsotriaena medus cinerea*	Dark grass brown	Not Assessed	Not Assessed	No	Common	Yes	Yes	
161	Nymphalidae (Brush Foots)	*Pandita sinope sinope*	Colonel	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
162	Nymphalidae (Brush Foots)	*Pantoporia hordonia hordonia*	Common lascar	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in J1001 EIS (2017)
163	Nymphalidae (Brush Foots)	*Pantoporia paraka paraka*	Perak lascar	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
164	Nymphalidae (Brush Foots)	*Parantica agleoides agleoides*	Dark glassy tiger	Not Assessed	Not Assessed	No	Common	Yes	Yes	
165	Nymphalidae (Brush Foots)	*Phaedyma columella singa*	Short banded sailor	Not Assessed	Not Assessed	No	Common	Yes	Yes	
166	Nymphalidae (Brush Foots)	*Phalanta phalantha phalantha*	Leopard	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017); J1001 EIS (2017)
167	Nymphalidae (Brush Foots)	*Polyura hebe plautus*	Plain nawab	Not Assessed	Not Assessed	No	Common	Yes	Yes	
168	Nymphalidae (Brush Foots)	*Polyura schreiber tisamenus*	Blue nawab	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
169	Nymphalidae (Brush Foots)	*Symbrenthia hippoclus selanaorana*	Malayan jester	Not Assessed	Not assessed	No	Very rare (seasonal migrant)	Yes	No	
170	Nymphalidae (Brush Foots)	*Tanaecia iapis puseda*	Horsfield's baron	Not Assessed	Not Assessed	No	Common	Yes	Yes	
171	Nymphalidae (Brush Foots)	*Tanaecia pelea pelea*	Malay viscount	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in J1001 EIS (2017)
172	Nymphalidae (Brush Foots)	*Vindula dejone erotella*	Cruiser	Not Assessed	Not Assessed	No	Common	Yes	No	
173	Nymphalidae (Brush Foots)	*Ypthima baldus newboldi*	Common five-ring	Not Assessed	Not Assessed	No	Common	Yes	No	
174	Nymphalidae (Brush Foots)	*Ypthima horsfieldii humei*	Malayan five-ring	Not Assessed	Not Assessed	No	Common	Yes	No	
175	Nymphalidae (Brush Foots)	*Ypthima huebneri*	Common four-ring	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
176	Nymphalidae (Brush Foots)	*Ypthima pandocus corticaria*	Common three-ring	Not Assessed	Not Assessed	No	Common	Yes	No	
177	Papilionidae (Swallowtails & Birdwings)	*Chilasa clytia clytia*	Common mime	Not Assessed	Not Assessed	No	Common	Yes	Yes	
178	Papilionidae (Swallowtails & Birdwings)	*Graphium agamemnon agamemnon*	Tailed jay	Not Assessed	Not Assessed	No	Common	Yes	No	Recorded in Tengah EBS (2017); J1001 EIS (2017)
179	Papilionidae (Swallowtails & Birdwings)	*Graphium sarpedon luctatius*	Common bluebottle	Not Assessed	Not Assessed	No	Common	Yes	Yes	

List of Probable and Recorded Faunal Species - Butterflies

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008; Jain et al, 2018)	Species of Conservation Significance	Distribution/ Abundance /Rarity (Khew, 2015)	Probable Species	Recorded Species	Remarks
180	Papilionidae (Swallowtails & Birdwings)	*Pachliopta aristolochiae asteris*	Common rose	Not Assessed	Vulnerable	Yes	Moderately common	Yes	Yes	
181	Papilionidae (Swallowtails & Birdwings)	*Papilio demoleus malayanus*	Lime butterfly	Not Assessed	Not Assessed	No	Common	Yes	Yes	
182	Papilionidae (Swallowtails & Birdwings)	*Papilio demolion demolion*	Banded swallowtail	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in Tengah EBS (2017); J1001 EIS (2017)
183	Papilionidae (Swallowtails & Birdwings)	*Papilio memnon agenor*	Great mormon	Not Assessed	Not Assessed	No	Moderately common	Yes	No	Recorded in J1001 EIS (2017)
184	Papilionidae (Swallowtails & Birdwings)	*Papilio polytes romulus*	Common mormon	Not Assessed	Not Assessed	No	Common	Yes	Yes	
185	Papilionidae (Swallowtails & Birdwings)	*Troides amphrysus ruficollis*	Malayan birdwing	Not Assessed; CITES protected (Appendix II)	Nationally Extinct (Rediscovered)	Yes	Very rare (seasonal migrant)	Yes	No	
186	Papilionidae (Swallowtails & Birdwings)	*Troides helena cerberus*	Common birdwing	Not Assessed; CITES protected (Appendix II)	Vulnerable	Yes	Moderately common	Yes	Yes	
187	Pieridae (Whites & Sulphurs)	*Appias libythea olferna*	Striped albatross	Not Assessed	Not Assessed	No	Common	Yes	Yes	
188	Pieridae (Whites & Sulphurs)	*Catopsilia pomona pomona*	Lemon emigrant	Not Assessed	Not Assessed	No	Common	Yes	Yes	
189	Pieridae (Whites & Sulphurs)	*Catopsilia pyranthe pyranthe*	Mottled emigrant	Not Assessed	Not Assessed	No	Common	Yes	Yes	
190	Pieridae (Whites & Sulphurs)	*Catopsilia scylla cornelia*	Orange emigrant	Not Assessed	Not Assessed	No	Common	Yes	No	
191	Pieridae (Whites & Sulphurs)	*Delias hyparete metarete*	Painted jezebel	Not Assessed	Not Assessed	No	Common	Yes	Yes	
192	Pieridae (Whites & Sulphurs)	*Eurema andersonii andersonii*	Anderson's grass yellow	Not Assessed	Not Assessed	No	Moderately common	Yes	Yes	
193	Pieridae (Whites & Sulphurs)	*Eurema blanda snelleni*	Three spot grass yellow	Not Assessed	Not Assessed	No	Common	Yes	Yes	
194	Pieridae (Whites & Sulphurs)	*Eurema hecabe contubernalis*	Common grass yellow	Not Assessed	Not Assessed	No	Common	Yes	Yes	

List of Probable and Recorded Faunal Species - Butterflies

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008; Jain et al, 2018)	Species of Conservation Significance	Distribution/ Abundance /Rarity (Khew, 2015)	Probable Species	Recorded Species	Remarks
195	Pieridae (Whites & Sulphurs)	*Leptosia nina malayana*	Psyche	Not Assessed	Not Assessed	No	Common	Yes	Yes	
196	Pieridae (Whites & Sulphurs)	*Pieris canidia canidia*	Cabbage white	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
197	Riodinidae (Metalmarks)	*Abisara geza niya*	Spotted judy	Not Assessed	Not Assessed	No	Moderately rare	Yes	No	
198	Riodinidae (Metalmarks)	*Abisara saturata kausambioides*	Malayan plum judy	Not Assessed	Not Assessed	No	Moderately common	Yes	No	
199	Riodinidae (Metalmarks)	*Abisara savitri savitri*	Malay tailed judy	Not Assessed	Not Assessed	No	Moderately rare	Yes	Yes	
200	Riodinidae (Metalmarks)	*Laxita thuisto thuisto*	Lesser harlequin	Not Assessed	Not Assessed	No	Rare	Yes	No	
201	Riodinidae (Metalmarks)	*Taxila haquinus haquinus*	Harlequin	Not Assessed	Endangered	Yes	Moderately rare	Yes	No	

List of Probable and Recorded Faunal Species - Decapod crustaceans

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Freshwater crab	Gecarcinucidae	*Parathelphusa maculata*	Maculate freshwater crab	Least Concern	Not Assessed	No	Native	Yes	No	
2	Freshwater shrimp	Palaemonidae	*Macrobrachium nipponense*	Oriental river prawn	Least Concern	Not Assessed	No	Non-native	Yes	No	
3	Freshwater shrimp	Palaemonidae	*Macrobrachium lanchesteri*	Ghost shrimp	Least Concern	Not Assessed	No	Non-native	Yes	No	

List of Probable and Recorded Faunal Species - Fish

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Anabantidae	*Anabas testudineus*	Oriental climbing perch	Data Deficient	Least Concern	No	Native	Yes	Yes	
2	Aplocheilidae	*Aplocheilus armatus*	Whitespot	Least Concern	Least Concern	No	Non-native	Yes	No	
3	Channidae	*Channa striata*	Common snakehead	Least Concern	Not Assessed	No	Native	Yes	Yes	
4	Cichlidae	*Amphilophus citrinellus*	Midas cichlid	Not Assessed	Not Assessed	No	Non-native	Yes	No	
5	Cichlidae	*Cichlasoma urophthalmum*	Mayan cichlid	Not Assessed	Not Assessed	No	Non-native	Yes	No	
6	Cichlidae	*Geophagus altifrons*	Red-striped eartheater	Not Assessed	Not Assessed	No	Non-native	Yes	No	
7	Cichlidae	*Heterotilapia buttikoferi*	Bumblebee tilapia	Least Concern	Not Assessed	No	Non-native	Yes	No	
8	Cichlidae	*Oreochromis mossambicus*	Mozambique tilapia	Vulnerable	Not Assessed	No	Non-native	Yes	No	Recorded in J1002 EIS (2016)
9	Cichlidae	*Oreochromis niloticus*	Nile tilapia	Not Assessed	Not Assessed	No	Non-native	Yes	No	
10	Clariidae	*Clarias cf. batrachus*	Common walking catfish	Not Assessed	Least Concern	Yes	Native	Yes	Yes	
11	Cyprinidae	*Barbodes rhombeus*	Indochinese spotted barb	Least Concern	Not Assessed	No	Non-native	Yes	No	
12	Cyprinidae	*Brachydanio albolineata*	Pearl danio	Not Assessed	Least Concern	No	Non-native	Yes	Yes	
13	Gobiidae	*Rhinogobius giurinus*	Barcheek goby	Least Concern	Not Assessed	No	Non-native	No	Yes	
14	Gobionellidae	*Brachygobius sabanus*	Lesser bumblebee goby	Data Deficient	Not Assessed	No	Non-native	Yes	No	
15	Osphronemidae	*Betta imbellis*	Crescent betta	Least Concern	Not Assessed	No	Native	Yes	No	Recorded in J1002 EIS (2016)
16	Osphronemidae	*Betta pugnax*	Malayan forest betta	Not Assessed	Least Concern	No	Native	Yes	No	
17	Osphronemidae	*Trichopodus trichopterus*	Threespot gouramy	Least Concern	Not Assessed	No	Native	Yes	Yes	
18	Osphronemidae	*Trichopsis vittata*	Croaking gouramy	Least Concern	Least Concern	No	Native	Yes	Yes	
19	Poeciliidae	*Gambusia affinis*	Mosquitofish	Least Concern	Least Concern	No	Non-native	Yes	No	Recorded in J1002 EIS (2016)
20	Poeciliidae	*Poecilia reticulata*	Guppy	Not Assessed	Least Concern	No	Non-native	Yes	Yes	
21	Poeciliidae	*Poecilia sphenops*	Common molly	Not Assessed	Not Assessed	No	Non-native	Yes	No	
22	Synbranchidae	*Monopterus javanensis*	Asian swamp-eel	Not Assessed	Least Concern	No	Native	Yes	Yes	
23	Zenarchopteridae	*Dermogenys collettei*	Sunda pygmy halfbeak	Not Assessed	Not Assessed	No	Native	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)

List of Probable and Recorded Faunal Species - Amphibians

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Signficance	Distribution/ Abundance/ Rarity (Baker & Lim, 2012)	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Toad	Bufonidae	*Duttaphrynus melanostictus*	Asian toad	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
2	Frog	Dicroglossidae	*Fejervarya cancrivora*	Crab-eating frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
3	Frog	Dicroglossidae	*Fejervarya limnocharis*	Field frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
4	Frog	Dicroglossidae	*Limnonectes blythii*	Malayan giant frog	Near Threatened	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
5	Frog	Eleutherodactylidae	*Eleutherodactylus planirostris*	Greenhouse frog	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	Yes	
6	Frog	Microhylidae	*Kaloula pulchra*	Banded bull frog	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	Yes	
7	Frog	Microhylidae	*Microhyla butleri*	Painted chorus frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
8	Frog	Microhylidae	*Microhyla heymonsi*	Dark-sided chorus frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
9	Frog	Microhylidae	*Microhyla mukhlesuri*	East Asian ornate chorus frog	Least Concern	Not Assessed	No	Restricted and Rare	Non-native	Yes	Yes	
10	Frog	Ranidae	*Hylarana erythraea*	Green paddy frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
11	Frog	Ranidae	*Lithobates catesbeianus*	American bullfrog	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	No	
12	Frog	Ranidae	*Sylvirana guentheri*	Guenther's frog	Least Concern	Not Assessed	No	Widespread but Uncommon	Non-native	Yes	Yes	
13	Frog	Rhacophoridae	*Polypedates leucomystax*	Four-lined tree frog	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	

List of Probable and Recorded Faunal Species - Reptiles

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Signficance	Distribution/Abundance/Rarity (Baker & Lim, 2012)	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Non-marine lizard	Agamidae	*Bronchocela cristatella*	Green crested lizard	Not Assessed	Not Assessed	No	Widespread but Uncommon	Native	Yes	Yes	
2	Non-marine lizard	Agamidae	*Calotes versicolor*	Changeable lizard	Not Assessed	Not Assessed	No	Widespread and Common	Non-native	Yes	Yes	
3	Non-marine lizard	Agamidae	*Draco sumatranus*	Sumatran flying dragon	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	No	
4	Non-marine lizard	Gekkonidae	*Gehyra mutilata*	Four-clawed gecko	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	No	Recorded in J1002 EIS (2016)
5	Non-marine lizard	Gekkonidae	*Gekko monarchus*	Spotted house gecko	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
6	Non-marine lizard	Gekkonidae	*Hemidactylus brookii*	Brooke's house gecko	Not Assessed	Not Assessed	No	Restricted and Rare	Non-native	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
7	Non-marine lizard	Gekkonidae	*Hemidactylus frenatus*	Spiny-tailed house gecko	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
8	Non-marine lizard	Gekkonidae	*Hemidactylus platyurus*	Flat-tailed gecko	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	No	Recorded in J1002 EIS (2016)
9	Non-marine lizard	Gekkonidae	*Hemiphyllodactylus typus*	Lowland dwarf gecko	Least Concern	Vulnerable	Yes	Restricted and Rare	Native	Yes	No	
10	Non-marine lizard	Scincidae	*Eutropis multifasciata*	Many-lined sun skink	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
11	Non-marine lizard	Scincidae	*Lygosoma bowringii*	Garden supple skink	Not Assessed	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
12	Non-marine lizard	Varanidae	*Varanus nebulosus*	Clouded monitor	Not Assessed	Not Assessed	No	Restricted but Common	Native	Yes	Yes	
13	Non-marine lizard	Varanidae	*Varanus salvator*	Malayan water monitor	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
14	Non-marine snake	Colubridae (Ahaetulliinae)	*Ahaetulla prasina*	Oriental whip snake	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
15	Non-marine snake	Colubridae (Ahaetulliinae)	*Chrysopelea paradisi*	Paradise gliding snake	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
16	Non-marine snake	Colubridae (Ahaetulliinae)	*Dendrelaphis caudolineatus*	Striped bronzeback	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
17	Non-marine snake	Colubridae (Ahaetulliinae)	*Dendrelaphis pictus*	Painted bronzeback	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
18	Non-marine snake	Colubridae (Colubrinae)	*Coelognathus flavolineatus*	Common Malayan racer	Least Concern	Endangered	Yes	Widespread but Rare	Native	Yes	Yes	
19	Non-marine snake	Colubridae (Colubrinae)	*Lycodon capucinus*	House wolf snake	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	
20	Non-marine snake	Colubridae (Colubrinae)	*Oligodon octolineatus*	Striped kukri snake	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
21	Non-marine snake	Colubridae (Colubrinae)	*Ptyas korros*	Indochinese rat snake	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	No	

List of Probable and Recorded Faunal Species - Reptiles

No.	Type	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Signficance	Distribution/Abundance/Rarity (Baker & Lim, 2012)	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
22	Non-marine snake	Colubridae (Natricinae)	*Xenochrophis vittatus*	Striped keelback	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	No	
23	Non-marine snake	Colubridae (Sibynophiinae)	*Sibynophis melanocephalus*	Black-headed collared snake	Least Concern	Endangered	Yes	Widespread but Uncommon	Native	Yes	No	
24	Non-marine snake	Elapidae	*Calliophis intestinalis*	Banded Malayan coral snake	Least Concern	Not Assessed	No	Widespread but Rare	Native	Yes	No	
25	Non-marine snake	Elapidae	*Naja sumatrana*	Equatorial spitting cobra	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
26	Non-marine snake	Elapidae	*Ophiophagus hannah*	King cobra	Vulnerable	Endangered	Yes	Restricted and Rare	Native	Yes	No	
27	Non-marine snake	Homalopsidae	*Homalopsis buccata*	Puff-faced water snake	Least Concern	Vulnerable	Yes	Widespread but Uncommon	Native	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
28	Non-marine snake	Pareidae	*Pareas margaritophorus*	White-spotted slug snake	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	No	
29	Non-marine snake	Pythonidae	*Malayopython reticulatus*	Reticulated python	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	
30	Non-marine snake	Typhlopidae	*Argyrophis muelleri*	White-bellied blind snake	Least Concern	Critically Endangered	Yes	Widespread but Rare	Native	Yes	No	
31	Non-marine snake	Typhlopidae	*Indotyphlops braminus*	Brahminy blind snake	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	
32	Non-marine snake	Xenopeltidae	*Xenopeltis unicolor*	Iridescent earth snake	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	No	
33	Non-marine turtle	Emydidae	*Trachemys decussata*	Cuban slider	Not Assessed	Not Assessed	No	NA	NA	Yes	No	Recorded in J1001 EIS (2017); Tengah EBS (2017)
34	Non-marine turtle	Emydidae	*Trachemys scripta*	Red-eared slider	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	Yes	
35	Non-marine turtle	Geomydidae	*Cuora amboinensis*	Malayan box terrapin	Vulnerable; CITES protected (Appendix II)	Not Assessed	Yes	Restricted but Common	Native	Yes	Yes	
36	Non-marine turtle	Geomydidae	*Heosemys grandis*	Giant Asian pond turtle	Vulnerable; CITES protected (Appendix II)	Not Assessed	No	NA	Non-native	Yes	No	Recorded in J1002 EIS (2016)

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
1	Acanthizidae	*Gerygone sulphurea*	Golden-bellied gerygone	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
2	Accipitridae	*Accipiter gularis*	Japanese sparrowhawk	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	Yes	
3	Accipitridae	*Accipiter soloensis*	Chinese sparrowhawk	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
4	Accipitridae	*Accipiter trivirgatus*	Crested goshawk	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	No	
5	Accipitridae	*Aviceda leuphotes*	Black baza	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
6	Accipitridae	*Buteo buteo*	Common buzzard	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
7	Accipitridae	*Elanus caeruleus*	Black-winged kite	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
8	Accipitridae	*Haliaeetus ichthyaetus*	Grey-headed fish eagle	Near Threatened	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
9	Accipitridae	*Haliaeetus leucogaster*	White-bellied sea eagle	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
10	Accipitridae	*Haliastur indus*	Brahminy kite	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	
11	Accipitridae	*Lophotriorchis kienerii*	Rufous-bellied hawk-eagle	Least Concern	Not Assessed	No	Rare	Winter visitor	NA	Yes	No	
12	Accipitridae	*Milvus migrans*	Black kite	Least Concern	Not Assessed	No	Rare	Winter visitor	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
13	Accipitridae	*Nisaetus cirrhatus*	Changeable hawk-eagle	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
14	Accipitridae	*Pernis ptilorhynchus*	Crested honey-buzzard	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant/non-breeding visitor	Yes	No	Recorded in Tengah EBS (2017)
15	Accipitridae	*Spilornis cheela*	Crested serpent eagle	Least Concern	Critically Endangered	Yes	Rare	Resident, breeding not proven	NA	Yes	Yes	
16	Aegithinidae	*Aegithina tiphia*	Common iora	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
17	Alcedinidae	*Alcedo atthis*	Common kingfisher	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	Yes	
18	Alcedinidae	*Alcedo meninting*	Blue-eared kingfisher	Least Concern	Critically Endangered	Yes	Rare	Resident breeder	NA	Yes	Yes	

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
19	Alcedinidae	*Ceyx erithaca*	Oriental dwarf kingfisher	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	
20	Alcedinidae	*Halcyon smyrnensis*	White-throated kingfisher	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
21	Alcedinidae	*Pelargopsis capensis*	Stork-billed kingfisher	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
22	Alcedinidae	*Todiramphus chloris*	Collared kingfisher	Least Concern	Not Assessed	No	Abundant	Introduced resident breeder	NA	Yes	Yes	
23	Apodidae	*Aerodramus fuciphagus*	Edible-nest swiftlet	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	
24	Apodidae	*Aerodramus maximus*	Black-nest swiftlet	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
25	Apodidae	*Apus pacificus*	Pacific swift	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)
26	Apodidae	*Collocalia affinis*	Plume-toed swiftlet	Not Assessed	Not Assessed	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
27	Ardeidae	*Ardea cinerea*	Grey heron	Least Concern	Vulnerable	Yes	Uncommon	Resident breeder	NA	Yes	No	Recorded in J1002 EIS (2016)
28	Ardeidae	*Ardea intermedia*	Intermediate egret	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	
29	Ardeidae	*Ardea purpurea*	Purple heron	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
30	Ardeidae	*Ardeola bacchus*	Chinese pond heron	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	No	
31	Ardeidae	*Ardeola speciosa*	Javan pond heron	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	
32	Ardeidae	*Bubulcus coromandus*	Eastern cattle egret	Least Concern	Not Assessed	No	Common	Winter visitor	Introduced resident, breeding not proven	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
33	Ardeidae	*Butorides striata*	Striated heron	Least Concern	Not Assessed	No	Common	Resident breeder	Winter visitor	Yes	No	
34	Ardeidae	*Egretta garzetta*	Little egret	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
35	Ardeidae	*Gorsachius melanolophus*	Malayan night heron	Least Concern	Not Assessed	No	Rare	Winter visitor	Passage migrant	Yes	Yes	
36	Ardeidae	*Ixobrychus cinnamomeus*	Cinnamon bittern	Least Concern	Not Assessed	No	Uncommon	Resident breeder	Winter visitor	Yes	No	
37	Ardeidae	*Ixobrychus eurhythmus*	Von Schrenck's bittern	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
38	Ardeidae	*Ixobrychus sinensis*	Yellow bittern	Least Concern	Not Assessed	No	Common	Resident breeder	Winter visitor	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
39	Ardeidae	*Nycticorax nycticorax*	Black-crowned night heron	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
40	Bucerotidae	*Anthracoceros albirostris*	Oriental pied hornbill	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	No	
41	Cacatuidae	*Cacatua goffiniana*	Tanimbar corella	Near Threatened	Not Assessed	No	Common	Introduced resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
42	Cacatuidae	*Cacatua sulphurea*	Yellow-crested cockatoo	Critically Endangered	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	No	
43	Campephagidae	*Lalage nigra*	Pied triller	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
44	Campephagidae	*Pericrocotus divaricatus*	Ashy minivet	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	Yes	
45	Caprimulgidae	*Caprimulgus affinis*	Savanna nightjar	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
46	Caprimulgidae	*Caprimulgus macrurus*	Large-tailed nightjar	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
47	Charadriidae	*Vanellus indicus*	Red-wattled lapwing	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
48	Ciconiidae	*Mycteria cinerea*	Milky stork	Least Concern	Not Assessed	No	NA	Introduced	NA	Yes	No	Recorded in J1002 EIS (2016)
49	Ciconiidae	*Mycteria leucocephala*	Painted stork	Least Concern	Not Assessed	No	NA	Introduced	NA	Yes	Yes	
50	Cisticolidae	*Cisticola juncidis*	Zitting cisticola	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
51	Cisticolidae	*Orthotomus atrogularis*	Dark-necked tailorbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
52	Cisticolidae	*Orthotomus ruficeps*	Ashy tailorbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in J1002 EIS (2016)
53	Cisticolidae	*Orthotomus sericeus*	Rufous-tailed tailorbird	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
54	Cisticolidae	*Orthotomus sutorius*	Common tailorbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
55	Cisticolidae	*Prinia flaviventris*	Yellow-bellied prinia	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
56	Columbidae	*Chalcophaps indica*	Common emerald dove	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
57	Columbidae	*Columba livia*	Rock dove	Least Concern	Not Assessed	No	Abundant	Introduced resident breeder	NA	Yes	No	

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
58	Columbidae	*Ducula bicolor*	Pied imperial pigeon	Least Concern	Not Assessed	No	Uncommon	Resident breeder	Non-breeding visitor/ introduced	Yes	Yes	
59	Columbidae	*Geopelia striata*	Zebra dove	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
60	Columbidae	*Ptilinopus jambu*	Jambu fruit dove	Near Threatened	Not Assessed	No	Uncommon	Non-breeding visitor	NA	Yes	No	
61	Columbidae	*Spilopelia chinensis*	Spotted dove	Least Concern	Not Assessed	No	Abundant	Introduced resident breeder	NA	Yes	Yes	
62	Columbidae	*Treron vernans*	Pink-necked green pigeon	Least Concern	Not Assessed	No	Abundant	Resident breeder	NA	Yes	Yes	
63	Coraciidae	*Eurystomus orientalis*	Oriental dollarbird	Least Concern	Not Assessed	No	Common	Resident breeder	Winter visitor	Yes	Yes	
64	Corvidae	*Corvus macrorhynchos*	Large-billed crow	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
65	Corvidae	*Corvus splendens*	House crow	Least Concern	Not Assessed	No	Common	Introduced resident breeder	NA	Yes	Yes	
66	Cuculidae	*Cacomantis merulinus*	Plaintive cuckoo	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in J1002 EIS (2016); J1001 EIS (2017); Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
67	Cuculidae	*Cacomantis sepulcralis*	Rusty-breasted cuckoo	Least Concern	Vulnerable	Yes	Uncommon	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
68	Cuculidae	*Cacomantis sonneratii*	Banded bay cuckoo	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
69	Cuculidae	*Centropus bengalensis*	Lesser coucal	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
70	Cuculidae	*Centropus sinensis*	Greater coucal	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
71	Cuculidae	*Chrysococcyx minutillus*	Little bronze-cuckoo	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
72	Cuculidae	*Chrysococcyx xanthorhynchus*	Violet cuckoo	Least Concern	Endangered	Yes	Uncommon	Resident breeder	Winter visitor	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
73	Cuculidae	*Clamator coromandus*	Chestnut-winged cuckoo	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
74	Cuculidae	*Cuculus micropterus*	Indian cuckoo	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)
75	Cuculidae	*Eudynamys scolopaceus*	Asian koel	Least Concern	Not Assessed	No	Common	Resident breeder	Winter visitor	Yes	Yes	
76	Cuculidae	*Phaenicophaeus sumatranus*	Chestnut-bellied malkoha	Near Threatened	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	
77	Dicaeidae	*Dicaeum cruentatum*	Scarlet-backed flowerpecker	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
78	Dicaeidae	*Dicaeum trigonostigma*	Orange-bellied flowerpecker	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
79	Dicruridae	*Dicrurus annectans*	Crow-billed drongo	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)
80	Dicruridae	*Dicrurus paradiseus*	Greater racket-tailed drongo	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
81	Estrildidae	*Lonchura atricapilla*	Chestnut munia	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
82	Estrildidae	*Lonchura cucullata*	Bronze mannikin	Least Concern	Not Assessed	No	NA	Introduced	NA	Yes	Yes	
83	Estrildidae	*Lonchura ferruginosa*	White-capped munia	Least Concern	Not Assessed	No	Rare	Introduced resident breeder	NA	Yes	No	
84	Estrildidae	*Lonchura leucogastroides*	Javan munia	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	Yes	
85	Estrildidae	*Lonchura maja*	White-headed munia	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
86	Estrildidae	*Lonchura punctulata*	Scaly-breasted munia	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
87	Falconidae	*Falco tinnunculus*	Common kestrel	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	
88	Hemiprocnidae	*Hemiprocne longipennis*	Grey-rumped treeswift	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
89	Hirundinidae	*Cecropis daurica*	Red-rumped swallow	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	
90	Hirundinidae	*Hirundo rustica*	Barn swallow	Least Concern	Not Assessed	No	Abundant	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
91	Hirundinidae	*Hirundo tahitica*	Pacific swallow	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
92	Laniidae	*Lanius cristatus*	Brown shrike	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	Yes	
93	Laniidae	*Lanius schach*	Long-tailed shrike	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	
94	Laniidae	*Lanius tigrinus*	Tiger shrike	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
95	Leiothrichidae	*Garrulax canorus*	Chinese hwamei	Least Concern	Not Assessed	No	Rare	Introduced resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
96	Leiothrichidae	*Garrulax leucolophus*	White-crested laughingthrush	Least Concern	Not Assessed	No	Common	Introduced resident breeder	NA	Yes	Yes	
97	Megalaimidae	*Psilopogon haemacephalus*	Coppersmith barbet	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
98	Megalaimidae	*Psilopogon lineatus*	Lineated barbet	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	Yes	
99	Meropidae	*Merops philippinus*	Blue-tailed bee-eater	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	Yes	
100	Meropidae	*Merops viridis*	Blue-throated bee-eater	Least Concern	Not Assessed	No	Common	Migrant breeder	NA	Yes	Yes	
101	Monarchidae	*Terpsiphone affinis*	Blyth's paradise flycatcher	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	
102	Monarchidae	*Terpsiphone atrocaudata*	Japanese paradise flycatcher	Near Threatened	Not Assessed	No	Rare	Passage migrant	NA	Yes	No	
103	Monarchidae	*Terpsiphone incei*	Amur paradise flycatcher	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in J1002 EIS (2016)
104	Monarchidae	*Terpsiphone paradisi*	Indian paradise flycatcher	Least Concern	Not Assessed	No	Rare	Accidental visitor	NA	Yes	No	Recorded in Tengah EBS (2017)
105	Motacillidae	*Anthus rufulus*	Paddyfield pipit	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
106	Motacillidae	*Dendronanthus indicus*	Forest wagtail	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
107	Motacillidae	*Motacilla alba*	White wagtail	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
108	Motacillidae	*Motacilla cinerea*	Grey wagtail	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)

List of Probable and Recorded Faunal Species - Birds

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109	Motacillidae	*Motacilla tschutschensis*	Eastern yellow wagtail	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	No	
110	Muscicapidae	*Copsychus malabaricus*	White-rumped shama	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
111	Muscicapidae	*Copsychus saularis*	Oriental magpie-robin	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
112	Muscicapidae	*Ficedula mugimaki*	Mugimaki flycatcher	Least Concern	Not Assessed	No	Uncommon	Passage migrant	NA	Yes	No	
113	Muscicapidae	*Ficedula zanthopygia*	Yellow-rumped flycatcher	Least Concern	Not Assessed	No	Uncommon	Passage migrant	NA	Yes	Yes	
114	Muscicapidae	*Larvivora cyane*	Siberian blue robin	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in Tengah EBS (2017)
115	Muscicapidae	*Muscicapa dauurica*	Asian brown flycatcher	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	Yes	
116	Muscicapidae	*Muscicapa sibirica*	Dark-sided flycatcher	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	
117	Muscicapidae	*Muscicapa williamsoni*	Brown-streaked flycatcher	Least Concern	Not Assessed	No	Rare	Winter visitor	NA	Yes	No	
118	Nectariniidae	*Aethopyga siparaja*	Crimson sunbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
119	Nectariniidae	*Anthreptes malacensis*	Brown-throated sunbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
120	Nectariniidae	*Arachnothera longirostra*	Little spiderhunter	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	
121	Nectariniidae	*Cinnyris jugularis*	Olive-backed sunbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
122	Nectariniidae	*Leptocoma brasiliana*	Van Hasselt's sunbird	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	Recorded in J1001 EIS (2017)
123	Oriolidae	*Oriolus chinensis*	Black-naped oriole	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
124	Pandionidae	*Pandion haliaetus*	Western osprey	Least Concern	Not Assessed	No	Common	Non-breeding visitor	NA	Yes	No	
125	Passeridae	*Passer montanus*	Eurasian tree sparrow	Least Concern	Not Assessed	No	Common	Resident breeder	Introduced?	Yes	No	Recorded in Tengah EBS (2017)
126	Pellorneidae	*Malacocincla abbotti*	Abbott's babbler	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
127	Phasianidae	*Excalfactoria chinensis*	King quail	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
128	Phasianidae	*Gallus gallus*	Red junglefowl	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
129	Phasianidae	*Gallus gallus (domestic)*	Domestic chicken	Not Assessed	Not Assessed	No	NA	Introduced	NA	Yes	No	Recorded in J1002 EIS (2016)
130	Phylloscopidae	*Phylloscopus borealis*	Arctic warbler	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
131	Phylloscopidae	*Phylloscopus coronatus*	Eastern crowned warbler	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	No	
132	Phylloscopidae	*Phylloscopus inornatus*	Yellow-browed warbler	Least Concern	Not Assessed	No	Rare	Winter visitor	Passage migrant	Yes	No	
133	Picidae	*Chrysophlegma miniaceum*	Banded woodpecker	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
134	Picidae	*Dinopium javanense*	Common flameback	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
135	Picidae	*Micropternus brachyurus*	Rufous woodpecker	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
136	Picidae	*Picus vittatus*	Laced woodpecker	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
137	Picidae	*Yungipicus moluccensis*	Sunda pygmy woodpecker	Least Concern	Not Assessed	No	Abundant	Resident breeder	NA	Yes	No	Recorded in J1002 EIS (2016); Tengah EBS (2017)
138	Pittidae	*Pitta moluccensis*	Blue-winged pitta	Least Concern	Not Assessed	Yes	Uncommon	Migrant breeder	Winter visitor/passage migrant	Yes	Yes	
139	Pittidae	*Pitta sordida*	Hooded pitta	Least Concern	Not Assessed	No	Uncommon	Winter visitor	Passage migrant	Yes	No	
140	Ploceidae	*Ploceus philippinus*	Baya weaver	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	Yes	
141	Psittaculidae	*Loriculus galgulus*	Blue-crowned hanging-parrot	Least Concern	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
142	Psittaculidae	*Psittacula alexandri*	Red-breasted parakeet	Near Threatened	Not Assessed	No	Common	Introduced resident breeder	NA	Yes	Yes	
143	Psittaculidae	*Psittacula krameri*	Rose-ringed parakeet	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	Yes	
144	Psittaculidae	*Psittacula longicauda*	Long-tailed parakeet	Vulnerable	Not Assessed	Yes	Common	Resident breeder	NA	Yes	Yes	
145	Psittaculidae	*Psittinus cyanurus*	Blue-rumped parrot	Near Threatened	Critically Endangered	No	Uncommon	Resident, breeding not proven	NA	Yes	No	Recorded in Tengah EBS (2017)
146	Psittaculidae	*Trichoglossus haematodus*	Coconut lorikeet	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	Yes	

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
147	Pycnonotidae	*Pycnonotus aurigaster*	Sooty-headed bulbul	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	No	
148	Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented bulbul	Least Concern	Not Assessed	No	Abundant	Introduced resident breeder	NA	Yes	Yes	
149	Pycnonotidae	*Pycnonotus jocosus*	Red-whiskered bulbul	Least Concern	Not Assessed	No	Uncommon	Introduced resident breeder	NA	Yes	Yes	
150	Pycnonotidae	*Pycnonotus plumosus*	Olive-winged bulbul	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
151	Pycnonotidae	*Pycnonotus zeylanicus*	Straw-headed bulbul	Critically Endangered	Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
152	Rallidae	*Amaurornis phoenicurus*	White-breasted waterhen	Least Concern	Not Assessed	No	Common	Resident breeder	Winter visitor	Yes	Yes	
153	Rallidae	*Lewinia striata*	Slaty-breasted rail	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017)
154	Rallidae	*Rallina eurizonoides*	Slaty-legged crake	Least Concern	Not Assessed	No	Rare	Winter visitor	Passage migrant	Yes	No	
155	Rallidae	*Rallina fasciata*	Red-legged crake	Least Concern	Vulnerable	Yes	Uncommon	Resident breeder	Winter visitor	Yes	Yes	
156	Rallidae	*Zapornia fusca*	Ruddy-breasted crake	Least Concern	Not Assessed	No	Uncommon	Resident breeder	Winter visitor	Yes	No	Recorded in Tengah EBS (2017)
157	Rhipiduridae	*Rhipidura javanica*	Malaysian pied fantail	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
158	Scolopacidae	*Actitis hypoleucos*	Common sandpiper	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	Yes	
159	Scolopacidae	*Gallinago gallinago*	Common snipe	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
160	Scolopacidae	*Gallinago stenura*	Pin-tailed snipe	Least Concern	Not Assessed	No	Common	Winter visitor	NA	Yes	No	
161	Scolopacidae	*Rostratula benghalensis*	Greater painted-snipe	Least Concern	Critically Endangered	Yes	Rare	Resident breeder	NA	Yes	No	
162	Strigidae	*Ketupa ketupu*	Buffy fish owl	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
163	Strigidae	*Otus lempiji*	Sunda scops owl	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
164	Strigidae	*Strix seloputo*	Spotted wood owl	Least Concern	Critically Endangered	Yes	Uncommon	Resident breeder	NA	Yes	Yes	
165	Sturnidae	*Acridotheres javanicus*	Javan myna	Least Concern	Not Assessed	No	Abundant	Introduced resident breeder	NA	Yes	Yes	
166	Sturnidae	*Acridotheres tristis*	Common myna	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	No	

