

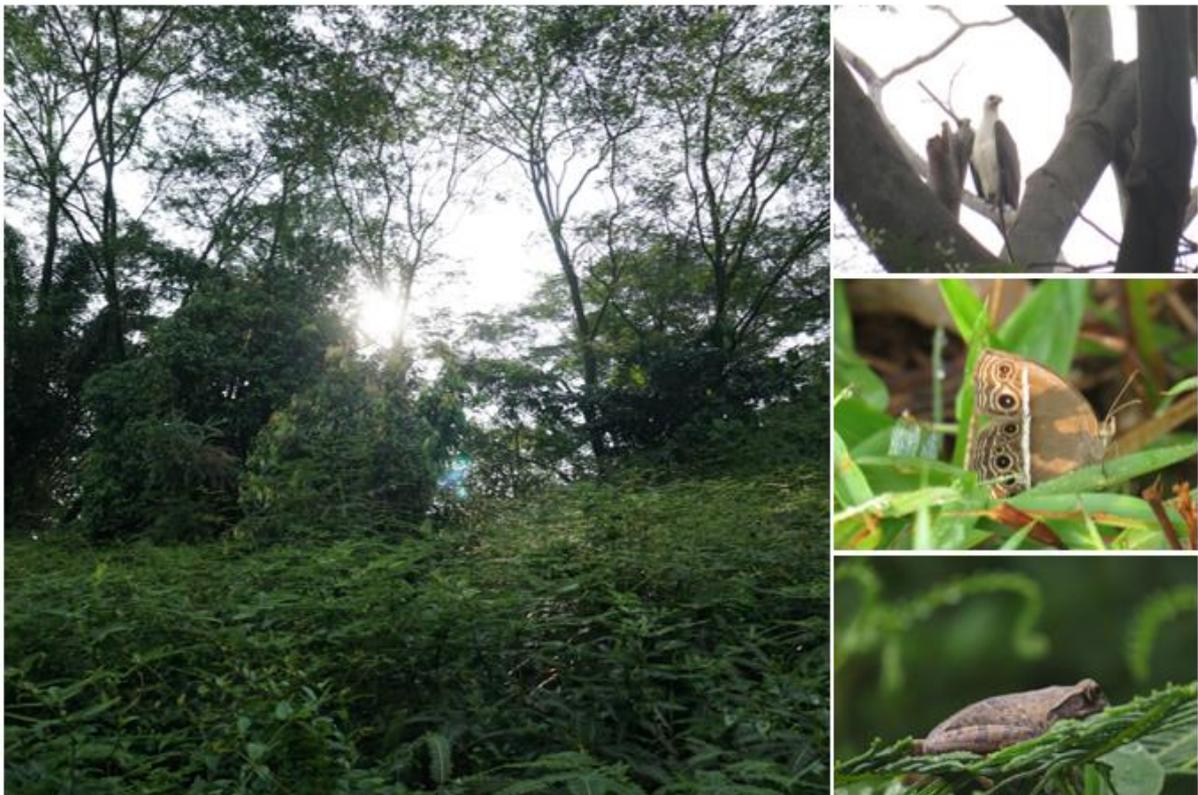
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WOODLANDS WAFER FAB PARK LAND PREPARATION WORKS

Final Biodiversity Impact Assessment Report



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ABBREVIATIONS

Abbreviation	Definition
BIA	Biodiversity Impact Assessment
CEMMP	Construction Environmental Management and Monitoring Plan
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
Cult.	cultivated
ECM	Earth Control Measure
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
ES	Environmental Score
GPS	Global Positioning System
ha	Hectare
IUCN	International Union for the Conservation of Nature
JTC	JTC Corporation
km	kilometer
LTA	Land Transport Authority
m	meter
MND	Ministry of National Development
MPA	Maritime and Port Authority of Singapore
NEA	National Environment Agency
NUS	National University of Singapore
n.d.	no date
NParks	National Parks Board
PUB	Public Utilities Board
RIAM	Rapid Impact Assessment Matrix
SRDB	Singapore Red Data Book
SS	Singapore Standards
SSO	Singapore Statutes Online
TAC	TEMBUSU Asia Consulting Pte Ltd
URA	Urban Redevelopment Authority
WWFP	Woodlands Wafer Fab Park

GLOSSARY

Abundance: The number of a single species recorded at any given time period or location.

Biodiversity: The variety of plant and animal life in the world, habitat or location, a high level of which is usually considered to be important and desirable. Biodiversity can be assessed at more focused taxonomic groups such as “bird biodiversity”, in which case it is interchangeably with “diversity”.

Conservation Status: A status given to a species that is threatened with becoming extinct either locally or globally. These species may be restricted to only a small area, show noticeable decline in abundance over time, or have a historically low global population size. Assessments can be made either at global level under the IUCN’s Red List of Threatened Species or at national level (e.g. Singapore’s Red Data Book of Threatened Plants and Animals).

Ecology: The pattern of relations between organisms and their environment.

Exotic: Species whose presence is a result of either intentional or unintentional human involvement.

Fauna: Referring to all animal life present in an area. Animals are defined as any species from the Kingdom Animalia.

Flora: Referring to all plant life present in an area. Plants are defined as any species from the Kingdom Plantae.

Genus: A taxonomic group above species. A genus consists of closely related species. For example, Grey Heron and Purple Heron are closely related species in the same genus *Ardea*, hence their scientific names are *Ardea cinerea* and *Ardea purpurea* respectively.

Habitat: The natural home or environment of an animal, plant, or other organisms.

Herpetofauna: A taxonomic sub-group that includes amphibians and reptiles.

Impact: Any positive or negative alteration of existing conditions caused directly or indirectly by the project.

Mitigation Measure: Means to prevent, reduce or control negative environmental effects of a project, and repair any damage to the environment caused by those effects through replacement, restoration, compensation or any other means.

Native: Species that have originated in a given area without human involvement or have arrived there without intentional or unintentional intervention of humans from an area in which they are native.

Odonates: A taxonomic sub-group of Insects that includes dragonflies and damselflies.

Population: The term population can be in reference to the total number of a species found in a given area (e.g. global population, or Singapore population). It is also used as a term to define distinct sub-sets of a species based on the level of inter-mixing. For example, an island may hold two populations of a species if there are two groups of the same species present and those groups are sufficiently prevented (geographically or behaviourally) from mixing, forming separate breeding populations.

Regeneration Forest: a forest that has its trees and plants regrown through various means, e.g. seed dispersion by wind and animals or through human assistance.

Species: The standard classification of living organisms. It is defined as a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. It is represented by the second word of the scientific name of an organism. For example, the scientific name of a Long-tailed Macaque is *Macaca fascicularis*, where *fascicularis* is its species name.

Taxa: In reference to a specific taxonomic group. In order of specificity, the taxonomic groups are Kingdom, Phylum, Class, Order, Family, Genus, Species.

Transect: A predefined line or belt along which observations and/or measurements are taken.

EXECUTIVE SUMMARY

JTC Corporation (JTC) plans to prepare the vegetated site off Woodlands Road in Woodlands Wafer Fab Park to anchor incoming strategic economic investments and create employment opportunities for Singaporeans. This development will involve land clearance and tree-felling of the vegetation within the site. TEMBUSU Asia Consulting Pte Ltd has been commissioned by JTC Corporation to provide consultancy services to conduct a biodiversity impact assessment for the land clearance stage of the project. The biodiversity impact assessment report has been prepared in accordance with the scope of work provided by the Client and taking into consideration consultations with the relevant public agencies.

This Biodiversity Impact Assessment (BIA) Report aims to provide a baseline assessment of the flora and fauna of the project site, identify the sensitive receptors pertaining to biodiversity, assess the potential impacts, and recommend appropriate mitigation measures to reduce the residual impacts to acceptable levels.

The project site is located in the northern region of Singapore. It is 120 m from Mandai Mangrove and Mudflat Nature Park, and about 400 m away from Marsiling Park. Its recent land use history and relative isolation from other green patches has left it relatively low in native biodiversity. However, the presence of several fast-growing, tall trees on the site makes this site suitable for nesting birds. The main findings for biodiversity have been summarised as follows.

At least 72 flora species were found in the project site during present surveys. The site consists of several vegetation types, including Albizia woodland, which comprises of tall introduced Albizia trees that form suitable nesting sites for breeding raptors. Most species found on the site were common native or introduced species. There was one locally vulnerable species found, *Oxyceros longiflorus*, but it is relatively common in other vegetated parts of Singapore such as nature reserves and forested areas. The conservation of this species on this site is deemed to be of low priority.

At least 123 fauna species were observed from baseline surveys. Species of conservation value were limited mainly to flying species such as birds, butterflies, and odonates, as these species were able to arrive and establish on the site following recent land clearance.

The forest within the project site is made of recently regrown vegetation, where habitat complexity is low. There are other green spaces around the project site with similar vegetation, which will act as alternative habitats for birds currently using the development site.

The project site is not directly connected, but in close proximity, to other green spaces such as the Mandai Mangrove and Mudflat Nature Park, the Rail Corridor, as well as several patches of woodlands in Kranji and Mandai. This network of green spaces can be utilized by birds as stepping stones as they move across sites.

The main project activity, land clearance, will generate impacts on the biodiversity of the project site. Impacts will be in the form of species mortality, habitat loss, and loss of connectivity. Additionally, potential impacts related to human-wildlife conflict and roadkill are

likely. The recommended mitigation measures, including the erection of proper hoarding, the translocation of any animals of conservation value, and the phased clearance of vegetation, aim to reduce these impacts related to biodiversity.

Overall, mitigation measures have been recommended based on the project activities. These prescribed measures, if diligently implemented during land clearance stage, should help to reduce the negative impacts on biodiversity generated from this project to acceptable levels. For the Woodlands Wafer Fab Park alone, proper implementation of the recommended mitigation measures (including no night works except for urgency or emergency cases, proper erection of noise barriers, and other noise mitigating measures) should minimise potential noise and light impacts to Mandai Mangrove and Mudflat Nature Park, and hence unlikely to affect the mudflats adversely. The construction phase EMMP should be developed once the Contractor is on board to monitor the impact of works on the environment.

1 INTRODUCTION

1.1 Project Background

JTC Corporation (JTC) is the Master Developer for the Woodlands Wafer Fab Park at Woodlands Industrial Park D. JTC is working to anchor incoming strategic economic investments which will be carried out in phases from 2023 to 2030. Projects will be located at Woodlands Wafer Fab Park, and will involve land clearance and tree-felling works within a vegetated site off Woodlands Road. A Biodiversity Impact Assessment (BIA) is required to study the impacts of the proposed land clearance to the site's environment and biodiversity and to recommend appropriate mitigation measures to minimise the impacts.

TEMBUSU Asia Consulting Pte Ltd (TAC) is commissioned by JTC Corporation to provide consultancy services to conduct an BIA for the project.

This BIA comprises of a biodiversity study which established the ecological baseline of the project site, studied the impacts of land clearance on the environment, and recommended appropriate mitigation measures. A biodiversity awareness training is also included to provide training for main personnel on site on biodiversity issues.

1.2 Biodiversity Impact Assessment Objectives

This BIA is conducted prior to the land clearance stage of the Woodlands Wafer Fab Park. The recommendations made in this report focus on the measures that are required to be implemented during the land clearance stage of this project to minimise the impact of the project's activities on biodiversity.

The principal objective of the BIA is to provide clear and concise technical information for decision-making on the potential environmental impacts associated with the land clearance project.

The key objectives of this BIA are to:

- Understand the biodiversity baseline through the collection of both primary and secondary data.
- Assess the impacts of the project on biodiversity during the land clearance stage.
- Present appropriate mitigation measures to reduce the level of impact on biodiversity for each activity assessed that has a moderate to major impact.

It is understood that the information presented in the BIA will contribute to decisions on:

- The overall acceptability of any adverse environmental consequences that are likely to arise as a result of the land clearance;
- The conditions and requirements for the land clearance to mitigate adverse biodiversity-related consequences whenever practicable;
- the acceptability of residual impacts after the proposed mitigation measures are implemented; and
- The proposed mitigation measures, in consultation with agencies.

1.3 Report Structure

This BIA report is structured as follows:

- Chapter 1 introduces the project background and the general information of the BIA, covering its objectives, report structure, and limitations.
- Chapter 2 provides the description of the proposed project, land use history of the project study area and its surroundings, and activities associated with the proposed project.
- Chapter 3 outlines the BIA approach, including its scope and impact assessment methodology that is applied in the preparation of this report.
- Chapter 4 presents the baseline study, assessment of environmental impacts on biodiversity and its proposed mitigation measures.
- Chapter 5 details the Biodiversity Management Framework for the project.
- Chapter 6 lists the references used in the report.

1.4 Limitations of the BIA Report

The scope of this BIA report was developed through discussions with JTC. This BIA report is only focused on the land clearance activities planned at this stage and does not cover any future developmental activities to be carried out by JTC within the project site. This BIA is meant to focus on only biodiversity issues (i.e. flora and fauna) and is not meant to be a comprehensive study of all the environmental aspects. The extent of collection of baseline data and assessment of impacts is guided by these considerations.

In preparing this report, we relied, in whole or in part, on data and information provided by JTC and third parties, which have been assumed to be accurate, complete, and reliable as of the time of writing.

2 PROJECT OVERVIEW

2.1 Project Location

The project site is in the northern region of Singapore. It is located on former industrial land at 1°26'2.43"N 103°45'47.63"E. It is bounded by Woodlands Road in the north, an open field in the south that is currently undergoing construction for industrial use, and industrial developments in the east. (Figure 2.1). The total land area is 8.4 ha and undulating with existing platform levels ranging from +3.5 m (along northwest boundary) to +11.5 m (along the southeast boundary).

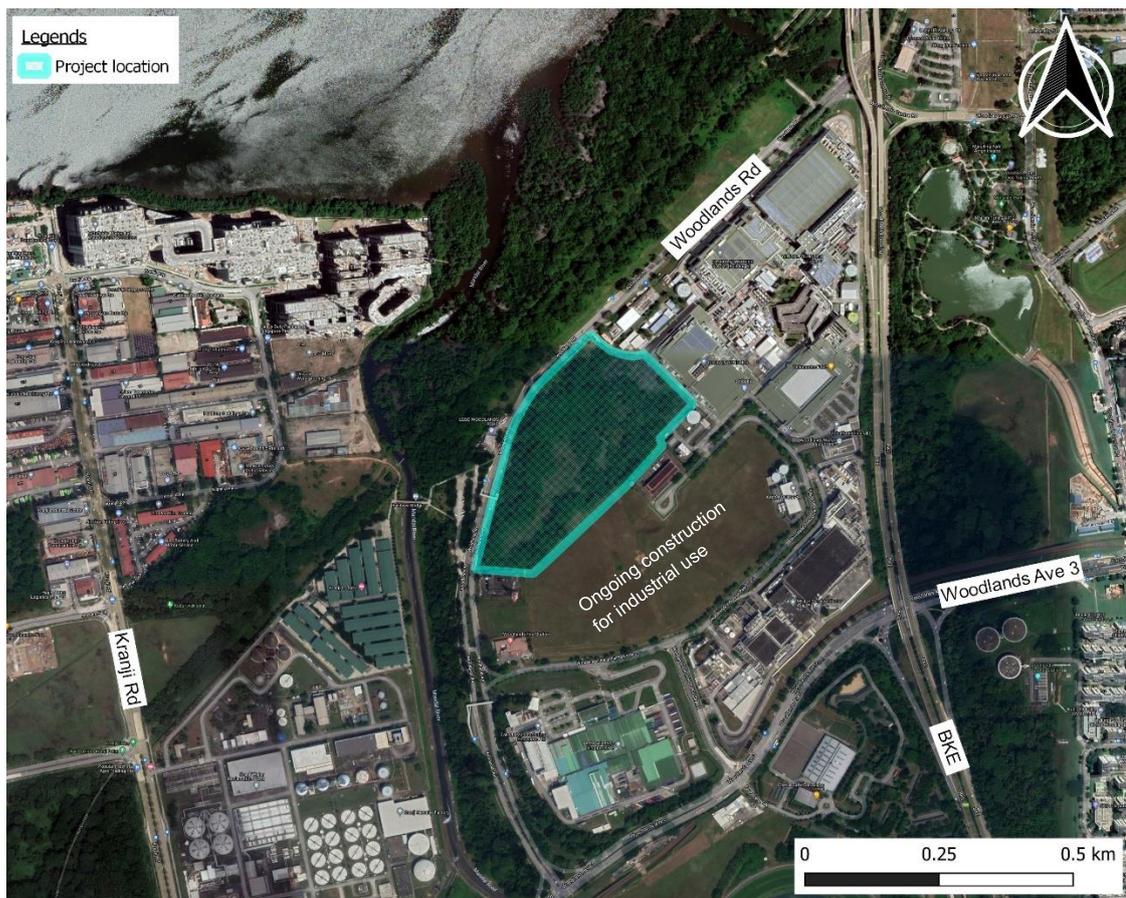


Figure 2.1. Location plan of proposed project

2.2 Land Use History

The Malayan Metal Box company factory (Figure 2.7) was the most significant recent land use for the development site. Clearing and levelling for the factory occurred soon after World War 2 and the buildings remained in place until circa 2000. The site was left unoccupied from circa 2000 until the present day (Figure 2.8), allowing spontaneous regrowth to establish. The site today is covered with mixed native and exotic regeneration dominated in part by Albizia woodland with areas of herbaceous. The overall land use summary is as follows:

19 th century	The site was originally cleared of forest as part of extensive gambier and pepper cultivation that covered most of Singapore Island (Figure 2.2)
Early 20 th century	The site was part of the Marsiling Rubber Estate and used for rubber cultivation at least for the early part of the twentieth century and possibly up to the war years (Figure 2.3).
Middle of 20 th century	The Malayan Metal Box Company factory was established on site soon after World War II. The site was levelled, and factory buildings established (Figure 2.4 and Figure 2.5).
Later 20 th and early 21 st century	The site was zoned for 'industry' in Master Plan 1980 and alienated by JTC in 1998 for industrial development. The industrial buildings remained in place until circa 2000. The 2002 topo map shows the site without structures. Spontaneous regrowth would have commenced at this time (Figure 2.6).

