Proposed Springleaf Precinct Master Plan

Environmental Impact Assessment

Draft Report

Urban Redevelopment Authority

Environmental Impact Assessment

June 2022

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Draft Report

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1 Introduction

The Urban Redevelopment Authority (URA) has sought consultancy services to develop a proposed Springleaf Precinct Master Plan with Urban Design Guidelines and carry out an Environmental Impact Assessment (EIA) for the Springleaf Precinct in Singapore. DHI Water & Environment (S) Pte Ltd (DHI) is a member of the multidisciplinary team with MKPL Architects Pte Ltd (Architect), Sitetectonix Private Limited (Landscape Architect), Arup Singapore Pte Ltd (Engineering), ArborCulture Pte Ltd (Ecology) and Web Earth Pte Ltd (Sustainability) that was appointed by URA through a 2-stage competition format. The awarded team was appointed to develop the concepts from the competition stage. The role of DHI has been to provide an objective review and assessment of the proposed Springleaf Precinct Master Plan to ensure that environmental impacts and their significance have been fully considered and will be appropriately addressed.

1.1 Overview of Proposed Development

Springleaf Precinct is intended as an urban village, with a total of approximately 2,000 dwelling units (DUs). The development will be done following Biodiversity Sensitive Urban Design (BSUD) principles. The multidisciplinary team has been engaging with URA, other Singapore Authorities and stakeholders to master plan and design a unique residential precinct at Springleaf that celebrates the natural assets and qualities of the site and introduces new housing typologies, designs and strategies that are sensitive to the biodiversity, hydrology and heritage of Springleaf (Figure 1-1).

Considering the ecological value of the site, development of a residential precinct absent of any mitigating measures would lead to a significant impact on the rich biodiversity within the site at present. This includes plant species such as the Critically Endangered *Elaeocarpus obtusus* ssp. Apiculatus that can be found within the forested area, and Critically Endangered animal species such as the Sunda Pangolin, Lesser Mousedeer, and Lesser Bamboo Bat. It will be particularly important for this site to achieve a balance between the residential and commercial developments and the preservation of the natural heritage.

Since 2014, URA has been in regular consultations with representatives from Nature Groups on development plans for Springleaf Precinct. In 2018, a Springleaf Forest Hydrology and Biodiversity Baseline Study was completed by NUS in collaboration with NParks. The findings and recommendations were subsequently also shared with the Nature Groups to seek feedback and brainstorm preliminary ideas and strategies for the site. Many of the ideas formulated through these discussions have been integrated into the design.

Figure 1-1 Overview of the Proposed Springleaf Precinct Master Plan (map credit: STX Landscape Architects).

1.2 Study Area and Sensitive Receptors

The proposed development is located in the Yishun Planning Area and is bounded by the Seletar Expressway (SLE), Mandai Road and Upper Thomson Road (Figure 1-2). Future developments will be well-served by the new Springleaf Thomson East-Coast Line MRT station along Upper Thomson Road that is expected to be ready by 2024. It will provide a direct connection from Springleaf to the Woodlands Regional Centre in the north, Orchard Road and the Central Business District in the south, with longer term plans to connect to Changi Airport in the east. The site presents opportunities to pilot new design development approaches that seek to optimise land use while protecting and enhancing significant biodiversity areas at the same time.

The development work area covers approximately an area of 33 ha. The EBS focussed only on the undeveloped areas of the site so covered a smaller 25 ha area. Based on the URA Master Plan 2019, the Environmental Sensitive Receptors (ESRs) surrounding the

development area include: Nature Reserves; Nature Parks; Reservoirs; Residential; Businesses; Places of Worship; Education Institutions; and Healthcare Facilities.

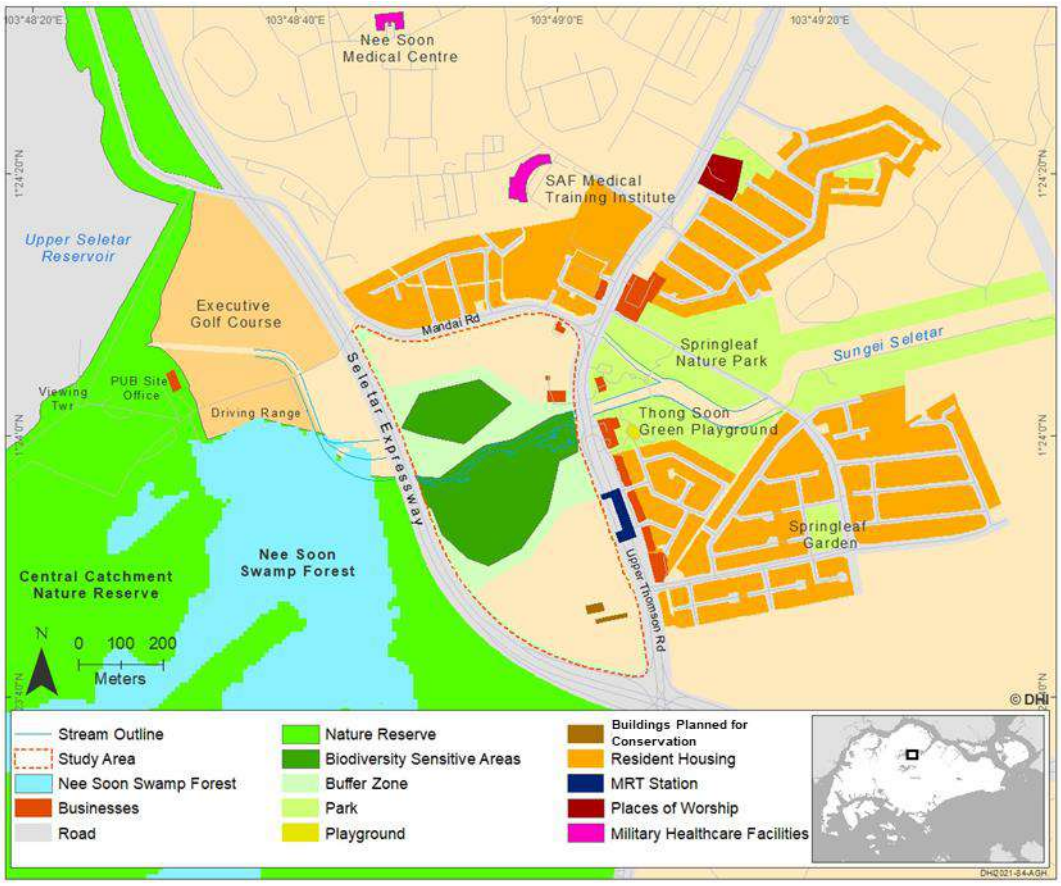


Figure 1-2 Overview of study area and nearby receptors

1.3 Objectives of EIA

The objectives of the EIA are:

- To establish environmental quality objectives for the future development and master planning of the study area
- To provide recommendations to guide developments for the study area
- To identify and assess the potential environmental impact of development activities for the area during the design, construction, operation and maintenance phases
- To propose and justify effective mitigation measures and guidelines (if any) to minimize impacts (e.g. pollution, environmental disturbance, and nuisance) of the site's master planning, design and building form, construction, and operational phase
- To design and specify the Environmental Monitoring and Management Plan (EMMP) to guide construction and operational phases to ensure the effectiveness of the recommended environmental protection and pollution control measures

The study is to carry out objective assessments of the various impacts of the future development and master planning in compliance with the requirements of relevant authorities and in accordance with international standards and practices where applicable. The study is to take into consideration seasonal variation throughout the course of the EIA where appropriate (e.g., within stream system, migratory patterns) and identify other potential impacts to provide comprehensive assessment of the impacts due to the development project.

2 Legislative Review

This chapter presents an overview of the national legislation, standards and policies relevant to the Project. Existing acts and guidelines seen as relevant are discussed in the following sections. International guidelines which the Project may adopt for elevated international recognition and compliance are also presented herein.

2.1 National Administrative Requirements

National environmental management requirements that are applicable to the Project are found in several Acts, Regulations and Guidelines as listed in Table 2-1.

Table 2-1 List of Applicable Acts, Regulations and Guidelines to the Project

Environmental Aspect	Applicable Acts, Regulations & Guidelines
General	• Code of Practice for Pollution Control, 2013 • Code of Practice on Environmental Health, 2017 • Code of Practice for Environmental Control Officers for Construction Sites, 2020
Surface Water Protection	• Environmental Protection and Management Act, 2002 • Public Utilities Act (Reservoirs, Catchment Areas and Waterway) Regulations, 2006 • Sewerage and Drainage Act, 2001 • Sewerage and Drainage Act (Surface Water Drainage) Regulations, 2008 • Environmental Protection and Management (Trade Effluent) Regulations, 2008 • Guidebook on Erosion and Sediment Control at Construction Sites (PUB, 2014) • Code of Practice on Surface Water Drainage, 6th Edition (PUB, 2011) • Managing Urban Runoff - Drainage Handbook 1st Edition (PUB, 2013) • Active Beautiful Clean (ABC) Waters Design Guidelines (PUB, 2014)
Air Quality Protection	• Environmental Protection and Management Act, 2002 • Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 • Environmental Protection and Management (Air Impurities) Regulations, 2008 • Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012 • Environmental Protection & Management (Prohibition on the Use of Open Fires) Order 2008 • Singapore Air Quality Targets (NEA) • Energy Conservation Act, 2014
Noise	• Environmental Protection and Management Act, 2002 • Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008

Environmental Aspect	Applicable Acts, Regulations & Guidelines
	• Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 • SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites • World Health Organisation Guidelines
Vibration	There are no local guidelines however reference can be taken from: • BS 6472 - 1:2008 “Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting” • BS 5228.2 – 2009 “Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration” • DIN4150 - Part 3:1999 “Structural Vibration Part 3 – Effects of vibration on structures
Wildlife Protection and Welfare	• Wildlife Act, 2000 • Singapore Red Data Book, Second Edition, 2008
Habitat Protection/ Conservation of Protected Areas	• Parks and Trees Act, 2006 • Parks and Trees Regulations, 2006 • Parks and Trees (Preservation of Trees) Order, revised 1998 • International Union for Conservation of Nature (IUCN) World Commission on Protection Areas (WCPA) Guidelines • International Finance Corporation Performance Standards and Guidelines • Guidelines on Greenery Provision and Tree Conservation for Developments (NParks) • Biodiversity Impact Assessment Guidelines (NParks, 2020)
Importation of Animals and Plants	• Endangered Species (Import and Export) Act, 2008 (Chapter 92A) • Animals and Birds Act, 2002, Chapter 7 • Control of Plants Act, 2000, Chapter 57A
Waste and Hazardous Substances Management Waste Management	• Environmental Public Health Act, 2002 • Environmental Protection and Management (Hazardous Substances) Regulations, 2008 • Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 • Sewerage and Drainage Act, 2001, Chapter 294 • Sewerage and Drainage (Trade Effluent) Regulations, 2008 • Resource Sustainability Act, 2019
Vectors and Pesticides Management	• Control of Vectors and Pesticides Act, 2002

2.2 National Policies and Plans

2.2.1 National Biodiversity Strategy and Action Plan (NBSAP)

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

2.2.2 Nature Conservation Master Plan

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

I. Conservation of key habitats

- Involves the safeguarding and strengthening of Singapore's core biodiversity areas by creating greenery nodes or buffer areas integrating with the urban landscape. Examples of developing ecological connections are establishing and broadening the Park Connector Network (PCN)

II. Habitat enhancement, restoration, and species recovery

- Aims to conserve rare native species and increase the native biodiversity of some of the disturbed areas e.g. enrichment planting in the Central Catchment Nature Reserves (CCNR) has provided a conducive environment for the Raffles' Banded Langur (*Presbytis femoralis femoralis*) to thrive

III. Applied research in conservation biology and planning

- Includes comprehensive surveys and long-term monitoring of ecosystems and species

IV. Community stewardship and outreach in nature

- Aims to encourage and build public interest and involvement in biodiversity conservation

2.2.3 Parks and Waterbodies Plan 2019

The Parks and Waterbodies Plan is a Special & Detailed Controls Plan that complements URA's Master Plan, and was first jointly developed by NParks and URA in 2002 to guide the land-use planning and development of parks, open spaces, interim greens, park connectors, promenades, nature reserves, nature areas and waterbodies.

2.2.4 Sustainable Singapore Blueprint 2015

The Sustainable Singapore Blueprint (SSB) 2015 features Singapore's vision and plans for a more sustainable and higher quality living environment to support the diverse needs and growing aspirations through various initiatives. The SSB sets targets to be achieved by 2030 for six aspects in Singapore: green and blue spaces, mobility, resources

sustainability, air quality, drainage and community stewardship. These targets are aimed achievable via the best practices adopted in the private, public and domestic sectors to maintain a pollution-free environment in Singapore.

2.2.5 Singapore Green Plan 2030

The Green Plan charts ambitious and concrete targets over the next 10 years, strengthening Singapore's commitments under the UN's 2030 Sustainable Development Agenda and Paris Agreement, and positioning to achieve long-term net-zero emission aspirations. The Green Plan has five key pillars:

- City in Nature: to create a green, liveable and sustainable home for Singaporeans;
- Sustainable Living: to make reducing carbon emissions, keeping our environment clean, and saving resources and energy a way of life in Singapore;
- Energy Reset: to use cleaner energy and increase our energy efficiency to lower our carbon footprint;
- Green Economy: to seek green growth opportunities to create new jobs, transform our industries, and harness sustainability as a competitive advantage; and
- Resilient Future: to build up Singapore's climate resilience and enhance our food security.

2.2.6 Green Mark Certification

The Green Mark certification scheme was launched in January 2005. It is a green building rating system designed to evaluate a building's environmental impact and performance. It provides a comprehensive framework for assessing the overall environmental performance of new and existing buildings to promote sustainable design, and best practices in construction and operations in buildings.

Four levels of certification include Green Mark Certified, Gold, Gold Plus and Platinum. Buildings are certified to one of these levels based on five categories for assessment of their climatic responsive design; building energy performance; resources stewardship; smart and healthy buildings; and advance green efforts. Additionally, a Green Mark Communities certification is due to be rolled out soon. This project aims for Platinum Certification, but will also take reference from the Green Mark Communities guidance.

2.2.7 ABC Waters Certification

The ABC Waters Certification Scheme is evaluated based on four categories – Active, Beautiful, Clean and Innovation. This project aims to achieve ABC Waters Certification (Gold), which distinguishes developers and professionals who integrate ABC Waters design strategies extensively, and have outstanding ABC Waters design. This certification is the highest accolade that can be attained by developers. For a project to be ABC Waters Certified (Gold), the project needs to attain a high score from the respective Active, Beautiful and Clean categories. In addition, treatment of surface run-off from at least 40% of the total site area must be attained through the use of ABC Waters design features.

3 Environmental Baseline Conditions

3.1 Overview

The Springleaf study area is bisected by a naturalised stream into northern and southern sections, and further categorised topographically into high and low grounds. The study area covers 25 ha and consists primarily of abandoned land and waste-woodland young secondary forests habitats, which are typically dominated by common early successional native species and weedy non-native species (Yee et al., 2016). Importantly, the vegetated area supports a freshwater swamp habitat of approximately 5 ha. There are also areas of open grassland and scrubland located along the banks of the stream, and within the northern low ground and southern low ground of the study area (Figure 3-1 and Figure 3-2).

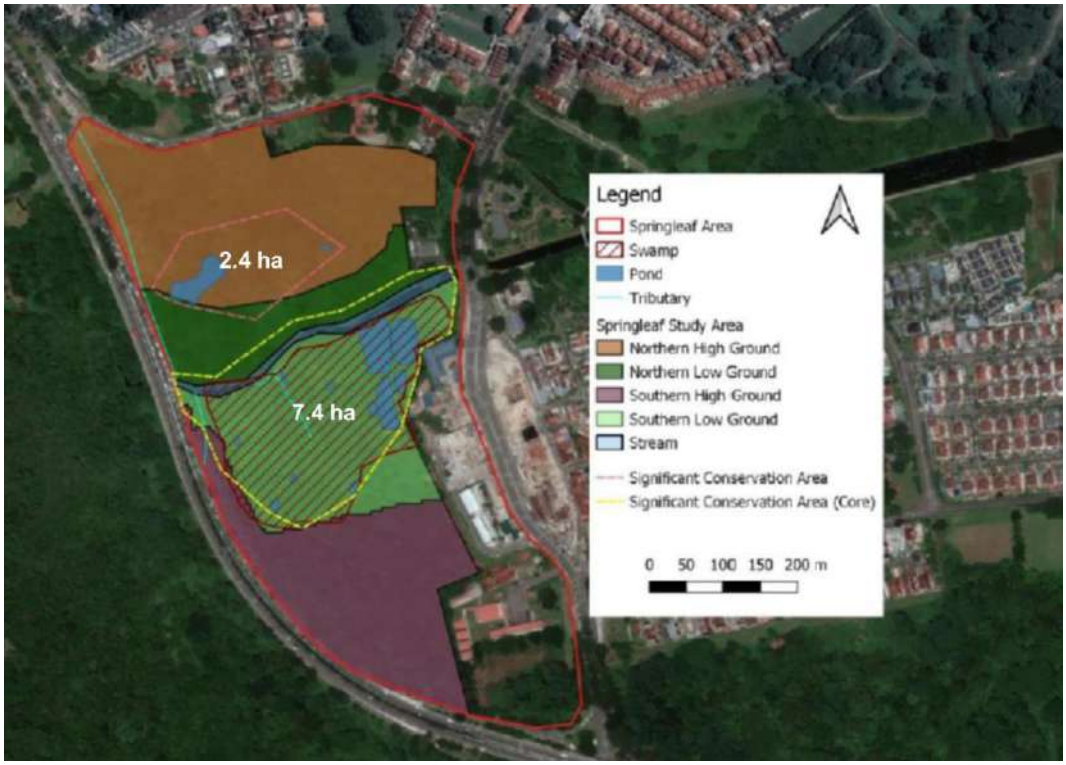


Figure 3-1 Springleaf study area showing the topographically divided sub-divisions. The sizes of the Core Conservation Area [labelled as Significant Conservation Area (Core)] and Significant Conservation Area are also shown.

Figure 3-2 Vegetation and habitat types identified within the Springleaf precinct (map credit: STX Landscape Architects).

Freshwater swamp habitats are very rare in Singapore (Yee et al., 2011), with the 5 km^2 Nee Soon Swamp Forest (NSSF) widely recognised as the only remaining patch of primary freshwater swamp forest in Singapore (Clews et al., 2018). NSSF is located adjacent and to the west of Springleaf Precinct, separated only by the Seletar Expressway (SLE). NSSF represents the most important area in Singapore for native aquatic fauna and flora, harbouring 48% of the freshwater fish, 71% of the amphibian, 28% of the reptiles and 34% of the bird fauna of Singapore. NSSF also supports the highest percentage of native and threatened freshwater fish and crustacean species on the island, as well as being the main (if not the only) habitat of the aquatic plant Hydrostemma. It is also the last refuge of two mammal species, the Banded Leaf Monkey, *Presbytis femoralis femoralis*, and the Cream-coloured Giant Squirrel, *Ratufa affinis affinis* (Ng & Lim, 1992). In the most recent documentation, a new species of luminous firefly was discovered from NSSF since 1909. It was first published in the journal *Animals* on 04 March 2021 (NUS News, 2021). Floristically, NSSF also supports a high species richness, with over 700 vascular plant species recorded (Turner et al., 1996).

In contrast to the amount of scientific surveys and research conducted in NSSF, there is a paucity of scientific literature available for the Springleaf study area, prior to the 2018 NUS study (NUS, 2018). A notable exception were the flora and fauna assessments commissioned by NParks and conducted between 2011 and 2013, prior to the construction of Springleaf Nature Park.

Springleaf forest covers the area presented as Zone A and D in Figure 3-2 and is secondary forest that has developed since the site was vacated. Flora surveys conducted in 2011 revealed that the Springleaf forest fragment supported two nationally extinct species – *Mallotus macrostachyus* and *Paederia verticillate*. In total, 72 plant species were previously recorded from Springleaf forest, of which 22 are Critically Endangered species; notably, the Critically Endangered *Elaeocarpus obtusus* ssp. *apiculatus* was reported to be found throughout the Springleaf Forest patch (NUS, 2018). In terms of fauna assemblage, 11 mammal species, 98 bird species, 11 reptile species, 15 amphibian species, 39 butterfly species, 33 odonate species and 21 freshwater fish species were recorded, with many of

these species of conservation significance (Rajathurai, 2011; Rajathurai, 2013). Springleaf forest is also an important area for avifauna, with the Crested Serpent Eagle, which occurs as a rare resident and rare migrant bird in Singapore, recorded there, as well as a more common migrant bird, the Black Baza (Lim, 2010).

The 2018 NUS study was the most recent and comprehensive biodiversity and hydrological survey of Springleaf forest, yielding a detailed biodiversity inventory. Based on distribution of conservation significant species recorded, the southern low ground, together with the stream corridor are recognized as the most important areas for biodiversity conservation planning, inhabited by majority of species with conservation significance for plants, mammals, amphibian, and aquatic fauna. This is followed by the northern high ground with significant number of critically endangered species of plants, mammals, avians and reptiles. Comparatively, both the northern low ground and southern high ground were found to accommodate less number of conservation-significant species. The low number of conservation-significant species at the northern low ground is likely attributable to the dominance of open scrubland and grassland there, which has lower structural complexity and hence support lesser habitat niches.

The historical connectivity of Springleaf forest, particularly its freshwater swamp habitat, with the adjacent NSSF is potentially the main driver for its rich native vascular plant flora and associated fauna, some of which are nationally threatened. Prior to the construction of the SLE in 1992, the Springleaf forest patch was contiguous with NSSF. Although Springleaf forest and NSSF are physically separated by SLE today, they remain hydrologically and ecologically contiguous via a freshwater stream and riparian vegetation underpassing the SLE viaduct. Moreover, the proximity of NSSF represents a source of propagules for the dispersal of plant species into Springleaf forest.

Despite its varied ecology, Springleaf forest patch has served as an ecologically and hydrologically sound buffer for NSSF in the recent decades since the development of the Springleaf neighbourhood. The nature of its freshwater ecosystem and its drainage makes the Springleaf freshwater swamp sensitive to external disturbances. Similar to NSSF, many flora and fauna species in Springleaf are obligate species with stringent habitat requirements. For example, a small rheophytic tree species, *Aglaia yzermannii*, can only be found in NSSF and Springleaf in Singapore. Freshwater fish species in Springleaf, the Slender Walking Catfish and Harlequin Rasbora, can only be found elsewhere in freshwater streams within CCNR.

Disturbance to Springleaf forest and its surrounding areas will pose a threat to these specialised groups of species, and in turn results in the loss of ecological functions that Springleaf forest provides to NSSF.

3.1.1 Springleaf Nature Park: Buffer for CCNR

The number of visitors to nature reserves have increased over the years as people become more aware of the benefits of regular exercise, or as more people take an interest in enjoying the outdoors. The resulting impacts include trail widening, erosion, and soil compaction. The cumulative effects of their activities can lead to habitat degradation and fragmentation in the reserves, eventually disrupting the normal behaviour, movement and dispersal patterns of the native flora and fauna.

Green buffers are a strategy being deployed by NParks to help ensure that sensitive core areas within the reserves are minimally disturbed so that they can maintain their role as an effective refuge for plants and animals that depend on these core areas for their survival. The strategic location of Springleaf Precinct connecting Springleaf Nature Park and the CCNR means that these areas can play a critical role as a green buffer to NSSF, especially as Springleaf Precinct harbours swamp forest and rich biodiversity of its own (Figure 3-3).

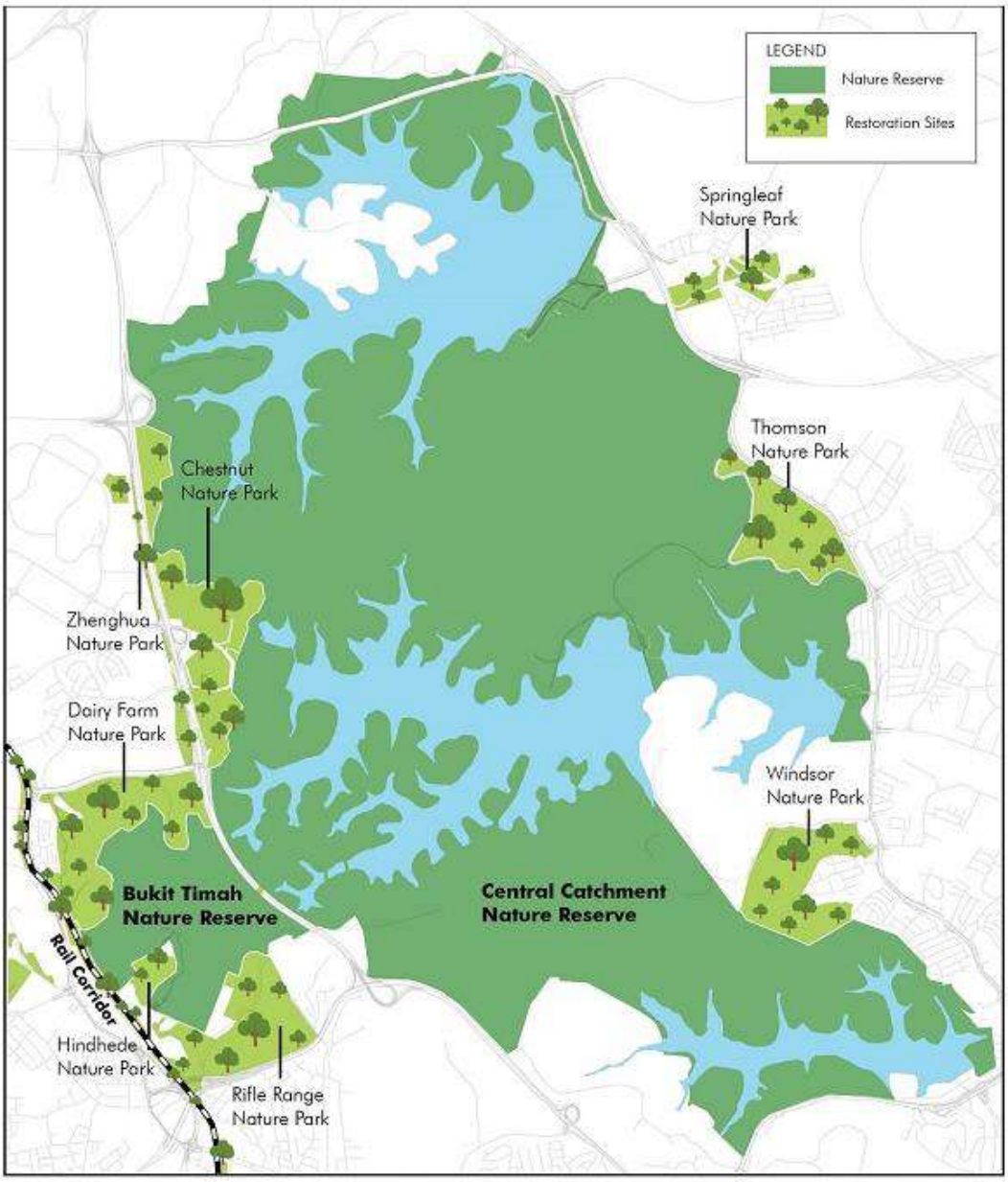


Figure 3-3 Nature Parks as buffers to the Central Catchment Nature Reserve (NParks)

3.2 History of Land Use

The Springleaf Precinct is enclosed within the junction of Upper Thomson Road, Mandai Road and Seletar Expressway. As presented in Figure 3-4, the Sungei Seletar Catchment prior to being dammed consisted of a mix of interconnected mangrove forest, freshwater

swamp forest and Dipterocarp forest habitats. The Springleaf Precinct sat at the interface between the rainfall fed freshwater and tidal saltwater environs.

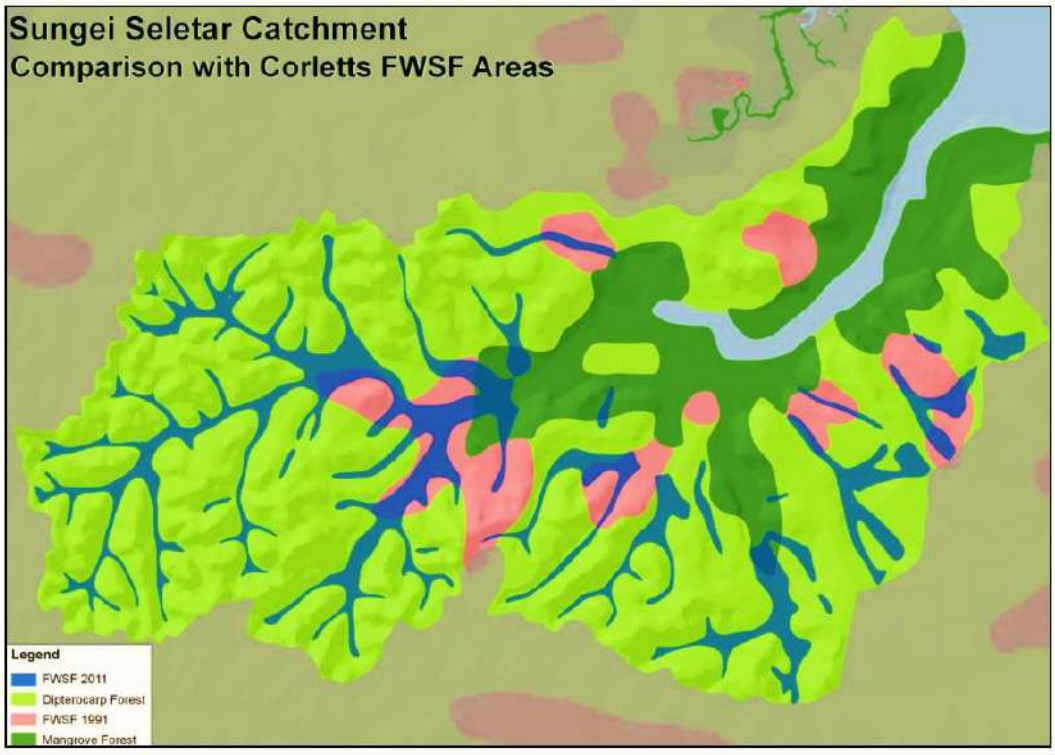


Figure 3-4 Comparison of estimated 2011 freshwater swamp forest zones with Corlett's 1991 map (O'Dempsey & Chew, 2011)

The precinct was historically adjacent to Chan Chu Kang village which was founded in 1850 when headman Chan Ah Lak formally leased 18 ha of land in the Sungei Seletar area for gambier and pepper cultivation from the British Colonial Government. As plantations and villages around Chan Chu Kang continued to increase in number, a Post Office and a Police Station were eventually setup, between the late 1800s and early 1900s, near the junction of Mandai Road (built in 1855) and Thomson Road (current Upper Thomson Road and Sembawang Road) to serve the growing needs of the community. Thomson Road (currently divided into Thomson Road, Upper Thomson Road and Sembawang Road) was an important and well-travelled road that connected Singapore's city centre to the former British Naval Base at Seletar. A Government Bungalow was also observed to be located along Thomson Road (current Upper Thomson Road) opposite to the current Springleaf Nature Park.

Based on historical maps found in the National Archive Singapore, it was observed that the western half of the Springleaf Precinct was part of a Forest Reserve (Figure 2). Prominent collectors of botanical and zoological specimens, including Henry Nicholas Ridley (the first director of the Singapore Botanic Gardens) made the first collections (Type Specimen) of native plant species from the forests near Chan Chu Kang during the late 1800s and early 1900s. In 1911, Lim Nee Soon set up Lim Nee Soon & Co., chop "Thong Bee" a rubber and pineapple trading company and built the Thong Aik Rubber Factory (later renamed as the Nee Soon and Sons Rubber Works in the 1920s and Lee Rubber in 1928) near Jalan Ulu Seletar (about 360 m North of the Post Office). The Rubber Factory could be spotted in the Map of 1924 (Figure 3). In the same map, the Post Office was also relocated to the current site. As the population in the surrounding area grows, demands for public amenities such as schools must be met. Hence, the Upper Thomson Secondary School located at the Southern end of the Springleaf Precinct was established in 1965. The school was relocated to their new campus site at Yishun in 1988 and changed its name to North View

Secondary School. The campus was taken over by Seletar Institute from 1988 to 1997 and has since been left vacant.

The Nee Soon Swamp Forest is clearly demarcated in the map of 1924. The swampy condition in the middle of the Springleaf Precinct was probably the reason why historically only the north and south areas were ever built up or cultivated. From the series of maps between 1911 to 1982, it was observed that the number of buildings at the north and south of the precinct continued to increase till it peaked in the 1970s. Historically, within the Springleaf Precinct, the village to the North of Sungei Seletar cultivated coconuts and vegetables, while the village to the South cultivated fruit orchards and vegetables.

In 1976, the Singapore Government initiated the Yishun New Town Project and started the resettling of village residents along Upper Thomson Road. By mid-1980s almost all of the villages in the Springleaf Precinct were relocated and the land has been left to nature since.

The construction of Lower Seletar Reservoir was completed in 1986. This project involved the damming of the mouth of Sungei Seletar with the construction of the Yishun Dam. Several of the tributaries near the mouth of Sungei Seletar were submerged and tributaries upstream of Sungei Seletar were rediverted and some tributaries realigned into canals. The portion of Sungei Seletar within the Springleaf Precinct was also realigned and straightened slightly. This canalisation project was done differently from others as the base of the canal was left natural with earth and not concretised and the banks were lined and held up with gabion wall for the stretch between Upper Thomson Road and Lentor Avenue. The stream banks within the precinct were turfed without gabion walls.

The Seletar Expressway project started in 1989 and was fully completed in 1998. The section of the expressway between Upper Thomson Road Exit and Mandai Avenue exit was elevated as a flyover to allow the continuous flow and connection of water from NSSF in the Central Catchment Nature Reserve and Upper Seletar Reservoir to Sungei Seletar and Lower Seletar Reservoir.

Figure 3-5 Project Site on a 1911 Map (National Archives of Singapore)

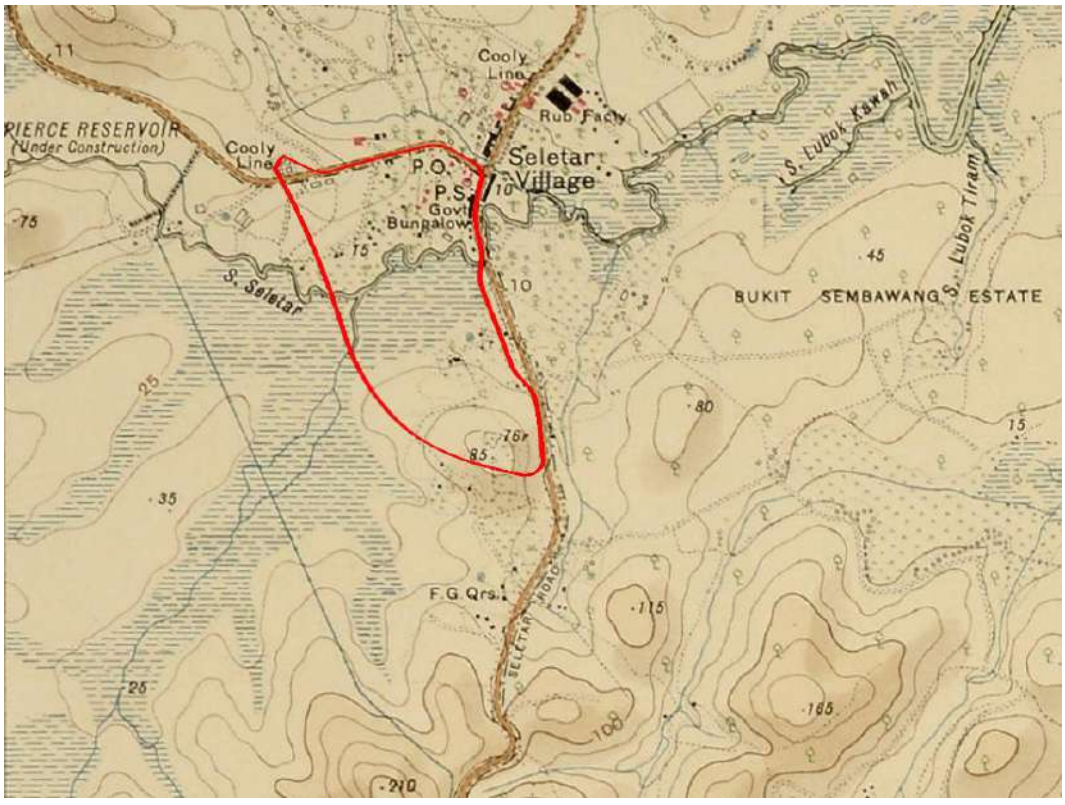


Figure 3-6 Project Site on a 1924 Map (National Archives of Singapore)

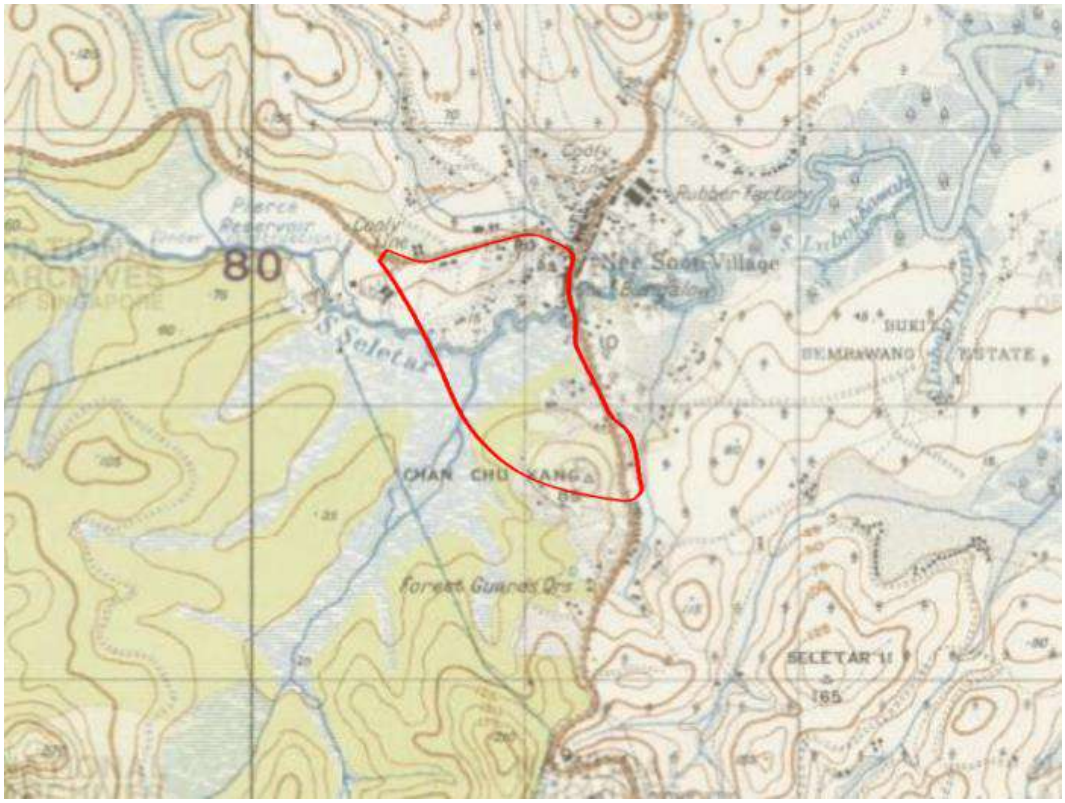


Figure 3-7 Project Site on a 1935 Map (National Archives of Singapore)

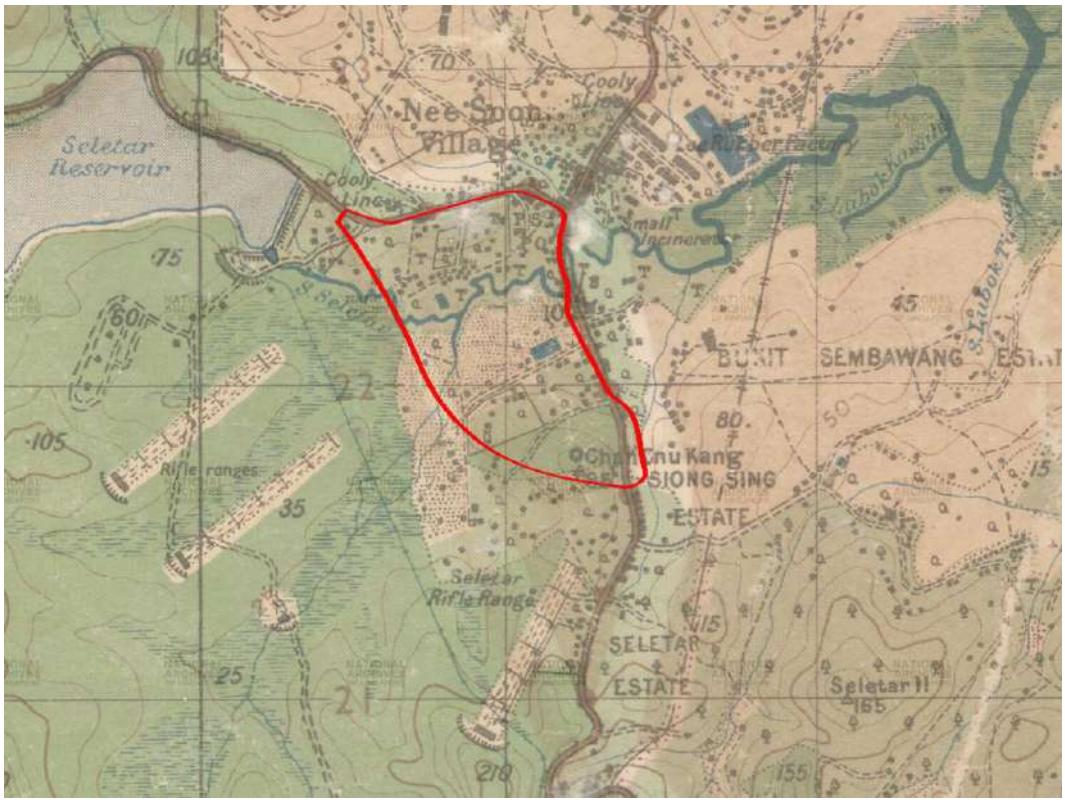


Figure 3-8 Project Site on a 1945 Map (National Archives of Singapore)

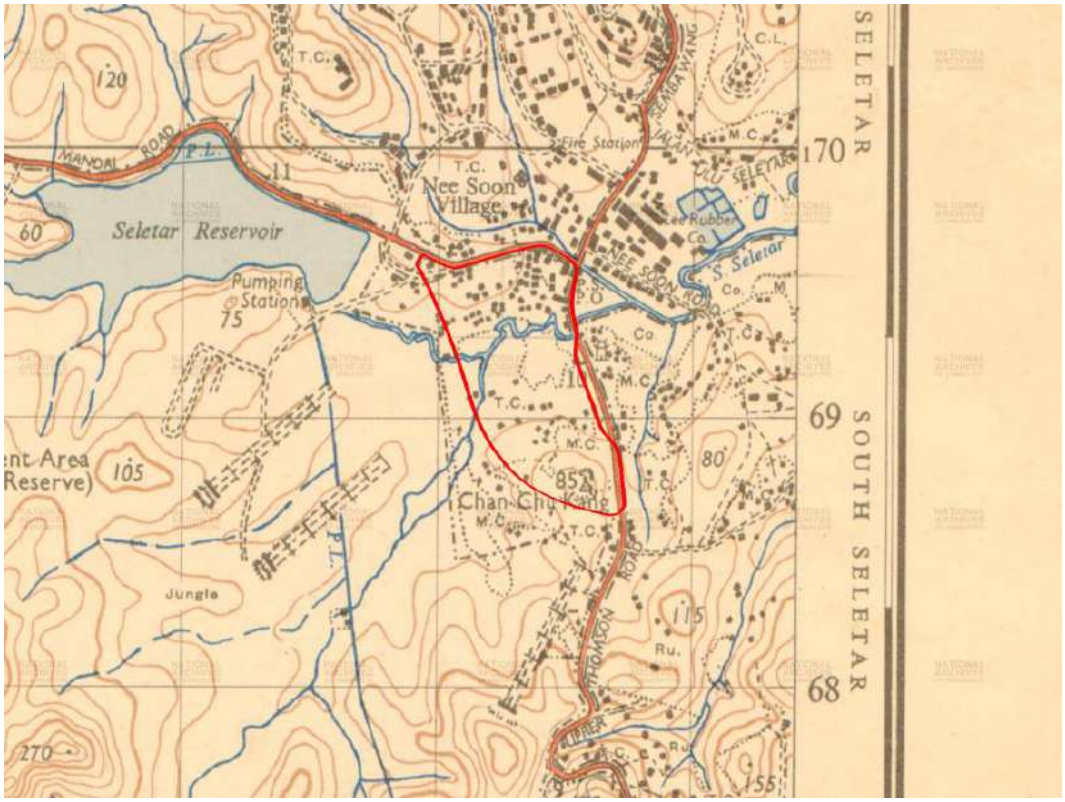


Figure 3-9 Project Site on a 1953 Map (National Archives of Singapore)

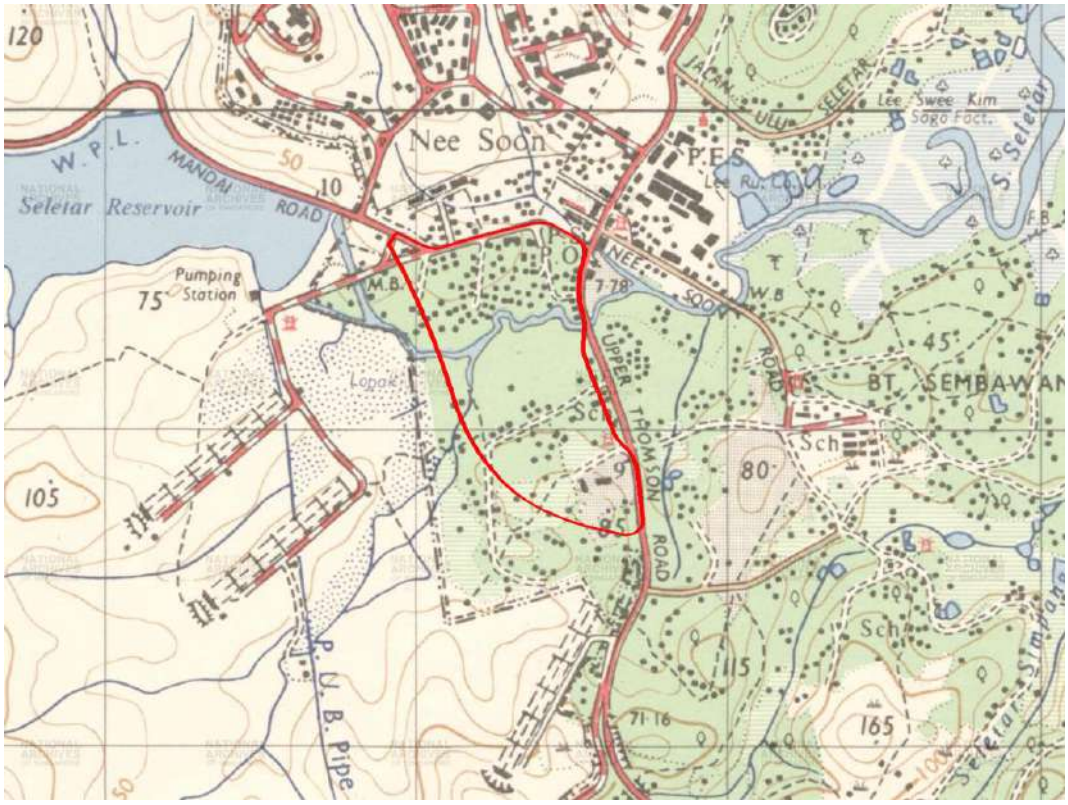


Figure 3-10 Project Site on a 1964 Map (National Archives of Singapore)