List of Probable and Recorded Faunal Species - Birds

No.	Family	Scientific Name	Common Name	Global Status (IUCN/CITES)	National Status (Davison et al., 2008)	Species of Conservation Significance	Distribution/ Abundance/ Rarity (NSS, 2020; Singapore Birds Project, 2020)	Primary Native Status (NSS, 2020; Singapre Birds Project, 2020)	Other Native Status (NSS, 2020; Singapre Birds Project, 2020)	Probable Species	Recorded Species	Remarks
167	Sturnidae	*Agropsar sturninus*	Daurian starling	Least Concern	Not Assessed	No	Common	Winter visitor	Passage migrant	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
168	Sturnidae	*Aplonis panayensis*	Asian glossy starling	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
169	Sturnidae	*Gracula religiosa*	Common hill myna	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in Tengah EBS (2017); NSS Tengah Forest Checklist (2018)
170	Timaliidae	*Mixornis gularis*	Pin-striped tit-babbler	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
171	Turdidae	*Geokichla citrina*	Orange-headed thrush	Least Concern	Not Assessed	No	Uncommon	Winter visitor	NA	Yes	Yes	
172	Turdidae	*Geokichla sibirica*	Siberian thrush	Least Concern	Not Assessed	No	Rare	Passage migrant	NA	Yes	No	
173	Turdidae	*Turdus obscurus*	Eyebrowed thrush	Least Concern	Not Assessed	No	Uncommon	Passage migrant	NA	Yes	No	
174	Turnicidae	*Turnix suscitator*	Barred buttonquail	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	Recorded in NSS Tengah Forest Checklist (2018)
175	Tytonidae	*Tyto javanica*	Eastern barn owl	Least Concern	Not Assessed	No	Uncommon	Resident breeder	NA	Yes	No	
176	Zosteropidae	*Zosterops simplex*	Swinhoe's white-eye	Least Concern	Not Assessed	No	Common	Resident breeder	NA	Yes	Yes	
-	Apodidae	*Aerodramus sp.*	NA	NA	NA	NA	NA	NA	NA	NA	Yes	

List of Probable and Recorded Faunal Species - Non-volant mammals

No.	Family	Scientific Name	Common Name	Global Status (IUCN, 2012)	National Status (Davison et al. 2008)	Species of Conservation Significance	Distribution/Rarity (Baker & Lim, 2012)	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Canidae	*Canis lupus familiaris*	Feral dog	Not Assessed	Not Assessed	No	NA	Non-native	Yes	Yes	
2	Cercopithecidae	*Macaca fascicularis*	Long-tailed macaque	Vulnerable	Not Assessed	Yes	Widespread and Common	Native	Yes	Yes	
3	Felidae	*Felis catus*	Feral cat	Not Assessed	Not Assessed	No	NA	Non-native	Yes	No	
4	Felidae	*Prionailurus bengalensis*	Mainland leopard cat	Least Concern	Critically Endangered	Yes	Restricted and Rare	Native	Yes	No	
5	Manidae	*Manis javanica*	Sunda pangolin	Critically Endangered	Critically Endangered	Yes	Widespread but Rare	Native	Yes	Yes	
6	Muridae	*Mus castaneus*	House mouse	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	
7	Muridae	*Rattus annandalei*	Annandale's rat	Least Concern	Not Assessed	No	Restricted but Common	Native	Yes	No	Recorded in Tengah EBS (2017)
8	Muridae	*Rattus exulans*	Polynesian rat	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	No	Recorded in Tengah EBS (2017)
9	Muridae	*Rattus norvegicus*	Brown rat	Least Concern	Not Assessed	No	Widespread and Common	Non-native	Yes	No	
10	Muridae	*Rattus tanezumi*	Oriental house rat	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	Recorded in Tengah EBS (2017)
11	Muridae	*Rattus tiomanicus*	Malaysian wood rat	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
12	Sciuridae	*Callosciurus notatus*	Plantain squirrel	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
13	Sciuridae	*Sundasciurus tenuis*	Slender squirrel	Least Concern	Not Assessed	Yes	Restricted but Common	Native	Yes	Yes	
14	Soricidae	*Suncus murinus*	House shrew	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	
15	Suidae	*Sus scrofa*	Wild pig	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
16	Tupaiidae	*Tupaia glis*	Common treeshrew	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
17	Viverridae	*Paradoxurus musangus*	Common palm civet	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	Yes	

List of Probable and Recorded Faunal Species - Bats

No.	Family	Scientific Name	Common Name	Global Status (IUCN, 2012)	National Status (Davison et al. 2008)	Species of Conservation Significance	Distribution/Rarity (Baker & Lim, 2012)	Native Status (Baker & Lim, 2012)	Probable Species	Recorded Species	Remarks
1	Emballonuridae	*Saccolaimus saccolaimus*	Pouch-bearing bat	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
2	Emballonuridae	*Taphozous melanopogon*	Black-bearded tomb bat	Least Concern	Endangered	Yes	Widespread but Rare	Native	Yes	Yes	
3	Pteropodidae	*Cynopterus brachyotis*	Lesser dog-faced fruit bat	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
4	Pteropodidae	*Eonycteris spelaea*	Cave nectar bat	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	No	
5	Pteropodidae	*Pteropus vampyrus*	Large flying fox	Near Threatened	Not Assessed	No	NA	Visitor	Yes	Yes	
6	Vespertilionidae	*Myotis 'adversus'*	Grey large-footed myotis	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	No	Recorded in Tengah EBS (2017)
7	Vespertilionidae	*Myotis muricola*	Whiskered myotis	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
8	Vespertilionidae	*Pipistrellus javanicus*	Javan pipistrelle	Least Concern	Not Assessed	No	Widespread but Uncommon	Native	Yes	Yes	
9	Vespertilionidae	*Scotophilus kuhlii*	Asiatic lesser yellow house bat	Least Concern	Not Assessed	No	Widespread and Common	Native	Yes	Yes	
10	Vespertilionidae	*Tylonycteris fulvida*	Lesser bamboo bat	Least Concern	Critically Endangered	Yes	Restricted and Rare	Native	Yes	No	
11	Vespertilionidae	*Tylonycteris malayana*	Greater bamboo bat	Least Concern	Not Assessed	Yes	Widespread and Common	Native	Yes	No	Recorded in Tengah EBS (2017)
-	Vespertilionidae	*Tylonycteris sp.*	NA	NA	NA	NA	NA	NA	NA	Yes	

Appendix 7C: Design Strategies for Biodiversity

Design Strategies for Biodiversity

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1. Summary of Mitigation Strategies for Biodiversity

This document addresses general design strategies for biodiversity that can be adopted and integrated into the Project and broader Tengah Town development. It is meant to supplement the mitigation measures outlined in the baseline impact assessment (**Section 7**). This document serves as a simplified guideline for designers and planners.

A summary of mitigation strategies for biodiversity in the order the mitigation hierarchy, i.e., avoid, minimize, enhance and compensate is shown in **Figure 1.1**. The locations where these strategies can be applicable in the EIS Study Area are represented in **Figure 1.2**, with the labels in the icons corresponding to the type of strategy.

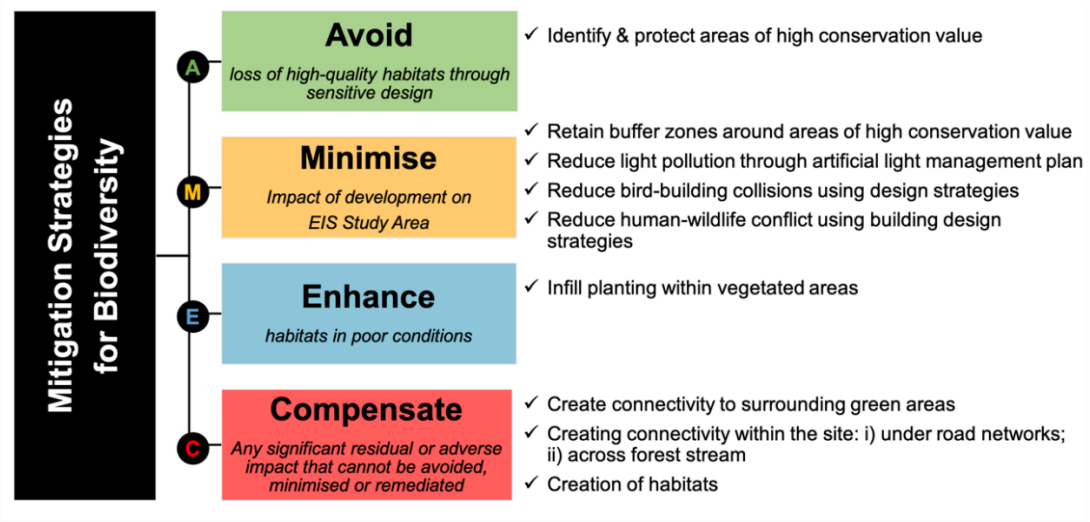


Figure 1.1. Summary of Mitigation Strategies for Biodiversity

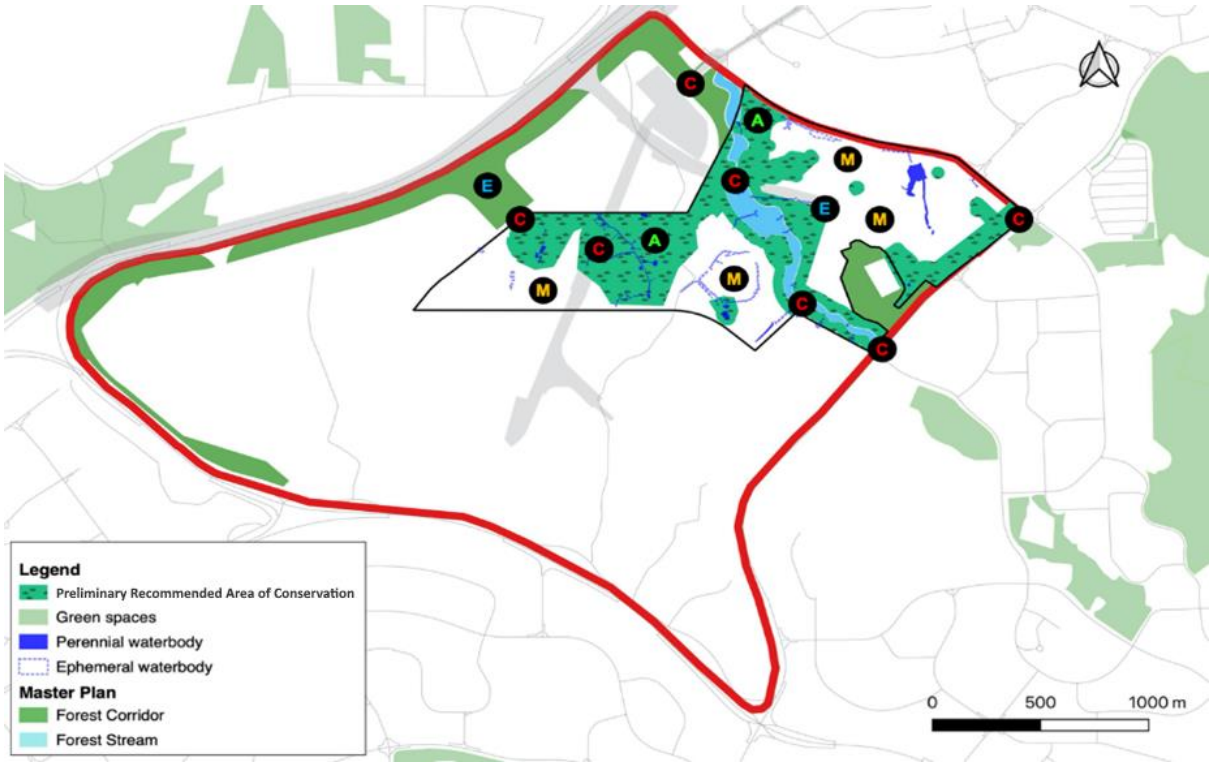


Figure 1.2. Summary of design strategies applicable in various parts of the EIS Study Area. The labels in the icons corresponds to the type of strategy listed in Figure 1.1.

2. Avoid

2.1. Identify and Protect Recommended Area of Conservation

Impact: **Loss of habitat & ecological connectivity**	The development results in the loss of extensive area of habitat and ecological connectivity within the EIS Study Area. The EIS Study Area (166 ha) provides habitats for many flora and fauna species of conservation significance. It also serves an important ecological connectivity as it facilitates the dispersal of flora and fauna between the Western Water Catchment Area, Bukit Timah Nature Reserve and Central Catchment Nature Reserve, which are biodiversity hotspots across the fragmented landscape in Singapore.
Solution: **Retain areas of high conservation value**	The Recommended Area of Conservation (RAC) was identified in **Section 7.5** of the EIS Report (**Figure 2.1**). The development should be intentionally designed/re-designed to avoid the RAC to prevent the loss of high-quality habitats for biodiversity.

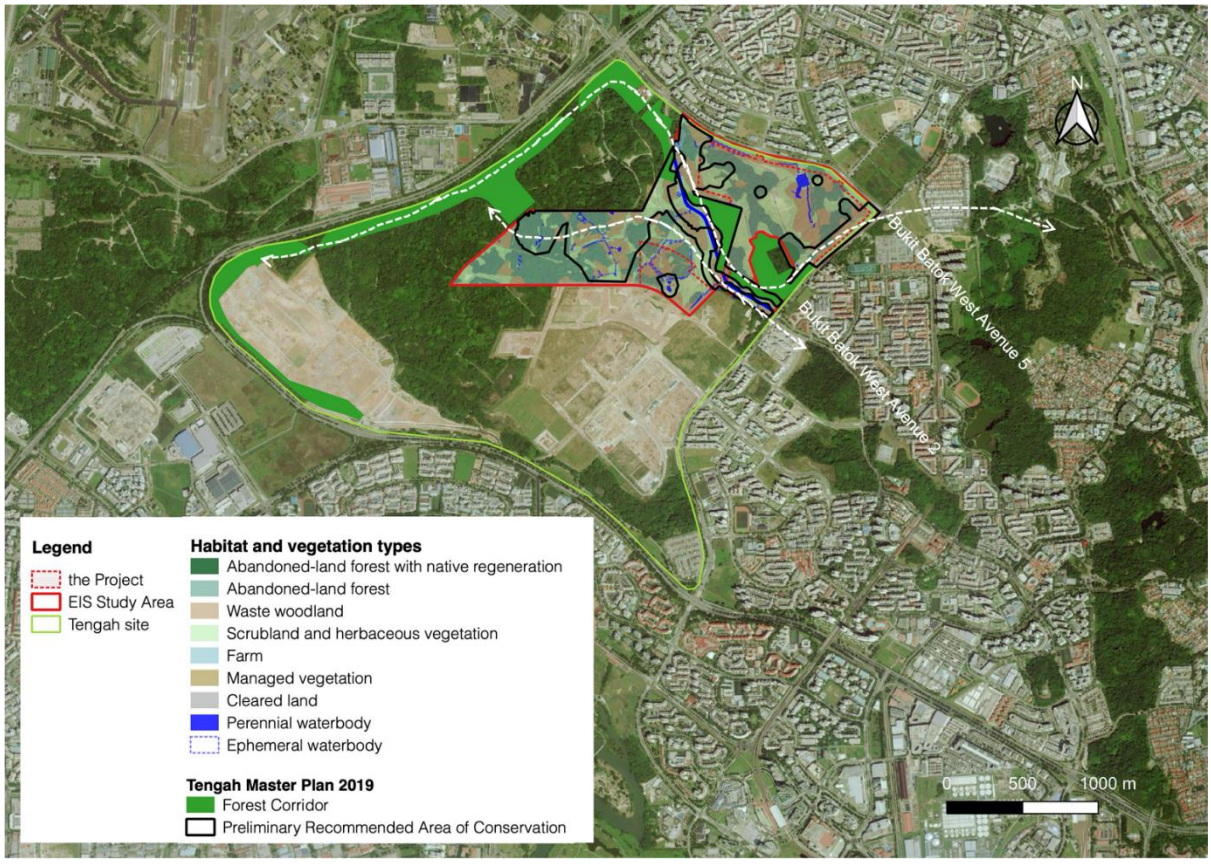


Figure 2.1. Preliminary Recommended Area of Conservation (outlined in black) and the Forest Corridor (shaded green) in the EIS Study Area. White arrows show potential connectivity through the site.

Base Map: ESRI

3. Minimise

3.1. Retain Buffer Zones around Features of High Ecological Value

Impact:

Forest edge effects

Habitat loss exposes the forest edges of the RAC to changes in microclimatic conditions, i.e., forest edge effects, which are detrimental if unmanaged. New forest edges are exposed to altered light, wind, humidity and sound levels that may result in i) reduced habitat suitability for native flora and fauna, which may die or move away from the edges; and ii) colonization of exotic flora and fauna, leading to undesirable changes of species composition.

Solution:

Retain buffer zones around features with high ecological value

A 30-m wide forested strip is recommended to be retained around identified habitats and specimens of high ecological value. It serves as a vegetated buffer to reduce changes in microclimatic conditions within the conserved areas (Murcia, 1995; Beacon Environmental Ltd, 2012; Dillaha et al.,1986). These areas are highlighted in **Figure 2.1**, including the open-country ponds and potential roosting sites for bamboo bats.

Vegetation density is important for an effective forest buffer (DaWalle, 2010).

- Wherever possible, native vegetation should be retained within the 30-m buffer. If this is not possible, cleared buffers should be planted to emulate the density and vegetation structure (i.e. trees and shrubs making up the canopy and understory) of the natural forest.
- Given that the height of trees in the site can be up to 30 m, the 30-m strip also serves as a buffer in the scenario of a tree fall. The planted vegetation will be deliberately tiered with shrubs at the outer edge followed by tree species of different mature height. This produces a graded canopy line that is shape-optimised to buffer against wind and rain to reduce tree failure at the forest edges (**Figure 3.1**).

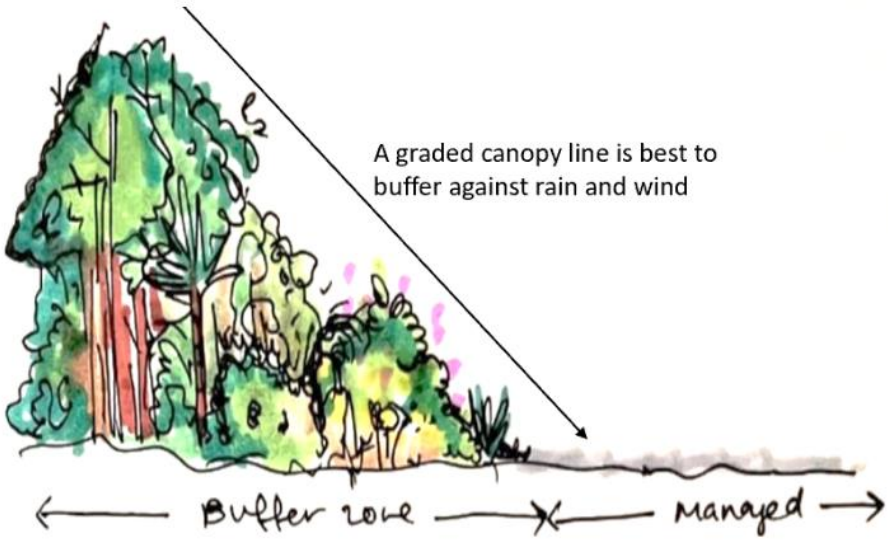


Figure 3.1. Example of buffer zone between forest and development.

3.2. Incorporate Artificial Light Management Plan

Impact:

Increased ecological light pollution

The development would result in increased ecological light pollution, which includes chronic or periodically increased illumination, unexpected changes in illumination, and direct glare experienced by flora and fauna (Longcore and Rich, 2004). Ecological light pollution has demonstrable effects on the behavioural and population ecology of organisms in natural settings. A source of ecological light pollution is sky glow, which is the brightness of the night sky caused by the reflected light scattered from particles in the atmosphere. Sky glow comprises both natural and artificial sky glow. As sky glow increases so does the potential for adverse impacts on wildlife which may affect foraging, reproduction, migration, and communication of wildlife.

Solution:

Design Artificial Light Management Plan

The artificial light management plan aims to minimize ecological light pollution by:

1) Establish "lighting buffer zones" with no artificial illumination and vary illuminance limits from the "lighting buffer zones" to the urban areas (**Figure 3.2**).
   - No artificial illumination within the proposed Forest Corridor and RAC.
   - Direct permanent artificial lightings away from the proposed Forest Corridor and RAC.
   - Higher levels of illuminance can be tolerated with increasing distance from these areas.
   - If a lighting buffer zone is not possible, minimise illumination in the transition zone between these protected areas and the urban areas.
2) Use adaptive light controls to manage light timing, intensity and colour (**Figure 3.2)**.
   - Example: smart controlled LED lights
   - Minimise the use lights during hours just before dawn and after dusk when crepuscular and nocturnal animals are the most active.
3) Minimise light spills, i.e., the light that falls outside the area intended to be lit, through (**Figure 3.2**):
   - Optimise the placement of lights by lighting only the object or area intended, and keeping lights close to the ground, directed and shielded.
   - Configure the location, orientation and height of buildings and structures (e.g., street lights).
   - Screen through soft landscaping or hard structures (walls, fences and bunding). Fencing can be overplanted with climbers to soften its appearance and provide a vegetated feature for fauna, but should never be relied on as the sole means of attenuating light spill.
4) Use wildlife-friendly light properties or features (**Figure 3.2**):
   - Use low-glare lighting and lights with reduced or filtered blue, violet and ultra-violet wavelengths.
   - Use non-reflective, dark-coloured surfaces to reduce contribution to sky glow.

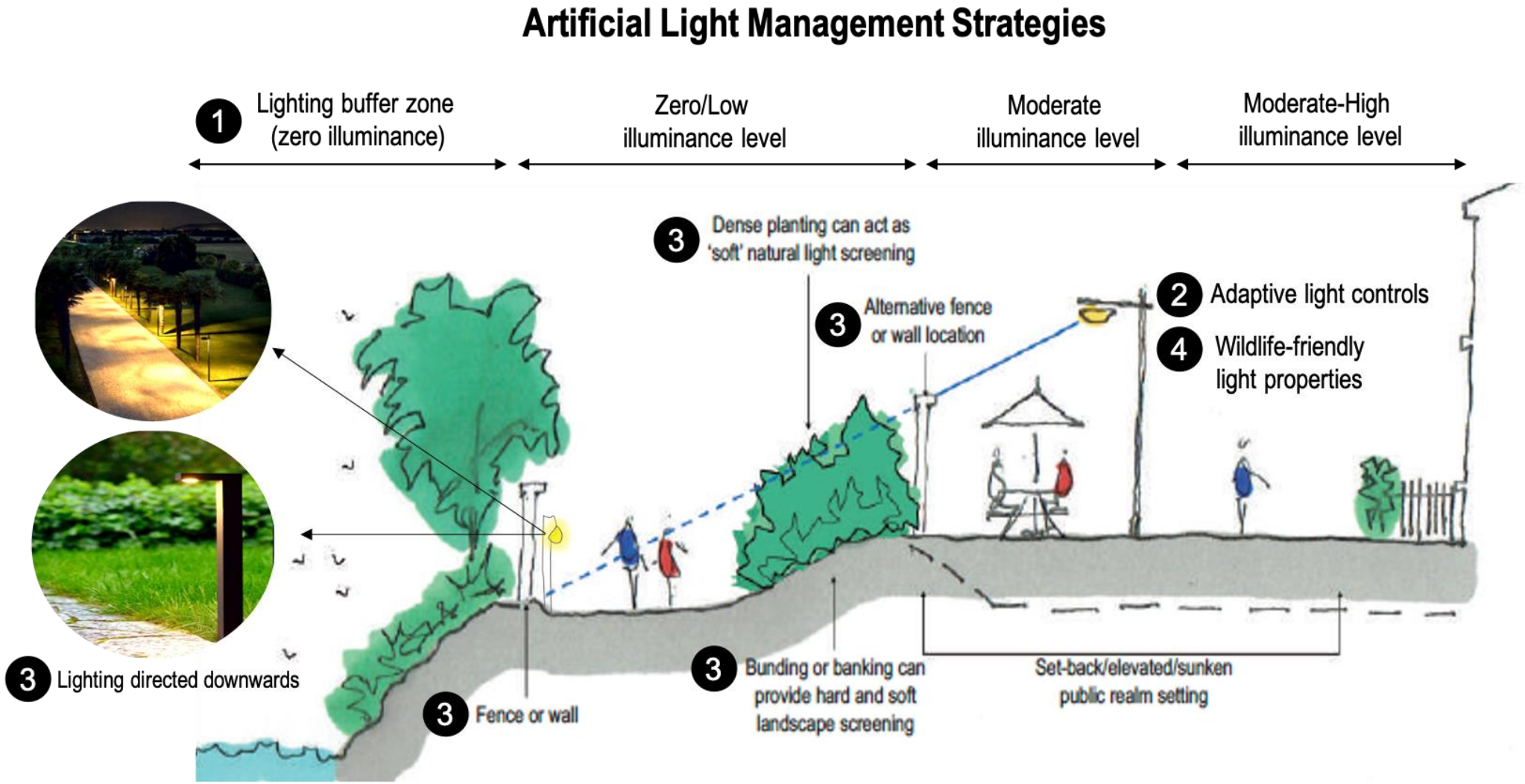


Figure 3.2: Summary of artificial light management strategies (adapted from Institute of Lighting Professionals, 2018). The numbers in the icons corresponds to the strategies listed above.

3.3. Integrate Bird-friendly Features into Buildings

Impact:

Bird-building collision

Bird-building collisions occurs frequently when birds fail to perceive the glass as a barrier due to reflection of sky or trees or flyway on the glass surface.

Solution:

Bird-friendly designs

Bird-building collisions can be reduced by integrating bird-friendly designs such as (Sheppard & Phillips, 2015):

1) Reduce the area of glass façade used in the building
2) Increase the visibility of glass (including mirrored and non-mirrored reflective glass, and transparent glass) or dampen reflections to reduce the appearance of clear passage to sky or vegetation through:
    - Using film coating, decals or dense patterns on glass:
        - A pattern density of 10 cm by 10cm or less;
        - Visual markers to be at least 5 mm in diameter;
        - Visual markers should be high contrast; and
        - Targeting exterior surface as it is the most effective for deterring bird collisions.
    - Physical barriers: Interior or exterior shades, grilles, sunshades, screens, blinds and netting:
        - To break up reflections on glass façade.
        - Confer the freedom of choosing to only use it during periods where bird collisions are expected to be most frequent, such as during the migratory seasons.
    - Placement of windows: angled glass, recessed windows and balconies:
        - The height to width ratio of the balcony is recommended to be 1:1 to block out the harshest sunlight during the brighter half of the day.
        - Louvres should be added to provide more shade.
        - Railings should be made from metal grilles or other opaque materials.
3) Avoid interior or exterior vegetation near windows as birds may confuse this with exterior vegetation and fly towards them. If they are close to natural vegetation, the façade should have shades or netting installed near the glass to prevent birds from crashing into it.
4) Buildings should not have courtyards or corridors that are enclosed by glass as these may confuse birds to fly through.

These strategies are illustrated in corresponding labels in **Figure 3.3**.

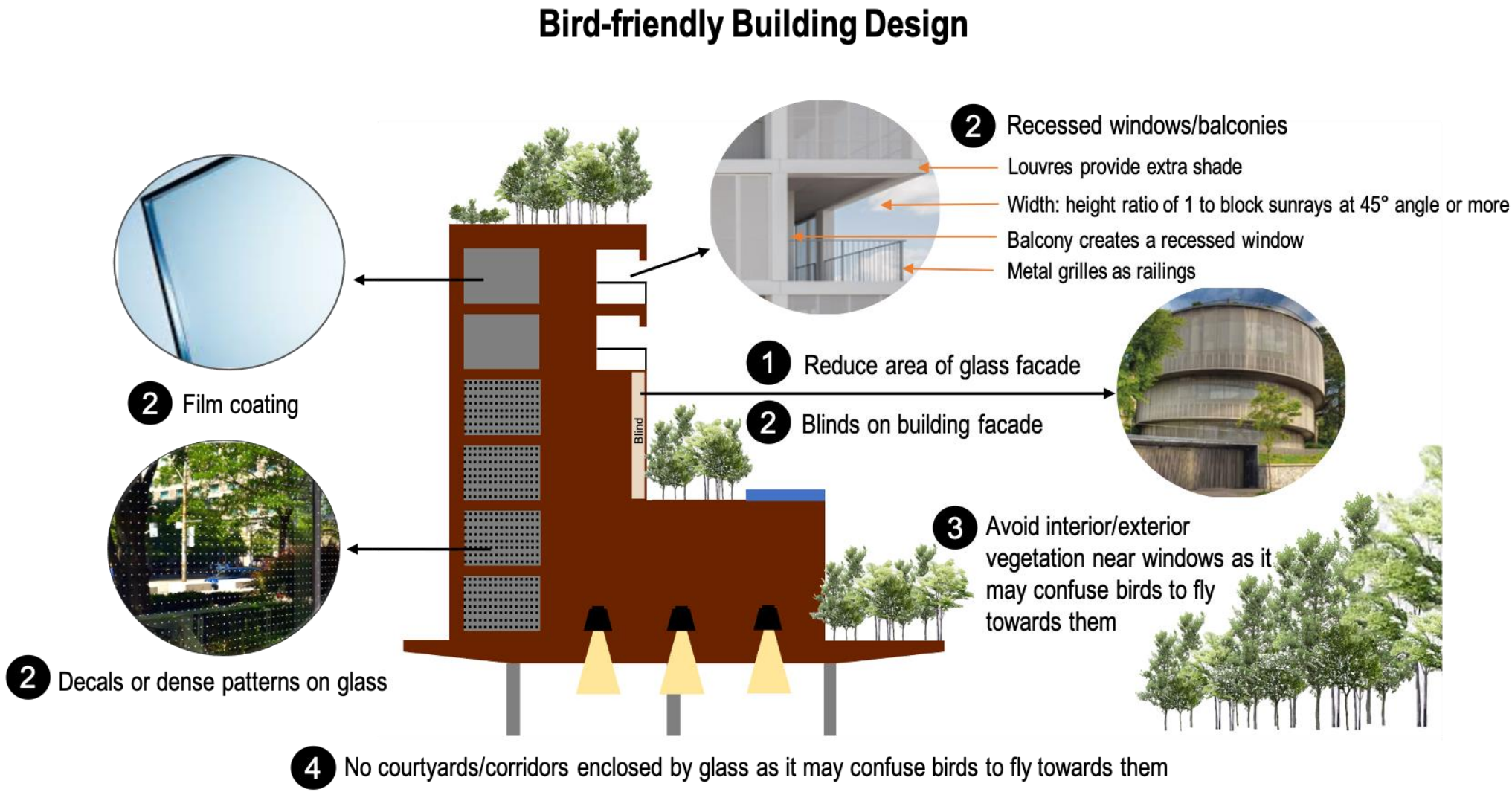


Figure 3.3: Summary of bird-friendly building design to prevent bird strikes. The numbers in the icons corresponds to the strategies listed above.

3.4. Incorporate Building Designs to Minimise Human-macaque Conflict

Impact:

Human-wildlife conflict

The long-tailed macaques (*Macaca fascicularis*) are edge species and are highly adaptable in urban environments. The chance of human-macaque encounters, and therefore, human-macaque conflict in the proposed development is high. Minimising human-macaque conflict requires site-specific recommendations. However, the general guidelines below can be considered:

Solution:

Building Design

1) The landscaping and infrastructure should keep in mind the capabilities and behaviour of the macaques. For instance:
   - Macaques are primarily arboreal and have a mean leaping distance of 2.2 m (Cannon & Leighton, 1994) and a maximum leaping distance of 5 m (Cant, 1988). Thus, there should be a 6 m buffer between the building façade and the tree line as well as any potential climbing structures (e.g., lamppost).
   - To prevent scaling, the walls and pillars should be smooth and any projections that could potentially be used as handholds should be spaced greater than 1.5 m apart (i.e., larger than the arm span of an adult male long-tailed macaque) (Jones-Engel et al., 2011).
   - There should also be a canti-levered section of the building to prevent them from scaling to the higher residential levels of the building.
   - Addition of invisible grills to balconies will prevent macaques from entering and if these grills are spaced less than 10 cm apart (vertically), they will also prevent birds from entering the residential areas.
   - Macaques are avid swimmers and would enter outdoor swimming pools accessible to them. Thus, the swimming pools should be placed indoors or at a height that is beyond reach to them.
2) Proper waste-management techniques are extremely crucial within the residential districts. Key features include:
   - Macaque-proof bins, i.e., inaccessible to macaques either through being enclosed, with secured ropes or ties, or complex opening/closing mechanisms (Jones-Engel et al., 2011)
   - Waste management centres should be enclosed and inaccessible to macaques, including vents.
3) Education

Reducing human-macaque conflict also involves behavioural change on the public's part. It is important to educate the public to not feed the macaques, and indicate proper behaviours to avoid conflict with macaques (e.g., Dos and Don'ts; Jones-Engel et al., 2011). Educational signages are cost-effective methods that can be implemented.

4) Others (Jones-Engel et al., 2011)
   - Enclosed carparks; owners can cover cars if concerned with damage
   - Walkways/bridges: wide enough for people to pass a macaque at >1m
   - Gardens: enclosed; motion-triggered water spurts

These strategies are illustrated in corresponding labels in **Figure 3.4**.

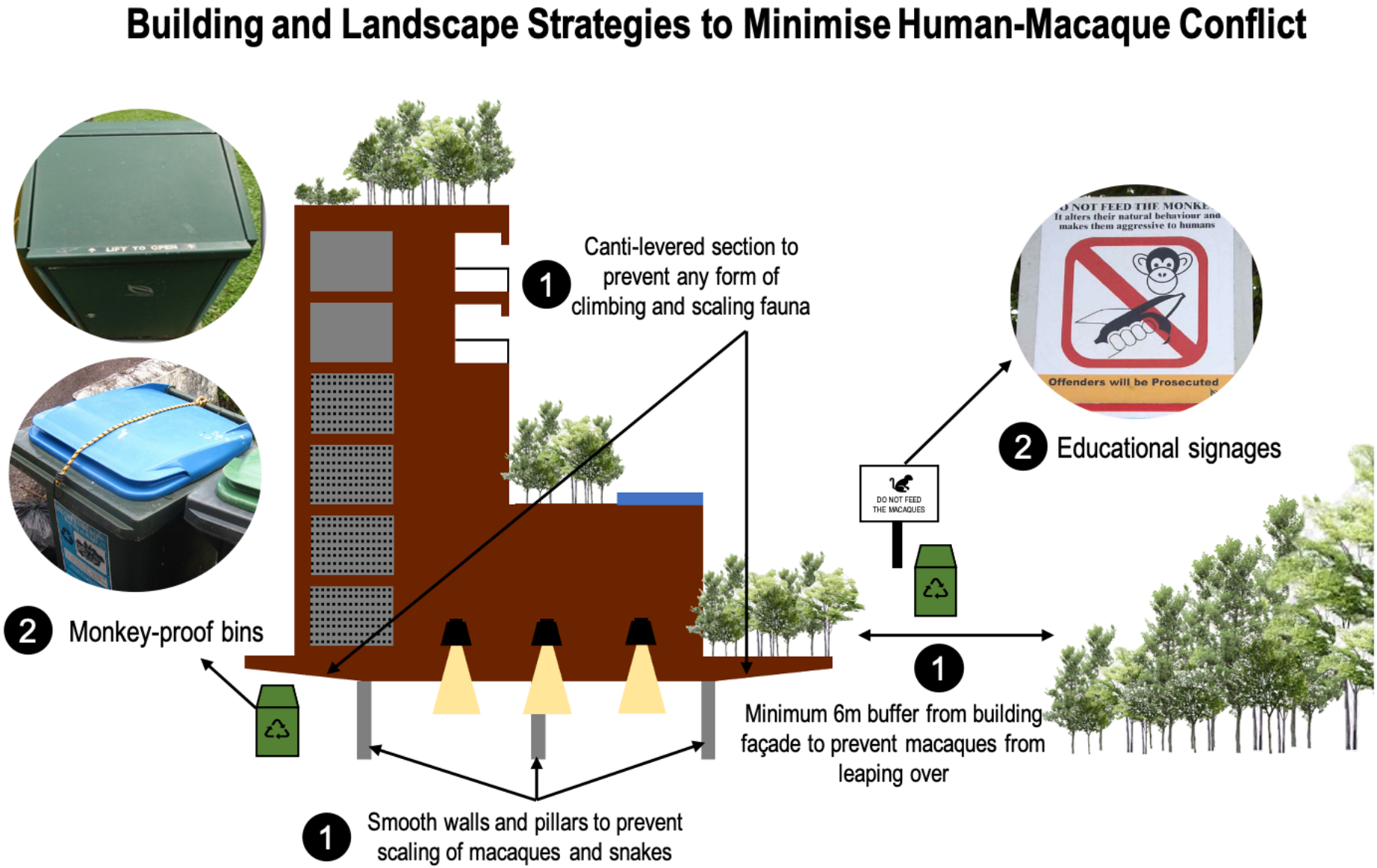


Figure 3.4. Building and landscape strategies to minimise human-macaque conflict. The numbers in the icons corresponds to the strategies listed above.