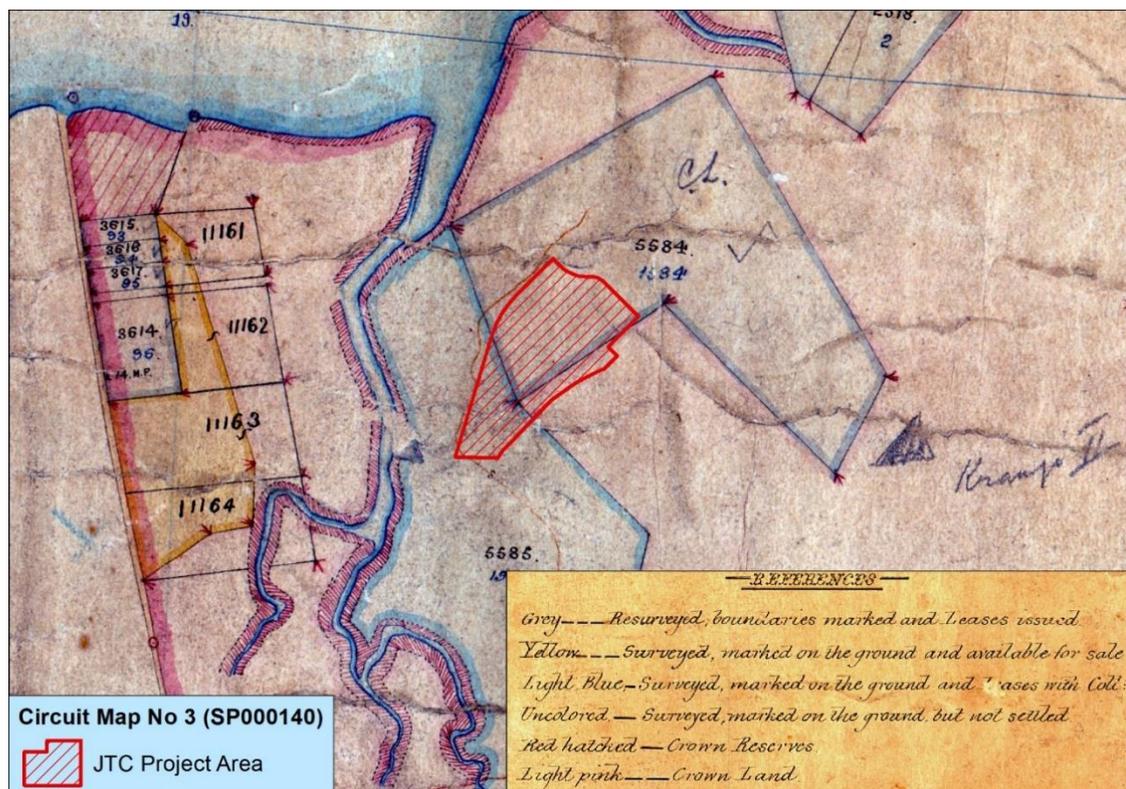


Figure 2.2. 19th century gambier and pepper plantations
(National Archives Singapore SP000140)

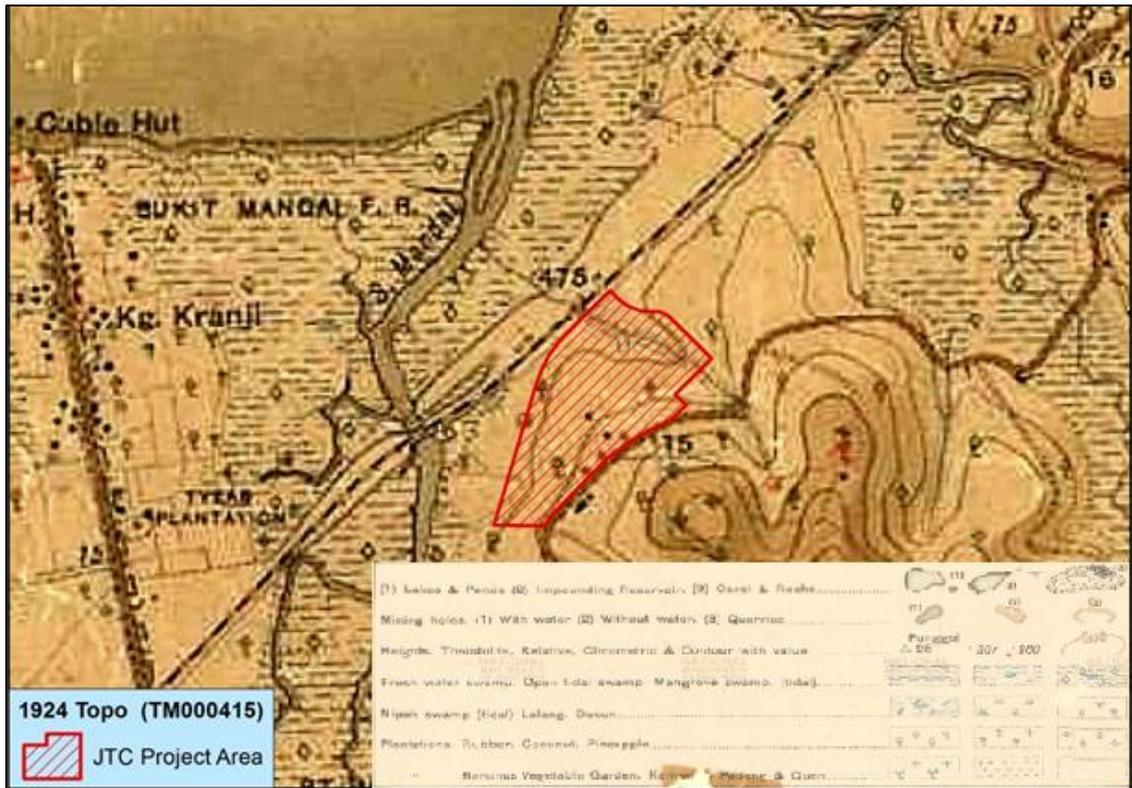


Figure 2.3. Early 20th century rubber plantation (National Archives Singapore TM000415)

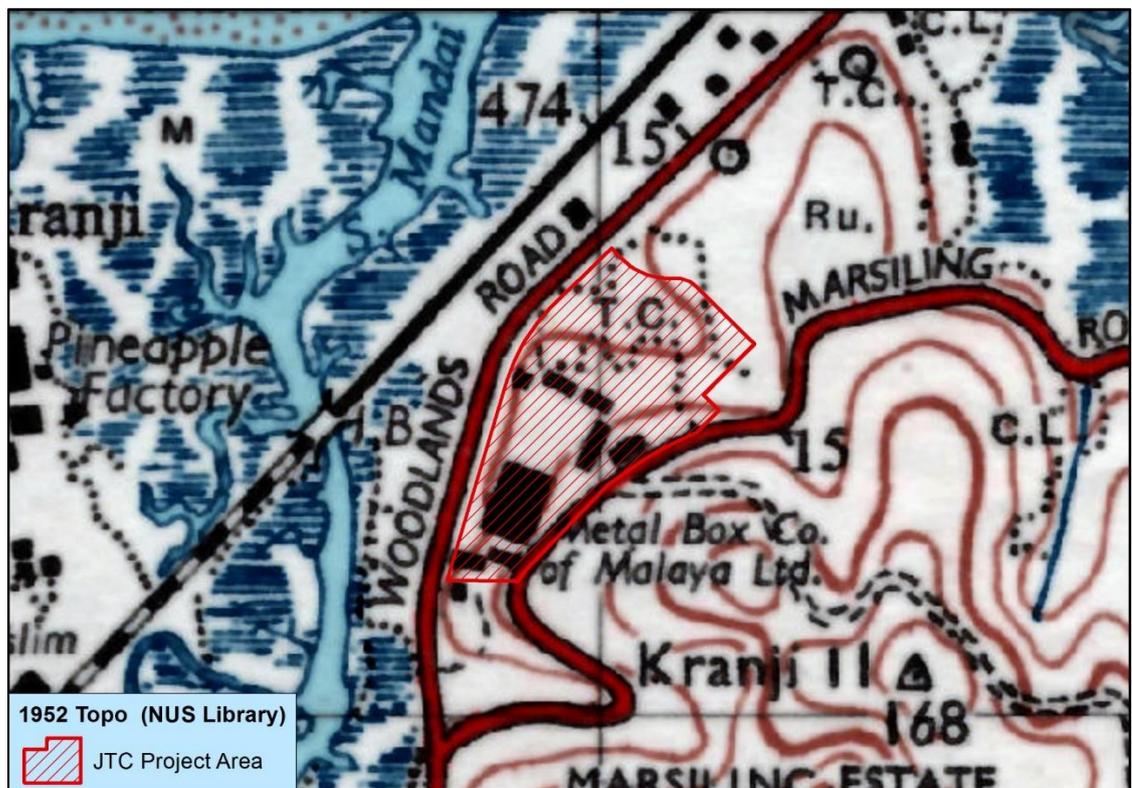


Figure 2.4. 1952 Topographic Map (NUS Map Library)



Figure 2.5. 1963 aerial photography (National Archives Singapore)



Figure 2.6. 2002 Topographic Map (NUS Map Library)



Figure 2.7. Malayan Metal Box Company in 1963 (National Archives Singapore PCD0266 – 0018)



Figure 2.8. The original entrance to the Malayan Metal Box Company
The metal gates remain until the present time.

2.4 Proposed Development

2.4.1 Project Footprint

JTC is working to anchor incoming strategic economic investment projects which are planned to be carried out in phases from 2023 to 2030 in Woodlands Wafer Fab Park. This current phase of the project involves the clearance of land in the project site in preparation for part of the Woodlands Wafer Fab Park development.

The project's scope of works for land clearance comprises following activities:

- Erection of hoarding and construction of perimeter drains.
- Felling of trees.

Within this scope of work, the hoarding works are targeted to commence in 2022. However, it should be noted that scope of works may overlap and not be carried out sequentially.

Figure 2.10 shows the satellite image of the area where tree-felling will be conducted to clear the land.



Figure 2.10. Proposed area for tree-felling

2.4.2 Activities Associated with Proposed Project

This study focuses on the first phase of the development, which entails land clearance on the site prior to allocation to a company for their construction project.

- The sequence of works for the land clearance works in this development is as follows:
- Erection of hoarding commencing from southeast boundary and towards northwest boundary (Woodlands Road).
 - Construction of perimeter drains.
 - Felling of trees within the site.

The site works are targeted to commence from 3Q 2022, implemented in two phases, and complete in 1Q 2023 (Figure 2.11). Tree felling works are targeted to commence from August 2022.

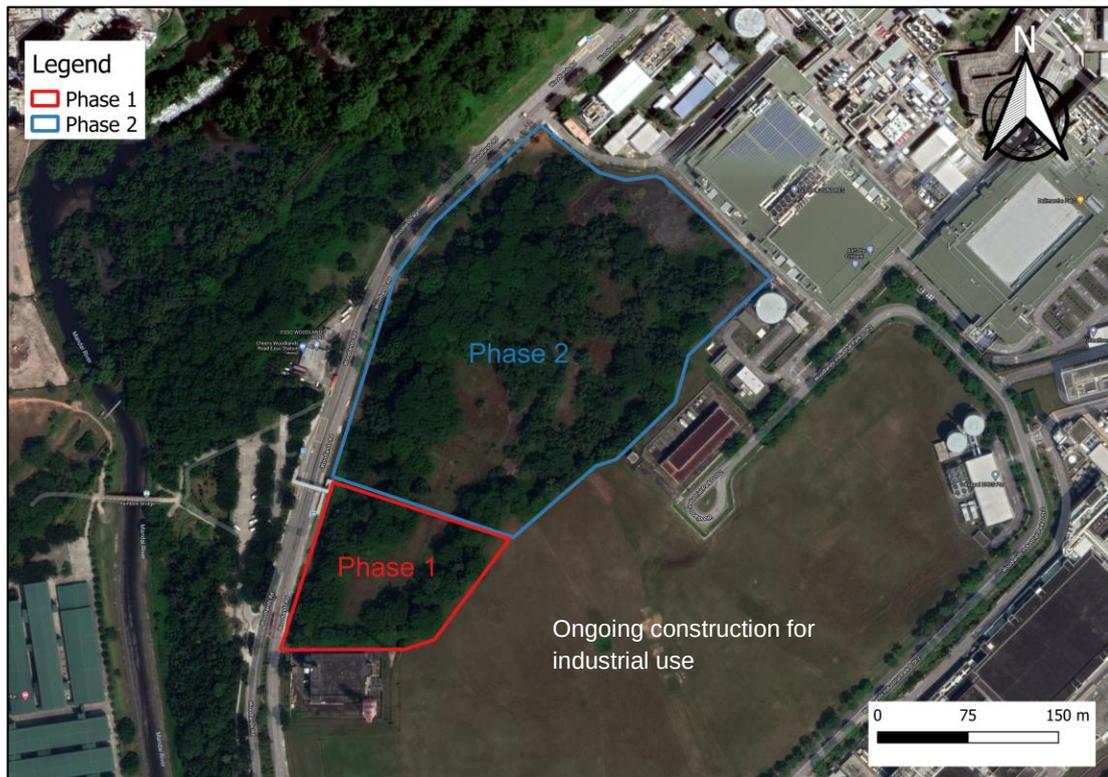


Figure 2.11. Phase 1 and Phase 2 of Hoarding plan

3 BIA APPROACH

3.1 Singapore's EIA Context

Singapore adopts a systematic framework to determine and mitigate the potential impact of any new development on the environment. In general, development projects are required to undergo a thorough evaluation process that addresses the development's potential impact on traffic, public health, heritage, and the environment. In addition, proposed development projects near sensitive areas, such as Nature Reserves, Nature Areas, marine and coastal areas, other areas of significant biodiversity or with potential trans-boundary impact, are subject to greater scrutiny.

For such projects, Technical Agencies (such as the National Parks Board, National Environment Agency, Maritime and Port Authority of Singapore, and Singapore Food Agency) are consulted more extensively.

Government agencies will assess the impact of the project and recommend whether further environmental studies are required. The developer is also required to ensure mitigating measures and monitoring plans are in place to minimise any environmental impact before the commencement of any works.

JTC Corporation was requested to conduct a flora and fauna baseline study as well as a broad overview of the impacts and potential mitigation measures associated with biodiversity.

3.2 Scope of Current Study

This BIA is conducted as per the discussions with the Client and the scoping consultation process with Technical Agencies.

The salient points of BIA scope are as follows:

- Establishment of baseline biodiversity data, which includes data source and data collection methodology.
- Biodiversity survey – Flora.
- Biodiversity survey – Fauna.
- Impact assessment of the vegetation clearance and tree felling on biodiversity.
- Recommend mitigation measures for impacts on biodiversity due to vegetation clearance and tree felling activities.
- Develop biodiversity management recommendations for land clearance stage.

3.3 Applicable Singapore and International Legislations

Table 3.1 lists relevant legislation, regulations and guidelines that govern the various environmental parameters within Singapore. Latest legislations and relevant subsidiary regulations can be accessed from the website of Singapore Statutes Online (SSO) (n.d.) at <https://sso.agc.gov.sg/>.

Table 3.1. List of applicable environmental legislations and guidelines

Parameter	Legislation, Regulations, and Guidelines
General	<ul style="list-style-type: none"> • Environmental Protection and Management Act, 2002 • Environmental Public Health Act, rev. 2002 • Singapore Code of Practice on Pollution Control (SS593: 2013)
Biodiversity	<ul style="list-style-type: none"> • The Wildlife Act 2020 • The Animals and Birds Act 2002 • Endangered Species (Import and Export) Act 2017 • The Parks and Trees Act 2006 • The Parks & Trees Regulations 2006 • The Parks & Trees Preservation Order 1998 • Parks & Trees (Composition of Offences Regulations) 2006 • Parks & Trees (Planning Areas) Notifications 2006 • Parks & Trees (Heritage Road Green Buffers) Order 2006 • Singapore Red Data Book, Second Edition, 2008 • IUCN Red List of Threatened Species to assess species vulnerability 2020 • CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention) 1983
Surface Water Quality	<ul style="list-style-type: none"> • Sewerage and Drainage Act 2001 • Sewerage and Drainage (Surface Water Drainage) Regulations 2007 • PUB Code of Practice on Surface Water Drainage (2018) • PUB Handbook on Managing Urban Runoff (2013) • PUB Guidebook on Erosion and Sediment Control at Construction Sites (2018)
Noise	<ul style="list-style-type: none"> • Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008 • Code of Practice for Noise Control on Construction and Demolition Sites SS602 (2014)

The legislation reflected in this table are generally related to biodiversity as well as surface water quality and noise, as these specific components are potentially affected by land clearance activities.

3.4 BIA Study Area

The BIA study area denotes the area where land clearance activities are predicted to have impacts on various environmental aspects within the site. For this project, the study area covers the entirety of area proposed to be cleared as can be seen in Figure 3.1.



Figure 3.1. Extent of project study area

The flora and fauna inhabiting the project site will be impacted by the land clearance for Woodlands Wafer Fab Park. Therefore, for baseline survey, the main groups studied were vegetation, birds, mammals, amphibians, reptiles, butterflies, and odonates. Aquatic surveys of decapod crustaceans, freshwater molluscs, and fish within natural waterbodies were also conducted. The identified sensitive receptors are discussed in the next section.

3.5 Identification of Sensitive Receptors

Table 3.2 lists the identified sensitive biodiversity receptors that may be affected during the development of the proposed project.

Table 3.2. Identified sensitive receptors

Aspects	Sensitive Receptors
Biodiversity	<ul style="list-style-type: none"> • Native flora and fauna of international conservation significance (i.e. classified as Critically Endangered, Endangered, or Vulnerable according to IUCN classification system) in the proposed project site. • Native flora and fauna of national conservation significance (i.e. classified as Critically Endangered, Endangered, and/or Vulnerable according to Singapore Red Data Book (Davison et al., 2008) or other relevant local status publications) in the proposed project site. • Habitats with high ecological value (i.e. environments that support species of conservation significance). • Personnel working on and around the site (Human-wildlife conflict).