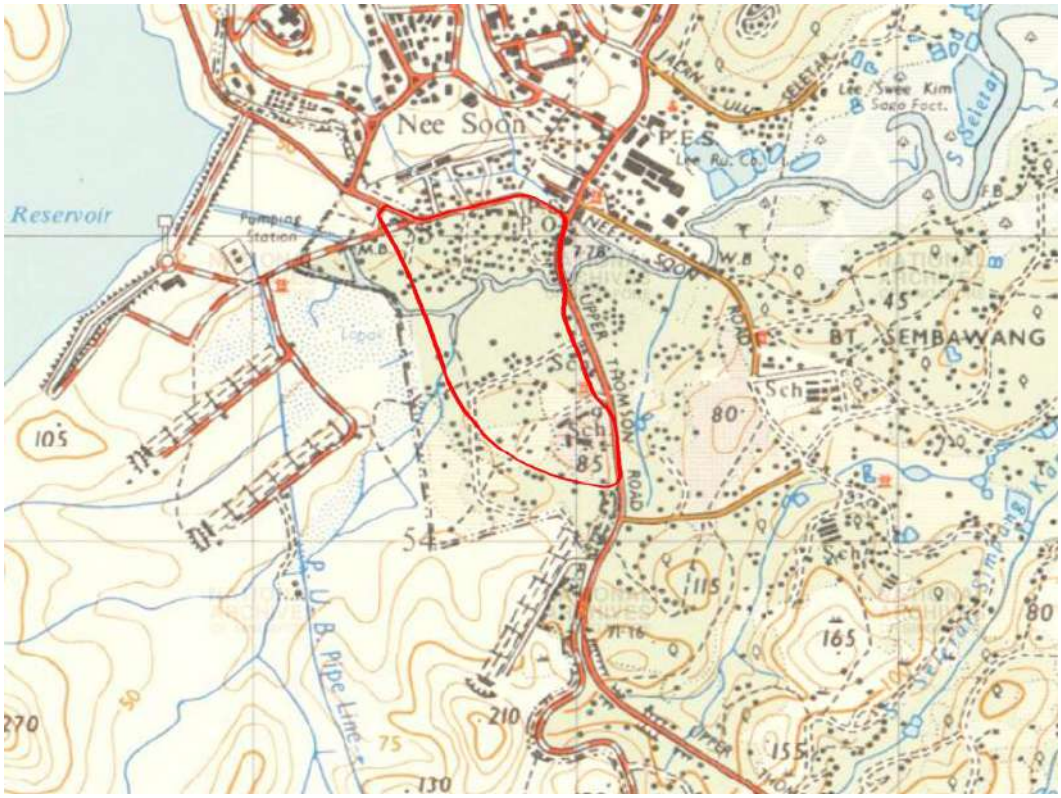


Figure 3-11 Project Site on a 1973 Map (National Archives of Singapore)

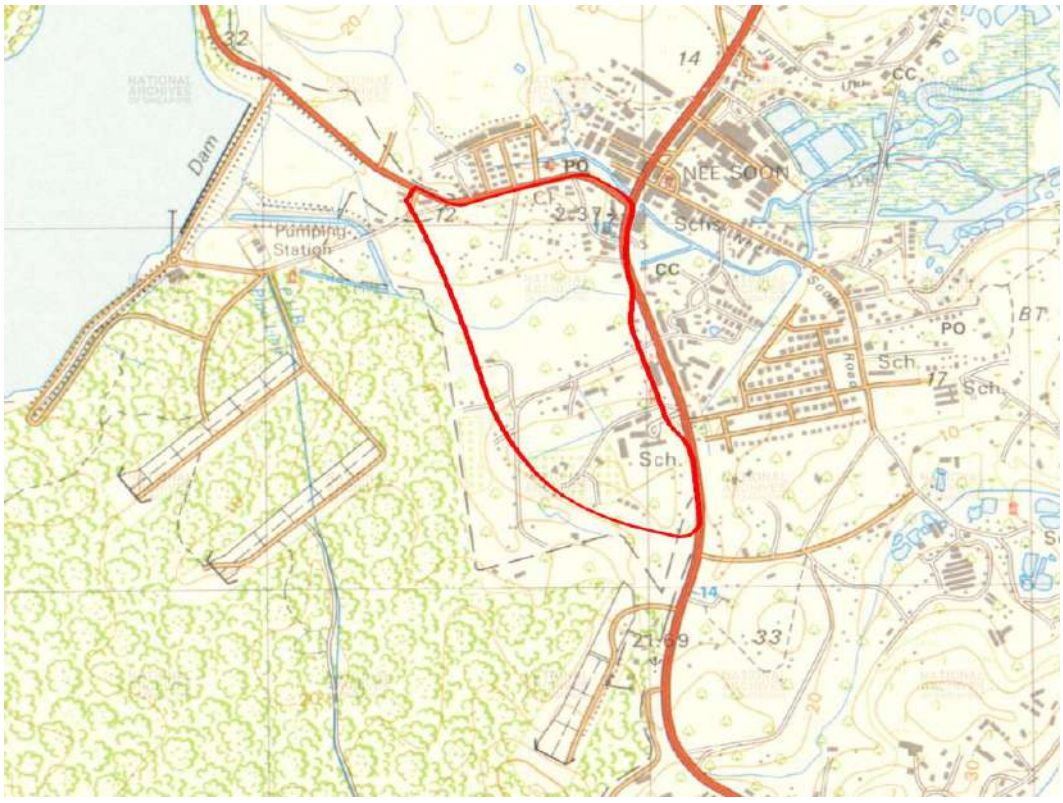


Figure 3-12 Project Site on a 1982 Map (National Archives of Singapore)

3.3 Ecology and Biodiversity Baseline Field Surveys

Springleaf Forest Hydrology and Biodiversity Baseline Studies was conducted by NUS (2018). A biodiversity baseline for Springleaf forest was established from the study and a biodiversity inventory was formed as further outlined below. In total, 283 species of plants, 21 species of mammals, 134 species of birds, 29 species of reptiles, 18 species of amphibians, 32 species of fish (19 in the present study), 3 species of shrimps, 64 species of butterflies and 42 species of dragonflies were recorded from Springleaf forest, including conservation significant species (Table 3-1).

Table 3-1 Summary of species richness across taxa recorded from the Biodiversity Baseline Study conducted by NUS (2018)

Taxa	Total Species Richness	Richness of Critically Endangered and Endangered Species	Richness of Conservation Significant Species
Plants	283	17	17
Mammals	21	5	5
Birds	134	8	20
Reptiles	29	2	7
Amphibians	18	2	4
Fish	32	2	5
Shrimp	3	0	1
Butterflies	64	0	7
Dragonflies	42	2	4

3.3.1 Flora

3.3.1.1 Methodology

Vegetation Plot Set-Up

Ten vegetation plots measuring 20 × 20 m were set up within three Areas of Interest (AOI). AOI1 surveyed the original Core Conservation Area and consisted of four plots (SF1, SF2, SF3, and SF4). AOI2 is an area with abundant *Knema malayana* (National Conservation Status: Endangered) trees and seedlings, and consisted of five plots (KM1, KM2, KM3, KM4 and KM5). AOI3 contained *Barringtonia racemosa* (National Conservation Status: Critically Endangered) with multiple densely-packed clusters of saplings and trees of this species, and consisted of only one plot (BR1).

The AOIs are found to the south of the canal that runs east–west across the Springleaf forest patch (Figure 3.2.1). The four sides of each plot run north–south or east–west. After delineating the plot perimeter, all trees ≥ 10 cm DBH were measured, tagged, identified and the approximate location within the plot estimated. When unknown species were encountered, voucher specimens were brought back for further identification work.

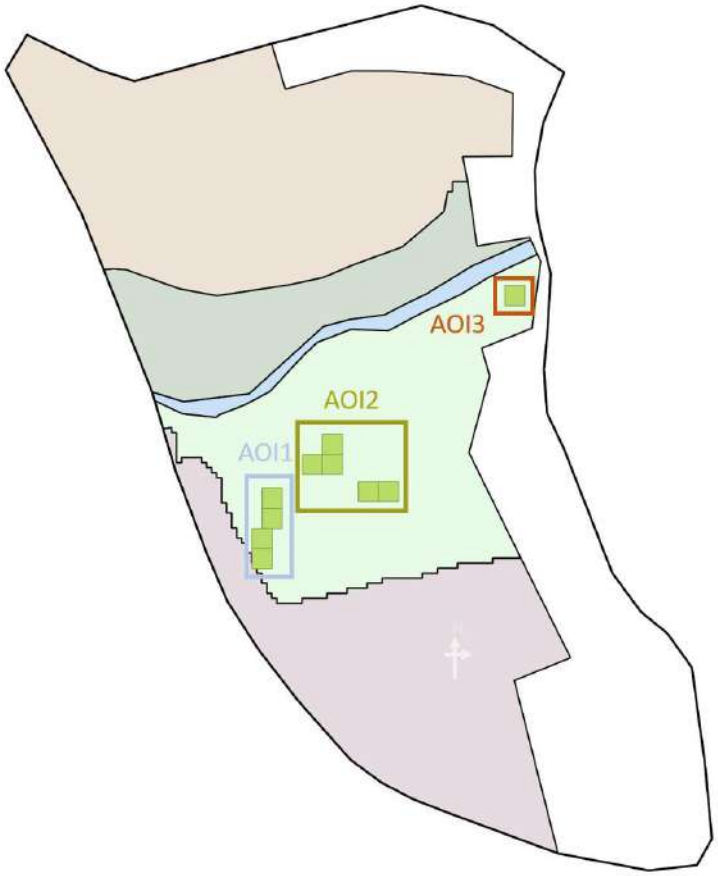


Figure 3-13 Map of ten vegetation plots set up in Springleaf forest

Walking Surveys and List Compilation

Walking surveys were conducted throughout the Springleaf forest patch. All vascular plant species encountered along these surveys were recorded. When the team encountered individuals of conservation significance—defined as national conservation status of Critically Endangered or presumed Nationally Extinct (and hence constituting a rediscovery) and not suspected to be a relic of cultivation—in the field, their Global Positioning System (GPS) coordinates were recorded using the GPS receiver. Individuals that could not be identified to species in the field had their coordinates recorded using the GPS receiver and voucher specimens brought back for identification work. The species list was then compiled, tabulated and mapped.

3.3.1.2 Flora Survey Results

17 critically endangered plant species were encountered in the surveys. Of these 2 critically endangered species, *Agelaea macrophylla* and *Elaeocarpus obtusus ssp*. *apiculatus* could be found throughout Springleaf Precinct and the remaining 15 species were only found in specific regions in the Springleaf Precinct.

Notably, *Aglaia yzermannii*, a small rheophytic tree species up to 5m tall and previously known to exist only in NSSF in Singapore (Chong et al., 2018), was also discovered in the NHG. However, its conservation status in Singapore is yet to be assessed (NUS, 2018).

3.3.2 Mammals and Bats

3.3.2.1 Methodology

Sampling Design

Mammal field surveys consisted of visual encounter surveys (VES), live-trapping and acoustic sampling for bats, and terrestrial camera trapping. Due to difficulty in finding roost sites and the inability to visually identify bats to species-level when they are flying, bat sampling required specific surveying techniques (i.e., live-trapping and acoustic sampling). All other mammals can be detected via VES and camera trapping, except for shrews which will require utilising small-mammal traps (e.g., Sherman and pitfall traps). Employing trapping for small mammals is labour intensive and was not deemed necessary for this study. Each survey was performed by a minimum of two surveyors between the hours of 0700 and 1100 for diurnal surveys and between 2000- and 0000-h for nocturnal surveys.

Visual Encounter Surveys (VES)

Two terrestrial transects that amounted to 2.23 km, one traversing the section north of Sungei Seletar (0.93-km) and one covering the section south of Sungei Seletar (1.3-km) were set up (Figure 3-14) were setup. A transect connecting the northern and southern sections was not feasible due to the freshwater swamp that occupies the whole area south of Sungei Seletar and dense vegetation running adjacent to the SLE. For nocturnal surveys, VES was conducted with torches to detect mammals by illumination and eye shine. After detection, mammals were observed with torches fitted with red LED's to reduce disturbance to their behaviour. Where possible, mammals were searched for on the ground, on vegetation, and in burrows and tree holes. In addition, their vocalizations were listened for and tracks and scats inspected. All mammals were identified to species level by way of sight, binoculars, and photography. For each observation, the location of each individual was recorded using a handheld GPS (Garmin 64S), and the number of individuals observed, along with important natural history notes were recorded. Transect surveys were executed twice a month, one diurnal and one nocturnal survey.

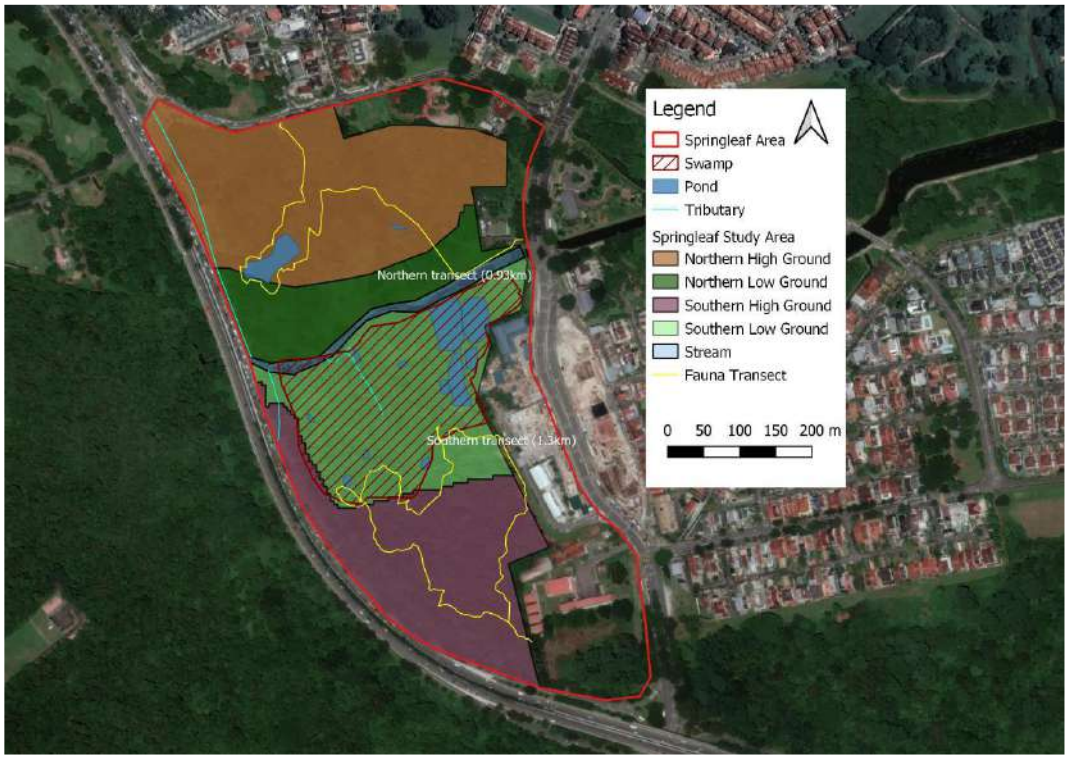


Figure 3-14 Map of Springleaf Forest showing the two mammal transects used from conducting visual encounter surveys

3.3.2.2 Bat Surveys

3.3.2.3 Methodology

Bat live-trapping was executed once a month and consisted of a combination of mist netting and harp trapping. During each bat survey, two sets (one mist net + one harp trap) of traps were set out at ground-level at two different locations (Figure 3-15). Mist netting targets the larger-sized fruit/nectar bats (Megachiroptera), while harp trapping targets the smaller insectivorous bats (Microchiroptera). Trap set-up was accomplished between 1730-h and 1930-h, and trapping was performed from 1930-h to 0000-h. At the end of each night, mist nets were disassembled and removed, while harp traps were left overnight and checked the following morning at 0800-h, then removed. Bats collected in the traps were identified and released immediately.

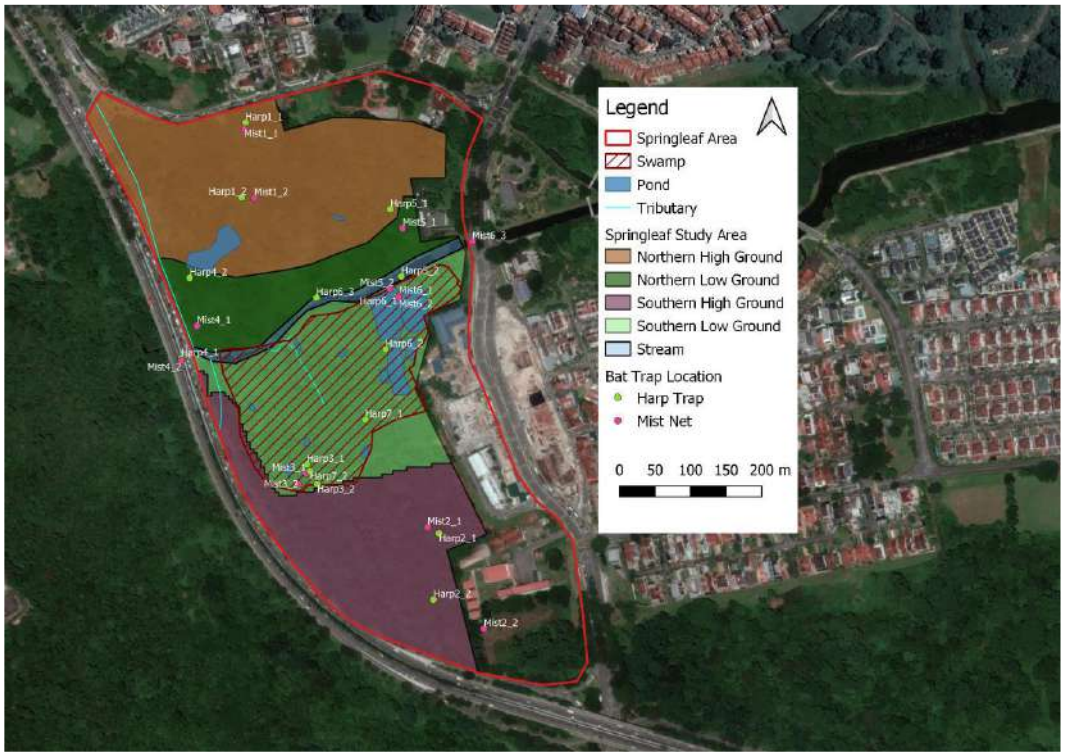


Figure 3-15 Map of Springleaf forest showing bat trap locations

3.3.2.4 Mammal and Bat Surveys Results

Five species of mammals were identified and found to be of conservation significance. All are listed as critically endangered in Singapore, namely; Sunda Pangolin, Lesser Mousedeer, Horsfield's Flying Squirrel, Smooth-coated Otter and Lesser Bamboo Bat. Sunda Pangolin is listed critically endangered globally and Smooth-coated Otter is listed as vulnerable globally. In addition, Sunda Pangolin is protected under CITES Appendix I, which prohibits international trade of species considered the most endangered (CITES, 2000). In Singapore, Sunda Pangolin is restricted mainly to CCNR, Bukit Batok, Western Catchment, Pulau Ubin and Pulau Tekong (Baker and Lim, 2012).

3.3.3 Birds

3.3.3.1 Methodology

Audiovisual encounter surveys were conducted to identify and count the avian diversity in Springleaf forest. The same number of surveys were allocated to the northern and southern survey sectors. In total, thirteen diurnal and seven nocturnal surveys were conducted over the course of this study. Birds were identified by sight or by call. Photographs of the birds were taken where possible. Existing records from the Springleaf forest area were also compiled (Rajathurai, 2011) and combined with the data collected from the present study to provide a full checklist.

Shannon-Wiener species diversity indices for avian communities were calculated for each sector using the formula:

$$H' = -\sum p_i \times ln\, p_i \qquad (3.3.1)$$

where *pi* refers to the proportion of individuals belonging to the *i*th species. This index can be used to compare the diversity of communities in two different areas.

3.3.3.2 Bird Surveys Result

Twenty species of birds were found with conservation significance locally. Among them, eight species are recognized as critically endangered, namely Black-crowned Night-Heron, Crested Serpent Eagle, Blue-rumped Parrot, Asian Drongo Cuckoo, Buffy Fish Owl, Plume-toed Swiftlet, Blue-eared Kingfisher, White-rumped Shama. Among them, Black-crowned Night-Heron is a freshwater wetland species and the rest are species that are restricted to forest habitat.

3.3.4 Amphibians and Reptiles

3.3.4.1 Methodology

Audiovisual encounter surveys were conducted to identify and count the avian diversity in Springleaf forest. The surveys were of similar survey effort allocated to the northern and southern survey sectors. Thirteen diurnal and seven nocturnal surveys were conducted over the course of this study. Photographs of the animals were taken where possible. Amphibians and reptiles were identified by sight, or in the case of amphibians, by call. Shannon-Wiener species diversity indices for amphibians and reptiles communities were calculated for each sector.

3.3.4.2 Amphibians and Reptiles Survey Result

Seven reptiles, namely Twin-barred Tree Snake, Gold-ringed Cat Snake, Malayan Swamp Skink, Striped Sun Skink, Yellow-striped Tree Skink, Black-bearded Flying Dragon, and Asian Softshell Turtle, and four amphibians, namely Blue-spotted Bush Frog, Manthey's Chorus Frog, Cinnamon Bush Frog, Golden-eared Rough-sided Frog, considered Locally Threatened in Singapore, with Blue-spotted Bush Frog and Manthey's Chorus Frog being listed as Critically Endangered, were encountered.

3.3.5 Dragonflies and Butterflies

3.3.5.1 Methodology

Visual encounter surveys were conducted to identify and count the dragonfly (odonate) and butterfly (rhopaloceran lepidopteran) diversity in Springleaf forest. Surveys were of similar survey effort allocated to the northern and southern survey sectors. In total, thirteen diurnal surveys were conducted over the course of this study. Photographs of the dragonflies and butterflies were taken where possible. Dragonflies and butterflies were identified by sight. Shannon-Wiener species diversity indices for odonate and rhopaloceran lepidopteran communities were calculated for each sector.

3.3.5.2 Dragonflies and Butterflies Survey Results

Four species of dragonflies were identified with conservation concern, namely Red-tailed Sprite (Near Threatened) Charming Flashwing (Endangered), Fiery Gem (Critically Endangered) and Interrupted Threadtail (Critically Endangered). One species of butterfly, Common Malayan Birdwing is listed in Singapore Red Data Book as Vulnerable species.

Six species are listed as moderately rare which could be recognized as with conservation significance, these include Spotted Black Crow, Common Evening Brown, Saturn, Tree Flitter, Bamboo Paintbrush Swift, Full Stop Swift.

3.3.6 Aquatic Fauna

3.3.6.1 Methodology

Rigid-frame push-nets (0.6 × 0.4 m; 1 mm mesh) were used to sample the fishes, decapod crustaceans, and molluscs in the stream/swampy areas of Springleaf. Box traps (0.7 × 0.45 m; 10 mm mesh) and cylindrical funnel traps (36.6 × 16 cm; 22 × 1 mm mesh) were deployed overnight, baited with chicken sausages, to sample nocturnal species. All sampled animals were identified, counted and subsequently released.

3.3.6.2 Fishes and Crustaceans Surveys Results

Five species of locally-threatened fish species (Spanner Barb, Forest Snakehead, Slender Walking Catfish, Harlequin Rasbora, and Bigmouth Stream Goby) and one locally-threatened prawn species (Sunda Freshwater Prawn) were encountered over the course of the surveys. Among them, two are listed in the Singapore Red Data book, namely the critically endangered species Slender Walking Catfish, and the endangered species Harlequin Rasbora. In Singapore, both species are distributed in forest streams in CCNR, including NSSF. Another five species of high conservation value previously recorded by Rajathurai (2011) from the study area were not encountered during the present study, viz., Spotted Eel-Loach (*Pangio muraeniformis*), Longnose Little Warty Catfish (*Parakysis longirostris*), Hasselt's Leaf Catfish (*Silurichthys hasselti*), Buff-backed Spiny Eel (*Macrognathus maculatus*) and Malayan Pikehead (*Luciocephalus pulcher*).

3.4 Surface Water

Swamp forest occurs in low-lying areas where slow-flowing streams drain shallow valleys. The ground becomes saturated with the water table close to the soil surface and there are often periods of flooding. Such swamps probably occurred historically in the upper reaches of all the rivers in Singapore (Corlett 1991). The water balance of the Nee Soon catchment is primarily driven by rainfall associated with two monsoon seasons, the northeast monsoon (October to early January) and the Southwest monsoon (late March to May), yet rainfall is typically plentiful even in the inter-monsoon seasons.

Although physically separated from the Nee Soon Swamp Forest (NSSF) by the Seletar Expressway, the Sungei Seletar connects the NSSF (upstream catchment) and the Springleaf site (downstream catchment). The hydrological connectivity includes the groundwater flowing from the NSSF to Springleaf. Connectivity between both catchments is significant, and changes to the Springleaf site such as urbanisation will in turn reduce infiltration resulting from rainfall (NUS, 2018).

Despite of small size, Springleaf water bodies have distinct characteristics. At this stage, although the variation between sites are not significant, the differences are still observed between swamp versus stream and between different stream sections. The swampy area has the lowest temperature, dissolved oxygen and pH, but highest conductivity, salinity and turbidity (NUS, 2018).

3.4.1 Methodology

In-situ water quality measurements were undertaken during a site visit on 11 January 2021 to provide a snapshot of baseline conditions of the freshwater bodies within the study area. Measurements were taken at a total of four (4) locations as shown in Figure 3-16. Measurements were undertaken at surface using a calibrated Aqua TROLL 600 Multiparameter Sonde.

Figure 3-16 Locations of *in-situ* water quality measurement

Table 3-2 Description of *in-situ* water quality measurement locations

Location	Description
WQ1	• Approximately mid-section of the Sungei Seletar within the Project area 
WQ2	• Freshwater swamp forest 

Location	Description
WQ3	• Downstream of Sungei Seletar 
WQ4	• Upstream of Sungei Seletar 

3.4.2 Results

The graphical presentations of the *in-situ* parameters readings at WQ1 to WQ4 are presented in Figure 3-17. The range of values captured at these locations reflect the physical characteristics of a freshwater body. In general, the results for all parameters do not differ significantly spatially. Results are consistent with the previous Baseline Study (NUS, 2018).

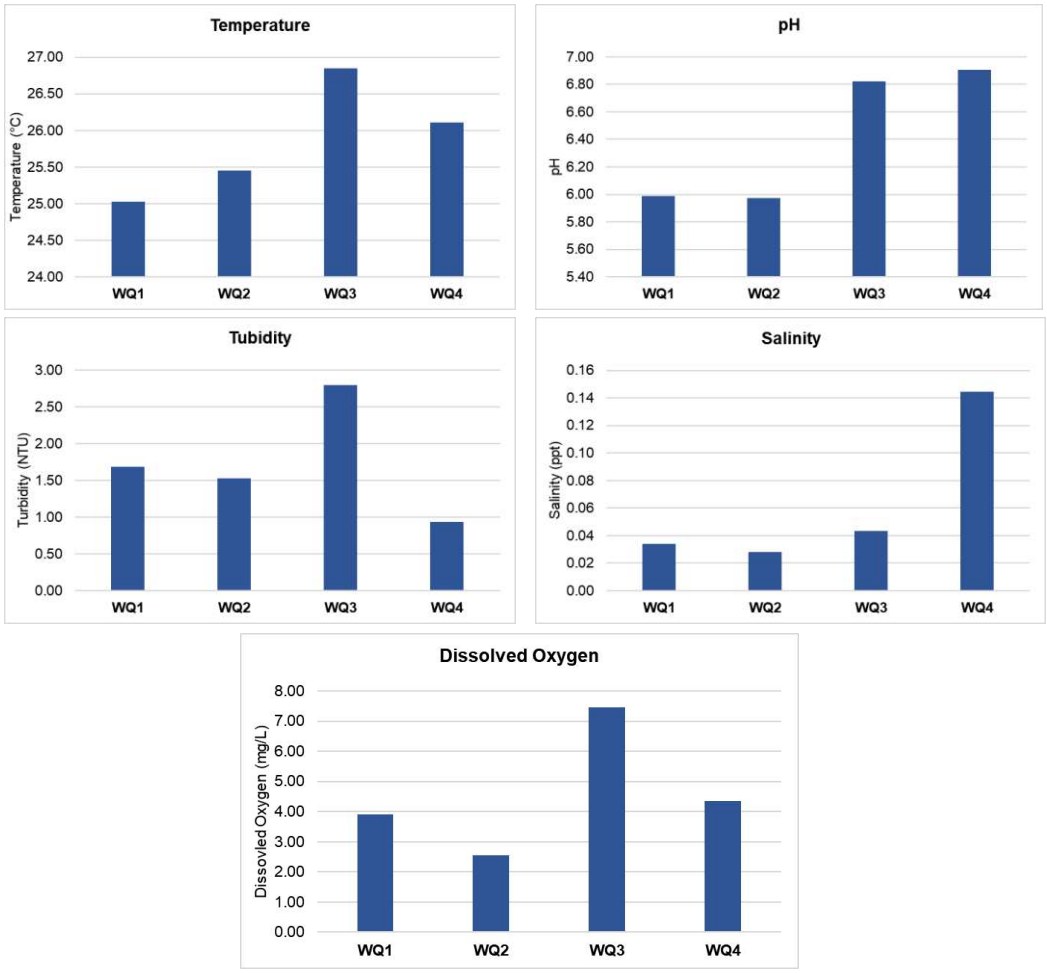


Figure 3-17 *In-situ* parameters measured

3.5 Soil and Groundwater

Belonging to both Triassic Bukit Timah Granite derived (the Rengam series) and Holocene alluvium derived (the Tengah series) soils, soil within the Springleaf site reveal a variety of characteristic in terms of soil type, ranging from Clay to Fine Sand soil (Figure 3-18).

The NSSF appears to be somewhat resilient to weather/climatic fluctuations, including the 2014–2016 drought, which contained the second driest year recorded for Singapore (Meteorological Service Singapore, 2015). In the simulated water balance for the 3-year study period, mean annual water storage loss in the catchment was an estimated 70 mm (Sun et al., 2018), a depth that surely taxed groundwater reserves feeding the swamp. Nevertheless, while many Singapore streams dried during the drought, much of the swamp area in Nee Soon remained wet or moist.

The soil in the freshwater swamp forest has been found to be rich in organic matter: presumably because the anaerobic nature of the waterlogged conditions reduces the rate of decomposition. However, this process has not proceeded far enough to develop soils of high enough organic matter content to be considered peats.

Springleaf surface soil pH is considered moderately high for forested areas (McCauley et al., 2009), ranging from 5.13 to 9.55, soil bulk density varies between 0.35 and 1.01 g/cm3, which is reasonable for forest soils, and soil TOC changes from 0.44 to 6.67%. Soil type varies within the study site, from clay soil to fine sand soil. The soil's TOC is homogeneous

and its bulk density is typical of forest soil. Soil elemental concentration is enriched compared to other local locations but is still unpolluted.

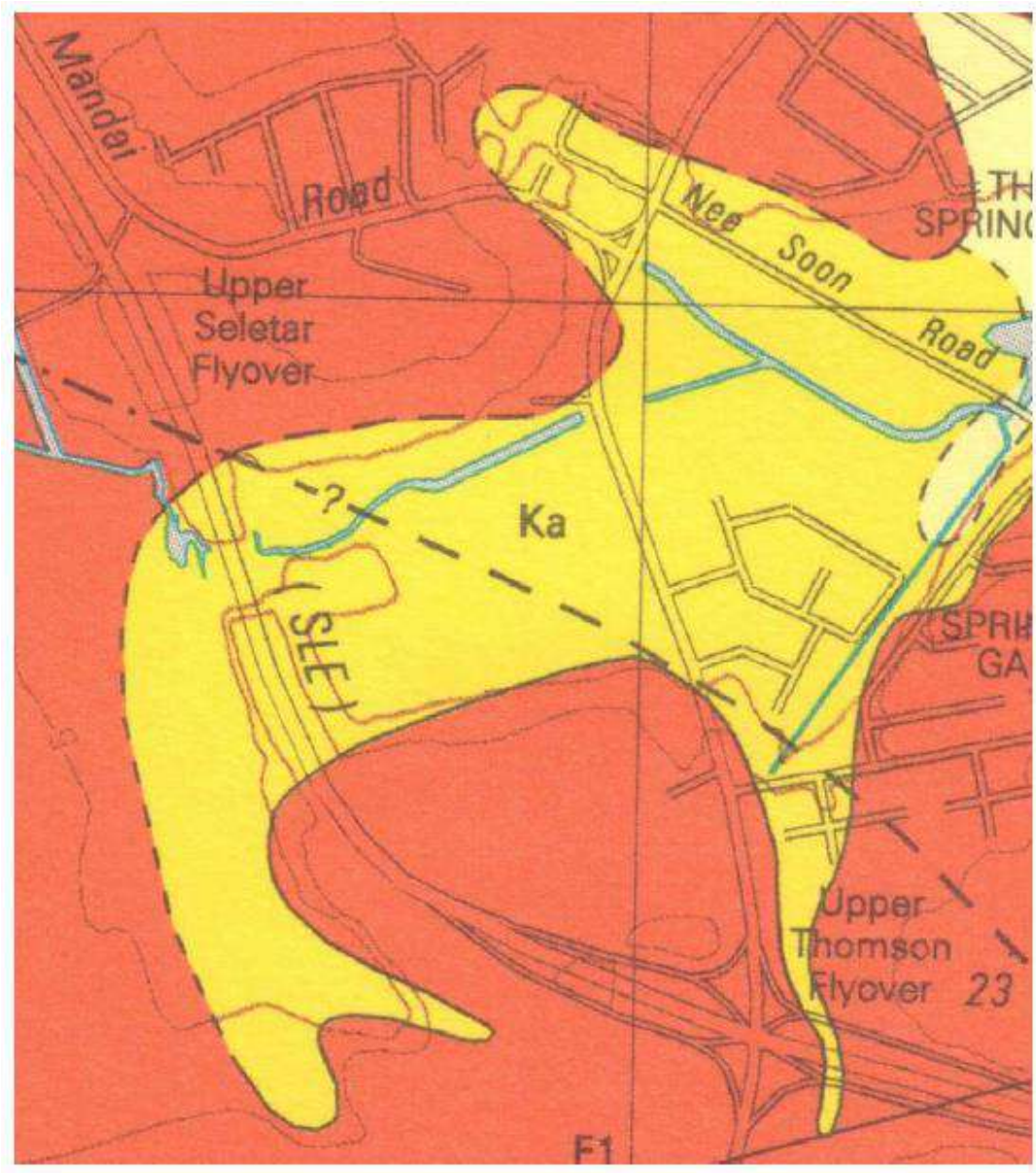


Figure 3-18 Geology of Springleaf area, Bukit Timah Formation (Red) and Kallang Formation (Yellow) (NUS, 2018)

3.6 Air Quality

Air quality in Singapore is influenced by both local and transboundary conditions. Domestic sources of air pollutants include industries and motor vehicles, while transboundary pollutants from land and forest fires in the region contribute to air pollution in Singapore during the southwest monsoon.

3.6.1 Methodology

Secondary data collection of the island wide air quality was used to establish the pre-work ambient air quality at the Project area, in accordance to the latest standards set by the NEA, which is the Singapore Ambient Air Quality Targets, Singapore Targets by 2020. The Singapore's air quality data was obtained from the Department of Statistics Singapore. The data was used to tabulate graphs to understand the trend of different air quality indicators.

3.6.2 Results

Wind

One year of data from 01 April 2019 to 31 March 2020 was extracted from three (3) nearby wind stations i.e. Admiralty, Khatib and Ang Mo Kio. The predominant wind direction at all wind stations are North, North-West and North-East. As an illustration, the wind rose plots for all three (3) stations are presented in Figure 3-19.

Figure 3-19 Wind data from the wind stations in the proximity of the project area

Air Pollutants

NEA conducts routine monitoring of ambient air quality through the Telemetric Air Quality Monitoring and Management System (TAQMMS). This system comprises remote monitoring stations around Singapore monitoring ambient air quality and roadside air quality. Common urban air pollutants including sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3) and particulate matter (PM_{10} and $PM_{2.5}$) are continuously measured at the NEA monitoring stations.

Annual mean air quality concentrations data for the past 10 years (2009 to 2019) from NEA has been analysed to derive the air quality baseline (Table 3-3). It is to note that these data do not reflect spatial variations in ambient air quality in different parts of Singapore hence it may not be representative for typical condition in the Springleaf precinct.

Annual means of 24-hr SO_2, 1-hr NO_2, 24-hr PM_{10} and 24-hr $PM_{2.5}$ were compared with the respective Singapore Air Quality Targets (annual mean target by 2020) as a reference for

the baseline. The annual means of 24-hr SO_2 and 1-hr NO_2 meet the respective Singapore Air Quality Targets by 2020, while the annual means of PM_{10} and $PM_{2.5}$ do not meet the Singapore Air Quality Targets. A graphical illustration of the annual air pollutants levels is shown in Figure 3-20.

Table 3-3 Annual mean air quality levels in Singapore from 2009 – 2019

Air Pollutant	Averaging Time	Unit	2020 Targets	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sulphur Dioxide (SO_2)	Annual Mean	µg/m^3	15	9	11	10	13	14	12	12	13	12	9	8
	Max. 24-hr Mean	µg/m^3	50	93	104	80	98	75	83	75	61	59	65	57
Nitrogen Dioxide (NO_2)	Annual Mean	µg/m^3	40	22	23	25	25	25	24	22	26	25	26	23
	Max. 1-hr Mean	µg/m^3	200	147	153	189	154	132	121	99	123	158	147	156
PM_{10}	Annual Mean	µg/m^3	20	29	26	27	29	31	30	37	26	25	29	30
	99th Percentile 24-hr Mean	µg/m^3	50	59	76	55	57	215	75	186	61	57	59	90
$PM_{2.5}$	Annual Mean	µg/m^3	12	19	17	17	19	20	18	24	15	14	15	16
	99th Percentile 24-hr Mean	µg/m^3	37.5	44	56	41	42	176	51	145	40	34	32	62
Carbon Monoxide (CO)	Max. 8-hr Mean	mg/m^3	10	1.9	2.4	2	1.9	5.5	1.8	3.3	2.2	1.7	2	1.7
	Max. 1-hr Mean	mg/m^3	30	3.9	2.8	2.6	2.4	7.5	2.7	3.5	2.7	2.3	2.5	2.3
Ozone (O_3)	Max. 8-hr Mean	µg/m^3	100	105	139	123	122	139	135	152	115	191	150	125

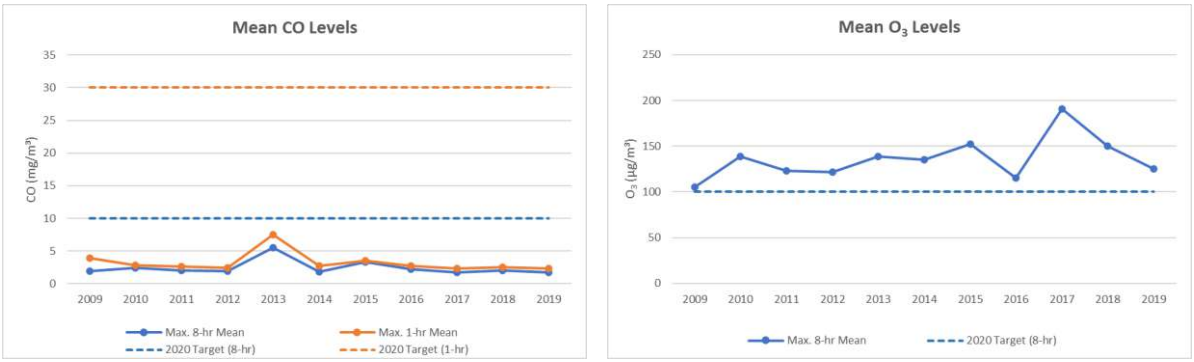


Figure 3-20 Annual mean air quality levels in Singapore from 2009 to 2019

3.7 Airborne Noise

3.7.1 Methodology

To establish pre-work ambient noise conditions of the Project area, spot measurements were undertaken during a site visit on 11 January 2021 to provide a snapshot baseline condition of the noise levels at the potentially affected areas. Measurements were taken at a total of five (5) locations as shown in Figure 3-21 to cover the northern and southern edge of the project footprint as well as along Sungei Seletar.

N1 is located deep within Springleaf Nature Park forest and along Sungei Seletar. It represents the baseline sound level for both the wildlife and visitors in the Nature Park. N2 is located within the study area near Upper Thomson Road, which give reference for the receptors on both sides of Upper Thomson Road in general. N3 is located near the SLE and represents the wildlife in Central Catchment Nature Reserve (CCNR) and Springleaf Nature Park area along the SLE. N4 is near Mandai Road and gives reference of the baseline noise level of the residential houses across Mandai Road. N5 is in the southern part of the project area, which represents the wildlife in the area near development Parcel 1 and 2. Figure 3-21 provides further details on the measurement locations.

Measurements were undertaken using a Sound Level Meter (Type 1). The instrument provides the functions and features vital for contemporary demand measurement standards and guidelines. The noise meter was calibrated at a recognized calibration laboratory within the valid period. A-weighted equivalent continuous noise level of Leq 5 mins was recorded.

Figure 3-21 Locations of airborne noise spot measurements

Table 3-4 Description of airborne noise spot measurement locations

Location	Description
N1	• Approximately mid-section of the Sungei Seletar within the Project area 

Location	Description
N2	• Downstream of Sungei Seletar • Walkway along Upper Thomson Road 
N3	• Upstream of Sungei Seletar • Underneath Seletar Expressway (SLE) 

Location	Description
N4	• Grass patch at the Northern edge of the Project area • Beside Mandai Road 
N5	• Grass patch at the Southern edge of the Project area 

3.7.2 Results

Table 3-5 presents the LAeq 5 mins readings at the five (5) spot locations N1 to N5 where the spot measurements were conducted in the forested area and further away from roads. The LAeq 5 mins recorded were 53 dBA at N1 and 54 dBA at N5 which while low in absolute terms are still clearly perceptible in a forested area. N2, N3 and N4 recorded relatively higher noise levels due to the influences from the traffic noise along Mandai Road, Upper Thomson Road and SLE, ambient sound level ranging from 63 dBA to 66 dBA.

Table 3-5 Ambient sound levels (5 minutes period)

Location	Date and Time	$LAeq_{5mins}$
N1	11 Jan 2021, 13:58	53
N2	11 Jan 2021, 14:43	65
N3	11 Jan 2021, 15:20	66
N4	11 Jan 2021, 16:11	63
N5	11 Jan 2021, 16:36	54

4 Description of Proposed Springleaf Precinct Master Plan

4.1 Key Planning Strategies

The Springleaf Precinct is intended to be developed in accordance with Biodiversity Sensitive Urban Design (BSUD) principles as outlined in Figure 4-1. The design team has integrated BSUD universally throughout the design to ensure that all aspects of the plan live up to the principles.

In addition, the following key planning strategies for guiding the visioning, conceptualisation, and detailed design of the Springleaf Precinct are:

- Designate a 30 m buffer zone around the two Significant Conservation Areas, which comprise of a Core Conservation Area and a Significant Conservation Area Figure 4-2 of high conservation priorities. This buffer zone is a “no development” area to be strengthened in its ecological system. The Core Conservation Area consists of low-lying areas in the southern part of Springleaf, including the freshwater swamp forest and naturalised stream corridor. The Significant Conservation Area covers the southwestern part of the northern high ground, and harbours a high diversity of mammal species around the pond.
- Do not build on the lower ground as it is too close to the stream corridor as well as to the ecologically sensitive ecosystems. Instead, strengthen the area to merge both ecologically sensitive clusters to form a larger ecologically sensitive core, an eco-heart, ensuring better protection to the flora and fauna. This will also create more habitats for the animals when development inadvertently would displace some of the animals.
- Enhancing the ecological connectivity of Springleaf forest across the larger ecological landscape, with the Central Catchment Nature Reserve and Springleaf Nature Park. Beneath the SLE viaduct, barriers such as railings are to be removed, and enhancement plantings carried to facilitate fauna movement. Cargo rope net bridges constructed across roads will also enhance movement of arboreal fauna. Conservation and riparian plantings of the stream corridor will further strengthen aquatic connectivity, while afforestation works will create canopy bridges with adjacent vegetated areas.
- Developments to be elevated off the ground to safeguard the forest floor. The majority of the ground plane to be kept free and maintained as natural ground to ensure that the undergrowth and the natural setting can be restored after development.
- Build an elevated boardwalk to facilitate connectivity as well as bringing the public closer to this unique area without causing any damage.
- Build lightly, with traditional stilt houses in more sensitive zones, where only the columns and the piles need to reach the ground. Roads and services are mostly elevated above the natural ground. Buildings in more sensitive zones are low rise and sparsely distributed allowing sunlight, rain and vegetation to grow in between them.
- When high rise is needed, build with a small footprint and at the location furthest from the ecologically sensitive epicentre. Surround the tower with greenery and trees so that birds can perch and build nests on them. Take advantage of the height as a refuge for birds, free from terrestrial predators. Use the skyrise greenery to generate more biodiversity.
- Use this ecologically sensitive site to promote a new development paradigm whereby people who love nature can adapt to a lifestyle without cars. Living here comes with a

certain privilege as well as responsibilities. For example, residents may need to walk from the MRT station or central carparking to their homes.

- In the planning of other infrastructure services, the emphasis is on minimising the footprint and impact. Furthermore, services connections to the regional networks from the development clusters should be made direct from the adjacent Mandai and Upper Thomson Road where available via the shortest paths, and no cross connection between the north and south sites should be considered in principle to avoid undesirable impact.