4. Enhance

4.1. Infill Planting Within Vegetated Areas

Impact:

Habitat degradation & fragmentation

Degraded habitats with lack of structural complexity will not be able to effectively serve its ecological role. Moreover, with the construction works in the site, the forested areas will become fragmented which will affect the genetic flow across the different vegetated areas. This would in turn result in a slower forest regeneration process. Lastly, a degraded and fragmented habitat will have large gaps that may allow for invasive exotic plant species to thrive. Yet not all invasive exotic species provide an important ecological function. Exotic plant species can also outcompete the native species, resulting in reduced ecosystem services of the forest.

Solution:

Infill planting within vegetation areas

Context-specific infill planting at degraded habitats creates resources and increases structural complexity that benefit wildlife and improve ecosystem services (Toivanen, 2007; Pimentel & Kounang, 1998). Native plants should be used in infill planting, and exotic species which do not provide an ecological function (e.g., oil palms and rampant, invasive species like *Cecropia* sp.) should be gradually phased out. To facilitate the establishment of plantings, shrubs will be planted alongside trees, which is especially helpful for the recruitment of native birds and ground-dwelling mammals (Eyre et al., 2010).

Infill planting makes use of the existing forest framework, to jump start succession into a more native dominated forest. It is a common reforestation strategy and is not difficult to implement. The framework emergent and canopy trees as well as native understory trees will be identified and retained. The other trees will be removed and, in its place, native species that is suitable to the site will be planted (**Figure 4.1**). This allows the existing biodiversity to be maintained while increase the chances of successful regeneration of the forest.

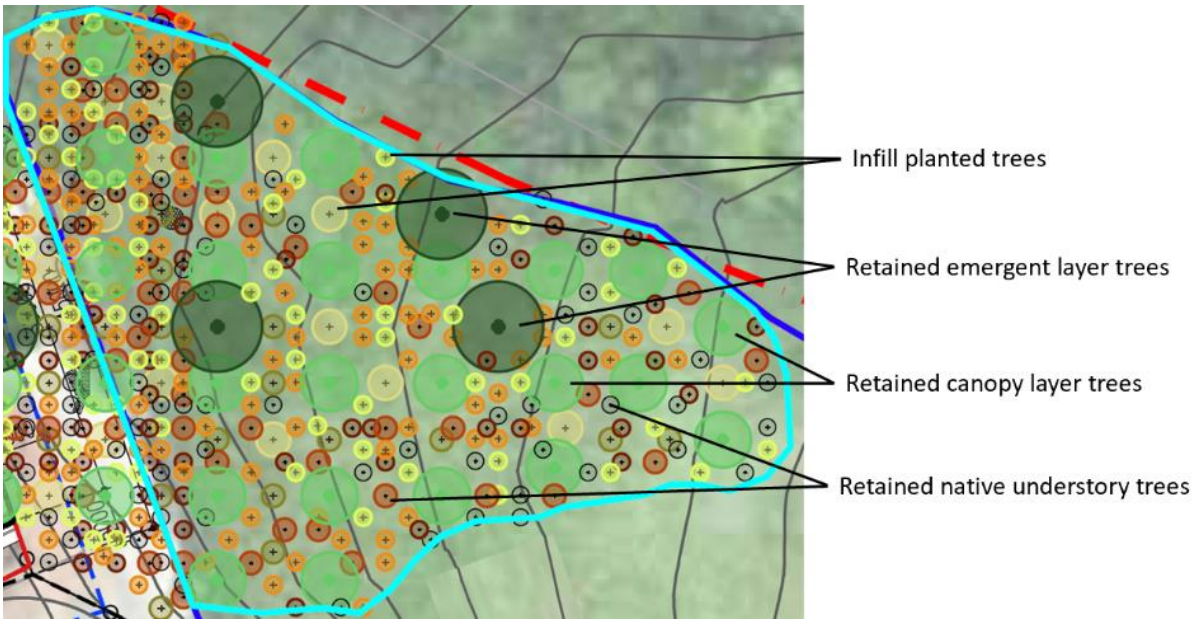


Figure 4.1: Example of infill planting plan

5. Compensate

Impact: Loss of habitat & connectivity	Even if the preliminary RAC were to be completely retained, the proposed development will still result in loss of an extensive area of forest. Despite the minimisation and enhancement strategies, the impact of the project is still major.
Solution: Habitat creation & enhancement of connectivity	Compensation strategies such as creating connection to surround green spaces and within the EIS Study Area as well as creating habitats can compensate for habitat loss through improving ecology function and increasing biodiversity.

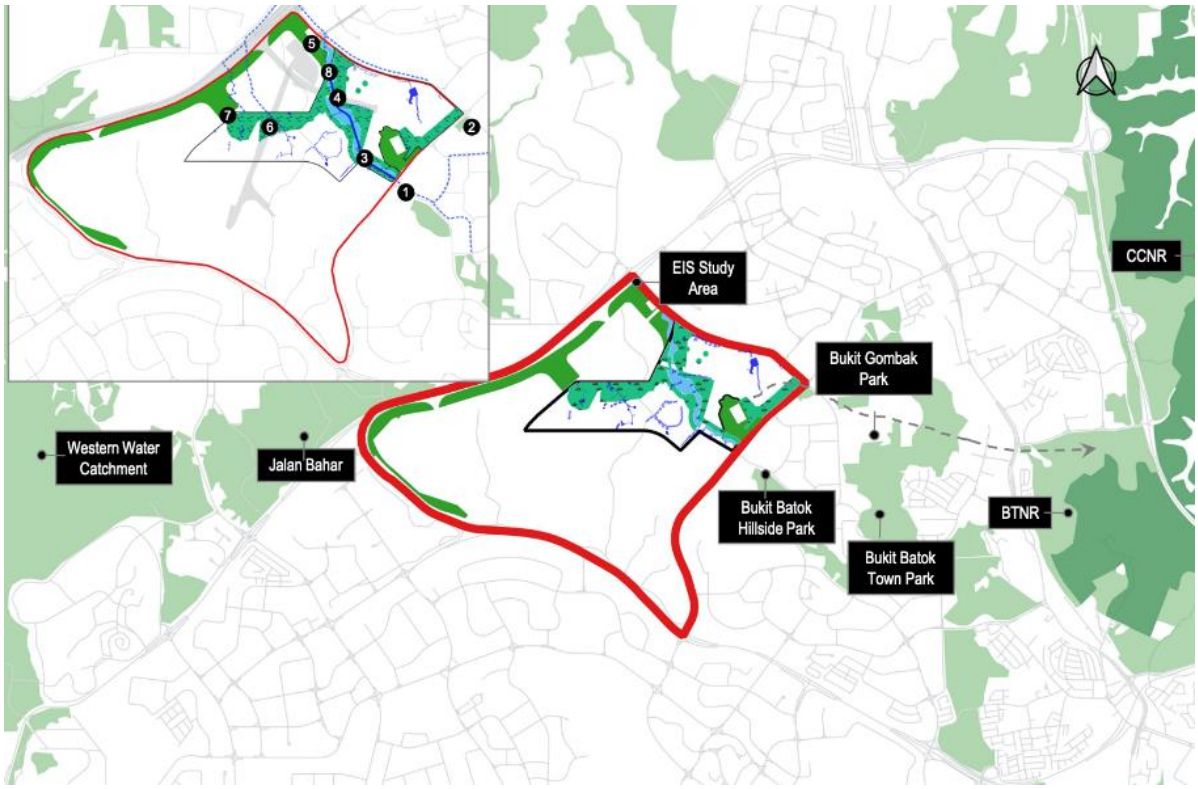


Figure 5.1: Connectivity of the EIS Study Area to surrounding green spaces. Inset: eight locations where barriers to connectivity will be addressed.

5.1. Create Connectivity to Surrounding Green Spaces

The ecological connectivity of the EIS Study Area can be enhanced by providing wildlife corridors to surrounding green spaces at two locations (**Figure 5.2**):

a) Via Bukit Batok West Avenue 5 to Bukit Gombak Park and Bukit Batok Town Park
b) Via Bukit Batok West Avenue 2 to Bukit Batok Hillside Park in the east

The gap in connectivity towards these green spaces can be addressed via strategies such as overpass and underpass.

i) Overpass

The bridge may be built with or without a dual purpose for humans and wildlife usage. For dual-purpose overpass, these zones should be separated by a physical barrier (e.g. height difference) and the biodiversity should be at least 1-m wide.

ii) Underpass

Wildlife crossings should be placed in targeted areas where there is a gap in vegetation connectivity, to maintain connectivity for ground-dwelling fauna. This also helps to reduce roadkills.

iii) Deck over existing canal

A deck over involves a structure being overlaid on the top of the canal, which then stretches parallel to the canal.

iv) Planting

Planting should be adopted to minimise gaps in connectivity and make habitats more favourable for fauna to move through. It should follow that described in **Section 3.1**. For light-weight structures, planting can target tall/dense flowering/fruiting small trees and shrubs that do not have very deep or extensive root system.

Barriers in connectivity were identified in seven locations (a–g) as illustrated in **Figure *5.2***.

- Gap in connectivity between EIS Study Area **(a)** and HomeTeamNS Forest **(b)** due to Bukit Batok Road
- Gap in connectivity between HomeTeamNS Forest **(b)** and state land **(c)** due to Bukit Batok West Avenue 5
- Lack of vegetation connectivity at state land **(c)** towards Bukit Gombak Park and Bukit Batok Town Park
- Gap in connectivity at the junction of Brickland Road/ Bukit Batok Road **(d)**
- Concrete canal as a barrier to connectivity **(d)**
- Gap in connectivity along Bukit Batok West Avenue 2 due to small road **(e)**
- Gap in connectivity to Bukit Batok Hillside Park due to Bukit Batok Avenue 2 **(f, g)**

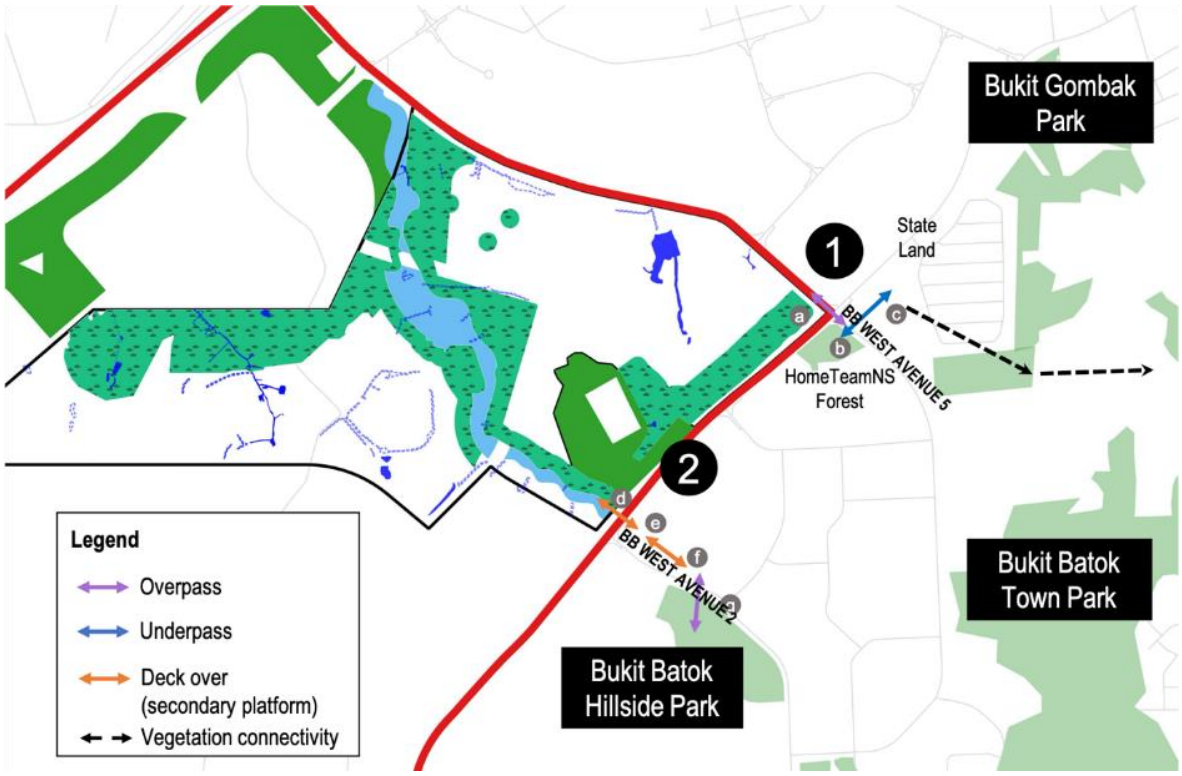


Figure 5.2. Strategies to address connectivity along 1) Bukit Batok West Avenue 5 and 2) Bukit Batok West Avenue 2.

5.2. Create Connectivity within Site

Based on the future master plan, barriers in connectivity were identified in several locations from road developments and proposed Forest Stream. Thus, design strategies are proposed in the following sections to address this.

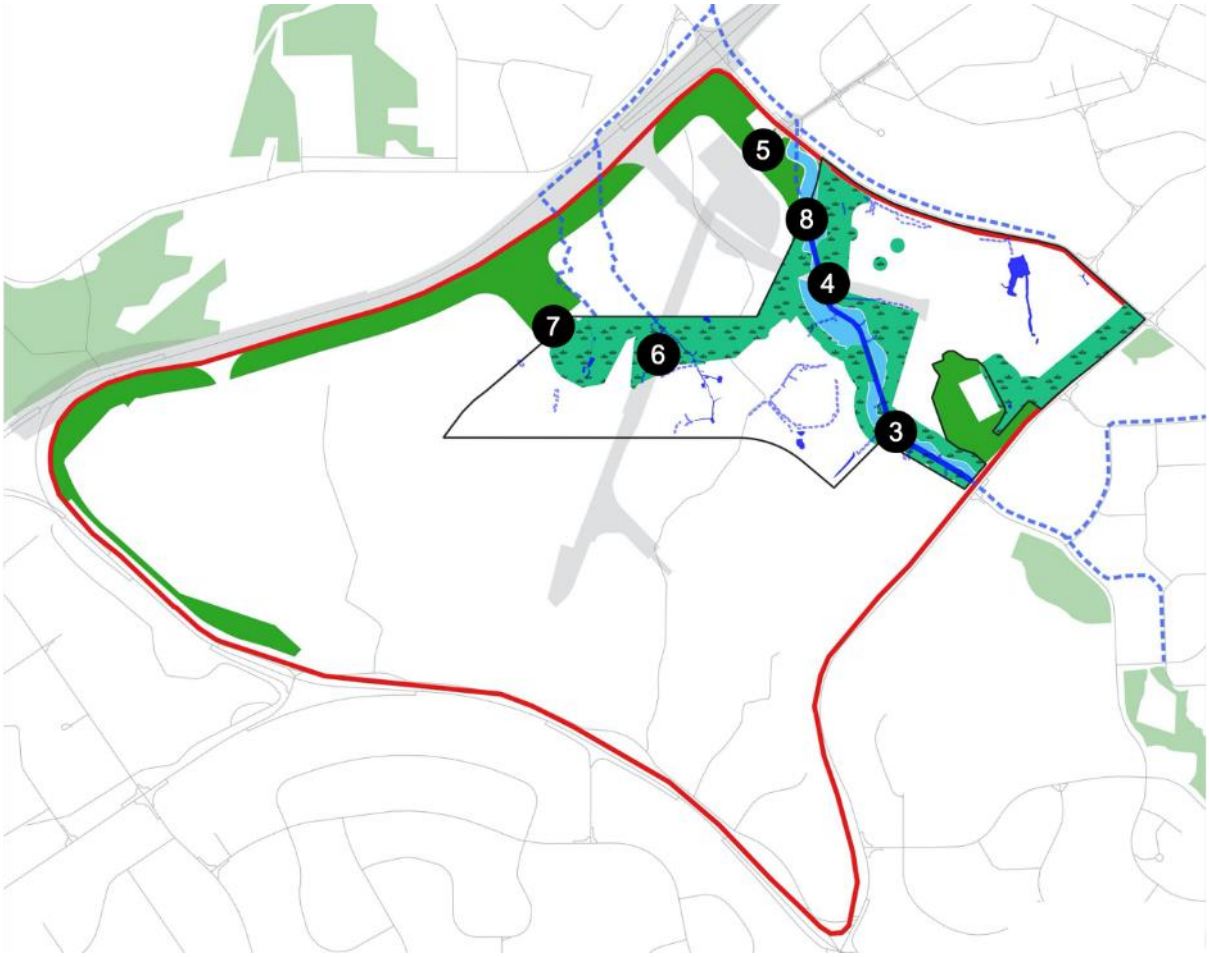


Figure 5.3: Summary of locations with barriers to connectivity within the EIS Study Area.

5.2.1. Provide Grade-separated Wildlife Crossings

Barriers in connectivity from road development were identified in locations 3–7 (**Figure 5.3**). Of these seven locations, six grade-separated crossings are planned by the respective agencies with the exception of one at location 7 which is pending future planning.

Grade-separated wildlife crossings helps to reduce roadkill, particularly for ground-dwelling fauna. It allows ground-dwelling fauna to safely use the terrestrial passage underneath or above the roads (**Figure 5.4**). Fences along the road and strategic planting of vegetation around the wildlife crossing may be considered to guide the fauna towards utilizing the crossing instead of the roads.

Key considerations:

- The minimum size of the passageway should be 1 m by 1 m to accommodate ground-dwelling fauna, namely the wild pigs (*Sus scrofa*), common palm civet (*Paradoxurus musangus*), mainland leopard cat (*Prionailurus bengalensis*) and Sunda pangolin (*Manis javanica*). Reptiles such as the black-spitting cobra (*Naja sumatrana*) may also use the culvert.
- Provide vegetation that slopes downwards on both sides of the culvert. The vegetation should not be too dense and allow light to pass through.
- Texture of the culvert should be a rough concrete finish to allow grip for the pangolin.

- The entry and exit of the culvert should be gentle to allow animals to climb easily. If it is steep, steps could be provided in the form of concrete steps or small rocks.
- If the culvert stretches across a relatively long section of road of >6 m, consider providing a light shaft. Animals may not use it if it is too dark.



Figure 5.4: Example of wildlife crossing along the proposed Forest Stream under road.

5.2.2. Provide Habitat Features across the Forest Stream

Connectivity along the forest stream in location 8 can be established by using the following strategies to facilitate the movement of ground-dwelling fauna across the stream:

- Placing recycled fallen logs from site clearance at multiple locations along the forest stream;
- Place floating wetlands along the forest streams where the waters are deeper and slow flowing;
- Design the forest stream to have a shallow littoral zone along the edges;
- Design permanent small islands amidst braided streams along the proposed forest stream;
- Plant a mixture of shrubs and grasses to make it attractive for animals to cross.

These strategies can also double up as habitat creation strategies, where different micro-habitats are created (**Section 5.2.3**).

5.2.3. Creation of Aquatic Habitats

The proposed Forest Stream holds much potential for the creation of different aquatic micro-habitats. The following strategies will also help to bridge the connectivity gap (**Section 5.2.2**).

- Gradual sloping stream banks with littoral zone and tiered planting of riparian vegetation to enhance habitat complexity (**Figure 5.5**).

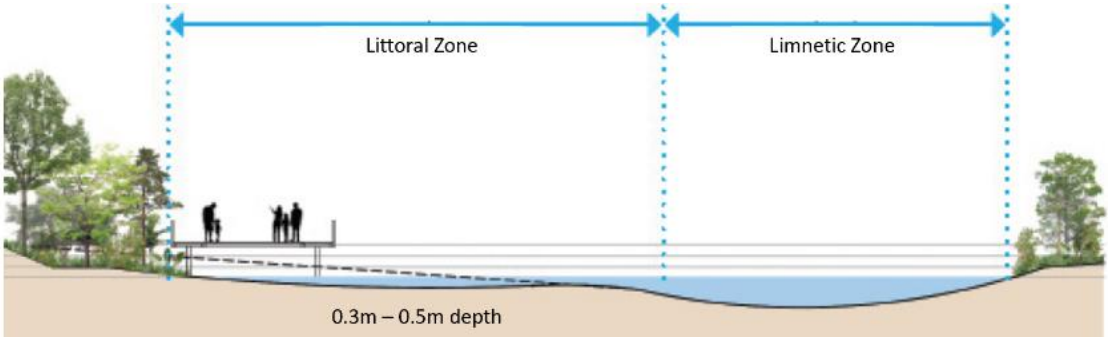


Figure 5.5: Example of stream with littoral zone and limnetic zone (adapted from Ramboll Studio Dreiseitl drawings)

- Braided streams with permanent dry islands (**Figure 5.6**), where the dry islands can be used as refuge area for terrestrial animals during storm events while the gentle gradient along its banks provides a conducive environment for fauna to stand on the slope to feed and to easily move across, particularly for catfish and snakeheads which may get washed out of the stream and ponds during floods.

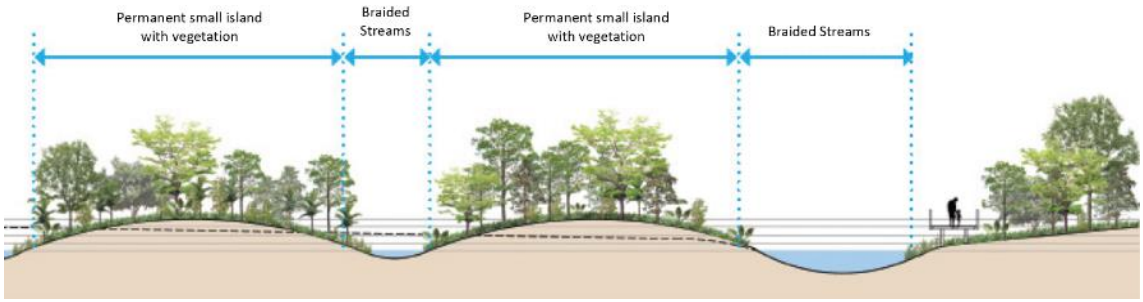


Figure 5.6 Example of braided streams with permanent small islands (adapted from Ramboll Studio Dreiseitl drawings)

- A mixture of conditions could be provided along the proposed Forest Stream to cater to species with different habitat requirements.
    - Open and shady conditions: provide overhanging vegetation to cater to species which favour such conditions.
    - Shallow and deep conditions: deep waters are favoured by some fish species while shallow waters are preferred by some frogs, reptiles and waterbirds.
    - Waterlogged conditions: allow water to overflow from the pond into the adjacent scrubland to create a marshy habitat for waterbirds. The habitat is also favourable to some odonate species such as the variable featherlegs (*Copera vittata*) if shady conditions are also present.
    - Macrophytes (submerged floating and emergent plants) logs and branches can be provided as resting and perching sites for odonates, fish and birds (Ngiam et al., 2017)
- The existing open-country pond in the southern part of the site (Pond1, Pond2) can be remediated to increase habitat suitability for more aquatic fauna.

- Macrophytes with phyto-remediative qualities can be planted to absorb and reduce the amount of nutrients in the pond. This would help to reduce duckweed biomass and increase light penetration to the pond bottom, thereby creating more conducive conditions for the introduction of submerged macrophytes that can provide refugia for odonate larvae as well as bioremediate the pond. Additionally, emergent macrophytes and larger-leafed floating macrophytes can be planted to create perching and oviposition sites for odonates.

5.3. Creation of Terrestrial Habitats

Habitat enhancement and creation in terrestrial habitats can be done along buffer zones to accelerate forest succession via reforestation (see infill planting in **Section 4.1**) to increase floristic diversity and structural complexity. These can also take the form of parks within Tengah Town.

5.4. Creation of Artificial Refugia for Pollinators

Artificial refugia for pollinators are proposed on the parks, rooftops and could complement the skyrise greenery. These pollinator houses will be introduced to attract solitary bees and wasps to take refuge,

and to serve as an educational element for residents and visitors. These habitats could also be installed in locations away from humans.

5.5. Creation of Habitats through Designing Skyrise Greenery

Roof gardens, green roofs, green terraces and green walls have the ecological potential to be functional habitats for biodiversity. Through appropriate planting and landscaping, skyrise greenery can provide food and shelter for fauna, particularly flying taxa such as birds, butterflies, bats and odonates. Skyrise greenery also serves as ecological stepping stones, enhancing ecological connectivity in the broader urban landscape (Mayrand & Clergeau, 2018). Moreover, the inclusion of skyrise greenery will soften the facade of the buildings, allowing them to blend seamlessly into the surrounding forest backdrop. Roof gardens, green terraces and green walls are proposed in the design plan and can follow the design principles for biodiversity-attracting skyrise greenery as shown in

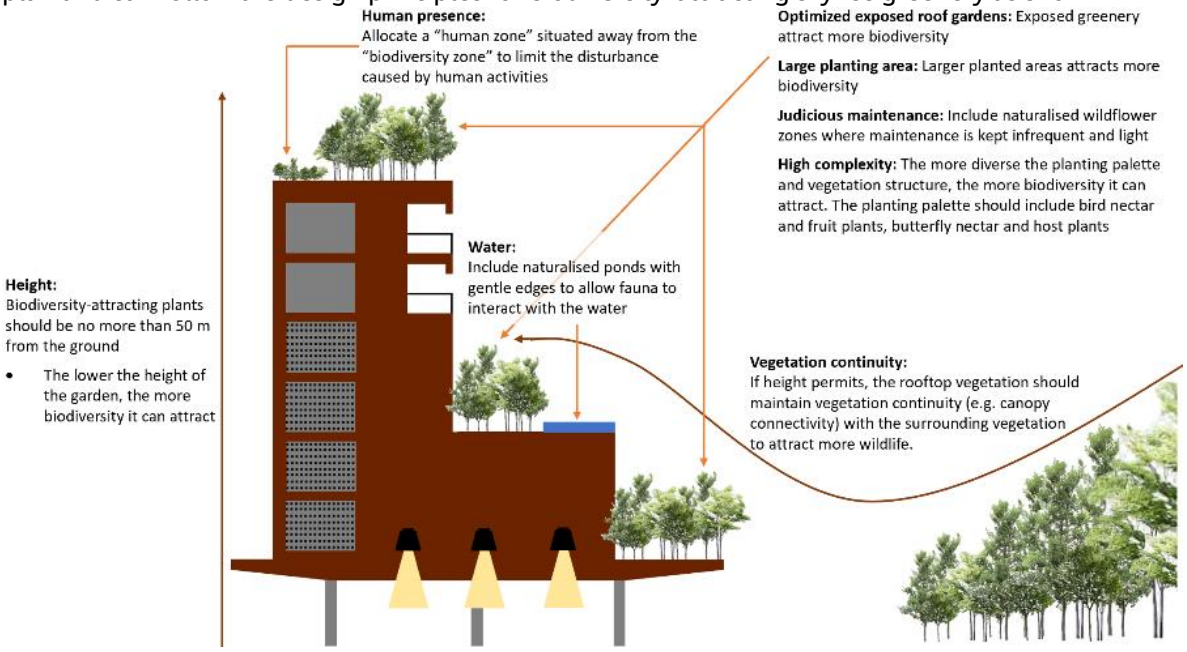


Figure 5.7 (Centre for Urban Greenery and Ecology, 2017).

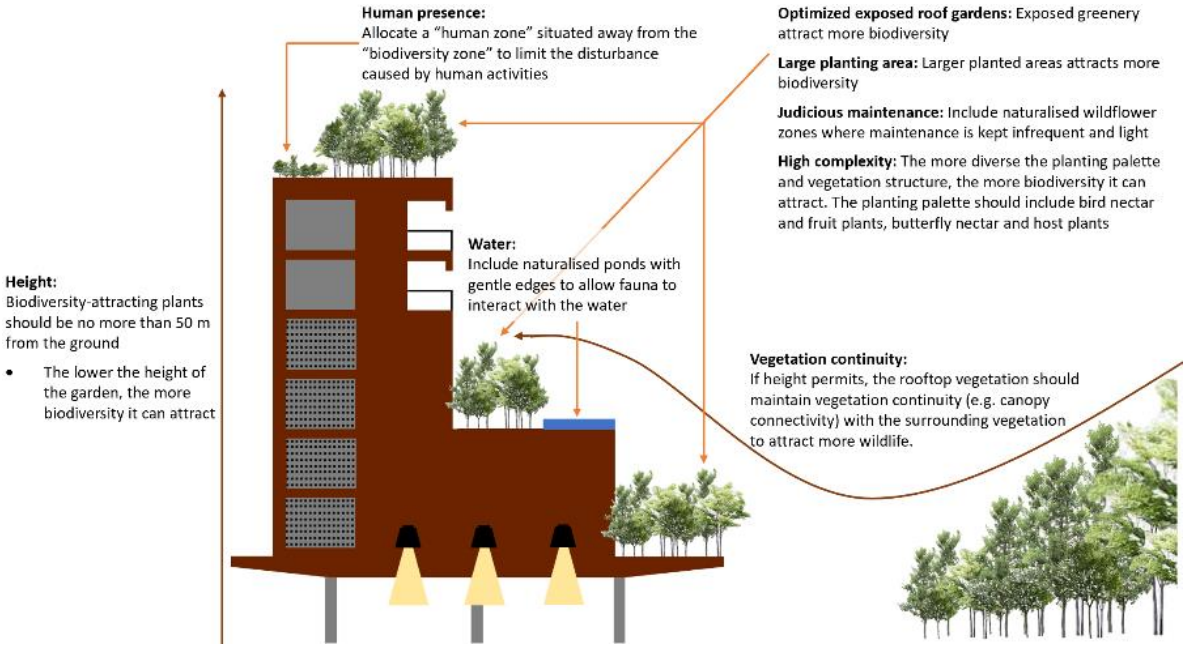


Figure 5.7: Summary of design principles for skyrise greenery

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Appendix 7D: Native Species Planting Palette

Native Species Planting Palette

Scientific Name	Native Status	Common Name	Habit	Forest Enhancement (Species to be planted in current forest, in closed habitat, to increase species diversity)	Forest Creation (fast growing pioneer species for areas in open canopy)	Market availability	Remarks
Adinandra dumosa	Native	Tiup-tiup	Tree	Yes	Yes	Limited	-
Agrostistachys borneensis	Native	Jenjulong	Tree	Yes	-	No	-
Alsophila latebrosa	Native	Tree Fern	Tree	Yes	-	Yes	Look into the possibility of salvaging from affected areas of the EIS Study Area
Alstonia angustiloba	Native	Common Pulai	Tree	Yes	-	Yes	-
Angiopteris evecta	Native	Elephant Fern	Herb	Yes	-	Yes	Look into the possibility of salvaging from affected areas of the EIS Study Area
Aporosa frutescens	Native	Rukum Utan	Tree	Yes	-	No	-
Aralidium pinnatifidum	Native	False Ivy-Palm	Tree	Yes	-	Yes	-
Archidendron clypearia	Native	Monkey-pod	Tree	Yes	-	Limited	-
Archidendron jiringa	Native	Jering	Tree	Yes	-	No or limited	Look into the possibility of salvaging from other forests
Ardisia elliptica	Native	Sea-shore Ardisia	Tree	Yes	-	Yes	-
Arthrophyllum diversifolium	Native	Ivy Palm	Tree	Yes	Yes	No	-
Arundina graminifolia	Native	Bamboo Orchid	Herb	-	-	Yes	Look into the possibility of salvaging from affected areas of the EIS Study Area
Asplenium nidus	Native	Bird's Nest Fern	Epiphyte	-	-	Yes	-
Bhesa paniculata	Native	Malayan Spindle Tree	Tree	Yes	-	No	-
Bhesa robusta	Native	Red-flowered Malayan Spindle Tree	Tree	Yes	-	No	-
Bouea oppositifolia	Native	Plum Mango	Tree	Yes	-	Limited	-
Bridelia tomentosa	Native	Pop-gun Seed	Tree	Yes	Yes	No or limited	Look into the possibility of harvesting/salvaging existing specimen in EIS Study Area
Buchanania arborescens	Native	Sparrows' Mango	Tree	Yes	-	Yes	-
Calophyllum inophyllum	Native	Penaga Laut	Tree	-	-	Yes	Look into the possibility of salvaging from affected areas of the EIS Study Area
Calophyllum soulattri	Native	Nicobar Canoe Tree	Tree	Yes	-	Yes	-
Carallia brachiata	Native	Freshwater Mangrove	Tree	Yes	-	Yes	-
Caryota mitis	Native	Fishtail Palm	Tree	Yes	Yes	Yes	-
Cayratia trifolia	Native	Three-leaved Wild Vine	Climber	Yes	-	Limited	-
Cerbera manghas	Native	Sea Mango	Tree	-	-	Yes	Those available in market are of red leaf variety
Chassalia curviflora	Native	-	Shrub	Yes	-	No	-
Cheilocostus speciosus	Native	Crepe Ginger	Herb	-	-	Yes	-
Cinnamomum iners	Native	Wild Cinnamon	Tree	Yes	-	Yes	-
Claoxylon indicum	Native	Laping Budak	Tree	Yes	Yes	No	-
Clausena excavata	Native	False Curry	Shrub	Yes	Yes	No	-
Cleistanthus sumatranus	Native	-	Tree	Yes	-	Yes	-
Clerodendrum laevifolium	Native	Swaddling Flower	Tree	Yes	Yes	Limited	-
Clerodendrum villosum	Native	-	Shrub	Yes	-	No	Need to collect & pregrow
Cratoxylum cochinchinense	Native	Yellow Cow Wood	Tree	Yes	-	Yes	-
Cratoxylum formosum	Native	Mempat	Tree	Yes	-	Yes	-
Cratoxylum maingayi	Native	Pink Mempat	Tree	Yes	-	Limited	-
Cyathula prostrata	Native	Hookweed	Shrub	-	Yes	Yes	-
Cyrtophyllum fragrans	Native	Tembusu	Tree	Yes	-	Yes	-
Cyrtostachys renda	Native	Lipstick Palm	Shrub	Yes	-	Yes	-
Derris trifoliata	Native	Common Derris	Climber	-	-	Limited	-
Dianella ensifolia	Native	Campanula Orchid	Herb	Yes	-	Yes	-
Dillenia indica	Native	Elephant Apple	Tree	Yes	-	Limited	-
Dillenia reticulata	Native	Stilted Simpoh	Tree	Yes	-	Limited	-
Dillenia suffruticosa	Native	Simpoh Air	Shrub	Yes	Yes	Yes	-
Diospyros buxifolia	Native	-	Tree	Yes	-	Yes	-
Dracaena porteri	Native	Jarum jarum	Shrub	Yes	-	Limited	-
Drynaria quercifolia	Native	Oak-leaf Fern	Epiphyte	-	-	Limited	-
Dyera costulata	Native	Jelutong	Tree	Yes	-	Limited	-
Elaeocarpus mastersii	Native	Small-leafed Oil Fruit	Tree	Yes	Yes	Yes	-
Elaeocarpus petiolatus	Native	-	Tree	Yes	-	No or limited	-
Eurycoma longifolia	Native	Tongkat Ali	Tree	Yes	-	Yes	-
Fagraea auriculata	Native	Pelir Musang	Climber	-	-	Yes	-
Ficus aurata	Native	Yellow Hairy Fig	Tree	Yes	-	No	-
Ficus caulocarpa	Native	Stem-Fruited Fig	Strangler	Yes	-	No	Look into the possibility of harvesting/salvaging existing specimen in EIS Study Area
Ficus deltoidea	Native	Rusty-leafed Bush Fig	Epiphyte	-	-	Yes	-
Ficus fistulosa	Native	Common Yellow Stem Fig	Tree	Yes	Yes	No	-
Ficus grossularioides	Native	White-leafed Fig	Tree	-	Yes	No	Look into the possibility of harvesting/salvaging existing specimen in EIS Study Area
Ficus heteropleura	Native	Sandy-leaved fig	Climber	Yes	-	No	-
Ficus microcarpa	Native	Malayan Banyan	Strangler	Yes	-	Yes	-
Ficus variegata	Native	Common Red Stem Fig	Tree	Yes	Yes	Limited	Look into the possibility of harvesting/salvaging existing specimen in EIS Study Area
Flacourtia rukam	Native	Batoko Plum	Tree	Yes	-	No	-
Garcinia atroviridis	Native	Asam Gelugor	Tree	Yes	-	No	-
Garcinia hombroniana	Native	Seashore Mangosteen	Tree	Yes	-	Yes	-
Gardenia tubifera	Native	Water Gardenia	Tree	Yes	-	Yes	-
Glochidion superbum	Native	Great-leaved Pin flower Tree	Tree	Yes	-	No	-
Glochidion zeylanicum var. zeylanicum	Native	-	Tree	Yes	-	No	Look into the possibility of salvaging from affected areas of the EIS Study Area
Glycosmis chlorosperma	Native	-	Shrub	Yes	-	No	-
Gnetum gnemon	Native	Melinjo	Tree	Yes	-	Yes	-
Guioa pleuropteris	Native	-	Tree	Yes	-	No	-
Hopea mengarawan	Native	Merawan Penak	Tree	Yes	-	No	-
Horsfieldia irya	Native	Pianggu	Tree	Yes	-	Limited	-
Horsfieldia superba	Native	Penarah	Tree	Yes	-	Limited	-
Hoya spp.	Native	-	Climber	-	-	Yes	-
Iguanura wallichiana	Native	-	Shrub	Yes	-	Limited	-
Ilex cymosa	Native	Marsh Holly	Tree	Yes	-	Yes	-