3.6 Impact Assessment Methodology

3.6.1 Identification of Impacts

The proposed project involves complete clearance of the existing vegetation, which will potentially impact the surrounding natural environment. These impacts include those that are direct in nature, such as loss of species due to vegetation clearance and road kills, and indirect impacts to biodiversity such as reduction of overall habitat connectivity in the area, isolation of populations due to reduced connectivity, and increased noise and light disturbance during the land clearance activities.

An assessment of the impacts of the vegetation clearance and tree felling includes:

- Scale and effects of vegetation removal from tree felling;
- Impact of land clearance activities on wildlife and their movements;
- Impact on ecological processes; and
- Significance of the above for species conservation in the immediate vicinity of the proposed project.

3.6.2 Assessment of Impacts

Based on the impact analysis of land clearance activities of the proposed project, suitable mitigation measures will be recommended for impacts which are deemed to have a minor to major negative impact on the environment.

Potential impacts will be quantified using the Rapid Impact Assessment Matrix (RIAM) method (Pastakia & Jensen, 1998), which is a system of scoring in which impacts of each project activity are evaluated against environmental receptors. This assessment method attributes values to each condition based on its importance (I), magnitude (M), permanence (P), reversibility (R), and cumulativity (C).

The parameters are tabulated in Table 3.3.

Table 3.3. List of parameters and respective scores assigned in RIAM method

Parameter	Description	Score
Importance (I)	Important to national/international interests	5
	Important to regional/national interests	4
	Important to areas immediately outside the local condition	3
	Important to the local condition (within a large direct impact area)	2
	Important only to the local condition (within a small direct impact area)	1
Magnitude (M)	Major positive benefit or change	+4
	Moderate positive benefit or change	+3
	Minor positive benefit or change	+2
	Slight positive benefit or change	+1
	No change/status quo	0
	Slight negative disadvantage or change	-1
	Minor negative disadvantage or change	-2
	Moderate negative disadvantage or change	-3
	Major negative disadvantage or change	-4

Permanence (P)	No change/Not applicable	1
	Temporary	2
	Permanent	3
Reversibility (R)	No change/Not applicable	1
	Reversible or controllable through Environmental Management and Monitoring Plan	2
	Irreversible	3
Cumulativity (C)	No change / Not applicable	1
	Non-cumulative/single	2
	Cumulative/synergistic	3

Given the ambiguity in the nature of assessing the 'magnitude' component, we use the following criteria to aid the assessment, tabulated in Table 3.4

Table 3.4. Description of the value of magnitudes in RIAM method

Magnitude	Description
Major positive benefit or change	A major positive benefit or change refers to significant improvements in baseline conditions and a significant reduction of stress or improvement in the baseline states of sensitive receptors.
Moderate positive benefit or change	A moderate positive benefit or change refers to significant improvements in local baseline conditions, which may lead to a moderate reduction of stress to sensitive receptors or improvement in their baseline state.
Minor positive benefit or change	A minor positive benefit or change implies that positive changes to baseline conditions are discernable but local. These changes may lead to local and limited reduction of stress to sensitive receptors.
Slight positive benefit or change	A slight positive benefit or change implies that changes in baseline conditions are unlikely to be detectable on-site, and thus unlikely to cause discernable reduction of stress to sensitive receptors.
No change/status quo	No change/status quo implies that changes in the baseline conditions are not expected, and unlikely to cause any stress to sensitive receptors.
Slight negative disadvantage or change	A slight negative disadvantage or change implies that changes in baseline conditions are unlikely to be detectable in the field, and thus are unlikely to cause discernable stress to sensitive receptors.
Minor negative disadvantage or change	A minor negative disadvantage or change implies that negative changes to baseline conditions are discernable but local. These may also refer to changes that are approaching thresholds for established standards or guidelines. These changes may lead to a local and limited increase in stress to sensitive receptors.
Moderate negative disadvantage or change	A moderate negative disadvantage or change refers to significant adverse changes in local baseline conditions. These may also refer to changes that are very close to exceeding established standards or guidelines or causing significant ecological impacts. These changes may lead to a moderate increase of stress to sensitive receptors.

Magnitude	Description
Major negative disadvantage or change	A major negative disadvantage or change refers to significant adverse changes in baseline conditions. These may also refer to changes that exceed established standards or guidelines or causing a complete loss of certain habitats or ecological components. These changes may lead to an unacceptable increase of stress to sensitive receptors.

These values will then contribute to the condition’s environmental score, where:

$$Environmental\ Score\ (ES) = I * M * (P + R + C).$$

The ES attained for each condition will then correlate to a measure of its impact, which are tabulated in Table 3.5.

Table 3.5. Environmental score range along with the degree of impact associated with each range

Range	Impact
116 to 180	Major positive change/impact
81 to 115	Moderate positive change/impact
37 to 80	Minor positive change/impact
7 to 36	Slight positive impact
-6 to +6	No impact / Status quo / Not applicable
-7 to -36	Slight negative change/impact
-37 to -80	Minor negative change/impact
-81 to -115	Moderate negative change/impact
-116 to -180	Major negative change/impact

3.6.3 Mitigation Measures

Where land clearance activities are deemed to have a minor to major negative impact on the environment, mitigation measures will be recommended to reduce the impacts of these activities on the environment.

Mitigation measures will follow a sequence of steps commonly referred to as mitigation hierarchy. The aim of this hierarchy is to limit the negative impacts of development on the natural environment, with the goal being to balance negative impacts with positive ones in order to achieve net loss for environmental aspects. The hierarchy is as follows:

- **Avoidance**
This involves taking measures to prevent any impacts. This can be done in several ways, including site selection to avoid sensitive receptors.
- **Minimisation**
This involves the careful reduction in spatial and temporal scale of the impact during land clearance activities to what is practically feasible.
- **Rehabilitation / Restoration**
Where impact reduction measures are not feasible, rehabilitation and restoration of degraded habitats where impacts have already occurred would be conducted.

- **Compensation**

This step involves offsetting any significant residual, negative impacts that could not be mitigated through the previous steps. This step is not often practical in Singapore and will only be explored if the other steps are not feasible.

3.7 Project Team

The team involved in the fieldwork, analysis, impact assessment, and report preparation for this project are listed in Table 3.6.

Table 3.6. List of project team members

No	Name	Designation
1	Mr Komal Pujara	Project Director
2	Ms Holly Siow	Project Manager / Lead Ecologist
3	Mr Anthony O'Dempsey	Flora Specialist
4	Ms Sarah Pascoe	Biodiversity Consultant
5	Ms Henrietta Woo	Ornithologist
6	Mr Jefferson	Biodiversity Consultant
7	Ms Lisa Lim	Environment Consultant

4 BIODIVERSITY

4.1 Introduction

The project site is located in a vegetated area adjacent to Woodlands Road. The site is situated approximately 120 m from Mandai Mangrove and Mudflat Nature Park and about 400 m from Marsiling Park. Mandai Mangrove and Mudflat Nature Park, as the name implies, consists of various habitat types, the most notable being a patch of mangrove forest, and the most extensive mudflat on mainland Singapore. The landward edge of the mangroves includes secondary regrowth forest vegetation. Marsiling Park is an urban park, but also consists of a stretch on mangrove forest.

The closest forested area is a strip of secondary forest across Woodlands Road on the northwest. However, the project site is not continuously connected to any forested/vegetated area.



Figure 4.1. Project locality and spatial context

Historically, the land use on the site included gambier, pepper, and rubber plantations. More recently, the site was cleared for the Malayan Metal Box Company factory, and the industrial buildings remained until circa 2000. Currently, even though the site is vegetated, the environmental conditions still reflect the site's previous land use, with much of the ground cover still showing evidence of sealed hard surfaces. Such conditions prevent many plant species from colonizing the site. As such, much of the site is currently dominated by introduced species that are able to thrive in the relatively harsh conditions of the site.

The following section describes the methodology of field surveys that were carried out to establish the baseline for biodiversity and identify the existing sensitive receptors within the project study area. The results of these surveys are then analysed and discussed to assess the likely impacts of the proposed development to the receptors. Measures to mitigate these impacts are recommended for implementation during the land clearance stage of the project.

4.2 Baseline Methodology

4.2.1 Desktop Review

A desktop review to collect secondary data was conducted. This included a thorough review of publicly available literature on the ecology and biodiversity of the site, as well as other publicly available material, which may include land use and other maps, photographs, and environmental data found on government websites.

Conventions

The species' local conservation status was mainly based on *Singapore Red Data Book (SRDB)* (Davison, Ng, & Ho, 2008). For flora, *The Checklist of the Total Vascular Plant Flora of Singapore* (Chong, Tan, & Corlett, 2009) was also referred to given that information in the SRDB is out of date. Conservation status for odonates was derived from *The Dragonflies of Singapore: An updated checklist and revision of the national conservation statuses* (Ngiam & Cheong, 2016). On the other hand, global conservation statuses were derived from the IUCN Red List of Threatened Species (IUCN, 2021).

A species is considered to be of conservation value if its conservation status is listed as Vulnerable, Endangered, or Critically Endangered.

Table 4.1. Conservation status for flora & fauna species and their respective definitions, adapted from IUCN Red List (2021) and Singapore Red Data Book (Davison, Ng, & Chew, 2008).

Conservation Status	Definition
<u>Global</u>	
Extinct (EX)	There is no reasonable doubt that the last individual has died. Exhaustive surveys in known and/or expected habitat, at appropriate times, throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Extinct in the Wild (EW)	Known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. Exhaustive surveys in known and/or expected habitat, at appropriate times, throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.

Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	Does not qualify as Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	Does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat.
Not Evaluated (NE)	Not yet been evaluated against the criteria.
<u>Local</u>	
Presumed Nationally Extinct (NE)	This species is extinct in Singapore but still survives outside Singapore. It has not been recorded within the last 30 years (plants) and 50 years (animals).
Critically Endangered (CR)	There are fewer than 50 mature individuals, or if more than 50 mature individuals but less than 250, with some evidence of decline or fragmentation.
Endangered (EN)	There are fewer than 250 mature individuals, and no other evidence of decline or fragmentation.
Vulnerable (VU)	There are fewer than 1000 mature individuals, but more than 250 and there may or may not be any other evidence of decline, small range size, or fragmentation.

For introduced plant species as well as species of uncertain origin, we have used the definitions from Chong et al. (2009), as seen in Table 4.2.

Table 4.2. Different categories of introduced plant species (Chong et al., 2009).

Exotic (Casual)	Exotic species that do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence.
Exotic (Naturalised)	Exotic species that form self-replacing, usually sexually -reproducing populations.
Exotic (Cultivated Only)	Exotic species that can only be found in cultivation or under direct human care.
Weed of Uncertain Origin	Species without biogeographical or historical evidence of being non-native, but are restricted to only human-modified or human-disturbed habitats.

4.2.2 Flora

Flora Field Assessment

Transects were conducted throughout the study area and its extremities with the aim of achieving comprehensive coverage of all flora habitats that occupy the study site.

For each transect:

- GPS positions are recorded on regular basis;
- Species encountered are recorded with reference to the GPS identifiers; and
- Photographs taken where required.

While some plant species have official local conservation status (Extinct or Critically Endangered), they are not considered significant findings due to their persistence from cultivation (i.e., plants that occur within vegetated areas in Singapore largely due to the historical cultivation of the species). These species are reflected in Table 4.3.

Table 4.3. Species with conservation status but are not considered of significant conservation value

Species	Conservation Status	Type	Comment
<i>Epipremnum pinnatum</i>	Critically Endangered	Climber	Persistent from cultivation
<i>Morinda citrifolia</i>	Nationally Extinct	Tree	Persistent from cultivation
<i>Syzygium myrtifolium</i>	Nationally Extinct	Tree	Persistent from cultivation
<i>Syzygium polyanthum</i>	Vulnerable	Tree	Persistent from cultivation

The flora study transects conducted are illustrated in Figure 4.2.



Figure 4.2. Flora study transect map

Species Identification

In general, most species that were encountered during the flora survey were not fertile and identifications were achieved by vegetative features, which may result in a degree of uncertainty for species that require fertile specimens to be reliably identified. Uncommon species were identified / verified with reference to the Biodiversity Online web site hosted by Lee Kong Chian Natural History Museum (LKCNHM) as well as through consultation with various experts in the community. **Appendix B** compiles the photos of plant species identified on the project site.

Vegetation Mapping

Based on the data collected on plant species and vegetation structure, the project site was mapped according to the present habitat types. The map also includes significant topographic features such as roads, waterbodies, and fences.

4.2.3 Fauna

Visual Encounter Surveys

A baseline fauna survey was conducted along systematic transects in the area, following available trails that spanned the length of the proposed alignment (Figure 4.3).

Since a large proportion of the target groups, particularly mammals, are predominantly nocturnal, both diurnal and nocturnal surveys were conducted. Three day transects and two night transects were carried out. For diurnal surveys, each transect was surveyed by at least two observers at points located 100 m apart, for approximately 10 minutes at each point and fauna observed in-between each point were also recorded. Night transects were done with at least three observers walking at a regular slow pace throughout the length of each transect. Each day transect was conducted three times, and each night transect was conducted twice for the whole study.

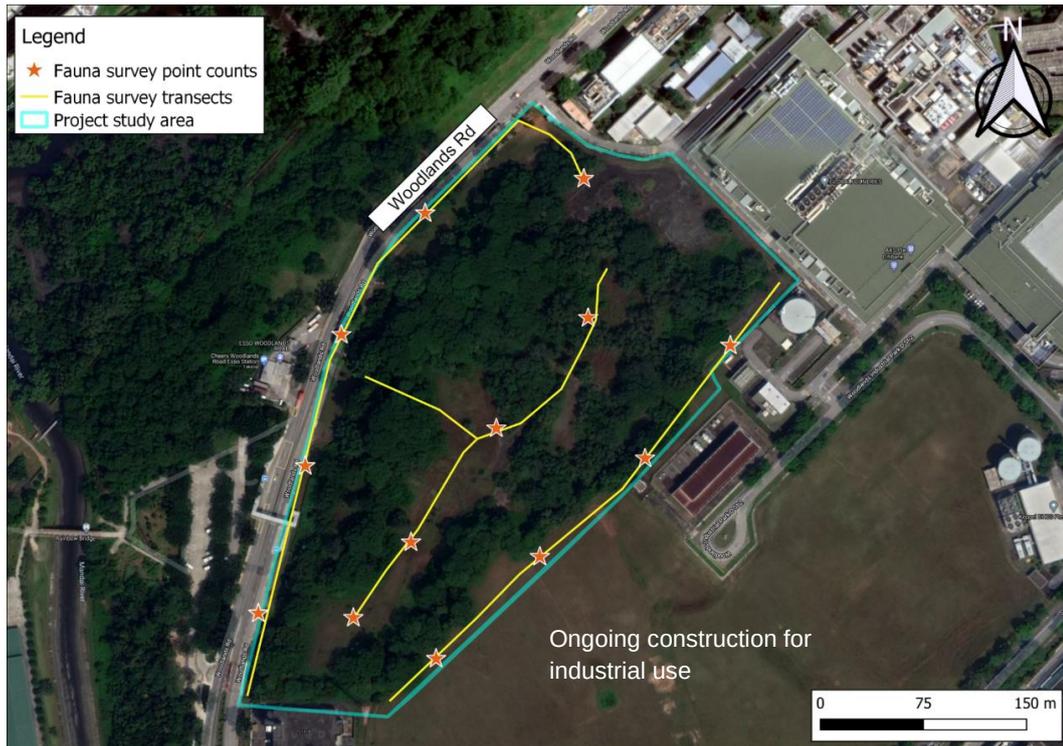


Figure 4.3. Fauna visual encounter survey map

Table 4.4. Timings in which surveys for targeted taxonomic groups were conducted.

Taxonomic Group	Survey Timings	Survey Methodology
Birds	0700 - 0900	Visual encounter survey; call recognition
Mammals	0700 – 0900 2000 – 2300	Visual encounter survey; call recognition
Herpetofauna (reptiles and amphibians)	0700 – 0900 2000 – 2300	Visual encounter survey; call recognition
Butterflies	0900 - 1100	Visual encounter survey
Odonates	0900 - 1100	Visual encounter survey

Camera Trapping

Three camera traps were deployed throughout the study area from 31 March to 12 May 2021 (see Table 4.5 for GPS coordinates and Figure 4.4 for their location on the map). These remotely activated cameras were equipped with infrared sensors that could be triggered by animal movements. Camera trapping is particularly useful for elusive or rare animals that are not often observed during visual encounter surveys. They also allow for 24-hour monitoring of the study site. The cameras used in this study take colour photos during the day and black and white photos at night using an infrared flash; the use of the latter avoids the problem of blinding or spooking the animals.