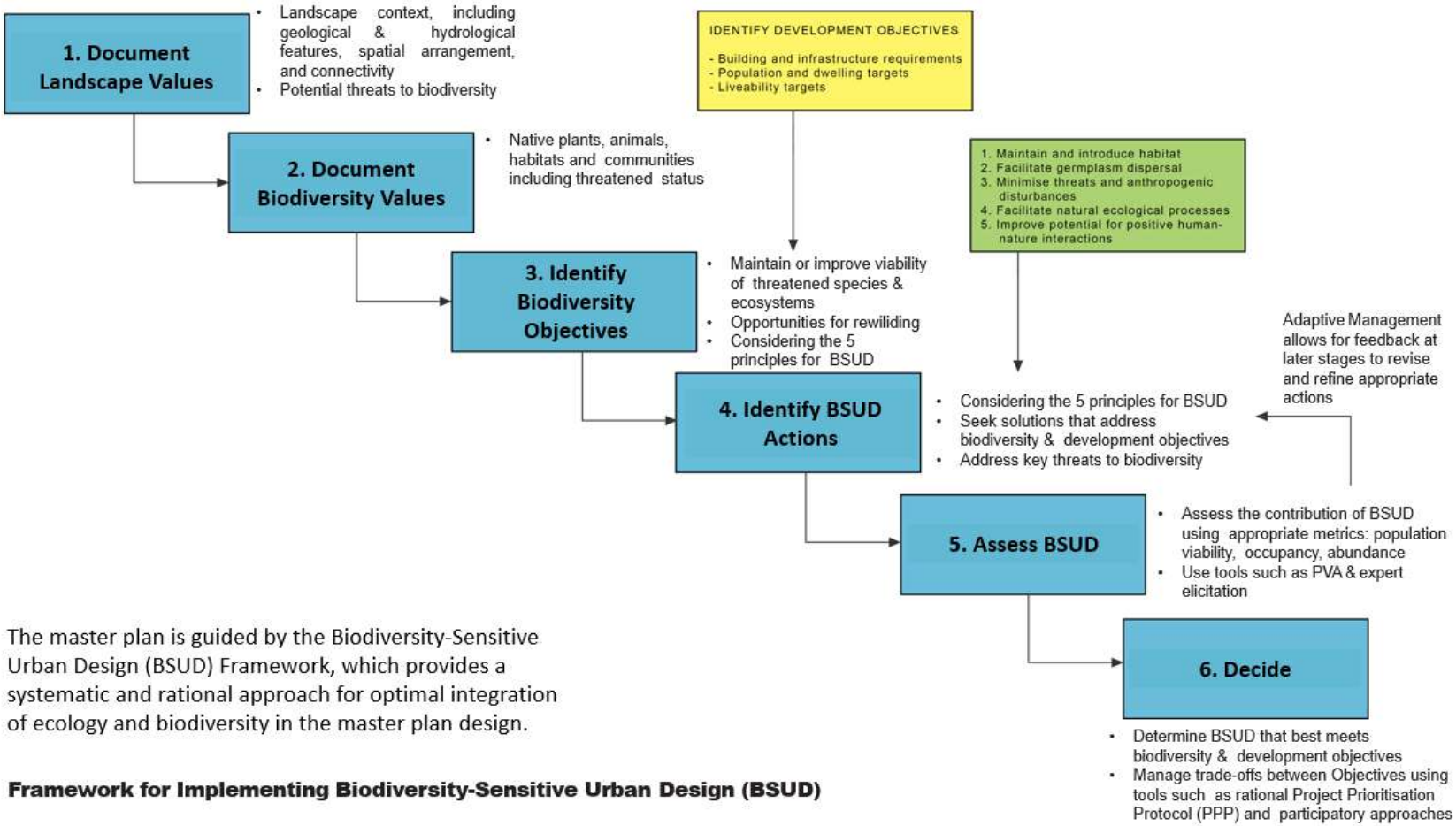


Figure 4-1 Biodiversity Sensitive Urban Design framework

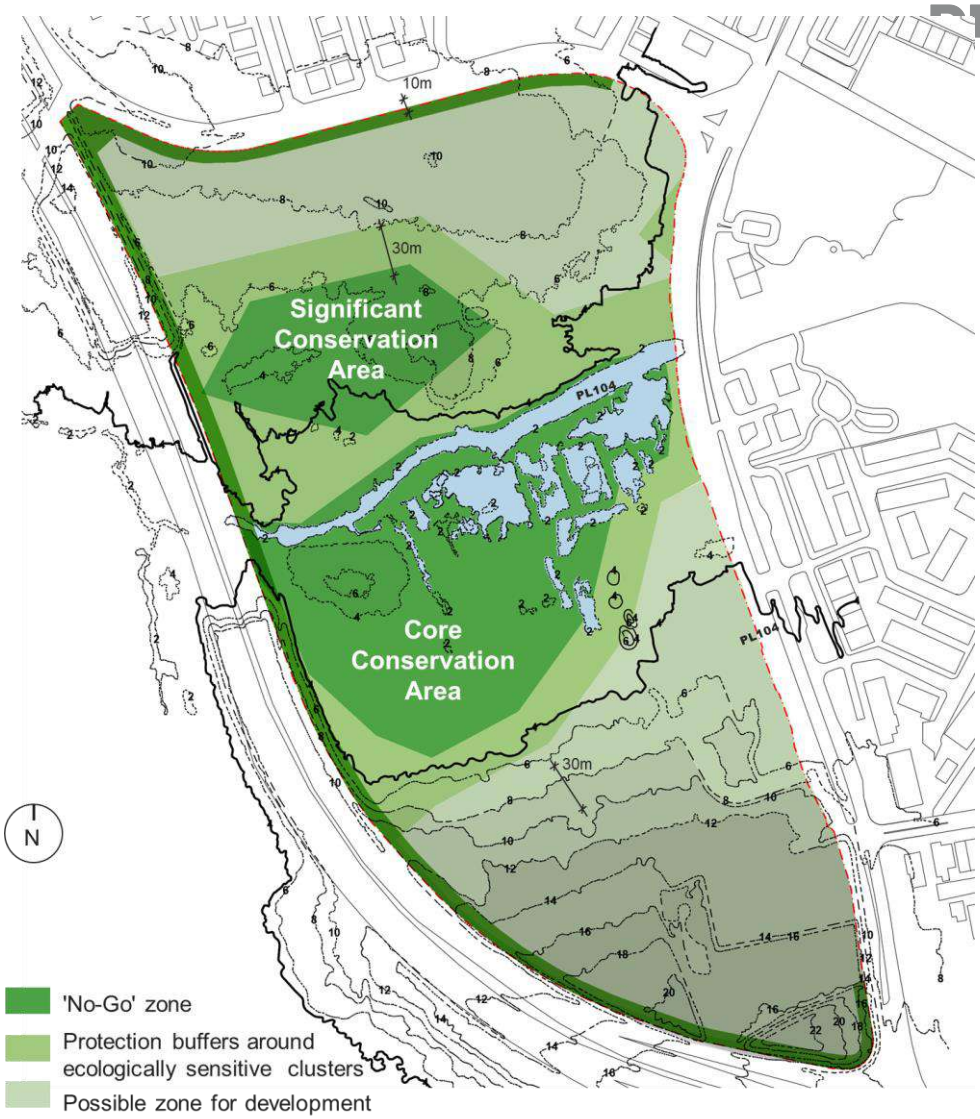


Figure 4-2 The Core Conservation Area and Significant Conservation Area are defined as Significant Conservation Areas and are designated “no-go” areas, while the adjacent 30m wide buffer zone is designated as a “no-development” zone (map credit: STX Landscape Architects)

4.2 Proposed Springleaf Precinct Master Plan

4.2.1 Urban Design Plan

The Springleaf Precinct Master Plan proposes high-rise towers to optimise residences on a smaller footprint concentrated at locations furthest from the ecologically sensitive epi-centre (ie. at north and south parcels) as an optimal way to meet the targeted dwelling units with minimal land take. The high-rise towers yield a total of 1,468 units (73.4% of target units), with a building footprint of about 3% of the total site area. Further details on the proposed parcels are provided in Table 4-1 and Figure 4-3.

The proposed development area for the site is 13.1 ha. The total site area is approximately 33 ha of which around 7.2 ha (or 22.4% of the site) has been considered disturbed through prior development, and was not included within the Baseline Study. The Southern Low Ground and Stream Corridor is considered Core Conservation Area (~ 7.4 ha). The north-west corner of the Northern High Ground is also a Significant Conservation Area (~ 2.4 ha). Together these Significant Conservation Areas (hereinafter referred to as such) combined to cover approximately 30% of the total site area. 72.4% of the existing green area is maintained. This total green area is made up of 9.8 ha of Significant Conservation Areas and 8.3 ha of other maintained green areas, including the buffer zones.

The towers are planned to avoid existing vulnerable and endangered tree species on site, as well as the existing mature trees with conservation value. About 50% of the required dwelling units are proposed to be within the existing urbanized/disturbed ground area. 35% of dwelling units are along the northern fringe, with about 15% of dwelling units as low-rise developments within the secondary forest area. The idea is to insert the housing in between existing trees, with sufficient setback from existing critical and endangered trees (Figure 4-4).

There are significant topographical changes within the site, with the low-lying swamp forest area below platform level 104.5 m, the northern edge at platform level 110.0 m and the highest point at the southern corner at platform level 122.0 m. There is significant level change between the site and Upper Thomson Road along its south-eastern boundary. The 1-in-50 year x 125% flood scenario was modelled for Sungei Seletar and showed that the proposed minimum platform level for each parcel and the proposed private and public boardwalk levels within the flood plains are above the modelled maximum flood level. Therefore, the existing river can be preserved to avoid detrimental ecological impact.

Table 4-1 Characteristics of the three development parcels

Parameters	Parcel 1a	Parcel 1b	Parcel 2
Parcel Area	23,019 m^2	66,864 m^2	42,651 m^2
Land use / zoning	Commercial and residential (integrated with MRT, existing bus stop and taxi stand)	Residential (integrated sensitively with protected forest area)	Residential
Type of proposed housing development	Low rise apartments in a village like setting	High rise apartments on southernmost corner, elevated low-rise apartments in the south western forested area	High rise apartments

Parameters	Parcel 1a	Parcel 1b	Parcel 2
Number of units	204	1097	700
Building height	Up to a maximum of 4 storeys for buildings adjacent to public plaza Up to a maximum of 2 storeys for buildings along the forest edge	Up to a maximum of 100 m for high rise towers on southern corner Up to a maximum of 30 m for mid-rise apartments that are elevated minimum 9 m off the ground	Up to a maximum of 61 m – 70 m for high rise towers
Gross plot ratio	0.90	1.21	1.10
Site porosity	30% green / landscaped 55% hard paved area 15% porous paving area	80% green / landscaped 5% hard paved area 15% porous paving area	70% green / landscaped 10% hard paved area 20% porous paving area

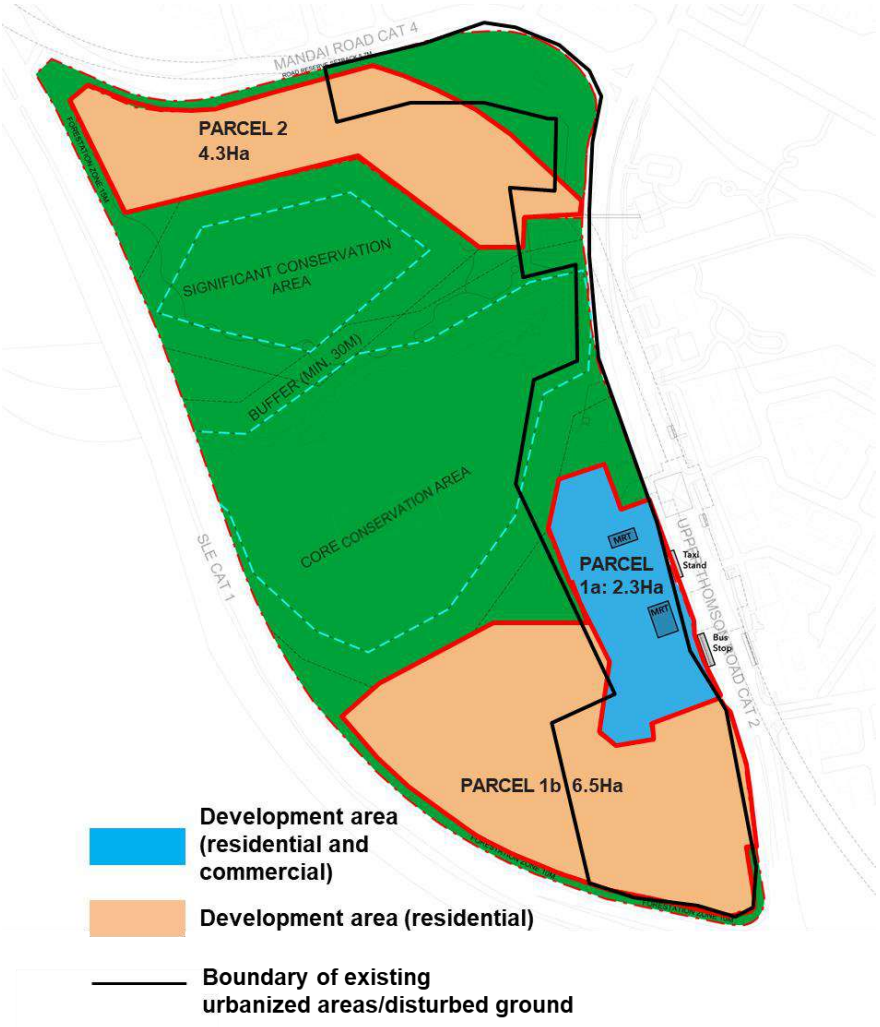


Figure 4-3 Main development parcels within Springleaf Precinct (map credit: MKPL Architects)

Development parcels will be privately owned land. However, Parcel 1a also has what is described as privately owned public spaces. Parcel 1b has designated Forest Links which are elevated walkways providing access to the buffer zone of the Core Conservation Area (Figure 4-5).

Building form and typology will be site sensitive and respond to the forest and natural topography. Buildings are to be designed with modularity for efficient and non-destructive construction process (Figure 4-6).

A combination of “Forest Towers” and “Tree Cottages” are proposed for the residential areas. The housing forms an elevated stratum, safeguarding the forest floor in line with the overall landscape strategy. This establishes a truly symbiotic relationship between the new residents and the land. The proposed Springleaf Precinct Master Plan also proposes an alternative plan whereby some of the Tree Cottages are replaced by Forest Towers – this option is elaborated further in Section 4.2.1.1.

Tree Cottages are low rise apartments on stilts, raised sufficiently high above ground to maintain minimal disruption to the ground cover. They are imagined to be like “camping in the forest”, where one is in harmony with nature, developing a new understanding of and respect for the unique ecosystem and diverse flora and fauna.

Forest Towers are high rise towers located at areas which are least critical in terms of ecological sensitivity. They are envisaged to be infused with abundant skyrise greenery, enabling the towers to be like “giant tree columns” rising above the forest. Full exposed glass facades are not allowed, they shall be carefully designed to minimise bird strike. Timber louvers for fenestrations to cut off internal night lighting will also be installed to minimise light pollution to the surrounding environment. Adjacent to the new Post Office Park to the north, development is imagined as “towers in the park”.

The development around Springleaf MRT is envisaged as a low rise “village development” with buildings organised around street and squares, integrated with massings of forest trees. There will be provisions for roof-top gardens above low rise blocks to encourage biophilic practices and enhance biodiversity within developments. There will be commercial and residential developments. A row of single-storey shophouses define a new streetscape complementing the existing row of shophouses on the opposite side of Upper Thomson Road. A new market place, i.e. the Red House, sits in the Village Square, defining the entry and arrival into Springleaf Precinct. Low rise residences are proposed along a landscaped street which ascends gently southwards, reflecting the undulating ground. Gaps between buildings at strategic locations allow connectivity between buildings and forest. The infusion of greenery into the Village Square provides deep shade and creates a relaxing, laid back atmosphere reflecting the inherent character of the site.

The former Seletar Institute buildings form part of the Forest Green Residences. The old classroom block is converted into duplex lofts and communal spaces. The canteen / hall block is re-purposed to form the Clubhouse. Together, the old campus forms the community heart of the development. The Towers mark the site corner whilst enjoying uninterrupted views of forest and distant views of Seletar Reservoir. The Cottages are raised on stilts and nestled quietly within the secondary forest.

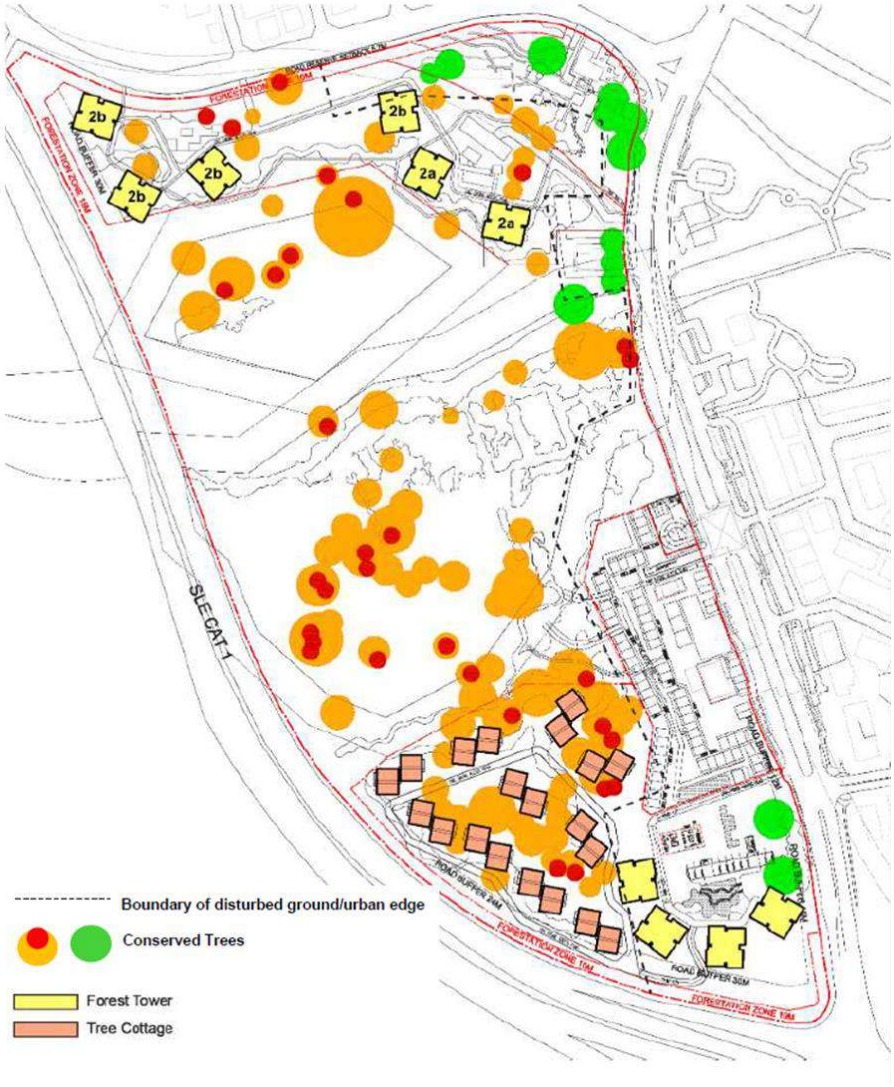


Figure 4-4 Locations of Forest Towers and Tree Cottages in relation to the locations of conserved trees (map credit: MKPL Architects).

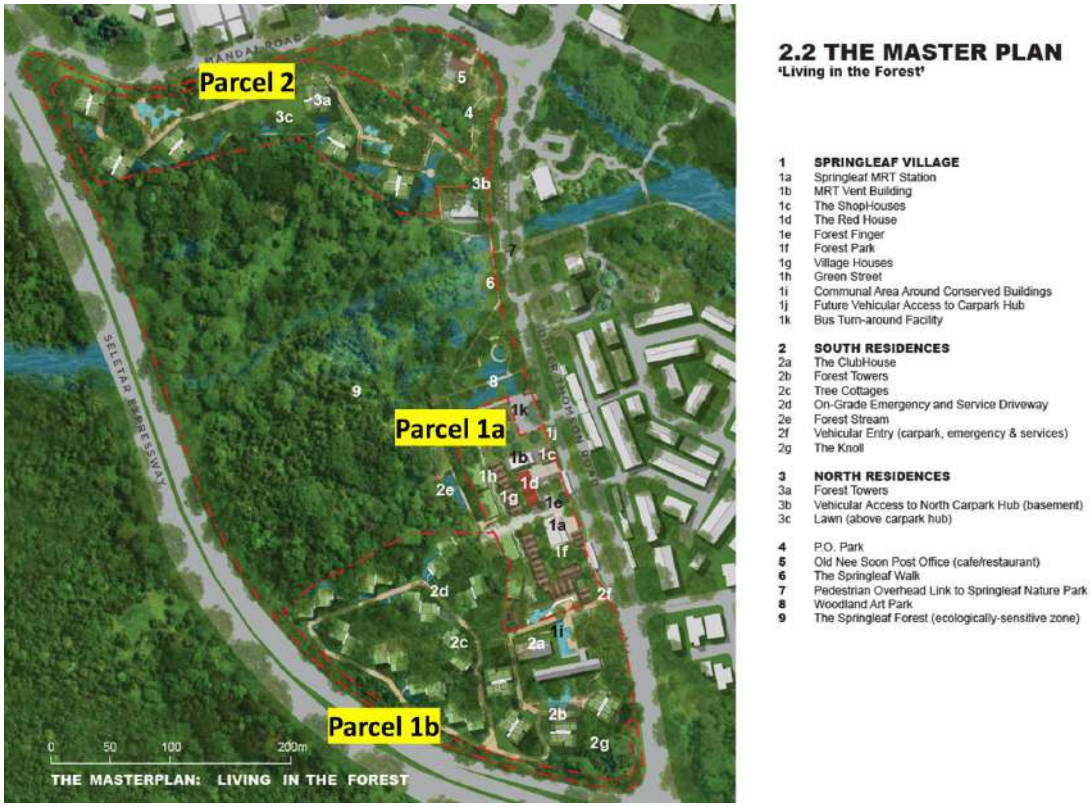


Figure 4-5 Locations of Village Houses, Forest Towers and Tree Cottages (map credit: MKPL Architects)

Forest Tower profile

Forest Tower section

Tree Cottages on stilts

Tree Cottages in the forest

Swimming Pool

View south towards Upper Seletar Reservoir

Village Development

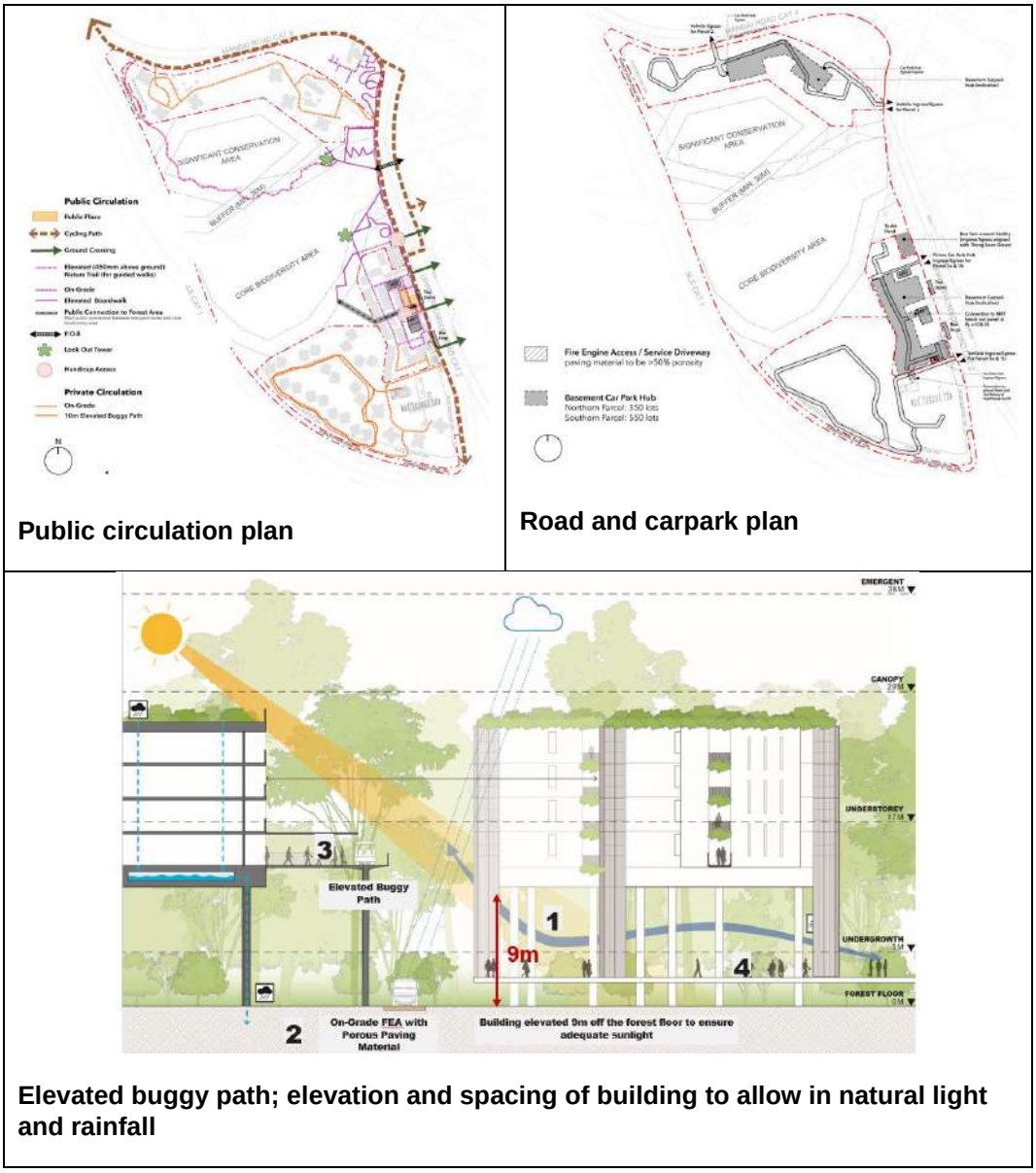
Connectivity between buildings and forest

Figure 4-6 Urban design plans and typologies (image credits: MKPL Architects)

On-grade paths enable Parcel 2 to be connected to the Village and MRT Station. Elevated boardwalks are part of the park / nature experience. Fire-engine access for Parcel 1b (Tree Cottages) area will be on-grade. An elevated buggy route is adjacent to the fire engine accessway, to minimise disturbance to existing trees in the secondary forest. Vehicle ingress and egress shall be limited to a few designated points on site for a car-lite precinct. Two basement carpark hubs are proposed to serve the Parcel 1a/1b and Parcel 2 respectively (Figure 4-7).

Elevated boardwalk within the buffer zone helps to connect the Parcels 1a/1b and 2 and allows both residents and public to use an alternative route to access both parcels within a

scenic and natural setting. The Elevated boardwalk would incorporate a wildlife fencing that would be both aesthetically pleasing and effective in keeping out larger mammals such as Sambar Deer and Wild Boar while letting smaller wildlife and climbing wildlife to move through. This allows the smaller wildlife to have a larger foraging area while minimising potential negative human-wildlife interactions that may arise from larger wildlife such as Sambar Deer and Wild Boar in the areas with higher human presence.



Public circulation plan

Road and carpark plan

Elevated buggy path; elevation and spacing of building to allow in natural light and rainfall

Figure 4-7 Elevated roads and walkways for accessing the site along with public circulation carpark access plans. (Image credit: MKPL Architects)

4.2.1.1 Alternative Urban Design Plan (Reduced Tree Cottages Option)

In the event that the site ecological conditions do not permit the full implementation of the proposed number of Tree Cottages, particularly in areas closer to high concentrations of conserved trees, a smaller number of Tree Cottages can be considered. The number of Tree Cottages could potentially be halved from 10 in the base option to 5, yielding a total of 160 dwelling units. The reduction in total dwelling units can be compensated by introducing up to 2 additional towers in the north, within Parcel 2, which can accommodate an additional 224 units (Figure 4-8 and Table 4-2). This option would result in Parcel 2 exceeding the 700 dwelling units limit set for the proposed Springleaf Precinct Master Plan base option, and may also cause implications on road widening works for Mandai Road.

Regardless of the options chosen, there will not be any high-rise towers built within the forested zone in the south, avoiding detrimental effects on the biodiversity of the area. Instead, all proposed high-rise towers are concentrated within disturbed grounds or the

more disturbed edges. Impact assessment has been carried out for both the proposed Springleaf Precinct Master Plan base options and the Reduce Tree Cottages option – for the latter, however, only the changes in impacts to biodiversity and ecology have been reassessed (see Section 6.1.6), as the biodiversity and ecological receptors are expected to respond most strongly to the proposed deviation from the proposed Springleaf Precinct Master Plan base option, while the other socio-physical sensitive receptors are expected to be largely unchanged.

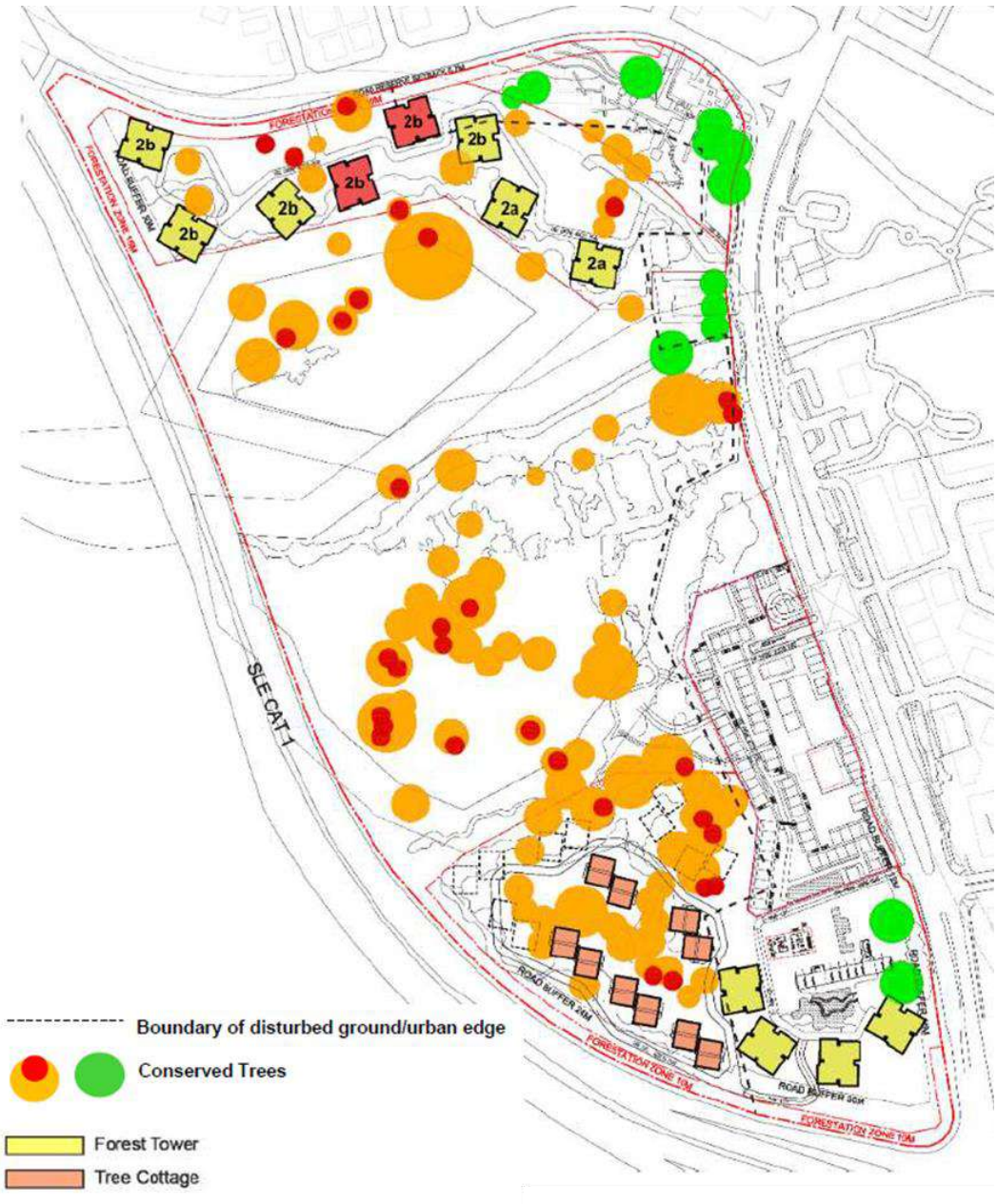


Figure 4-8 Locations of Tree Cottages and Forest Towers, under an alternative option with the number of Tree Cottages halved from the proposed Springleaf Precinct Master Plan base option. (Image credit: MKPL Architects).

Table 4-2 Comparison of development characteristics and dwelling units between the proposed Springleaf Precinct Master Plan base option and the alternative option with reduced number of Tree Cottages.

Masterplan Base Option

Plot	Housing Type	No. of Towers/Modules	Capacity per Tower	Total Units
1A	Village Houses			204
Total DUs in Parcel 1A				**204**
1B	Forest Towers	4	192	768
	Tree Cottages	10	32	320
	Duplex Lofts (1st and 2nd storey of SI)		9	9
	Apartments (3rd and 4th storey of SI)			0
Total DUs in Parcel 1B				**1097**
2	Forest Towers Type 2a (14 storeys)	4	112	448
	Forest Towers 2b (16 storeys)	2	128	256
Total DUs in Parcel 2				**700**
Total DUs				**2001**

Reduced Tree Cottages Option

Plot	Housing Type	No. of Towers/Modules	Capacity per Tower	Total Units
1A	Village Houses			204
Total DUs in Parcel 1A				**204**
1B	Forest Towers	4	192	768
	Tree Cottages	5	32	160
	Duplex Lofts (1st and 2nd storey of SI)		9	9
Total DUs in Parcel 1B				**937**
2	Forest Towers Type 2a (14 storeys)	6	112	672
	Forest Towers 2b (16 storeys)	2	128	256
Total DUs in Parcel 2				**928**
Total DUs				**2069**

4.2.2 Ecological and Landscape Plan

The Springleaf Precinct Masterplan includes a technical report on landscape and ecology plan, which is elaborated in detail in **Appendix B**, particularly on the biodiversity conservation strategies to be adopted for design, construction, and species inhabitation. In general it can be assumed that landscape work within the private parcels will be the responsibility of the Private Developer and in public lands by the State. The key strategies and measures covered as part of the ecological and landscape plan are as follows:

- Reconciliation of human activities with wildlife passage and co-habitation to strike a balance in between development and habitat / biodiversity protection. The preferred option advocates sharing rather than taking away habitat from animals (Figure 4-9).
- Minimize impact of public access into 30 m buffer areas and Significant Conservation Areas with proper intervention to segregate human and wildlife activities. The strategy outlines the proposed elevated walkways inspired by the kelong structures of olden days in public and private domains. The elevated structure allows a degree of controlled penetration of humans and can double-up as barriers to prevent larger animals like Sambar Deer and Wild Boars from coming through into areas that are highly populated and more urbanized in character.
- Plan infrastructure to enhance connectivity for animals between Springleaf, CCNR / NSSF and forests across Upper Thomson Road. This includes identified areas of specific intervention to facilitate animal crossings and movement between northern and southern conservation areas of the site.
- ABC Waters design features in the public domain within the 30 m buffer zone act as a protective measure in addition to the ABC Waters design features proposed within the development parcels. ABC Waters design features within the public domain are to be done by the State/NParks; those within the sold land parcels are done by the developer. However, in practice it will be more streamlined for the developer to carry out planting inside/outside the parcels simultaneously, and thus it is plausible for State/NParks to request developer to perform the tree planting outside development as part of the whole development package and reflect the costs in bidding price during tendering processes.
- Limit site penetration by the public for proper managed human activities and movements, minimizing human intervention and limited access onto the ground for the protection of natural habitats at Core Conservation Areas and Freshwater Swamp Forest.
- Facilitation of site connectivity demonstrates the hierarchy of the site mobility and circulation in response to the evaluation and close study of site context, natural terrain, and sensitive ecology and biodiversity of the site.
- Access route from Parcel 2 to MRT station shown with the site layout incorporated within the development parcel to illustrate a fully on-ground access connection to the MRT.
- Art Park will be located next to the bus turn-around facility, which will be converted to a community farming area when the bus turn-around facility is vacated in the future. The Sustainability Educational Centre, which is a central hub for sustainable living, will be sited within the Red House. The purpose of the Sustainable Education Center is to promote sustainable living with the residential community within the development (reduce water or electricity use, growing their own food, etc.), and also serve as a central hub of information for biodiversity and conservation as well.
- Playgrounds and Community Farms are proposed for on-ground recreational facilities within the forested residential development.
- All existing endangered trees and landscape features shall be conserved.
- Lush landscaping shall be used for parcel boundaries and softscape areas are to be extensively planted.
- Restricted use of artificial fertilisers, herbicides and pesticides.
- Planting zones and characteristics are derived from the careful analysis of existing vegetation and identification of broad habitat areas with varying degree of biodiversity sensitivity and significance. The planting palettes will then be developed to suit the natural environment of the site, to reinforce the character of each zone identified and to enrich the biodiversity of the site.
- Tree planting density defines the planting zones and its characteristic based on tree canopy coverage (demonstrated with broad assumption made). This will serve as a guide for development of the tree planting palettes for each zone.
- Native planting and matrix demonstrates the use of native plant species across the site based on the characteristic of each zone identified. The matrix outlines the recommended plant species and the percentages of landscape signature (native found

currently within Springleaf), native and non-native plants to guide the development in achieving the landscape signature character on each respective zone (Figure 4-10).

Figure 4-9 Two options for habitat sharing within the Tree Cottages area. Colours indicate the areas where different fauna types are allowed to enter (map credit: STX Landscape Architects). The shared habitat model, where wildlife can access the ground level beneath the Tree Cottages, is also shown in the side profile diagram in Figure 4-7.

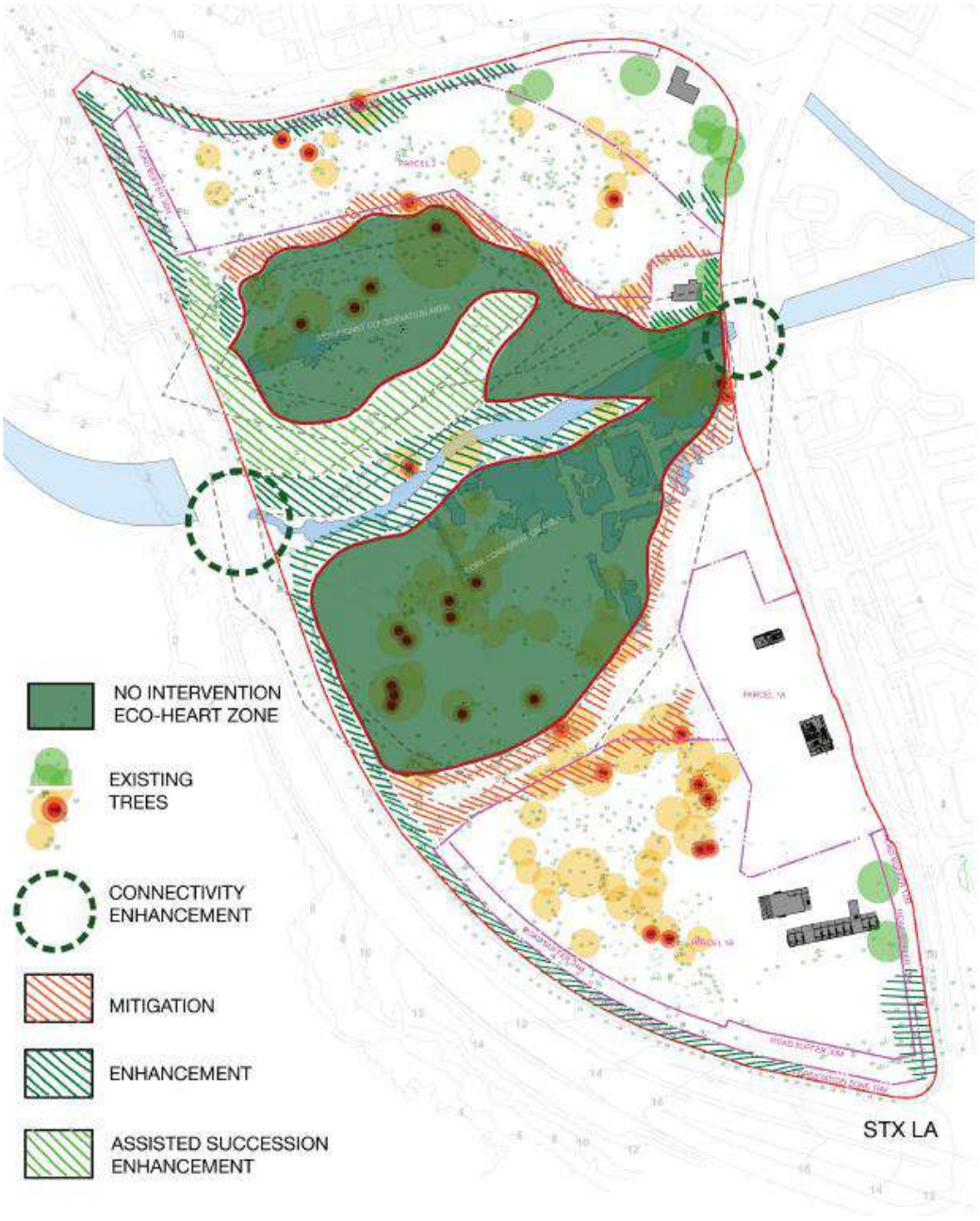


Figure 4-10 Areas within Springleaf where habitat enhancement and assisted succession works are planned (image credit: STX Landscape Architects).

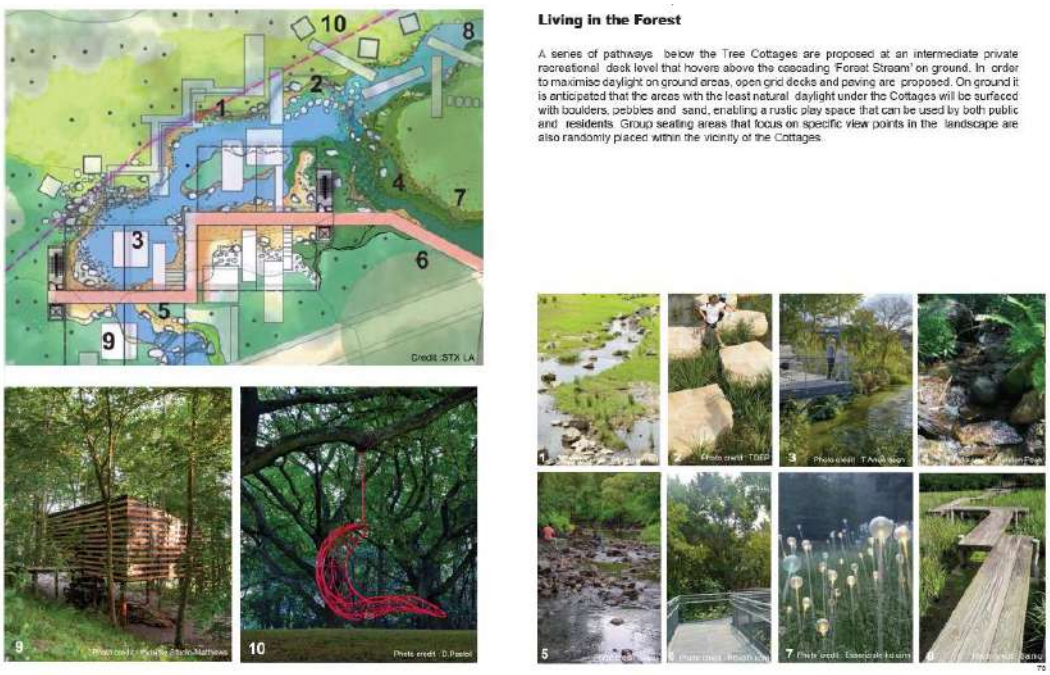


Figure 4-11 Living in the Forest (image credit: STX Landscape Architects).

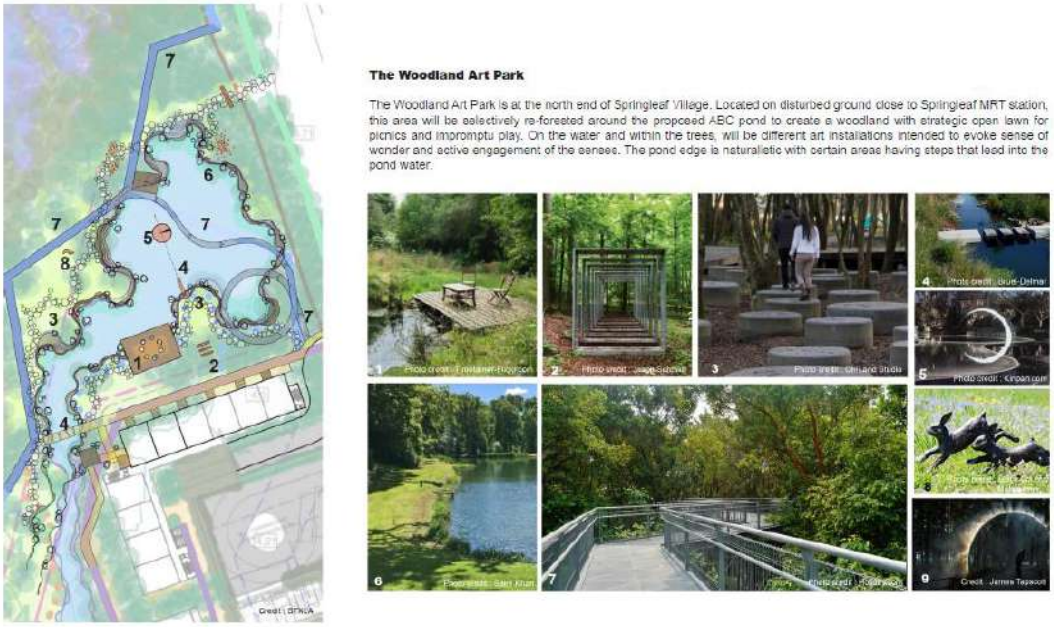


Figure 4-12 The Woodland Art Park (image credit: STX Landscape Architects).