Native Species Planting Palette

Scientific Name	Native Status	Common Name	Habit	Forest Enhancement (Species to be planted in current forest, in closed habitat, to increase species diversity)	Forest Creation (fast growing pioneer species for areas in open canopy)	Market availability	Remarks
Ixora congesta	Native	Malayan Ixora, Jarum-Jarum, Khem Deang	Shurb	Yes	-	Yes	-
Koompassia malaccensis	Native	Kempas	Tree	Yes	-	Yes	-
Kopsia singapurensis	Native	Singapore Kopsia	Tree	Yes	-	Limited	-
Leea angulata	Native	Memali	Tree	Yes	-	Limited	Look into the possibility of salvaging/propagating from existing affected population in EIS Study Area
Leea indica	Native	Bandicoot Berry	Shrub	Yes	-	Yes	-
Leea rubra	Native	Red Leea	Shrub	-	-	Yes	-
Lepisanthes rubiginosa	Native	-	Tree	Yes	-	No or limited	-
Licuala spinosa	Native	Mangrove Fan Palm	Shrub	Yes	-	Yes	-
Litsea elliptica	Native	Medang	Tree	Yes	-	No	-
Macaranga bancana	Native	Common Mahang	Tree	-	Yes	Limited	-
Macaranga gigantea	Native	Giant Mahang	Tree	Yes	Yes	Limited	-
Macaranga heynei	Native	Blue Mahang	Tree	-	Yes	No or limited	-
Mallotus paniculatus	Native	Turn-in-the-wind	Tree	Yes	Yes	Limited	-
Mangifera caesia	Native	Binjai	Tree	Yes	-	Yes	-
Maranthes corymbosa	Native	Merbatu	Tree	Yes	-	No or limited	-
Melaleuca cajaputi	Native	Cajaput Tree	Tree	-	-	Yes	-
Melaleuca cajuputi	Native	Gelam	Shrub	Yes	-	Yes	-
Melastoma malabathricum	Native	Singapore Rhododendron	Shrub	Yes	Yes	Yes	-
Memecylon caeruleum	Native	Blue Strawberry Flowers	Tree	Yes	-	Yes	-
Memecylon pauciflorum	Native	Cherry Shrub	Tree	Yes	-	Yes	-
Morinda citrifolia	WOUO	Noni	Tree	-	Yes	Yes	-
Neobalanocarpus heimii	Native	Cengal	Tree	Yes	-	Yes	-
Neolitsea cassia	Native	-	Shrub	Yes	-	Yes	-
Neolitsea zeylanica	Native	-	Tree	Yes	-	Yes	-
Oxyceros longifolia	Native	-	Climber	Yes	-	Limited	-
Palaquium obovatum	Native	White Gutta	Tree	Yes	-	Yes	-
Pandanus atrocarpus	Native	-	Tree	-	-	No	-
Pandanus houlletii	Native	Pandan Hutan	Shrub	Yes	-	No	-
Pandanus parvus	Native	-	Shrub	-	-	No	-
Parkia speciosa	Native	Petai	Tree	Yes	-	Yes	-
Peltophorum pterocarpum	Native	Yellow Flame	Tree	-	-	Yes	-
Peronema canescens	Native	False Elder	Tree	Yes	-	Limited	-
Phymatosorus scolopendria	Native	Monarch Fern	Epiphyte	-	-	Limited	-
Piper sarmentosum	Native	Wild Pepper	Climber	-	-	Yes	-
Pittosporum ferrugineum	Native	Belalang Puak	Shrub	Yes	-	No or limited	-
Ploiarium alternifolium	Native	Cicada Tree	Shrub	-	-	Yes	-
Podocarpus polystachyus	Native	Sea Teak	Tree	-	-	Yes	-
Pometia pinnata	Native	Fijian Longan	Tree	-	-	Yes	-
Pongamia pinnata	Native	Seashore Mempari	Tree	-	-	Yes	-
Pouteria obovata	Native	Sea Gutta	Tree	Yes	-	Yes	-
Premna serratifolia	Native	Buas-Buas	Climber	Yes	-	No or limited	-
Pteleocarpa lamponga	Native	Tembusu Tikus	Tree	Yes	-	Yes	-
Pternandra coerulescens	Native	Cursed Shade	Tree	Yes	-	No	-
Rapanea porteriana	Native	-	Shrub	-	-	No or limited	-
Rhodamnia cinerea	Native	Silverback	Tree	Yes	-	Limited	-
Rhodomyrtus tomentosa	Native	Rose Myrtle	Shrub	-	-	Yes	-
Rothmannia macrophylla	Native	Angel's trumpet	Shrub	Yes	-	Limited	-
Sandoricum koetjape	Native	Santol	Tree	Yes	-	Yes	-
Scaphium macropodum	Native	Kembang Semangkuk Jantung	Tree	Yes	-	Yes	-
Shorea leprosula	Native	Meranti Tembaga	Tree	Yes	-	Yes	-
Sterculia cordata	Native	Kelumpang	Tree	Yes	-	Yes	-
Sterculia macrophylla	Native	Broad-leaved Sterculia	Tree	Yes	-	No or limited	-
Sterculia parviflora	Native	Kelumpang Burung	Tree	Yes	-	Yes	-
Sterculia rubiginosa	Native	Rusty Sterculia	Tree	Yes	-	Yes	-
Streblus elongatus	Native	Tempinis Tree	Tree	Yes	-	Yes	-
Syzygium borneense	Native	-	Tree	Yes	-	No	-
Syzygium glaucum	Native	Eugenia glauca	Tree	Yes	-	Yes	-
Syzygium grande	Native	Sea Apple	Tree	Yes	-	Yes	-
Syzygium lineatum	Native	Common Kelat	Tree	Yes	-	Yes	-
Syzygium myrtifolium	Native	-	Tree	Yes	-	Yes	-
Syzygium polyanthum	Native	Indonesian Bay Leaf	Tree	Yes	-	Yes	-
Syzygium syzygioides	Native	Kelat Hitam	Tree	Yes	-	No or limited	-
Syzygium zeylanicum	Native	Kelat Nasi Nasi	Tree	Yes	Yes	Yes	-
Tabernaemontana corymbosa	Native	Great Rosebay	Tree	Yes	-	No	-
Tarenna odorata	Native	-	Shrub	-	-	No	-
Terminalia catappa	Native	Sea Almond	Tree	-	-	Yes	-
Thottea grandiflora	Native	Bunga Semubut	Shrub	Yes	-	Limited	-
Thunbergia laurifolia	Native	Laurel-leaved Thunbergia	Climber	-	-	Yes	-
Timonius wallichianus	Native	Silver Timon	Tree	Yes	-	No	-
Tristaniopsis merguensis	Native	Hill Tristania	Tree	Yes	-	Yes	-
Tristaniopsis obovata	Native	Sea Tristania	Tree	Yes	-	Yes	-
Tristaniopsis whiteana	Native	River Tristiana	Tree	Yes	-	Yes	-
Tristellateia australasiae	Native	Shower of Gold Climber	Climber	-	-	Yes	-
Tylophora flexuosa	Native	-	Climber	-	-	No	-
Ventilago malaccensis	Native	-	Climber	Yes	-	No	-
Vernonia arborea	Native	Tree Vernonia	Tree	-	-	Yes	-
Vitex pinnata	Native	Leban	Tree	Yes	Yes	Yes	-

Appendix 7E: Method Statement for Passive Wildlife Shepherding

Method Statement for Passive Wildlife Shepherding (Directional Site Clearance) at the Project

The objective of passive wildlife shepherding is to remove target fauna from the worksite before construction works begin to prevent fauna entrapment, injury and mortality, whilst minimizing contact between human and wildlife. Target fauna are snakes and ground-dwelling mammals such as Wild Pig (*Sus scrofa*) and Sunda Pangolin (*Manis javanica*), as well as other animals that may be implicated in human-wildlife conflict. Passive wildlife shepherding involves directional site clearance within the hoarded worksite towards a forested wildlife refuge area. The disturbance generated by the site clearance activities will encourage target fauna to move out of the worksite on their own.

The area of the site to be cleared is split into smaller zones (Figure 1). For each zone, the site clearance workflow involves the following components:

- Hoarding installation
- Pre-site clearance fauna inspection
- Directional site clearance / passive wildlife shepherding
- Post-site clearance fauna inspection

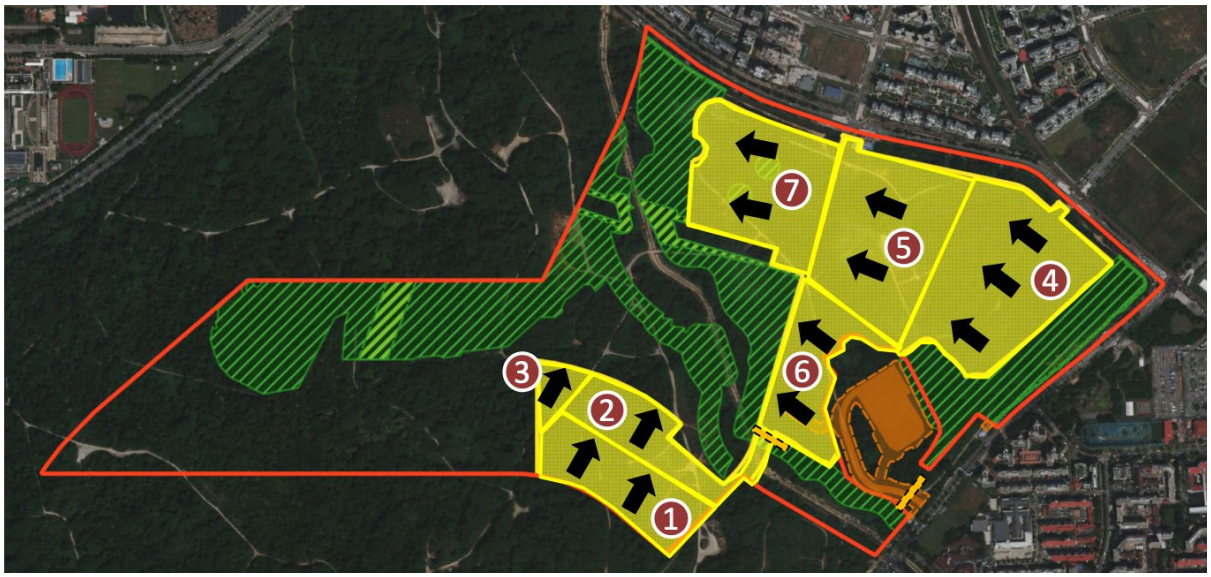


Figure 1. Proposed zonation of the Project worksite and direction of site clearance
Base Map: ESRI
Note: For the purposes of this study, Figure 1 shows an indicative revised boundary assuming that agencies will avoid the Recommended Area of Conservation (RAC). Agencies are studying possible changes to the land use plan to balance conservation and development in response to the RAC.

1. Hoarding and temporary barrier installation

Firstly, the installation of the hoarding and temporary barrier is to be completed by the contractor. The temporary barriers should meet the following specifications (Figure 2):

- At least 1.8-m high
- Have sufficient counterweight to withstand impact from large animals (e.g., wild pig)
- Covered with an opaque sheet as large animals may attempt to jump over the barrier If they are able to see the other side

Gaps/gates that are approximately 6-m wide should be incorporated at a suitable location along the temporary barrier for each zone as the wildlife exit points. The suitability of the exact locations of the exit points will be confirmed on-site to ensure that shepherded wildlife can exit into a forested area effectively.

After installation of the hoarding, the Ecologist will inspect the integrity of the hoarding to ensure that they can effectively prevent wildlife entry/exit.



Figure 2. Examples of temporary barriers.

2. Pre-site Clearance Fauna Inspection

The objective for the pre-site clearance fauna inspection is to minimize fauna injury and mortality during tree felling and vegetation clearance by identifying fauna or nesting structures that are being actively used such as bird nests, tree hollows and burrows. The validity of this inspection should be no more than seven days. The following will be achieved during the pre-site clearance fauna inspections:

- Inspection for (potentially) active animal nests, hollows and other nesting structures, and any animals that may potentially get trapped/injured or die during site clearance. Animals (e.g., snakes) that may be implicated in human-wildlife conflict during site clearance will also be identified.
- Schedule site clearance to avoid the key bird breeding season, if feasible.
- Reporting and documentation of fauna observations and recommended mitigating measures.

3. Directional Site Clearance / Passive Wildlife Shepherding

Prior to site clearance, the Ecologist will conduct a briefing for the site clearance personnel on the wildlife that may be encountered and how to respond to them. A camera trap will be placed outside each of the wildlife exit points throughout the duration of site clearance to monitor the exit/entry of target fauna. The data from the camera traps will be retrieved at least once a week.

The Ecologist will inspect any enclosed tree protection zones (TPZ) within the zones to be cleared to ensure there are no target fauna prior to site clearance. If there are any fauna trapped in the TPZs, the Ecologist will develop methods to remove them in consultation with NParks.

The site clearance for each zone will begin furthest from the exit point(s) and gradually move towards the exit point(s) to flush animals out of the worksite. Figure 1 shows the sequence and direction for the site clearance. The wildlife exit points will be opened by the Contractor before the start of site clearance works each day and closed at the end of each work day throughout the duration of the site clearance to prevent animals from returning to the worksite.

Shrubs and ground cover will be removed by means of an excavator. Trees will be removed according to approved tree felling methods. For areas with dense shrubs and ground cover, the contractor will disturb the vegetation with long sticks to flush any animals that may be hiding inside and allow them to move away prior to vegetation removal using an excavator.

4. Post-site Clearance Fauna Inspection

After site clearance has been completed in each zone, the Ecologist will visually inspect the zone for presence of target fauna species. The exit point(s) will be sealed and the camera traps will be removed if there are no remaining fauna in the cleared zone. If there are remaining fauna on-site, the Ecologist will develop methods to remove them in consultation with NParks. The exit points may be re-opened if necessary.

Appendix 8A: Photographic Log of Airborne Noise Baseline Sampling

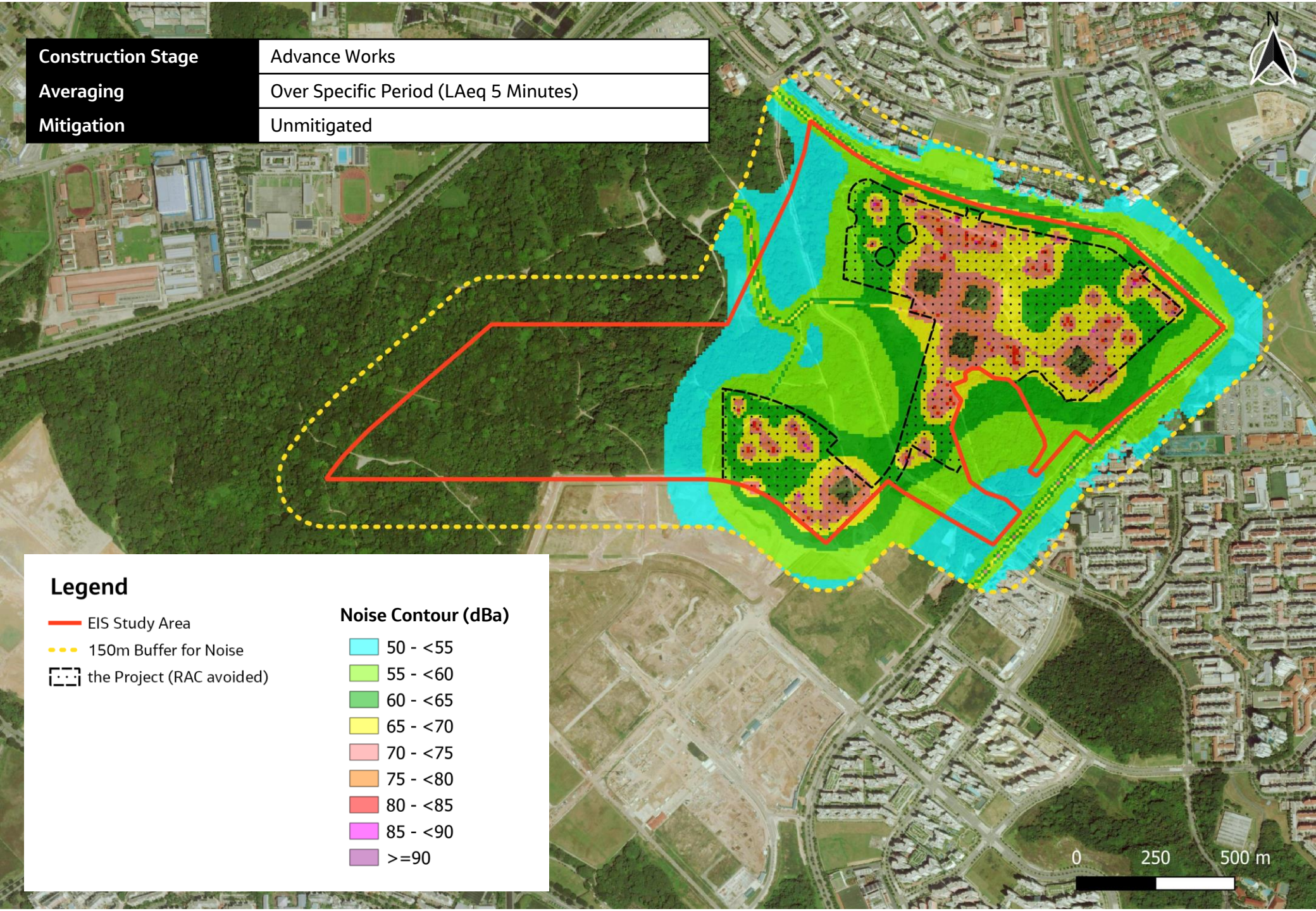
Appendix 8A: Photographic Log of Airborne Noise Baseline Sampling

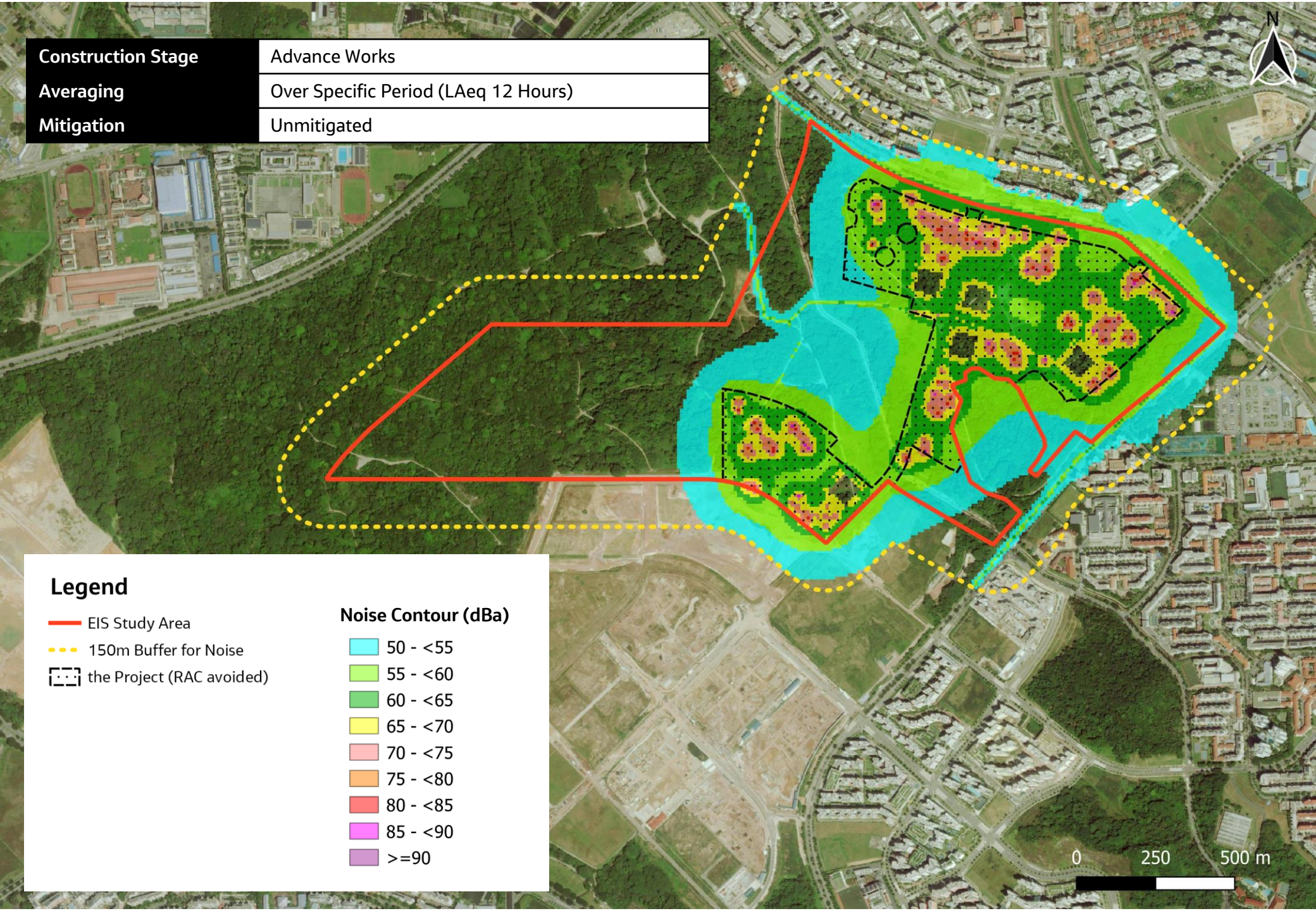
Details	Photograph
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Photograph ID: 2 **Sample ID:** N2 **Photo Location:** 01°22'20.91"N 103°44'37.60"E At an open space of the ground floor of Block 805C Kean Hong Close **Sampling Date:** 10 to 17 Feb 2020	
Photograph ID: 3 **Sample ID:** N3 **Photo Location:** At an open space of the ground floor of Block 484B Choa Chu Kang Avenue 5 **Sampling Date:** 17 to 24 Feb 2020	

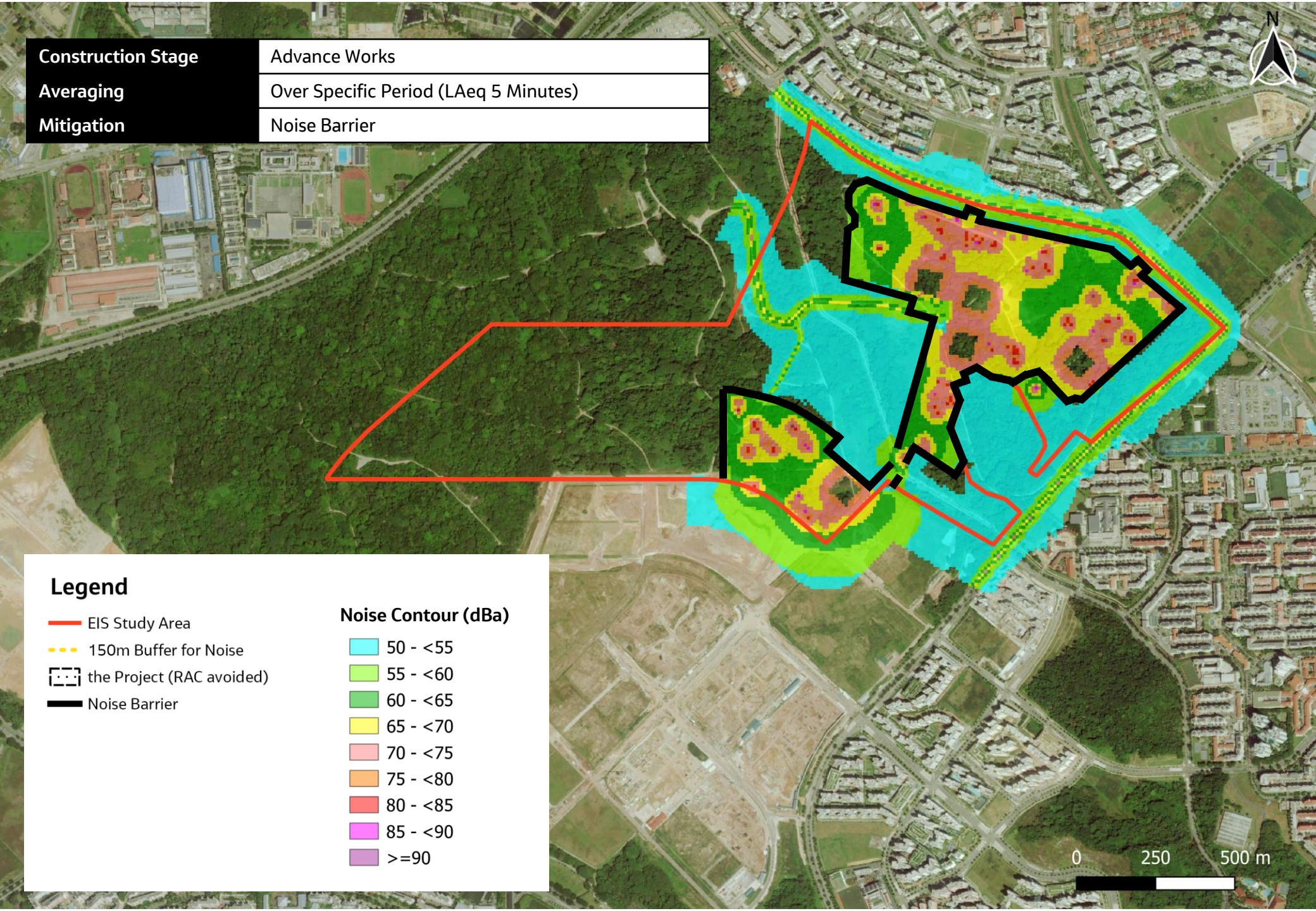
Appendix 8A: Photographic Log of Airborne Noise Baseline Sampling

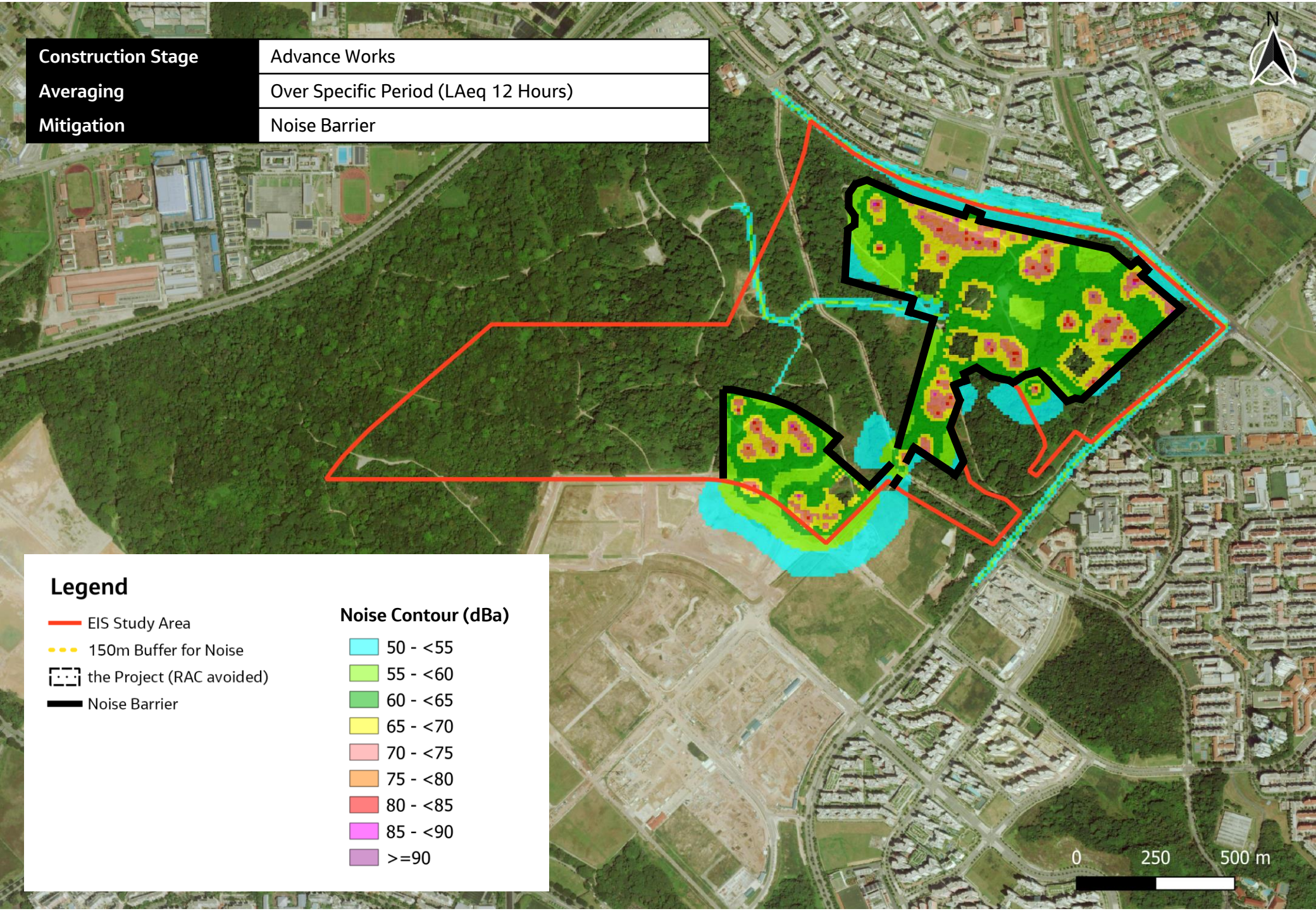
Details	Photograph
Photograph ID: 4 **Sample ID:** N4 **Photo Location:** 01°22'17.27"N 103°44'15.37"E At an open space of eastern side of the EIS Study Area **Sampling Date:** 3 to 10 Mar 2020	
Photograph ID: 5 **Sample ID:** N5 **Photo Location:** 01°22'0.48"N 103°43'35.16"E At an open space of western side of the EIS Study Area **Sampling Date:** 10 to 17 Mar 2020	

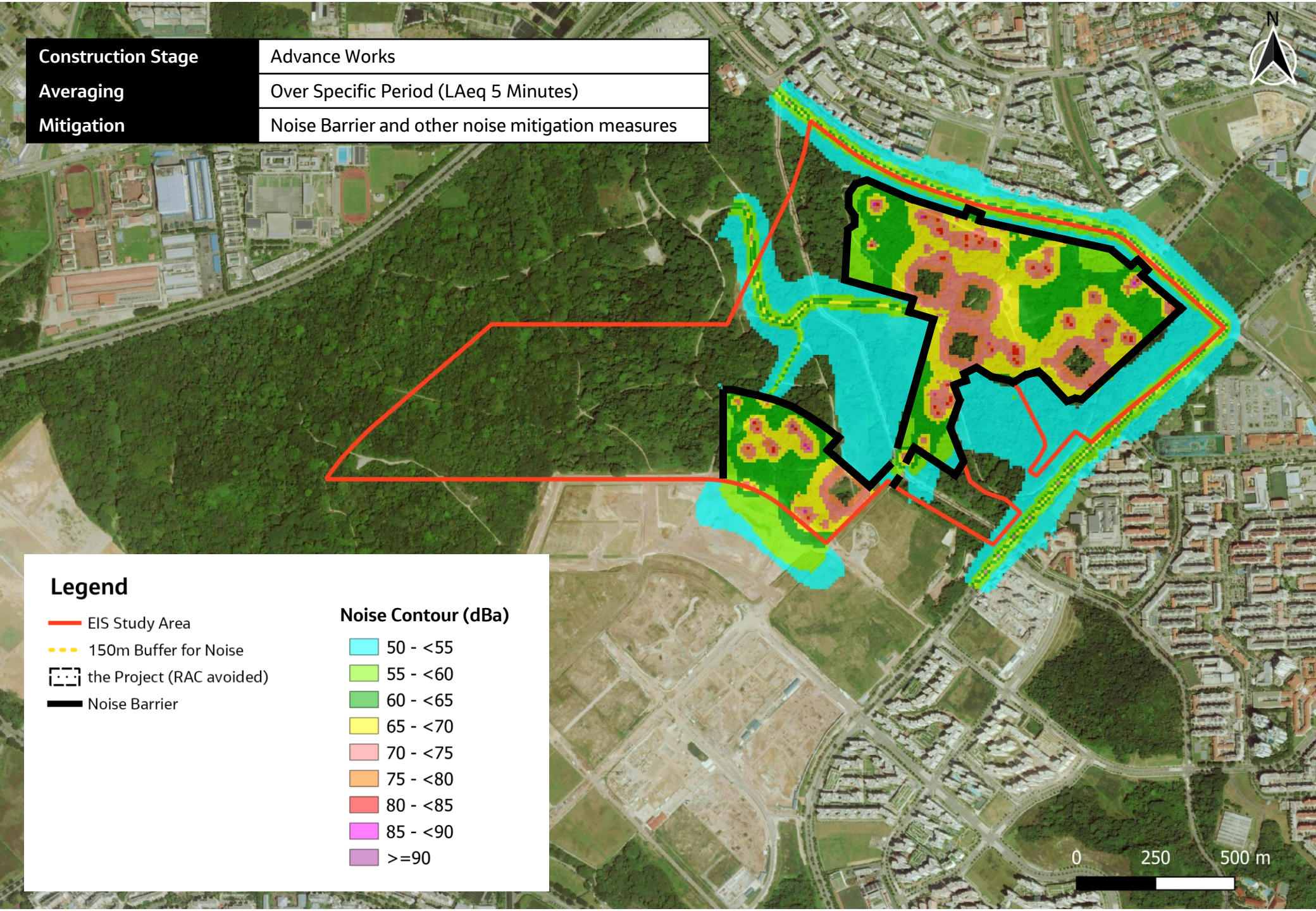
Appendix 8B: Noise Contours

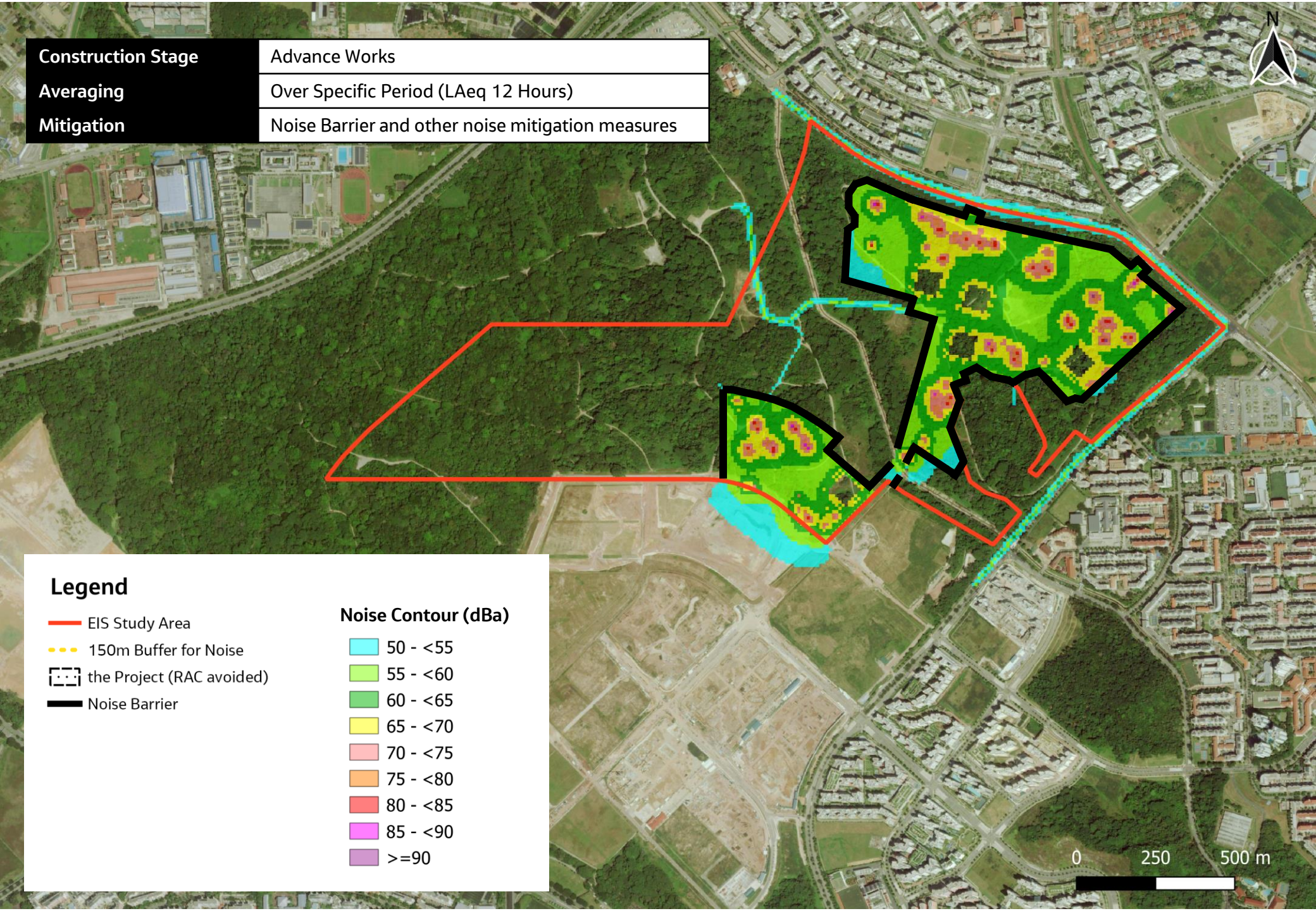

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
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500 m