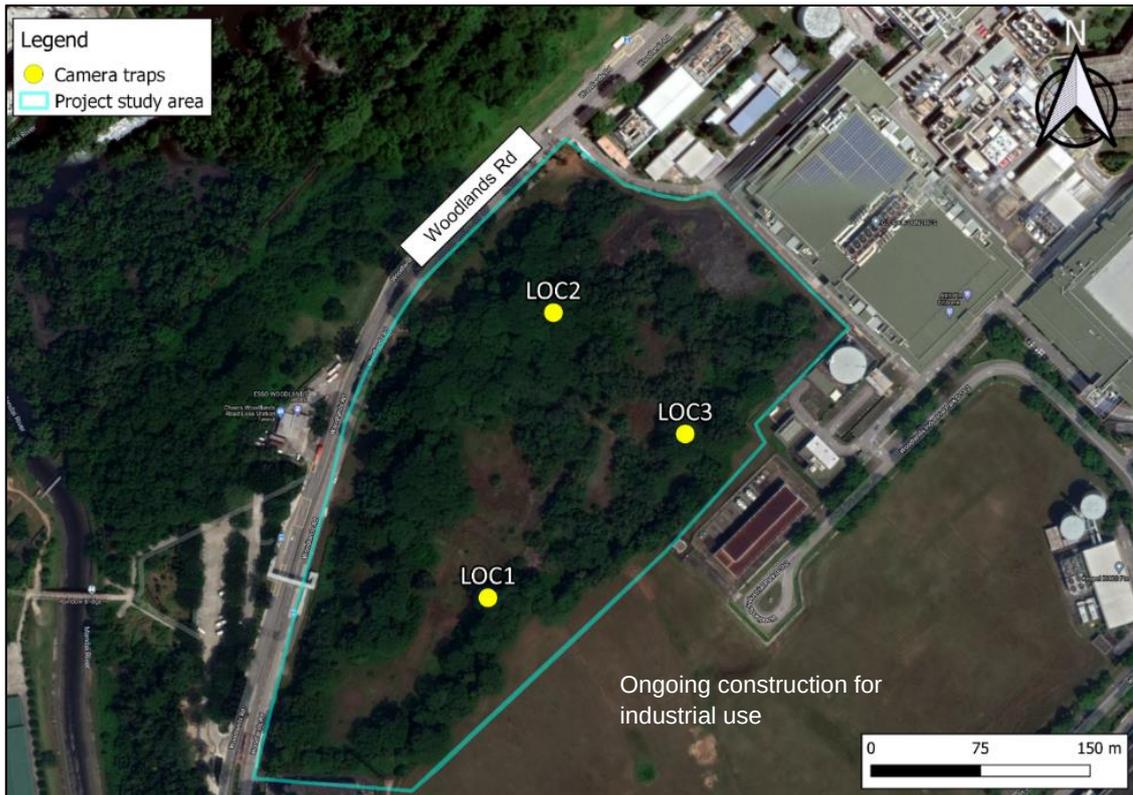


Figure 4.4. Location of the camera traps within the project study area

Table 4.5. Camera traps' coordinate within project study area

Camera ID	Latitude	Longitude
LOC1	1.434949972	103.763599
LOC2	1.434198031	103.76441
LOC3	1.433181977	103.763196

Cameras were deployed in areas with expected high animal activity, such as grasses, shrubs, watering holes, fruiting trees, and fallen branches and logs. These areas were indicated by animal tracks, scats, wallows, markings, and trails. Cameras were set to take a sequence of three photos each time they were triggered, with a 5 second interval between each sequence. Cameras were secured to tree trunks 30cm above the ground, which is just below the shoulder height of the largest species expected to be present, the Wild Boar (*Sus scrofa*). Setting the cameras at this height optimises the focal area of the cameras for capturing smaller animals.

The images taken from camera LOC3 were partially obscured due to a technical glitch, and a portion of the photos were not identifiable. However, identification of animal species were still possible from the remaining images.



Figure 4.5. Example of camera trap setup

Aquatic Surveys

Two surveys (night) were conducted at the pond present in the project site (Figure 4.6). Stream surveys were conducted through the use of hand nets. Fish, molluscs, and decapod crustaceans were trapped and identified to family level or higher. All specimens were released after identification.

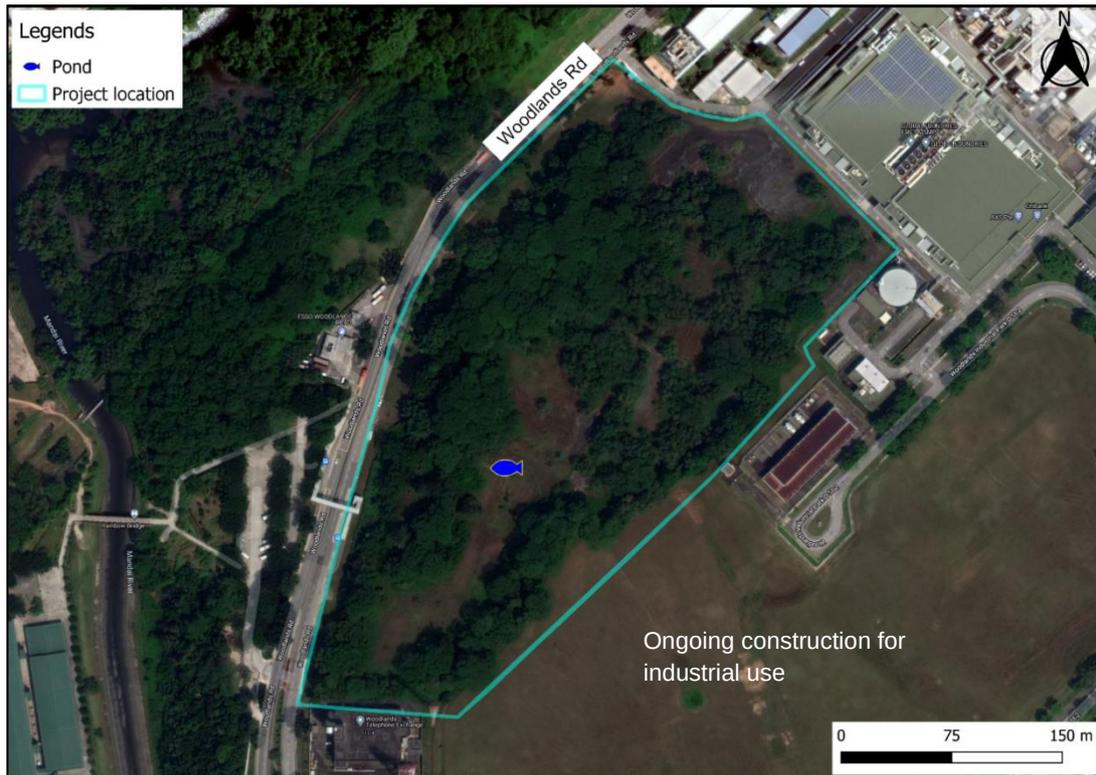


Figure 4.6. Aquatic survey location within project study area

4.3 Baseline Results and Discussion

4.3.1 Flora

4.3.1.1 Flora Field Assessment

Appendices A and B respectively report the full list of flora sightings and photographs of observed plants. A total of 72 plant species were recorded during field surveys.

The project site consists of 48.6% native (n=35) and 51.4% exotic (n=37) species. The high proportion of introduced species on the site is due largely to its land use history, where the land was previously completely cleared and developed for other land uses.

Table 4.6. Composition of plant species present on the project site

Native Status	Local Conservation Status	No. of Species	Percentage (%)
Native	Common	11	15.28
	Vulnerable	1	1.39
	Common (Cultivated)	19	26.39
	Vulnerable (Cultivated)	1	1.39
	Critically Endangered (Cultivated)	1	1.39
	Extinct (Cultivated)	2	2.78
Introduced	Exotic (Naturalised)	23	31.94
	Exotic (Casual)	10	13.89
	Exotic (Cultivated Only)	3	4.17
	Weed of Uncertain Origin	1	1.39
Total		72	100.00

4.3.1.2 Vegetation Mapping

The forest within the project site consists of recently regrown vegetation, where habitat complexity is low.

The study area is dominated by the following three broad vegetation types:

- **Albizia Woodland:** Woodland dominated by *Falcataria mollucana* but also includes an understory featuring native species such as *Caryota mitis*, *Terminalia catappa* and *Ficus religiosa* species as prominent species.
- **Herbaceous:** The herbaceous areas are mainly grass and ferns occupying the hard surfaced locations of former factory buildings.
- **Exotic Dominated Woodland:** Mixed Exotic and Native regeneration forest distinct from Albizia woodland. This type is variously dominated by exotics such as *Acacia auriculiformis*, *Pithecellobium dulce* and *Clausena excavata*. The understory includes native species such as *Caryota mitis*, *Terminalia catappa* and various *Ficus* and *Syzygium* species as prominent species.

Figure 4.8 includes a habitat map illustrating where the various habitats are present on the project site.



Herbaceous growth with scattered
Acacia trees



Albizia woodland with herbaceous growth
in the foreground



Albizia woodland



Former factory entrance overgrown with *Ficus pumila*
and other climbers

Figure 4.7. Vegetation types in project site



Figure 4.8. Habitat map of project study area

4.3.1.3 Species of Conservation Status

Five species with local conservation status were found on the project site (Table 4.7). However, with the exception of the locally vulnerable *Oxyceros longiflorus*, all species of conservation status encountered on site are considered to be persistent from cultivation and therefore are not subject to conservation concern.

Table 4.7. Species with conservation statuses found on the site

Species	Conservation Status	Type	Comment
<i>Epipremnum pinnatum</i>	Critically Endangered	Climber	Persistent from cultivation
<i>Morinda citrifolia</i>	Nationally Extinct	Tree	Persistent from cultivation
<i>Oxyceros longiflorus</i>	Vulnerable	Climber	Found occasionally throughout site
<i>Syzygium myrtifolium</i>	Nationally Extinct	Tree	Persistent from cultivation
<i>Syzygium polyanthum</i>	Vulnerable	Tree	Persistent from cultivation

Although *O. longiflorus* is listed as locally vulnerable, it is fairly common in vegetated area within Singapore. Instances of the species encountered at this site are located at the following WGS84 (GPS) coordinates:

Table 4.8. Coordinates of *Oxyceros longiflorus* in the project study area

Longitude	Latitude
103.76411	1.43559
103.76385	1.43452
103.76263	1.43244



Figure 4.9. Locally vulnerable species, *Oxyceros longiflorus* found on project site

4.3.2 Fauna

The complete list of fauna sightings and photographs of observed animals can be found respectively in **Appendix A** and **Appendix C**.

4.3.2.1 Birds

At least 60 species were observed, of which 10 are of conservation significance (one locally and globally threatened, 6 locally threatened and 3 globally threatened or near threatened). Figure 4.10 depicts the distribution of number of species of the locally threatened bird species at each point count location. Locally threatened species include the Endangered, Blue-crowned Hanging Parrot (*Loriculus galgulus*), Changeable Hawk-eagle (*Nisaetus cirrhatus*), Oriental Magpie-robin (*Copsychus saularis*), and Straw-headed Bulbul (*Pycnonotus zeylanicus*); the Vulnerable Red-legged Crake (*Rallina fasciata*), Rusty-breasted Cuckoo (*Cacomantis sepulcralis*) and Grey Heron (*Ardea cinerea*). The Straw-headed Bulbul is also listed as globally critically endangered.

Other globally threatened or near-threatened species include the Vulnerable Javan Myna (*Acridotheres javanicus*) and Long-tailed Parakeet (*Psittacula longicauda*) and the Near Threatened, Red-breasted Parakeet (*Psittacula alexandri*). However, both Javan Myna and Red-breasted Parakeet are introduced to Singapore.

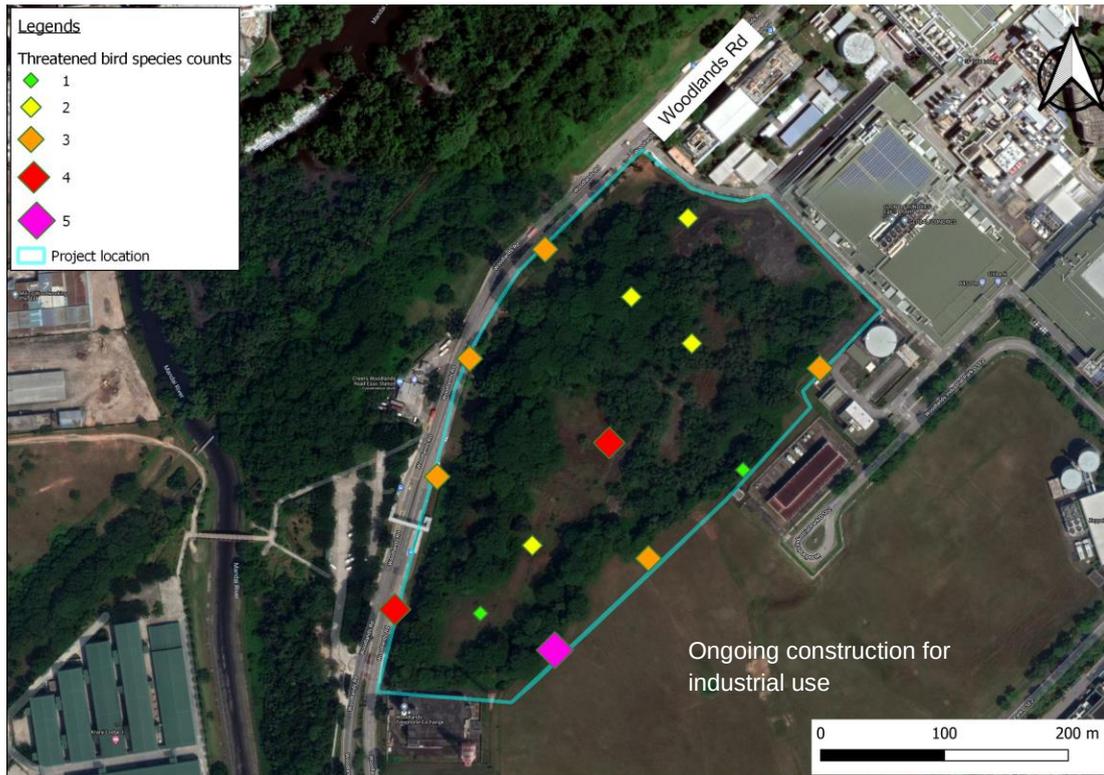


Figure 4.10. Distribution of threatened bird species in project study area

On-site observation of several forest species (including the Red-legged Crake, Blue-crowned Hanging Parrot, and Straw-headed Bulbul) indicates the site's importance as habitat and foraging ground for such species.

The Straw-headed Bulbul is also a noteworthy species given its globally critically endangered status. While populations of Straw-headed Bulbul on Singapore's mainland have been stable over the past few years, this species' numbers in the rest of Southeast Asia have been declining (Yong, et al., 2018). Singapore is an important stronghold of this species, and its habitat needs to be preserved for its continued persistence. This bird species is found in other vegetated areas in Singapore, including several Nature Reserves and Nature Areas.

There was a presence of two raptor nests in the forest edge along Woodlands Road (Figure 4.11). At least one of the raptor nests had confirmed sighting of a juvenile White-bellied Sea Eagle (*Haliaeetus leucogaster*) (Figure 4.12).

Another juvenile Changeable Hawk Eagle (*Nisaetus cirrhatus*) (Figure 4.13) was sighted amidst the canopy close to the centre of the project site. Given its underdeveloped flight skills as a juvenile, it is likely that the second raptor nest is utilised by this Changeable Hawk Eagle.

Overall, most species of birds observed are common throughout Singapore. However, the ability of flight in birds, which makes them relatively more motile compared to terrestrial species, has contributed to the presence of several species of conservation value on the site.



Figure 4.11. Raptor nest in project site



Figure 4.12. A White-bellied Sea Eagle juvenile adjacent to its nest



Figure 4.13. Juvenile Changeable Hawk Eagle

4.3.2.2 Mammals

A total of 5 mammal species were observed at the site. All mammal species sighted are native, widespread, and common in Singapore.

There was no evidence of Wild Pigs (*Sus scrofa*) within the project site, either from visual encounter surveys, camera traps, or evidence through scat or wallows.

4.3.2.3 Herpetofauna

A total of 14 herpetofauna (9 amphibians and 5 reptiles, including one unidentified monitor lizard) species were found on the project site. All species are considered widespread and common. Malayan Giant Frog (*Limnonectes blythii*) was encountered, and while this species is relatively common near stream habitats in Singapore, it is listed as globally near-threatened. Five of the species recorded have been introduced to Singapore: Changeable Lizard (*Calotes versicolor*), Banded Bullfrog (*Kaloula pulchra*), Gunther's Frog (*Sylvirana guentheri*), East Asian Ornate Chorus Frog (*Microhyla fissipes*), and Brooke's House Gecko (*Hemidactylus brookii*).

The absence of any herpetofauna species of conservation value detected during transect surveys is expected due to their nature. Reptiles are generally elusive and are not observed frequently in surveys. Furthermore, other survey methods, particularly camera trapping, are not effective in detecting most herpetofauna species, given that many of these species are too small to be detected (especially frogs and some lizards), some species do not move quickly enough to be detected (e.g., some snakes), and the different habits of many of these species (some species are burrowing or largely arboreal

and beyond the field of view of camera traps). More importantly, herpetofauna species diversity is dependent largely on the variety and quality of habitats present at the site. In particular, most amphibians have specific requirements for waterbodies where they live out the larval stage of their lives. As such, most herpetofauna, particularly amphibians of conservation value on mainland Singapore are restricted to mature forests in the Central Nature Reserves and its surrounding forests. Herpetofauna of conservation significance present on this site, if any, are likely very rare and elusive, and are unlikely to be encountered during site visits.

4.3.2.4 Terrestrial Invertebrates

A total of 29 butterfly species and 14 odonates (dragonflies and damselflies) were encountered during the diurnal biodiversity surveys.

Of the butterflies surveyed, two species are considered Moderately Rare in Singapore. These include the King Crow (*Euploea phaenareta castelnaui*) and The Malayan (*Megisba malaya sikkima*).

The list of odonates included one that is both globally and locally Near-threatened, the Mangrove Marshal (*Pornothemis starrei*). This species is found predominantly in coastal areas such as mangroves and creeks and is threatened due to the loss of suitable coastal habitat (IUCN, 2021). Its presence in the project site is likely due to the site's proximity to mangrove habitat at Mandai.

4.3.2.5 Aquatic Fauna

No fish or decapod crustacean species were found from surveys of aquatic fauna from the waterbodies on the project site. Snails from 2 families (Planorbidae and Thiariidae) were identified from the surveys.

4.3.2.6 Camera Trapping

Three camera traps (LOC 1–3) were deployed for a total of 42 days from 31 March to 12 May 2021. Photos were taken daily during the duration of the survey. As the camera traps took a sequence of three photos each time they were triggered, the photos were separated according to their respective sequences. Sequences separated by more than five minutes were assumed to be independent sightings.

Ninety-three independent sightings (Table 4.9) identified from more than 282 photos of 14 identified fauna species (Figure 4.14) were collected from the 3 camera traps. Six detections were made of animals that could not be identified to species level. These unidentified detections were not counted towards the total the overall species count.