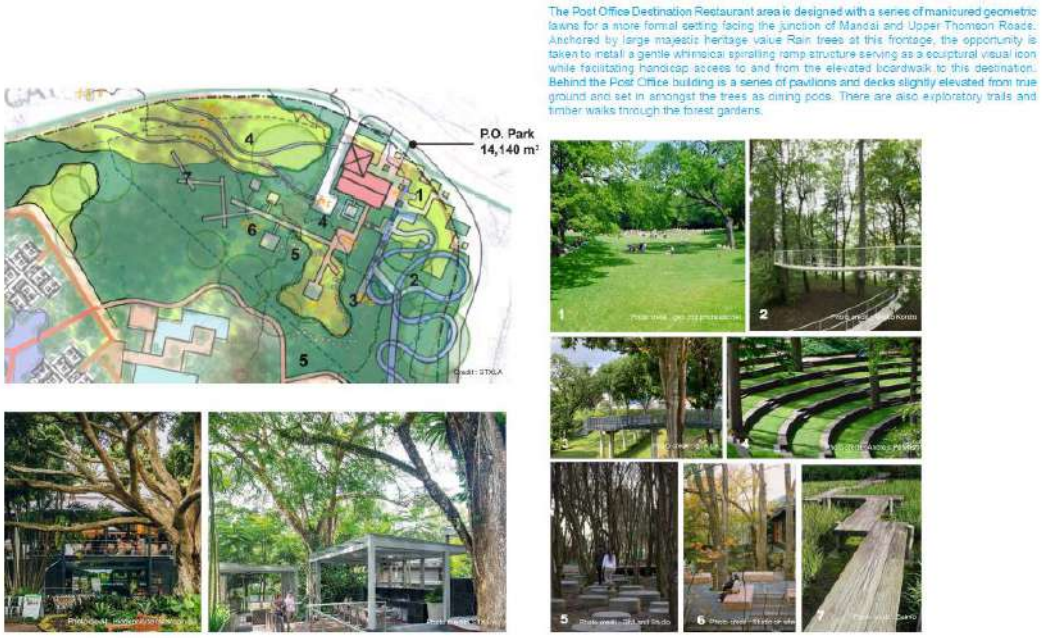


Figure 4-13 The Post Office Park (image credit: STX Landscape Architects).

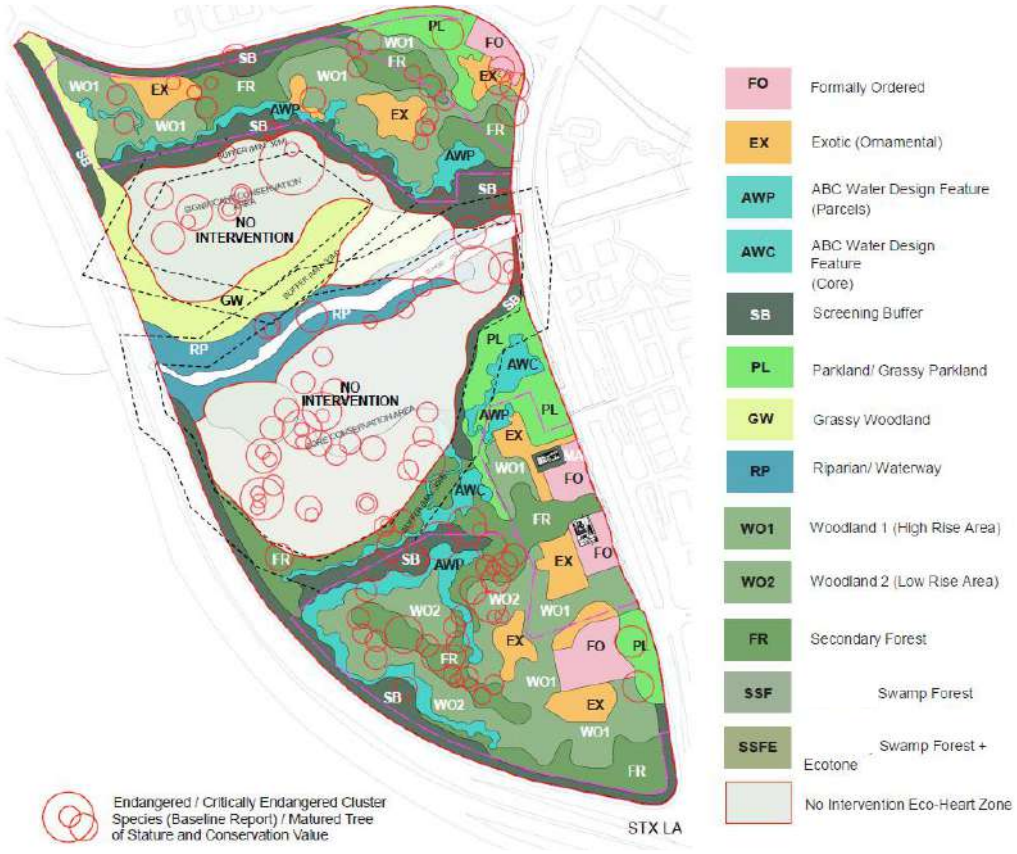


Figure 4-14 Planting zones and characteristics (Map credit: STX Landscape Architects).

4.2.3 Stormwater Management Plan

The proposed Springleaf Precinct Master Plan blue-green requirements include:

- To achieve PUB Code of Practice on Surface Water Drainage Clause 7.1.5 detentions requirements through the use of ABC Waters design feature
- To adopt a rainfall intensity with an additional climate correction factor of 25%
- To achieve ABC Waters (Gold) with treatment of surface run-off at least 60% of the total site through the use of ABC Waters design features
- To meet a desired target of 80% reduction in total suspended sediment (TSS), 45% in total phosphorus (TP) and 45% in total nitrogen (TN)

The design incorporates features such as bio-retention swales and soak away rain gardens to detain, filter and clean runoff. Assuming total water depth of ABC Waters features for treatment and detention is approximately 0.5 m, excluding permanent water depth, the sizes of the ABC Waters features have been found to be more than sufficient for the three parcels.

Additional detention is designed beyond the private parcels on the south side, to provide additional stormwater capture and percolate water towards the Freshwater Swamp Forest within the Core Conservation Area. In terms of ecological value, the land to the south is more at critical risk from diversion of water than the land to the north. Overflow from Parcel 1b will flow towards and recharge the freshwater swamp forest via vegetated ABC Waters bioswales, which can cleanse pollutants and also enhance biodiversity and facilitate their movement. Overflow from Parcel 1a will flow towards the Art Pond, with ABC Waters features added to increase treatment capacity. The Art Pond will be outside the development parcels and is likely to be managed separately by a Park Developer.

Calculations carried out to check for detention requirements have demonstrated that based on a target 10 year storm event, the Art Pond must be constructed alongside with Parcel 1A in order to meet the detention requirements of Parcel 1A. Having the Art Pond constructed allows each sub-parcel to fulfil their own detention requirements separately with more flexibility and to comfortably meet the ABC Waters criteria.

Based on the Springleaf Masterplan surface treatment design and the conceptual ABC Waters Features design to promote groundwater infiltration, the post-development runoff coefficient of 0.80 is achievable on site (Table 4-3). For each parcel, the detention and ABC Waters Gold Certification requirements can also be met.

Table 4-3 Characteristics of the three development parcels

Parcel	Total Area (ha)	Surface Cover					Weighted Runoff Coefficient
		Hardscape	Porous	Softscape (true ground)	Softscape (non-true ground)	ABC Waters Features (Unlined)	
1A	2.3	35%	15%	27%	20%	3%	0.785
1B	6.6	5%	15%	39%	30%	11%	0.665
2	5.3	10%	20%	39%	20%	11%	0.665
Runoff coefficient, C		1.00	0.80	0.45	0.90	0.45	-

The proposed Springleaf Precinct Master Plan also calls for hydrological integrity to be maintained by maximising groundwater percolation. The proposed Springleaf Precinct Master Plan development guidelines stipulates the maximum area of hard paved areas allowed for each development parcel and requires as much of the ground cover to be green or porous in nature (Figure 4-15). Other than the actual footprint of the buildings and roads, the remaining areas of the parcels are largely porous either through landscaping or the use of porous paving materials.

Figure 4-15 The maximum coverage of hard paved areas allowed as stipulated by the proposed Springleaf Precinct Master Plan guidelines (Image credit: MKPL Architects).

4.2.4 Sustainability Plan

Within the proposed Springleaf Precinct Master Plan there is an overarching aim for circular carbon neutrality. This includes segregation of waste at site and use of recyclable materials or engineered timber grown sustainably. The development should minimise concrete usage, enhance cement replacement and use of green concrete. The development should also focus on prefabricated, design for manufacturing and assembly and modular construction.

Springleaf Precinct will be a car-lite development that encourages pedestrian movement.

Buildings are to be orientated to reduce the solar exposure on their east and west sides and increase on the north and south sides. There will be mutual shading in open public spaces.

Photovoltaics are proposed on the Forest Towers roofs in Parcels 1b and 2 (low-rise Tree Cottages will not have photovoltaics installed as they are shaded by tree canopies). 100% lights are to be LED lights for energy savings with daylight sensors to control the lighting.

Massing will allow the wind flow from the prominent north and south wind direction. Outdoor naturally ventilated spaces are to achieve a minimum wind velocity of 0.6 m/s, with wind corridors to facilitate cross ventilation. There will be ceiling fans provided in the bedrooms, living rooms and dining areas to facilitate natural ventilation and reduce air conditioning demand.

There will be greenery on the terraces on the upper levels. High solar reflectance index materials (> 39) will be used on the exposed areas to reduce urban heat island and cool paints will be used on the solar exposed surfaces. Water fountains are recommended for evaporative cooling in the public areas.

The construction works should adopt innovative construction technologies which focus on using sustainable building material and off-site fabrication. There is opportunity to explore the use of sustainable building materials such as Mass Engineered Timber (MET) for the low-rise developments in the project, particularly the Tree Cottages. MET buildings have lower carbon footprint and net carbon emissions compared to steel or concrete buildings. Moreover, the components can be pre-fabricated off-site, minimising on-site wet works and disturbances of the natural ground around the Tree Cottages. The architectural expression of the timber panelling would be compatible with the overall character of the forested site. The MET should be chemically treated to prevent termite attack, by elevating off-ground, the risk of decay can be greatly reduced.

Rainwater will be stored in the rainwater harvest tanks and pumped to roof level for release in the form of droplets to cool down the ambient temperature and improve the micro-climate. There is a target to offset 100% of irrigation water demand from rainwater harvesting and grey water recycling. The technical requirements for installation of grey water recycling systems can be obtained from PUB's guide[1]. Water from rainwater harvesting will be used for irrigation of the landscape areas. Runoff will be directed to the ABC Waters features.

Rooftop and community organic farming is promoted. 100% of food waste will be composted and reused within the site.

[1] Technical Guide for Greywater Recycling. 1st Edition Sep 2014, PUB.
https://www.pub.gov.sg/Documents/greywaterTech.pdf

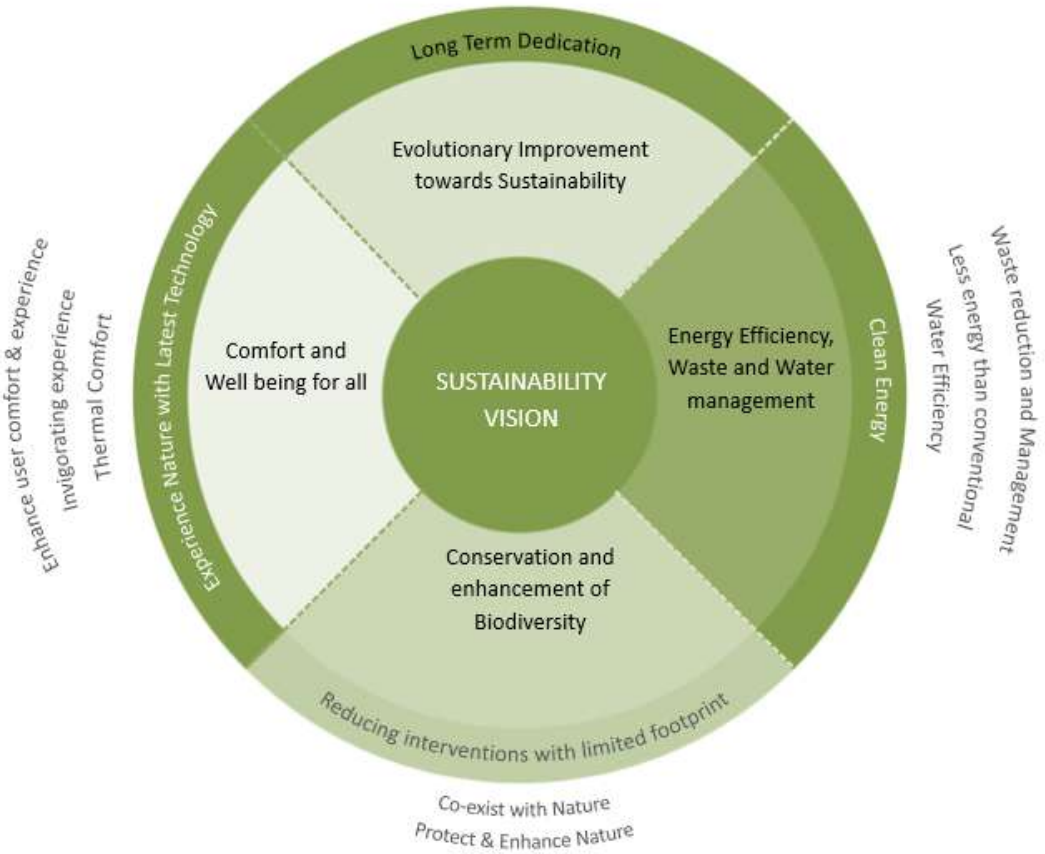


Figure 4-16 Broad sustainability strategies

4.3 Construction Sequence

The land will be sold to Developer(s) who will be responsible for the detailed design in accordance with the Design Guidelines. The Developer(s) will then engage Engineers and Contractor(s) to design and build the Springleaf Precinct. The Contractor(s) will need to ensure a comprehensive Environmental Management and Monitoring Plan (EMMP) is implemented during the construction works.

The construction of Parcels 1 and 2 will be phased separately. It is not yet confirmed if the parcels will be tendered out in combination or separately. However, Parcel 1 should develop first followed by Parcel 2, and with Parcel 1a developing prior to Parcel 1b to facilitate amenities provisions and logistics. Nevertheless, construction work is likely to be span several years once underway.

Construction will need to take place in an ecologically sensitive manner. As the existing terrain is vegetated and undulating, the Project will include some site clearance and earthworks to achieve the platform levels required, construction of sewers, drains and roads, as well as building works such as foundation, utilities / services laying, superstructure construction and reinstatement works etc.

The construction activities are likely to include the following:

1. Setting up site office
2. Setting up temporary holding areas
3. Site investigation works (including tree inventory surveys)

4. Setting out works
5. Salvaging of saplings of native tree species
6. Selective vegetation clearance work
7. Installation of site hoarding
8. Additional tree felling and excavation works to platform levels
9. Construction of temporary access roads
10. Excavation and installation of diaphragm walls
11. Formwork, earth retaining and stabilising structures
12. Bored piling works for heavy load bearing zones along with group piles
13. Completion of deep foundations
14. Construction of permanent roads and elevated driveways
15. Laying of water, sewers and drainage
16. Construction of pile cap, RC base slab and beam, permeant RC wall
17. Reinforcing, in-situ concreting and waterproofing works
18. Construction of houses, cottages and towers
19. Installation of elevated boardwalks
20. Architectural finishes
21. Mechanical and electrical works
22. Landscaping and ABC Waters features
23. Furnishings
24. Commissioning

Construction work will be sequenced to ensure that the impacts to the Core Conservation Area are minimised. This will be achieved by working from the northern and southern extremities of the site, where the biodiversity and conservation value of habitats were found to be lower. Reference can be taken from how the MRT station construction was done. All temporary offices and storage areas will be placed on pre-disturbed ground.

The types of equipment likely to be used on site may include excavators, dump trucks, generators, concrete trucks, compactors, rollers, cranes, semi-trailers, pilling rig, welding machines, launching girders and pavers.

4.4 Operations and Maintenance

The Management Corporation Strata Title (MCST) will be responsible for the operations and maintenance of the strata title development within the private lands. The MCST will be responsible to ensure that suitable Standard Operating Procedures (SOPs) are in place in accordance with the Building Maintenance and Strata Management Act.

Outside the private lands, responsibility for maintenance of the Core Conservation Area, Buffer Zone and other public lands will remain with the Government Authorities such as NParks, PUB and LTA. In case enhancement works within the public lands are necessary during operations and maintenance stage there will need to be a commitment to implement these works to ensure the overall vision of the Springleaf Precinct Master Plan can be achieved to offset other environmental impacts.

5 Impact Assessment Methodology

The impact assessment methodology is presented below.

5.1 Assessment Process

The general impact assessment process is illustrated in Figure 5-1 and is composed of the following key stages:

1. Scope – this is the stage during which the parameters for the assessment are agreed including the environmental pressures and receptors to be assessed, the spatial and temporal scales of the assessment, the assessment criteria and objectives and the assessment methodology. The identified environmental pressures and the corresponding sensitive receptors are presented in a matrix format in Table 5-1.

2. Measure – during this stage of the assessment, the receptors identified in the Scoping stage are fully described either through field surveys or desktop literature searches forming the baseline for the assessment. In addition, the change in environmental parameters as a result of the project (otherwise known as pressures) are described. This is dependent on a full project description and may rely on modelling exercises to describe for example changes in water quality. It is important to note that at this stage, the assessment merely describes the change in magnitude of environmental parameters as a result of the project.

3. Assess – this is the stage during which the *Impact Significance* is assessed of the environmental changes or pressures and their influence on sensitive environmental receptors. This is dependent on illustrating an impact pathway between an environmental pressure and receptor. A change in environmental parameters does not necessarily mean that there is an impact if there is no sensitive receptor being affected by the change. It is at this stage in the assessment, in the receptor chapters, that the significance of the impact is discussed. Aspects such as the importance of the receptor and the recoverability from the impact are also discussed. Impact significance will be assessed for both the construction and post-construction (operation) stages of the development.

4. Manage – this is the stage that outlines what management measures are required to mitigate the impacts to an acceptable level and what monitoring is required to ensure that impacts are managed accordingly. Impact significance will be re-evaluated on the basis that mitigation measures are implemented, to derive the Residual Impact significance.

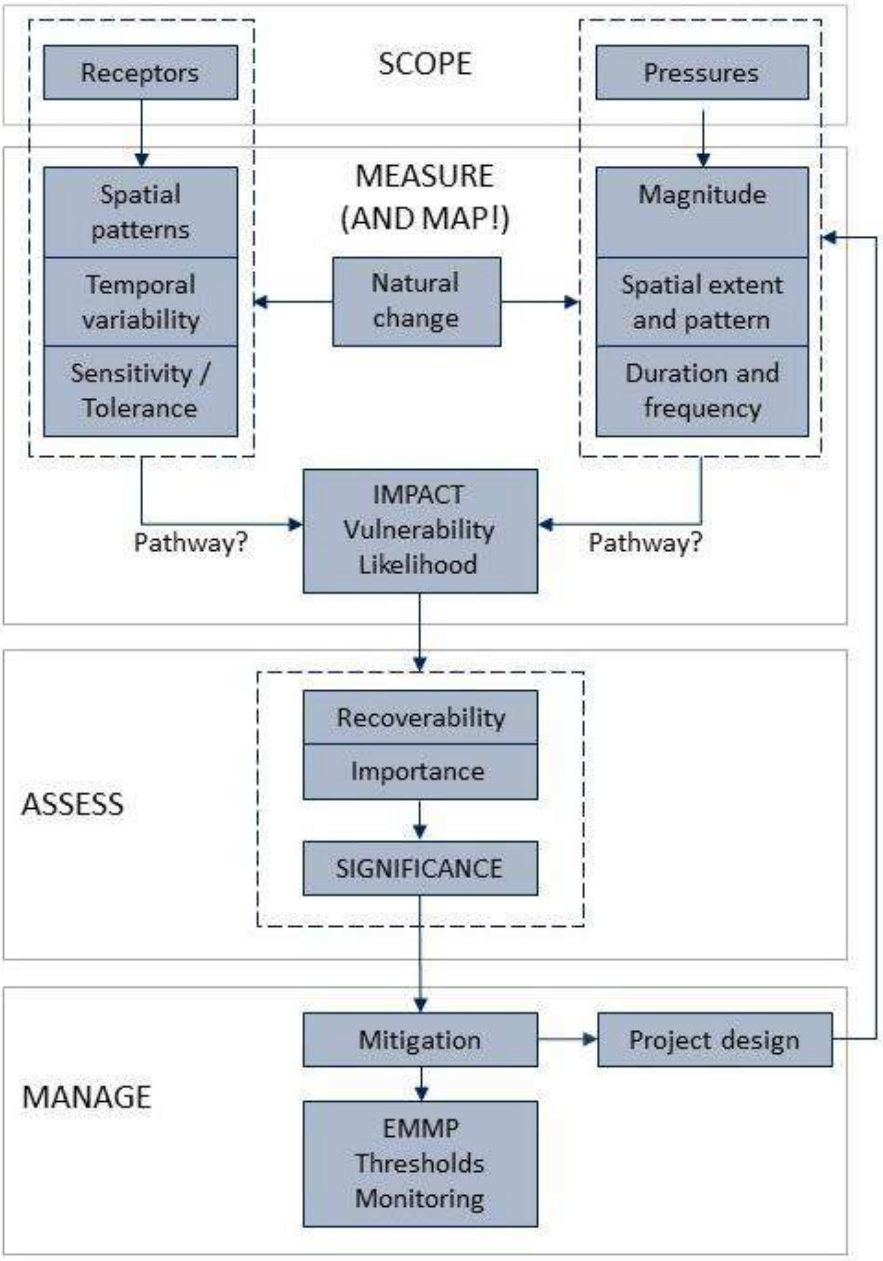


Figure 5-1 Diagram of the assessment process illustrating key stages

5.2 Environmental Scoping Matrix

The environmental scoping matrix is presented in Table 5-1, showing possible short (S) and long term (L) impacts. Short term impacts are largely confined to the construction stage of the development, while long term impacts extend into the post-construction (operational) stage of the development. (SL) refers to impacts that affect both the construction and post-construction stages, and hence are of both short and long term in nature.

Table 5-1 Environmental scoping matrix showing the identified sensitive receptors and the corresponding predicted environmental impacts. Some of the predicted environmental impacts are positive in nature following adoption of mitigation measures.

Sensitive Receptors	Biodiversity & Ecology					Hydrology				Noise & Vibration		Air & Light		Human Comfort		
	Loss of flora and fauna[2]	Loss of ecosystem function	Loss of ecological connectivity	Forest edge effects	Introduction of invasive species	Change in surface drainage	Change in ground-water levels	Change in water quality	Change in soil quality	Noise pollution	Ground vibration	Air pollution	Light pollution	Human-wildlife conflict	Change in micro-climate	Visual aesthetics
Young secondary forest	**S**	**L**	**L**	**L**	**L**											
Scrubland / grassland	**S**	**L**	**L**													
Freshwater swamp forest	**S**	**L**	**L**	**L**	**L**	**SL**	**SL**	**SL**	**SL**							
Urban vegetation	**S**															
Naturalised stream				**L**	**L**	**SL**	**SL**	**SL**								
Birds	**S**	**L**	**L**	**L**						**SL**	**SL**	**SL**	**SL**	**L**		
Reptiles and amphibians	**S**	**L**	**L**	**L**						**SL**	**SL**	**SL**	**SL**	**L**		
Mammals and bats	**S**	**L**	**L**	**L**						**SL**	**SL**	**SL**	**SL**	**L**		

[2] This pressure and related impacts are long-term effects although vegetation clearance takes place during construction phase of the development.

Sensitive Receptors	Biodiversity & Ecology					Hydrology				Noise & Vibration		Air & Light		Human Comfort		
	Loss of flora and fauna[2]	Loss of ecosystem function	Loss of ecological connectivity	Forest edge effects	Introduction of invasive species	Change in surface drainage	Change in ground-water levels	Change in water quality	Change in soil quality	Noise pollution	Ground vibration	Air pollution	Light pollution	Human-wildlife conflict	Change in micro-climate	Visual aesthetics
Odonates		**L**	**L**	**L**		**SL**		**SL**								
Freshwater organisms		**L**	**L**	**L**		**SL**		**SL**								
Central Catchment Nature Reserve			**L**		**L**	**SL**	**SL**									
Springleaf Nature Park			**L**													
Lower Seletar Reservoir						**SL**	**SL**	**SL**								
Residents										**S**	**S**	**S**		**L**	**L**	**L**
Recreational users										**S**		**S**		**L**		**L**
Businesses										**S**	**S**	**S**		**L**		**L**

5.3 Modelling Tools

The modelling tools utilised in the assessment of magnitude of change are presented in Table 5-2. Where modelling tools are not applicable, analyses of impacts have been made through comparison with other case studies, review of scientific literature and expert judgement.

Table 5-2 Modelling tools utilised in the assessment of magnitude of change

Parameters	Construction	Post-construction
Surface water	-	InfoWorks ICM
Groundwater	-	MIKE SHE
Noise	Numerical calculation	-
Vibration	British Standards Calculation	-

5.4 Rapid Impact Assessment Matrix

The NParks Biodiversity Impact Assessment (BIA) Guidelines recommend the use of the Rapid Impact Assessment Matrix (RIAM) methodology for assessing and summarising the overall significance of impacts in an EIA. Hence, RIAM is the impact assessment methodology applied in this report. RIAM allows for a holistic, rapid and transparent presentation and summary of the overall project impacts, and ultimately aids in pinpointing the most significant impacts predicted, in accordance with the broad definitions presented in Table 5-3.

Table 5-3 Broad definitions for each level of predicted impact significance.

Impact Significance	Definition
No Impact	Changes are significantly below physical detection level and below the reliability of numerical models, so that no change to the quality or functionality of the receptor will occur.
Slight Impact	Changes can be resolved by numerical models, but are difficult to detect in the field as they are associated with changes that cause stress, not mortality, to ecosystems. Slight impacts may be recoverable once the stress factor has been removed.
Minor Impact	Changes can be resolved by numerical models and are likely to be detected in the field, but to a spatial scale that is unlikely to have any secondary consequences.
Moderate Impact	Changes can be resolved by numerical models and are detectable in the field. Moderate impacts are expected to be locally significant.
Major Impact	Changes are detectable in the field and are likely to be related to significant habitat loss. Major impacts are likely to have secondary influences beyond the area of assessment.

With RIAM, the significance of an impact is determined by translating an environmental score (ES) to impact significance via a predetermined list of impact levels (Table 5-7). The formula for determining the ES is as follows:

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

The formula variables are defined as:

(I) Importance – Assigns a level of importance in terms of the socio-political interests related to the receptor.

(M) Magnitude – Expresses the level of change in a physio-chemical parameter or the scale of loss/change to ecological and socio-economic receptors. Importantly, the value should reflect the magnitude of change at the particular receptor. In this way, the impact pathway is considered, i.e., whether there is a spatial and/or temporal overlap between the change and receptor.

(P) Permanence – Assigns a score based on the duration of an impact, i.e., the temporal scale of loss/change.

(R) Recoverability – The score expresses whether the receptor can recover from the impact.

(C) Cumulative Impact – A score is defined based on the cumulative potential of an impact. Cumulative is a measure of whether the impact will have cumulative effects over time or whether it is a single direct impact. For example, the loss of flora and fauna species is cumulative, given that it is also associated with other impact such as the loss of ecosystem functioning and ecological connectivity.

The RIAM approach therefore couples the potential 'impact magnitude' at the sensitive receptor(s) in question with an assessment of the Importance, Permanence, Recoverability and Cumulative Impact in the Environmental Score formula.

Potential impact 'Magnitude' (M) is based on the relationship between the analysed physio-chemical, biological, or socio-economic deviation from the baseline (i.e. present day conditions in this case) and the environmental standards, benchmarks, guidelines, or tolerance limits established in the legal framework for this EIA.

Table 5-5 presents the generic definitions for impact magnitude, while comprehensive definitions tailored for each environmental factor is elaborated in the impact prediction and evaluation section.

The Importance (I) and Cumulative Impact (C) potential are more subjectively determined or based on expert opinion, whereas Recoverability (R) and Permanence (P) of the impact are related to the duration of a certain project activity or the possibility of a receptor to recover from or to reverse the impact.

Table 5-4 Scoring for the Importance of an environmentally sensitive receptor

Importance	Score
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 conditions (within a large direct impact area)	2
Important only to the local condition (within a small direct impact area)	1

Table 5-5 Scoring for the Magnitude of Impact

Magnitude	Score
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

Table 5-6 Scoring criteria for Permanence, Recoverability and Cumulative potential of the Impact

RIAM Variable	Score	Criteria
Permanence (P)	2	Temporary or short-term change.
	3	Permanent change or long-term; value and/or function unlikely to return.
Recoverability (R)	2	Recoverable or controllable through EMMP
	3	Irrecoverable
Cumulative Impact (C)	2	Impact can be defined as non-cumulative/single (not interaction with other impacts).
	3	Present of obvious cumulative/cascading effect that will affect other projects or activities or trigger secondary impacts.

Table 5-7 Environmental scores for the impact of development

Environmental Scores (Range Bands)	Impact Indicators	Impact Significance Translated from Environmental Scores
116 to 180	D	Major positive change/impact
81 to 115	C	Moderate positive change/impact
37 to 80	B	Minor positive change/impact
7 to 36	A	Slight positive impact
-6 to +6	N	No impact/Status quote/Not applicable
-7 to -36	-A	Slight negative change/impact
-37 to -80	-B	Minor negative change/impact
-81 to -115	-C	Moderate negative change/impact
-116 to -180	-D	Major negative change/impact

5.5 Impact Assessment Reporting Flow

In this EIA, individual impact assessment sections are carefully structured to illustrate the key components involved in analysing environmental impacts, namely:

- Evaluation framework
- Sensitive receptors
- Pressures and pathways

The evaluation framework details the applicable environmental standards, guidelines, benchmarks or tolerance limits used to assess environmental compliance. It then elaborates the specific criteria used to define the varying levels of impact Magnitude.

The section on sensitive receptors outlines key characteristics of all environmentally sensitive receptors and elaborates the specific criteria used to define the varying levels of receptor Importance.

The section on pressures and pathways outlines the predicted environmental stresses and pressures and their linkages with associated environmentally sensitive receptors. Scoring for receptor Importance, impact Magnitude, Permanence, Recoverability, and Cumulative nature are then shown clearly, and the resultant Environmental Score and hence Impact Significance reported. Mitigation measures are also recommended, following which Impact Significance is re-evaluated to derive the Residual Impact Significance. Mitigation measures are expected to only affect the RIAM variable of impact Magnitude, hence only the change in impact Magnitude will be shown for the evaluation of Residual Impact Significance.

5.6 Mitigation Measures

Mitigation is normally required at least for those impacts scored as Moderate or Major. The migration should be designed to reduce the impact down to an acceptable level. Slight or Minor impacts may also require some type of mitigation, but it may also be enough to managed by having appropriate environmental procedures in place.

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

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

The mitigation hierarchy concept is presented in Figure 5-2 and Figure 5-3. In developing mitigation measures, the first focus is on measures that will avoid or minimise impacts through the design and management of the Project followed by those that restore or offset. Where impacts cannot be avoided, environmental mitigation measures will also be incorporated into the final detailed construction design and specified for appropriate construction methodology.

It is important to note that not all impacts are necessarily negative. In a project like this, where a lot of effort has gone into achieving a biodiversity and water sensitive urban design within the master planning, there are actions that have been recommended to create net

positive gains. Typically, this involves a combination of avoidance, minimisation, restoration and/or offsets. Avoidance, minimisation and/or restoration alone are generally not enough to achieve a net gain and some form of offset is also necessary.

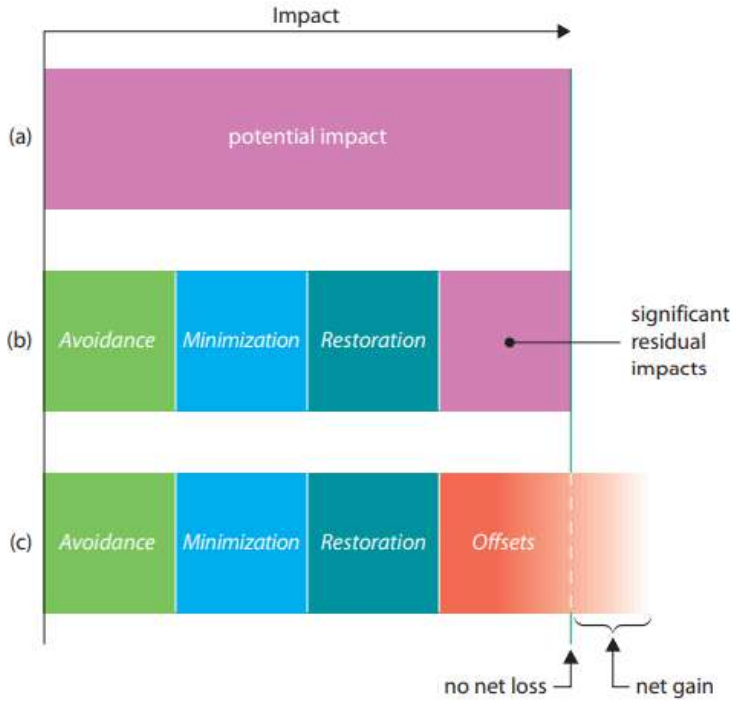


Figure 5-2 Mitigation hierarchy showing the difference between net loss and gain

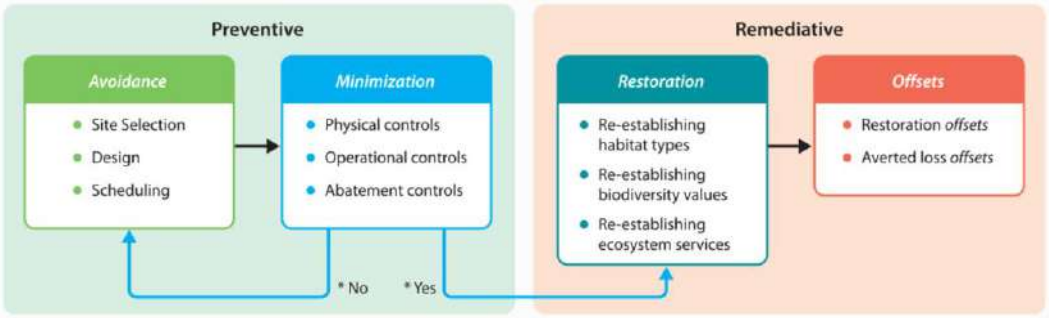


Figure 5-3 Mitigation hierarchy showing avoidance, minimisation, restoration and offsets

6 Evaluation of Impacts and Proposed Mitigation Measures

This chapter analyses and assesses the predicted environmental impacts during construction and post-construction phases of the Springleaf Precinct.

6.1 Biodiversity and Ecology

The conservation value of the biodiversity within the Springleaf site is relatively high, especially the Core Conservation Area of the freshwater swamp forest as a high portion of the flora and fauna are found only within the Springleaf site and the NSSF, and not anywhere else in Singapore. Based on consolidated data, the Baseline Study indicated that there are around 70 flora and fauna species of conservation significance within Springleaf Forest of which 38 are Endangered or Critically Endangered (NUS, 2018).

6.1.1 Evaluation Framework

The magnitude of change used for the biodiversity and ecology is presented in Table 6-1, and has been analysed using expert judgement and referenced to other scientific studies.

Table 6-1 Score for magnitude of impacts on biodiversity and ecology receptors

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	• Affects the entire habitat or a significant proportion of it and the long-term viability or function of the habitat is threatened • Affects entire population or a significant part of it causing a substantial decline in abundance or change in and recovery of the population (or another dependent on it) is not possible either at all or within several generations due to natural recruitment
-3	Moderate negative disadvantage or change	• Affects part of the habitat but does not threaten the long-term viability or function of the habitat • Effect causes a substantial change in abundance or reduction in distribution of a population over one or more generations but does not threaten the long-term viability or function of that population, or any population dependent on it
-2	Minor negative disadvantage or change	• Affects only a small area of habitat such that there is no loss of viability or function of the habitat • Effect does not cause a substantial change in the population of the species, or other species dependent on it
-1	Slight negative disadvantage or change	• No or very limited loss of habitat • Effect is within the normal range of natural variation accustomed to by the population of the species
0	No change	• Status quo

Score	Generic Criteria	Specific Criteria
+ 1	Slight positive advantage or change	• Limited net gain in habitat quality and/or species abundance/distribution via habitat/species remediation efforts
+2	Minor positive advantage or change	• Small to medium net gain in habitat quality and/or species abundance/distribution via habitat/species remediation efforts

6.1.2 Sensitive Receptors

The receptors prone to changes in biodiversity and ecology include the young secondary forest, scrubland / grassland, freshwater swamp forest, urban vegetation, naturalised stream, birds, reptiles and amphibians, mammals (including bats), and the adjacent Central Catchment Nature Reserve. The vegetation and habitat types present are also shown in Figure 3-2. The scores for assessing the importance of the biodiversity and ecology prone receptors are provided in Table 6-2.

Table 6-2 Score for importance of biodiversity and ecology receptors

Score	Generic Criteria	Specific Criteria
5	Important to national/international interests	• Nationally designated sites, habitats of biological and ecological importance, e.g. designated Nature Reserves and Nature Areas • Natural freshwater streams and freshwater swamps • Limited potential for substitution, harbours many species of with a highly restricted distribution range • Contains a high proportion of conservation-significant taxa/species, e.g. listed Critically Endangered in the Singapore Red Data Book
4	Important to regional/national interests	• Large forested sites with closed canopy cover, outside of designated nature reserves and nature areas • Key habitats for several conservation-significant taxa/species, e.g. listed Critically Endangered in the Singapore Red Data Book. • Important for the functioning and integrity of adjacent habitats.
3	Important to areas immediately outside the local condition	• Considered to be endangered or vulnerable in the Singapore Red Data Book. • Medium importance and rarity on a national level. • Limited potential for substitution. • Important for the functioning and integrity of adjacent habitats.

Score	Generic Criteria	Specific Criteria
2	Important to the local conditions (within a large direct impact area)	• Considered least concern in the Singapore Red Data Book. • Habitats with some local biodiversity and potential for substitution. • Modified habitats with limited biodiversity and ecological value.
1	Important only to the local condition (within a small direct impact area)	• Species of no national importance. • Limited ecological importance. • Highly modified or fragmented habitats of little to no biodiversity value.

6.1.3 Pressures and Pathways

The identified environmental impacts on various sensitive receptors, and the predicted impact pathways, are elaborated in the subsequent sections. Mitigation measures to reduce the impact magnitude are also recommended.

6.1.3.1 Loss of Flora and Fauna

Young Secondary Forest

Site clearance required for the development work of the Tree Cottages and Forest Towers would require the clearing of secondary forests from part of the Northern High Ground (NHG) and Southern High Ground (SHG) of the project area. Some of the impacts on those secondary forests would be permanent and would result in the reduction of vegetation cover and habitat for flora and fauna. Without mitigation this would result in a major negative change.

To mitigate loss of flora and fauna in the Springleaf forest, Significant Conservation Areas (Figure 1.1) are planned to be established following the results and recommendations from the Baseline Study. Significant Conservation Areas allow for no major intrusive development. One of the Significant Conservation Areas is established in the southwestern part of the NHG of the Springleaf forest encompassing the freshwater pond consisting of young secondary forests, referred to as a Significant Conservation Area.

Faunistically, the NHG is of particular importance because significant numbers of critically endangered species of plants, mammals, avians and reptiles are found there, particularly the presence of Malayan Colugo (*Galeopterus variegatus*), Sunda Pangolin (*Manis javanica*), Common Palm Civet (*Paradoxurus musangus*) and Sambar Deer (*Rusa unicolor*). The reason for the higher biodiversity could be that the pond serves as a permanent watering source for the fauna in that location and that the surrounding forest has several tall trees that are suitable for arboreal fauna such as Malayan Colugo (*Galeopterus variegatus*) and raptors like Changeable Hawk Eagle (*Spizaetus cirrhatus*).

Floristically, the NHG has the second highest numbers of threatened and Critically Endangered plant species that is found in Springleaf forest. The *Aglaia yzermannii*, which is a recent new record for Singapore (Chong et al., 2018), is not known to be found anywhere else in Singapore except in NSSF but was found in the NHG.

On top of establishing the Significant Conservation Areas, a buffer zone of 30 m width will further be zoned around the Significant Conservation Area in the NHG. Likewise, the buffer zone is a “no development” area.

For this development, the north and north eastern part of the NHG that are outside of the Significant Conservation Area and buffer zone, and secondary forest in SHG would be affected. However, careful planning and design should be done to retain as many flora on site, especially flora that are of conservation significance and mature trees of stature and conservation value (Figure 6-1). Should removal of such flora be unavoidable, transplanting or sapling harvesting should be done to mitigate such loss. A tree and sapling nursery within the development site tended by horticultural professionals is recommended to grow and care for the trees and saplings to allow them to acclimatise and reduce injury due to handling and the need to transport the planting bags to another external nursery. These salvaged trees and saplings could eventually be transplanted into suitable locations in the Springleaf forest (refer to Landscape and Ecology Plan in **Appendix B** for more details).

Before the clearing of any secondary forest, trees should be verified and tagged by a Certified Arborist to determine which are for removal, transplanting, suitable for sapling harvesting or to be retained on site. Tree Protection Zones (TPZs) should be installed around trees or tree clusters that are to be retained on site. Wildlife shepherding should be conducted in tandem with the installation of perimeter hoarding and tree-felling. Before any tree or shrub is to be fell or removed, a pre-felling fauna survey should be conducted to detect any fauna that is hidden or trapped in tree cavities or presence of any fauna nests or hives (refer to Landscape and Ecology Plan in **Appendix B** for more details). Should fauna be found on a tree during a pre-felling fauna inspection, tree felling work should stop around that tree and the fauna would be to be allowed to leave by itself. If the fauna is found to be injured or trapped, professionally approved wildlife handlers should be engaged to help remove the fauna. If an active nest is found with eggs or hatchlings, tree felling work should be stopped for that tree and surrounding trees for the duration that the hatchlings are in the nest.

Figure 6-1 Location of conservation significant tree species, and mature trees of stature and conservation value to be retained in Springleaf forest, indicated by circles. The size of the circles represents the approximate crown area (image credit: STX Landscape Architects)

Prior to mitigation, impact magnitude is scored at -4, given the spatial extent of young secondary forest loss, and the substantial reduction in flora and fauna abundance. Such habitat loss and conversion to buildings is also permanent and irrecoverable, and cumulative in nature given the secondary impacts on other ecological properties such as ecosystem services. Following mitigation, in particular tree retention and habitat enhancement, impact magnitude could be reduced to -3, with a residual impact significance of Moderate Negative. Impact magnitude can be reduced further with a proposed reduction in the number of Tree Cottages planned for the SHG, hence reducing the area of young secondary forest cleared.

Scrubland / Grassland

Grassland in the Springleaf forest are mainly found at the Northern Low Ground (NLG) and banks of the stream in the Southern Low Ground (SLG). Both areas are protected from

development within the Significant Conservation Areas and buffer zones. Therefore, no extensive clearing of grassland would be done for this project, hence even without mitigation, the result would be only slight.

Out of the four regions in Springleaf forest, the NLG has the lowest biodiversity of native and threatened species as it consists mainly of open grassland. However, due to such openness, the NLG together with the NHG provide the ideal refugia and basking sites for reptiles to thrive in. In the grassland of both NLG and SLG, there are similar assemblages of dragonfly and butterfly communities.

To further enhance biodiversity, patches of reforestation at the grassland of NLG would be proposed using both traditional reforestation method and the Miyawaki Method (refer to Landscape and Ecology Plan in **Appendix B** for more details). This assisted succession will help to enhance the grassland habitat. This would also help enhance the secondary forest edge in the NHG.

Prior to mitigation, impact magnitude is scored at -2, given the limited spatial extent of grassland and scrubland habitat loss. Any potential loss of grassland patches is expected to be temporary and recoverable, and of a non-cumulative nature. Following mitigation, in particular habitat enhancement via assisted succession and afforestation, impact magnitude is reduced to -1, with a residual impact significance of Slight Negative.

Freshwater Swamp Forest

The freshwater swamp forest found in the SLG of Springleaf forest will be protected from development within the Core Conservation Area and the buffer zone. Should the hydrology of the Freshwater Swamp Forest remain unchanged during and after the construction phase, even without mitigation, the loss of flora and fauna should be only slight. Although the freshwater swamp forest habitat is designated a no-go zone, fauna species with activity and foraging ranges that extend beyond the swamp forest habitat may be negatively affected.

The SLG together with the stream corridor are recognized as the most important areas for biodiversity conservation planning, inhabited by the majority of species with conservation significance for plants, mammals, amphibian, and aquatic fauna in the Springleaf forest.

Prior to mitigation, impact magnitude is scored at -2, given the limited predicted impact on fauna populations utilising the freshwater swamp habitat. While the predicted impact is permanent in nature, given the conversion of adjacent habitats to housing developments, it is expected to be recoverable over time, in tandem with the surrounding habitat enhancement works and ecological connectivity enhancement. It is expected to be non-cumulative in nature too. As such, impact magnitude could be reduced to -1 for the scoring of residual impact significance, yielding “Slight Negative”.

Urban Vegetation

Streetscape trees around the Springleaf Precinct would be retained. These trees are most commonly the Rain Tree (*Samanea saman*) and Angsana (*Pterocarpus indicus*). These mature and tall trees along Upper Thomson Road and Mandai Road help to be a refuge and rest point for several arboreal fauna and birds. They provide continuous aerial connectivity to birds, both sentinel and migratory often at the edge of the Springleaf Precinct where disturbances is the highest.

Vegetation planting within the development would inevitably comprise of both native and non-native flora species for the purpose of landscaping and design. However, careful planning has been made in the selection of non-native flora that are non-invasive and are

suitable for growth in an urban built-up condition. These chosen non-native flora may even complement native flora species in providing food and shelter for the fauna at site.

Prior to mitigation, impact magnitude is scored at -2, given the expected loss of some streetscape trees during construction. This loss is expected to be permanent but recoverable, and of a non-cumulative nature. Following mitigation, where felled streetscape trees will be replaced and potentially planted using a multi-tiered approach, impact magnitude is reduced to 0, with a residual impact significance of No Impact.

Birds

The whole Springleaf forest has high avifauna diversity, with the Northern Sector having more avifauna diversity than the Southern Sector. Part of the secondary forest in the southwestern portion of NHG, the NLG and the SLG are protected within the Significant Conservation Areas and a further 30 m buffer zone around them. This will help preserve avian diversity at the secondary forest and riparian vegetation area. However, birds residing at such areas may still be affected by construction but would not be lost.

Avifauna residing at the secondary forest at the NHG and SHG would be displaced once site clearing starts. Smaller birds like the Common Tailorbird (*Orthotomus sutorius*) and Olive-backed Sunbird (*Nectarinia jugularis*) with a smaller ranges would likely find refuge in the adjacent habitats but larger birds like Brahminy Kite (*Haliastur indus*) and Buffy Fish Owl (*Ketupa ketupu*) could be displaced.