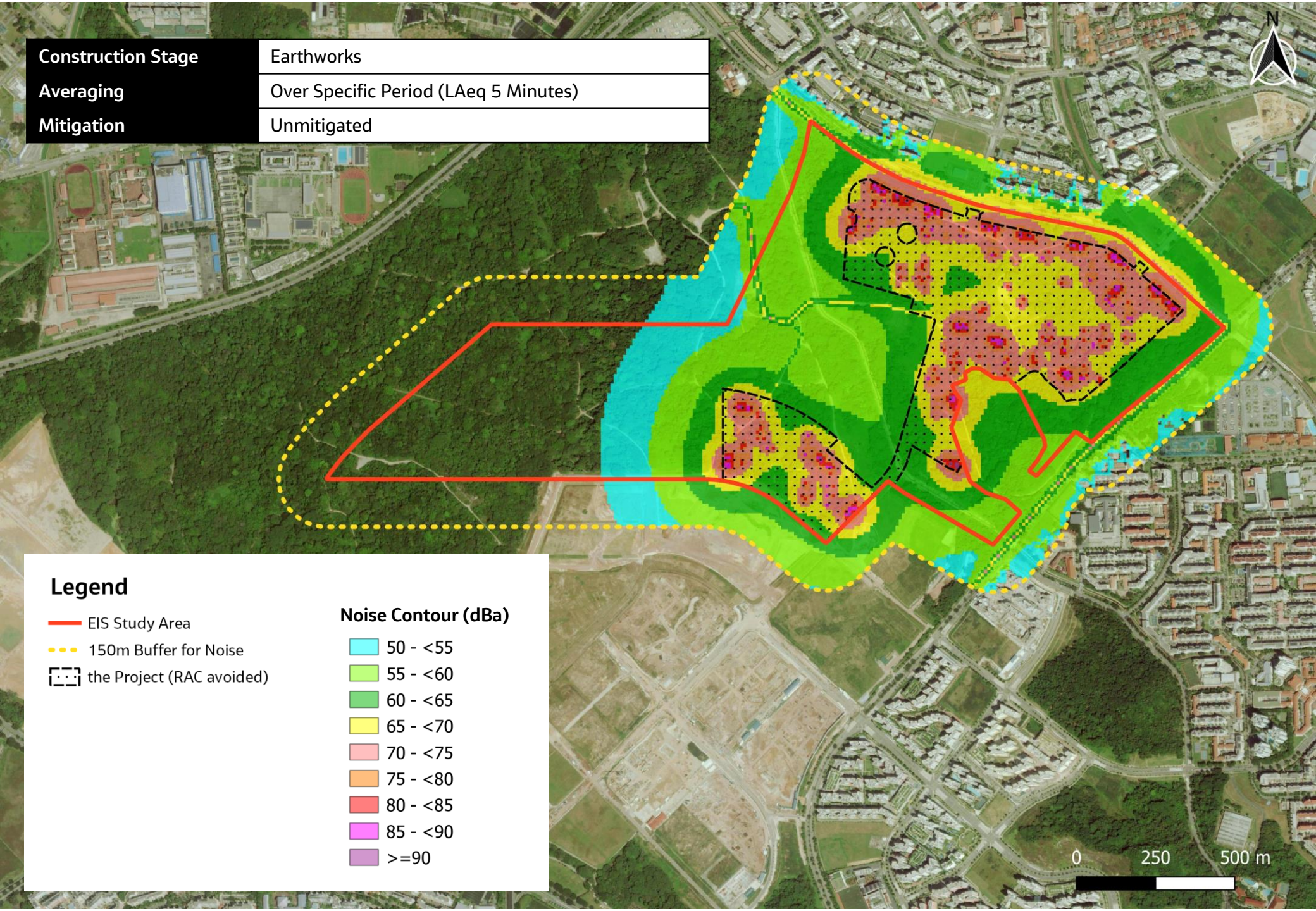

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
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60 - <65
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85 - <90
>=90
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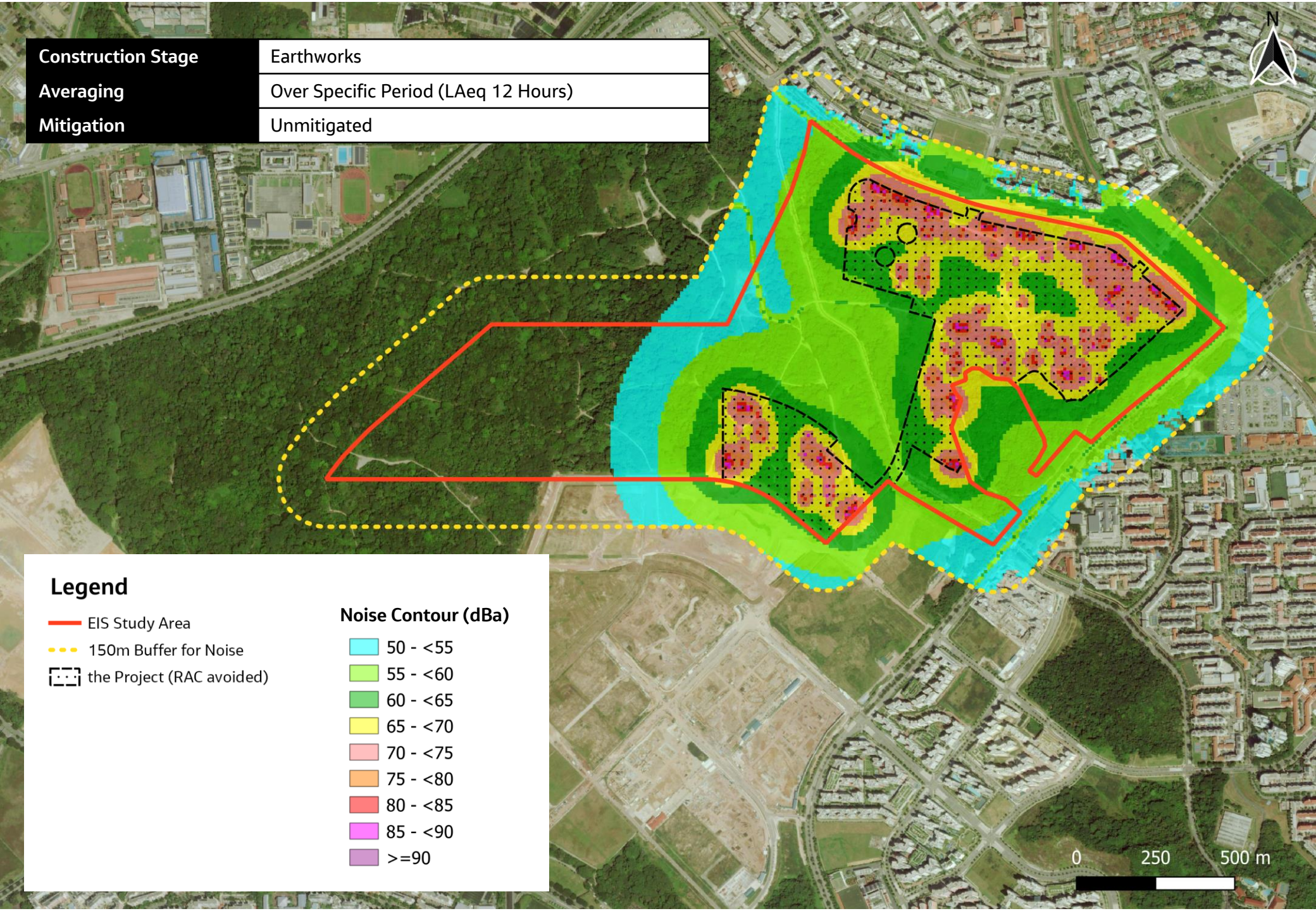

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
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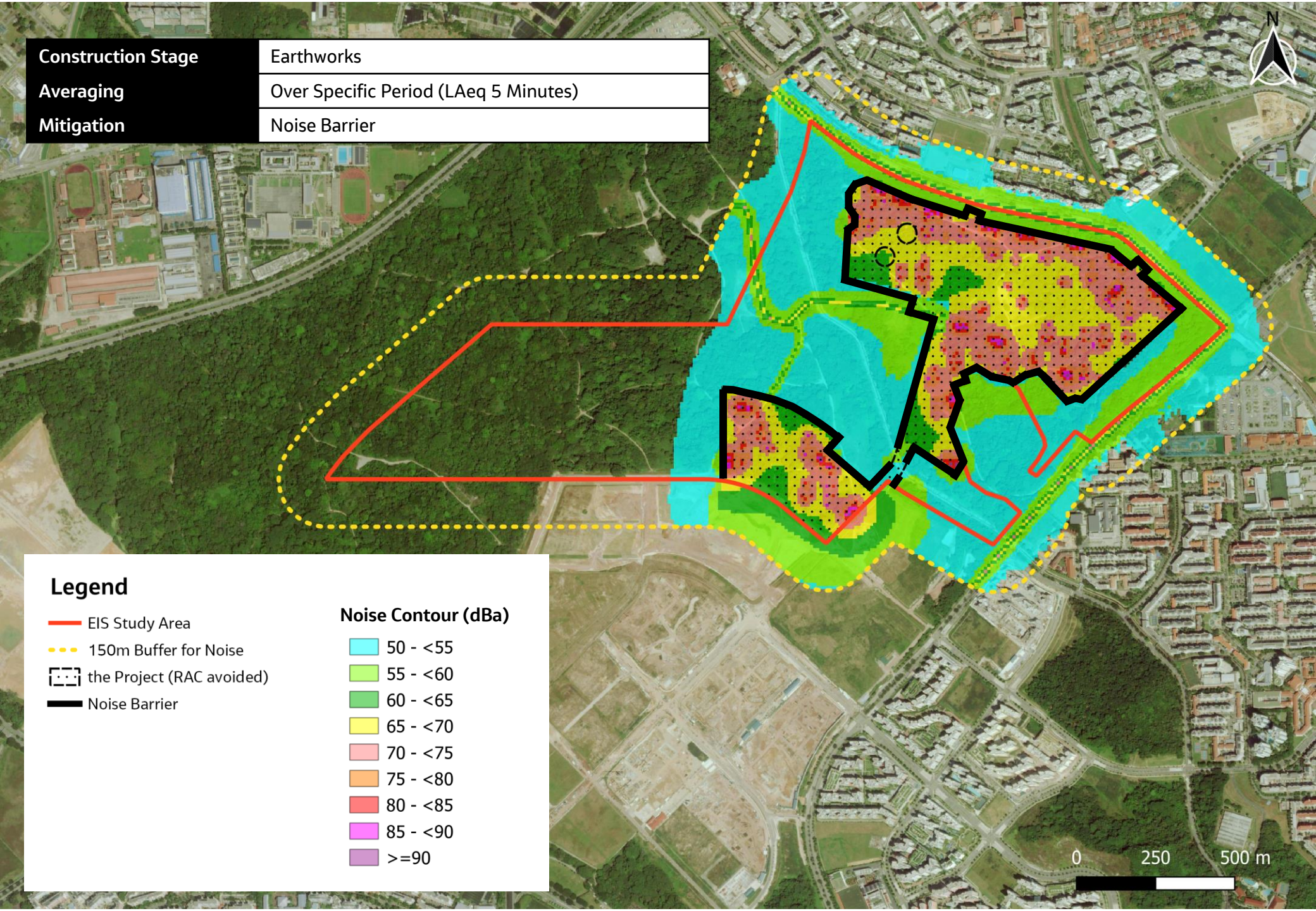

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier
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Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
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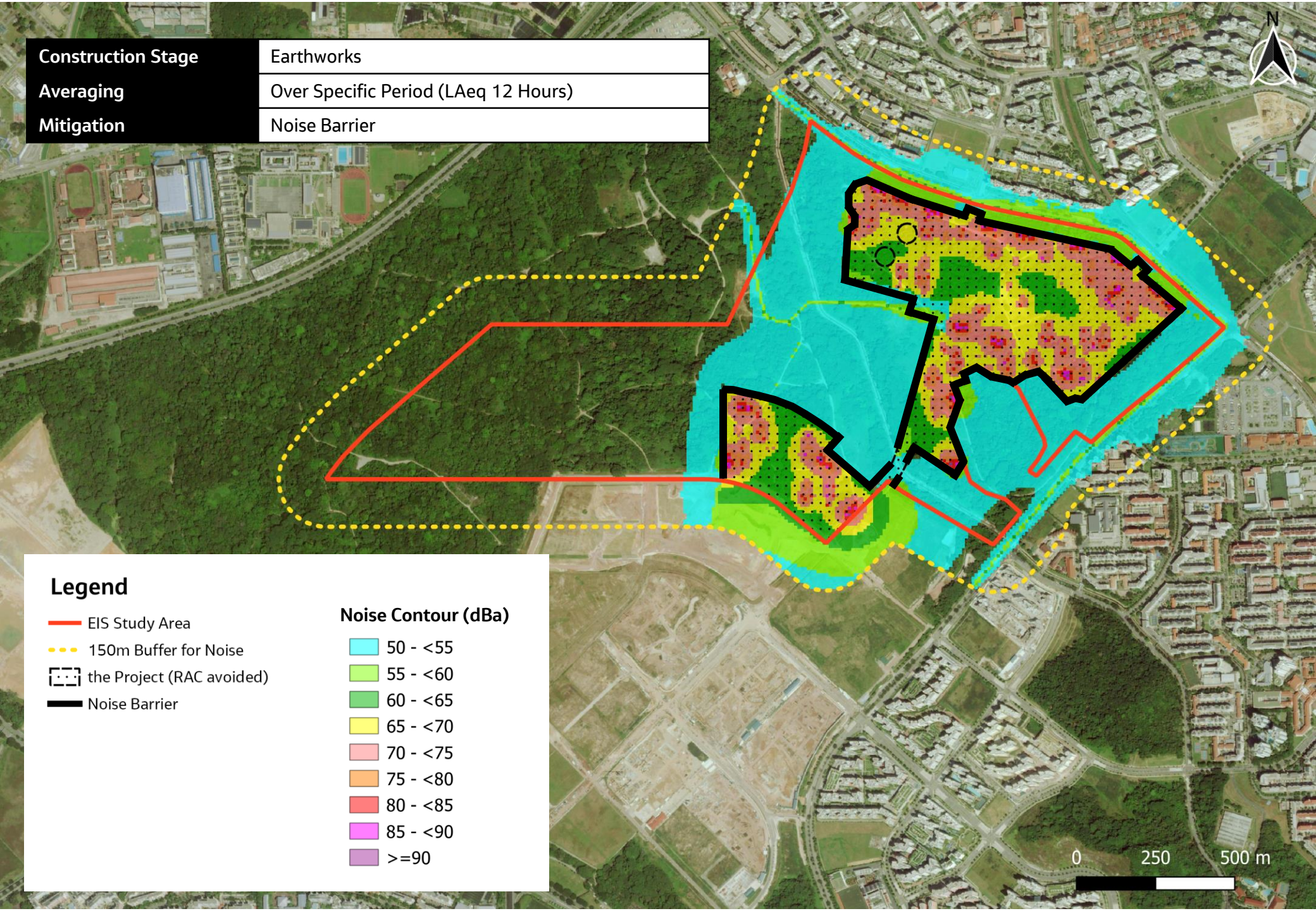

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier and other noise mitigation measures
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Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
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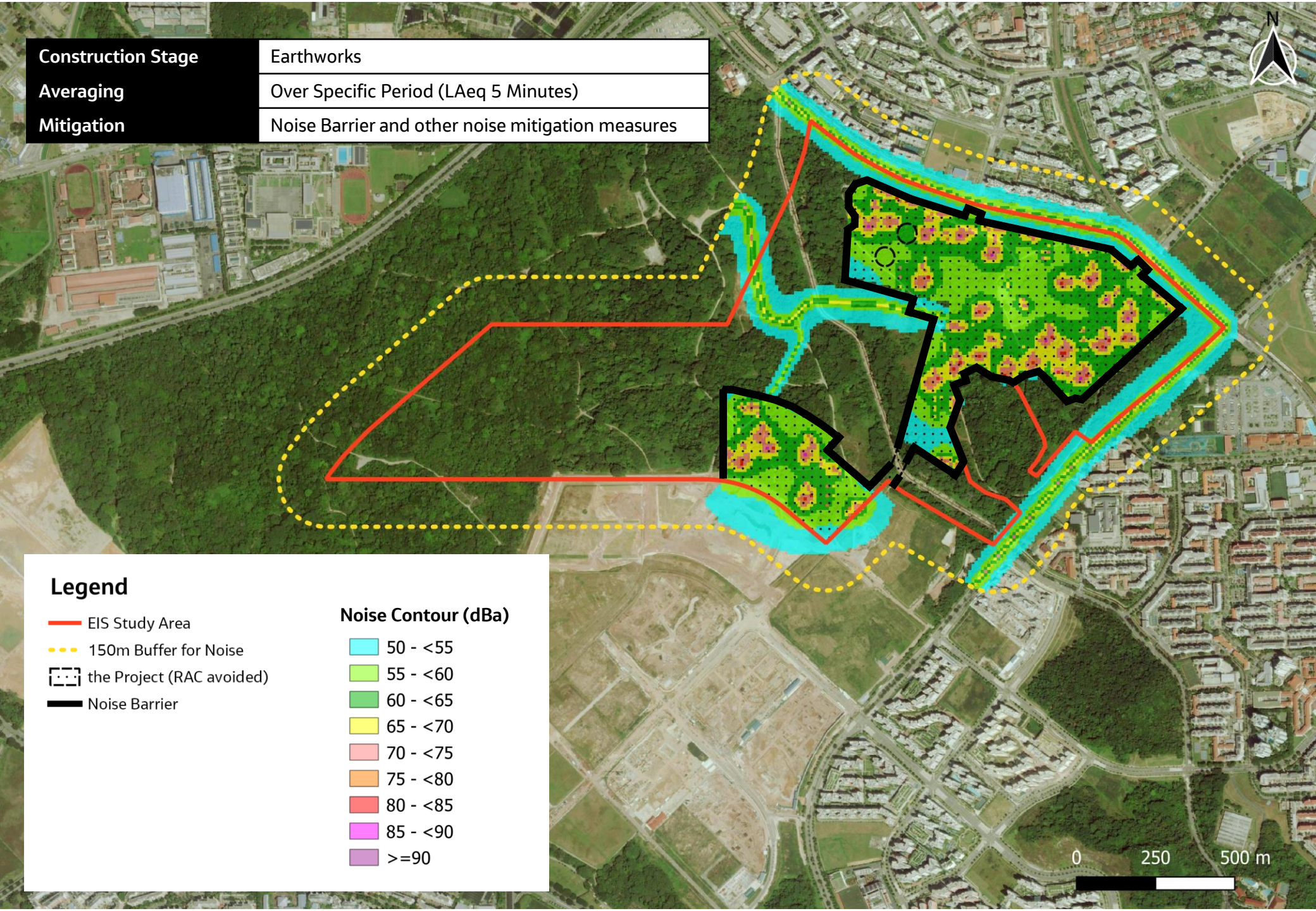

Construction Stage
Advance Works
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
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Legend
EIS Study Area
150m Buffer for Noise
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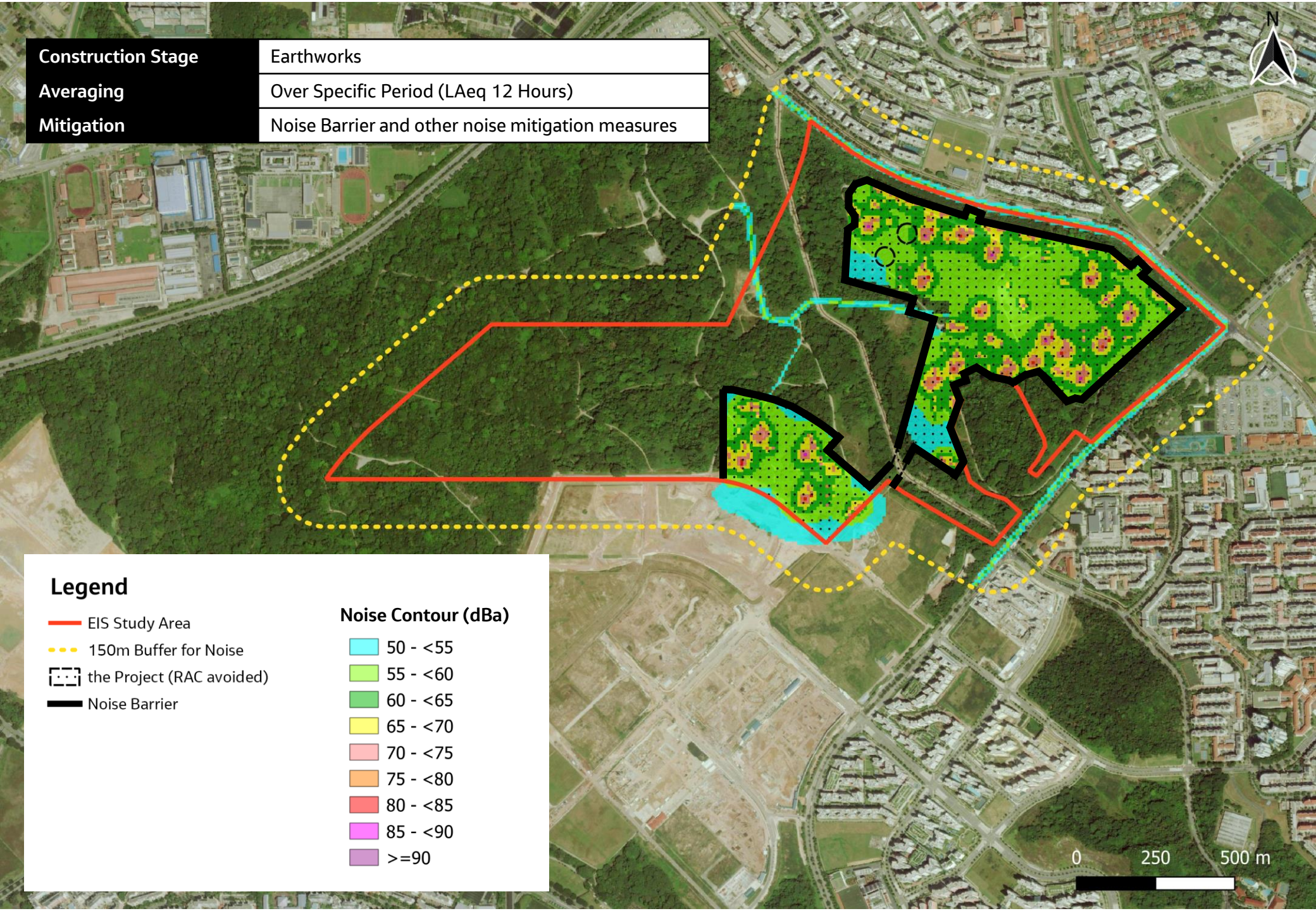

Construction Stage
Earthworks
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
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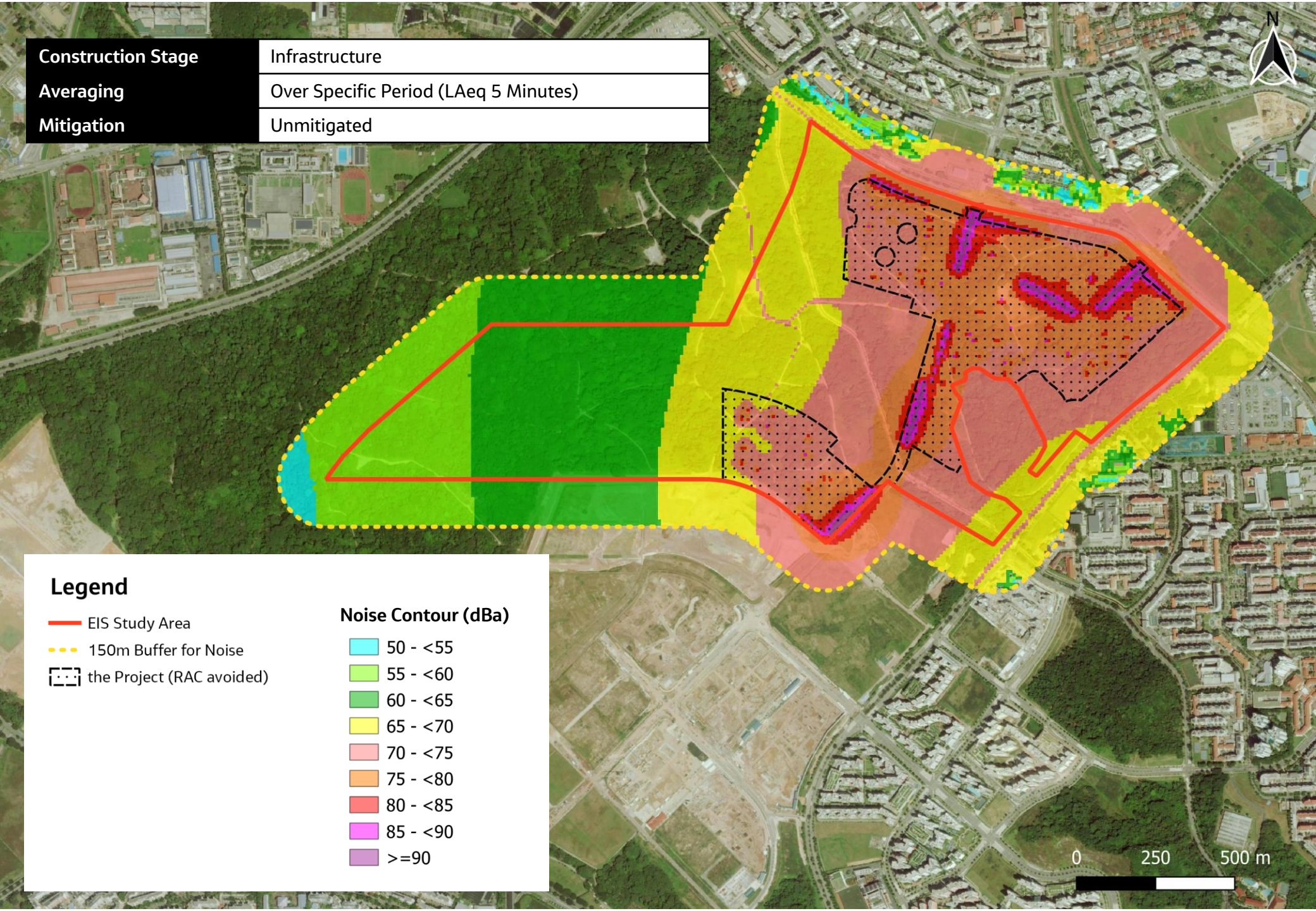

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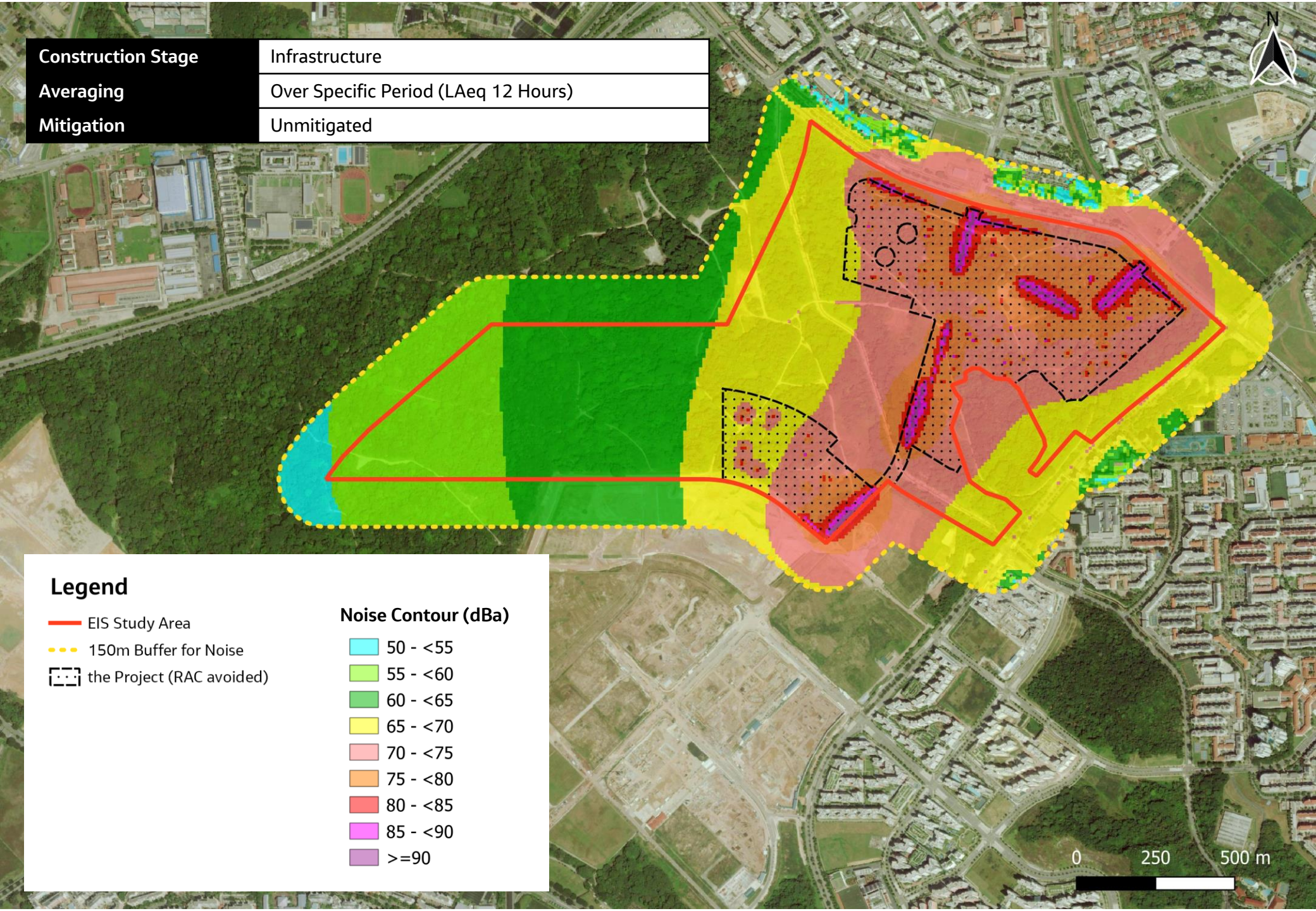

Construction Stage
Earthworks
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Mitigation
Noise Barrier
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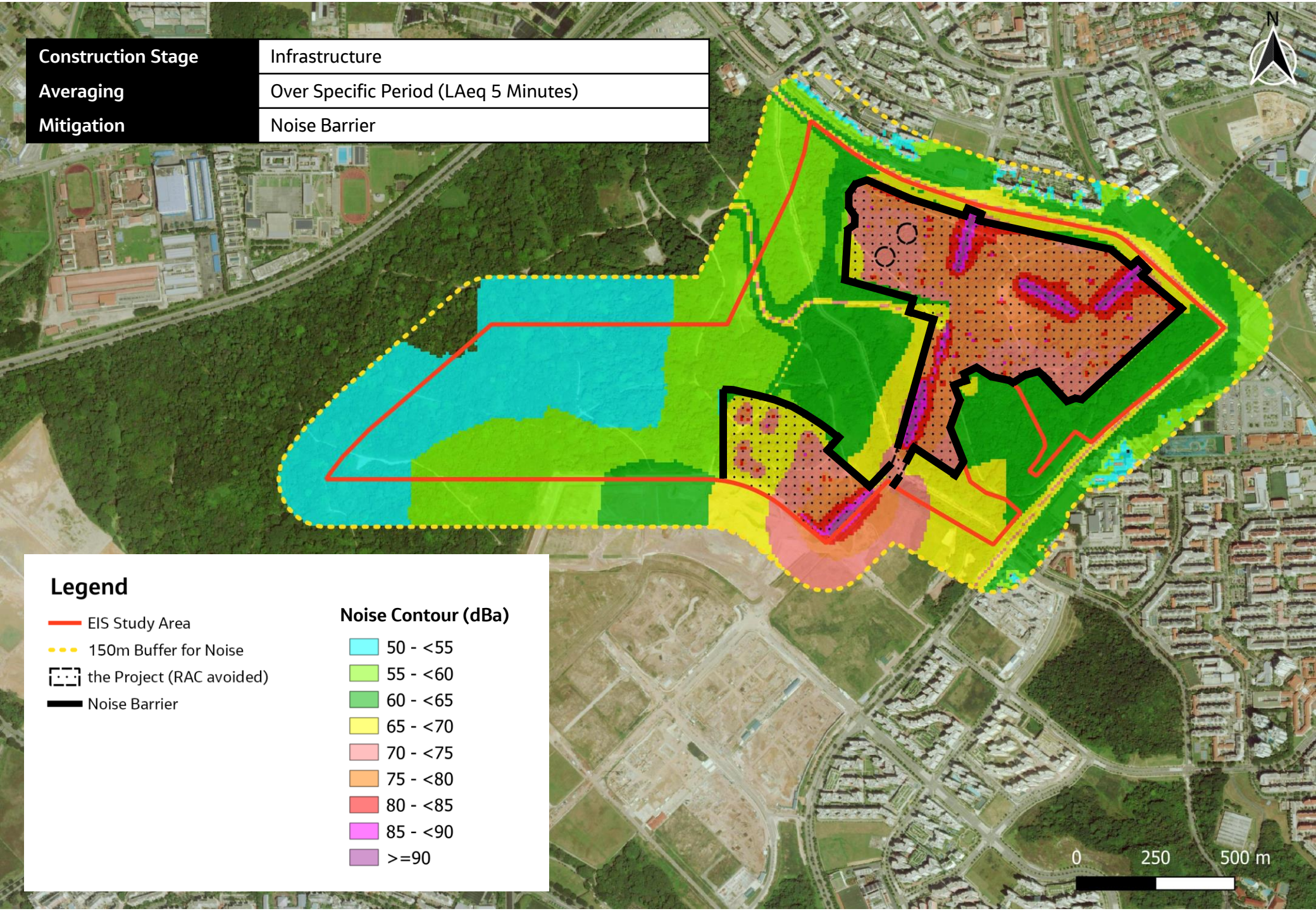

Construction Stage
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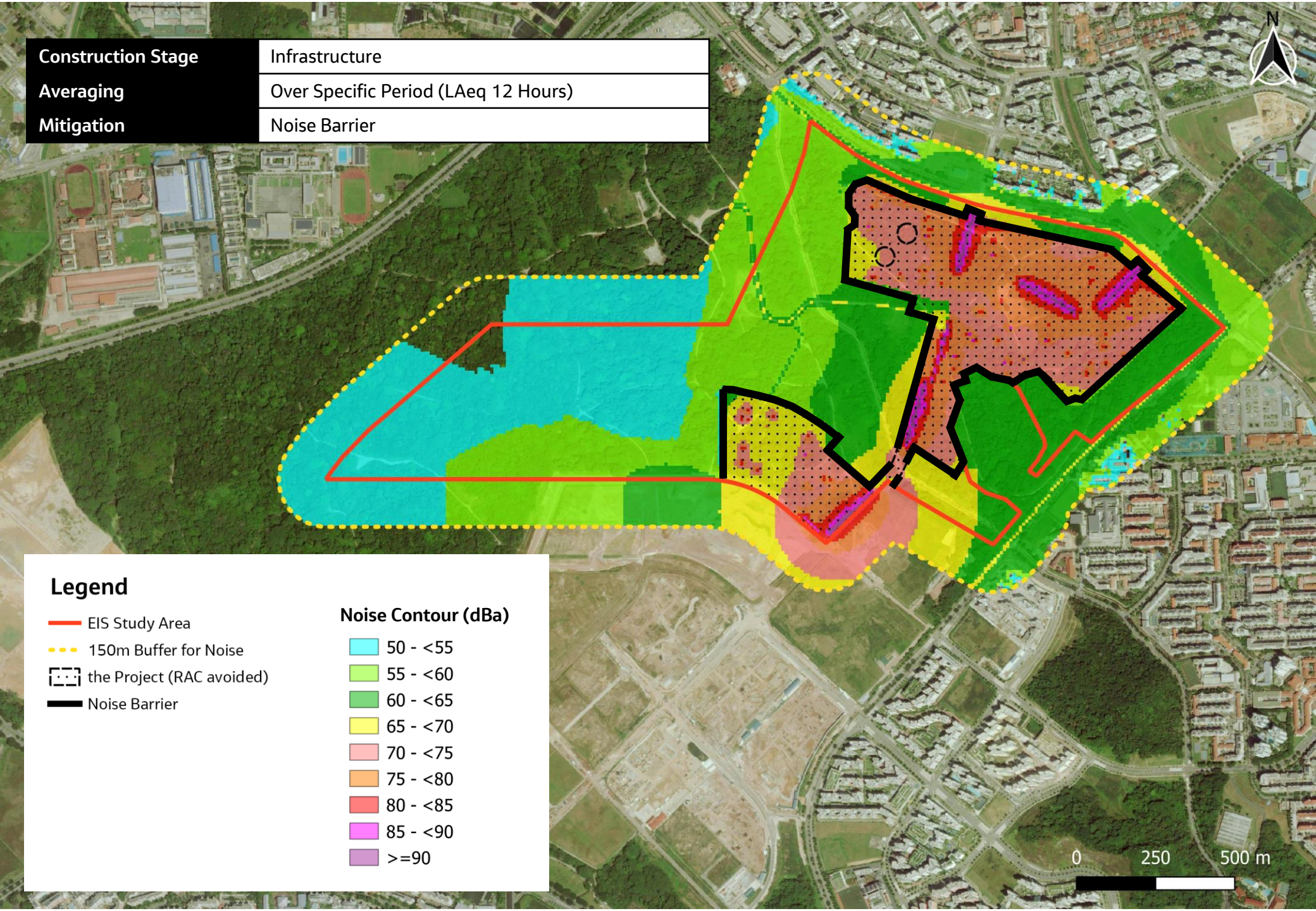