Table 4.9. Number of species sightings from each camera (* locally threatened species)

Species	LOC 1	LOC2	LOC3
Changeable Hawk-eagle*	2		
Changeable Lizard		2	
Common Palm Civet		2	
Common Treeshrew		2	

Species	LOC 1	LOC2	LOC3
Emerald Dove			1
Javan Myna	3	1	
Laced Woodpecker		1	
Oriental Magpie Robin*	26		
Pied triller	2		
Pink-necked Green Pigeon	1		
Plantain Squirrel		2	
Unidentified Rat		2	1
Unidentified Skink		1	
Unidentified		3	
Unidentified Monitor Lizard			1
White-breasted Waterhen		20	11
White-throated Kingfisher	5		
Yellow-vented Bulbul	4		
Total Number of Detections	43	36	14
Total identified species	7	7	2
Total number of species	7	10	4

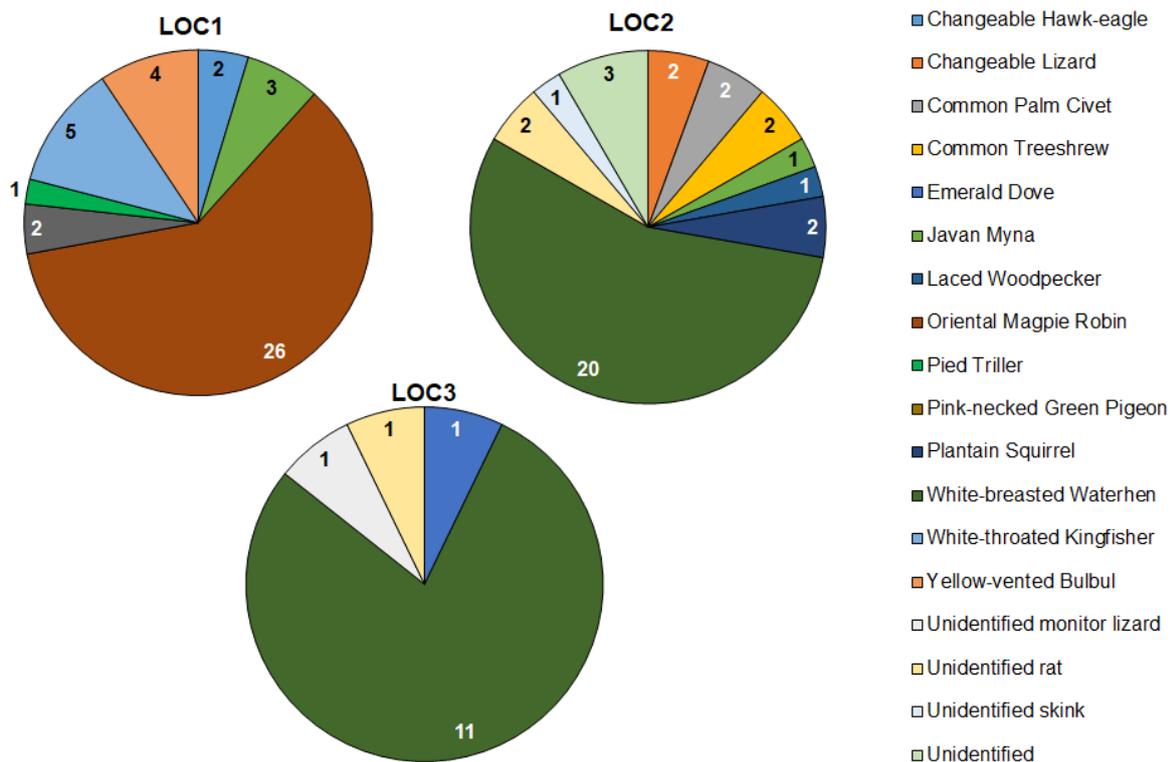


Figure 4.14. Number of species sightings captured by each camera

Of all the cameras, Camera LOC2 caught the highest number of species (a total of 10 species).

The species most commonly recorded was the Oriental Magpie Robin (*Copsychus*

sularis), with a total of 26 detections captured across all three camera traps.

The cameras captured two threatened species: the locally endangered Changeable Hawk-eagle (*Nisaetus cirrhatus*) (Figure 4.15) and Oriental Magpie-robin (*Copsychus saularis*) found in LOC1 (Figure 4.17). Other common species captured included the Common Palm Civet (*Paradoxurus hermaphroditus*) (Figure 4.16).



Figure 4.15. Changeable-hawk Eagle captured at LOC1



Figure 4.16. Common Palm Civet (circled in red) captured by camera LOC2



Figure 4.17. Oriental Magpie Robin captured at LOC1

4.3.3 Summary of Flora and Fauna Baseline

At least 72 flora species and 122 fauna species (birds, mammals, reptiles, amphibians, lepidoptera, and odonates) were observed in the project study area.

The site is located on land previously used for an industrial development and was unvegetated until circa 2000. The ground conditions on the site still include sealed areas which were formed from the former factory floor. Additionally, the site has been left unoccupied for a relatively short amount of time. Floristically, these likely explain why the proportion of introduced to native plants is relatively high, compared to other secondary regrowth forests in Singapore.

The forest within the project site is made of recently regrown vegetation, where habitat complexity is low. There are other green spaces around the project site with similar vegetation, which will act as alternative habitats for birds currently using the development site.

The site also consisted of a low number of fauna species of conservation value, with 10 threatened or near-threatened bird species, one near-threatened dragonfly species, and one globally near-threatened amphibian species. The low fauna diversity can be explained by the site's land use history, as well as its relative isolation from other forest patches. While volant (flying) animals such as birds, butterflies, and dragonflies are able to arrive at the project site from other locations, this project site is separated from other vegetated areas by roads, and less motile species will have difficulty arriving and establishing populations at the site.

While this project site is relatively low in species diversity, the presence of trees such as the Albizia (*Falcataria mollucana*) makes this site suitable for nesting birds, particularly

raptors. Based on our observations between March and May 2021, both nests recorded were likely used by nesting raptors.

In terms of overall connectivity, the project site is not directly connected, but in close proximity, to other green spaces such as the Mandai Mangrove and Mudflat Nature Park, the Rail Corridor, as well as several patches of woodlands in Kranji and Mandai. This network of green spaces, including the project site, can be utilised by birds as stepping stones to move across sites. This network can also provide an alternative breeding habitat for bird species that face pressures from the loss of such habitats elsewhere in the area.

4.4 Impact Assessment

4.4.1 Identification of Sources of Potential Impacts

Given that this phase of the project is the land clearance stage of the Woodlands Wafer Fab Park, impacts identified are limited to this activity. Vegetation clearance is expected to impact the sensitive biodiversity receptors, which may result in species mortality (for both flora and fauna) and habitat loss (mainly for fauna). Sources of impacts from land clearance and associated activities include:

- Clearance of vegetation for site access, setting up of temporary hoarding, and other forms of working space (temporary).
- Clearance of vegetation and damage to habitats due to land clearance and tree felling (permanent).
- Any soil works necessary for land preparation.
- Increase in noise and light levels during land clearance works.

4.4.2 Identification of Potential Impacts

This section summarises the potential impacts affecting biodiversity receptors that may take place during the land clearance of the project site.

Species Disturbance and Mortality

For the purpose of impact assessment, focus is given to species that are either rare or globally/locally threatened according to the local and international databases. Section 4.3 discussed the composition of flora and fauna on the project site.

Species mortality will be most prominent within the project footprint, where the full project area will be cleared of vegetation. Approximately 1700 trees are likely to be cleared from this project site. However, most plant species encountered on the site are common native or introduced, with the exception being *Oxyceros longiflorus*, which is locally vulnerable. Although this species is listed as vulnerable, it is relatively common in forested areas within Singapore. Hence, it is not recommended for any transplanting or retaining of the species as part of a mitigation measure for this project site.

The project site contains several fauna species of conservation value. These species are all capable of flight, including several threatened bird species such as the endangered Straw-headed Bulbul and Changeable Hawk Eagle. While no active

translocation of threatened species is necessary, these species are particularly vulnerable while they are nesting. These species will be impacted if schedules of vegetation clearance do not consider the possibility of nesting birds.

Loss of Habitats and Connectivity between Habitats

Vegetation clearance leads to the loss of habitats for fauna species and reduction of foraging habitat, food sources, roosting, breeding and nesting sites, and other resources needed for the continued survival of a species. This site, while not biodiverse, has tall trees which are suitable habitats for nesting raptors. The clearance of these trees will result in the loss of some of these suitable habitats. However, the vicinity around the project site, particularly the area south of Mandai Mangrove and Mudflats Nature Park, still consists of forest habitat with many tall Albizia trees. Such habitat is also common throughout many other forested sites in Singapore.

Loss of connectivity between habitats due to the land clearance and tree felling of project area may lead to reduced movement between populations between the network of green spaces in proximity to project site. Loss of connectivity between populations can in turn lead to reduced gene flow and reduced resilience of species. Studies have been conducted in Singapore to show that fragmentation can lead to reduced genetic diversity of various group of birds, including understory insectivorous babblers (Cros et al., 2019). Fragmentation is also known to affect frog species in Singapore (Bickford et al., 2010). Few other such studies have been conducted in Singapore, but it is likely that similar trends are applicable to other species here.

Changes in Soil and Topography

Vegetation plays an important role in soil stability. Where vegetation clearance takes place, soil will be left vulnerable to erosion, particularly during rainy periods. Erosion may lead to sediment runoff and siltation of waterways surrounding the project site.

Human–Wildlife Conflict

Based on surveys along transects and camera trap data, there was no evidence of feral dogs or Wild Pigs within the project site. However, there is the possibility of such animals using the site prior to clearance or trying to enter the site through gaps in hoarding or by digging under barriers, and this may result in potential human-wildlife conflict.

Potential Roadkill

The project site is located along and adjacent to Woodlands Road, which is relatively busy during the day. During the land clearance phase, if measures are not taken, animals are likely to run across Woodlands Road. This may lead to an increased incidence of roadkill, which poses negative impacts on both the wildlife present on the site as well as drivers along the road.

Light Disturbance on Forested Areas

Artificial lighting may be used to illuminate the project site, particularly if night works are conducted. This may cause a disturbance to flora and fauna found in vegetated areas around the site. It is assumed that all land clearance activities will be limited to daytime, except for urgent or emergency cases. As such, any light impacts during this phase are expected to be negligible.

Noise Disturbance on Forested Areas

Tree felling and land clearance works may generate some levels of noise, which may affect sensitive animals. Some species, particularly nocturnal species which rely on their hearing for movement, communication, and foraging, are likely to be impacted by increased noise levels. Chronic and frequent noise such as traffic noise interferes with animals' abilities to detect important sounds, whereas intermittent and unpredictable noise such as piling, honking from vehicles and machinery and shouting is often perceived as a threat (Francis & Barber, 2013). This may alter species' behaviour and impair their ability to forage and avoid predation, leading to decreased survivability.

However, as land clearance activities will be limited to the daytime (except for urgent or emergency cases), and the area already faces relatively high level of ambient noise from vehicular traffic and industrial developments, any impacts from noise during this phase are expected to be negligible.

Based on the assessment above, some of the potential impacts on site's biodiversity are deemed to be permanent in nature while the others are short-term and reversible. Appropriate measures are to be proposed to mitigate these impacts.

4.4.3 Evaluation of Potential Impacts

Table 4.10 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

4.5 Mitigation Measures

Mitigation measures should be available to reduce the impacts of the works on the biodiversity. While the entire project site will be cleared of vegetation, where applicable, mitigation measures should also be implemented to protect the surrounding areas from adverse impacts to biodiversity.

Mortality of fauna species of conservation value should be avoided. In general, the fauna of conservation value recorded include birds, dragonflies, and butterflies, all of which are capable of flight and therefore relatively highly motile. Land clearance works are unlikely to greatly affect their survivability. However, some measures can be put in place to further decrease species mortality. Prior to any tree felling, the project site should be inspected for active bird nests or holes, and chicks should be allowed to fledge prior to tree felling. Should any vertebrate species of conservation value been seen, such species should be translocated prior to tree felling. Areas that have been inspected should then be felled in stages, allowing for the systematic inspection of potential fauna on the site. Where possible, tree felling works should avoid the peak breeding season of many birds (between the months of mid-March and July).

Phased clearance will allow many flying animals, including birds, to leave and fly to other patches. However, as the subject area is bounded by roads, non-flying animals trying to escape might cross the roads, which might pose a danger for both the animals and road users. Mortality from roadkills of highly motile fauna species must be avoided. Hoarding

should be erected along the whole edge of Woodlands Road prior to the commencement of any tree-felling works. Also, large vertebrates and vertebrates of conservation value found within the site should be actively translocated. While Wild Pigs and feral dogs were not detected in the site during the baseline surveys, should individuals arrive at the site before land clearance, these individuals should be removed prior to tree-felling.

As the land clearance phase of this project entails the complete removal of vegetation within project site, it is not feasible to retain habitats within this site. Mitigation measures for the loss of habitat thus include allowing any nesting birds to fledge prior to their clearance. As the existing habitats present on the project site are common in the vicinity of the project, no further mitigation measures are recommended for this impact.

It is assumed that all land clearance activities will be limited to daytime as far as possible, thus any light impacts during this phase on surrounding vegetated areas are expected to be negligible. However, any lights used for works should be turned off when not in use. For the WWFP alone, proper implementation of the recommended mitigation measures (including no night works except for emergency or urgent cases, proper erection of noise barriers, and other mitigation measures) should minimise potential noise and light impacts to Mandai Mangrove and Mudflat Nature Park, and hence unlikely to adversely affect the mudflats. The construction phase EMMP should be developed once Contractor is onboard to monitor the impact of works on environment.

Hoarding should be monitored regularly to ensure that no animals are entering the site either through gaps or by digging under the hoarding. To prevent other wild animals from scavenging on construction site, areas for food consumption, storage, and waste disposal should be demarcated and managed. The personnel should also be briefed on what to do should they encounter specific wild animals.

In summary, the mitigation measures that should be implemented to mitigate the impacts on sensitive biodiversity receptors are as follows:

- Erect hoarding along Woodlands Road prior to vegetation clearance
- Visually inspect trees and holes for nesting birds and species of conservation value prior to felling
- Conduct tree felling in stages
- Avoid felling during peak bird breeding period from mid-March to July
- Translocate any vertebrate species of conservation value sighted
- Remove Wild Pigs or feral dogs prior to land clearance if any are sighted
- Implement proper ECMS to prevent sediment runoff and siltation of waterways
- Regularly monitor hoarding to ensure that there are no gaps
- Establish designated areas for food and waste disposal
- Demarcate and manage areas for food consumption, storage, and waste disposal
- Limit works to daytime (i.e., 8 am to 6 pm)
- Turn off artificial lights when not in use
- Conduct information sessions for workers on what to do upon encountering wildlife

Table 4.10. Environmental Scores of the identified impacts on site's biodiversity with corresponding mitigation measures

Impact component	Predicted impact before mitigation							Mitigation measures	Predicted impact after mitigation						
	I	M	P	R	C	ES	Impact		I	M	P	R	C	ES	Impact
Flora and fauna mortality due to vegetation clearance for land clearance and tree-felling.	3	-3	3	3	3	-81	Moderate negative	<ul style="list-style-type: none"> Avoid felling during peak bird breeding season (mid-March to July). Visually inspect trees for nesting birds and animal prior to tree-felling. Fauna relocation by qualified agencies and/or specialist when necessary. Phased directional land clearance and tree-felling. 	3	-2	3	3	3	-54	Minor negative
Loss of habitats due to vegetation clearance for land clearance and tree-felling.	3	-2	3	3	3	-54	Minor negative	<ul style="list-style-type: none"> Visual inspect trees and holes for nesting birds and animals prior to felling. Ensure fauna has left nest before felling. 	3	-2	3	3	3	-54	Minor negative
Light disturbance to sensitive fauna and flora species in vegetated areas around project site.	1	-2	2	2	2	-12	Slight negative	<ul style="list-style-type: none"> Avoid nightworks. Direct construction lights away from forested areas during night works. 	1	0	2	2	2	0	No Impact
Roadkill or road injury to fauna attempting to cross the road.	1	-3	2	2	3	-21	Slight negative	<ul style="list-style-type: none"> Erect hoarding along Woodlands Road prior to vegetation clearance. 	1	-2	2	2	3	-14	Slight negative
Noise disturbance to sensitive fauna and flora species in vegetated areas around project site.	1	-2	2	2	2	-12	Slight negative	<ul style="list-style-type: none"> Avoid nightworks. 	1	-1	2	2	2	-6	No Impact
Potential human-wildlife conflict.	1	-3	2	2	2	-18	Slight negative	<ul style="list-style-type: none"> Establish designated areas for food and waste disposal. Regularly monitor hoarding to ensure that there are no gaps. Conduct information sessions on what to do upon encountering wildlife. 	1	-2	2	2	2	-12	Slight negative

5 FAUNA MANAGEMENT PLAN

Given that the location of the site currently forested, it is necessary to minimise impacts to biodiversity. The development of a proper Fauna Management Plan will help to reduce impacts to fauna, while also reducing the risk of human-wildlife conflict, which may pose a human health and safety issue if not managed.

It is recommended that an ecologist is engaged to re-evaluate and adapt this plan prior to any land clearance works as well as to supervise the land clearance activities.

A proper Fauna Management Plan aims to:

- Minimise the risk of road hazards and kills from the terrestrial fauna that are displaced from the project site onto adjacent roads.
- Minimise the risk of human-wildlife conflict from animals still remaining within the project boundaries.
- Ensure continued ecological connectivity between the fragmented habitats at all times during the project's construction.

Besides the Fauna Management Plan presented here, other mitigation measures for biodiversity detailed in Section 4.5 should be incorporated into a comprehensive implementation-stage Environmental Management and Monitoring Plan.

5.1 Biodiversity Awareness Training

Prior to land clearance activities, a biodiversity awareness training conducted by a trained ecologist should be arranged. This training should impart important information on the ecological importance of the site, and the importance of minimising impacts to the natural environment. Also, they should be trained on common fauna species they may encounter, and what to do should they have any wildlife encounters.

After the initial training, training reviews should be incorporated regularly during toolbox briefings.

5.2 Fauna Management for Land Clearance

Fauna management includes the following:

- Planned hoarding prior to clearance;
- A pre-clearance fauna inspection;
- Active relocation of target species (if necessary); and
- Directional/ phased clearance of trees.

Site clearance to be conducted in the following steps:

- Permanent hoarding along the road edges of the proposed working boundaries to prevent fauna from escaping onto the road;
- Capture and removal of wild pigs if encountered;
- Translocate any wildlife (other than wild pigs) encountered within the hoardings;

- Manual clearing of undergrowth in phases and the phased installation, and relocation of permanent & temporary hoarding to prevent return of wildlife;
- Inspection of trees and tree holes for arboreal fauna, and relocation by qualified agencies and/or specialists; and
- Felling of remaining trees.