Although trees within the secondary forest parts of NHG and SHG would need to be removed due to development in those parcels, trees with conservation significance would be planned to be retained as part of the landscape and design (Figure 6-1). The retained trees would continue to provide food and shelter for avifauna after development and together with the new landscaping at site. Therefore, some avifauna that is displaced during the construction period may return.

Prior to mitigation, impact magnitude is scored at -3, given the substantial displacement of avifauna from the cleared young secondary forests. Such displacement is also permanent and irrecoverable given the habitat conversion to buildings, and cumulative in nature. Following mitigation, in particular tree retention and afforestation works, impact magnitude is reduced to -2, with a residual impact significance of Minor Negative.

Reptiles and Amphibians

From the Baseline Survey, the Northern Sector, particularly the secondary forest in NHG is of conservation importance to reptiles. With the NLG being mostly grassland, the openness attracts reptiles to bask in the sun and the abundance of insects among the grassland provides a good source of food. The NLG together with the NHG provide the ideal refugia and basking sites for the reptiles to thrive in. The Southern Sector, especially the SLG area is of conservation importance to amphibians.

Part of the secondary forest in the southwestern portion of NHG, the NLG and the SLG are protected within the Significant Conservation Areas and the further 30 m buffer zone around them. This will help preserve reptiles and amphibians diversity at the secondary forest and riparian vegetation and freshwater swamp forest area.

Prior to mitigation, impact magnitude is scored at -3, given the substantial displacement of reptiles from the cleared young secondary forests in NHG. Such displacement is also permanent and irrecoverable given the habitat conversion to buildings, and cumulative in nature. Following mitigation, in particular the designation of Significant Conservation Areas and buffer zones, impact magnitude is reduced to -2, with a residual impact significance of Minor Negative.

Mammals

From the Baseline Study, there are two significant conservation areas for mammals within the Springleaf forest. The one with lower priority is in the Northern Sector covering the southwestern part of the NHG area around the pond. The area around the pond recorded a diversity of mammal species such as Sunda Pangolin (*Manis javanica*), Common Palm Civet (*Paradoxurus musangus*) and Sambar Deer (*Rusa unicolor*). The pond holds water throughout the year and possibly serves as a watering source. The tall trees surrounding the pond also serves as an important Colugo (*Galeopterus variegatus*) habitat. This northern area is within the Biodiversity Sensitive Area and the buffer zone, hence protected from development. The impact would be slight as the clearing of secondary forest in the NHG would displace some mammals into the Biodiversity Sensitive Area and the buffer zone causing a competition for food and shelter.

The other crucial conservation area for mammal is the freshwater swamp area at the south of the stream. From the Baseline Study many mammal species inhabit the swamp. The freshwater swamp is an important habitat and is critical for the survival of many species, even though no mammal in Singapore is a swamp-obligate. A critically endangered bat species, the Lesser Bamboo Bat (*Tylonycteris pachypus*), was found in the freshwater swamp forest and along the naturalised stream. Given that *Tylonycteris pachypus* is a bamboo-obligate species, a mitigation measure would be to identify the location of all bamboo stands in the development area and safeguard them from removal.

The freshwater swamp area is within the Core Conservation Area and the buffer zone, hence protected from development. However, the impact would be slight negative as the clearing of secondary forest in the SHG would displace some mammals into the swamp forest causing a competition for food and shelter.

Prior to mitigation, impact magnitude is scored at -3, given the substantial displacement of mammals from the cleared young secondary forests into the Core Conservation Areas, causing competition for resources. Such displacement is also permanent and irrecoverable given the habitat conversion to buildings, and cumulative in nature. Following mitigation, in particular the designation of Core Conservation Areas and buffer zones, impact magnitude is reduced to -2, with a residual impact significance of Minor Negative.

6.1.3.2 Loss of Ecosystem Services and Functions

Ecosystem function is a broad term that includes ecosystem services, which are biogeochemical processes driven, regulated, and maintained collectively by species communities within ecosystems (Hooper et al., 2005).

Ecosystem services can be categorised into four broad categories (Table 6-3), following guidelines for Ecological Impact Assessments published by the Chartered Institute of Ecology and Environmental Management in UK (CIEEM, 2018). In the context of Springleaf precinct and Singapore, provisioning ecosystem services are not applicable as resources are not directly extracted from the ecosystems. Regulating ecosystem services would be most relevant, particularly in the regulation of microclimate and water quality. However, the impact on water quality has been assessed in the Hydrology Section instead.

Table 6-3 Categories and examples of ecosystem services and functions (CIEEM, 2018).

Ecosystem services	Description	Examples
Supporting services	Services necessary for the production of all other ecosystem services	• Primary production/photosynthesis – carbon sequestration • Nutrient and carbon cycling • Soil formation • Pollination • Seed dispersal
Provisioning services	Products obtained from ecosystems	• Food • Fuel • Medicinal resources
Regulating services	Benefits obtained from the regulation of ecosystem processes	• Climate regulation • Water purification • Air quality regulation • Regulation of pests and diseases • Regulation of surface runoff and soil erosion
Cultural services	Non-material benefits people obtain from ecosystems	• Recreation • Tourism • Aesthetics • Science and education

Young Secondary Forest

The forest at the NHG and SHG was likely regenerated from around the mid-1980s when the villages in the area were resettled. Hence, the forest has had well over 30 years of native plant re-colonisation and succession with many of the flora likely seeded from the CCNR. This duration is sufficient to re-establish healthy ecosystem services and functions and means that disturbance to the forest could setback the ecosystem by an equivalent duration.

Site clearance required for the development work would require the clearing of young secondary forests from the NHG and SHG of the project area. We can expect the conversion of forest cover to buildings and urbanised surfaces to raise the ambient temperatures, given the reduction in evapotranspiration and the associated cooling capacity. The elevated ambient temperatures will be most pronounced during night hours, when trapped heat is slowly released from urban structures, leading to an urban heat island effect.

Clearance of the young secondary forest will also result in a marked loss of carbon sequestration capacity in above ground biomass and soil. Carbon stocks locked in the biomass and soil will be emitted, raising atmospheric carbon dioxide levels.

Excavation and clearance works will modify the vertical profile of the soil layers and cause soil compaction, impacting the soil faunal communities and ecosystem process and consequently the ecosystem service of nutrient cycling.

Cultural ecosystem service, in the form of visual aesthetics, will also be lost with the clearance of the young secondary forests, particularly for residents living next to the development parcels.

Recommended mitigation measures are similar to those proposed in Section 6.1.3.1. Prior to mitigation, impact magnitude is scored at -4, given the spatial extent of young secondary forest loss. Such habitat loss and conversion to buildings is also permanent and irrecoverable, and cumulative in nature given the regulating nature of ecosystem services on other ecological properties. Following mitigation to minimise loss in ecosystem services and function, in particular tree retention and habitat enhancement, impact magnitude is reduced to -3, with a residual impact significance of Moderate Negative.

Scrubland / Grassland

Grasslands in the Springleaf forest are mainly found at the NLG and banks of the stream in the SLG. Both areas are protected from development within the Core Conservation Areas and buffer zones. Therefore, no extensive clearing of grassland would be done for this project.

Reforestation would be conducted at selected areas of grasslands. This would increase the provisioning of ecosystem services, particularly for carbon sequestration and storage, and for climate regulation. Above-ground biomass will be increased with reforestation efforts, and hence the size of above ground carbon stock as well. Trees provide canopy cover that shade the ground and enhances evapotranspiration capacity, thereby helping to cool the riparian zone along the stream.

Prior to mitigation, impact magnitude is scored at -2, given the limited spatial extent of grassland and scrubland habitat loss. Any potential loss of ecosystem services provided by grasslands is expected to be temporary and recoverable, and of a non-cumulative nature. Following mitigation, in particular assisted succession and afforestation, ecosystem services will increase and impact magnitude becomes positive at +1, with a residual impact significance of Slight Positive.

Freshwater Swamp Forest

The freshwater swamp area was never cultivated and only "disconnected" from the NSSF when the SLE was completed in 1992, hence still remains largely intact. The freshwater swamp forest habitat in Springleaf is vital for regulating water quality and maintaining the surface and groundwater hydrology of the area. The freshwater swamp forest also plays a vital role in carbon sequestration, particularly below ground. In the adjacent NSSF, the topsoil was reported to contain up to 40-50% in organic matter (Nguyen et al., 2018). Being a rare habitat type in Singapore and harbouring rich biodiversity, the freshwater swamp habitat in Springleaf is also important in providing cultural ecosystem services in the form of science and education opportunities.

Given that the freshwater swamp forest in Springleaf and its buffer zone will be designated as a Core Conservation Area and protected from development, the impact on its ecosystem functioning and capacity to provision ecosystem services will be minimal.

Prior to mitigation, impact magnitude is scored at -2, given the limited predicted impact on ecosystem services resulting from clearance of surrounding habitats. While the predicted impact is permanent in nature, given the conversion of adjacent habitats to housing developments, it is expected to be recoverable over time, in tandem with the surrounding habitat enhancement works and ecological connectivity enhancement. It is expected to be cumulative in nature too. Given that mitigation works will be conducted around the freshwater swamp forest habitat, impact magnitude could be reduced to -1 for the scoring of residual impact significance, yielding “Slight Negative”.

Urban Vegetation

Streetscape trees around the Springleaf Precinct, particularly mature and tall individuals of Rain Tree (*Samanea saman*) and Angsana (*Pterocarpus indicus*) would be retained. These streetscape trees provide ecosystem services in the form of climate regulation by canopy shading, and also regulate air quality by filtering pollutants from vehicular emissions. The aesthetical qualities of streetscape trees provide a certain degree of aesthetical ecosystem service.

Prior to mitigation, impact magnitude is scored at -2, given the expected loss of some streetscape trees and hence ecosystem services during construction. This loss is expected to be permanent but recoverable, and of a non-cumulative nature. Following mitigation, where felled streetscape trees will be replaced and potentially planted using a multi-tiered approach, ecosystem services can be restored in the long-term and impact magnitude is reduced to 0, with a residual impact significance of No Impact.

Native Fauna

Birds, bats, and butterflies are fauna taxa that provide crucial supporting ecosystem services in the form of pollination and seed dispersal. The young secondary forest habitat in the northern sector of the Springleaf study area harbours abundant roosting sites for birds and forms an important conservation area for avifauna, which are important seed dispersers. Similarly, findings from the baseline fauna surveys revealed the young secondary forest in the northern sector to be a conservation significant area for butterflies, which are important pollinators. Large-scale clearance of the young secondary forest habitat for development would likely result in the extirpation of these important seed dispersers and pollinators.

Frugivorous and nectarivorous bats also serve as important pollinators and seed dispersers. While mist net and harp trap bat surveys yielded insufficient data to pinpoint significant conservation areas for bats, acoustic sampling revealed the presence of three bat species within the proposed development parcels in the northern and southern sectors. Nonetheless, these three bat species are predominantly insectivorous and hence not pollinators nor seed dispersers. The impact of forest clearance on the pollination and seed dispersal ecosystem service provided by bats in Springleaf is thus expected to be limited.

Construction scheduling should take note of the seasonal and daily timing of bird activity to minimise potential impacts, as shown in Figure 6-2.

Prior to mitigation, impact magnitude is scored at -3, given the predicted substantial displacement of birds and butterflies from the cleared young secondary forests. Such displacement is also permanent and irrecoverable given the habitat conversion to buildings, and cumulative in nature given the knock-on effects from loss of pollination and seed dispersal. Following mitigation, in particular tree retention and afforestation works, some avifauna and butterfly population will return, and impact magnitude is reduced to -2, with a residual impact significance of Minor Negative.

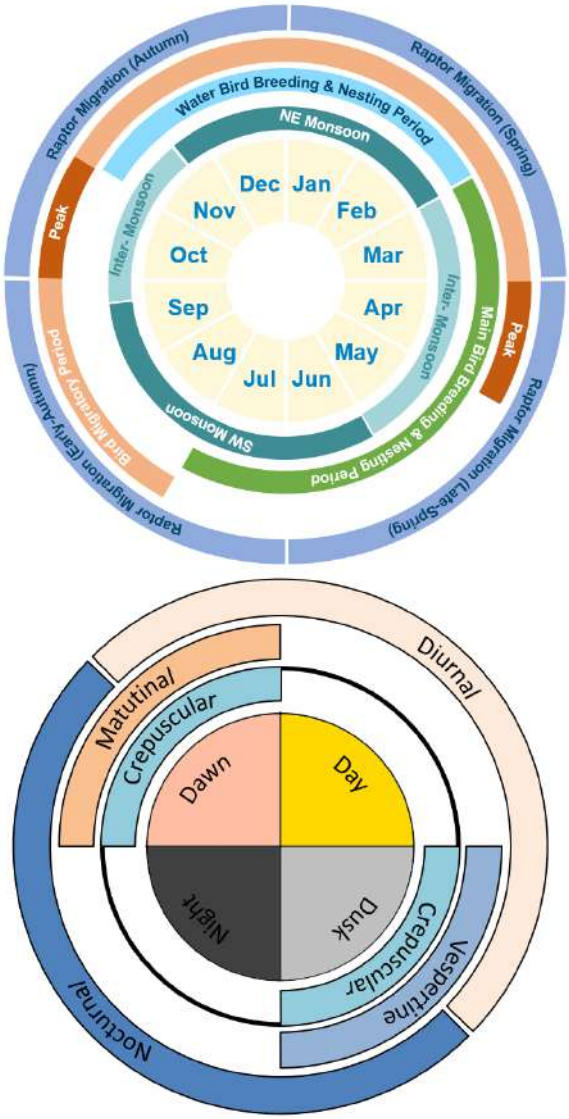


Figure 6-2 Seasonal and daily cycles of bird activity

6.1.3.3 Loss of Ecological Connectivity

Ecological connectivity is targeted to be strengthened at strategic locations identified in Figure 6-3, for terrestrial, arboreal, aquatic, and volant fauna.

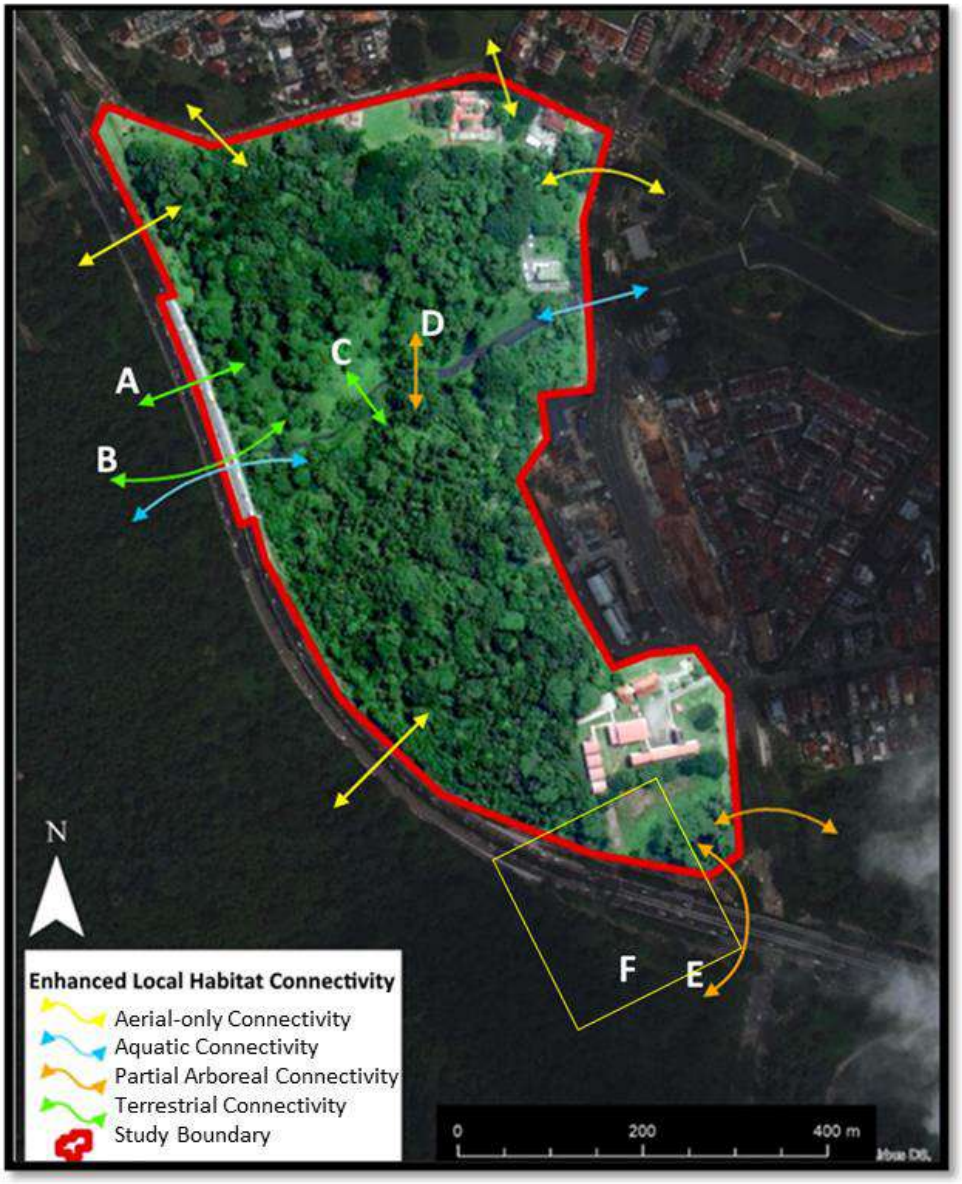


Figure 6-3 Strategic locations where ecological and habitat connectivity is targeted to be strengthened (image credit: ArborCulture Pte Ltd).

Young Secondary Forest

The two main patches of secondary forest in the Springleaf Precinct are in the NHG and SHG. These forests were formed from abandoned cultivated land after the villages in Springleaf Precinct were relocated. Historically, both secondary forests in NHG and SHG were not connected to each other due to the freshwater swamp forest and the stream in the middle separating the two. At site, the secondary forest in the NHG is connected to the grassland NLG while the secondary forest in SHG is connected to the swamp forest in SLG.

The two secondary forests were already separated from nearby forest patches by Mandai Road and Upper Thomson Road and were further cut-off from NSSF in 1992 with the construction of the SLE.

This development will see the partial yet substantial removal of secondary forest from both NHG and SHG. However, careful and selective retaining of trees, especially trees with conservation significance is proposed within the proposed Springleaf Precinct Master Plan.

Mitigation measures to improve ecological connectivity between the young secondary forest in NHG with CCNR include the removal of drainage railings along SLE and covering of the open drains to permit fauna crossing under the elevated viaduct (Figure 6-4).

Figure 6-4 Mitigation measures to permit fauna crossings under the elevated SLE viaduct and hence improve ecological connectivity (image credit: ArborCulture Pte Ltd).

Scrubland / Grassland

The two main patches of scrubland / grassland in the Springleaf Precinct are in the NLG and SLG. These grasslands were formed from abandoned cultivated land after the villages in Springleaf Precinct were relocated in the 1980s and after the straightening of the stream in the 1970s. Both grasslands in NLG and SLG were not connected to each other due to the stream in the middle separating the two.

To improve connectivity between the two grasslands, rope bridges and wood bridges are proposed to be constructed over Sungei Seletar to connect the Biodiversity Sensitive Areas and the buffer zones.

Freshwater Swamp Forest

The freshwater swamp forest in Springleaf Precinct was part of the NSSF until 1992 when the SLE was constructed. The connections between NSSF and the Freshwater Swamp Forest are the stream, groundwater and the narrow patch of ground under the SLE in the SLG.

To enhance connectivity, the planting up of the ground under SLE with shade-resistant plants for ground cover to encourage movement of fauna under SLE is proposed. Connectivity through human intervention could happen by collection and propagation of rare plant species in NSSF or those restricted to NSSF and replanting them into the Freshwater Swamp Forest. To allow greater movement of native animals between the primary and downstream swamp forest the trapezoidal drain running parallel to the SLE could be covered and the fencing removed.

Figure 6-5 Proposed plantings under SLE viaduct to encourage terrestrial fauna such as the Malayan Pangolin to cross between the downstream freshwater swamp forest and CCNR (image credit: Arborculture Pte Ltd).

Birds

Springleaf Precinct has a high bird diversity that accounts for about one third of the total number of bird species in Singapore. The Springleaf Precinct is also an important part of the avian corridor that connects the north eastern Khatib Bongsu Nature Park to Lower Seletar Reservoir to Springleaf Nature Park to Springleaf Precinct and eventually to the Central Catchment Nature Reserve.

This is especially relevant or pertinent for the dispersal or movement of the globally critically endangered Straw-headed Bulbul (*Pycnonotus zeylanicus*), which is regularly recorded at Khatib Bongsu along the eastern coast, Springleaf Nature Park and the Springleaf Precinct.

For this development, the secondary forest at NHG and SHG will be cleared for development, while the Significant Conservation Areas and the buffer zone remain intact. This would cause a minor negative impact to bird connectivity in Springleaf Precinct. However, with mitigation such as retaining selective trees with conservation significance in the development, planting of native trees that are bird-attracting or bird benefiting trees and leaving the Significant Conservation Areas intact, the connectivity for birds will be less impacted.

Reptiles and Amphibians

There are more species of reptiles in the north and more amphibian species in the south of the stream in Springleaf Precinct. This is likely because the grassland at NLG and secondary woodland at NHG provide ideal refugia and basking sites for the reptiles to thrive in. The presence of the swamp forest in the SLG is attributed to a higher amphibian community.

The removal of the secondary forest in the NHG and SHG should not affect reptiles and amphibians to a large extend since the NLG and SLG will still remain intact. However, if the water level in the swamp forest were to be affected by the construction or if contaminated discharge were to flow into the swamp forest, it would contribute to a minor negative impact for the amphibians.

Connectivity between the NLG and SLG could be improved by a wood bridge constructed over Sungei Seletar to connect the Biodiversity Sensitive Areas and buffer zones.

Mammals and Bats

For the Springleaf Precinct, being surrounded by busy roads makes it difficult for terrestrial based fauna to cross to any adjacent vegetated area. The only “safe” connection with NSSF and CCNR is through the stretch of land under the SLE. To improve connectivity for mammals, that section under SLE could be planted with shade-resistant plants for ground cover to encourage movement of fauna. Cargo net rope fauna crossings can also be installed across the at-grade roads (Figure 6-6).

To improve connectivity for mammals and other terrestrial fauna between the NLG and SLG it is recommended to have a wood bridge crossing either in the form of a tree trunk that is felled across the stream or lashing of several smaller tree trunks together to form a raft-like bridge across it. To improve connectivity between NLG and NHG to CCNR, the open drain along SLE, about 125 m in length, could be covered and the barricade for the drain be removed (Figure 6-4). This would allow mammals and other fauna to move freely between the north of Springleaf Forest and CCNR.

Figure 6-6 Cargo net rope crossings can be installed to facilitate crossings of arboreal fauna between Springleaf and CCNR (image credit: Arborculture Pte Ltd).

Odonates and Freshwater Organisms

Given that the wetland habitats in Springleaf, namely the naturalised stream and freshwater swamp forest, that odonates and freshwater organisms are dependent on will be kept intact, the loss of ecological connectivity to these taxa is predicted to be Slight Negative. The development could potentially impact some of the tributaries that lead from the NHG and SHG towards the wetland habitats and disrupt ecological connectivity, albeit to a small degree.

Following mitigation measures, in the form of the proposed ABC Waters features such as bioretention swales, rain gardens, and vegetated swales, the residual impact significance is predicted to be Slight Positive (Table 6-6). These ABC Waters features and the riparian plantings will increase the availability of wetland habitats and microhabitats for odonates and freshwater organisms, and allow them to move more freely across the landscape. Riparian enhancement plantings along the banks of the naturalised stream (Figure 4-10) will also strengthen ecological connectivity of odonates and freshwater organisms between Springleaf and NSSF.

Central Catchment Nature Reserve

The Springleaf Precinct was largely cut-off terrestrially from the Central Catchment Nature Reserve (CCNR) after the completion of Seletar Expressway (SLE) in 1992. The north eastern and southern tips of Springleaf Precinct are connected indirectly to CCNR terrestrially due to vehicular roads which makes terrestrial movement for wildlife dangerous. The only part that still has uninterrupted terrestrial connectivity between Springleaf Precinct and CCNR is the short stretch next to Sungei Seletar under the flyover section of SLE. A long open drain with railings on both sides runs along SLE (Figure 6-7) and Springleaf Precinct at the NLG and NHG West border, this caused an uncrossable barrier to mid and large mammals. Following the recommendation of the enhancement planting works of the area under SLE, and the removal of railings and covering of the open drain, movement of wildlife will be greatly improved between Springleaf Precinct and CCNR.

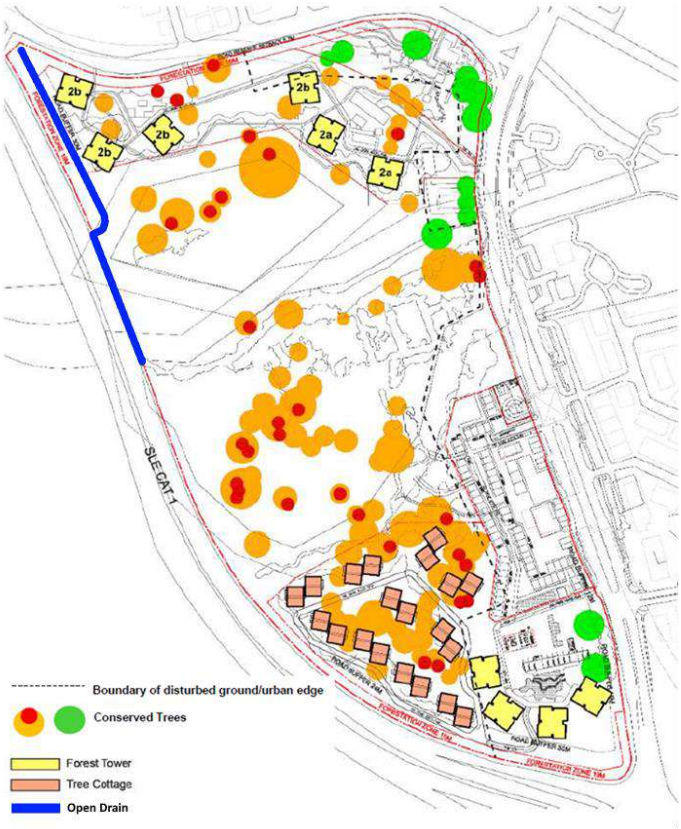


Figure 6-7 Open drain with railings on both sides runs along SLE (image credit: DHI).

Springleaf Nature Park

Springleaf Nature Park is ecologically connected to the Springleaf Precinct in two ways. Firstly aquatically through Sungei Seletar, and secondly aerially by birds and bats. Terrestrial ecological connectivity is difficult between these two areas due to the busy six-laned Upper Thomson Road. Arboreally, these two areas are not connected for several matured Rain Trees (*Samanea saman*) were removed from both road sides and middle divider of Upper Thomson Road due to road diversion works required by the construction of Springleaf MRT. Should the proposed ecological connection enhancements and reforestation programme to the Springleaf Precinct be carried out, the precinct's capacity to carry wildlife would increase. This would in turn aid in the movement of birds and bats between Springleaf Nature Park and Springleaf Precinct in search of food and shelter.

Aquatic ecological connectivity, however, may remain as it is as the Sungei Seletar stretch in the Springleaf Precinct is to be left intact.

6.1.3.4 Forest Edge Effects

Land clearance activities results in habitat fragmentation and exposes the core areas of forest habitats to newly created edge habitats and the associated edge effects. The reduced area of the conserved forest fragments will also increase the influence of edge effects, given the increase in habitat edge to area ratio. The introduction of edge effects will impact flora, fauna, and habitat properties.

Young Secondary Forest

Clearance of the young secondary forest will introduce edge effects that perturbs habitat microclimate, resulting in elevated temperatures, reduced humidity, increased wind speeds, and increased light availability. Increased wind speeds at the newly exposed forest edge will likely increase the susceptibility of trees to wind-induced damage and treefalls, and consequently elevated tree mortality. Studies on forest fragmentation have reported increased tree mortalities up to 300 m deep from a forest edge, and reduced humidity up to 100 m deep (Laurance et al., 2018).

Edge effects can also potentially facilitate the introduction of invasive flora species, due to the increase in light availability which typically favours the establishment of fast-growing exotic species compared to shade-tolerant and slow-growing native species. The elevated tree mortalities also indirectly increase light availability by creating tree fall gaps, allowing the establishment of dormant seeds of invasive species that may be present in the soil seed bank. An example of an invasive flora species is *Cecropia pachystachya*, which is observed to be proliferating in edge habitats, particularly in northern Singapore, with multiple records located in close proximity to Springleaf Precinct (Lok et al., 2010) and also within Springleaf itself (NUS, 2018). It is thus highly probable that *Cecropia pachystachya* will begin to establish in the newly created edge habitats following land clearance works.

Freshwater Swamp Forest

The freshwater swamp forest will be conserved, together with a buffer zone of at least 30 m width, thereby helping to minimise the impact of edge effects. Nonetheless, some edge effects may still arise from vegetation clearance of the adjacent secondary forest habitats, given that studies on forest fragmentation have reported increased tree mortalities up to 300 m deep from a forest edge, and reduced humidity up 100 m deep (Laurance et al., 2018). However, these edge effects are expected to be minimal.

Naturalised Stream

The naturalised stream and its banks will be protected from development. However, the baseline condition is subjected to edge effects as the stream and its banks have low canopy cover. Enhancement of the riparian vegetation via the proposed plantings will further reduce edge effects (Figure 4-10).

Native Fauna

Edge effects brought about by habitat loss will also impact fauna distribution and behaviour. For example, forest-dependent specialist species will retreat away from the edge and move into the core areas of forest habitats. Edge effects also allow opportunistic generalist fauna species such as Javan Mynah, and urban-adapted species such as stray dogs and cats to enter the retained forest habitats, potentially altering predator-prey dynamics.

6.1.3.5 Introduction of Invasive Species

Young Secondary Forest

The NHG and SHG of Springleaf Precinct became secondary forest when cultivated lands were left to grow naturally after the villages there were resettled. This has caused a mix of native and non-native flora species in the secondary forest. The secondary forest in NHG comprises of more invasive species than the secondary forest in SHG. Prominent invasive flora species found at Springleaf forest are wind dispersed species such as African Tulip (*Spathodea campanulate*), Ambay Pumpwood (*Cecropia pachystachya*) and Albizia (*Falcataria moluccana*).

Invasive species often out compete native species for food and space. Any introduction of invasive species in the secondary forest would have minor negative impact to the flora and fauna. In order to prevent the spread of invasive species, especially invasive flora from landscape planting, the non-native flora chosen for the development should be assessed for possibility of turning into an invasive species.

Recommended mitigation measures include targeted habitat enhancement by replanting with native species and manual removal of invasive flora species (Figure 6-7).

Figure 6-7 Target proportion of native flora species across Springleaf following habitat enhancement works (image credit: STX Landscape Architects).

Freshwater Swamp Forest

The freshwater swamp is a sensitive and diminishing habitat in Singapore. It is prone to both terrestrial and aquatic invasive species. The freshwater swamp is a good habitat for amphibians and is possible to be invaded by invasive frog species such as the Gunther's frog (*Sylvirana guentheri*).

Naturalised Stream

The stream in the Springleaf Precinct has invasive fishes like the Ocellate River Stingray (*Potamotrygon motoro*) and Peacock Bass (*Cichla orinocensis*) and invasive aquatic plant

Hydrilla (*Hydrilla verticillate*). Nonetheless, potential for these invasive species to spread and establish upstream in NSSF is low, given its acidic waters, and the frequent directional release of water from Upper Seletar Reservoir to Lower Seletar Reservoir. Invasive fishes, if predatory, would often reduce the population of smaller native fishes. That seems to be the case for the stream.

Central Catchment Nature Reserve

The potential for the development to result in the introduction of invasive species to NSSF and CCNR is predicted to be low. The unique habitat of NSSF appears to confer resistance to invasive species. The acidic water of the freshwater streams, its low water temperatures and the thick overhanging canopy cover has meant that introduced freshwater fish species are found only at the edges of the swamp forest habitat, and not within the main stream itself (Li et al., 2016) or at the middle to upper catchments (Cai et al., 2018). Instead, the main and more pertinent source of non-native freshwater species introductions is from Upper Seletar Reservoir. Similarly, introduced terrestrial snails and slugs were only found from the outskirts of NSSF (Lim et al., 2018). Enhancement plantings to the riparian vegetation along the naturalised stream within Springleaf should also confer more advantage to native over introduced aquatic species, which tend to prefer disturbed sites (Cai et al., 2018).

6.1.4 Mitigation Measures

There are avoidance, minimisation, restoration and offsets proposed to protect the biodiversity and ecology, both during construction and post-construction phases as presented in Table 6-4. It is to be noted that some mitigation measures are to be implemented prior to the sale of the land parcels and transfer of ownership to the construction contractor and developer, and some of these mitigation measures would have to be carried out by public agencies on state-owned land. The sequencing of mitigation measures and dependency of agencies' involvement are also highlighted in Table 6-4 where applicable.

Table 6-4 Biodiversity and ecology mitigation measures by hierarchy type proposed at each phase of development

Stage	Hierarchy	Mitigation Measures
Design	Avoidance	• The Significant Conservation Areas should be conserved and considered a No-Go Zone. • Dwelling units should be planned within existing urbanised or disturbed ground areas as far as possible, rather than high value forest. • A 30 m buffer zone around the protected No-Go Zone is designated as a further safeguard, enhancing the protection to the ecologically sensitive core. • Safeguarding as much greenery as possible within the development sites, by requiring conservation of mature trees and the endangered/critically endangered tree species, as well as implementing a landscape planting guide to maintain the green/forested character of the site
	Minimization	• Tree Cottages and walkways raised on stilts, to minimise impact on the forest ground, within the secondary forest zone. • Proposed reduction in the number of tree cottages, hence reducing the area of young secondary forest cleared
	Restoration	• Existing habitat types to form the basis for the planting palette, which aims to retain and enhance the distinctive landscape

Stage	Hierarchy	Mitigation Measures
		character within the different zones of the site and ensure for example that a natural assemblage of bats, dragonflies, damselflies, butterflies, and other insects are encouraged.
	Offsets	• Tree planting within the 30 m buffer zone will establish a future forest. • Connectivity between Springleaf and adjacent forest should be enhanced through targeted reforestation or revegetation of corridors, such as the SLE underpass and riparian vegetation along Sungei Seletar, buffer zones, as well as areas within the developed parcels. • To install rope bridges and wooden logs over Sungei Seletar and at strategic road crossing to improve connectivity between forested areas for arboreal animals, while wooden logs will be used by terrestrial animals. • To remove the physical obstruction under the SLE (i.e. the drain and barricade on the side of Springleaf) to improve ecological connectivity. • The mitigation measures to strengthen ecological measures are to be implemented prior to sale of the development parcels, wildlife shepherding works, tree and sapling transplanting and salvaging, and vegetation clearance works. This will facilitate fauna movement out from the development area and into adjacent retained forests. The agencies involved include NParks, PUB, and SLA. • A planting palette should be used that includes a list of species that could be suitable for growth conditions in the SLE underpass with low light and dry ground, and adjacent to the SLE underpass (Sungei Seletar) which has sufficient light but intermittently flooded ground, and that could be planted in and around waterways. • Additional screen planting is proposed along the site boundaries along SLE and Mandai Road, enhancing the green edges of the site.
Construction	Avoidance	• There should be safeguarding of greenery as much as possible within the development sites, by requiring conservation of mature trees and the endangered/critically endangered tree species. • Although the forest crown is dominated by non-native species, it is recommended that these large trees are not felled as they provide important functions for fauna, such as roosting habitats, but also provide shade to the understory. • Before felling trees, the Arborist must ensure native saplings have already been tagged and identified by a Native Flora Specialist. • Trees to be kept and trees that do not need to be felled should have appropriate tree protection zones based on consultation with Arborist. • The alignment of the fence line should take into consideration the location of trees on site.
	Minimization	• Method Statements to be prepared for construction in proximity to trees and Flora Specialist/Arborist to review Tree Felling Method Statement and proposed schedule of works. • Contractor to engage with Flora Specialist/Arborist to confirm species of conservation significance on site and appropriate management as well as complete a 'Verification of Tree Protection Checklist' prior to the start of site clearance. • Any proposal to remove or prune any trees > 1 m girth (regardless of native or SRDB status), or flora which are listed as EN, CR, or VU in SRDB will need approval from NParks.

Stage	Hierarchy	Mitigation Measures
		• Flora Specialist/Arborist to identify and tag trees approved to be felled by NParks for ease of identification. Tree removal is to be carried out according to the method statement to be submitted and approved by the Superintendent Officer. Only directional felling methods with a hinge and back cut shall be deployed. Trees shall not be felled by pushing over with heavy machinery. • Construction footprints should remain as small as reasonably possible. • Vegetated buffer and swamp forest to be protected by appropriate fencing and buffers early in the construction process, with staggered development timing. • Prior to clearing, the entire construction site is to be hoarded, and to consult NParks (Wildlife Management) for site specific wildlife shepherding or removal plan based on the carrying capacity of the area • Pre-felling tree surveys are conducted to determine if any fauna is currently inhabiting any trees earmarked for felling. • Erect hoarding and barriers progressively to prevent fauna from entering project site. • To reduce the possibility of wild boar entering the construction site, fencing should be buried 0.5 to 1 m into the ground. • Ensure material imported into the Project area will be checked for contamination from weed/invasive species seeds/vegetative matter at source. • Sterilization of vehicles and equipment, and appropriate selection of materials to minimize introduction of weeds, nutrients and other pollutants.
	Restoration	• Salvaging of native plant saplings from within the development sites should take place prior to sale of development parcel and construction and grown within a nursery on site and/or within NParks' nurseries. NParks will be involved.
	Offsets	• The Miyawaki afforestation method is a rapid restoration method that is appropriate for restoring small areas of degraded forests and wastelands within 15-20 years. • The framework species method is conducted for larger areas and uses around 20-30 fruit-bearing species that attract fauna for the purposes of seed dispersal.
Operation and Maintenance	Avoidance	• Pesticides identified to have adverse effects on the environment should not be used on the premises of the development. • Fumigation should be used within the premises of the development. • Freshwater fish should not used in any water features within the development.
	Minimization	• It is not necessary nor recommended to use fertilizers due to the proximity of sensitive waterways but instead tilling and compost can be added to soften the soil to replenish the nutrients necessary for plant growth.
	Restoration	• Plants salvaged within site or the same species found within the site should be used for landscaping to maintain the species assemblage of the area.
	Offsets	• Invasive exotic tree species to be progressively manually removed and replaced with native species, where appropriate.

6.1.5 Assessment Ratings (Base Proposed Springleaf Precinct Master Plan Option)

Based on the analysis the impact assessment scoring has been completed and is presented in Table 6-5 for construction phase impacts and Table 6-6 for post-construction impacts, for the base proposed Springleaf Precinct Master Plan option.

Table 6-5 Construction phase impact assessment for ecological and biodiversity sensitive receptors, for the base proposed Springleaf Precinct Master Plan option (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of flora and fauna	Young secondary forest	4	-4	3	3	3	-144	Major Negative	-3	-108	Moderate Negative
	Scrubland / grassland	2	-2	2	2	2	-24	Slight Negative	-1	-12	Slight Negative
	Freshwater swamp forest	5	-2	2	2	2	-60	Minor Negative	-1	-30	Slight Negative
	Urban vegetation	1	-2	3	2	2	-14	Slight Negative	0	0	No Impact
	Birds	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative
	Reptiles and amphibians	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative
	Mammals	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative

Table 6-6 Post-construction phase impact assessment for ecological and biodiversity sensitive receptors, for the base proposed Springleaf Precinct Master Plan option (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of ecosystem services and function	Young secondary forest	4	-4	3	3	3	-144	Major Negative	-3	-108	Moderate Negative
	Scrubland / grassland	2	-2	2	2	2	-24	Slight Negative	1	+16	Slight Positive
	Freshwater swamp forest	5	-2	2	2	3	-70	Minor Negative	-1	-35	Slight Negative
	Urban vegetation	1	-2	3	2	2	-14	Slight Negative	1	+7	Slight Positive
	Native fauna	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative
Loss of ecological connectivity	Young secondary forest	4	-3	3	3	3	-108	Moderate Negative	-2	-72	Minor Negative
	Scrubland / grassland	2	-2	3	2	2	-28	Slight Negative	-1	-14	Slight Negative
	Freshwater swamp forest	5	-2	3	2	2	-70	Minor Negative	-1	-35	Slight Negative
	Birds	3	-3	3	3	2	-72	Minor Negative	-1	-24	Slight Negative
	Reptiles and amphibians	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
	Mammals	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
	Odonates	3	-1	2	2	2	-18	Slight Negative	1	+18	Slight Positive
	Freshwater organisms	3	-2	2	2	2	-36	Slight Negative	-1	-18	Slight Negative
	Springleaf Nature Park	3	-1	3	2	2	-21	Slight Negative	0	0	No Impact

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Forest edge effects	Young secondary forest	4	-4	3	3	3	-144	Major Negative	-3	-108	Moderate Negative
	Scrubland / grassland	2	-2	3	2	2	-28	Slight Negative	1	+14	Slight Positive
	Freshwater swamp forest	5	-1	3	2	2	-35	Slight Negative	1	+35	Slight Positive
	Native fauna	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
Introduction of invasive species	Young secondary forest	4	-2	3	3	3	-72	Minor Negative	-1	-36	Slight Negative
	Freshwater swamp forest	5	-2	3	3	3	-90	Moderate Negative	-1	-45	Minor Negative
	Naturalised stream	3	-2	3	3	3	-54	Minor Negative	-1	-27	Slight Negative
	Central Catchment Nature Reserve	5	-2	3	3	3	-90	Moderate Negative	-1	-45	Minor Negative

6.1.6 Assessment Ratings (Reduced Tree Cottages Proposed Springleaf Precinct Master Plan Option)

In addition to the assessment of biodiversity and ecological impact significance for the base proposed Springleaf Precinct Master Plan option presented in Section 6.1.5, impact significance for selected ecological and biodiversity receptors that will be affected by a reduction of the number of Tree Cottages in the alternative proposed Springleaf Precinct Master Plan option were also re-evaluated (see Section 4.2.1.1 for details on the reduced Tree Cottages option). As the reduction of five tree cottages and the associated addition of two Forest Towers will be sited within the young secondary forest habitat type, the re-evaluation of impact significance has not been conducted for the freshwater swamp forest, naturalised stream, freshwater organisms, odonates, grasslands, urban vegetation, and Springleaf Nature Park.

6.1.6.1 Loss of Flora and Fauna

The main positive outcome from halving the number of tree cottages from the base proposed Springleaf Precinct Master Plan would be the reduction in the area of young

secondary forest habitats that needs to be cleared during the construction stage. Although some of the areal reduction in young secondary forest clearance is offset by the addition of two Forest Towers in Parcel 2, overall, the net reduction in young secondary forest clearance remains significant. More importantly, the removed tree cottages overlap an area with a high density of conservation-significant flora species (Figure 6-8), while the additional two forest towers will be within an area with lesser conservation-significant flora species, and also near edge habitats of lower conservation value. Therefore, the removal of five forest cottages from the Parcel 1b will potentially reduce the loss of conservation-significant flora species and provide more buffer for the retained conservation-significant flora species. Moreover, the removal of five tree cottages means there is now an opportunity to increase the size of the Core Conservation Area and shift the buffer zone southwards as well as remove some supporting infrastructure such as part of the fire engine access road. Enhancement plantings can also be conducted in the additional retained young secondary forest with the removal of five Tree Cottages to increase the diversity of native flora. The remaining five tree cottages can also be oriented in such a way to maximise the buffer for retained conservation-significant flora, instead of being oriented in the same direction.

Compared to the base proposed Springleaf Precinct Master Plan option, impact magnitude for young secondary forest is thus reduced by a score of 1, provided that the addition of two Forest Towers in Parcel 2 does not result in the loss of conservation-significant flora or mature trees of retention value. Consequently, residual impact significance is reduced from Moderate Negative in the base proposed Springleaf Precinct Master Plan option to Minor Negative in the alternative option (Table 6-7).

For the receptor of birds, impact significance remains unchanged relative to the base proposed Springleaf Precinct Master Plan option, given that the biodiversity baseline surveys found the northern parcel to harbour a richer and diverse community of birds compared to the southern parcels (NUS, 2018). Nonetheless, the potential loss of habitats for avifauna with the addition of two Forest Towers in Parcel 2 is compensated by the safeguarding of more young secondary forest with the removal of five forest cottages in Parcel 1b.

For the receptor of reptiles and amphibians, while the southern parcel recorded a more diverse community of amphibians, the northern parcel supports a more species rich assemblage of reptiles. Therefore, the impact significance remains unchanged relative to the base proposed Springleaf Precinct Master Plan option.

For the receptor of mammals, the biodiversity baseline surveys revealed that the significant conservation areas for mammals lie within the Core Conservation Area and Significant Conservation Area, which will be protected. Therefore, the impact significance of the reduced Tree Cottages option also remains unchanged relative to the base proposed Springleaf Precinct Master Plan option.

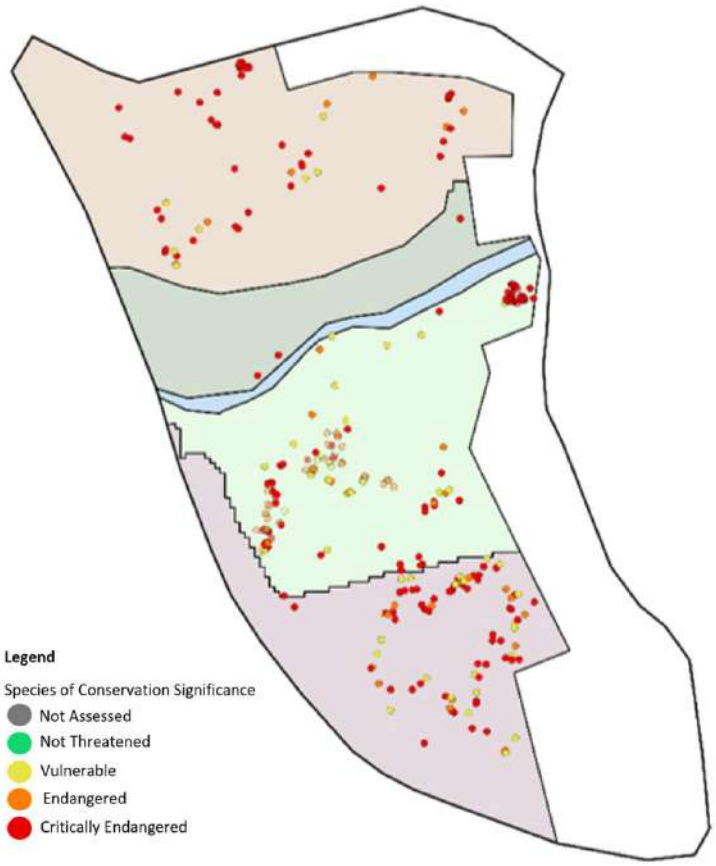


Figure 6-8 Locations of conservation-significant flora species (vulnerable, endangered, or critically endangered) recorded from the baseline flora surveys (NUS, 2018), showing a dense concentration of conservation-significant flora species overlapping with the area where five tree cottages would be removed in the alternative option.