Construction Stage
Earthworks
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
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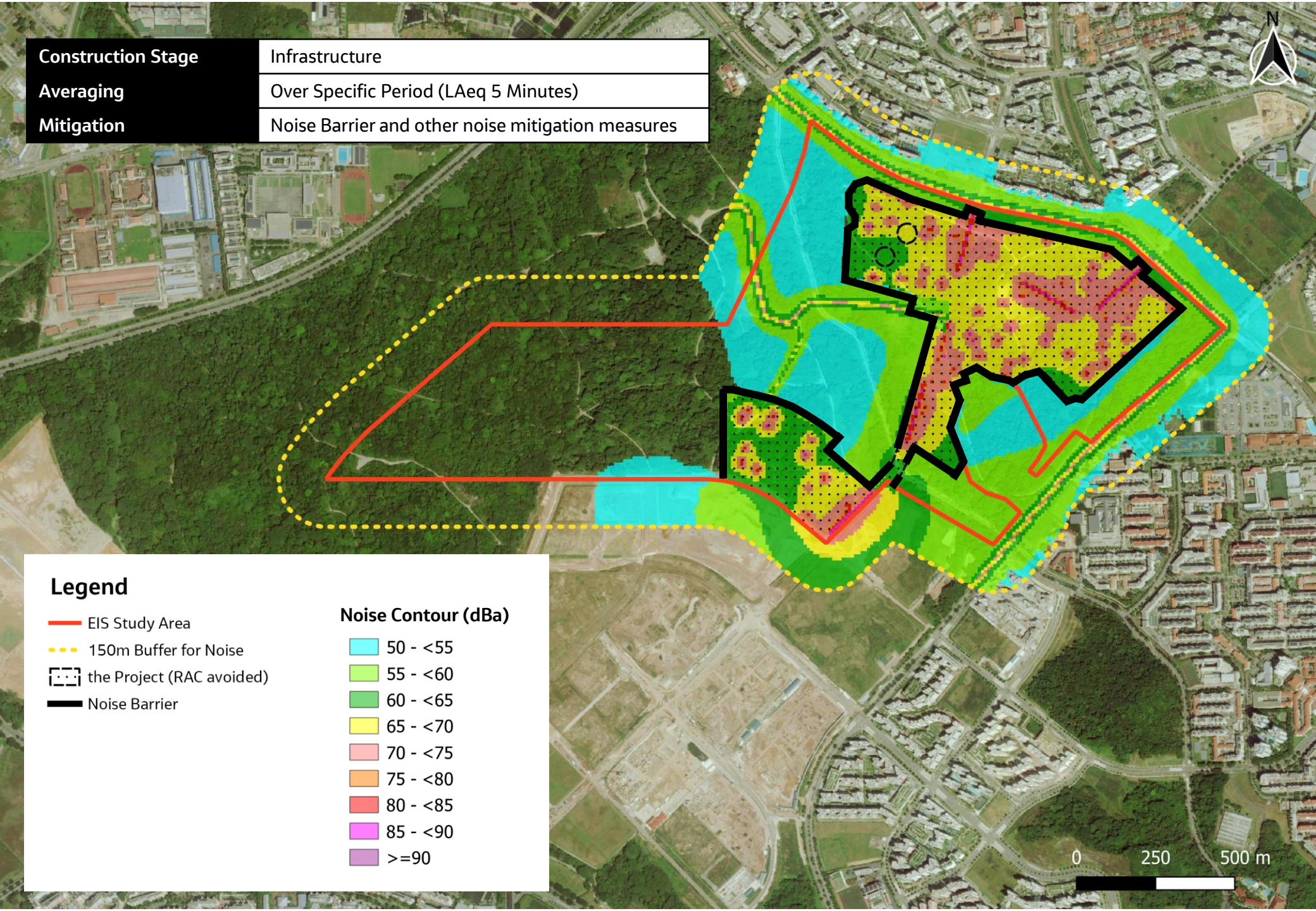

Construction Stage
Earthworks
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
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Noise Contour (dBa)
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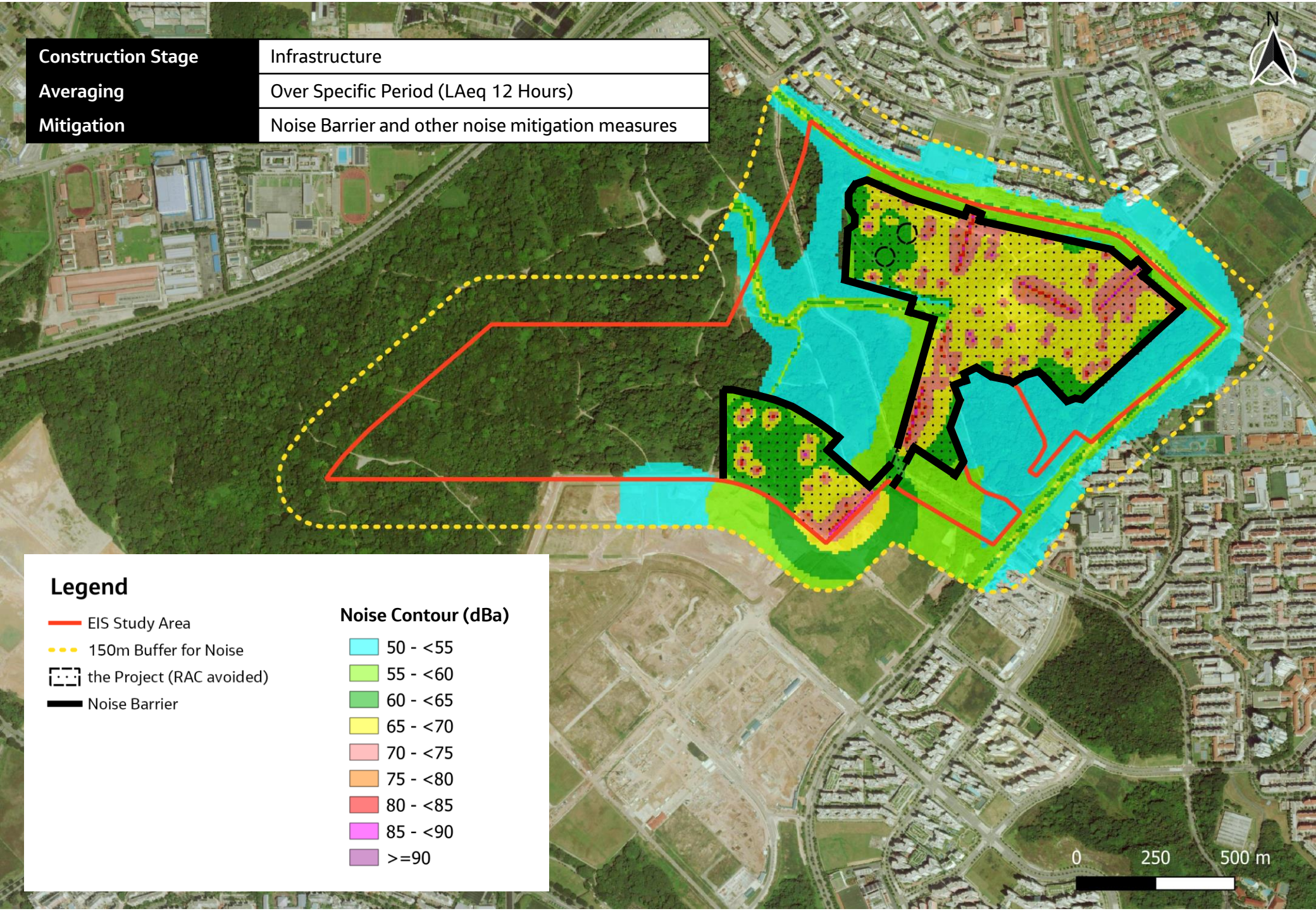

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Unmitigated
N
Legend
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150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
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65 - <70
70 - <75
75 - <80
80 - <85
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250
500 m

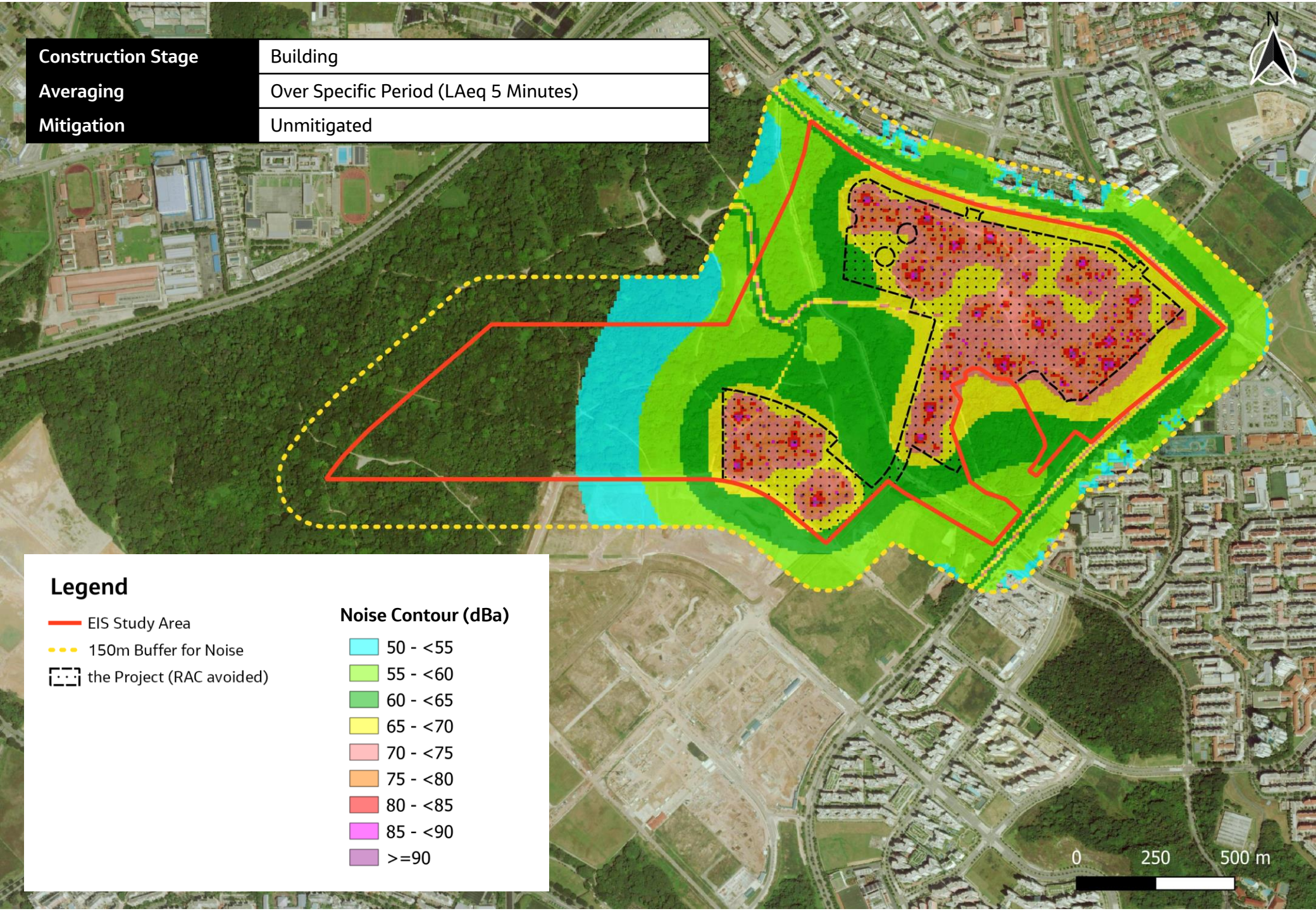

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

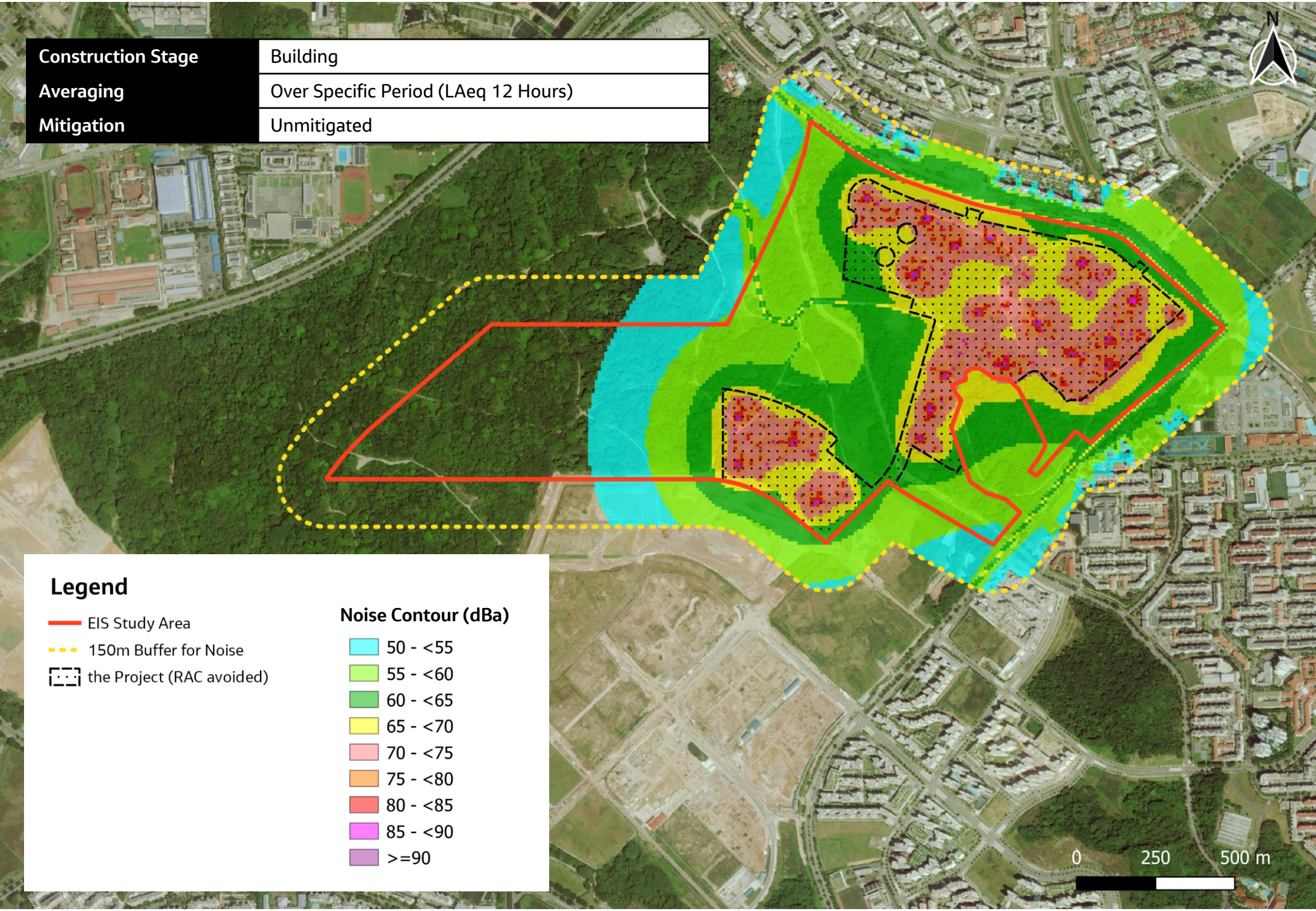

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

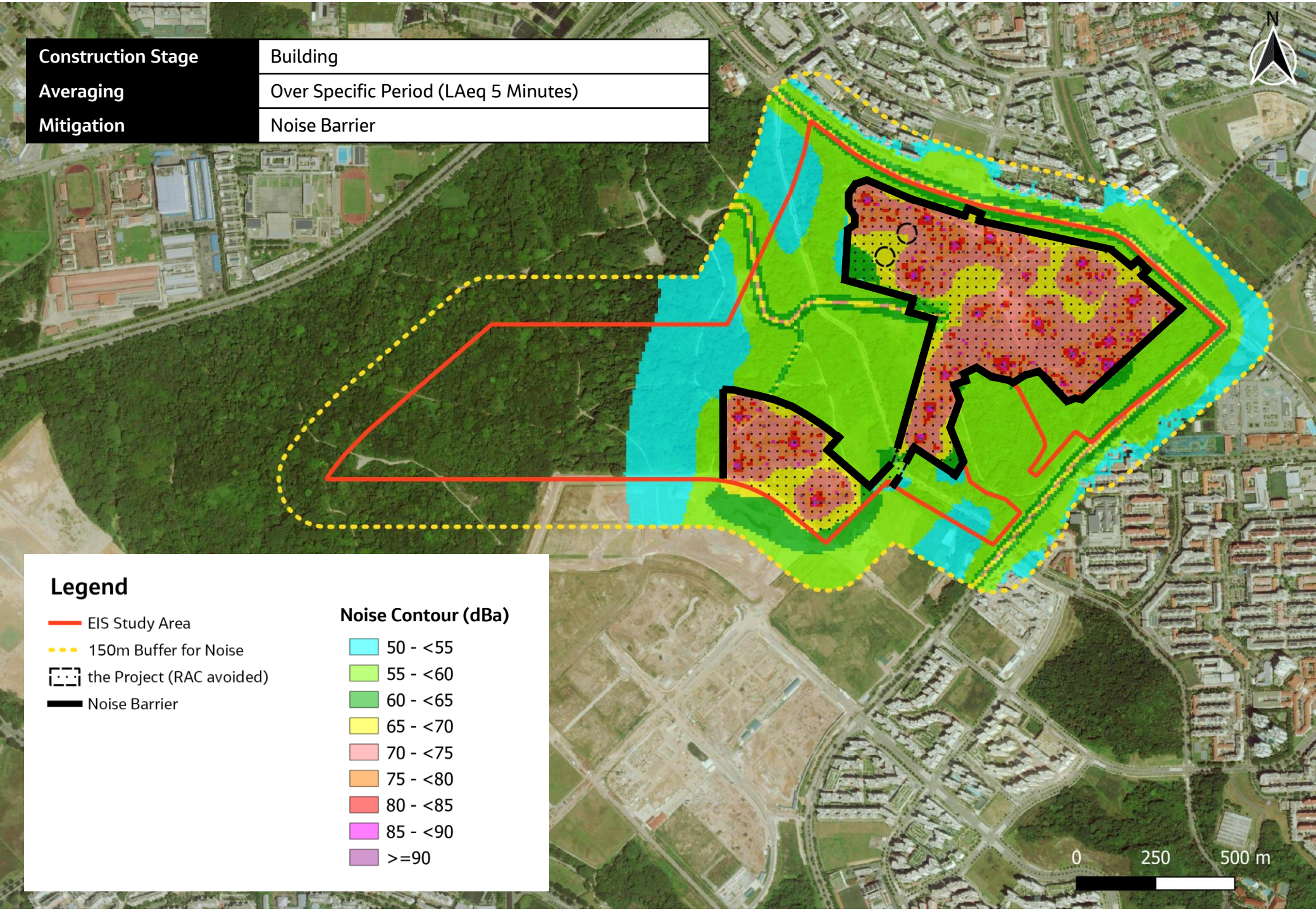

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

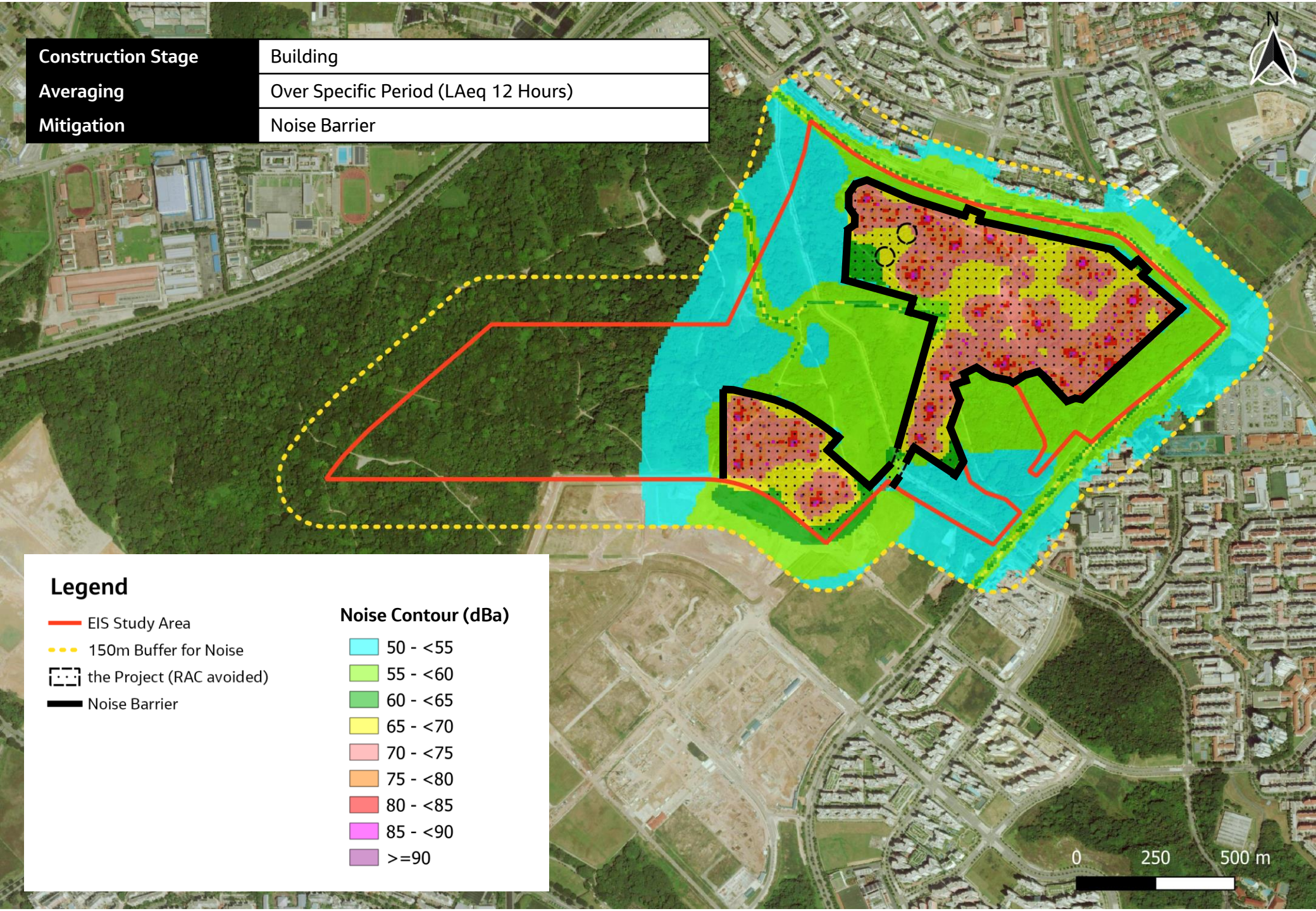

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

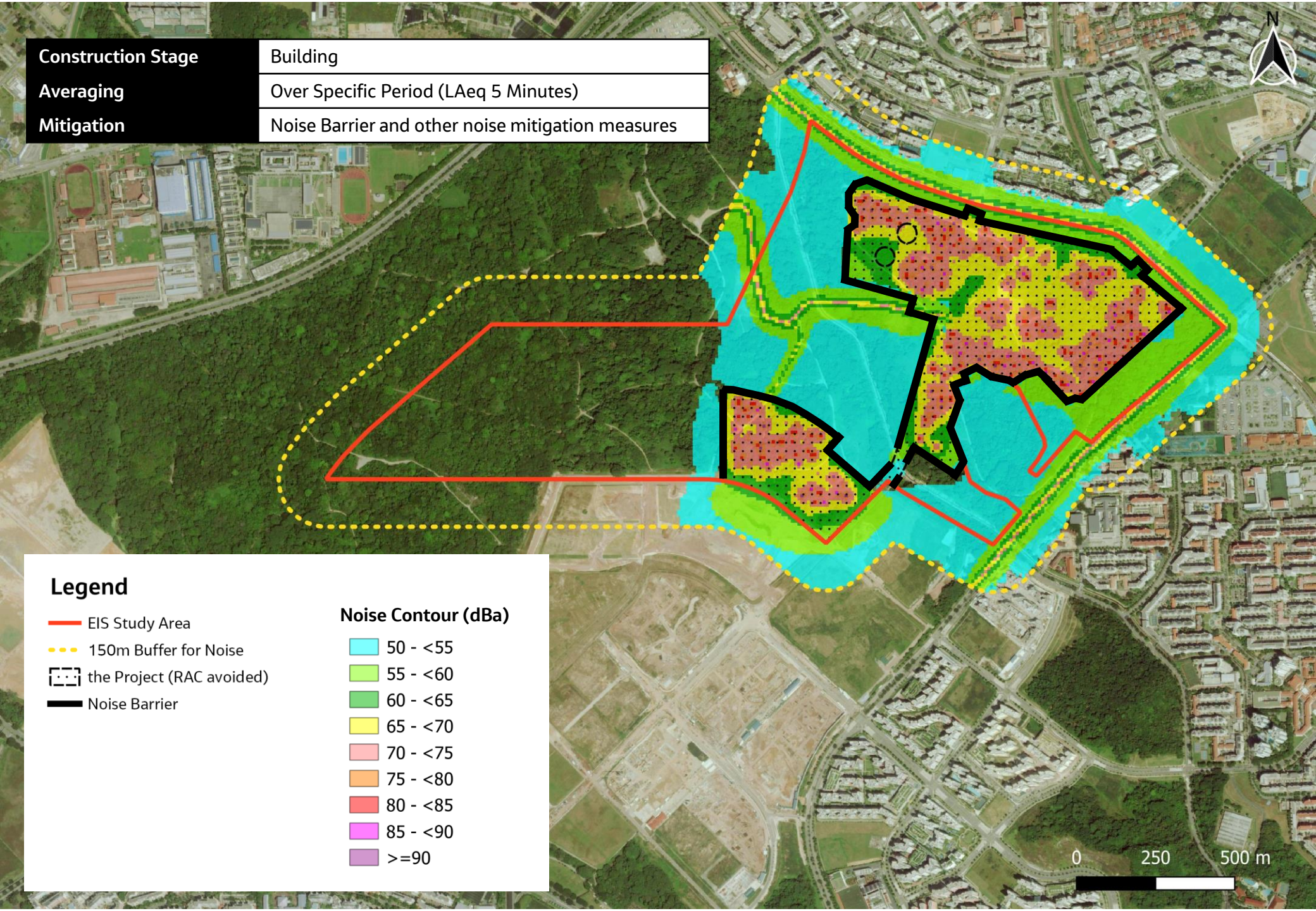

Construction Stage
Infrastructure
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

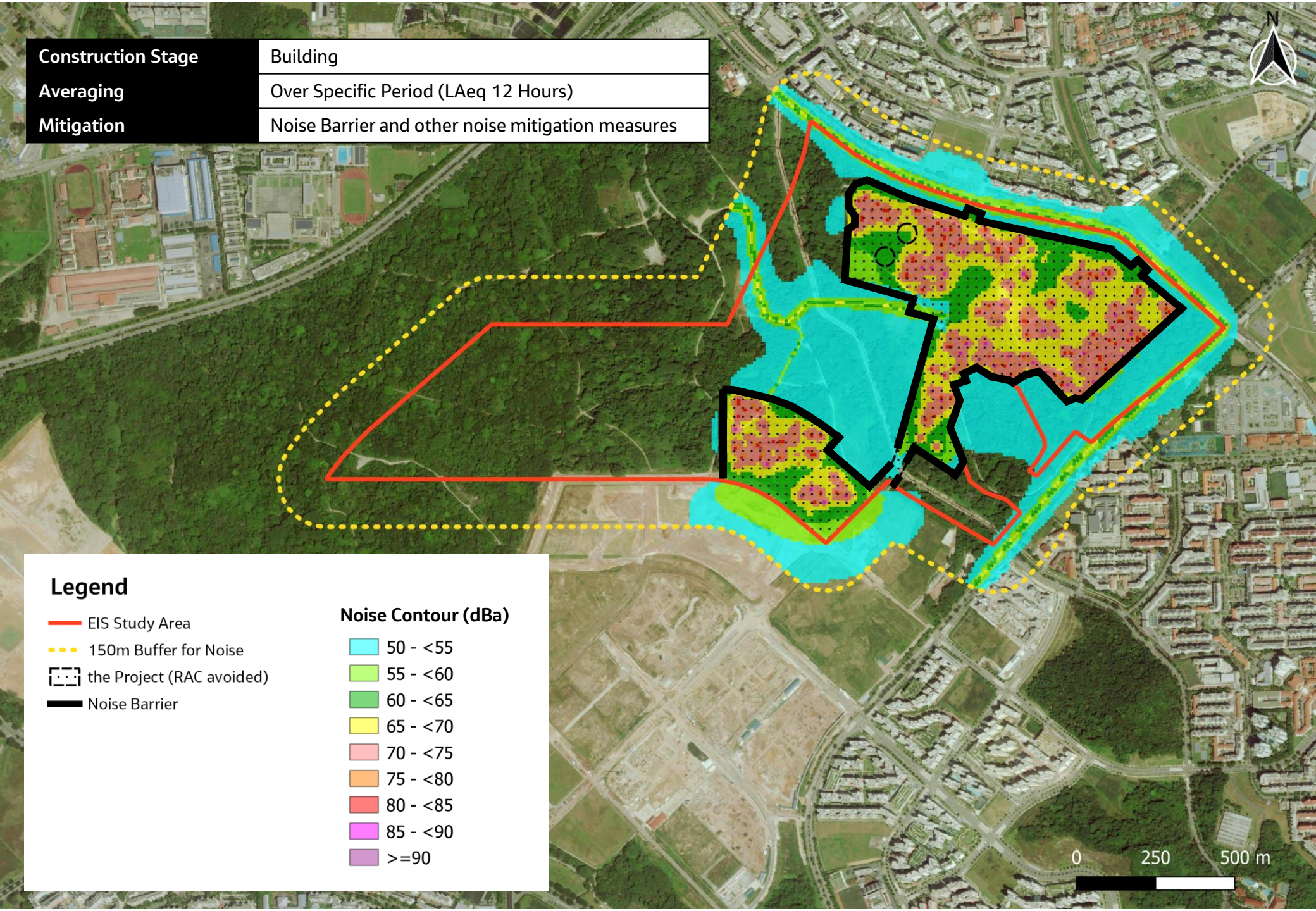

Construction Stage
Building
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m


Construction Stage
Building
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Unmitigated
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m


Construction Stage
Building
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m


Construction Stage
Building
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m


Construction Stage
Building
Averaging
Over Specific Period (LAeq 5 Minutes)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m


Construction Stage
Building
Averaging
Over Specific Period (LAeq 12 Hours)
Mitigation
Noise Barrier and other noise mitigation measures
N
Legend
EIS Study Area
150m Buffer for Noise
the Project (RAC avoided)
Noise Barrier
Noise Contour (dBa)
50 - <55
55 - <60
60 - <65
65 - <70
70 - <75
75 - <80
80 - <85
85 - <90
>=90
0
250
500 m

Appendix 8C: Detailed Residual Impacts of Noise Impacts to Affected Community and Fauna

Table 1: Summary of Evaluation of Residual Impacts to Affected Community and Fauna for All 4 Construction Stages for Specific Period (LAeq 12 hours)

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
Over Specific Period (LAeq 12 hours)					
Stage 1 - Advance Works					
N-I1	Noise emission from construction site NSR 1 - residential	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 2 - residential	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 3 - residential	-40	Minor Negative	-40	Minor Negative
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-297	Major Negative
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-198	Moderate Negative
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	Minor Negative	-99	Minor Negative
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-99	Minor Negative	-99	Minor Negative
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-198	Moderate Negative

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-132	**Moderate Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-60	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**
Stage 2 - Earthworks					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 2 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 3 - residential	-40	**Minor Negative**	-40	**Minor Negative**
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-198	**Moderate Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-198	**Moderate Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-99	**Minor Negative**
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-132	**Moderate Negative**
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-132	**Moderate Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-20	**Minor Negative**
Stage 3 - Infrastructure					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-80	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 2 - residential	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 3 - residential	-40	Minor Negative	-40	Minor Negative
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-198	Moderate Negative
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-297	Major Negative
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-99	Minor Negative
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-198	Moderate Negative	-297	Major Negative
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-66	Minor Negative
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-66	Minor Negative
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-132	Moderate Negative

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-132	**Moderate Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-60	**Minor Negative**
Stage 4 - Building					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 2 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 3 - residential	-40	**Minor Negative**	-40	**Minor Negative**
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-297	**Major Negative**
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-198	**Moderate Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-198	**Moderate Negative**	-99	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-198	**Moderate Negative**	-99	**Minor Negative**
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-198	**Moderate Negative**
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-132	**Moderate Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-132	**Moderate Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-132	**Moderate Negative**	-99	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-60	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-40	**Minor Negative**	-20	**Minor Negative**

Table 2: Summary of Evaluation of Residual Impacts to Affected Community and Fauna for All 4 Construction Stages for 5 mins (L_{Aeq} 5 mins)

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
Over 5 mins (L_{Aeq} 5 mins)					
Stage 1 - Advance Works					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 2 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 3 - residential	-40	**Minor Negative**	-40	**Minor Negative**
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**
Stage 2 - Earthworks					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 2 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 3 - residential	-40	**Minor Negative**	-40	**Minor Negative**
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-198	**Moderate Negative**	-99	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-198	**Moderate Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-132	**Moderate Negative**	-66	**Minor Negative**
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-132	**Moderate Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-40	**Minor Negative**	-20	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**
Stage 3 - Infrastructure					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 2 - residential	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	Minor Negative	-40	Minor Negative
	Noise emission from construction site to NSR 3 - residential	-40	Minor Negative	-40	Minor Negative
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-99	Minor Negative
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-297	Major Negative	-99	Minor Negative
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	Minor Negative	-99	Minor Negative
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-99	Minor Negative	-99	Minor Negative
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-66	Minor Negative
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-198	Moderate Negative	-66	Minor Negative
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	Minor Negative	-66	Minor Negative

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-20	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**
Stage 4 - Building					
N-I1	Noise emission from construction site NSR 1 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Ichiban Montessori Childcare Center (NSR 2 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 2 - residential	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to Hong Kah Primary School and Dunearn Secondary School (NSR 3 - school)	-40	**Minor Negative**	-40	**Minor Negative**
	Noise emission from construction site to NSR 3 - residential	-40	**Minor Negative**	-40	**Minor Negative**
N-I2	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-297	**Major Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 4 arboreal fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**

Impact Register		Before Mitigation Measures		Post Mitigation Measures (Residual Significance)	
ID	Impacts	Environmental Scores (ES)	Range Bands of ES	Environmental Scores (ES)	Range Bands of ES
	Noise emission from construction site to NSR 5 arboreal fauna of Priority/ Sensitivity Level - High	-99	**Minor Negative**	-99	**Minor Negative**
N-I3	Noise emission from construction site to NSR 4 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-198	**Moderate Negative**	-66	**Minor Negative**
	Noise emission from construction site to NS4 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR 5 ground-dwelling and understory fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
	Noise emission from construction site to NSR5 arboreal fauna of Priority/ Sensitivity Level - Medium	-66	**Minor Negative**	-66	**Minor Negative**
N-I4	Noise emission from construction site to NSR 4 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-60	**Minor Negative**	-20	**Minor Negative**
	Noise emission from construction site to NSR 5 - ground-dwelling and understory fauna of Priority/ Sensitivity Level - Low	-20	**Minor Negative**	-20	**Minor Negative**

Appendix 9A: Baseline Ambient Air Quality Results

TEST REPORT

Our Reference No.	:	**R201188**	Date of Monitoring	:	10/02/20 to 02/03/20
Project Code / Ref.	:	-	Date Reported	:	10/03/2020

Customer Ref. No.	:	-
Customer Name	:	CH2M HILL Singapore Pte Ltd (Jacobs)
Customer Address	:	150 Beach Road Gateway West 34th Floor Singapore 189720

Attention To	:	Ms Catherine Baldedara
Subject	:	**Baseline Ambient Air Monitoring Along Perimeter of Tengah**
Description	:	7-day PM Monitoring per location at 3 locations from 10/02/20 to 02/03/20

Cai Junqin

Executive Engineer,
Env Services

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No.: 201422686C
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Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 : +65 6262 3736 (Lab) : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

SCOPE OF WORK

Baseline Ambient Air Monitoring was carried out at 3 locations for a period of 7 days each along the perimeter of Tengah. The monitoring stations were setup near the HDB estates situated along Brickland Road and Bukit Batok Road. The scope of work and description are as follows:

Table 1: Scope of work carried out

Location ID	GPS Coordinates	Monitoring Period	Parameters	Range of Detection	Data
A1	N 01° 22' 32.0" E 103° 44' 11.0"	10/02/20 to 17/02/20	PM_{10}	0 to 1000 $\mu g/m^3$	10-min Ave
			$PM_{2.5}$		
A2	N 01° 22' 20.6" E 103° 44' 37.7"	17/02/20 to 24/02/20	PM_{10}		
			$PM_{2.5}$		
A3	N 01° 21' 57.8" E 103° 44' 43.6"	24/02/20 to 02/03/20	PM_{10}		
			$PM_{2.5}$		

MONITORING LOCATION

The monitoring locations are shown in the Google Earth image below.