Upon completion of the phased clearance, the permanent hoarding will cover the full perimeter of the project site.

5.2.1 Target Species for Fauna Management

A list of target fauna species has been developed based on the findings of Biodiversity Impact Assessment. Besides species encountered during the baseline surveys, other probable species that exist on the site were also included. This list was developed with the following considerations:

- Probable presence of species in the project area prior to construction;
- Risks to species from being in close proximity to construction activities;
- Practicality of relocating species from the project site;
- Conservation significance of species; and
- Risk of road kills, road hazards, and/or human-wildlife conflict arising from uncontrolled species displacement from the project area.

Given that the whole project site will be cleared, and in order to not endanger the terrestrial fauna species found in the site (since this patch is not directly connected to forested areas) as well as drivers and pedestrians along the road, we do not recommend wildlife shepherding for this project. Target animals (except wild pigs) encountered should be actively translocated by a certified animal management contractor (the list of which can be found [here](#)). The list in Table 5.1 details the targeted species for active translocation.

Table 5.1. List of identified target species for active translocation

Category	Species	Active Hours
Active Translocation	King Cobra	Diurnal
	Black Spitting Cobra	Diurnal
	Malayan Water Monitor	Diurnal
	Clouded Monitor	Diurnal
	Reticulated Python	Nocturnal
	Other snake species	Diurnal and nocturnal
	Feral Dog	Diurnal and nocturnal

If any wild pig is spotted at or around the site at any time during the project, NParks is to be informed as soon as possible at nparks_wildlife_management@nparks.gov.sg for advice and subsequent action. An approved wild boar removal contractor must also be engaged to trap and remove the said animals, the process of which may take about 4–8 weeks.

5.2.2 Methodology and Approach

All fauna management activities should only take place during daylight hours (8 am to 6 pm) where possible. It may include a combination of the following activities:

- Installation of hoarding along project boundaries, which would help to guide target terrestrial fauna in the intended direction of movement and as a barrier to prevent wildlife displacement onto adjacent roads;
- Installation of temporary hoarding along width of cleared areas to prevent wildlife from re-entering the cleared areas;
- Careful survey to check for the presence of target fauna species and any active nests or dens; and
- Active translocation by a certified animal management company.

Initial hoarding and undergrowth clearance should commence at two weeks prior to planned clearance. After clearance of undergrowth, cleared areas should be hoarded up to prevent target terrestrial fauna from returning to the site.

In the event that any target fauna listed in Table 5.1 are encountered during this process, active translocation should be conducted. NParks' Animal Rescue Centre should also be called immediately for the next course of action (i.e., whether the animal should be translocated to another site or euthanised). If the animal(s) is advised to be translocated, the engaged certified wildlife management contractor is to conduct the translocation.

No attempt should be made by uncertified members of the EMMP team, workers, or other unqualified personnel at any point to handle animals on site. Handling animals without appropriate certification is illegal under the recent Wildlife Act of June 2020.

For trees that are subjected to removal, it is necessary to check for the presence of fauna species before each individual tree is felled.

The ecologist shall inspect the tree for the presence of fauna, including birds, bats, arboreal mammals, and arboreal herpetofauna. The ecologist should do the following:

- Check the crown of the tree for bird nests.
- Check along the trunk from the bottom up for holes in which animals could be nesting.
- Scan the trunk and all the branches for animals using the tree.
- Scan the ground for potential nests, eggs, or burrows.

Photographs of all nests, tree holes, and burrows should be taken for record purposes.

In the event that the presence of birds, bats, arboreal mammals and herpetofauna, are found on the tree, tree felling, or transplanting must be postponed until the animal has left the tree on its own accord.

Tree felling or transplanting should not occur during peak breeding season for birds in Singapore, between the months of mid-March to July. Outside these months, if active nests are detected on the tree, nests shall be left undisturbed until the young birds have fledged. Inactive nests should be removed to minimize the possibility of a new nesting

attempt. Tree felling or transplanting shall occur only when no active nests are present on the tree.

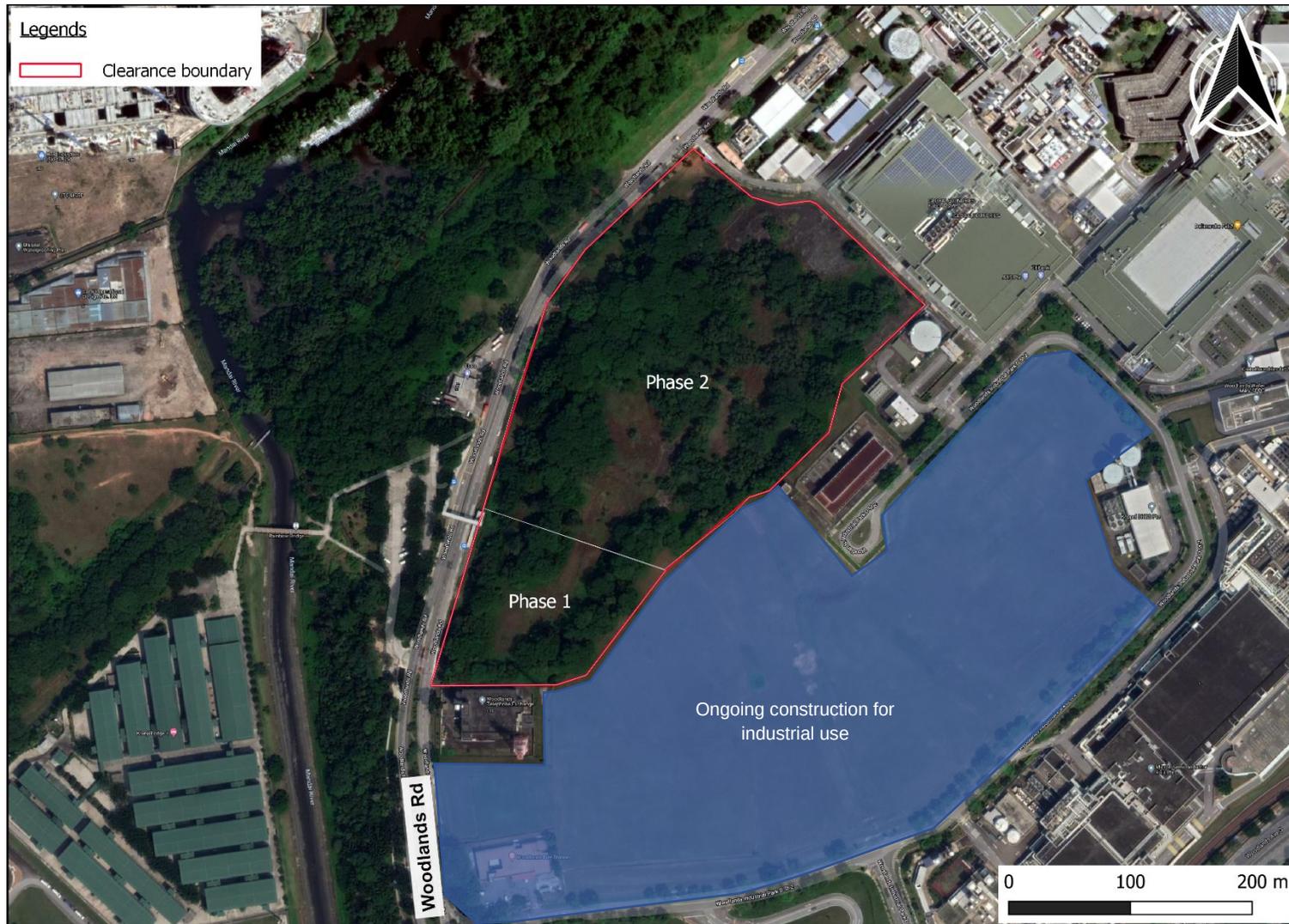
Once the tree felling is complete, the tree should be inspected again for any animals that were not detected earlier. Should an animal be detected after felling, NParks Animal Response Centre or ACRES should be contacted immediately, especially since the animal might be injured.

Through the undertaking of the general approach here, a register shall be maintained to record:

- i) the activities that were carried out;
- ii) the species, numbers, GPS locations, dates, timings, and actions taken (if any) for each target fauna which was identified; and
- iii) the description, GPS location, and actions taken (if any) for each burrow, inhabited tree hole and nest that was identified.

5.2.3 Spatial Visualisation of the Hoarding and Directional Clearance Plan

The below figures illustrate the scheduled phasing for vegetation clearance. These activities should take place during daylight hours only (i.e., 8 am to 6 pm) and a minimum of one rest day (i.e., Sunday) per week shall be provided to reduce disturbance to wildlife. Tree felling may commence once understory vegetation has been cleared.



Land clearance would be conducted in two phases, with the respective area for each indicated in the map.

Figure 5.1. Directional Clearance 1



Hoarding for the Phase 1 clearance is to be erected along Woodlands Road, continuing southward before turning eastward and terminate at Phase 1 clearance boundary to prevent animals from running out into the open areas, especially Woodlands Road.

Figure 5.2. Directional Clearance 2

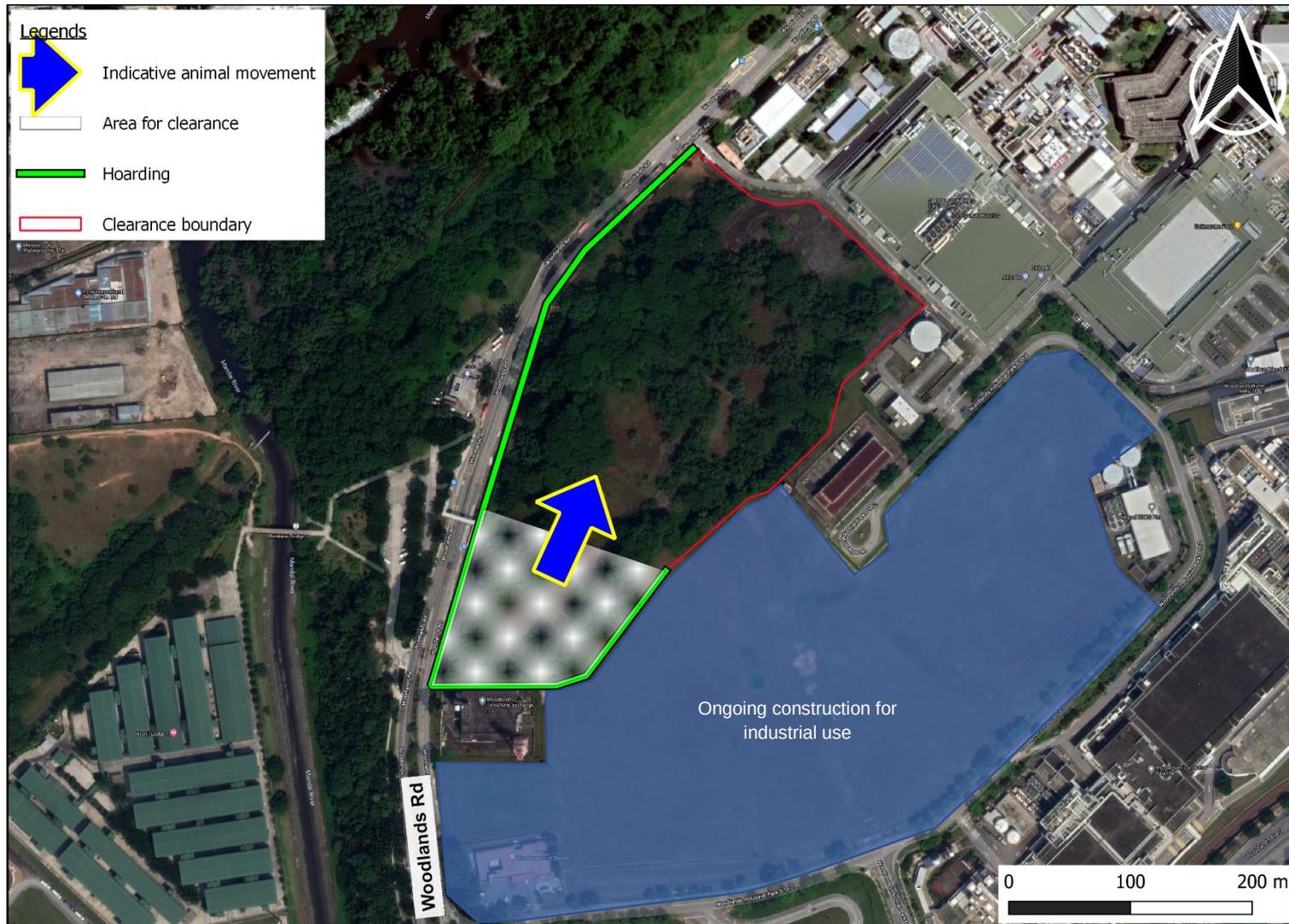
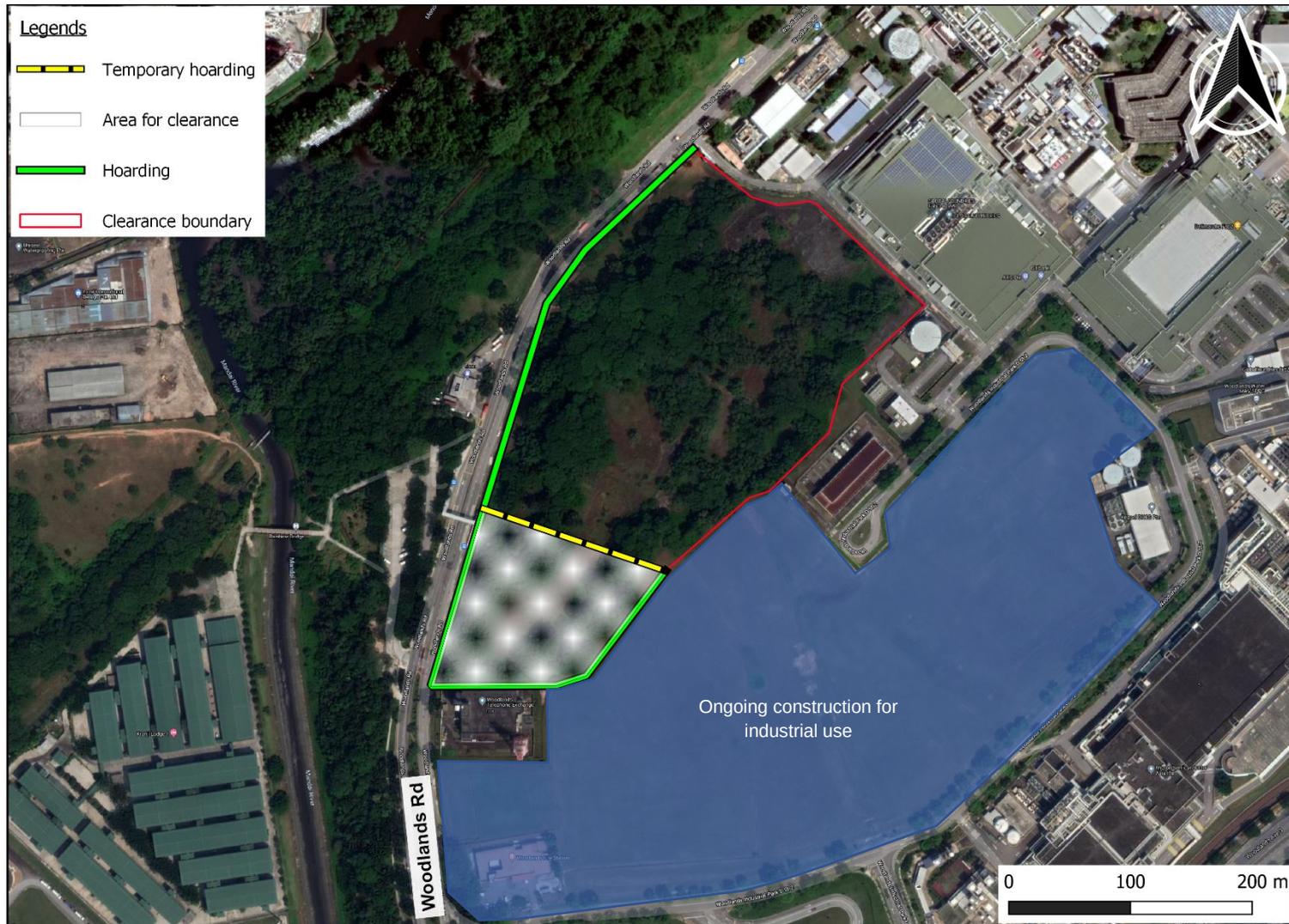


Figure 5.3. Directional Clearance 3

Phase 1 clearance shall then commence, going northward gradually.

Understorey vegetation clearance shall first be conducted.

Once understorey vegetation is cleared and trees are about to be felled, all tree holes, nests, and burrows should be recorded and inspected for wildlife presence.



Cleared areas will be temporarily hoarded at the edge to prevent fauna from re-entering cleared areas.

Figure 5.4. Directional Clearance 4



Next, hoarding shall be erected along the rest of the clearance boundary for the Phase 2 clearance.