6.1.6.2 Loss of Ecosystem Services and Functions

Mirroring the reduction in impacts on young secondary forest for loss of flora under the reduced tree cottages option, the impact magnitude of loss of ecosystem services and functions in young secondary forests is also reduced by 1, resulting in a residual impact significance of Minor Negative (Table 6-8). This is attributed to the retention of a greater spatial coverage of young secondary forest, hence contributing to the maintenance of a higher level of ecosystem services and functioning, e.g. in above and below-ground carbon storage and microclimate amelioration.

For native fauna, the reduced Tree Cottages option is expected not to change the residual impact significance, which remains at Minor Negative (Table 6-8), given the minimal changes to fauna abundance and community structure.

6.1.6.3 Loss of Ecological Connectivity

Under the reduced Tree Cottages option, it is expected that the impact of loss of ecological connectivity would remain the same, hence residual impact significance is unchanged (Table 6-8), given that that barriers to ecological connectivity (e.g. Seletar Expressway)

and the proposed mitigation measures to enhance ecological connectivity remains unchanged.

6.1.6.4 Forest Edge Effects

Under the reduced Tree Cottages option, the impact of forest edge effects within the young secondary forests is expected to be reduced as compared to the base proposed Springleaf Precinct Master Plan option, resulting in a residual impact significance of Minor Negative (Table 6-8). The overall reduced number of residential blocks within the young secondary forests translates into a reduced perimeter of forest that will be exposed to edge effect conditions. For native fauna, the impact significance remains unchanged given the minimal changes expected to fauna abundance and community structure.

6.1.6.5 Introduction of Invasive Species

Under the reduced Tree Cottages option, the impact of introduction of invasive species within the young secondary forests is expected to remain unchanged (Table 6-8), given that the risk of invasive species introduction remains (e.g. introduced by residents), and that once introduced, invasive species tend to establish rapidly.

6.1.6.6 Assessment Ratings

Based on the analysis for the alternative option, the impact assessment scoring has been completed and is presented in Table 6-7Table 6-5 for construction phase impacts and Table 6-8 for post-construction impacts. Compared to the evaluation of impact significance for the base proposed Springleaf Precinct Master Plan option, impact significance for the reduced Tree Cottages option remains largely similar, and is changed (reduced) only for the receptor of young secondary forest, for the predicted impacts of loss of flora and fauna, loss of ecosystem services and functions, and forest edge effects.

Table 6-7 Construction phase impact assessment for ecological and biodiversity sensitive receptors, for the reduced Tree Cottages option (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of flora and fauna	Young secondary forest	4	-3	3	3	3	-108	Moderate Negative	-2	-72	Minor Negative
	Birds	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative
	Reptiles and amphibians	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
	Mammals	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative

Table 6-8 Post-construction phase impact assessment for ecological and biodiversity sensitive receptors, for the reduced Tree Cottages option (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of ecosystem services and function	Young secondary forest	4	-3	3	3	3	-108	Moderate Negative	-2	-72	Minor Negative
	Native fauna	3	-3	3	3	3	-81	Moderate Negative	-2	-54	Minor Negative
Loss of ecological connectivity	Young secondary forest	4	-3	3	3	3	-108	Moderate Negative	-2	-72	Minor Negative
	Birds	3	-3	3	3	2	-72	Minor Negative	-1	-24	Slight Negative
	Reptiles and amphibians	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
	Mammals	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
Forest edge effects	Young secondary forest	4	-3	3	3	3	-108	Moderate Negative	-2	-72	Minor Negative
	Native fauna	3	-2	3	2	2	-42	Minor Negative	-1	-21	Slight Negative
Introduction of invasive species	Young secondary forest	4	-2	3	3	3	-72	Minor Negative	-1	-36	Slight Negative

6.2 Hydrology

The assessment of impacts to hydrology is presented in this section covering surface water, groundwater and water quality.

6.2.1 Evaluation Framework

Guidance for the surface water, groundwater and water quality at Springleaf are presented in Table 6-9 and Table 6-10.

Table 6-9 Guidance for surface water runoff and groundwater at Springleaf

Factor	Within Development Areas
Stormwater Runoff	• To achieve PUB COP on Surface Water Drainage Clause 7.1.5 detention requirements • To achieve ABC Waters Certification (Gold) with treatment of surface run-off at least 60% of the total site using ABC Waters design features • To adopt a rainfall intensity an additional climate correction factor of 25% for ABC Waters design
Water Table	• Design to maintain water table at or above current dry and wet season minimum levels in comparison to baseline

Table 6-10 Guidance for water quality at Springleaf

Classification	Averages from Baseline Survey	Allowable Limits for Trade Effluent Discharge	ABC Waters Stormwater Treatment Objectives
Total suspended solids	3 mg/L in stream 4 mg/L in freshwater swamp forest	50 mg/L for waterway 30 mg/L for controlled waterway	80% removal or less than 10 mg/L
Total nitrogen	0.3 mg/L in stream 0.8 mg/L in freshwater swamp forest	-	45% removal or less than 1.2 mg/L
Nitrate (as NO_3)	-	- 20 mg/L for controlled waterway	-
Total phosphorus	1 mg/L in stream 1 mg/L in freshwater swamp forest	-	45% removal or less than 0.08 mg/L
Phosphate (as PO_4)	-	5 mg/L for waterway 2 mg/L for controlled waterway	-

The magnitude of change used for the hydrology is presented in Table 6-11, and has been analysed using models and referenced to other scientific studies.

Table 6-11 Score for magnitude of hydrology receptors

Score	Generic Criteria	Specific Criteria	
		Surface Water	Groundwater
-4	Major negative disadvantage or change	• Severe effects on water quality which are likely to be long lasting (months or more) permanent or give rise to indirect ecological or socio-economic impacts • Likely to involve significant alterations to existing drainage regimes and patterns	• Abstractions or discharge to aquifer expected to cause potentially severe effects on groundwater quality which are likely to be long lasting (years or permanent) or give rise to indirect ecological or socio-economic impacts • Likely to involve significant changes to groundwater flows (vertical or horizontal) or quality
-3	Moderate negative disadvantage or change	• Potential localised effects on water quality which are likely to be long last (weeks or months) and give rise to indirect ecological or socio-economic impacts • Likely to involve significant alterations to existing drainage regimes and patterns	• Abstraction or discharge to aquifer expected to cause potential localised effects on groundwater quality which is likely to be long lasting or give risk to indirect ecological or socio-economic impacts • Likely to involve significant changes to existing groundwater recharge or discharge regimes which result in longer term changes to groundwater flows (vertical or horizontal) or quality
-2	Minor negative disadvantage or change	• Short term localised effects on surface water quality but which are likely to return to equilibrium conditions within a short timeframe (hours or days at most) • Likely to be some alteration to existing drainage regimes and characteristics, although the frequency and magnitude of flooding upstream or downstream is not expected to be materially affected	• Abstraction or discharge to aquifer may cause localised changes in water quality in the aquifer system but short term localised effects only which return to equilibrium conditions within a short timeframe (months) • There is likely to be some alteration to existing groundwater recharge or discharge regimes although these

Score	Generic Criteria	Specific Criteria	
		Surface Water	Groundwater
			changes are unlikely to result in any significant longer term changes to groundwater levels, quality or flows
-1	Slight negative disadvantage or change	• Short term localised effects on surface water quality but likely to be highly transitory (lasting hours) and well within natural fluctuations • No alterations to existing drainage regimes and characteristics and thus negligible or no impact on upstream or downstream flood flows	• Short term localised effects on groundwater quality but likely to be highly transitory (lasting hours) and well within natural fluctuations • Negligible or no impact on groundwater recharge or discharge regimes
0	No change	• Status quo	• Status quo

6.2.2 Sensitive Receptors

The receptors sensitive to changes in hydrology include the freshwater swamp forest, naturalised stream, the fauna associated with waterways such as odonates and freshwater organisms, the Nature Reserve and the Lower Seletar Reservoir. The scores for assessing the importance of the hydrology receptors are provided in Table 6-12.

Table 6-12 Score for importance of hydrology receptors

Score	Generic Criteria	Specific Criteria	
		Surface Water	Groundwater
5	Important to national/international interests	The surface water resource is wholly relied upon locally, with no suitable technically or economically feasible alternatives or is important at a regional or transboundary watershed level for provisioning services or contribution to dependent ecosystems	The groundwater resource is wholly relied upon locally, with no suitable technically or economically feasible alternatives or is important at a regional or transboundary watershed level for provisioning services or contribution to dependent ecosystems
4	Important to regional/national interests		
3	Important to areas immediately outside the local condition	The surface water resource has local importance in terms of provisioning services but there is ample capacity or adequate opportunity for alternative sources of comparable quality	The groundwater resource is an important water supply and is currently used but there is capacity or adequate opportunity for alternative sources of comparable quality
2	Important to the local conditions (within a		

Score	Generic Criteria	Specific Criteria	
		Surface Water	Groundwater
	large direct impact area)		
1	Important only to the local condition (within a small direct impact area)	The surface water resource has little or no role in terms of provisioning or services of the local community or ecosystem	The groundwater resource is not currently abstracted and has little or no role in terms of provisioning or services of the local community or ecosystem

6.2.3 Pressures and Pathways

6.2.3.1 Change in Surface Drainage

Hydrology modelling was performed by Arup using InfoWorks ICM. Four model scenarios were considered as follows:

Wet Weather

1. 1-in-10 year event + 25% Climate Change Factor for Pre-development scenario
2. 1-in-10 year event + 25% Climate Change Factor for Post-development scenario

Extreme Storm Event

1. 1-in-50 year event + 25% Climate Change Factor for Pre-development scenario
2. 1-in-50 year event + 25% Climate Change Factor for Post-development scenario

Due to the absence of boundary conditions for the dry weather, no modelling was completed for this scenario.

Overall, the hydrological modelling results indicated that Springleaf development appears to have negligible impact to the flood extent and depth of Sungei Seletar. Only 0.9% and 1.2% of the site experienced a change in flood depths for the wet weather and extreme storm event respectively. The difference in flood depths between Post-Development and Pre-development scenario within Springleaf precinct is approximately 10cm to 20cm. The extent of flooding is contained within the existing floodplains and overlap with the existing Core Conservation Area (Figure 6-9).

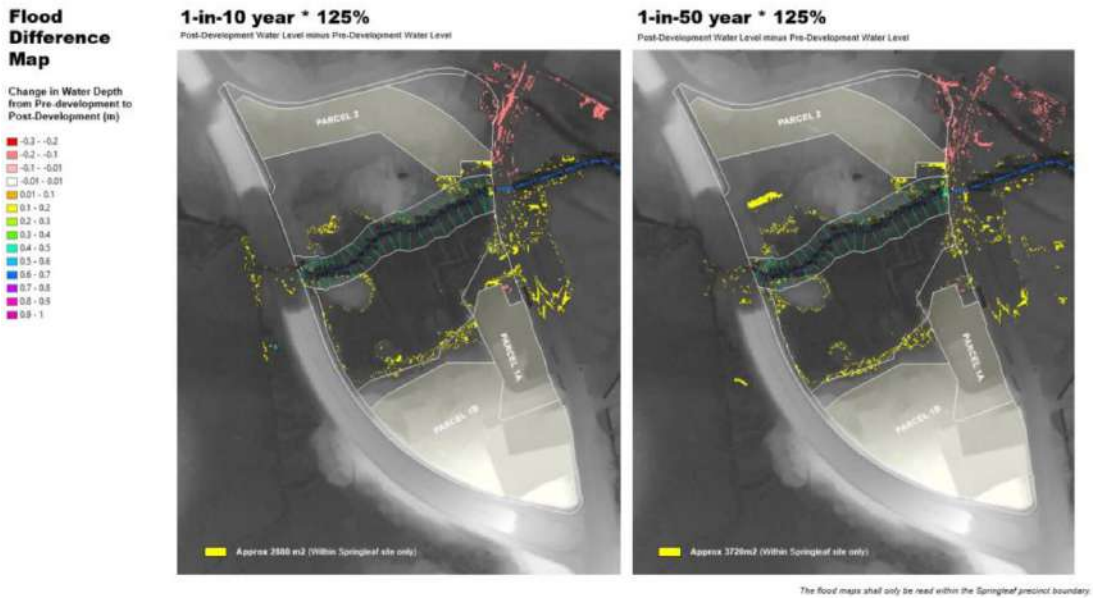


Figure 6-9 Flood difference map pre- and post-development, for a 1-in-10 year storm event (left) and 1-in-50 year extreme storm event (right) (image credit: Arup).

The maximum flood depth maps, pre- and post-development, for a 1-in-10 year storm event and 1-in-50 year extreme storm event are shown in Figure 6-10 and Figure 6-11 respectively. The extent of flooding for all scenarios modelled is generally contained within the existing lower-lying floodplains where the flood depths are deeper. The floodplains tally with the existing core conservation area. Flood maps have shown that backflow to NSSF is likely to occur upstream of Springleaf Site during such a large storm event when Sungei Seletar's capacity has been exceeded and surcharged. It is important to note that the flood levels beyond the Springleaf site (e.g. Upper Thomson Road) shall be read with caution. This is because the existing roadside drains outside of Springleaf boundary, that could have intercepted some of the surcharged flood water, were not included as part of the model due to insufficient data.

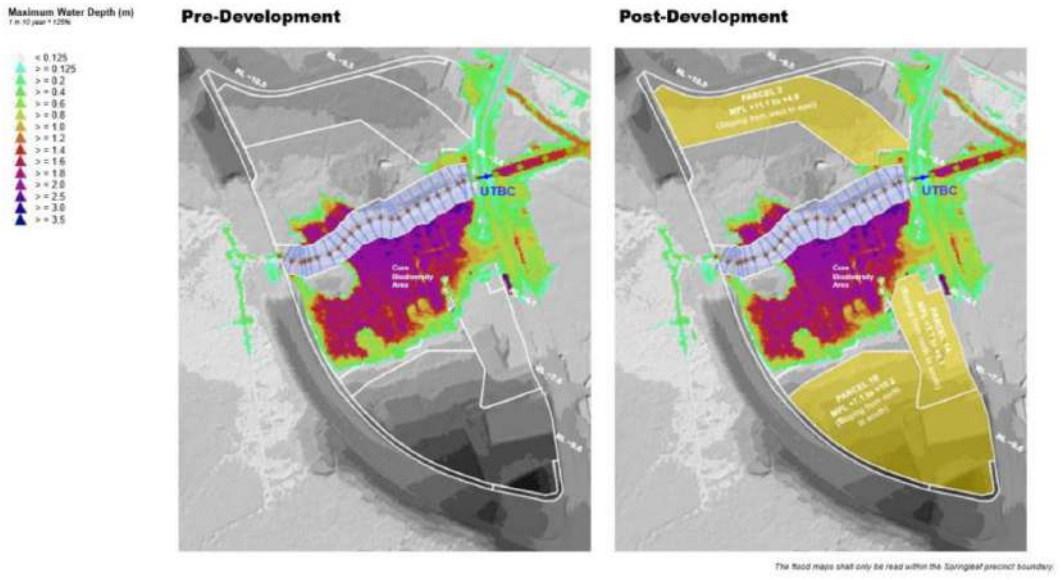


Figure 6-10 Maximum flood depth map for a 1-in-10 year storm event, pre-development (left) and post-development (right) (image credit: Arup).

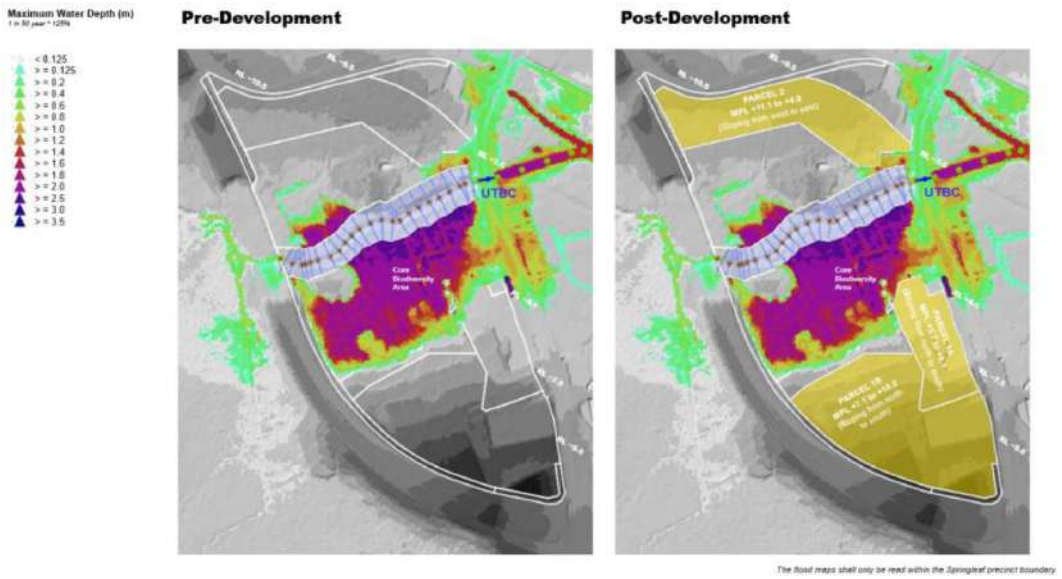


Figure 6-11 Maximum flood depth map for a 1-in-50 year extreme storm event, pre-development (left) and post-development (right) (image credit: Arup).

Freshwater Swamp Forest

The proposed Springleaf Precinct Master Plan has taken into account the sensitivity of the freshwater swamp forest in the low lying zone, and taken steps to ensure that stormwater will still percolate through to the swamp forest. This includes the ABC Waters features within the commercial and residential areas as well as bioretention swales and rain gardens within the buffer zone as an extra measure to detain, cleanse and percolate water to the swamp forest.

Figure 6-12 and Figure 6-13 present the ABC Waters features that are to be implemented to the south while Figure 6-14 shows the predicted surface flow regimes of the site, and the locations of the overflow discharge originating from the development parcels and leading to the naturalised stream. The configurations will be planned in a way to direct similar volumes of water and similar rates to the freshwater swamp forest to maintain the water levels and ensure no additional erosion.

The modelling predicted that based on a 1-in-50 year flood event, the flood extent for both the pre-development and post-development scenarios would be highly similar because the flow rate contributing to Sungei Seletar from Springleaf Precinct is much smaller compared to the incoming upstream flow rates of the larger catchment. Hence, the freshwater swamp forest is likely to experience similar flood conditions during heavy rainfall and experience no additional stress.

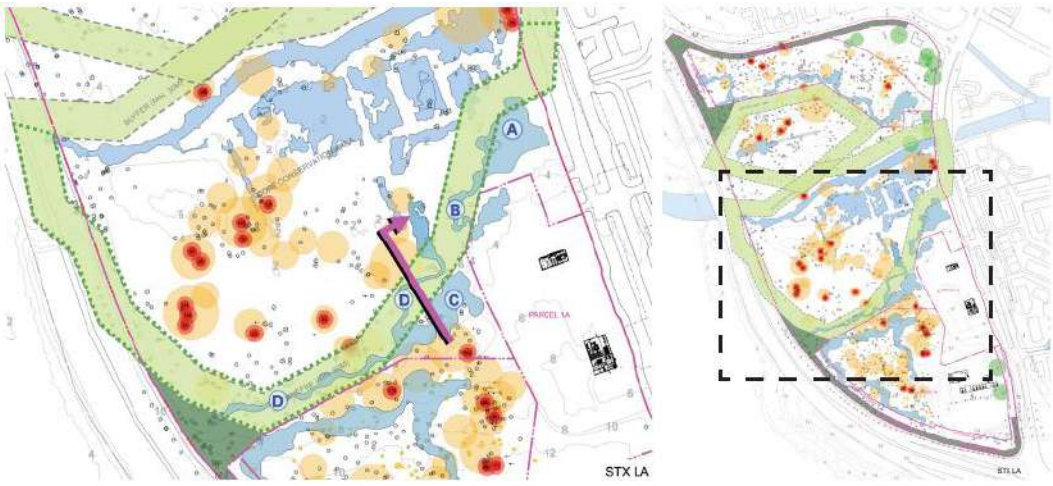


Figure 6-12 ABC Waters design features (dark blue) (map credit: STX Landscape Architects).

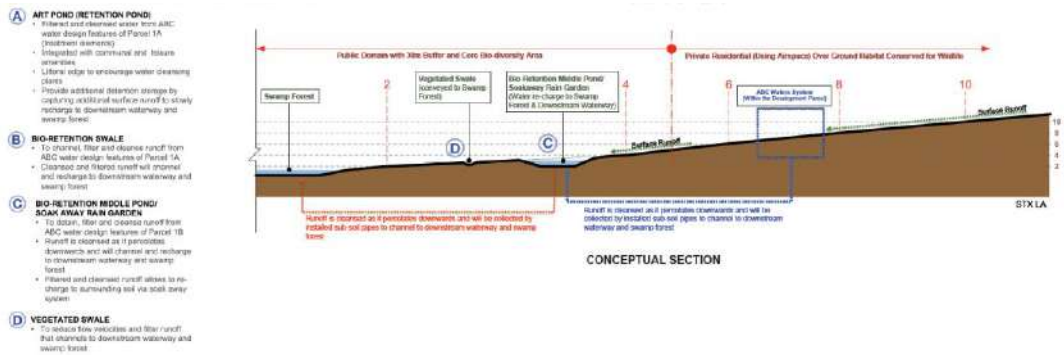


Figure 6-13 Cross section of ABC Waters features design to detain and retain overland water flows (image credit: STX Landscape Architects).

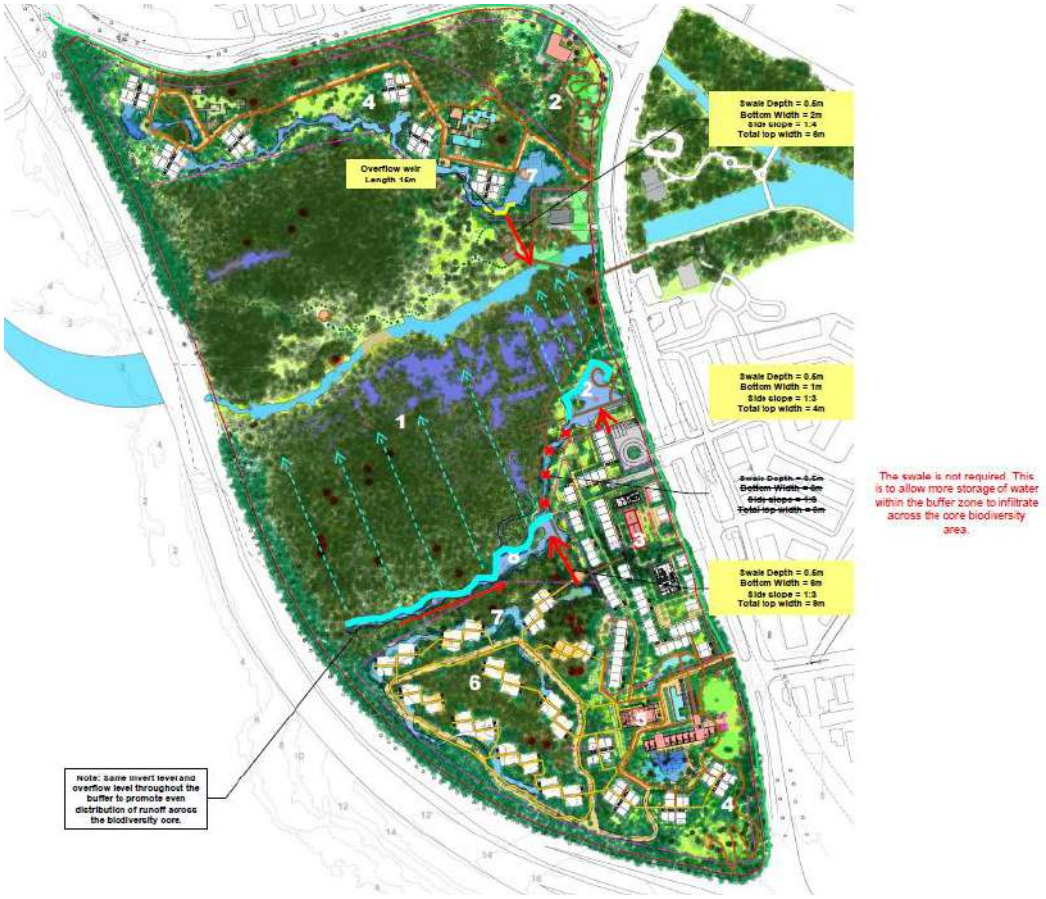


Figure 6-14 Surface runoff and infiltrated baseflow within Springleaf. ABC Waters design features are indicated by blue shaded regions (image credit: Arup)

Naturalised Stream

The estimation of runoff and flood level for existing and proposed scenarios were determined. Table 6-13 summarizes the estimated peak flows generated by the catchments within the Springleaf Precinct and associated water levels at the discharge points for pre-development and post-development.

It was also observed that the water level and peak velocity between N01 and XS02, near the inlet, is much larger in the downstream sections. This is attributed to a supercritical flow in this localised area due to the sudden spike of large inflows from the given boundary conditions, causing slight instability issues. This may be attributed to the lack of Sungei Seletar data upstream of the Springleaf site which resulted in the boundary condition being set up without a buffer section upstream for instabilities to attenuate before reaching the Springleaf site.

The maximum water level within the floodplains adjacent to the site is around +4.50 to +4.60m SHD. The flood maps shown in Figure 6-10 and 6-11 should be read with caution within the boundaries of the Springleaf Site Boundary. Any flooding that is shown outside of the boundary (e.g. along Upper Thomson Road) is not reflective of the reality as the model inputs are for the 2D Model are only confined within the site boundaries. It is

important to note that Upper Thomson Road along Springleaf is not known to be a flood prone area or flooding hot spot from PUB's website[3].

Table 6-13 Summary of pre-development and post-development Estimated Peak Flows, Peak Velocity and Water Levels at Sungei Seletar (Section A)

River Reach	Pre-Development			Post-Development		
	Peak Flow	Maximum Water Level	Peak Velocity	Peak Flow	Maximum Water Level	Peak Velocity
	m^3/s	m SHD	m/s	m^3/s	m SHD	m/s
N01	192.0	5.14	3.65	192.0	5.14	3.62
XS02	183.1	4.95	4.60	183.0	4.95	4.56
XS03	186.2	4.69	3.14	186.3	4.70	3.08
XS04	188.6	4.62	2.35	188.4	4.64	2.30
XS23	184.2	4.60	2.23	184.5	4.62	2.20
XS05	186.4	4.57	2.03	186.6	4.58	2.01
XS06	188.3	4.51	1.51	188.5	4.53	1.51
XS07	184.5	4.50	1.55	185.2	4.51	1.52
XS08	181.7	4.48	1.39	181.0	4.49	1.36
XS09	174.9	4.48	1.37	175.7	4.50	1.35
XS10	171.7	4.47	1.17	172.0	4.48	1.15
XS11	160.4	4.47	1.21	161.1	4.48	1.20
XS12	156.5	4.46	1.11	156.8	4.47	1.11
XS13	164.1	4.44	1.12	164.7	4.45	1.11
XS14	151.0	4.44	1.04	152.1	4.45	1.03
XS15	134.9	4.46	1.16	133.1	4.47	1.14
XS16	135.8	4.43	1.05	135.8	4.44	1.04
XS17	132.5	4.44	1.08	130.8	4.45	1.06
XS18	137.2	4.41	0.91	134.6	4.43	0.89
XS19	124.9	4.41	0.82	125.0	4.43	0.82
XS20	96.5	4.41	0.53	97.0	4.43	0.52
XS21	77.2	4.41	0.45	77.5	4.43	0.45

[3] https://www.pub.gov.sg/drainage/floodmanagement

Odonates and Freshwater Organisms

Cai *et al*, (2018) found that the low diversity and richness of the odonate community in most of Nee Soon freshwater swamp forest can be primarily explained by the distance from forest edge, canopy cover of the riparian vegetation, distance from nearby open area, shallow water depth, water with high oxidation-reduction potential (ORP) reading, water with low pH value, stream with low angle smooth bank and stream surrounded by swampy area. The presence of pool habitats, substrate with more silt, less sand, less overhanging root in stream bank, high heterogeneity of riparian vegetation and the wider channel partially explained the high diversity level of odonates in the outskirts and open areas of the NSSF.

The inter-relationships between the hydrology and ecology are complex and not well understood so it is sensible to minimise any local changes to the hydrology as put forward for Springleaf Precinct. The design of the ABC Waters features should ensure that comparative rates of flow of water still reach the freshwater swamp forest and the water table sits at a similar level.

The proposed Springleaf Precinct Master Plan does include planting of riparian vegetation in and around the stream and edges of the freshwater swamp forest, with the intention of increasing the diversity and abundance of odonates, including hopefully swamp forest dependent odonate species. This will be done by using planting palettes that keep to the species assemblage found within Springleaf. By increasing the complexity of the habitat through this planting and reinforcing the edges it is likely that the freshwater organisms of the site will also be conserved.

Central Catchment Nature Reserve

There is a confluence point upstream of the Springleaf Precinct on the other side of SLE where water flowing down from NSSF merges with water coming from Upper Seletar Reservoir (Figure 6-15). While the NSSF stream systems maintain baseflow, the reservoir significantly increases water discharge into the study site's waterway typically for a day or two through the release of "flood gate" water. There could be a possibility of water exchange between the waterway and the swampy area during high flow (NUS, 2018).

Figure 6-15 Confluence upstream of Springleaf Precinct on other side of SLE

Under a 1-in-50 year flood event, there is predicted to be some backflow that results in water pushing back beyond the SLE (Figure 6-16). However, this already occurs even pre-development and model results indicate there is virtually no change between the pre-development and post-development condition. These temporary flood conditions, lasting only a matter of hours, would not be anticipated to cause any lasting impacts in the Central Catchment Nature Reserve and in fact may be beneficial for NSSF by helping to recharge the groundwater.

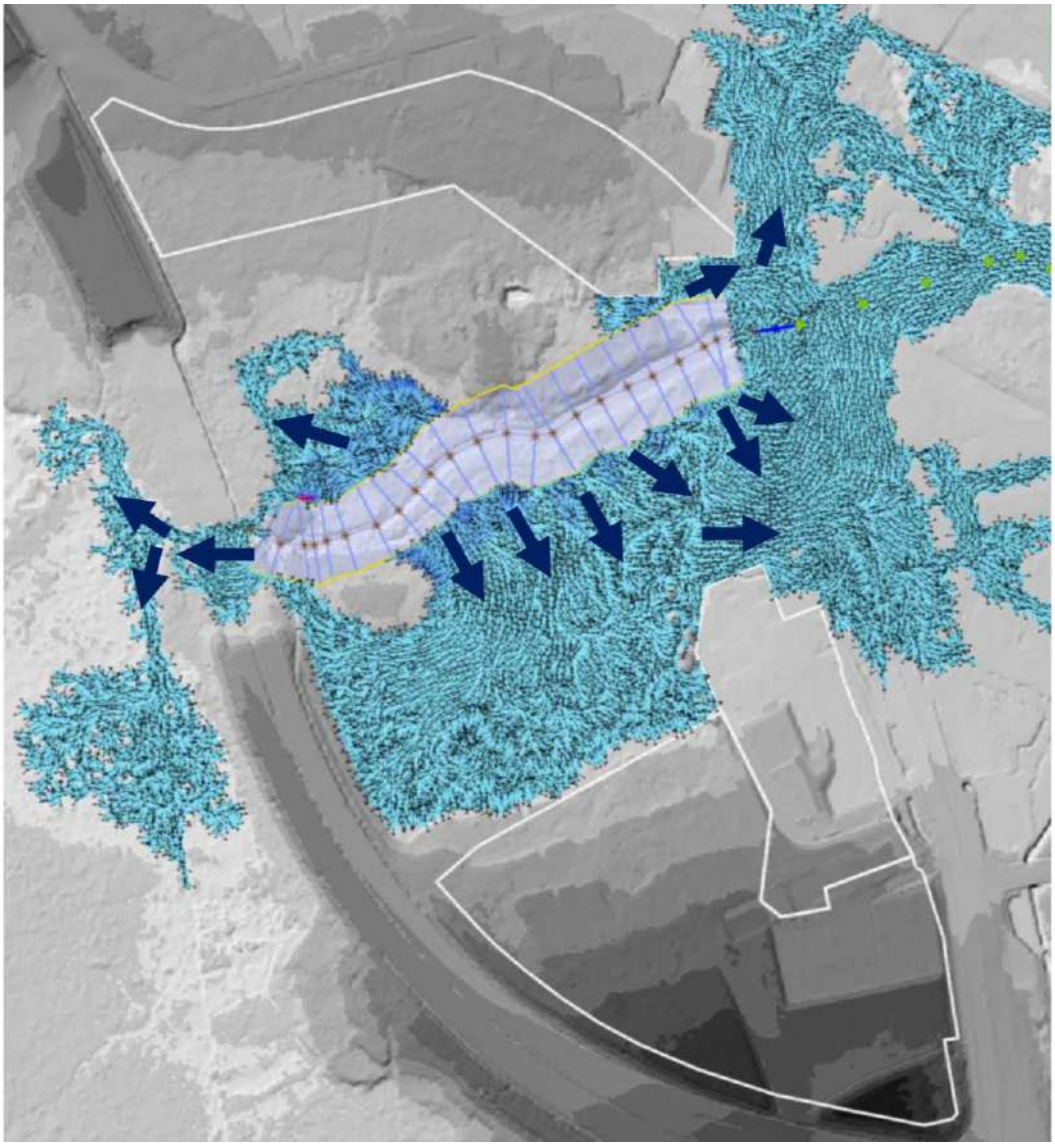


Figure 6-16 Post-development surface flow patterns in the scenario of a flood event (image credit: Arup)

Lower Seletar Reservoir

It was observed that the 2-cell box culvert beneath Upper Thomson Road is surcharged at the peak storm period with a corresponding maximum capacity of approximately 57 m^3/s, behaving as a drowned orifice.

Downstream of the culvert below Upper Thomson Road through to Lentor Avenue, there is approximately 1.0 m of freeboard between the water level and the pathway level in a dry weather condition.

Simulation results for the pre-development scenario shows that Sungei Seletar does not have sufficient capacity to accommodate a 1-in-50 year storm event. The water level within the channel will overtop the banks and pathway levels beyond +2.5 m SHD. The water level rises with the hyetograph as the rainfall intensity increases. Sungei Seletar will start to experience surcharge.

This flood level will propagate and accumulate downstream to Lower Seletar Reservoir. The model assumes that the flood water is bound by the width of the as-built channel cross-sections.

Similar to the pre-development scenario, simulation results for the post-development study, shows that Sungei Seletar does not have sufficient capacity to accommodate a 1-in-50 year storm event. The water level within the channel will overtop the banks and pathway levels beyond +2.5 m SHD. The water level rises with the hyetograph as the rainfall intensity increases. The lower stretch of Sungei Seletar will start to experience surcharge.

This flood level will propagate and accumulate downstream to Lower Seletar Reservoir.

6.2.3.2 Change in Groundwater Levels

Potential changes in groundwater levels in response to the development of Springleaf and future climate changes were modelled using the MIKE-SHE numerical model. In the original Springleaf Forest Hydrology and Biodiversity Baseline Studies (NUS, 2018), the modelling was based on a 100% urbanized scenario for Springleaf, given the absence of a development plan then. In addition, the 2018 model incorporated a vertical wall of 20 m deep from the ground surface along SLE (except the stream corridor), representing foundation and basement of future buildings. In an updated 2021 model, the model was parameterised with a revised development plan (hereinafter referred to as the DHI development scenario), and the vertical wall was omitted from the model too.

The MIKE-SHE numerical model domain covers a large area of about 2000 ha, including NSSF and four surrounding reservoirs (Upper Seletar, Lower Peirce, Upper Peirce and Lower Seletar Reservoirs). Three numerical simulations of the following scenarios for NSSF and Springleaf catchments were conducted:

- **Simulation-1 Scenario (Present Climate)**: Instead of the 100% urbanized scenario in the original Baseline Study (NUS, 2018), the new development plan scenario is now considered, under the present rainfall events from Jan 2013 to Jun 2018.
- **Simulation-2 Scenario (Future Climate; Dry/S10)**: The new development plan is now considered, under a combination of low rainfall and maximum operational reservoir levels.
- **Simulation-3 Scenario (Future Climate: Wet/S12)**: The new development plan is now considered, under a combination of high rainfall and maximum operational reservoir levels.

The detailed definition of scenarios S10 and S12 can be referred to in Section 3.4.6 of the original Springleaf Baseline Study (NUS, 2018). The eight sub-catchments of NSSF modelled are shown in Figure 6-17.

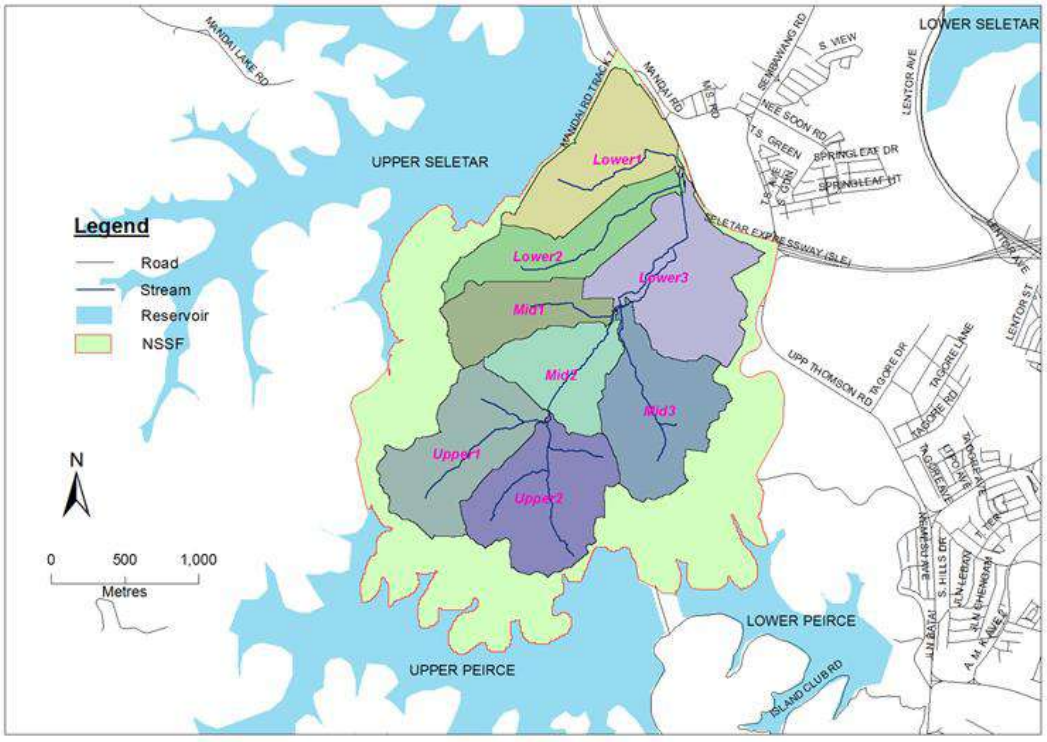


Figure 6-17 Map of the 8 sub-catchments in NSSF assessed (image credit: NUS)

Overall, under the DHI development scenario, the updated 2021 modelling results revealed that the changes in simulated groundwater tables over the entire NSSF catchment were negligible (Figure 6-18; Table 6-14). In contrast, the original Springleaf Baseline Study (NUS, 2018) predicted that groundwater levels over the entire NSSF catchment would be reduced, particularly for three sub-catchments close to Springleaf (Lower1, Lower2 and Lower3), where the average groundwater tables decreased by 6% - 17%. Under the DHI development scenario, the average groundwater tables in the aforementioned sub-catchments were predicted to increase by 1% - 2% instead (Figure 6-18; Table 6-14).

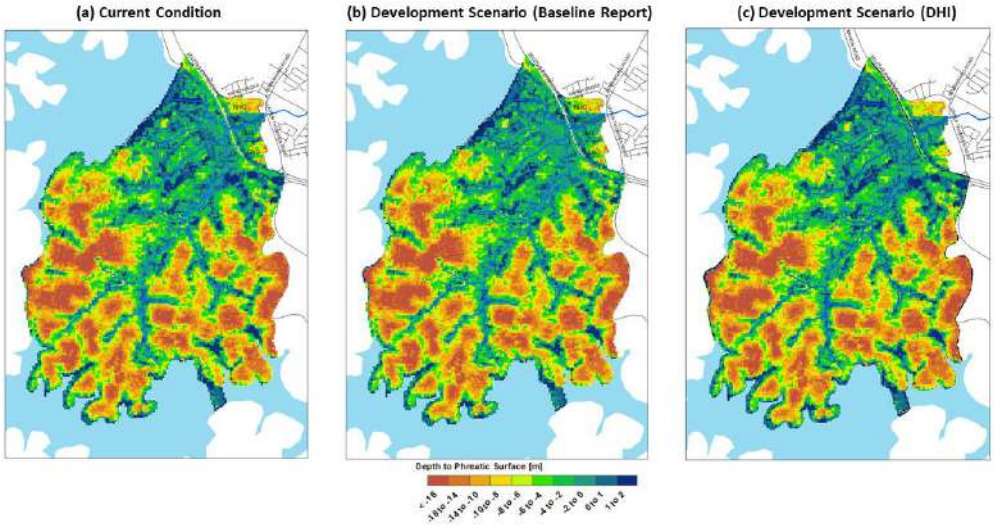


Figure 6-18 Groundwater table maps of NSSF and Springleaf, averaged over 2017: Simulation-1 Scenario (Present Climate) (image credit: NUS)

Table 6-14 Summary of groundwater table in sub-catchments in NSSF, and the entire NSSF and Springleaf Catchments, averaged over 2017: Simulation-1 Scenario (Present Climate).

Sub-catchment	Average Groundwater Table (m, below Ground Surface)		
	Present Condition	Development Scenario (Baseline Report)	Development Scenario (DHI)
Lower1	-1.41	-1.57	-1.38
Lower2	-3.74	-3.95	-3.70
Lower3	-3.58	-4.19	-3.51
Mid1	-6.50	-6.48	-6.51
Mid2	-6.51	-6.50	-6.56
Mid3	-7.78	-7.90	-7.81
Upper1	-10.52	-10.52	-10.58
Upper2	-8.59	-8.69	-8.61
Entire NSSF Catchment	-7.16	-7.29	-7.16
Entire NSSF and Springleaf Catchments	-7.04	-7.16	-7.05

Within Springleaf catchment only, the simulated groundwater table under DHI development scenario generally does not change relative to the current condition (Figure 6-19). A difference map of groundwater is shown in Figure 6-20 to illuminate the changes more clearly under Simulation-1 scenario (Present Climate). It can be seen that the negligible changes are found mainly near the stream and the boundary of the Springleaf-NSSF (Figure 6-20).

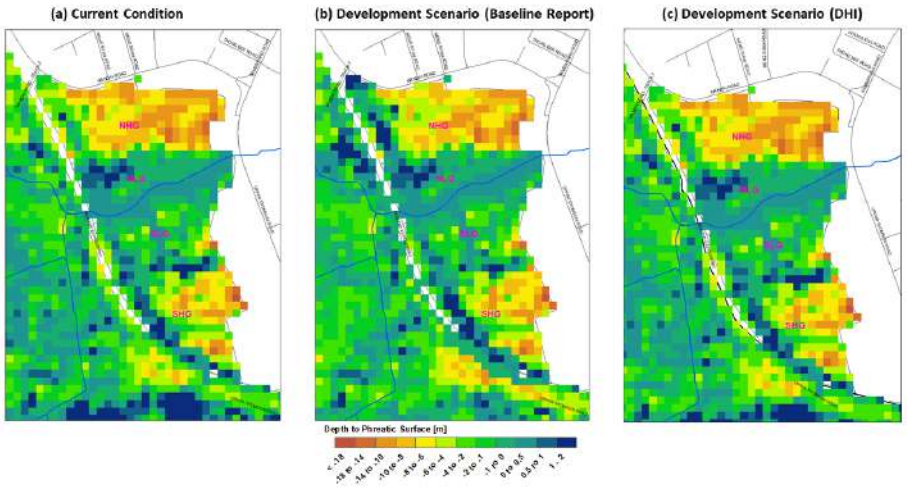


Figure 6-19 Groundwater table maps of Springleaf only, averaged over 2017: Simulation-1 Scenario (Present Climate) (image credit: NUS)

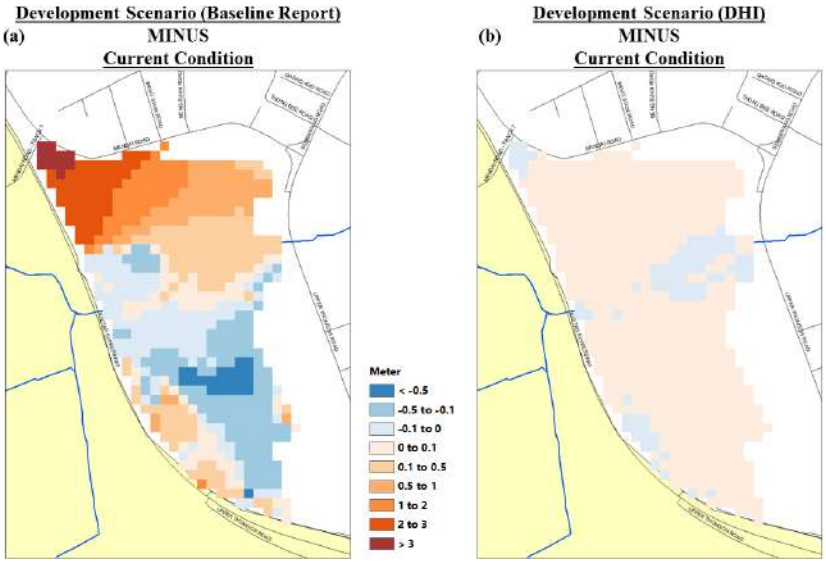


Figure 6-20 Difference map of groundwater table of Springleaf, Simulation-1 Scenario (Present Climate) (image credit: NUS)

There is uncertainty around what future climate change rainfall conditions will occur in Singapore, since it depends on how effectively international carbon abatement strategies are implemented. NUS tested two possible climate change scenarios based on future climate projections taken from the Regional Climate Model – WRF. The scenarios assume the proposed Springleaf Precinct Master Plan is implemented in full and shows water levels could:

- Drop by on average 1.26 m across the whole catchment compared to present conditions assuming a low rainfall and high reservoir level climate change scenario.
- Rise by on average 0.12 m across the whole catchment compared to present conditions assuming a high rainfall and high reservoir level climate change scenario.