SAMPLING METHODOLOGY AND EQUIPMENT

PM10 and PM2.5

PM10 and PM2.5 were monitored using Met One Aerocet 531S Particle Mas Profiler & Counter (Serial No: W25124). The analyser was solar and battery operated and uses light scattering laser photometer, providing real time aerosol mass reading and data logging for both PM10 and PM2.5. The instrument was housed inside a weatherproof enclosure with its air intake connected to a moisture trap to minimise the effects of humidity.

Data logging was set at 10-minute intervals while 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. Equipment calibration certificate is attached in Appendix A of this report.

SINGAPORE AMBIENT AIR QUALITY TARGETS

Table 2: The following table summarises the Singapore Ambient Air Quality Guidelines

Pollutant	Singapore Targets by 2020
Particulate Matter ($PM_{2.5}$)	**24-hour mean: 37.5 μg/m^3**
Particulate Matter (PM_{10})	**24-hour mean: 50 μg/m^3**

MONITORING RESULTS

The results for the various parameters monitored were summarised in the following tables. Hourly data and Trend Charts for 2 pollutants at both locations are attached in Appendix B and Appendix C respectively.

Table 3: Summary of Air Quality Results for A1

		A1 Air Quality Data Summary							Target Guidelines
		10/02/20 to 11/02/20	11/02/20 to 12/02/20	12/02/20 to 13/02/20	13/02/20 to 14/02/20	14/02/20 to 15/02/20	15/02/20 to 16/02/20	16/02/20 to 17/02/20	
24 HR Average Result	PM_{10} ($\mu g/m^3$)	22.6	25.2	40.1	37.0	34.3	32.0	38.2	50 $\mu g/m^3$
	$PM_{2.5}$ ($\mu g/m^3$)	14.6	15.1	19.0	18.3	18.0	17.5	23.2	37.5 $\mu g/m^3$

Note:

1) The date range represents data collected between 10-Feb-2020, 3pm to 17-Feb-2020, 3pm.

Table 4: Summary of Air Quality Results for A2

		A2 Air Quality Data Summary							Target Guidelines
		17/02/20 to 18/02/20	18/02/20 to 19/02/20	19/02/20 to 20/02/20	20/02/20 to 21/02/20	21/02/20 to 22/02/20	22/02/20 to 23/02/20	23/02/20 to 24/02/20	
24 HR Average Result	PM_{10} ($\mu g/m^3$)	14.4	22.7	32.9	33.9	31.6	29.8	28.5	50 $\mu g/m^3$
	$PM_{2.5}$ ($\mu g/m^3$)	7.9	12.9	16.6	17.1	17.9	15.4	16.8	37.5 $\mu g/m^3$

Note:

1) The date range represents data collected between 17-Feb-2020, 4pm to 24-Feb-2020, 4pm.

Table 5: Summary of Air Quality Results for A3

		A3 Air Quality Data Summary							Target Guidelines
		24/02/20 to 25/02/20	25/02/20 to 26/02/20	26/02/20 to 27/02/20	27/02/20 to 28/02/20	28/02/20 to 29/02/20	29/02/20 to 01/03/20	01/03/20 to 02/03/20	
24 HR Average Result	PM_{10} ($\mu g/m^3$)	**57.8**	39.7	31.7	24.3	31.1	34.7	26.9	50 $\mu g/m^3$
	$PM_{2.5}$ ($\mu g/m^3$)	25.3	19.0	14.5	12.1	15.4	17.2	13.4	37.5 $\mu g/m^3$

Note:

1) The date range represents data collected between 24-Feb-2020, 5pm to 02-Mar-2020, 5pm.
2) Bolded results indicate that the corresponding guideline has been exceeded.

CONCLUSION

Based on the data obtained from the baseline monitoring, almost all PM 24-hour averages were within the target guidelines throughout the monitoring period with the exception of PM_{10} with exceeding the target guideline between 24-Feb and 25-Feb at location A3.

Met One Instruments
1600 Washington Blvd
Grants Pass, OR 97526
(541) 471-7111
(541) 471-7116 (Fax)
Service@metone.com

Calibration Certificate

As Received

This certificate documents the as received condition of your instrument. Calibration was verified using accepted industry methods, equipment, procedures and standards that are traceable to NIST and ISO.

Instrument Model# *Aerocet-531S* Instrument Serial# *W25124*

Date of comparison against standard *3-21-2019* Sensor # *17125*

Quality Control Technician *Daisy Jones* AJ24

Temperature *23* °C Relative Humidity *31* %

Test Procedure: *AEROCET-531S-6100*

As Received	Value	Range	Condition
Zero Count	0	Less than 5 particles in 5 min.	PASS
Air Flow	.104	.092 to .108 CFM	PASS

PSL Size Micron	LOT# NIST	As Received PSL Count Comparison	Allowable PSL Count Comparison	Allowable Size Accuracy	As Received Condition
0.3	196947	47.24	10% to 90%	+/- 10 %	PASS
0.5	180556	43.14	10% to 90%	+/- 10 %	PASS
1.0	193291	43.46	10% to 90%	+/- 10 %	PASS

Standards	Model	SN	Cal Due
Particle Counter	GT-526	M1759	8/4/2019
Flowmeter	DCL-M	103751	2/8/2020
DMM	289	23740018	5/3/2019
RH/TEMP SENSOR	083E-1-6	R20313	9/18/2019

Calibration was performed by direct comparison to a count standard.

Met One Instruments
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Service@metone.com

Calibration Certificate

The calibration results on this report certify that this instrument complies with the product specifications at the time of calibration. Calibration was performed according to accepted industry methods using equipment, procedures, and standards that are traceable to NIST and ISO.

Recommended calibration interval is 12 months from the first day of use.

Instrument Model# Aerocet-531S Instrument Serial# W25124

Date of Calibration 3/22/2019 Sensor # 17125

Daisy Jones Calibration Technician

Quality Check

Temperature 23 °C Relative Humidity 32 %

Test Procedure: AEROCET-531S-6100

PSL Size (µm)	Test Results	Test Spec.	Lot# NIST	Expiration
0.3	Pass	± 10%	196947	04/30/2021
0.5	Pass	± 10%	180556	02/28/2020
1.0	Pass	± 10%	193291	1/31/2021
2.5	Pass	± 10%	REF	NA
5.0	Pass	± 10%	REF	NA
10.0	Pass	± 10%	REF	NA

Standards	Model	SN	Cal Due
Particle Counter	GT-526	M1759	8/4/2019
Flowmeter	DCL-M	103751	2/8/2020
DMM	289	23740018	5/3/2019
RH/TEMP SENSOR	083E-1-6	R20313	9/18/2019

This calibration certificate shall not be reproduced except in full, without the written approval of Met One Instruments Inc.

Location A1

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
2/10/2020 15:00	14.5	11.5
2/10/2020 16:00	22.3	19.0
2/10/2020 17:00	25.8	21.4
2/10/2020 18:00	12.6	7.8
2/10/2020 19:00	12.6	7.2
2/10/2020 20:00	15.2	9.2
2/10/2020 21:00	19.6	11.6
2/10/2020 22:00	23.4	14.0
2/10/2020 23:00	20.1	9.9
2/11/2020 0:00	21.0	9.6
2/11/2020 1:00	24.1	13.9
2/11/2020 2:00	23.8	12.1
2/11/2020 3:00	22.5	11.6
2/11/2020 4:00	29.8	19.0
2/11/2020 5:00	32.8	23.1
2/11/2020 6:00	44.3	34.2
2/11/2020 7:00	42.2	30.6
2/11/2020 8:00	37.5	25.2
2/11/2020 9:00	33.6	21.0
2/11/2020 10:00	21.1	12.3
2/11/2020 11:00	15.4	9.1
2/11/2020 12:00	10.7	6.5
2/11/2020 13:00	9.5	5.6
2/11/2020 14:00	9.1	4.8
2/11/2020 15:00	13.4	7.8
2/11/2020 16:00	13.7	7.8
2/11/2020 17:00	14.9	8.2
2/11/2020 18:00	16.5	8.8
2/11/2020 19:00	20.0	9.4
2/11/2020 20:00	22.4	11.3
2/11/2020 21:00	17.7	10.3
2/11/2020 22:00	18.6	11.3
2/11/2020 23:00	21.5	11.7
2/12/2020 0:00	28.7	16.4
2/12/2020 1:00	33.7	22.0
2/12/2020 2:00	42.4	30.2
2/12/2020 3:00	31.9	22.0
2/12/2020 4:00	24.1	15.4
2/12/2020 5:00	23.3	15.1
2/12/2020 6:00	30.1	21.0
2/12/2020 7:00	34.1	23.8
2/12/2020 8:00	45.8	25.3
2/12/2020 9:00	48.4	24.5
2/12/2020 10:00	26.5	13.0
2/12/2020 11:00	18.9	9.9
2/12/2020 12:00	19.0	11.2
2/12/2020 13:00	19.3	12.3
2/12/2020 14:00	20.1	14.0
2/12/2020 15:00	21.9	14.0
2/12/2020 16:00	24.0	14.8
2/12/2020 17:00	21.5	12.5
2/12/2020 18:00	22.2	12.4
2/12/2020 19:00	29.7	15.0
2/12/2020 20:00	32.4	14.8
2/12/2020 21:00	41.5	19.9
2/12/2020 22:00	42.9	19.3

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
2/12/2020 23:00	43.6	18.5
2/13/2020 0:00	45.8	19.3
2/13/2020 1:00	46.8	18.8
2/13/2020 2:00	48.5	18.5
2/13/2020 3:00	52.6	22.6
2/13/2020 4:00	59.3	25.7
2/13/2020 5:00	57.9	26.3
2/13/2020 6:00	62.2	28.8
2/13/2020 7:00	63.7	29.8
2/13/2020 8:00	66.5	31.1
2/13/2020 9:00	48.1	23.0
2/13/2020 10:00	32.5	16.5
2/13/2020 11:00	28.5	15.1
2/13/2020 12:00	25.7	14.0
2/13/2020 13:00	22.7	12.6
2/13/2020 14:00	22.0	12.3
2/13/2020 15:00	21.9	12.8
2/13/2020 16:00	22.1	12.8
2/13/2020 17:00	27.0	14.2
2/13/2020 18:00	29.2	14.8
2/13/2020 19:00	29.6	14.8
2/13/2020 20:00	35.1	16.8
2/13/2020 21:00	36.8	17.6
2/13/2020 22:00	38.3	17.9
2/13/2020 23:00	43.4	20.3
2/14/2020 0:00	46.3	21.0
2/14/2020 1:00	45.3	20.7
2/14/2020 2:00	45.5	20.6
2/14/2020 3:00	47.6	21.7
2/14/2020 4:00	56.4	26.6
2/14/2020 5:00	58.1	28.8
2/14/2020 6:00	52.8	25.2
2/14/2020 7:00	49.6	23.7
2/14/2020 8:00	45.3	21.8
2/14/2020 9:00	38.3	18.9
2/14/2020 10:00	31.3	16.5
2/14/2020 11:00	26.9	14.9
2/14/2020 12:00	21.0	12.1
2/14/2020 13:00	20.0	12.1
2/14/2020 14:00	20.4	11.9
2/14/2020 15:00	18.3	10.7
2/14/2020 16:00	21.2	11.5
2/14/2020 17:00	23.3	12.5
2/14/2020 18:00	26.2	14.2
2/14/2020 19:00	28.6	14.9
2/14/2020 20:00	31.0	16.7
2/14/2020 21:00	31.1	16.2
2/14/2020 22:00	31.8	15.4
2/14/2020 23:00	32.9	15.2
2/15/2020 0:00	37.1	15.3
2/15/2020 1:00	39.0	15.4
2/15/2020 2:00	44.7	20.2
2/15/2020 3:00	43.1	19.8
2/15/2020 4:00	50.4	25.7
2/15/2020 5:00	49.1	25.3
2/15/2020 6:00	45.8	24.8

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
2/15/2020 7:00	49.8	28.0
2/15/2020 8:00	47.9	26.3
2/15/2020 9:00	45.3	24.5
2/15/2020 10:00	33.7	19.1
2/15/2020 11:00	21.6	12.1
2/15/2020 12:00	20.5	12.5
2/15/2020 13:00	27.7	19.8
2/15/2020 14:00	22.2	15.3
2/15/2020 15:00	30.8	21.7
2/15/2020 16:00	28.3	16.3
2/15/2020 17:00	26.5	15.3
2/15/2020 18:00	26.6	15.2
2/15/2020 19:00	30.5	15.8
2/15/2020 20:00	42.2	17.0
2/15/2020 21:00	33.6	16.9
2/15/2020 22:00	26.9	14.4
2/15/2020 23:00	28.5	13.1
2/16/2020 0:00	24.5	12.0
2/16/2020 1:00	29.5	12.4
2/16/2020 2:00	31.4	13.6
2/16/2020 3:00	32.4	15.2
2/16/2020 4:00	35.5	14.9
2/16/2020 5:00	33.0	16.0
2/16/2020 6:00	34.2	16.4
2/16/2020 7:00	30.4	14.0
2/16/2020 8:00	32.6	15.0
2/16/2020 9:00	26.2	14.3
2/16/2020 10:00	26.5	15.1
2/16/2020 11:00	36.3	26.0
2/16/2020 12:00	54.0	42.9
2/16/2020 13:00	32.6	22.6
2/16/2020 14:00	35.9	24.9
2/16/2020 15:00	39.0	27.7
2/16/2020 16:00	47.9	35.9
2/16/2020 17:00	58.1	43.7
2/16/2020 18:00	41.1	32.4
2/16/2020 19:00	34.8	24.8
2/16/2020 20:00	41.2	27.7
2/16/2020 21:00	45.8	28.6
2/16/2020 22:00	53.6	32.5
2/16/2020 23:00	41.4	23.2
2/17/2020 0:00	40.4	20.6
2/17/2020 1:00	43.6	22.2
2/17/2020 2:00	46.4	23.4
2/17/2020 3:00	47.2	26.5
2/17/2020 4:00	50.8	28.7
2/17/2020 5:00	55.1	31.6
2/17/2020 6:00	45.6	25.6
2/17/2020 7:00	38.1	19.5
2/17/2020 8:00	29.7	15.7
2/17/2020 9:00	25.5	14.3
2/17/2020 10:00	20.9	11.6
2/17/2020 11:00	22.2	11.8
2/17/2020 12:00	19.8	11.4
2/17/2020 13:00	15.0	9.2
2/17/2020 14:00	13.4	8.3

Location A2

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
2/17/2020 16:00	10.8	7.2
2/17/2020 17:00	9.2	5.7
2/17/2020 18:00	8.9	5.8
2/17/2020 19:00	11.2	7.7
2/17/2020 20:00	14.2	9.8
2/17/2020 21:00	14.6	9.5
2/17/2020 22:00	13.2	7.6
2/17/2020 23:00	15.6	8.1
2/18/2020 0:00	17.8	8.3
2/18/2020 1:00	17.4	7.7
2/18/2020 2:00	20.4	8.8
2/18/2020 3:00	26.8	12.9
2/18/2020 4:00	24.7	11.6
2/18/2020 5:00	23.1	11.2
2/18/2020 6:00	20.0	9.7
2/18/2020 7:00	10.1	5.9
2/18/2020 8:00	9.6	5.7
2/18/2020 9:00	9.2	5.5
2/18/2020 10:00	11.7	6.3
2/18/2020 11:00	13.7	7.8
2/18/2020 12:00	14.1	7.8
2/18/2020 13:00	9.2	5.2
2/18/2020 14:00	11.1	7.2
2/18/2020 15:00	9.1	5.9
2/18/2020 16:00	9.8	5.3
2/18/2020 17:00	13.3	7.9
2/18/2020 18:00	12.9	7.3
2/18/2020 19:00	15.1	7.6
2/18/2020 20:00	15.5	8.7
2/18/2020 21:00	19.7	10.2
2/18/2020 22:00	22.5	10.5
2/18/2020 23:00	17.3	10.5
2/19/2020 0:00	18.6	11.6
2/19/2020 1:00	20.9	12
2/19/2020 2:00	28.3	16.5
2/19/2020 3:00	22.7	11.3
2/19/2020 4:00	17.7	10.3
2/19/2020 5:00	19	10.8
2/19/2020 6:00	21.6	12
2/19/2020 7:00	28	16.3
2/19/2020 8:00	29.8	20.5
2/19/2020 9:00	33.5	23.9
2/19/2020 10:00	46.1	25.5
2/19/2020 11:00	47.7	24.8
2/19/2020 12:00	26.1	13.3
2/19/2020 13:00	18.7	9.9
2/19/2020 14:00	19.2	11
2/19/2020 15:00	21.1	12.1
2/19/2020 16:00	22.8	13.2
2/19/2020 17:00	27.8	13.4
2/19/2020 18:00	28.6	14.9
2/19/2020 19:00	29.1	14.8
2/19/2020 20:00	34.9	16.5
2/19/2020 21:00	36	18.3
2/19/2020 22:00	37.6	17.4
2/19/2020 23:00	43.7	20.3

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
2/20/2020 0:00	45.6	21.2
2/20/2020 1:00	46.2	21.2
2/20/2020 2:00	45.4	21
2/20/2020 3:00	48.2	21.5
2/20/2020 4:00	39.2	19.7
2/20/2020 5:00	31.4	16.5
2/20/2020 6:00	27.4	15
2/20/2020 7:00	35.6	16.4
2/20/2020 8:00	37.3	18.2
2/20/2020 9:00	37.7	19.7
2/20/2020 10:00	30.9	17.3
2/20/2020 11:00	27.4	14.3
2/20/2020 12:00	20.5	11.3
2/20/2020 13:00	20	12.7
2/20/2020 14:00	19.9	12.1
2/20/2020 15:00	17.5	11.1
2/20/2020 16:00	21.9	11.4
2/20/2020 17:00	23.4	12.4
2/20/2020 18:00	26.3	14.7
2/20/2020 19:00	29.1	14.8
2/20/2020 20:00	31.7	17.5
2/20/2020 21:00	31.7	16.6
2/20/2020 22:00	32	15.8
2/20/2020 23:00	32.5	14.4
2/21/2020 0:00	37.4	14.5
2/21/2020 1:00	38.8	14.7
2/21/2020 2:00	44.3	19.7
2/21/2020 3:00	43.5	20
2/21/2020 4:00	51.1	25.6
2/21/2020 5:00	49.7	24.6
2/21/2020 6:00	48.3	21.4
2/21/2020 7:00	38.3	20.1
2/21/2020 8:00	31.3	16
2/21/2020 9:00	27.4	15.7
2/21/2020 10:00	35.9	15.5
2/21/2020 11:00	37.8	17.5
2/21/2020 12:00	37.5	19.9
2/21/2020 13:00	27.7	20.7
2/21/2020 14:00	21.6	16
2/21/2020 15:00	13.9	11.2
2/21/2020 16:00	21.4	19.9
2/21/2020 17:00	26	21.5
2/21/2020 18:00	13	8.6
2/21/2020 19:00	12.5	8.1
2/21/2020 20:00	14.8	9.6
2/21/2020 21:00	20	11.6
2/21/2020 22:00	24.2	14.1
2/21/2020 23:00	20.7	9.6
2/22/2020 0:00	20.9	9.9
2/22/2020 1:00	23.8	14
2/22/2020 2:00	23.8	11.3
2/22/2020 3:00	22	11.7
2/22/2020 4:00	30.3	19.3
2/22/2020 5:00	33.7	23.8
2/22/2020 6:00	44.4	35.1
2/22/2020 7:00	37.6	15.1

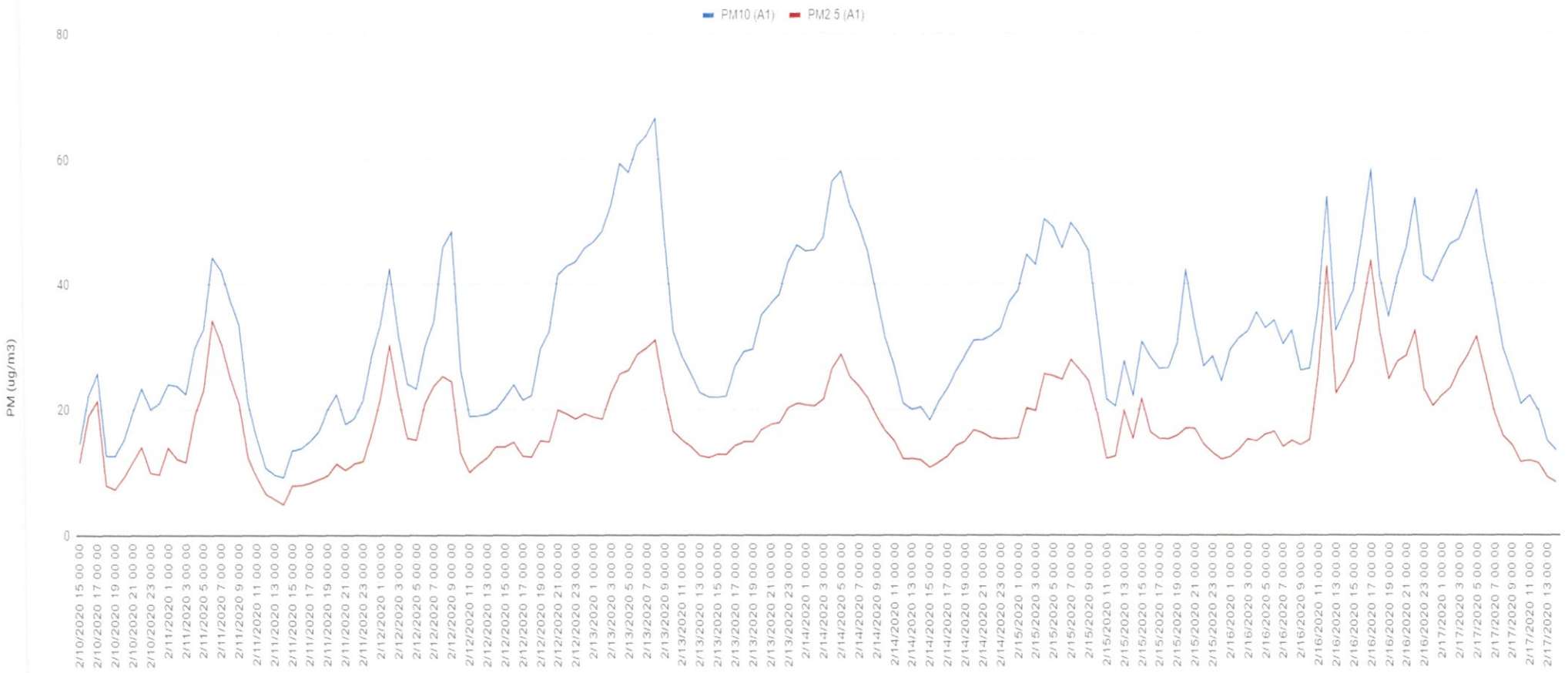
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2/22/2020 9:00	44.1	19.7
2/22/2020 10:00	43.9	19.8
2/22/2020 11:00	50.5	25.3
2/22/2020 12:00	48.6	25.3
2/22/2020 13:00	46.3	25.3
2/22/2020 14:00	49.2	28.7
2/22/2020 15:00	47.9	25.6
2/22/2020 16:00	45.1	24.6
2/22/2020 17:00	33.8	19
2/22/2020 18:00	20.3	13.7
2/22/2020 19:00	26.5	18.9
2/22/2020 20:00	23	16.4
2/22/2020 21:00	32	22.1
2/22/2020 22:00	27.9	16.6
2/22/2020 23:00	25.4	13.8
2/23/2020 0:00	25.8	14.2
2/23/2020 1:00	28.4	11.5
2/23/2020 2:00	24.7	12.6
2/23/2020 3:00	29.6	13.6
2/23/2020 4:00	30.9	13.4
2/23/2020 5:00	32.4	14.6
2/23/2020 6:00	23.7	12.5
2/23/2020 7:00	28.8	13.2
2/23/2020 8:00	31.4	13.2
2/23/2020 9:00	32.2	15.3
2/23/2020 10:00	36	14.8
2/23/2020 11:00	34	16.5
2/23/2020 12:00	33.4	16.7
2/23/2020 13:00	31.1	13.6
2/23/2020 14:00	32.5	14.1
2/23/2020 15:00	25.8	14.7
2/23/2020 16:00	45.9	23.8
2/23/2020 17:00	33.7	19.1
2/23/2020 18:00	19.6	14.3
2/23/2020 19:00	26.1	18.5
2/23/2020 20:00	22.8	16.4
2/23/2020 21:00	31.6	22.9
2/23/2020 22:00	22.8	16.4
2/23/2020 23:00	31.6	22.9
2/24/2020 0:00	27.7	16.2
2/24/2020 1:00	25.5	13.6
2/24/2020 2:00	26	13.7
2/24/2020 3:00	29.3	10.6
2/24/2020 4:00	24.4	13.2
2/24/2020 5:00	29.6	14.5
2/24/2020 6:00	30.9	14.2
2/24/2020 7:00	32.1	15.2
2/24/2020 8:00	27.8	15.4
2/24/2020 9:00	35.4	15.1
2/24/2020 10:00	38	18.1
2/24/2020 11:00	38.2	20.7
2/24/2020 12:00	28.1	20.5
2/24/2020 13:00	20.8	16.8
2/24/2020 14:00	14.5	11.6
2/24/2020 15:00	21.3	19.5

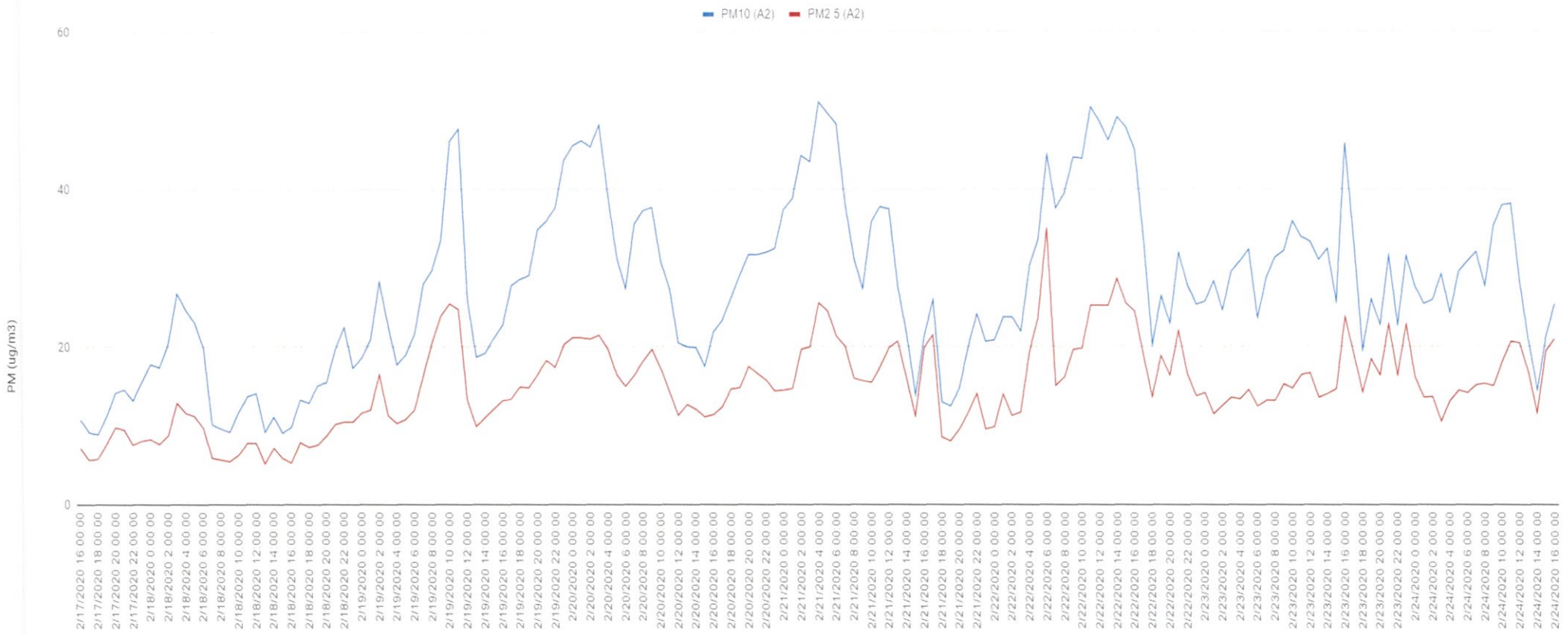
Location A3

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2/24/2020 19:00	60.7	27.0
2/24/2020 20:00	65.3	28.1
2/24/2020 21:00	67.0	28.7
2/24/2020 22:00	70.1	30.0
2/24/2020 23:00	69.8	29.0
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2/25/2020 1:00	65.4	26.6
2/25/2020 2:00	64.2	26.1
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2/25/2020 4:00	72.8	30.4
2/25/2020 5:00	74.9	32.6
2/25/2020 6:00	77.2	33.5
2/25/2020 7:00	83.3	37.2
2/25/2020 8:00	69.9	28.8
2/25/2020 9:00	62.3	26.1
2/25/2020 10:00	48.1	21.8
2/25/2020 11:00	40.5	19.5
2/25/2020 12:00	37.5	17.8
2/25/2020 13:00	34.2	16.4
2/25/2020 14:00	31.6	15.6
2/25/2020 15:00	29.2	14.5
2/25/2020 16:00	28.9	14.3
2/25/2020 17:00	27.5	13.7
2/25/2020 18:00	31.8	15.1
2/25/2020 19:00	34.2	16.4
2/25/2020 20:00	42.7	20.3
2/25/2020 21:00	45.8	21.4
2/25/2020 22:00	38.5	18.8
2/25/2020 23:00	39.6	19.4
2/26/2020 0:00	39.3	18.9
2/26/2020 1:00	43.0	20.2
2/26/2020 2:00	47.2	22.7
2/26/2020 3:00	57.8	28.3
2/26/2020 4:00	56.5	27.1
2/26/2020 5:00	52.1	24.3
2/26/2020 6:00	51.9	23.9
2/26/2020 7:00	55.4	25.0
2/26/2020 8:00	48.8	22.8
2/26/2020 9:00	44.7	20.5
2/26/2020 10:00	37.1	17.5
2/26/2020 11:00	33.5	15.7
2/26/2020 12:00	28.4	13.9
2/26/2020 13:00	26.2	13.0
2/26/2020 14:00	25.6	12.6
2/26/2020 15:00	24.2	12.4
2/26/2020 16:00	21.8	11.6
2/26/2020 17:00	25.8	12.8
2/26/2020 18:00	28.2	13.9
2/26/2020 19:00	29.5	14.8
2/26/2020 20:00	33.8	16.4
2/26/2020 21:00	36.3	17.5
2/26/2020 22:00	37.1	17.8
2/26/2020 23:00	34.5	15.5
2/27/2020 0:00	35.3	15.8

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
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2/27/2020 2:00	34.5	16.4
2/27/2020 3:00	29.8	13.4
2/27/2020 4:00	30.9	12.5
2/27/2020 5:00	34.0	14.2
2/27/2020 6:00	41.4	17.1
2/27/2020 7:00	42.0	18.1
2/27/2020 8:00	45.3	18.3
2/27/2020 9:00	40.4	16.5
2/27/2020 10:00	31.2	14.0
2/27/2020 11:00	27.7	13.0
2/27/2020 12:00	24.0	11.0
2/27/2020 13:00	20.7	9.9
2/27/2020 14:00	14.8	6.9
2/27/2020 15:00	21.7	11.5
2/27/2020 16:00	26.5	13.8
2/27/2020 17:00	12.4	6.3
2/27/2020 18:00	11.7	6.2
2/27/2020 19:00	14.8	7.3
2/27/2020 20:00	18.8	8.8
2/27/2020 21:00	22.5	11.6
2/27/2020 22:00	19.6	10.4
2/27/2020 23:00	20.9	10.4
2/28/2020 0:00	23.5	12.2
2/28/2020 1:00	23.8	11.8
2/28/2020 2:00	22.3	10.4
2/28/2020 3:00	29.8	14.2
2/28/2020 4:00	32.4	17.1
2/28/2020 5:00	43.9	23.3
2/28/2020 6:00	41.6	19.6
2/28/2020 7:00	36.6	18.9
2/28/2020 8:00	33.4	15.9
2/28/2020 9:00	21.5	11.4
2/28/2020 10:00	14.8	7.8
2/28/2020 11:00	21.3	9.8
2/28/2020 12:00	17.6	8.6
2/28/2020 13:00	21.5	10.2
2/28/2020 14:00	23.3	10.9
2/28/2020 15:00	26.9	13.6
2/28/2020 16:00	29.1	14.9
2/28/2020 17:00	31.4	16.6
2/28/2020 18:00	31.0	15.6
2/28/2020 19:00	32.5	15.8
2/28/2020 20:00	33.2	15.5
2/28/2020 21:00	37.4	18.8
2/28/2020 22:00	38.1	19.2
2/28/2020 23:00	35.5	17.1
2/29/2020 0:00	33.9	15.7
2/29/2020 1:00	31.0	15.0
2/29/2020 2:00	30.0	14.1
2/29/2020 3:00	35.9	18.7
2/29/2020 4:00	39.5	18.6
2/29/2020 5:00	38.4	18.2
2/29/2020 6:00	36.1	17.4
2/29/2020 7:00	33.1	16.3
2/29/2020 8:00	21.5	11.3

Time	PM10 (ug/m3)	PM2.5 (ug/m3)
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2/29/2020 11:00	32.2	15.4
2/29/2020 12:00	29.2	15.0
2/29/2020 13:00	20.7	10.9
2/29/2020 14:00	23.4	12.1
2/29/2020 15:00	27.3	13.6
2/29/2020 16:00	28.4	14.5
2/29/2020 17:00	31.1	16.2
2/29/2020 18:00	35.7	17.7
2/29/2020 19:00	35.5	16.4
2/29/2020 20:00	41.0	21.3
2/29/2020 21:00	43.0	21.4
2/29/2020 22:00	46.7	21.8
2/29/2020 23:00	39.5	20.5
3/1/2020 0:00	31.1	16.1
3/1/2020 1:00	35.7	18.2
3/1/2020 2:00	35.5	18.0
3/1/2020 3:00	35.3	17.7
3/1/2020 4:00	29.1	13.7
3/1/2020 5:00	28.4	14.7
3/1/2020 6:00	29.4	13.7
3/1/2020 7:00	33.4	16.3
3/1/2020 8:00	35.2	17.4
3/1/2020 9:00	27.8	14.7
3/1/2020 10:00	28.6	14.0
3/1/2020 11:00	33.5	16.0
3/1/2020 12:00	35.6	18.3
3/1/2020 13:00	37.4	17.6
3/1/2020 14:00	33.9	15.6
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3/1/2020 16:00	34.7	17.9
3/1/2020 17:00	34.2	17.0
3/1/2020 18:00	30.4	15.3
3/1/2020 19:00	37.7	18.3
3/1/2020 20:00	31.9	16.3
3/1/2020 21:00	28.2	13.2
3/1/2020 22:00	25.3	12.7
3/1/2020 23:00	23.6	12.2
3/2/2020 0:00	21.4	10.9
3/2/2020 1:00	21.8	10.4
3/2/2020 2:00	21.5	11.2
3/2/2020 3:00	27.4	13.2
3/2/2020 4:00	28.4	15.1
3/2/2020 5:00	29.0	14.1
3/2/2020 6:00	34.5	17.8
3/2/2020 7:00	31.4	16.3
3/2/2020 8:00	29.2	14.4
3/2/2020 9:00	26.3	13.4
3/2/2020 10:00	26.1	13.0
3/2/2020 11:00	28.8	13.9
3/2/2020 12:00	23.9	11.8
3/2/2020 13:00	21.4	11.3
3/2/2020 14:00	18.1	8.8
3/2/2020 15:00	21.8	10.8
3/2/2020 16:00	22.5	11.0


PM10 (A1)
PM2.5 (A1)
PM (ug/m3)
80
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40
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0
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2/17/2020 13:00:00