Figure 5.5. Directional Clearance 5

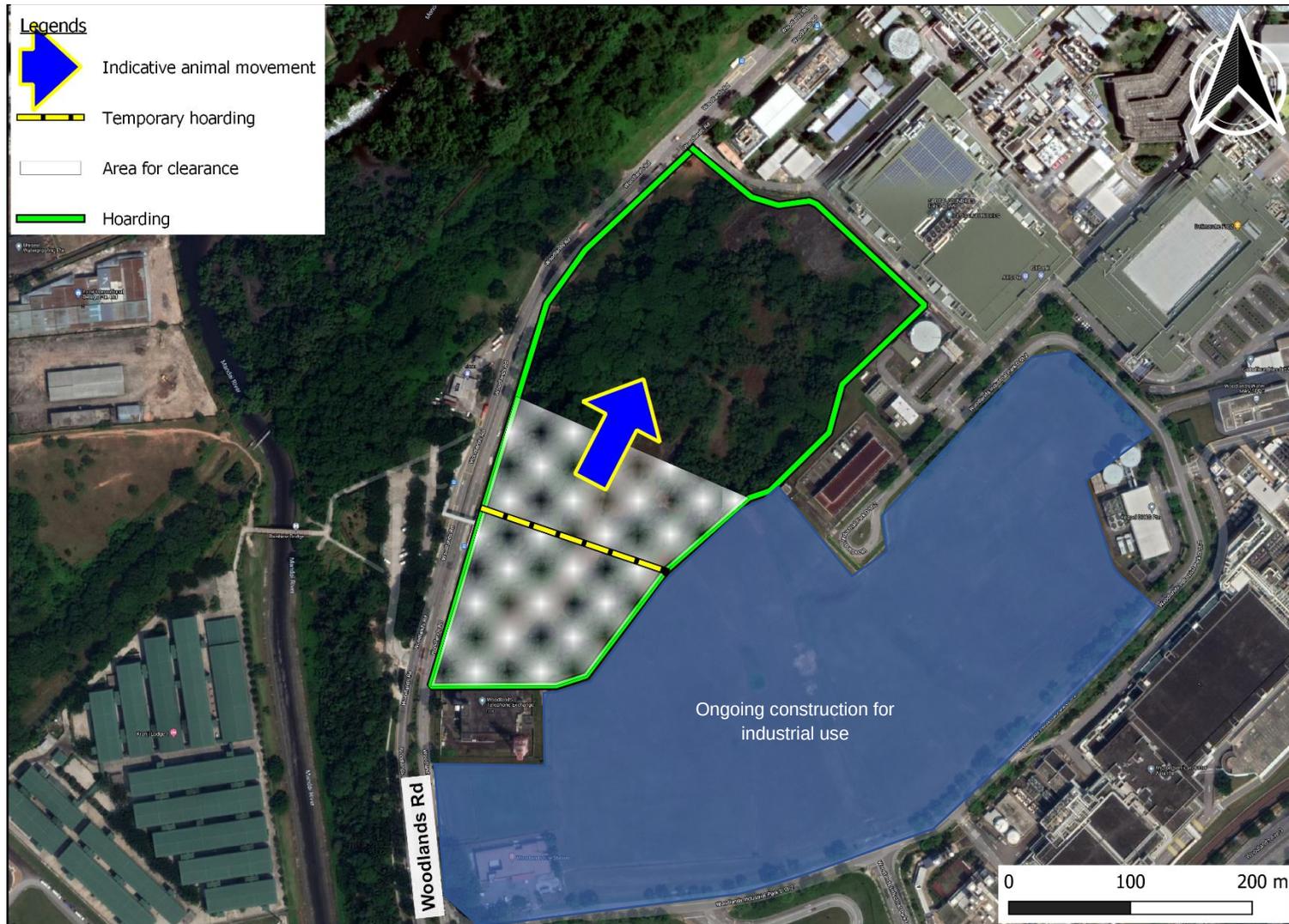


Figure 5.6. Directional Clearance 6

Phase 2 clearance is to be conducted in three stages, beginning with the first one-third immediately adjacent to Phase 1 clearance area.

Understorey vegetation clearance shall firstly be conducted.

Once understorey vegetation is cleared and trees are about to be felled, all tree holes, nests, and burrows should be recorded and inspected for wildlife presence.



Cleared areas will be temporarily hoarded at the edge to prevent fauna from re-entering cleared areas.

Figure 5.7. Directional Clearance 7

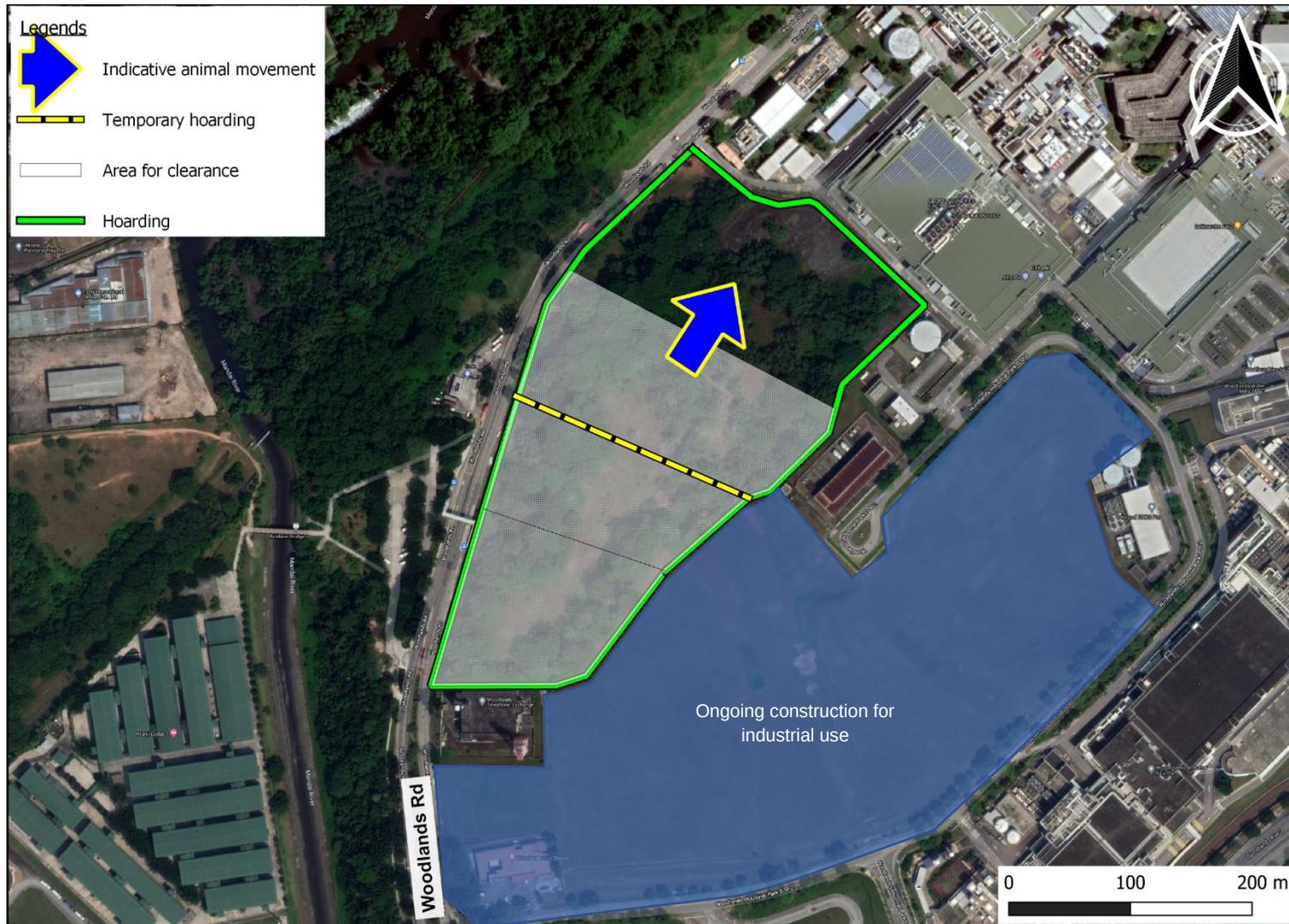


Figure 5.8. Directional Clearance 8

The second one - third of Phase 2 clearance is to be conducted next.

Understorey vegetation clearance shall first be conducted.

Once understorey vegetation is cleared and trees are about to be felled, all tree holes, nests, and burrows should be recorded and inspected for wildlife presence.



Cleared areas will be temporarily hoarded at the edge to prevent fauna from re-entering cleared areas.

Figure 5.9. Directional Clearance 9



The final one-third of Phase 2 clearance is to be conducted next.

Upon completion of clearance, temporary hoardings can be removed.

Figure 5.10. Directional Clearance 10

5.3 Wildlife Response and Rescue Plan

Even upon the completion of wildlife shepherding works, it is highly probable that animals might be able to enter the site and get trapped, particularly burrowing or climbing animals. Whenever fauna is encountered within the working areas, all construction activities should be stopped immediately, and the Wildlife Response and Rescue Plan should be followed. Only certified personnel are allowed to handle wildlife. NParks Animal Rescue Centre should be notified should there be a need for animal translocation. A sample Wildlife Response and Rescue Plan is detailed below. This plan can be tweaked during the implementation-stage EMMP.

Table 5.2. Wildlife response and rescue plan protocol

Particular	Within the project site					Outside project site
Timeframe	During working hours					Any time
Animal Type	Large, Highly Mobile Animals e.g. Wild Boar, Feral Dog		Non-Large Animals			Any
			Venomous / Poisonous e.g. King Cobra, Black Spitting Cobra		Non-venomous / poisonous e.g. Malayan Water Monitor	
Animal Condition	Alive / Moving / Resting	Dead	Alive / Moving / Resting	Dead	Any	-
Risk To Human	High	Low	High	Low	Low	-
Response	<ul style="list-style-type: none"> a. Stop work on work site b. Report to SO, SO Rep and PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform Ecologist, who will contact NParks/ ACRES for 	<ul style="list-style-type: none"> a. Barricade affected area b. Report to SO, SO Rep and PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform Ecologist. e. If required, Contractor to assist 	<ul style="list-style-type: none"> a. Stop work at affected area; if possible, barricade affected area b. Report to SO, SO Rep and PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform Ecologist, 	<ul style="list-style-type: none"> a. Barricade affected area b. Report to SO, SO Rep and PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform Ecologist. e. If required, Contractor to assist 	<ul style="list-style-type: none"> a. Stop work at affected area; if possible, barricade affected area b. Report to SO, SO Rep and PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform Ecologist, 	<ul style="list-style-type: none"> a. Notify NParks Animal Rescue Centre/ ACRES hotline if necessary

Particular	Within the project site					Outside project site
	next steps if necessary	with transporting of the Wild Animal to Disposal Location	who will contact NParks/ ACRES for next steps if necessary	with transporting of Wild Animal to Disposal Location	who will contact NParks/ ACRES for next steps if necessary	
Remarks	<ul style="list-style-type: none"> • No attempts shall be made by Contractors to handle the animal • Contractor to take photograph of the animal if possible. • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Rescue Centre or ACRES hotline 	<ul style="list-style-type: none"> • Contractor to take photograph of the animal 	<ul style="list-style-type: none"> • No attempts shall be made by Contractors to handle the animal • Contractor to take photograph of the animal if possible. • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Rescue Centre or ACRES hotline 	<ul style="list-style-type: none"> • Contractor to take photograph of the animal. 	<ul style="list-style-type: none"> • No attempts shall be made by contractors to handle the animal • Contractor to take photograph of the animal if possible. • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Rescue Centre or ACRES hotline 	<ul style="list-style-type: none"> • Contractor is encouraged to report • Reports could be from Public and/or Contractor's Staff • If required, CEMMP In-charge to contact PM for assistance of transferring Wildlife Animal Carcass to Disposal Location

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Appendix A

List of Species Recorded in Project Study Area

Table B.1. List of flora found in the project study area

No	Family	Species	Status	Type
1	Adiantaceae	<i>Adiantum latifolium</i>	Naturalised (Cult.)	Herb
2	Anacardiaceae	<i>Mangifera indica</i>	Exotic (Cult.)	Tree
3	Araceae	<i>Aglaonema commutatum</i>	Exotic (Cult.)	Herb
4	Araceae	<i>Alocasia macrorrhizos</i>	Naturalised (Cult.)	Herb
5	Araceae	<i>Dieffenbachia seguine</i>	Exotic (Cult.)	herb
6	Araceae	<i>Epipremnum pinnatum</i>	Critically Endangered (Cult.)	Climber
7	Araceae	<i>Syngonium podophyllum</i>	Naturalised	Climber
8	Araliaceae	<i>Polyscias diversifolia</i>	Common (Cult.)	Tree
9	Arecaceae	<i>Caryota mitis</i>	Common (Cult.)	Tree
10	Arecaceae	<i>Cocos nucifera</i>	Naturalised (Cult.)	Tree
11	Arecaceae	<i>Elaeis guineensis</i>	Exotic (Cult.)	Tree
12	Arecaceae	<i>Ptychosperma macarthurii</i>	Naturalised (Cult.)	Tree
13	Aspleniaceae	<i>Asplenium nidus</i>	Common (Cult.)	Epiphyte
14	Asteraceae	<i>Bidens pilosa</i>	Naturalised (Cult.)	Herb
15	Bignoniaceae	<i>Spathodea campanulata</i>	Naturalised (Cult.)	Tree
16	Bignoniaceae	<i>Tabebuia rosea</i>	Exotic (Cult.)	Tree
17	Casuarinaceae	<i>Casuarina equisetifolia</i>	Common (Cult.)	Tree
18	Combretaceae	<i>Terminalia catappa</i>	Common	Tree
19	Convolvulaceae	<i>Ipomoea cairica</i>	Naturalised (Cult.)	Climber
20	Cucurbitaceae	<i>Coccinia grandis</i>	Naturalised (Cult.)	climber
21	Cyperaceae	<i>Kyllinga polyphylla</i>	Naturalised (Cult.)	Herb
22	Dilleniaceae	<i>Dillenia suffruticosa</i>	Common (Cult.)	Shrub
23	Dilleniaceae	<i>Tetracera indica</i>	Common	Climber
24	Euphorbiaceae	<i>Claoxylon indicum</i>	Common (Cult.)	Tree
25	Euphorbiaceae	<i>Macaranga gigantea</i>	Common	Tree
26	Euphorbiaceae	<i>Macaranga heynei</i>	Common	Tree

No	Family	Species	Status	Type
27	Euphorbiaceae	<i>Mallotus paniculatus</i>	Common (Cult.)	Tree
28	Euphorbiaceae	<i>Manihot carthagenesis</i>	Naturalised (Cult.)	Tree
29	Fabaceae	<i>Acacia auriculiformis</i>	Naturalised (Cult.)	Tree
30	Fabaceae	<i>Adenantha pavonina</i>	Naturalised (Cult.)	Tree
31	Fabaceae	<i>Andira inermis</i>	Exotic (Cult.)	Tree
32	Fabaceae	<i>Canavalia cathartica</i>	Common	Climber
33	Fabaceae	<i>Falcataria moluccana</i>	Naturalised (Cult.)	Tree
34	Fabaceae	<i>Leucaena leucocephala</i>	Naturalised	Tree
35	Fabaceae	<i>Mimosa pudica</i>	Naturalised (Cult.)	Shrub
36	Fabaceae	<i>Pithecellobium dulce</i>	Exotic (Cult.)	Tree
37	Fabaceae	<i>Pterocarpus indicus</i>	Exotic (Cult.)	Tree
38	Heliconiaceae	<i>Heliconia latispartha</i>	Exotic (Cult.)	Herb
39	Lamiaceae	<i>Vitex pinnata</i>	Common (Cult.)	Tree
40	Lauraceae	<i>Cinnamomum iners</i>	Common (Cult.)	Tree
41	Malvaceae	<i>Muntingia calabura</i>	Naturalised (Cult.)	Tree
42	Melastomataceae	<i>Clidemia hirta</i>	Naturalised (Cult.)	Shrub
43	Melastomataceae	<i>Melastoma malabathricum</i>	Common (Cult.)	Shrub
44	Moraceae	<i>Ficus fistulosa</i>	Common (Cult.)	Tree
45	Moraceae	<i>Ficus grossularioides</i>	Common (Cult.)	Tree
46	Moraceae	<i>Ficus hispida</i>	Exotic (Cult.)	Tree
47	Moraceae	<i>Ficus pumila</i>	Exotic (Cult.)	Climber
48	Moraceae	<i>Ficus variegata</i>	Common (Cult.)	Tree
49	Musaceae	<i>Musa acuminata</i>	Exotic (Cult.)	Herb
50	Myrtaceae	<i>Syzygium cumini</i>	Common	Tree
51	Myrtaceae	<i>Syzygium grande</i>	Common (Cult.)	Tree
52	Myrtaceae	<i>Syzygium myrtifolium</i>	[Extinct] (Cult.)	Tree
53	Myrtaceae	<i>Syzygium polyanthum</i>	Vulnerable (Cult.)	Tree

No	Family	Species	Status	Type
54	Oleandraceae	<i>Nephrolepis biserrata</i>	Common	Herb
55	Orchidaceae	<i>Spathoglottis plicata</i>	Common (Cult.)	Herb
56	Phyllanthaceae	<i>Bridelia tomentosa</i>	Common	Tree
57	Piperaceae	<i>Piper aduncum</i>	Naturalised	Tree
58	Piperaceae	<i>Piper sarmentosum</i>	Common (Cult.)	Climber
59	Poaceae	<i>Bambusa heterostachya</i>	Exotic (Cult.)	Herb
60	Poaceae	<i>Pennisetum purpureum</i>	Naturalised	Herb
61	Polypodiaceae	<i>Pyrrisia piloselloides</i>	Common	epiphyte
62	Rubiaceae	<i>Oxyceros longiflorus</i>	Vulnerable	Climber
63	Rubiaceae	<i>Paederia foetida</i>	Common (Cult.)	Climber
64	Rubiaceae	<i>Morinda citrifolia</i>	Extinct (Cult.)	Tree
65	Ruscaceae	<i>Dracaena fragrens</i>	Exotic (Cult.)	Shrub
66	Rutaceae	<i>Clausena excavata</i>	Common (Cult.)	Shrub
67	Thelypteridaceae	<i>Pronephrium triphyllum</i>	Common	Herb
68	Thelypteridaceae	<i>Cyclosorus interruptus</i>	Common	Herb
69	Urticaceae	<i>Cecropia pachystachya</i>	Naturalised	Tree
70	Verbenaceae	<i>Lantana camara</i>	Naturalised (Cult.)	Shrub
71	Vitaceae	<i>Cissus hastata</i>	Weed (Cult.)	Climber
72	Vitaceae	<i>Leea indica</i>	Common (Cult.)	Tree

Note:

- When Conservation Status is shown in brackets (e.g. [Extinct]), the species is considered persistent from cultivation and of low significance.