Irrespective of how the proposed Springleaf Precinct Master Plan is implemented, the results highlight the potentially significant influence future climate change could play on the water table across the site (Figure 6-21). Therefore, any measures to retain or supplement groundwater on site are likely to be beneficial over the longer term.

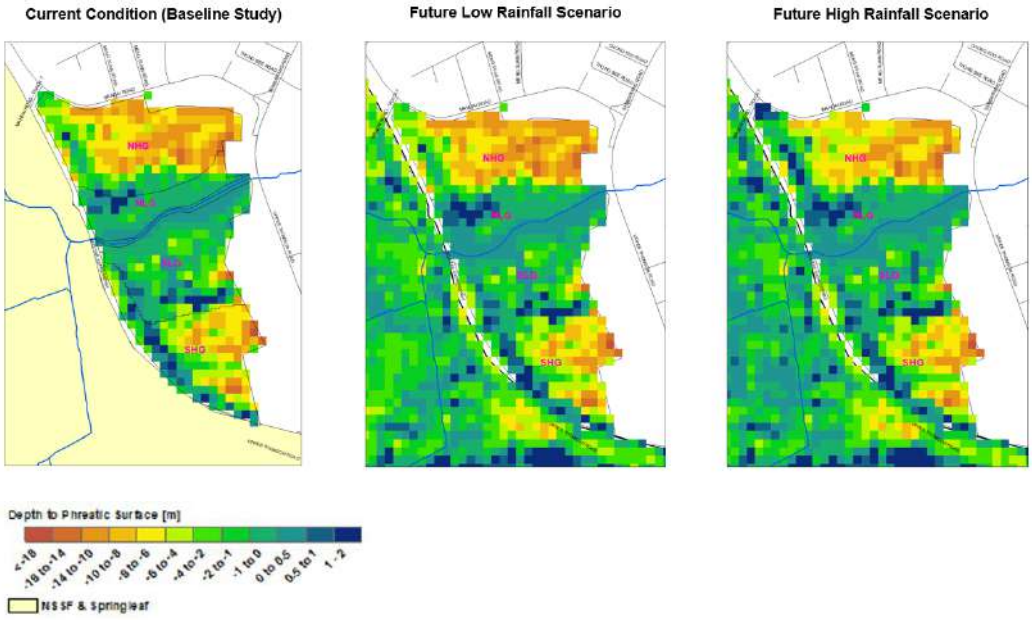


Figure 6-21 Predicted water level changes under future climate change low and high rainfall scenarios (image credit: NUS)

Freshwater Swamp Forest

Simulations and modelling of groundwater tables revealed that the proposed development, with its proposed hydrological mitigation measures implemented, would only result in negligible changes to groundwater levels within Springleaf catchment. Moreover, the absence of development within the freshwater swamp forest, given its protection within the Core Conservation Area, helps to greatly limit the predicted impact magnitude and significance during the post-construction phase (Table 6-18). Within the adjacent development parcels, the adoption of mitigation measures in the form of Biodiversity Sensitive Urban Design principles, PUB's ABC Waters features, and the blue-green requirements in the proposed Springleaf Precinct Master Plan, also help to minimise surface runoff and maximise groundwater recharge, further limiting the impacts to groundwater levels within the freshwater swamp forest habitat post construction.

In contrast, the predicted magnitude and significance of impact to groundwater levels would be larger in the shorter term, during the construction stage (Table 6-17), given that the cut-and-cover excavation works for underground facilities such as carparks and utilities in Springleaf would be likely to require dewatering systems to be implemented to depress the groundwater table to allow construction in dry conditions. This will potentially cause the groundwater table outside the excavation zone to also be lowered, although the spatial extent of groundwater drawdown is difficult to predict, and would depend on the permeability of the various soil layers, as well as the type of dewatering system eventually implemented.

Naturalised Stream

Given that the simulations and modelling of groundwater tables showed negligible changes to groundwater levels across the entire NSSF and Springleaf Catchments, the predicted magnitude and significance of a lowered groundwater table and reduced baseflow to the naturalised stream, post construction and with adoption of mitigation measures, is predicted to be minimal (Table 6-18).

Central Catchment Nature Reserve (Nee Soon Swamp Forest)

Across the broader NSSF catchment area, the potential for dewatering systems installed in Springleaf during construction to lower the groundwater table is expected to be much reduced (Table 6-17), given the physical distance, as opposed to the proximity of the freshwater swamp forest within Springleaf.

Post construction, the impacts to groundwater levels within NSSF catchment, with adoption of mitigation measures, is also predicted to be minimal (Table 6-18), in concurrence with the groundwater modelling and simulation results.

Lower Seletar Reservoir

During the construction stage, the potential for dewatering systems installed in Springleaf to affect the groundwater supply to Lower Seletar Reservoir is limited, given that the catchment area of the reservoir is much broader and includes many other tributaries and groundwater sources (Table 6-17).

Post construction, the impacts to groundwater levels within Lower Seletar Reservoir is also predicted to be minimal with adoption of mitigation measures, reflecting the results from groundwater modelling and simulation for the combined NSSF and Springleaf catchments (Table 6-18).

6.2.3.3 Change in Water Quality

A study has been conducted by Song *et al.* (2019) for a large-scale monitoring of 12 key water quality parameters of suspended solids, nutrients, and heavy metals for stormwater runoff in urban discharges from nine urban land uses with varying sizes in Singapore. It was found that, in general, the average of the event mean concentrations for total nitrogen, total phosphorus, total organic carbon, total suspended solids, and phosphate in parkland land use were higher than the other eight studied land uses. Particularly, there was significant correlation between TSS and most of the other tested water quality parameters in all land uses.

The exposed soil from excavated activities and various construction materials will be carried by the excess rainwater, forming surface runoff during rainfall. The surface runoff may contain turbidity, debris, refuse, oil and grease and other contaminants such as hazardous substances/chemical/diesel spillages that may impact the water quality in nearby watercourses. Surface runoff from the site may contain elevated quantities of suspended solids and contamination content that may entail negative impact to the water quality, if they enter the receiving waterbodies.

Table 6-15 The average of the event mean concentrations (EMCs) for water quality parameters

Land Use	Mixed	Resid-ential	Food Centre	Business District	Car Workshop	Industry	Resid-ential Road	Major Road	Parkland
TN	1.85 (0.13)	1.16 (0.21)	0.93 (0.20)	1.08 (0.15)	1.56 (0.35)	1.61 (0.23)	1.11 (0.15)	1.14 (0.19)	3.02 (0.37)
TP	0.17 (0.02)	0.07 (0.01)	0.08 (0.02)	0.09 (0.02)	0.07 (0.02)	0.12 (0.02)	0.13 (0.01)	0.05 (0.01)	0.31 (0.03)
PO_4-P	0.03 (0.001)	0.02 (0.001)	0.02 (0.01)	0.02 (0.001)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.01 (0.001)	0.14 (0.01)
NO_3-N	0.72 (0.06)	0.59 (0.17)	0.38 (0.12)	0.58 (0.13)	0.78 (0.18)	0.61 (0.19)	0.29 (0.08)	0.52 (0.11)	0.75 (0.10)
NH_4-N	0.27 (0.07)	0.10 (0.02)	0.19 (0.04)	0.07 (0.01)	0.14 (0.02)	0.42 (0.12)	0.11 (0.01)	0.15 (0.03)	0.24 (0.04)
TSS	112.07 (13.70)	31.92 (4.66)	17.23 (4.70)	50.84 (6.68)	37.67 (11.89)	35.57 (5.53)	142.76 (32.68)	23.84 (4.37)	147.34 (35.30)
TOC	2.04 (0.31)	0.98 (0.11)	1.08 (0.14)	1.50 (0.36)	1.97 (0.32)	2.03 (0.45)	2.33 (0.65)	2.26 (0.24)	4.16 (0.18)
Zn	0.20 (0.03)	0.06 (0.01)	0.20 (0.05)	0.45 (0.07)	0.23 (0.05)	0.38 (0.07)	0.21 (0.06)	0.13 (0.03)	0.18 (0.08)
Cu	0.02 (0.00)	0.01 (0.00)	0.01 (0.00)	0.03 (0.01)	0.02 (0.001)	0.09 (0.03)	0.02 (0.01)	0.02 (0.001)	0.12 (0.05)
Fe	1.88 (0.32)	1.43 (0.30)	0.41 (0.07)	1.24 (0.18)	0.94 (0.24)	1.89 (0.36)	3.00 (1.13)	0.68 (0.19)	0.65 (0.34)
Mn	0.05 (0.01)	0.02 (0.001)	0.02 (0.001)	0.04 (0.01)	0.02 (0.001)	0.04 (0.01)	0.04 (0.01)	0.02 (0.001)	0.02 (0.01)
Ni	0.004 (0.004)	0.003 (0.0001)	0.003 (0.0001)	0.004 (0.0003)	0.004 (0.0006)	0.01 (0.002)	0.004 (0.0004)	0.007 (0.002)	0.005 (0.0007)
n	8	8	6	8	8	8	8	8	4
s	89	86	61	90	75	86	89	80	39

Note: Number in brackets means the standard error, "n" is the number of sampling events and "s" is the number of total samples at each sampling site. TN: total nitrogen, TP: total phosphorus, TSS: total suspended solids, TOC: total organic carbon.

With any developments, there is a change in surface runoff water quality parameters compared to the existing undeveloped condition. Increased concentrations of some parameters such as suspended solids, nitrogen and phosphorous not only affect the water but also impair the health of aquatic organisms through reduced dissolved oxygen from increased turbidity and likelihood of algae blooms. The use of carefully-designed ABC Waters features is a tried-and-proven method in Singapore to manage the stormwater runoff quality before entering waterways and waterbodies.

For typical design of the ABC Waters features (e.g. typical ranges for extended detention depth, filtration medium thickness and hydraulic conductivity) the performances of the proposed ABC Waters features can be checked against the treatment performance curves for total suspended solid (TSS), total phosphorus (TP) and total nitrogen (TN) found in PUB's Condensed Booklet on Engineering Procedures for ABC Waters Design Features. Should the ABC Waters features deviate significantly from the typical design that were used to develop the treatment performance curves, the developer shall then do additional analysis to verify the overall treatment performance of the ABC Waters features treatment train, which will then be subject to approval from PUB.

The first flush is the initial surface runoff during a storm event and usually contains a more concentrated water pollution compared to the remainder of the rain event. Therefore, the designer shall consider measures to manage contaminants and debris from the first flush of stormwater at the upstream source. The proposed measures shall consider the ease of maintenance of these measures to ensure efficiency of the solution and to prevent any likelihood of stagnant water.

Freshwater Swamp Forest

It is likely that the runoff coefficient will increase within the developed area due to some paving and compaction resulting in the faster flow velocity mobilising more sediments and nutrients in the water.

The study by Song *et al.* (2019) found that event mean concentrations of TSS, TN and TP from mixed use, residential and parkland land uses can be at a level where some form of water quality treatment would be necessary to protect the downstream freshwater swamp forest, especially for TSS concentration.

It should be noted however that the Baseline Survey by NUS (2018) found that the average concentrations of TSS (4 mg/L), TN (0.8 mg/L) and TP (1 mg/L) are already relatively high within the secondary forest and it is possible that the nutrients provide some beneficial function. Therefore, it may not be necessary to treat the water to for example drinking water standard. Instead, sensibly positioned and sized ABC Waters features, as have been recommended in the proposed Springleaf Precinct Master Plan, will provide benefit by allowing a suitable level of natural treatment.

Naturalised Stream

The study by Song *et al* (2019) found that event mean concentrations of TSS, TN and TP from mixed use, residential and parkland land uses can be at a level where some form of water quality treatment would be necessary to protect the Sungei Seletar water quality.

It should be noted however that the Baseline Survey by NUS (2018) found that the average concentrations of TSS (3 mg/L), TN (0.3 mg/L) and TP (1 mg/L) are already relatively high within the Sungei Seletar. Therefore, it may not be necessary to treat the water to for example drinking water standard. Instead, sensibly positioned and sized ABC Waters features, as have been recommended in the proposed Springleaf Precinct Master Plan , will provide benefit by allowing a suitable level of natural treatment. The proposed Springleaf Precinct Master Plan does not include any provision for recreational use of the waterway but these type of standards may be something to aim for after treatment through the ABC Waters features as there is also the Springleaf Nature Park downstream.

Odonates and Freshwater Organisms

Cai *et al*, (2018) found water with high ORP reading, water with low pH value helped explained the low diversity and richness of the odonate community in most of Nee Soon freshwater swamp forest, while presence of pool habitats, substrate with more silt, less sand, less overhanging root in stream bank, high heterogeneity of riparian vegetation and the wider channel partially explained the high diversity level of odonates in the outskirts and open areas of the Nee Soon freshwater swamp forest.

The inter-relationships between the water quality and ecology are complex. It is sensible to minimise any local changes to the water quality as put forward for Springleaf Precinct. The design of the ABC Waters features should ensure that any discharge to the stream should be at a similar water quality level.

Lower Seletar Reservoir

The study by Song *et al.* (2019) found that event mean concentrations of TSS, TN and TP from mixed use, residential and parkland land uses can be at a level where some form of water quality treatment would be necessary to protect the Sungei Seletar water quality.

It should be noted however that the Baseline Survey by NUS (2018) found that the average concentrations of TSS (3 mg/L), TN (0.3 mg/L) and TP (1 mg/L) are already relatively high within the Sungei Seletar that feeds the Lower Seletar Reservoir. Therefore, it may not be necessary to treat the water to for example drinking water standard as PUB also has

treatment processes for the reservoir water. Instead, sensibly positioned and sized ABC Waters features, as have been recommended in the proposed Springleaf Precinct Master Plan, will provide benefit by allowing a suitable level of natural treatment.

6.2.3.4 Change in Soil Quality

Freshwater Swamp Forest

During the site clearance of the construction, tree-felling and removal involve removing of underground roots that will lead to soil disturbance and surface change. This will potentially increase the risk of soil erosion which may affect the freshwater swamp forest downstream. Soil along the stream is soft and waterlogged and will be more impacted by erosion.

Slope failure is not considered a risk during clearing phase as the steepest natural slopes on site are relatively low gradient. Depending on the design slope and construction sequence, there is potential risk of slope failure during earth works and other construction activities, especially from deep excavation works. After construction completes, it is anticipated that design slopes will be of sufficient gradient as to minimise risk of slope failure. Design slopes will be vegetated or otherwise covered to minimise erosion impacts which may ultimately result in downstream siltation.

In Singapore's context, it is required by law that ECM has to be designed and signed off by a Qualified Erosion Control Professionals (QECP), and Earth Retaining or Stabilising Structure (ERSS) have to be designed and submitted to BCA by a Qualified Person (QP) for slope greater than 1.5 m depth. As for depth less than 1.5 m, good practice in construction requires contractor to implement temporary measures to control soil erosion and slope stability. In addition, it is also required that Professional Engineer (PE Geo) to be engaged for design and BCA submission on temporary and permanent earth retaining structures for steep slopes, particularly for the slope cutting. There are reasonable opportunities for prevention and mitigation of slope failure and soil erosion. Soil erosion will stop when the site is changed to designed contours.

It is very likely that the runoff coefficient will increase within the developed area due to some paving and compaction and the faster flow velocity of stormwater runoff can mobilise more sediments in the water and potentially cause scouring. This can also happen through a change in soil type and condition if for example new soil is imported for building or landscaping purposes within the site. The freshwater swamp forest is sensitive in that the water is often stagnant and silts and organic materials settle out and accumulate, characterising the conditions. If more turbulent flows are created this can disturb the sediment and change the water quality characteristics, with potential flow on effects to the aquatic ecology.

The proposed ABC Waters features within the commercial and residential areas as well as bioretention swales and rain gardens within the buffer zone provide an effective way to detain, cleanse and percolate water to the swamp forest. Studies in Punggol East have shown that the runoff coefficient with and without ABC Waters units deployment were in the order of 0.68 and 0.86 respectively, with clear downstream benefits in terms of reducing initial runoff volume and velocity and lower the risk of scouring. Except during extreme stormwater events the majority of runoff will be directed to the freshwater swamp forest through percolating into the soil.

6.2.4 Mitigation Measures

There are avoidance, minimisation and offsets proposed to protect the hydrology during design, construction and post-construction phases as presented in Table 6-16.

Table 6-16 Hydrology mitigation measures by hierarchy type proposed at each phase of development

Stage	Hierarchy	Mitigation Measures
Design	Avoidance	• Nil
	Minimization	• Within the development areas, guidelines will be put in place stipulating maximum areas of hard paved areas allowed, requiring much of the ground to be green or porous, to minimise surface runoff and maximise groundwater percolation. • Tree Cottages, which are low rise apartments on stilts, raised sufficiently high above ground to maintain minimal disruption to the ground cover, allowing for some groundwater percolation. • Each development parcel will have its own ABC Waters network utilising a mix of bio-retention swales and rain gardens. • ABC Waters features to be unlined except where permanent water intended. • Erosion control measures should be designed to minimise any impact to the freshwater swamp forest, with no direct discharge to the sensitive ecological areas.
	Restoration	• Nil
	Offsets	• ABC Waters swales are proposed within the 30 m buffer zone at the south, to act as a 'protective moat' around the core areas of the site, to intercept, cleanse and percolate run-off from the development parcels on higher ground. • The Art Park will be a permanent waterbody with capacity to hold any excess stormwater runoff.
Construction	Avoidance	• All chemicals and fuels must be properly labelled. • No refueling or equipment maintenance near waterbodies. • Adequate number of portable sanitary facilities located far away from any waterbodies to be provided according to relevant regulations and managed by a licensed third party. • All chemicals and fuels used during construction activities shall be properly stored in designated containers and location and bunded concrete paved area far away from any waterbodies. • No waste shall be disposed outside designated waste bins and on unpaved ground or near any water bodies. • All waste onsite shall be kept in designated waste containers and bunded concrete paved areas far away from any waterbodies.
	Minimization	• Slopes, particularly slopes that face down towards the freshwater swamp, should be stabilized to reduce erosion risk. • Re-vegetate exposed ground as soon as possible to stabilise surfaces and minimise re-entrainment of dust and potential for erosion of waste spoil to watercourses. • Minimise the area of exposed ground, and the volume of soil and construction material handled at any one time by properly scheduling the construction activities (such as demolition works, earthworks and building construction). • Before construction work commences, ECM proposal duly designed and endorsed by appointed Qualified Erosion Control Professional (QECP) shall be submitted to PUB in accordance with PUB requirements, and copied to the Developer.

Stage	Hierarchy	Mitigation Measures
		• No construction works shall commence without adequate ECM facilities to ensure no discharge containing TSS in concentration greater than the prescribed limits throughout the project, especially during the site clearance stage. • Clean stormwater runoff water may be used to replenish the Swamp Forest. • Unclean (ie. turbid) stormwater runoff can be detained and percolated through the soil but should not be directly discharged overland into the Swamp Forest. • The used water from the washing bay should be collected and then be re-used in the washing facility or disposed of after being treated by ECM. • A TSS meter and CCTV camera should be installed at the entrance to any public drains on-site. This is to ensure that parameters of any discharged water are below allowable limits for discharge to public drainage or watercourse, or within permissible levels in any approval letter. • Equipment such as generator sets and diesel day tank to be bunded to capture and control oil, grease and other spills. • All diesel storage to be contained and with capacity of at least 115% or more than the volume of diesel storage • All spill containment facilities and spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Provide spill kits in case of a leak or spill of a chemical within the contract boundary. • All spills must be cleaned within the same day or immediately under wet weather conditions. • All the waste shall be collected at least every 5 days by licensed waste collector. • Discharge of pumped dewatered groundwater from excavations to the NSSF or Freshwater Swamp Forest is strictly prohibited. • Pumped dewatered groundwater shall not be disposed to the ECM treatment plant; discharge shall either be to temporary storage tanks for removal by third party licensed wastewater collector; or to a temporary treatment system prior to discharge to a discharge point agreed with PUB. • Regularly monitor the groundwater levels at the locations determined as required via geotechnical design to detect any drawdowns in groundwater tables early • Limit potential groundwater drawdown and subsequent water level impacts during any excavation, e.g. use groundwater recharge wells as necessary during excavation and dewatering works. • The method to limit groundwater drawdown shall be provided as part of the EMMP and extent determined by geotechnical design. • For all locations with excavation of depth near or deeper than groundwater level, an environmental baseline borehole shall be installed in the middle of the area where excavation will be carried out and the groundwater and soil of each locations be tested against the Dutch Intervention and Target Standards. • Post-construction, breach excavation support walls or retaining walls to allow movement of groundwater to recharge the groundwater table
	Restoration	• Based on borehole water level monitoring, in the case that the water table level drops below baseline levels in or around the Significant Conservation Areas during dewatering activities then

Stage	Hierarchy	Mitigation Measures
		Contractor shall supplement through recharge of the groundwater with suitable quality water.
	Offsets	• Nil
Operation and Maintenance	Avoidance	• Nil
	Minimization	• ABC Waters features to be regularly inspected and maintained.
	Restoration	• Nil
	Offsets	• Nil

6.2.5 Assessment Ratings

Based on the analysis the impact assessment scoring has been completed and is presented in Table 6-17 for construction phase impacts and Table 6-18 for post-construction impacts.

Table 6-17 Construction stage impact assessment for hydrological impacts on sensitive receptors. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Change in surface drainage	Freshwater swamp forest	5	-2	2	3	2	-70	Minor Negative	-1	-35	Slight Negative
	Naturalised stream	4	-2	2	2	2	-48	Minor Negative	-1	-24	Slight Negative
	Odonates and freshwater organisms	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative
	Central Catchment Nature Reserve	5	-1	2	3	2	-35	Slight Negative	0	0	No Impact
	Lower Seletar Reservoir	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
Change in groundwater levels	Freshwater swamp forest	5	-2	2	2	3	-70	Minor Negative	-1	-35	Slight Negative
	Central Catchment Nature Reserve	5	-1	2	2	3	-35	Slight Negative	-1	-35	Slight Negative
	Lower Seletar Reservoir	4	-1	2	2	3	-28	Slight Negative	-1	-28	Slight Negative

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Change in water quality	Freshwater swamp forest	5	-2	2	3	2	-70	Minor Negative	-1	-35	Slight Impact
	Naturalised stream	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
	Odonates and freshwater organisms	3	-1	2	2	2	-18	Slight Negative	0	0	No Impact
	Lower Seletar Reservoir	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
Change in soil quality	Freshwater swamp forest	5	-1	2	3	2	-35	Slight Negative	0	0	No Impact

Table 6-18 Post-construction impact assessment for hydrological impacts on sensitive receptors. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Change in surface drainage	Freshwater swamp forest	5	-2	2	3	2	-70	Minor Negative	0	0	No Impact
	Naturalised stream	4	-2	2	2	2	-48	Minor Negative	0	0	No Impact
	Odonates and freshwater organisms	3	-1	2	2	2	-18	Slight Negative	0	0	No Impact
	Central Catchment Nature Reserve	5	-1	2	3	2	-35	Slight Negative	0	0	No Impact
	Lower Seletar Reservoir	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
	Freshwater swamp forest	5	-3	3	3	3	-135	Major Negative	-1	-45	Minor Negative

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Change in groundwater levels	Naturalised stream	4	-1	2	2	3	-28	Slight Negative	-1	-28	Slight Negative
	Central Catchment Nature Reserve	5	-2	3	3	3	-90	Moderate Negative	0	0	No Impact
	Lower Seletar Reservoir	4	-1	3	3	3	-36	Slight Negative	0	0	No Impact
Change in water quality	Freshwater swamp forest	5	-2	2	3	2	-70	Minor Negative	-1	-35	Slight Negative
	Naturalised stream	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
	Odonates and freshwater organisms	3	-1	2	2	2	-18	Slight Negative	0	0	No Impact
	Lower Seletar Reservoir	4	-1	2	2	2	-24	Slight Negative	0	0	No Impact
Change in soil quality	Freshwater swamp forest	5	-1	2	3	2	-35	Slight Negative	0	0	No Impact

6.3 Noise and Vibration

This section presents the analyses and assessment of impacts related to noise and vibration generating from the construction phase of the project. No sound- or vibration-intensive activities are anticipated for operation phase of this development.

6.3.1 Evaluation Framework

Noise impact on the nearby human receptors and fauna in the Core Conservation Area and Significant Conservation Area is anticipated from the construction activities. Depending on the receptors' sensitivity, NEA has set out criteria for different type of receptors. The criteria stated in NEA's Environmental Protection and Management (Control of Noise at Construction Sites) Regulations is listed below (Table 6-19 and Table 6-20).

Table 6-19 Maximum Permissible Noise Levels for Construction Site – Weekday (Monday to Saturday)

Types of Affected Buildings	Maximum Permissible Noise Levels dBA		
	7 am - 7 pm	7 pm - 10 pm	10 pm - 7 am
(a) Hospitals, schools, institutions of higher learning, homes for the aged sick	60 (Leq 12 hrs)	50 (Leq 12 hrs)	50 (Leq 12 hrs)
	75 (Leq 5 mins)	55 (Leq 5 mins)	55 (Leq 5 mins)
(b) Residential buildings located less than 150 m from the construction site	75 (Leq 12 hrs)	65 (Leq 1 hr)	55 (Leq 1 hr)
	90 (Leq 5 mins)	70 (Leq 5 mins)	55 (Leq 5 mins)
(c) Buildings other than those in (a) and (b) above	75 (Leq 12 hrs)	65 (Leq 12 hrs)	65 (Leq 12 hrs)
	90 (Leq 5 mins)	70 (Leq 5 mins)	70 (Leq 5 mins)

Table 6-20 Maximum Permissible Noise Levels for Construction Site – Sunday and Public Holidays

Types of Affected Buildings	Maximum Permissible Noise Levels dBA		
	7 am - 7 pm	7 pm - 10 pm	7 am - 7 pm
(a) Hospitals, schools, institutions of higher learning, homes for the aged sick	60 (Leq 12 hrs)	50 (Leq 12 hrs)	50 (Leq 12 hrs)
	75 (Leq 5 mins)	55 (Leq 5 mins)	55 (Leq 5 mins)
(b) Residential buildings located less than 150m from the construction site	75 (Leq 12 hrs)	65 (Leq 1 hr)	55 (Leq 1 hr)
	75 (Leq 5 mins)	55 (Leq 5 mins)	55 (Leq 5 mins)
(c) Buildings other than those in (a) and (b) above	75 (Leq 12 hrs)	65 (Leq 12 hrs)	65 (Leq 12 hrs)
	90 (Leq 5 mins)	70 (Leq 5 mins)	70 (Leq 5 mins)

Note:

1. With effect from 01 September 2010, construction sites within 150 m from residences will not be allowed to work from 10 pm on the night before a Sunday or Public Holiday to 10 am on the day itself.
2. For sites commencing work on or after 01 September 2011, NEA will extend this prohibition to the rest of the day on Sunday and Public Holidays.
3. Correction factor is to be applied for the NSRs where the baseline noise level is higher than the criteria stated in above tables.

The above NEA's criteria focus on managing construction noise impact on humans and may not be appropriate for animals. Animals rely on meaningful sounds for communication, navigation, avoiding danger and finding food against a background of noise. Birds in

particular use auditory signals in species distinction, mating, territorial defence, danger detection, advertisement of food sources, and flock cohesion. Urban, anthropogenic noise such as those produced by cars and machinery are dramatically different from noise in a natural habitat. Such noise is typically louder and lower in pitch. This causes well-documented behavioural changes and physiological responses in birds, and interferes with auditory cues (Ortega 2012). The effects of noise on other species are poorly understood and fauna will perceive noise impacts differently (AMEC Americas Ltd 2005; Office of Planning, Environment & Realty; Eco Logical Australia 2006).

There are no current government policies or other widely accepted guidelines as to noise levels or thresholds of relevance for terrestrial fauna, partly because the effects of noise on most fauna species are poorly understood (Larkin *et al.* 1996, Brown 2001; OSB 2003). Some reasons for the limited understanding of the effects of noise on fauna are as follows:

- Responses to noise disturbance cannot be generalised across species
- Studies of one species cannot be extended to other species
- Responses even of individuals within a single species may vary
- Hearing characteristics are species-specific – e.g. noise impacts on humans are determined using a frequency weighting filter (A-weighting) which corresponds to human hearing characteristics, determined through laboratory testing. The frequency-dependent hearing characteristics of animals cannot be determined in this way
- When studying the effects of noise on animals, it can be difficult to separate noise effects from other sensory disturbing effects (for example, visual or olfactory cues)
- Experimental research in a laboratory is not always applicable in a natural setting

As put forward by various organisations, the noise levels to protect sensitive animal species is recommended to be ideally levels as low as 55 dB, within 100 m from source (The Nature Conservancy, 2015). Further studies have suggested that higher noise levels of around 68 dB may reduce birds' foraging ability and eventually lead them to avoid and abandon the habitat (Ortega, 2012). For this study 60 dB has been taken as a benchmark, given that different species have varied tolerance to anthropogenic noise and noise levels within Springleaf forest already approach these levels due to the SLE and other road traffic, aircraft flight paths and construction nearby (Parris and Schneider, 2008).

Vibration

Guidelines for vibration impact thresholds are available for dealing with human discomfort, and for dealing with structural or cosmetic damage to buildings. In both instances, thresholds are provided in the form of Peak Particle Velocity (PPV), in millimetres per second (mm/sec), which can be defined as the instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position.

Humans are particularly sensitive to vibration with the threshold of perception typically being in the PPV range of 0.14 to 0.3 mm/sec and levels above this may cause annoyance or interfere with work activities, for example delicate procedures in hospital operating theatres. Vibration at higher levels can be described as unpleasant or even painful. BS 5228-2 Code of Practice for Noise and Vibration Control on Construction and Open Sites provides guidance on vibration and its control and management on various site types. The standard also presents details on the human response to vibration and outlines these effects. Vibration propagation from the project's construction activities to nearby receptors is quantified using empirical vibration prediction formulae provided in said standard.

Although rarely happens, vibrations from a construction site can sometimes be sufficiently intense to promote minor damage to nearby structures which in this case include the residential buildings and shop houses to the north and/or east of Springleaf precinct and the Springleaf MRT Station of the Thomson-East Coast Line. For assessing potential structural damage related to the Project, this study employed response limits of buildings from British Standard 7385-2 *Evaluation and Measurement for Vibration in Buildings. Guide to Damage Levels Arising from Groundborne Vibration* (BS 7385-2). Table 6-21 presents frequency dependent threshold levels which are judged to give a minimal risk of vibration-induced damage. BS 7385-2 also notes that the probability of damage tends towards zero at 12.5 mm/s PPV. The more conservative limits that apply to vibration frequencies below 15 Hz are used in this assessment, i.e., 15 mm/s applies to the residential buildings and shophouses.

It should be noted that although impact mechanisms between vibration intensive activities and animals are understood, representative limits based on which significance of impact can be assessed are not available. More discussions are provided in the corresponding impact assessment sections later in this chapter.

Table 6-21 Transient vibration guide values for cosmetic damage

Building type	**Peak component particle velocity in frequency range of predominant pulse**	
	4 Hz to 15 Hz	**15 Hz and above**
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 H z	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Table 6-22 Assessment criteria for magnitude of noise and vibration at environmental sensitive receptors. The guidance levels for vibration are in relation to human's threshold of perception

Score	Generic Criteria	Specific Criteria	
		Noise	Vibration
-4	Major negative disadvantage or change	Noise levels are more than 10 dB(A) above the relevant criteria	≥ 10 mm/s, vibration is likely to be intolerable for any more than a brief exposure
-3	Moderate negative disadvantage or change	Noise levels are between 5 and 10 dB(A) above the relevant criteria	≥ 1 mm/s and < 10 mm/s, vibration will likely cause complaints but can be tolerated if prior warning and explanation is provided
-2	Minor negative disadvantage or change	Noise levels are less than 5 dB(A) above the relevant criteria	≥ 0.14 mm/s and < 1 mm/s, vibration may be just perceptible but complaints unlikely
-1	Slight negative disadvantage or change	Noise levels are at or below the relevant criteria	< 0.14 mm/s, vibration is barely perceptible in the most sensitive situations for most vibration frequencies
0	No change	Status quo	Status quo

6.3.2 Sensitive Receptors

Noise and vibration sensitive receptors (NVSR) typically include birds, reptiles and amphibians, mammals and bats, residents, recreational users, places of worship, education institutions, healthcare facilities, and some vibration-sensitive industries such as semiconductor. Not all of these facility types are present within the vicinity of Springleaf development, for example, sensitive industries. Some other facilities, such as the SAF Medical Training Institute and places of worship, are sufficiently far away to be unaffected by the Project, as far as noise and vibration is concerned.

The noise and vibration influence zones are typically within several hundred meters from an emission source. For the purpose of this assessment, a study area of 200 m around the development footprint is defined. This study extent is typical for noise impact assessment but is on the conservative side for vibration assessment. As shown in Figure 6-22, the receptors that fall within this area include:

- Terrestrial fauna in Springleaf Nature Park – focusing on terrestrial fauna immediately outside development footprint and within the biodiversity sensitive areas as shown in Figure 6-22[4]

[4] Assessment of impacts from the construction phase of the development does not cover receptors whose habitats will be permanently cleared.

- Terrestrial fauna in Central Catchment Nature Reserve (CCNR) – approximately 40 m to the west of the Project
- Residents at Meng Suan Road – 30 m to the north
- Residents at Mandai Road (house 20-38) and at Thong Bee Road – about 100 m to the north
- Occupants of Thong Soon Green shophouses – approximately 80 m to the east
- Recreational receptors at Springleaf Nature Park and Park Connector east of Upper Thomson Road[5] – 50 m to the east (only relevant to noise impact assessment)

It is noted that the future Springleaf MRT Station is located directly adjacent to Parcel 1a. The MRT station is planned to be completed by 2024, which is likely the time construction of the resident and commercial premises in Parcel 1 will start. There might be some concerns over vibration-intensive activities for Parcel 1 causing structural impacts on the newly completed MRT Station. It is however assumed that this issue will be addressed as part of compliance to local engineering standards and codes of practice and is not assessed in this EIA.

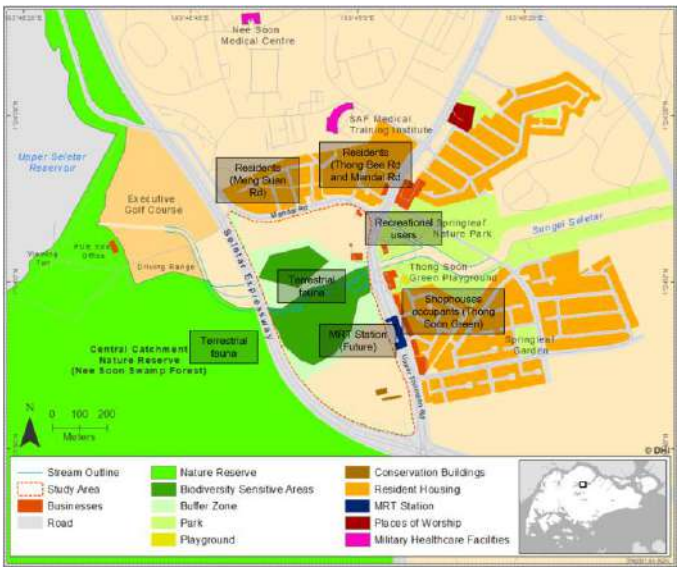


Figure 6-22 NVSRs for the Project

As part of the RIAM framework, 'Importance' scores are to be assigned to the NVSRs, for calculation of overall Environmental Score for each impact. The assessment of the importance of social-economic receptors is guided by the matrix provided in Table 6-21. Importance of biodiversity and ecological receptors is assessed based on the matrix presented in Section 6.1.2.

[5] The part of Springleaf Nature Park to the west of Upper Thomson Road is not open to public.

Table 6-23 Scoring matrix for importance of social-economic receptors to noise and vibration impacts

Score	Generic Criteria	Specific Criteria
5	Important to national/international interests	Receptor locations that are socio-economic assets specifically protected by national or international policies or legislation and are of significance to the livelihoods of the area at regional or national scale.
4	Important to regional/national interests	Receptor locations where more sensitive members of public are exposed for eight hours or more in a day, for example, hospitals, and residential care homes; or locations where vibration impacts likely result in economic consequences, for example semiconductor facilities
3	Important to areas immediately outside the local condition	Receptor locations where members of public are exposed for eight hours or more in a day, for example, residential properties and schools.
2	Important to the local conditions (within a large direct impact area)	Receptor locations where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office, shop workers.
1	Important only to the local condition (within a small direct impact area)	Receptor locations where human exposure is transient, for example public footpath, playing fields, parks.

With the specific criteria established in Table 6-22 and Table 6-21, importance scores have been assigned to the identified receptors as follows.

Table 6-24 Importance scores for noise and vibration sensitive receptors

Noise/Vibration Sensitive Receptors	Importance Scores
Terrestrial fauna in Springleaf forest	5
Terrestrial fauna in Central Catchment Nature Reserve (CCNR)	5
Residents at Meng Suan Road	3
Residents at Mandai Road (house 20-38) and at Thong Bee Road	3
Occupants of Thong Soon Green shophouses	2
Recreational receptors at Springleaf Nature Park and Park Connector east of Upper Thomson Road	1

6.3.3 Pressures and Pathways

Specific details of construction works will not be available until a contractor(s) has been appointed and detailed design has commenced. Therefore, for the purpose of assessing noise and vibration impacts, representative construction activities and worst-case scenarios have been assumed based on typical construction practice for similar projects.

Relevant construction activities to noise and vibration impact assessment are foundation works, particularly land compaction and bored piling, which is required in all the land parcels. Given that sensitive receptors are spatially distributed, several noise and vibration-intensive work locations were assumed as shown in Table 6-1 and Figure 6-23, to ensure conservative assessment for all the identified receptors.

Table 6-25 Assumed bored piling locations and corresponding receptors of concern

Source	Receptor of Concern
P1	Residents at Meng Suan Road Residents at Mandai Road (house 20-38) and at Thong Bee Road
P2	Terrestrial fauna in Springleaf Nature Park
P3	Occupants of Thong Soon Green shophouses Recreational receptors at Springleaf Nature Park and Park Connector outside development footprint
P4	Terrestrial fauna in Central Catchment Nature Reserve

Figure 6-23 Locations of bored piling assumed for vibration impact assessment.

6.3.3.1 Noise Pollution

At this stage there is no detailed construction plan formulated yet. From the anticipated construction activities for the planned development, it is expected that bore piling will cause the most significant noise impact. Thus, estimation of noise impact on the surrounding NSRs was done through calculation, considering a single source of bore piling at the nearest distance from the proposed development to the NSR without any mitigation (i.e. no hoarding). The sound power level (SPW) from bore piling is 115 dBA, with reference to the "Sound Power Levels for Items of Powered Mechanical Equipment (PME)". The sound pressure level (SPL) predicted at various NSRs are presented in Table 6-26.

The results indicate that, when bore piling is being carried out at the worst locations to the respective NSRs, the noise impact without mitigation can be as high as 95 dBA at the nearest NSR, i.e. the Springleaf forest. This only indicates the noise impact from the worst one single source. Other than bore piling, use of other powered mechanical equipment is also expected, e.g. excavator, generators, cranes, compactor etc. When a confirmed construction method is available, including types and number of equipment used and the estimated duration of PME operation, numerical modelling can be carried out for more detailed assessment.

Table 6-26 Estimated Noise Impact from Bore Piling

NSR ID	NSR Description	Distance from construction	SPW at Source (dBA)	SPL at NSR (dBA)
NSR1	Terrestrial fauna in Springleaf forest	10 m	115	95
NSR2	Terrestrial fauna in Central Catchment Nature Reserve	40 m	115	83
NSR3	Residents at Meng Suan Road	30 m	115	85
NSR4	Residents at Mandai Road (house 20-38) and at Thong Bee Road	100 m	115	75
NSR5	Occupants of Thong Soon Green shophouses	80 m	115	77
NSR6	Recreational receptors at Springleaf Nature Park and Park Connector to the east of the study area	50 m	115	81

Native Fauna

The potential effects of noise on terrestrial fauna include physical damage to hearing organs, increased energy expenditure or physical injury while responding to noise, interference with normal animal activities, and impaired communication. The ongoing impacts of these effects can include habitat loss through avoidance, reduced reproductive success and increased mortality. Some fauna become stressed by noise, which can affect foraging or breeding, or they may leave an area, whereas other species or populations do not seem to be affected or may adjust to noise over time.

A few species, have adapted to living in cities through phenotypic plasticity – by altering the frequency of their songs to avoid masking, and thrive in cities (Slabbekoorn & Ripmeester, 2008). However, not all birds are capable of such behavioural changes, and

most are negatively affected by anthropogenic noise and will actively avoid sources of such noise. As a result, for example, species diversity and breeding densities of birds are lower along roads and highways, which has repeatedly been linked to traffic load (FHWA, 2017; Slabbekoorn & Ripmeester, 2008).

As far as determining impacts to fauna, the nature of the noise (e.g. high or low pitch; sudden or continuous) needs to be considered as well as the 'loudness' (measured in dB(A)). Many bird species are more sensitive to sudden loud noises rather than continuous noise or noise that builds and fades away.

The construction activities will inevitably affect the neighbouring wildlife in the surrounding forested area. From the above calculations, without any mitigation, construction noise impact during bore piling could be as high as 95 dBA at the immediate surroundings (i.e. 10 m from the bore piling location).

Prior to bore piling, site clearance and earth works will take place. The noise and disturbances from these activities will likely keep most of the animals away from the construction area. The actual distance between the fauna and the construction works may be further. Also, hoardings will be installed along the works boundary which will help act as a physical barrier to screen some noise and contribute to attenuation of the construction noise.

As discussed in Section 6.3.1, though the noise thresholds of various fauna are not well-studied, they can be stressed and show behavioural changes, change in foraging, or impaired auditory ability etc. Noise impact of birds is relatively better studied and the threshold of 60 dB is adopted in this study. As such, significant negative impact is anticipated for the fauna in Springleaf forest compare with the predicted SPL of 95 dBA.

The Central Catchment Nature Reserve (CCNR) is about 40 m away to the west of the proposed development. The SPL at the edge of CCNR contributed from bore piling can be as high as 83 dBA. The edge of CCNR adjacent to the SLE is subjected to higher background noise from the traffic along SLE. The baseline noise measurement at N2 along SLE was recorded to be 65 dBA. Any fauna inhabiting the CCNR near SLE should have adapted to the higher noise level. The predicted noise from bore piling at CCNR (83 dBA) is much higher than the background level (65 dBA), hence significant impact is anticipated for the wildlife in CCNR.

Residents, Recreational Users and Businesses

The houses Meng Suan Road are about 30 m from the proposed development, and those along Mandai Road and Thong Bee Road are about 100 m from the development. The predicted sound levels contributed from bore piling are 85 dBA and 75 dBA respectively. The maximum permissible construction noise at residential receivers on weekdays daytime is Leq 5 mins 90 dBA. The predicted noise level at these NSRs are within the criteria. Depending on the works scheduling and planning, the duration of bore piling works would probably not last for a long duration, and the equivalent noise level over 12 hours may be lower.

The Springleaf Nature Park and Park Connector is at the east of the study area across Upper Thomson Road. Predicted noise impact from bore piling at the recreational receptors at Springleaf Nature Park and the Park Connector is 85 dBA, which complies with NEA's guideline on the maximum permissible construction noise at other receivers on weekdays (Monday to Saturday) daytime of Leq 5 mins 90 dBA.

Predicted noise impact from bored piling at the Thong Soon Green shophouses across Upper Thomson Road is 77 dBA, which complies with NEA's guideline on the maximum

permissible construction noise for other receivers on weekdays (Monday to Saturday) daytime of Leq 5 mins 90 dBA.

Table 6-27 Evaluation of Construction Noise Impact Magnitude

NSR ID	NSR Description	Noise level criteria / Baseline level (dBA)	Predicted SPL at NSR (dBA)	Impact evaluation	Magnitude Score
NSR1	Terrestrial fauna in Springleaf forest	60 / 53	95	Predicted SPL greater than both baseline and criteria by more than 10 dBA	-4
NSR2	Terrestrial fauna in Central Catchment Nature Reserve	60 / 65	83	Predicted SPL greater than both baseline and criteria by more than 10 dBA	-4
NSR3	Residents at Meng Suan Road	90 / 63	85	Predicted SPL greater than baseline but below relevant criteria	-1
NSR4	Residents at Mandai Road (house 20-38) and at Thong Bee Road	90 / 63	75	Predicted SPL greater than baseline but below relevant criteria	-1
NSR5	Occupants of Thong Soon Green shophouses	90 / 65	77	Predicted SPL greater than baseline but below relevant criteria	-1
NSR6	Recreational receptors at Springleaf Nature Park and Park Connector	90 / 53	85	Predicted SPL greater than baseline but below relevant criteria	-1

The prediction of unmitigated construction noise impact on the NSRs is presented above. Mitigation at source should be first considered, such as the use of quieter construction equipment. One can refer to NEA's Guidelines on Quieter Construction Fund for the list of suggested equipment. During construction, boundary hoarding will be installed which will screen some of the noise generated from the construction activities. Temporary sound barriers, noise absorbing materials or extra height can be added to the hoarding to further

reduce noise transmission to the respective NSRs. This should be adopted especially for the fauna inhabiting Springleaf forest. Construction work schedule and operation duration was not accounted for in the prediction of impact, due to limited information available at this stage. However, when planning for the construction noise, administrative mitigation measures such as avoiding prolonged noisy activities and noisy works during night-time, placing noisy equipment away from the work boundary as practical and facing away from the receptors should be adopted.

During operational phase of the development, though noise intensive activities are not likely to take place, increased anthropogenic activities within the development will lead to increased noise level experienced by the wildlife in Springleaf forest, especially at the areas immediate neighbouring the development. Some species may be able to eventually adapt to the noise level, others may leave the area. While this long-term slight impact is difficult to entirely avoid, the future users should learn to appreciate the tranquillity and co-existence with the nature, and not to disturb the wildlife as much as they can.

6.3.3.2 Ground Vibration

Construction activities can cause ground vibrations which spread through the ground and diminish in strength with distance. The resulting vibrating impacts close to the source vary depending on the equipment and methods employed and that felt at remote sensitive receptors depends on the distance of the receptors, and the material properties of the medium through which vibration is propagated. It is assumed for this assessment that vibratory piling or compaction will be adopted for this development, that creates continuous vibration over the construction cycle, i.e., vibratory stimulus is maintained over time. A comparison was made between results of vibratory piling and vibratory compaction activities and the more conservative results are reported here.

Native Fauna

The adoption of substrate-born signalling (i.e. vibrations carried in a substrate) have been extensively studied in a variety of taxa, in the context of recruitment of food, sexual selection, territory defence, predator-prey interactions or navigation. The substrate could be the ground, or a plant leaf or stem, or a spider's web. On the contrary, relatively little is known about how animals detect and are affected by substrate-borne vibration produced by anthropogenic sources. No thresholds have been found to support the assessment of vibration impacts related to this Project on animals within Springleaf forest and CCNR. This section aims to provide some of the evidence gathered from literature that impact pathways and mechanisms between anthropogenic vibration sources and animals.