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PM2.5 (A2)
PM (ug/m3)
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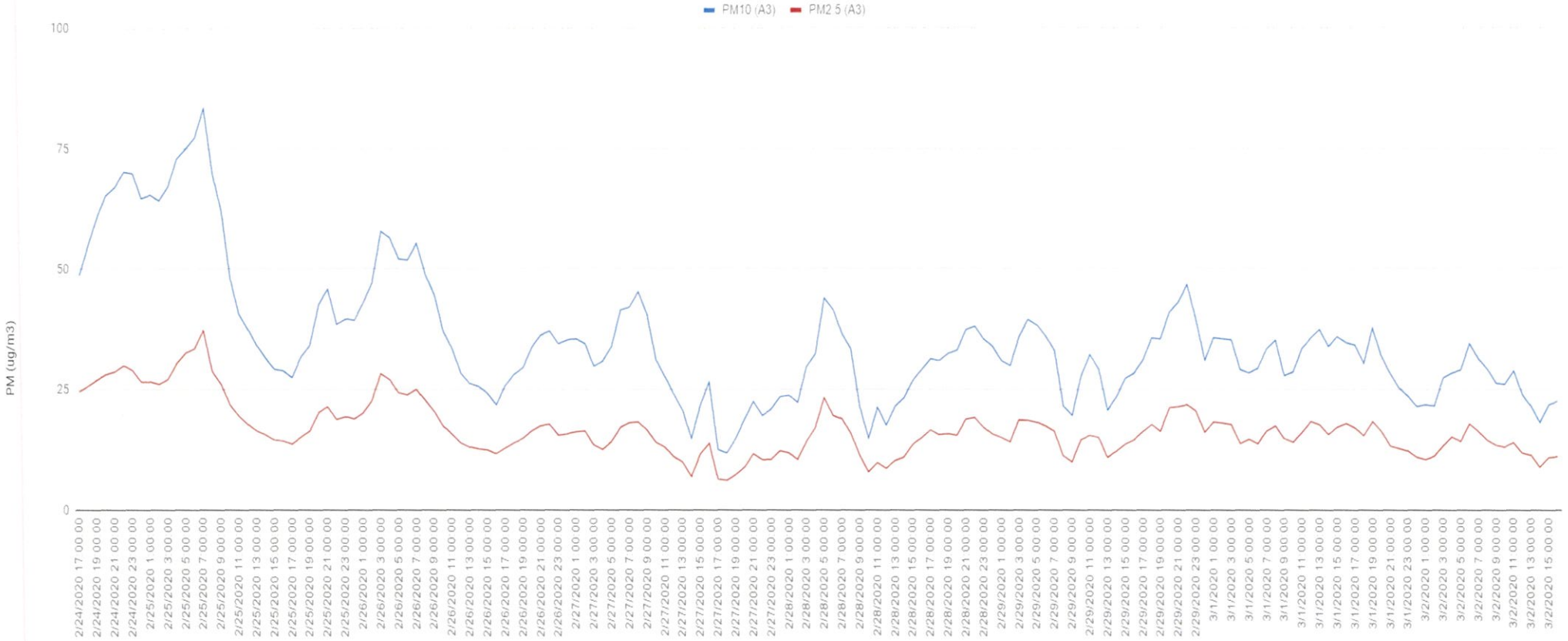

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PM2.5 (A3)
PM (ug/m3)
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3/2/2020 7:00:00
3/2/2020 9:00:00
3/2/2020 11:00:00
3/2/2020 13:00:00
3/2/2020 15:00:00

Photo 1: Ambient Air Monitoring Station at Location A1 (10/02/20 to 17/02/20)



Photo 2: Ambient Air Monitoring Station at Location A2 (17/02/20 to 24/02/20)



Photo 3: Ambient Air Monitoring Station at Location A3 (24/02/20 to 02/03/20)

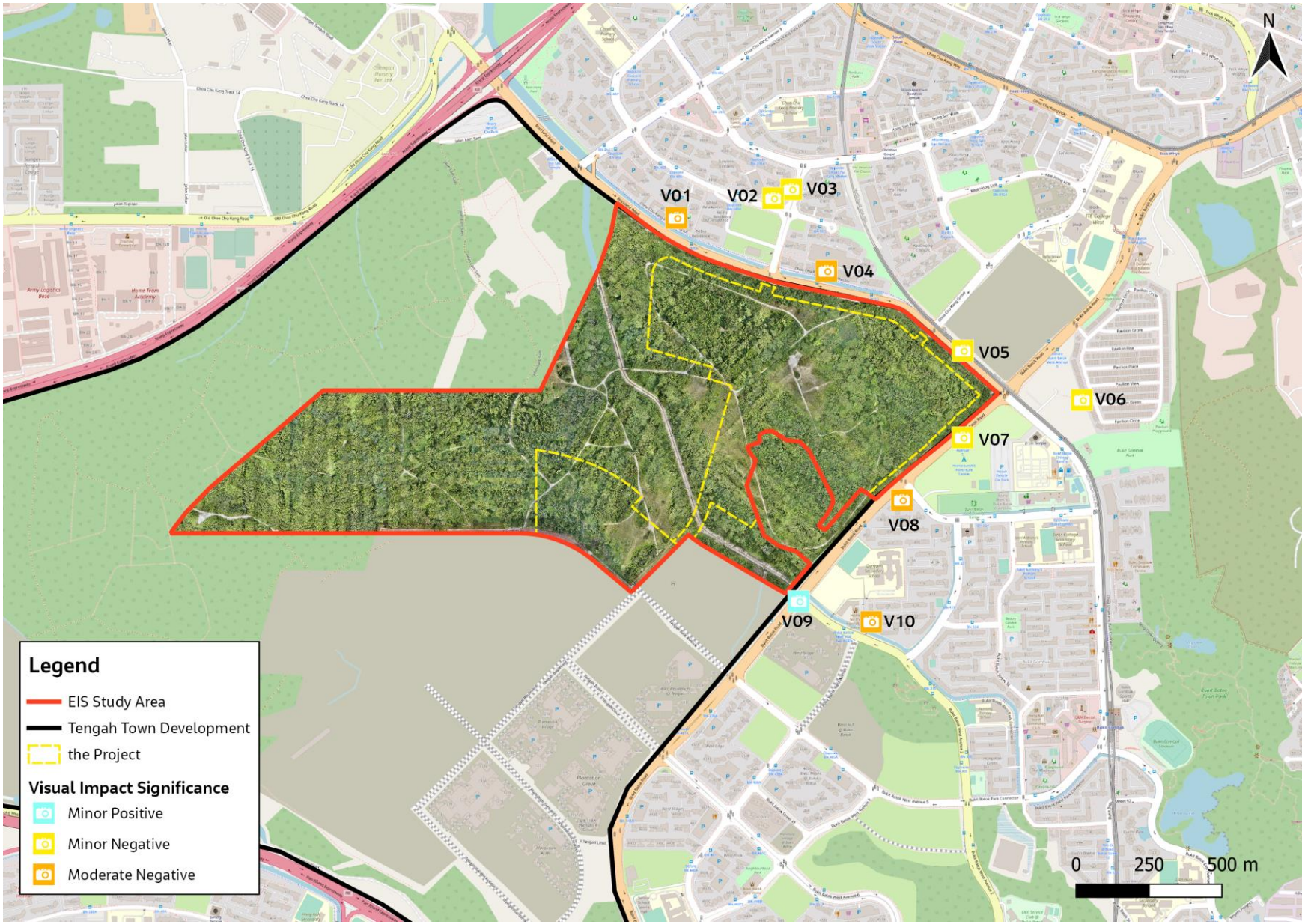


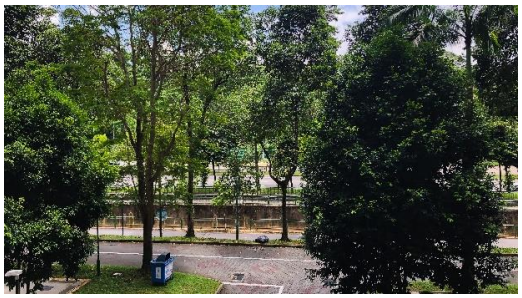
Appendix 9B: Photographic Log of Ambient Air Quality Sampling

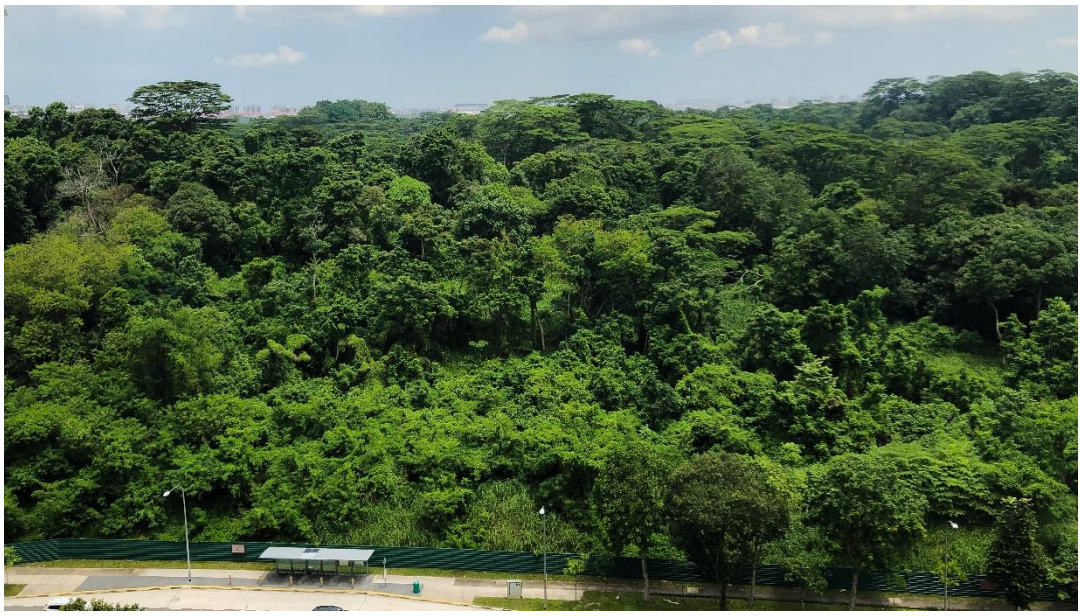
Appendix 9B: Photographic Log of Ambient Air Quality Sampling

Details	Photograph
Photograph ID: 1 **Sample ID:** A1 **Photo Location:** At an open space of the ground floor of Block 484B Choa Chu Kang Avenue 5 **Sampling Date:** 10 Feb to 17 Feb 2020	
Photograph ID: 2 **Sample ID:** A2 **Photo Location:** At an open space of the ground floor of Block 805C Kean Hong Close **Sampling Date:** 17 to 24 Feb 2020	
Photograph ID: 3 **Sample ID:** A3 **Photo Location:** At an open space of the ground floor of Block 484B Choa Chu Kang Avenue 5 **Sampling Date:** 24 Feb to 2 Mar 2020	

Appendix 10A: Detailed Assessment of Visual Impacts to the Various Viewpoints


N
V01
V02
V03
V04
V05
V06
V07
V08
V09
V10
Legend
EIS Study Area
Tengah Town Development
the Project
Visual Impact Significance
Minor Positive
Minor Negative
Moderate Negative
0
250
500 m

Viewpoint 01 (VO1): Block 485A Choa Chu Kang		
Location		
Visual Description	V01 has views into the north side of the EIS Study Area. It has clear open views of the forest is near enough that trees can identified as unique elements within the site. On the higher floors, the views are quite expansive, stretching quite far into the distance. Views on the lower floors, 8th and below, into the EIS Study Area are screened by roadside trees.	
VSRs	Residents with the occasional visitors to the homes.	
Existing View	 Level 3	 Level 8

Viewpoint 01 (VO1): Block 485A Choa Chu Kang			
	 Level 16		
Construction Phase View	Minor amount of land clearance/ trees felling and construction work as it mostly faces into the area which is marked out to be reserved as a park. The forest fringe buffer is also expected to be retained in front of this VSRs which will continue to screen out lower views.		
Operation View	Mix of residential area and the park /forest. A large visual change from baseline is not expected. Views into the new development are expected to still be screened by vegetation at the lower floors.		
Magnitude of Visual Change (Higher Floors, above 8th)	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible.	High
	Distance	< 75 m away. Can easily dominate the landscape.	High
	Landscape Character	View of forest.	High Sensitivity
	Number of VSRs	Large number of residents staying across the various higher floors (above 8th).	High
	Duration	Large amount of time spent at residential estates.	High
	Overall	Although the potential to impact is high, the visual change is very minimal, reducing the overall impact.	**Major Visual Change (A2.2)**
Rapid Impact Assessment Matrix (RIAM)	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is highly noticeable and will result in significant adverse impacts. All of the criteria used to assess the visual changes are rated high for the higher floors.	**3: Major**
		The visual change effect is barely discernible over the current baseline view. The view is predominately screened by intervening vegetation for the lower floors.	**0: Negligible**

Viewpoint 01 (VO1): Block 485A Choa Chu Kang				
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.		**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.		**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.		**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.		**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.		**3: Cumulative**
	Environmental Score (ES)	**(-8) x (13) = -104**	**For VSRs on the higher floors – above 8th floor**	
		(0) x (13) = 0	**For VSRs on the lower floors – 8th floor and below**	
	Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	**For VSRs on the higher floors – above 8th floor**	
		Negligible/ No Change	**For VSRs on the lower floors – 8th floor and below**	

Viewpoint 02 (VO2): Block 490A Choa Chu Kang Ave 5	
Location	
Visual Description	V02 has views into the north side of the EIS Study Area. It has clear open views of the forest but is some distance away, resulting in a large part of the view being part of the open empty field and two low

<table>
<tr><th colspan="4">Viewpoint 02 (VO2): Block 490A Choa Chu Kang Ave 5</th></tr>
<tr><td></td><td colspan="3">buildings. The various floors in the block have various views but most floors can largely view into the EIS Study Area. The distance away from the Study Area allow for several forest layers to be seen.</td></tr>
<tr><td>VSRs</td><td colspan="3">Residents with the occasional visitors to the homes.</td></tr>
<tr><td>Existing View</td><td colspan="3"> 
Level 3
 
Level 7
 
Level 16</td></tr>
<tr><td>Construction Phase View</td><td colspan="3">Largely land clearance/ trees felling and construction work.</td></tr>
<tr><td>Operation View</td><td colspan="3">Visual change from baseline would be the replacement of most of the vegetation seen now by buildings.</td></tr>
<tr><td>Magnitude of Visual Change</td><td colspan="3"><table>
<tr><th>Criteria</th><th>Impact</th><th>Impact Rating</th></tr>
<tr><td>Visibility</td><td>Clearly visible</td><td>High</td></tr>
<tr><td>Distance</td><td>280 m away. Noticeable and can dominate the landscape.</td><td>Moderate</td></tr>
<tr><td>Landscape Character</td><td>View of forest.</td><td>High Sensitivity</td></tr>
<tr><td>Number of VSRs</td><td>Large number of residents staying across the various floors.</td><td>High</td></tr>
<tr><td>Duration</td><td>Large amount of time spent at residential estates</td><td>High</td></tr>
<tr><td>Overall</td><td>The impact rating for most criteria is high but viewpoint is set relatively far back.</td><td>Moderate Visual Change (A2.2)</td></tr>
</table></td></tr>
</table>

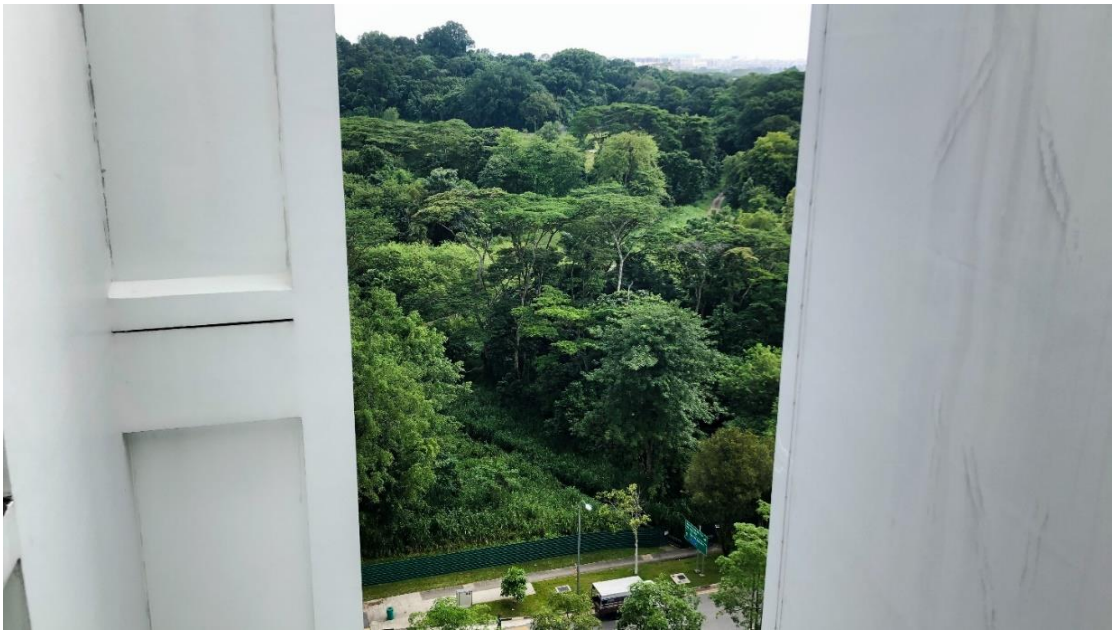
Viewpoint 02 (VO2): Block 490A Choa Chu Kang Ave 5			
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is noticeable and may result in significant adverse impacts. Most of the criteria used to assess the visual changes are rated higher than low.	**2: Moderate**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(-8) x (13) = - 104**
	Range Bands ES/ Impact Severity Significance		**Moderate Negative Impact**

Viewpoint 03 (VO3): Bus Stop – Blk 490B	
Location	

Viewpoint 03 (VO3): Bus Stop – Blk 490B			
Visual Description	V03 has views into the north side of the EIS Study Area. It has limited horizontal view of the forest, with the sides being blocked by HDB buildings and road side trees. The limited view consists of several layers of trees, including several tall ones. Due to the considerable distance away, a large part of the view consists of the road leading to the site.		
VSRs	Drivers, passengers, in particular those waiting for buses, as well as joggers and pedestrians travelling by.		
Existing View			
Construction Phase View	Largely land clearance/ trees felling and construction work.		
Operation View	Replacement of most of the vegetation seen now by buildings.		
Magnitude of Visual Change	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Limited visibility.	Moderate
	Distance	330 m. Noticeable but may not dominate the landscape.	Moderate
	Landscape Character	View of forest.	High Sensitivity
	Number of VSRs	Large number of pedestrians, driver and passengers.	High
	Duration	Fleeting time spent	Low
	Overall	Impact rating for most criteria is moderate/ high but time spent in this location is very limited for most.	**Minor Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	Visual change is noticeable but will not result in significant adverse impacts. One or more of the criteria used to assess the visual changes are rated low.	**1: Minor**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**

Viewpoint 03 (VO3): Bus Stop – Blk 490B			
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(-4) x (13) = -13**
	Range Bands ES/ Impact Severity Significance		**Minor Negative Impact**

Viewpoint 04 (VO4): Block 805B Keat Hong Close		
Location		
Visual Description	V04 has views into the north side of the EIS Study Area. It has clear open views of the forest and scrubland and is near enough that trees can identified as unique elements within the site. A gap in the vegetation suggests the presence of a drain but the drain is not actually visible. A dirt road can be seen from the higher floors. Views on the lower floors, 9th and below, into the EIS Study Area are partially screened by roadside trees.	
VSRs	Residents with the occasional visitors to the homes.	
Existing View	 Level 3	 Level 9

Viewpoint 04 (VO4): Block 805B Keat Hong Close			
	 Level 17		
Construction Phase View	During the construction phase, it is expected that the VSRs on the top floor would see largely land clearance/tree felling and construction work. A forest fringe buffer is expected to be kept in front of these VSRs which will screen out lower views into the construction site.		
Operation View	View of residential area. The visual change from baseline would be the replacement of most of the vegetation seen now by buildings for the top floors. The retained forest fringe buffer is expected to continue to screen lower views into the new development.		
Magnitude of Visual Change (Higher Floors, above 9th)	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible	High
	Distance	50 m away. Can easily dominate the landscape.	High
	Landscape Character	View of forest	High Sensitivity
	Number of VSRs	Large number of residents staying across the higher floors (above 9th).	High
	Duration	Large amount of time spent at residential estates	High
	Overall	The impact rating for all criteria is high.	**Major Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is highly noticeable and will result in significant adverse impacts. All of the criteria used to assess the visual changes are rated high.	**3: Major**
		The visual change effect is barely discernible over the current baseline view. The view is predominately screened by intervening vegetation.	**0: Negligible**

Viewpoint 04 (VO4): Block 805B Keat Hong Close			
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)	**(-12) x (13) = -156**	**For VSRs on the higher floors – above 9th floor**
		(0) x (13) = 0	**For VSRs on the lower floors – 9th floor and below**
	Range Bands ES/ Impact Severity Significance	**Moderate Negative Impact**	**For VSRs on the higher floors – above 9th floor**
		Negligible/ No Change	**For VSRs on the lower floors – 9th floor and below**

Viewpoint 05 (VO5): MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations	
Location	

Viewpoint 05 (VO5): MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations			
Visual Description	V05 was taken from a travelling elevated MRT heading north from Bukit Gombak to Choa Chu Kang MRT Stations. It has views into the north-east side of the EIS Study Area. It has clear elevated views of the forest and scrubland. Although the train travels relatively slowly in this region, it is fast enough that unique elements are difficult to identify.		
VSRs	MRT passengers. However, not all of which would be facing this direction of the EIS Study Area.		
Existing View	 		
Construction Phase View	Largely land clearance/tree felling and construction work. A forest fringe buffer is expected to be kept in front of this area which will screen out a considerable amount of view.		
Operation View	View would be of a commercial and residential area with the forest fringe screening some views. The visual change from baseline would be the view of buildings behind the present vegetation in view.		
Magnitude of Visual Change	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible.	High
	Distance	30 m away. Dominates the landscape but not easy to identify unique elements due to train movement.	Moderate
	Landscape Character	View of forest.	High Sensitivity
	Number of VSRs	Moderate, as not all passengers would be facing the area.	Moderate
	Duration	Fleeting	Low
	Overall	The impact rating for most criteria is high but time spent is limited.	**Minor Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is noticeable but will not result in significant adverse impacts. One or more of the criteria used to assess the visual changes are rated low.	**1: Minor**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**

Viewpoint 05 (VO5): MRT – Between Bukit Gombak and Choa Chu Kang MRT Stations			
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(-4) x (13) = -52**
	Range Bands ES/ Impact Severity Significance		**Minor Negative Impact**

Viewpoint 06 (VO6): Pavilion Circle	
Location	
Visual Description	V06 has views into the northeast side of the EIS Study Area. It has clear open views of the forest but is some distance away, resulting in a large part of the view being part of the open empty field. The MRT track also runs across blocking some of the view.
VSRs	Residents with the occasional visitors to the homes.
Existing View	
Construction Phase View	Largely land clearance/tree felling and construction work.

Viewpoint 06 (VO6): Pavilion Circle			
Operation View	View of a commercial and residential area. The visual change from baseline would be the replacement of most of the vegetation seen now by buildings with a forest fringe screening the bottom portion.		
Magnitude of Visual Impact	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible.	High
	Distance	> 320 m away. Noticeable but may not dominate the landscape.	Moderate
	Landscape Character	View of forest.	High Sensitivity
	Number of VSRs	Low. Landed properties have a lower density of residents and limited number of houses have views facing the area.	Low
	Duration	Large amount of time spent at residential estates	High
	Overall	The impact rating for most criteria is moderate or high but the number of VSRs is low.	**Minor Negative Visual Impact (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is noticeable but will not result in significant adverse impacts. One or more of the criteria used to assess the visual changes are rated low.	**1: Minor**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(-4) x (13) = -52**
	Range Bands ES/ Impact Severity Significance		**Minor Negative Impact**

<table>
<tr><th colspan="4">Viewpoint 07 (V07): Bus Stop – Aft Bukit Batok West Ave 5</th></tr>
<tr><td>Location</td><td colspan="3">  </td></tr>
<tr><td>Visual Description</td><td colspan="3">V07 has views into the east side of the EIS Study Area. It has clear open views of the forest but is partially screened by the site hoardings and roadside trees. The low angle results in the views being only of the outer trees and scrubland of Tengah without deeper views within.</td></tr>
<tr><td>VSRs</td><td colspan="3">Mostly be drivers, passengers, in particular those waiting for buses, as well as joggers and pedestrians travelling by.</td></tr>
<tr><td>Existing View</td><td colspan="3">  </td></tr>
<tr><td>Construction Phase View</td><td colspan="3">Largely land clearance/ tree felling and construction work.</td></tr>
<tr><td>Operation View</td><td colspan="3">View of residential and commercial area with a forest fringe nearer to it. The visual change from baseline would be a blockage of the sky but with vegetation still lining the view.</td></tr>
<tr><td rowspan="4">Magnitude of Visual Impact</td><td>Criteria</td><td>Impact</td><td>Impact Rating</td></tr>
<tr><td>Visibility</td><td>Clearly visible</td><td>High</td></tr>
<tr><td>Distance</td><td>< 50 m away. Easily dominates the landscape.</td><td>High</td></tr>
<tr><td>Landscape Character</td><td>View of forest.</td><td>High Sensitivity</td></tr>
</table>

Viewpoint 07 (VO7): Bus Stop – Aft Bukit Batok West Ave 5			
	Number of VSRs	Large number of pedestrians, driver and passengers.	High
	Duration	Fleeting time spent	Low
	Overall	The impact rating for most criteria is high but time spent in this location is very limited for most.	**Minor Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is noticeable but will not result in significant adverse impacts. One or more of the criteria used to assess the visual changes are rated low.	**1: Minor**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(-4) x (13) = -52**
	Range Bands ES/ Impact Severity Significance		**Minor Negative Impact**

<table>
<tr><th colspan="3">Viewpoint 08 (V08): Block 405 Bukit Batok West</th></tr>
<tr><td>Location</td><td colspan="2">  </td></tr>
<tr><td>Visual Description</td><td colspan="2">V08 has views in the east side of the EIS Study Area. It has clear open views of the forest and scrubland and is near enough that trees can identified as unique elements within the site. The presence of a dirt road can be seen from on the higher floors. Views on the lower floors, 8th and below, into the EIS Study Area are partially screened by roadside trees.</td></tr>
<tr><td>VSRs</td><td colspan="2">Residents with the occasional visitors to the homes.</td></tr>
<tr><td>Existing View</td><td> 
Level 3</td><td> 
Level 8</td></tr>
</table>

Viewpoint 08 (VO8): Block 405 Bukit Batok West			
	 Level 16		
Construction Phase View	During the construction phase, it is expected that the VSRs on the top floor would see largely land clearance/tree felling and construction work. A forest fringe buffer is expected to be kept in front of these VSRs which will screen out lower views into the construction site.		
Operation View	View of residential area. The visual change from baseline would be the replacement of most of the vegetation seen now by buildings for the top floors. The retained forest fringe buffer is expected to continue screen lower views into the new development.		
Magnitude of Visual Change (Higher Floors only, above 8th)	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible	High
	Distance	50 m away. Easily dominates the landscape.	High
	Landscape Character	View of forest, scrubland and a dirt road.	High Sensitivity
	Number of VSRs	Large number of residents staying across the higher floors.	High
	Duration	Large amount of time spent at residential estates	High
	Overall	The impact rating for all criteria is high.	**Major Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is highly noticeable and will result in significant adverse impacts for the higher floors, above 8th. All of the criteria used to assess the visual changes are rated high.	**3: Major**

Viewpoint 08 (VO8): Block 405 Bukit Batok West			
		The visual change effect is barely discernible over the current baseline view for lower floors. The view is predominately screened by intervening vegetation.	**0: Negligible**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)	**(-12) x (13) = -156**	**For VSRs on the higher floors – above 8th floor**
		(0) x (13) = 0	**For VSRs on the lower floors – 8th floor and below**
	Range Bands ES/ Impact Severity Significance	**Moderate negative impact**	**For VSRs on the higher floors – above 8th floor**
		Negligible/ No Change	**For VSRs on the lower floors – 8th floor and below**

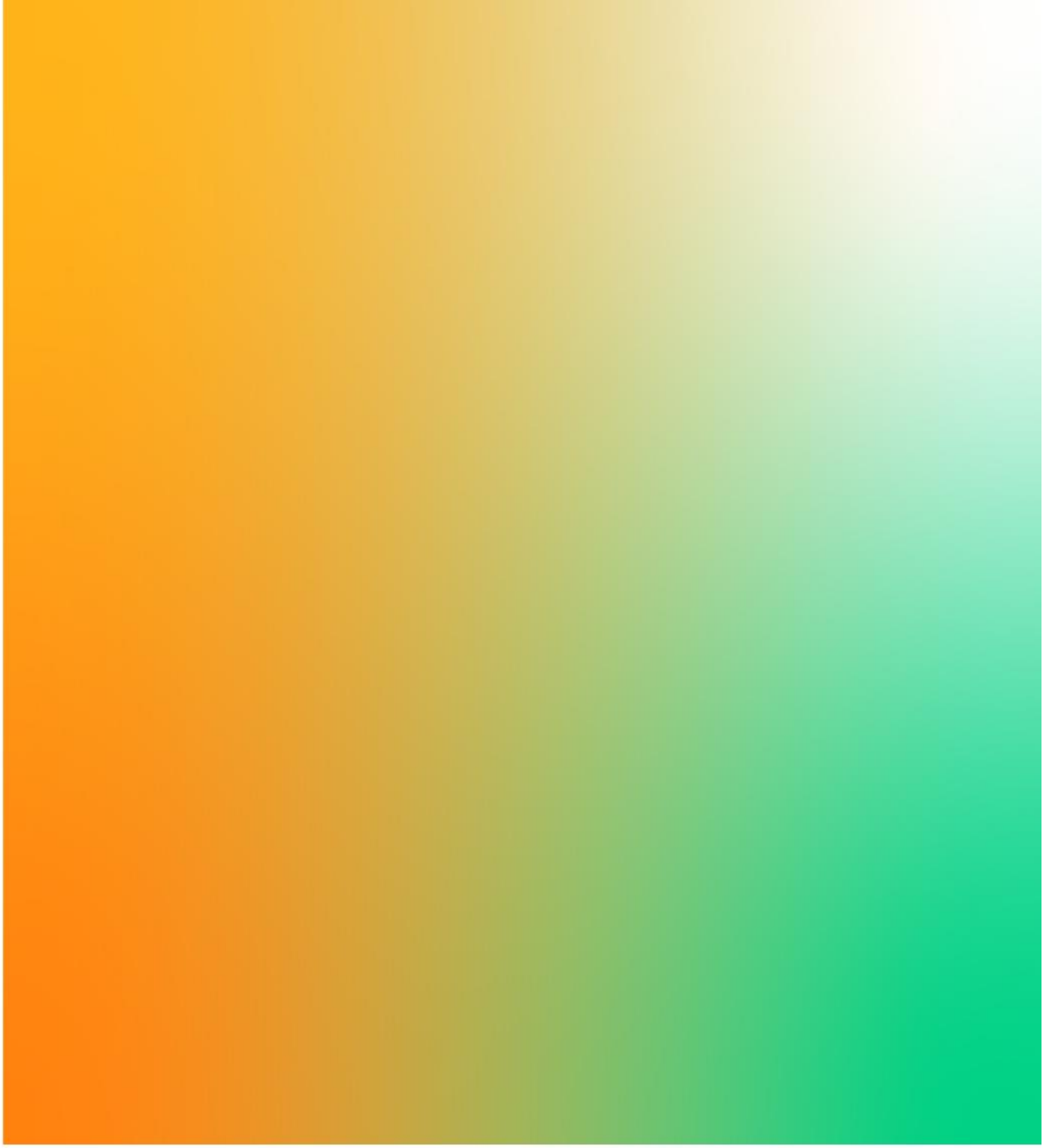
<table>
<tr><th colspan="4">Viewpoint 09 (V09): Intersection between Bukit Batok Road and Bukit Batok West Avenue 2</th></tr>
<tr><td>Location</td><td colspan="3">  </td></tr>
<tr><td>Visual Description</td><td colspan="3">V09 has views into the east side of the EIS Study Area. It has clear open views of the forest but is partially screened by the site hoardings and roadside trees. The low angle results in the views being only of the outer trees of Tengah without deeper views within. It has a view of the canal. To the east of the view, is cleared land for the construction of other HDBs in the Tengah Town Development.</td></tr>
<tr><td>VSRs</td><td colspan="3">Drivers, passengers, as well as joggers and pedestrians travelling by.</td></tr>
<tr><td>Existing View</td><td colspan="3">   </td></tr>
<tr><td>Construction Phase View</td><td colspan="3">It is expected that this viewpoint would have most of its visuals retained as it is slated for the Forest Corridor. There may be minor construction done in the area to turn the concrete canal into a naturalised canal (Forest Stream).</td></tr>
<tr><td>Operation View</td><td colspan="3">Visual change from baseline would be limited and with the possibility of increasing the natural look of the place resulting in a positive impact.</td></tr>
<tr><td rowspan="5">Magnitude of Visual Impact</td><td>Criteria</td><td>Impact</td><td>Impact Rating</td></tr>
<tr><td>Visibility</td><td>Clearly visible</td><td>High</td></tr>
<tr><td>Distance</td><td>< 50 m away. Easily dominates the landscape.</td><td>High</td></tr>
<tr><td>Landscape Character</td><td>View of main canal.</td><td>Low</td></tr>
<tr><td>Number of VSRs</td><td>Large number of pedestrians, driver and passengers.</td><td>High</td></tr>
</table>

Viewpoint 09 (VO9): Intersection between Bukit Batok Road and Bukit Batok West Avenue 2			
	Duration	Fleeting time spent	Low
	Overall	The impact rating for most criteria is high but time spent in this location is very limited for most.	**Minor Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a gain in quality of view.	**1: Positive**
	A2.2: Magnitude of Changes	The visual change is noticeable but will not result in significant impacts. One or more of the criteria used to assess the visual changes are rated low.	**1: Minor**
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)		**(4) x (13) = 52**
	Range Bands ES/ Impact Severity Significance		**Minor Positive Impact**

Viewpoint 10 (VO10): Block 426 Bukit Batok West	
Location	
Visual Description	V10 has views into the east side of the EIS Study Area. It has open views of the forest including further into the site more than a kilometre in. The view is limited by the buildings of old Hong Kah Primary School and Bukit Batok Home for the Aged in front. To the east of the view is cleared land for the construction of other HDBs in the Tengah Town Development. The views can only be seen from the higher floors, above 5th floor, of the block.
VSRs	Residents with the occasional visitors to the homes.
Existing View	 Level 10

Viewpoint 10 (VO10): Block 426 Bukit Batok West			
	 Level 5		
Construction Phase View	It is expected that this viewpoint would have its part of the visuals retained as it is slated for the Forest Corridor. The rest of the area would see largely land clearance/tree felling and construction work. The lower floors, 5th floor and below, will be screened by the buildings in front of it.		
Operation View	View of the forest corridor and residential areas. The visual change from baseline would be the replacement of part of the vegetation seen now by buildings. The lower floors will continue to be screened by the buildings in front of it.		
Magnitude of Visual Change (Higher Floors only, above 5th)	**Criteria**	**Impact**	**Impact Rating**
	Visibility	Clearly visible	High
	Distance	260 m away. Noticeable and can dominate the landscape.	Moderate
	Landscape Character	View of forest but with cleared land in the view reducing sensitivity.	Moderate sensitivity
	Number of VSRs	Large number of residents staying across the top floors.	High
	Duration	Large amount of time spent at residential estates	High
	Overall	The impact rating for most criteria is moderate or high.	**Moderate Visual Change (A2.2)**
RIAM	**Assessment Criterion**	**Rating Justification/ Definition**	**Score Rating**
	A1: Value	Sensitive receivers are localised to those with a view in the 500 m visual buffer from Tengah.	**2: Tengah**
	A2.1: Impact Nature	Sensitive receivers perceive a loss in quality of view.	**-1: Negative**
	A2.2: Magnitude of Changes	The visual change is noticeable and may result in significant adverse impacts for views on the higher floors. Most of the criteria used to assess the visual changes are rated higher than low.	**2: Moderate**
		The visual change effect is barely discernible over the current baseline view. The lower view is predominately screened by intervening infrastructure	**0: Negligible**

Viewpoint 10 (VO10): Block 426 Bukit Batok West			
	A2.3: Impact Extent	Visual impacts extends outside of the Project boundary to the viewers in Tengah.	**2: Tengah**
	B1: Permanence	Infrastructure and other features constructed are meant to be a permanent fixture.	**4: Long Term**
	B2: Impact Pathway	Visual changes are a direct impact on the sensitive receivers.	**3: Direct**
	B3: Reversibility	Construction of infrastructure is permanent with the reversibility requiring demolition and rehabilitation of the site which take immense amount of efforts.	**3: Irreversible**
	B4: Cumulative	Part of a larger Tengah development which is similarly undergoing tree felling and construction works.	**3: Cumulative**
	Environmental Score (ES)	**(-4) x (13) = -52**	**For VSRs on the higher floors - above 5th floor**
		(0) x (13) = 0	**For VSRs on the lower floors – 5th floor and below**
	Range Bands ES/ Impact Severity Significance	**Minor Negative Impact**	**For VSRs on the higher floors - above 5th floor**
		Negligible/ No Change	**For VSRs on the lower floors – 5th floor and below**



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