Table B.2. List of birds found in the project study area

No	Family	Species name	Common Name	Local Status	Local Conservation Status (SRDB)	IUCN status
1	Accipitridae	<i>Haliastur indus</i>	Brahminy Kite	RB		LC
2	Accipitridae	<i>Nisaetus cirrhatus</i>	Changeable Hawk-eagle	RB (F/W)	EN	LC
3	Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Sea Eagle	RB		LC
4	Aegithinidae	<i>Aegithina tiphia</i>	Common Iora	RB		LC
5	Alcedinidae	<i>Todirhamphus chloris</i>	Collared Kingfisher	RB		LC
6	Alcedinidae	<i>Halcyon smyrnensis</i>	White-throated Kingfisher	RB		LC
7	Apodidae	<i>Ardea alba</i>	Great Egret	WV		LC
8	Apodidae	Family Apodidae	Swiftlet			
9	Ardeidae	<i>Ardea cinerea</i>	Grey Heron	RB	VU	LC
10	Ardeidae	<i>Ixobrychus sinensis</i>	Yellow Bittern	RB, WV		LC
11	Campephagidae	<i>Pericrocotus divaricatus</i>	Ashy Minivet	WV PM (F/W)		LC
12	Campephagidae	<i>Lalage nigra</i>	Pied Triller	RB		LC
13	Caprimulgidae	<i>Caprimulgus macrurus</i>	Large-tailed Nightjar	RB		LC
14	Caprimulgidae	<i>Caprimulgus affinis</i>	Savanna Nightjar	RB		LC
15	Ciconiidae	<i>Mycteria (cinerea x leucocephala)</i>	Hybrid Stork			
16	Cisticolidae	<i>Orthotomus sericeus</i>	Rufous-tailed Tailorbird	RB		LC
17	Cisticolidae	<i>Orthotomus sutorius</i>	Common Tailorbird	RB		LC
18	Cisticolidae	<i>Orthotomus atrogularis</i>	Dark-necked Tailorbird	RB (F/W)		LC
19	Cisticolidae	<i>Cisticola juncidis</i>	Zitting Cisticola	RB		LC
20	Cisticolidae	<i>Prinia flaviventris</i>	Yellow-bellied Prinia	RB		LC
21	Columbidae	<i>Treron vernans</i>	Pink-necked Green Pigeon	RB		LC
22	Columbidae	<i>Columba livia</i>	Rock Pigeon	IRB		LC

No	Family	Species name	Common Name	Local Status	Local Conservation Status (SRDB)	IUCN status
23	Columbidae	<i>Streptopelia chinensis</i>	Spotted Dove	RB		LC
24	Columbidae	<i>Geopelia striata</i>	Zebra Dove	RB		LC
25	Columbidae	<i>Chalcophaps indica</i>	Common Emerald Dove	RB		LC
26	Coraciidae	<i>Eurystomus orientalis</i>	Oriental Dollarbird	RB, WV		LC
27	Corvidae	<i>Corvus splendens</i>	House Crow	IRB		LC
28	Cuculidae	<i>Chrysococcyx minutillus</i>	Little Bronze Cuckoo	RB		LC
29	Cuculidae	<i>Cacomantis sepulcralis</i>	Rusty-breasted Cuckoo	RB	VU	LC
30	Dicaeidae	<i>Dicaeum cruentatum</i>	Scarlet-backed Flowerpecker	RB		LC
31	Dicruridae	<i>Dicrurus paradiseus</i>	Greater Racket-tailed Drongo	RB		LC
32	Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow	RB		LC
33	Megalaimidae	<i>Psilopogon haemacephalus</i>	Coppersmith Barbet	RB		LC
34	Megalaimidae	<i>Psilopogon lineatus</i>	Lineated Barbet	IRB		LC
35	Meropidae	<i>Merops viridis</i>	Blue-throated Bee-eater	MB (F/W)		LC
36	Meropidae	<i>Merops philippinus</i>	Blue-tailed Bee-eater	WV		LC
37	Motacillidae	<i>Anthus rufulus</i>	Paddyfield Pipit	RB		LC
38	Muscicapidae	<i>Muscicapa dauurica</i>	Asian Brown Flycatcher	WV, PM (F/W)		LC
39	Muscicapidae	<i>Copsychus saularis</i>	Oriental Magpie-robin	RB	EN	LC
40	Nectariniidae	<i>Anthreptes malacensis</i>	Brown-throated Sunbird	RB		LC
41	Nectariniidae	<i>Aethopyga siparaja</i>	Crimson Sunbird	RB (F/W)		LC
42	Nectariniidae	<i>Cinnyris jugularis</i>	Olive-backed Sunbird	RB		LC
43	Nectariniidae	<i>Leptocoma brasiliana</i>	Van Hasselt's Sunbird	RB		LC
44	Oriolidae	<i>Oriolus chinensis</i>	Black-naped Oriole	RB, WV / PM		LC

No	Family	Species name	Common Name	Local Status	Local Conservation Status (SRDB)	IUCN status
45	Phylloscopidae	<i>Phylloscopus borealis</i>	Arctic Warbler	WV, PM (F/W)		LC
46	Picidae	<i>Chrysophlegma miniaceum</i>	Banded Woodpecker	RB		LC
47	Picidae	<i>Dinopium javanense</i>	Common Flameback	RB (F/W)		LC
48	Picidae	<i>Picus vittatus</i>	Laced Woodpecker	RB (F/W)		LC
49	Psittacidae	<i>Psittacula longicauda</i>	Long-tailed Parakeet	RB (F/W)		VU
50	Psittacidae	<i>Psittacula alexandri</i>	Red-breasted Parakeet	IRB		NT
51	Psittacidae	<i>Psittacula krameria</i>	Rose-ringed Parakeet	IRB		LC
52	Psittacidae	<i>Loriculus galgulus</i>	Blue-crowned Hanging Parrot	RB	EN	LC
53	Pycnonotidae	<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul	IRB		LC
54	Pycnonotidae	<i>Pycnonotus zeylanicus</i>	Straw-headed Bulbul	RB (F/W)	EN	CR
55	Pycnonotidae	<i>Pycnonotus goiavier</i>	Yellow-vented Bulbul	RB		LC
56	Rallidae	<i>Rallina fasciata</i>	Red-legged Crake	RB, WV	VU	LC
57	Rallidae	<i>Amaurornis phoenicurus</i>	White-breasted Waterhen	RB		LC
58	Sturnidae	<i>Aplonis panayensis</i>	Asian Glossy Starling	RB		LC
59	Sturnidae	<i>Acridotheres javanicus</i>	Javan Myna	IRB		VU
60	Zosteropidae	<i>Zosterops simplex</i>	Swinhoe's White-eye	I? RB		LC

Local Status

I = Introduced
F/W = Forest / Woodland species
RB = Resident Breeder
WV = Winter Visitor
PM = Passage Migrant
MB = Migrant Breeder
NBV = Non-breeding visitor

Abundance

A = Abundant
C = Common
U = Uncommon
R = Rare

Table B.3. List of mammals found in the project study area

No.	Family	Species name	Common Name	Local Status	Local Conservation Status	IUCN status
1	Muridae	<i>Rattus tanezumi</i>	Asian House Rat	Native	–	LC
2	Pteropodidae	<i>Cynopterus brachyotis</i>	Lesser Dog-faced Fruit Bat	Native	–	LC
3	Sciuridae	<i>Callosciurus notatus</i>	Plantain Squirrel	Native	–	LC
4	Tupaiaidae	<i>Tupaia glis</i>	Common Treeshrew	Native	–	LC
5	Viverridae	<i>Paradoxurus hermaphroditus</i>	Common Palm Civet	Native	–	LC

Table B.4. List of herpetofauna found in the project study area

No.	Family	Species name	Common Name	Local Status (derived from <i>Wild Animals of Singapore</i>)	Local Conservation Status	IUCN status
Reptiles						
1	Agamidae	<i>Calotes versicolor</i>	Changeable Lizard	Widespread and common	Introduced	LC
2	Gekkonidae	<i>Hemidactylus frenatus</i>	Spiny-tailed House Gecko	Widespread and common		LC
3	Gekkonidae	<i>Hemidactylus brookii</i>	Brooke's House Gecko			LC
4	Scincidae	<i>Eutropis multifasciata</i>	Common Sun Skink	Widespread and common		LC
5	Varanidae	–	Unidentified Monitor Lizard			
Amphibians						
1	Bufoidea	<i>Duttaphrynus melanostictus</i>	Asian Toad	Widespread and common		LC
2	Dicroglossidae	<i>Fejervarya limnocharis</i>	Field Frog	Widespread and common		LC
3	Dicroglossidae	<i>Limnonectes blythii</i>	Malayan Giant Frog	Widespread and common		NT
4	Microhylidae	<i>Microhyla butleri</i>	Painted Chorus Frog	Widespread and common		LC
5	Microhylidae	<i>Microhyla fissipes</i> *	East Asian Ornate Chorus Frog	Widespread and common*	Introduced	LC
6	Microhylidae	<i>Microrhyla heymonisi</i>	Dark-sided Chorus Frog	Widespread and common		LC
7	Microhylidae	<i>Kaloula pulchra</i>	Banded Bullfrog	Widespread and common	Introduced	LC
8	Ranidae	<i>Sylvirana guentheri</i>	Gunther's Frog		Introduced	LC
9	Rhacophoridae	<i>Polypedates leucomystax</i>	Four-lined Tree Frog	Widespread and common		LC

* *M. fissipes* is listed as “restricted and rare” in the book but this species has since been found in many other locations around Singapore.

Table B.5. List of butterflies found in the project study area

No.	Family	Subfamily	Species name	Common Name	Local Status*	IUCN status
1	Hesperiidae	Hesperiinae	<i>Potanthus omaha omaha</i>	Lesser Dart	Common	
2	Hesperiidae	Hesperiinae	<i>Taractrocera archias quinta</i>	Yellow Grass Dart	Moderately Common	
3	Hesperiidae	Hesperiinae	<i>Iambrix salsala salsala</i>	Chestnut Bob	Common	
4	Hesperiidae	Hesperiinae	<i>Pelopidas agna agna</i>	Bengal Swift	Moderately Common	
5	Hesperiidae	Hesperiinae	<i>Pelopidas mathias mathias</i>	Small Branded Swift	Common	
6	Hesperiidae	Hesperiinae	<i>Polytremis lubricans lubricans</i>	Contiguous Swift	Common	
7	Hesperiidae	Hesperiinae	<i>Pelopidas agna agna</i>	Bengal Swift	Moderately Common	
8	Lycaenidae	Polyommatainae	<i>Megisba malaya sikkima</i>	The Malayan	Moderately Rare	
9	Lycaenidae	Polyommatainae	<i>Zizula hylax pygmaea</i>	Pygy Grass Blue	Common	
10	Lycaenidae	Polyommatainae	<i>Zizeeria maha serica</i>	Pale Grass Blue	Common	
11	Lycaenidae	Polyommatainae	<i>Zizina otis lampa</i>	Lesser Grass Blue	Common	
12	Lycaenidae	Polyommatainae	<i>Prosotas dubiosa lumpura</i>	Tailless Line Blue	Common	
13	Nymphalidae	Satyrinae	<i>Mycalesis mineus</i>	Dark Brand Bush Brown	Common	
14	Nymphalidae	Satyrinae	<i>Mycalesis visala phamis</i>	Long Brand Bush Brown	Moderately Common	
15	Nymphalidae	Satyrinae	<i>Orsotriaena medus cinerea</i>	Dark Grass Brown	Common	
16	Nymphalidae	Heliconiinae	<i>Acraea terpsicore</i>	Tawny Coster	Common	
17	Nymphalidae	Satyrinae	<i>Elymnias hypermnestra agina</i>	Common Palmfly	Common	
18	Nymphalidae	Nymphalinae	<i>Junonia orithya</i>	Blue Pansy	Common	
19	Nymphalidae	Nymphalinae	<i>Junonia hedonia ida</i>	Chocolate Pansy	Common	
20	Nymphalidae	Nymphalinae	<i>Junonia almana javana</i>	Peacock Pansy	Common	LC
21	Nymphalidae	Nymphalinae	<i>Hypolimnys anomala anomala</i>	Malayan Eggfly	Common	
22	Nymphalidae	Satyrinae	<i>Mycalesis perseus cepheus</i>	Dingy Bush Brown	Moderately Common	
23	Nymphalidae	Danainae	<i>Euploea phaenareta castelnaui</i>	King Crow	Moderately Rare	
24	Papilionidae	Papilioninae	<i>Papilio polytes romulus</i>	Common Mormon	Common	
25	Pieridae	Pierinae	<i>Appias libythea olferna</i>	Striped Albatross	Common	

No.	Family	Subfamily	Species name	Common Name	Local Status*	IUCN status
26	Pieridae	Pierinae	<i>Delias hyparete metarete</i>	Painted Jezebel	Common	
27	Pieridae	Coliadinae	<i>Eurema blanda snelleni</i>	Three Spot Grass Yellow	Common	
28	Pieridae	Coliadinae	<i>Eurema hecabe contubernalis</i>	Common Grass Yellow	Common	
29	Pieridae	Coliadinae	<i>Catopsilia pomona pomona</i>	Lemon Emigrant	Common	

* Derived from Khew, S. (2015). A field guide to the butterflies of Singapore / Khew Sin Khoo. (2nd ed.). Ink on Paper Communications.

Table A.6. List of odonates found in the project study area

No.	Family	Species name	Common Name	Distribution and Rarity	Local Conservation Status	IUCN status
1	Coenagrionidae	<i>Ceriagrion cerinorubellum</i>	Ornate Coraltail	Widespread and common	LC	LC
2	Libellulidae	<i>Rhyothemis phyllis</i>	Yellow-barred Flutterer	Widespread and common	LC	LC
3	Libellulidae	<i>Neurothemis fluctuans</i>	Common Parasol	Widespread and common	LC	LC
4	Libellulidae	<i>Orthetrum luzonicum</i>	Slender Blue Skimmer	Widespread & Common	LC	LC
5	Libellulidae	<i>Orthetrum sabina</i>	Variegated Green Skimmer	Widespread and common	LC	LC
6	Libellulidae	<i>Orthetrum testaceum</i>	Scarlet Skimmer	Widespread and common	LC	LC
7	Libellulidae	<i>Rhodothemis rufa</i>	Common Redbolt	Widespread and common	LC	LC
8	Libellulidae	<i>Pornothemis starrei</i>	Mangrove Marshal	Widespread but uncommon	NT	NT
9	Libellulidae	<i>Lathrecista asiatica</i>	Scarlet Grenadier	Widespread and common	LC	LC
10	Libellulidae	<i>Agrionoptera insignis</i>	Grenadier	Widespread & Common	LC	LC
11	Libellulidae	<i>Camacinia gigantea</i>	Sultan	Widespread but Uncommon	LC	LC
12	Libellulidae	<i>Pantala flavescens</i>	Wandering Glider	Widespread and common	LC	LC
13	Libellulidae	<i>Orthetrum glaucum</i>	Blue Skimmer	Widespread & Common	LC	LC
14	Libellulidae	<i>Orchithemis pulcherrima</i>	Variable Sentinel	Widespread & Common	LC	LC

Appendix B

Photographs of Plants Observed in Project Study Area



Acrostichum aureum



Acrostichum aureum



Adenanthera pavonina



Casuarina equisetifolia



Bridelia tomentosa



Cocos nucifera



Cyclosorus interruptus



Cyclosorus interruptus (moist ground)



Epipremnum pinnatum



Ficus microcarpa



Ficus pumila



Ficus religiosa



Leea indica



Leucaena leucocephala



Macaranga gigantea



Morinda citrifolia



Muntingia calabura



Neptunia plena (moist ground)



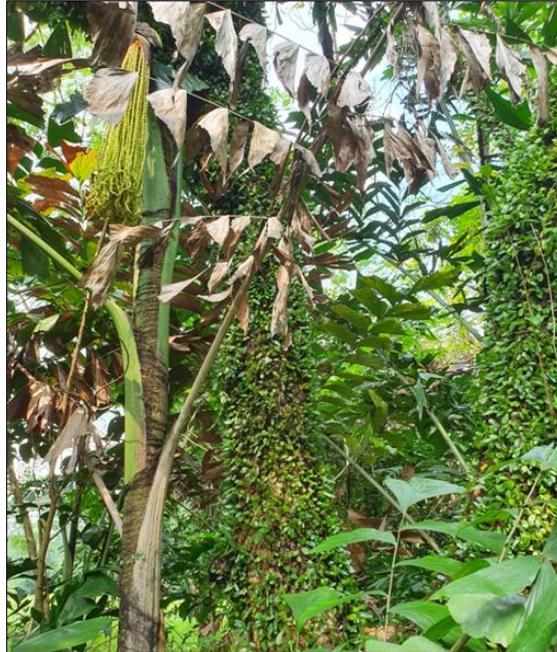
Oxyceros longiflorus



Pithecellobium dulce



Polyscias diversifolia



Caryota mitis and *Pyrrosia piloselloides*
(epiphyte)



Syzygium cumini



Syzygium cumini
(growing about sealed surface)



Spathoglottis plicata



Syzygium polyanthum



Tabebuia rosea



Terminalia catapa



Tetracera indica



Vitex pinnata

Appendix C

Photographs of Animals Observed in Project Study Area



Brahminy Kite



Black-naped Oriole



Blue-throated Bee-eater



Blue-tailed Bee-eater



Changeable Hawk Eagle



Large-tailed Nightjar



Lined Barbet



Long-tailed Parakeet



Oriental Dollarbird



Oriental Magpie Robin



Olive-backed Sunbird



Red-whiskered Bulbul



Savanna Nightjar



Straw-headed Bulbul



White-bellied Sea Eagle



Plantain Squirrel



Asian Toad



Banded Bullfrog



Field Frog



Four-lined Tree Frog



Brooke's House Gecko



Changeable Lizard



Common Sun Skink



Common Grass Yellow



Common Pamfly



Contiguous Swift



Dark Brand Bush Brown



Dark Grass Brown



King Crow



Lesser Dart



Lesser Grass Blue



Malayan



Pale Grass Blue



Tawny Coster



Three Spot Grass Yellow



Small Branded Swift



Blue Skimmer



Common Parasol



Mangrove Marshal



Ornate Coraltail



Sultan



Scarlet Grenadier



Variegated Green Skimmer



Wandering Glider



Thiaridae (mollusc)



Lymnaeidae (mollusc)