Amphibians

Amphibians comprise the terrestrial vertebrates most sensitive to vibrations. Anurans (frogs and toads) are known to make advertisement calls which are essential to species recognition, sexual selection and female choice, which directly affects male reproductive success. Some anurans are known to emit seismic signals together with airborne sound. For example, male white-lipped frogs use seismic signals for intraspecific communication and the signals have sufficient amplitude to be sensed easily by another frog several meters away. Anurans' seismic communication channel could be cluttered with anthropogenic interferences.

The presence of anthropogenic noise and vibration sources nearby may affect the anuran community at biodiversity sensitive areas within Springleaf in several ways. The most direct consequence is local dispersal of amphibian species in Springleaf forest. Other effects are related to anurans' reproductivity.

Reproduction usually depends on a female frog's ability to respond correctly to the advertisement signals of a conspecific male. Female anurans exhibit movement, i.e., phonotaxis, towards male choruses, and anthropogenic noise and vibration may impair an individual ability to detect and respond to advertisement call, affecting mate attraction.

Substrate vibration can also impact calling activity of male anurans. Call activity not only attracts mates but also predators and substrate vibration can signal imminent predation danger. Male anurans could perceive the unknown vibration cue as a predator approach and thereby reduce or cease calling activity to reduce the chance of being located by the predator.

A study conducted in 2017 demonstrated a clear negative effect of anthropogenic vibrations on anuran communication (Caorsi, 2019). A tactile sound transducer was buried in the natural habitat of a population of midwife toads (*Alytes obstetricans*) in Somiedo Natural Park of Spain to emit simulated vibrations from two anthropogenic activities: road traffic and wind turbines. The scientists then measured parameters important for reproductive success: call rate, call duration and dominant frequency. It was found that call rate by male midwife toads was at its maximum during no-stimulus periods, decreased during synthetic emission – as a control for the acoustic properties of the stimuli – and reduced further during playback of actual recordings of traffic and wind turbine vibrations. The experiments revealed anthropogenic vibratory stimuli caused a strong reduction on the calling activity in focal males, decreasing their mean call rate by 50% in relation to that in absence of anthropogenic vibrations.

Reptiles

There is no documentation of snakes' ability to emit vibration signal as some anurans were found to be able to. Snakes however have an acute vibration sensitivity that may be used for communication and detection of predators and prey. Although lack of both an outer ear and a tympanic middle ear which allow most tetrapods ability to hear sound pressure in air, snakes hear through their inner ear. With their heads on the ground, snakes pick up incoming seismic/vibration wave through their lower jaws. These vibrations are then transmitted directly into the inner ear by means of a chain of bones attached to the lower jaw.

One study confirmed that snakes can detect aerial sound, but their sound-pressure sensitivity of the studied python is poor and limited to low frequencies (80 to 160 Hz) (Bech Christensen *et al*, 2012). Their sensitivity decreased at higher frequencies, falling from 78 dBre, 20 mPa at 160 Hz to 96 dBre, 20 mPa at 800 Hz. The study also concluded that pythons do not hear sound pressure *per se*, but instead use their vibration sensitivity to detect airborne sound via sound-induced head vibrations.

Little is documented in literature about how construction sites may impact the reptile community in their vicinity. However, with vibrations emitted from piling or land compaction work likely being in the range of frequencies that snakes are sensitive to, construction activities for Springleaf Precinct are expected to create some avoidance behaviour among reptiles during the construction period. That means snakes and other reptiles in Springleaf forest may temporarily leave the area for CCNR where much less disturbance is felt.

Mammals and Bats

Vibration also plays a role in communication between other animal species, apart from anurans and snakes that were discussed in the previous sections, ranging from insects to elephants. Vibration is important in predator–prey interactions, mother and young relationships, mate choice, and recruitment of food. For example, blind subterranean mole rats, *Spalax ehrenbergi*, process sensory information from vibrations produced by their head-banging neighbours through a somatosensory channel that is independent of the

auditory mechanism. They also lay their jaws against their burrow walls in a behaviour that appears to enhance bony conduction of vibrations to their inner ears. No specific information is found regarding utilization of vibration signals in social behaviour or survival of pangolin and mousedeer found in the study area.

In terms of effects of vibration, anecdotal reports include a reduction in mouse breeding efficiency in rodent breeding colonies, reductions in food intake and weight gain, and behavioural modifications. In other animals, low-level whole-body vibration can induce stress, alter behaviours (avoidance is one) and result in physiological changes (Norton, 2011). Norton *et al* examined vibration caused by various construction equipment and evaluated them relative to resonance frequency ranges and sensitive frequency ranges of humans, rats and mice. It was found that the construction vibration sources generated vibration in frequency ranges that are more likely to affect rats and mice as compared with humans and construction vibration likely would affect mice more than humans.

In general, mammals within Springleaf forest are expected to experience temporary stress and express short-term avoidance behaviour in response to vibration emitted from the construction of Springleaf Precinct. The extent of this is not known in absence of sensitive and resonance thresholds relevant to the species found here.

With the said effects from construction vibration on the various ecological receptors and that the predicted vibration level at the biodiverse area within Springleaf forest is high, the magnitude of impact on terrestrial fauna here is assessed to be major (-4). It is noted that the predicted PPV at CCNR is corresponding to a magnitude score of -3, i.e., a 'Moderate Negative Change' on humans. However, assessing vibration impact on fauna based on sensitive and resonance thresholds of human might warrant an understatement of the impact level given the evidence related to laboratory mice discussed earlier. The conservative magnitude score is therefore used instead, corresponding to a 'Major Negative Change'.

Table 6-28 Conservative prediction of ground borne vibration levels within Springleaf and Central Catchment Nature Reserve

Receptors	Distance from source (m)	50th percentile PPV (mm/s)	95th percentile PPV (mm/s)	Magnitude score
Terrestrial fauna in Springleaf	8	4.9	21.0	-4
Terrestrial fauna in Central Catchment Nature Reserve	80	0.3	1.4	-4

Residents and Businesses

Table 6-29 tabulates the conservative predictions of 50th and 95th percentile ground borne vibration levels at the residential and commercial receptors within the vicinity of the development area. On an average day, the vibration levels created by the project are estimated to be around the perception threshold of humans, i.e., 0.3 mm/s, and likely will not result in complaint. The predicted 95th percentile values are however just into the range that will likely cause complaint from the community, i.e., 1.0 mm/s. These levels can often be tolerated if prior warning and explanation are given to the community. It should be noted that these values are likely exceeded for only 5% of the time. For conservative assessment of significance of impact, magnitude scores are assigned based on 95th percentile resultant PPV.

Table 6-29 Conservative prediction of ground borne vibration levels at nearby residential premises and shophouses. Magnitude scores are assigned based on predicted 95th percentile PPV

Receptors	Distance to source (m)	50th percentile PPV (mm/s)	95th percentile PPV (mm/s)	Magnitude score
Residents at Meng Suan Road	87	0.3	1.3	-3
Residents at Mandai Road (house 20-38) and at Thong Bee Road	135	0.2	0.7	-2
Occupants of Thong Soon Green shophouses	76	0.3	1.5	-3

In residential accommodation, vibrations can promote anxiety lest some structural mishap might occur. It is however noted that the resultant PPV at all the residents and shop houses are significantly below 12.5 mm/s PPV which has been noted by BS 7385-2 as close to zero probability of damage to buildings.

6.3.4 Mitigation Measures

There are avoidance and minimisation proposed to protect from noise and vibration during design, construction and post-construction phases as presented in Table 6-30.

Table 6-30 Noise and vibration mitigation measures by hierarchy type proposed at each phase of development

Stage	Hierarchy	Mitigation Measures
Design	Avoidance	• Nil
	Minimization	• A 30 m buffer zone around the protected No-Go Zone is designated as a further safeguard, enhancing the protection to the ecologically sensitive core.
	Restoration	• Nil
	Offsets	• Nil
Construction	Avoidance	• Many of the fauna found on site are nocturnal (active at night) or crepuscular (active at dawn and dusk), so works must only commence after 0800HRS and end at 1700HRS.
	Minimization	• Strategic selection of quiet models of construction equipment, i.e., generators, rebar cutting machine, excavators. • Install rubber lining within demolition chutes and enclose the façade of the demolition worksite directed towards nearby receptors with acoustic curtains, where possible. • Limit the number of equipment operating concurrently on site or switch to a quieter model where applicable. • Turn noisy equipment off when not in use. • Undertake spot checks of construction equipment to ensure that equipment is operating within its noise specification. • In sensitive areas, noise barriers should be erected between the construction site and the residential or forested areas.

Stage	Hierarchy	Mitigation Measures
		• Erect temporary noise barriers of at least STC20 around smaller worksites where noisy activities to be carried out over a short-term period, e.g., concreting or road breaking. • Substitution with less intrusive equipment/method or isolation of vibration source from any connected structures and control the spread of vibration. • Vibration cut-off trenches can be used to stop the vibration spread. • Lowering energy inputs per blow and reducing resistance to penetration with for example pre-boring, mudding in or adding water.
	Restoration	• Nil
	Offsets	• Nil
Operation and Maintenance	Avoidance	• Many of the fauna found on site are nocturnal (active at night) or crepuscular (active at dawn and dusk), so noisy activities close to the Core Biodiversity should cease between 0800HRS and 1700HRS.
	Minimization	• Nil
	Restoration	• Nil
	Offsets	• Nil

6.3.5 Assessment Ratings

Based on the analysis, the impact assessment scoring has been completed and is presented in Table 6-31 for construction phase impacts and Table 6-32 for post-construction impacts.

Table 6-31 Construction phase impact assessment for noise and vibration on sensitive receptors (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Noise pollution	Native fauna	3	-4	2	2	2	-72	Minor Negative	-3	-54	Minor Negative
	Residents	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative
	Recreational users	1	-1	2	2	2	-6	No Impact	-1	-6	No Impact
	Businesses	2	-1	2	2	2	-12	Slight Negative	-1	-12	Slight Negative
Ground vibrations	Native fauna	3	-4	2	2	2	-72	Minor Negative	-3	-54	Minor Negative

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
	Residents	3	-3	2	2	2	-54	Minor Negative	-2	-36	Slight Negative
	Businesses	2	-3	2	2	2	-36	Slight Negative	-3	-36	Slight Negative

Table 6-32 Post-construction phase impact assessment for noise and vibration on sensitive receptors (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Noise pollution	Native fauna	3	-1	3	2	2	-21	Slight Negative	-1	-21	Slight Negative
Ground vibrations	Native fauna	3	-1	3	2	2	-21	Slight Negative	-1	-21	Slight Negative

6.4 Air and Light

This section presents the analyses and assessment of impacts related to air pollutants generating from the construction phase and light generating from the construction and operation phase of the project. No atmospheric emission intensive activities are anticipated for the operation phase of this development.

6.4.1 Evaluation Framework

Vegetation clearance and probable demolition of existing structures will be undertaken to accommodate the new development. Other construction activities including earthworks, excavations, stockpiling, movement of vehicles and material handling activities which will generate atmospheric emissions of particulates.

Emission from heavy vehicles may also increase the concentration of pollutants such as CO, NO_2 and SO_2. With effect from 1 July 2012, all off-road diesel engines imported into Singapore must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards, according to Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012. These off-road diesel engines include construction machinery (e.g., power generators) which are used during the construction phase. Hence, air emissions from vehicles and equipment will be controlled at source.

The scale of the project works can give some indication on the likelihood of significant dust emissions occurring, although this is also subject to how well the site is managed. The LTA EIA for the Underground Cross Island Line suggests that a significant dust generating construction project may have several of the following characteristics (ERM, 2019):

Demolition:

- Total building volume 20,000 – 50,000 m^3
- Construction material with potential for dust release
- Demolition activities undertaken 10 – 20 m above ground level

Construction:

- Total building volume 25,000 – 100,000 m^3
- Potentially dusty construction material
- On-site concrete batching

Earthworks:

- Total site area 2,500 to 10,000 m^2
- Moderately dusty soil type
- 5 – 10 heavy earth moving vehicles active at any one time
- Total material moved 20,000 tonnes to 100,000 tonnes

Trackout:

- 10 – 50 HDV (> 3.5 t) outward movements in any one day
- Moderately dusty surface material
- Unpaved road length 50 m – 100 m

In terms of night-time lighting, there is a balance between maintaining enough light for the safety of residents and users of the area compared to minimising the light levels to prevent disturbance to crepuscular and nocturnal animals. There are options available beyond just reducing the intensity of light such as using light wavelengths that are wildlife friendly (i.e. orange, 590 nanometers or above (sodium-vapor lamp or LED)). NParks has a Mechanical & Electrical Service Checklist that recommends outdoor lighting for footpaths be maintained at an average of 5 lux with the darkest spot of minimum 1 lux; and for playgrounds average of 20 lux with the darkest spot of minimum 6 lux. On the other hand, the Mandai Park Holdings EIA recommended that night-time target light levels of 0.06 lux for vegetated areas in the immediate vicinity of project components; and 0.33 lux for vegetated areas further away from project components be applied to be as close as possible to baseline levels during a moonless night.

The magnitude of change used for the air and light is presented in Table 6-31, and has been analysed using expert judgement and referenced to other scientific studies.

Table 6-33 Score for magnitude of air quality and light receptors

Score	Generic Criteria	Specific Criteria	
		Air	Light
-4	Major negative disadvantage or change	• Fundamental change to the air quality conditions assessed resulting in long term or permanent change, typically widespread in nature and requiring significant intervention to return to baseline; would violate national standards • Certain or very likely that an incidence will occur under normal operating conditions	• Fundamental change to the night lighting conditions assessed resulting in long term or permanent change, typically widespread in nature and requiring significant intervention to return to baseline; would violate national standards • Certain or very likely that an incidence will occur under normal operating conditions
-3	Moderate negative disadvantage or change		
-2	Minor negative disadvantage or change	• Detectable change to the air quality conditions assessed resulting in non-fundamental temporary change • Likely to occur at some time under normal operating conditions	• Detectable change to the night lighting conditions assessed resulting in non-fundamental temporary change • Likely to occur at some time under normal operating conditions
-1	Slight negative disadvantage or change	• Detectable but small change to the air quality conditions assessed • Air quality changes may occur at some time under normal operating conditions	• Detectable but small change to night lighting conditions assessed. • Night lighting may occur at some time under normal operating conditions
0	No change	• No perceptible change to the air quality conditions assessed • Air quality changes unlikely to occur under normal operating conditions but may occur in exceptional circumstances	• No perceptible change to the night lighting conditions assessed. • Night lighting unlikely to occur under normal operating conditions but may occur in exceptional circumstances

6.4.2 Sensitive Receptors

Air

Air sensitive receptors (ASRs) typically include flora and fauna, residents, recreational users, businesses, education institutions, and healthcare facilities. Not all of these facility types are present within the vicinity of Springleaf development. Some of other facilities, such as SAF Medical Training Institute is sufficiently far away to be affected by the Project, as far as air quality is concerned.

The air quality influence zone is typically within several hundred meters from an emission source. For the purpose of this assessment, a study area of 200 m around the development footprint is defined. Biodiversity, residential, businesses and recreational receptors in the vicinity of the Project development have been identified as ASRs that could be impacted by dust from the construction works:

- Terrestrial flora and fauna in Springleaf forest – focusing on terrestrial fauna immediately outside development footprint and within the Significant Conservation Areas as shown in Figure 6-24[6]
- Terrestrial flora and fauna in Central Catchment Nature Reserve – approximately 40 m to the west of the Project
- Residents at Meng Suan Road – 30 m to the north
- Residents at Mandai Road (house 20-38) and at Thong Bee Road – about 100 m to the north
- Occupants of Thong Soon Green shophouses – approximately 80 m to the east
- Recreational receptors at Springleaf Nature Park and Park Connector east of Upper Thomson Road – 50 m to the east

Light

Night-time pollution generally focuses on the encroachment of artificial light into previously unlit areas. This can be manifested by a wide variety of lighting devices including construction lightings, public street lighting, architecture, domestic sources and vehicles during the construction and operation phases of the Project. Light pollution can potentially induce harmful effects on the wildlife, such as disruption of migratory patterns for birds and reduced metamorphosis for certain nocturnal species (Longcore, T. & Rich, C., 2004). Hence, terrestrial fauna has been identified as the light sensitive receptors (LSRs) that could be impacted by the night-time light pollution:

- Terrestrial fauna in Springleaf forest – focusing on terrestrial fauna immediately outside development footprint and within the Significant Conservation Areas as shown in Figure 6-24[7]
- Terrestrial fauna in Central Catchment Nature Reserve – approximately 40 m to the west of the Project

[6] Assessment of impacts from the construction phase of the development does not cover receptors whose habitats will be permanently cleared.

[7] Assessment of impacts from the construction phase of the development does not cover receptors whose habitats will be permanently cleared.

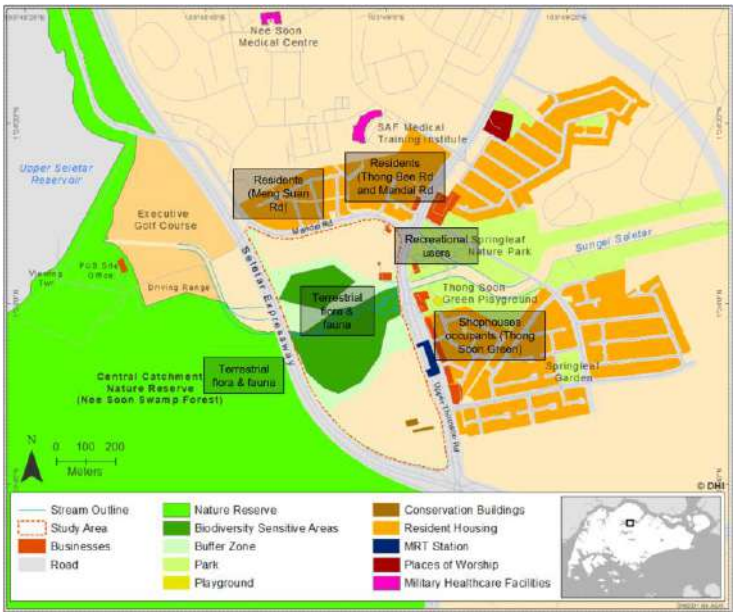


Figure 6-24 ASRs and LSRs for the Project

As part of RIAM framework, 'Importance' scores are to be assigned to the ASRs and LSRs, for calculation of overall Environmental Score for each impact. The assessment of the importance of social-economic receptors to air quality and light impacts is guided by the matrix provided in Table 6-34. Importance of biodiversity and ecological receptors is assessed based on the matrix presented in Section 6.1.2.

Table 6-34 Score for importance of social-economic air quality and light receptors

Score	Generic Criteria	Specific Criteria
5	Important to national/international interests	The receptors affected are specifically protected by national or international policies or legislation and are of significance at the regional or national scale, for example fauna in CCNR and Springleaf forest
4	Important to regional/national interests	Locations where more sensitive members of the public are exposed for eight hours or more in a day, for example, hospital and residential-care homes
3	Important to areas immediately outside the local condition	Locations where members of the public are exposed for eight hours or more in a day, for example, residential properties and schools
2	Important to the local conditions (within a large direct impact area)	Locations where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office and shop workers
1	Important only to the local condition (within a small direct impact area)	Receptors with transient exposure, for example recreational users of parks and playgrounds

6.4.3 Pressures and Pathways

Specific details of construction works will not be available until a contractor(s) has been appointed and detailed design has commenced.

6.4.3.1 Air Pollution

Construction activities such as site clearance and formation, excavation, construction of foundation and superstructure can generate dust. In particular, the scale of the earthworks in constructing the underground carparks and foundations for the Forest Towers is likely to be of a scale where nuisance dust will be generated. Anthropogenic dust emissions due to increased construction activities, such as the use of construction vehicles and equipment and material handling activities, can contribute towards decreased air quality which, besides from humans, can impact flora and fauna. Once dust is airborne it can travel some distance with the prevailing wind. Figure 6-25 shows the predominant wind direction in this area, and indicates that the areas that may be more prone to dust problems are the Core Conservation Area from any dust generated in Parcel 1a and 1b or residents on the northside of Mandai Road from any dust generated in Parcel 2.

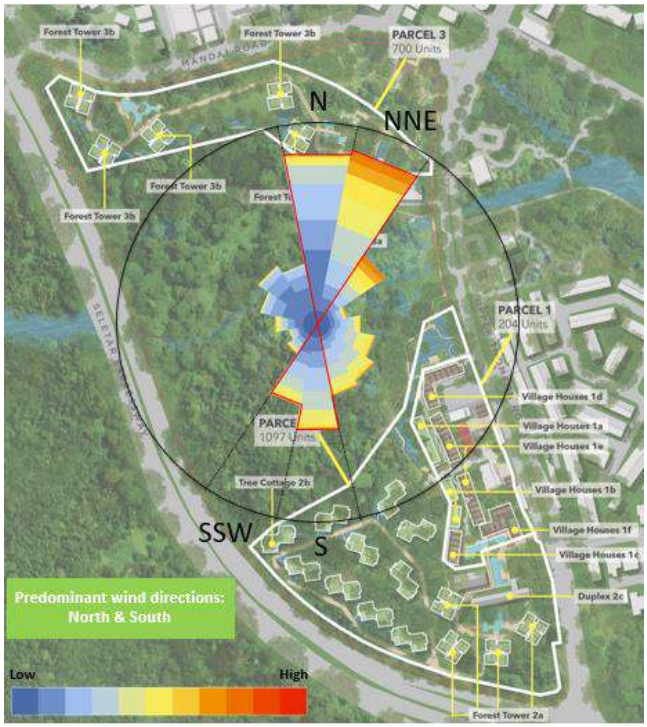


Figure 6-25 Predominant wind directions at the Springleaf site (Image credit: Web Earth)

Native Fauna

The ability of trees to trap dust efficiently has led to them often being used as screens to hinder dust transport (Farmer, 1991). Hence, elevated dust emissions can lead to increased dust loadings on leaves which impact important processes such as photosynthesis, respiration, and growth (Farmer, 1991). The extent and severity of dust deposition can vary depending on a number of factors. The distance which dust can travel would mainly depend on the activity generating the dust, the dust particle size, wind speed, wind direction and whether there are any physical entities that would block the dust travel. Nevertheless, Singapore's typically tropical climate which receives abundant rainfall, can reduce the extent of dust travel and wash off any deposited dust on foliage (Meteorological Service of Singapore, 2020). In view of this, project dust emissions would not pose a high risk to vegetation.

Studies have shown that elevated levels of dust emissions can have an impact on avifauna. A study by Saha and Pradhy (2011) in West Bengal, India compared the suspended

particulate matter of two forests, one located near an area with excessive concentrations of dust due to large scale mining and crushing of naturally occurring stones activities and another located further away from these activities (2530.25 – 4264.49 μg/cm^3 vs 137.28 – 183.71 μg/cm^3). The forest nearer the source of pollution had a significantly lower density and number of bird species than the forest located further away. Birds being lung breathers may experience symptoms related to the respiratory system, cardiovascular system and eyes (Saha and Pradhy, 2011). Although impacts of air pollution on avifauna are well established (e.g., respiratory distress, elevated stress levels), literature on thresholds for dust emissions on avifauna are not known. Furthermore, there is comparatively more research focussing on exposure toward heavy metals (e.g., mercury), chemicals (e.g., pesticides) and other aerosols (e.g., carbon monoxide).

There is little published research on the sensitivity of reptiles and amphibians to dust. Both are air breathing so are likely to experience difficulties if air quality deteriorates. Reptiles are believed to be more resilient than amphibians which breathe through lungs and their skin. Their skin has to stay wet in order for them to absorb oxygen, so they secrete mucous to keep their skin moist. If this process is interrupted, they become unable to breathe.

Mammals and bats are likely to be affected by dust in a similar way that humans are. At low levels dust will act as an irritant but if prolonged higher concentrations are present in the air it may be difficult for the animals to avoid and cause health problems. Considering the highly specialized respiratory organs of bats, the high metabolic cost of powered flight in low air density, and the unknown impacts of these increasing pollutants on respiratory function, flight in this space may be severely hampered for many species. Impacts to crepuscular and nocturnal mammals and bats can be somewhat avoided by limiting any construction works in the evening and at night.

Besides the physical effects of dust emission, the chemical composition of dust can also impact fauna when breathed in or when it enters the freshwater environment through dissolution at the air-water interface and rain events. Dust containing heavy metals such as lead can impact water quality which freshwater organisms are dependent on. It is important to note that dust emissions from project activities are neither likely to hit the concentrations observed by Pradhy (2011) nor be a source of dust generated containing harmful heavy metals.

Residents, Recreational Users, Businesses

Human exposure to high concentrations of dust ($PM_{2.5}$ and PM_{10}) above recommended levels could potentially result in negative health effects. A decrease in air quality from dust levels will potentially cause respiratory and visibility problems. Vehicular emissions from the ingress and egress of heavy vehicles at the project site can increase the concentration of dust particles and the concentration of pollutants such as CO, NO_2 and SO_2. People with pre-existing health conditions such as asthma or other respiratory issues will be at greater risk. Affected residents may adopt measures such as using masks and home air purifiers, potentially resulting in extra costs and aggravated medical conditions.

Given the general northerly wind direction, residents that may be most affected by dust are those living on the northward side of Mandai Road. The dust would come from excavation and other earthworks associated with Parcel 2 construction, particularly the roads, carpark and Forest Towers foundations.

Dust is more of a nuisance to recreational users than a serious health hazard as they have more leeway than residents to move away from the impacted area, ensuring only temporary exposure. Nevertheless, very dusty conditions would spoil the excursion and could lead to complaints. The main recreational area in the vicinity is the Springleaf Nature Park and this is situated for enough away and in a direction that dust impacts should be limited.

The main businesses in the area are situated along the eastern edge of Upper Thomson Road. These businesses have been exposed to considerable disturbance recently through the construction work for the new Springleaf Thomson East-Coast Line MRT station as well as other road widening work. They have shown themselves to be resilient to construction impacts, although further construction work may add additional stress. The dust generated from the Springleaf Precinct work is likely to be at lower levels than from the closer recent construction work. However, Springleaf Precinct construction work is still close enough that a nuisance may occur.

Dust nuisance is expected in general during construction. During operation, only small amounts of increased traffic is expected in the area, and the emission would not be expected to cause significant change of the overall air quality in the area, thus no significant long-term air quality impact is anticipated.

With good construction site management and works practice, the potential air quality impact on nearby receptors is anticipated to be slight and temporary. To further limit impacts, dedicated air quality modelling and monitoring can be carried out at a later stage, once the construction work plans and sequence are determined, and additional mitigations implemented if necessary.

6.4.3.2 Light Pollution

Native Fauna

Birds that migrate or hunt at night navigate by moonlight and starlight. Artificial light can cause them to wander off course and toward the dangerous night-time landscapes of cities. Every year millions of birds die colliding with needlessly illuminated buildings and towers. Migratory birds depend on cues from properly timed seasonal schedules. Artificial lights can cause them to migrate too early or too late and miss ideal climate conditions for nesting, foraging and other behaviours.

Illumination can also disrupt circadian rhythms of wildlife by extending diurnal or crepuscular behaviours in the vicinity of a work site, as well as disorient and disrupt orientation in nocturnal animals, e.g. Sunda pangolin. Glare from artificial lights can also impact wetland habitats that are home to amphibians whose night-time croaking is part of the breeding ritual. Artificial lights disrupt this nocturnal activity, interfering with reproduction and reducing populations.

Nocturnal animals sleep during the day and are active at night. Light pollution radically alters their night-time environment by turning night into day. Illumination from the worksite will result in avoidance from light-intolerant species, or attraction of light-tolerant species or insects. This may alter natural competition dynamics and divert food sources for insect-dependent species. Other impacts to wildlife from artificial lighting include disruption of reproductive behaviours and communication patterns which have downstream impacts on ecosystem functions.

Fauna around the periphery of the Springleaf site is already exposed to existing artificial road and building lighting, therefore the potential for the new apartments to result in lighting impacts to fauna at the new edge habitats is low. Furthermore, the final design and orientation of the lighting systems installed should adopt best practices that can further limit impacts. Moreover, skyrise greenery on the building facades and planter boxes can serve to further filter the amount of lighting emitted from the apartments and into the core conservation area.

6.4.4 Mitigation Measures

There are avoidance and minimisation proposed to protect from air and light pollution during design, construction and post-construction phases as presented in Table 6-35.

Table 6-35 Air and light mitigation measures by hierarchy type proposed at each phase of development

Stage	Hierarchy	Mitigation Measures
Design	Avoidance	• Nil
	Minimization	• A 30 m buffer zone around the protected No-Go Zone is designated as a further safeguard, enhancing the protection to the ecologically sensitive core. • Lights operating at night should be: of low wavelengths and narrow spectrum, e.g. low pressure sodium 18 W; pointed downwards instead of sideways or upwards; kept to the boundary between construction site and human habitation (e.g. streets) as opposed to boundaries between construction site and the forest; pointed to ensure that beams are pointed into the construction site if lights are needed at forest boundary; kept at a maximum height of 8 m; and kept at a minimum distance of 25 m between lights (refer to Landscape and Ecology plan in Appendix B for more details).
	Restoration	• Nil
	Offsets	• Nil
Construction	Avoidance	• Illumination with a high UV component should be avoided to reduce impacts on insects. • Many of the fauna found on site are nocturnal (active at night) or crepuscular (active at dawn and dusk), so works must only commence after 0800HRS and end at 1700HRS.
	Minimization	• Before construction work commences, ECM proposal duly designed and endorsed by appointed Qualified Erosion Control Professional (QECP) shall be submitted to PUB in accordance with PUB requirements and copied to the Developer. • Stockpiles that are not in used, in particular during dry periods, to be covered with well-maintained tarpaulin, keeping at a maximum height of 2 m. • Minimize traffic delays caused by movement of construction vehicles by planning transport route and transport period that avoid congestion. • All equipment and machinery used at the construction worksites are to be maintained and operated in a manner such that it does not give rise to smoke emissions. • All vehicles and machinery upon entry and exit of the site to be cleaned at the bunded wheel washing bay to remove any dust, sediments, seeds, plant, weeds pathogens or contaminating material. • All vehicles and equipment are not to be left idling when not in use and will be periodically checked during maintenance and inspection to ensure emissions are within the prescribed exhaust emission and noise limits. • Avoid use of diesel- or petrol-powered generators by using mains electricity or battery powered equipment where possible, and if safety concerns can be overcome. • All large vehicles with power output over 37 kW are to have exhaust after-treatment systems installed.

Stage	Hierarchy	Mitigation Measures
		• Downwards and inwards facing parameter lighting, timers and/or motion sensor activation. • There should be no direct lighting of fauna crossings and all lighting should be directed away from vegetated areas and habitats. • Narrow spectrum lights may be used to minimise impacts on the nocturnal functions of species.
	Restoration	• Nil
	Offsets	• Nil
Operation and Maintenance	Avoidance	• Many of the fauna found on site are nocturnal (active at night) or crepuscular (active at dawn and dusk), so night lighting within 20m of the Core Conservation Area and buffer areas should be avoided between 0800HRS and 1700HRS.
	Minimization	• Outside operating hours, low lux level lighting with light shields will be needed along pathways, paved areas and in areas where public access cannot be prevented. • Where permanent lights are to be employed, the lighting configuration (such as spacing between lighting poles) will be designed to ensure the darker areas are present between lit areas to provide darker passages for sensitive fauna to pass. • Upward and directional lighting to be avoided to prevent light escaping into unintended areas.
	Restoration	• Nil
	Offsets	• Nil

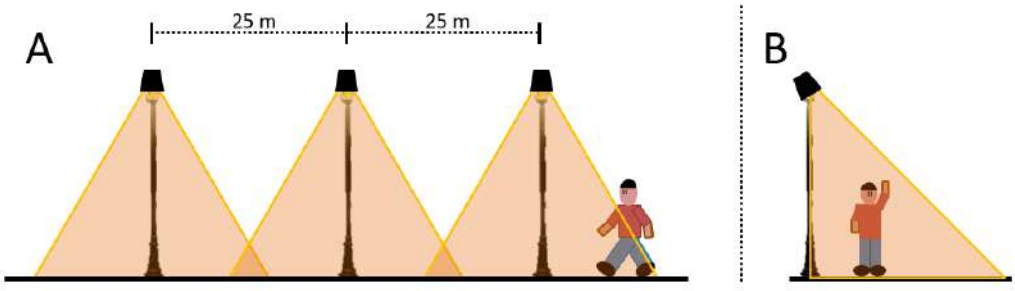


Figure 6-26 Light sources should be spaced at a minimum of 25 m apart from each other. Light sources should have shades that point downwards, allowing for some aerial areas between light sources to be dark and allow bats to fly in between them. Lights should be pointed down and illuminate only the path. Lights should not be allowed to spill off the path and into the surrounding habitat (image credit: Arborculture Pte Ltd)

6.4.5 Assessment Ratings

Based on the analysis the impact assessment scoring has been completed and is presented in Table 6-36 for construction phase impacts, and Table 6-37 for post-construction impacts.

Table 6-36 Construction stage impact assessment for air and light pollution on sensitive receptors. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Air Pollution	Native fauna	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative
	Residents	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative
	Recreational users	1	-1	2	2	2	-6	No Impact	-1	-6	No Impact
	Businesses	2	-1	2	2	2	-12	Slight Negative	-1	-12	Slight Negative
Light Pollution	Native fauna	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative

Table 6-37 Post-construction impact assessment for air and light pollution on sensitive receptors. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Air Pollution	Native fauna	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative
Light Pollution	Native fauna	3	-1	2	2	2	-18	Slight Negative	-1	-18	Slight Negative

6.5 Human Comfort

6.5.1 Evaluation Framework

The magnitude of change used for the human comfort is presented in Table 6-38, and has been analysed using expert judgement and referenced to other scientific studies.

Table 6-38 Score for magnitude of human comfort receptors

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	1. A clearly evident change in the safety, comfort or view at a close distance, substantial affecting, or continuously occurring. The change may be medium to long term and would not be reversible
-3	Moderate negative disadvantage or change	2. A noticeable change in the safety, comfort or view, at an intermediate distance, affecting, or regularly occurring. The change may be medium to long term and may not be reversible
-2	Minor negative disadvantage or change	3. A subtle change in the safety, comfort or view, at long distances, sometimes affecting, or occasionally occurring. The change may be short term
-1	Slight negative disadvantage or change	4. A change in safety, comfort or view which is barely or rarely perceptible, at very long distances, rarely affecting, or for a short duration. The change may be short term
0	No change	5. Status quo

6.5.2 Sensitive Receptors

Visual receptors are defined as people that have viewpoints of the worksite and/or final development. The level of sensitivity of visual receptors varies according to the occupation or activity of the person experiencing the view, location and context of the view, and the extent to which their attention or interest may be focussed on the view and their visual amenity.

The receptors sensitive to changes in human comfort include residents, recreational users, and businesses, and the wildlife that may be interacting with humans (in aspect of human-wildlife conflicts). The scores for assessing the importance of the human comfort receptors are provided in Table 6-39. Importance of biodiversity and ecological receptors is assessed based on the matrix presented in Section 6.1.2.

Table 6-39 Score for importance of human comfort receptors

Score	Generic Criteria	Specific Criteria
5	Important to national/international interests	1. Communities where the development results in changes in the landscape setting or valued views 2. Occupiers of residential properties with views affected by the development
4	Important to regional/national interests	3. Users of all outdoor recreational facilities, including public rights of way, whose interest may be focused on the landscape 4. People enjoying passive recreation such as urban viewpoints, locations with scenic views and seating facilities
3	Important to areas immediately outside the local condition	5. People engaged in outdoor sports or recreation
2	Important to the local conditions (within a large direct impact area)	6. People at their place of work whose attention is primarily focused on their work activity
1	Important only to the local condition (within a small direct impact area)	7. People travelling through or past the affected landscape in cars or trains along a recognised commuter route, major road or motorway

6.5.3 Pressures and Pathways

6.5.3.1 Human Wildlife Conflict

The proposed Springleaf Precinct Master Plan includes shared space for residents and wildlife, with the ground plane left clear. This is a deliberate move and generally a positive for the local ecosystem services, however it also increases the chances for human wildlife conflict which may take different forms from people disturbing nests through to people being bitten by wild boar. There are steps that can be taken to mitigate the risks and the proposed Springleaf Precinct Master Plan addresses many of these through use of some kelong fencing. Even so there will remain some potential negative outcomes. On the other hand having residents living closer to the wild also promotes a greater connection to and respect of nature and health benefits such as lowering blood pressure and reducing stress.

Vector control will include no pesticides or thermal fogging, daily manual inspection and eradication of mosquito breeding source, active and passive mosquito traps, and *Bacillus thuringiensis israelensis* (BTI) mosquito larvae control granules and solution.

Native Fauna

Some urbanised species of birds such as the Javan mynah are very accustomed to be close to people. However, most bird species will actively avoid human contact. This is particularly the case for many of the illusive forest dependent species. The main risk to birds is people disturbing their nests or attempting to feed them.

There are some risk interactions between humans and both reptiles and amphibians. Reptiles and amphibians can be attracted to areas with water, such as the ABC Waters features. Snakes and large monitoring lizards would be the main cause of concern. Most

amphibians are harmless to humans but would be vulnerable to being disturbed by human activity.

Large mammals such as Wild Boar and Sambar Deer will be restricted from entering through fencing. However, small mammals like the Lesser Mouse Deer, Malayan Colugo, Common Palm Civet and Long-tailed Macaque may enter and be in close contact with humans. Only the Macaque is of particular concern if they are defending their young or scavenging food.

Residents, Recreational Users and Businesses

Loss of existing habitat will force existing wildlife, particularly mammals and reptiles, to move to nearby adjacent areas to seek new foraging grounds. Due to the close distance of the site to surrounding residential developments, it is possible for mammals, reptiles and insects to encroach into nearby housing estates during site clearance. Most of the wildlife only attack when they are threatened, and the residents in the neighbouring estates are equipped with options to respond to animal encounters by informing NParks or contacting Acres.

Interaction between human and wildlife is likely to happen during site clearance and construction, but this exposure is temporary as construction workers will leave the site once the construction is completed. Wildlife shepherding and tree felling inspections can reduce harm to fauna.

The presence of some forest dependent species shows that the area may serve as a refugium for some of these species. Sightings of wild boars in the city are not unheard of and they are usually most commonly involved in human-wildlife conflict in Singapore. Similarly, dangerous animals such a venomous snakes or vectors like mosquitos can cause serious harm.

The existing forest is habitat for animal vectors that can potentially transmit diseases, especially mosquitoes, rats, fleas and flies. When the vegetated habitat is removed during the site clearance, insects and vectors will move to the surrounding areas, potentially causing nuisance and transmitting disease. These vectors are opportunistic and if given a favourable environment to inhabit and breed, they could spread diseases and lead to outbreaks.

In Singapore, the vector which has created the most concern is mosquitoes as they transmit diseases such as Dengue, Malaria and Zika, and it remains a challenge to control their population as they breed easily on stagnant water which can be found everywhere. For instance, a construction site might be a potential breeding ground due to the accumulation of stagnant water due to constant rainfall and the mismanagement of water supply and wastewater. If buildings are not constructed immediately after earthworks are done, water might accumulate and stagnate at the lower regions of the site and become potential breeding grounds for mosquitoes.

The risk to recreational users from wildlife conflict is not likely to be any more or less than visiting any other nature area in Singapore, such as Sungei Buloh or MacRitchie Reservoir. There are effective mitigation measures that can be implemented such as ensuring no feeding of animals, fully contained rubbish bins, and selective use of fencing or elevated walkways.

The animals are likely to seek new grounds once their habitats are disturbed. They may cross the existing roads and roads under construction surrounding the site boundary to other habitats, inadvertently wondering into the business district. There may also cause potential roadkill impact.

6.5.3.2 Change in Microclimate

Residents

We can expect the conversion of forest cover to buildings and urbanised surfaces to raise the ambient temperatures and lower humidity, given the reduction in evapotranspiration and the associated cooling capacity. The elevated ambient temperatures will be most pronounced during night hours, when trapped heat is slowly released from urban structures, leading to an urban heat island effect.

Existing residents at Meng Suan Road, Mandai Road, Thong Bee Road and Thong Soon estates will be most vulnerable to elevated ambient temperatures and the urban heat island effect, given their proximity to the loss of forest cover and the presence of new buildings. Nonetheless, the urban heat island effect will be mitigated through the adoption of design guidelines to maximise thermal comfort. For example, new buildings within the Springleaf development will be orientated to reduce thermal heat gain on the façade. Vertical greenery will also be planted to minimise heat gain on the building façade.

6.5.3.3 Visual Aesthetics

While construction is underway the area will have reduced visual aesthetics for what is likely to be several years, with much of the work areas encircled by hoarding and large construction machinery visible on the skyline. However, once commissioned and completed the site is planned to have considerably enhanced visual aesthetics. While new man-made features are to be built, the proposed Springleaf Precinct Master Plan denotes the future development design to be mingled with the natural landscape in a harmonious manner. Greenery and ABC Waters features are key component of the development, skyrise greenery will also be included in the Forest Towers. See examples of the landscapes in Figure 6-27 to Figure 6-31.

Figure 6-27 Design elements – Preserved Habitat Zone (image credit: STX Landscape Architects)

Figure 6-28 Design elements – Urban Village Zone (image credit: STX Landscape Architects)

Figure 6-29 Design elements – Leisure Zone (image credit: STX Landscape Architects)

Figure 6-30 Design elements – Neighbourhood Zone (image credit: STX Landscape Architects)

Figure 6-31 Design elements – Forest Dwelling Zone (image credit: STX Landscape Architects)

Residents, Recreational Users and Business

The proposed Springleaf Precinct Master Plan includes landscape design that aims to reinforce the appeal for residents and recreational users and improve the accessibility for observing the most scenic viewpoints. This is likely to turn the area from what was largely bypassed by visitors due to poor accessibility into one that becomes a focal point for the residents and recreational users to enjoy. There are some unique elements to Springleaf with the changing terrain, meandering waterway and fascinating natural heritage including iconic trees like the *Pandanus atrocarpus*. With added connection to the Springleaf Nature Park, more people can enjoy the nature and scenery, and the people attracted to the area should have positive flow on effects to the local businesses.

6.5.4 Mitigation Measures

There are avoidance, minimisation, restoration and offsets proposed to protect human comfort during design, construction and post-construction phases as presented in Table 6-40.

Table 6-40 Human comfort mitigation measures by hierarchy type proposed at each phase of development

Stage	Hierarchy	Mitigation Measures
Design	Avoidance	• In the more urbanized edge of the site, there may be a need for a low-impact barrier, to keep out larger animals, e.g. Wild Boar and Sambar Deer but still allow passage of smaller animals through into the site.
	Minimization	• Glazed facades sufficiently setback from the building edge to minimize likelihood of bird collision. • Window decals, reducing reflectivity, grills, reduce reflective window aspect on dominant flight path direction. • The building massing on site is carefully planned to ensure sufficient porosity and openness between buildings to encourage wind flow and ventilation which will positively impact the microenvironment around the buildings. • The new development is nestled in a predominantly wooded area and the design avoids having large unshaded hard surfaces to minimize heat island effect. • The key public spaces, e.g. the Village Square and Green Street are tree-lined and well shaded, ensuring thermal comfort of the users of the spaces.
	Restoration	• Landscaped decks to be provided around the Towers, to achieve a greenery-infused tower outlook. • The ‘shared habitat model’ proposes that humans and wildlife co-exist within the same plot of land, potentially offering a new approach to development within ecologically sensitive sites.
	Offsets	• Lookout towers, elevated boardwalks and guided trails on ground to provide managed access to the site for the best vistas. • Allowing trails into the edge of sensitive habitat allows the public and residents to experience this sensitive habitat.
Construction	Avoidance	• No baiting, trapping (cage and glue) or use of poison is allowed for vector control without NParks approval.
	Minimization	• Prior to sale of development parcel and site clearing, the entire construction site is to be hoarded, and to consult NParks (Wildlife Management) for site specific wildlife shepherding or removal plan

Stage	Hierarchy	Mitigation Measures
		• The Contractor is required to implement comprehensive vector surveillance and control at the site, including all necessary measures to prevent the site from becoming favourable to the breeding and harbouring of vectors. • Where applicable source reduction shall be used as the main form of vector control with food consumption and storage strictly restricted to designated areas where lidded rubbish bins are available. • Reduce the use or application of non-toxic and eco-friendly pesticides during the construction as it may spread to nearby areas. Any use of pesticide, thermal fogging or Bti will have to be approved with NParks. • Implement a speed limit and post the speed limit on signs at regular intervals along vehicle access routes
	Restoration	• Nil
	Offsets	• Nil
Operation and Maintenance	Avoidance	• Signage indicating no animal feeding. • Cues to Care, such as encouraging visitors to keep plastic bags and food inside their bags to decrease the chances of a negative human-wildlife interaction (such as with wild boar or long-tailed macaques). • Pets must be managed within the development: cats must never be allowed to roam within a development at any time of day; dogs must be kept on the lead at all times while they are within the development; owners must immediately clean up after their dogs defecate; aquatic pets, such as red-eared sliders or pet fish, must never be released into any permanent waterbody within the development (they could wash into the swamp forest during an overflow event from a strong storm); and pet birds must not be allowed to fly freely within the development.
	Minimization	• Nil
	Restoration	• Residents actively participate in maintaining the forest ground, as part of the stewardship of the land.
	Offsets	• Interpretive signs can be placed and interspersed along the trail to provide educational information about the habitat. • Guided walks are a good form of outdoor education and outreach programs.

6.5.5 Assessment Ratings

Based on the analysis the impact assessment scoring has been completed and is presented in Table 6-41 for post-construction impacts.

Table 6-41 Post-construction impact assessment for the changes in human comfort on sensitive receptors (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score). The change in impact Magnitude following mitigation (if any), and the residual impact significance is also shown.

Predicted Impact	Sensitive Receptors	*Without* Mitigation							*With* Mitigation		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Human-wildlife conflict	Native fauna	3	-2	3	2	3	-48	Minor Negative	-1	-24	Slight Negative
	Residents	3	-3	3	2	2	-63	Minor Negative	-2	-42	Minor Negative
	Recreational users	1	-2	3	2	2	-14	Slight Negative	-1	-7	Slight Negative
	Businesses	2	-2	3	2	2	-28	Slight Negative	-1	-14	Slight Negative
Changes in microclimate	Residents	3	-1	3	2	2	-21	Slight Negative	0	0	No Impact
Visual aesthetics	Residents	3	-1	3	3	2	-24	Slight Negative	+3	+72	Minor Positive
	Recreational users	1	-1	3	3	2	-8	Slight Negative	+3	+24	Slight Positive
	Businesses	2	-1	3	3	2	-16	Slight Negative	+3	+48	Minor Positive

7 Environmental Management Framework

This section outlines the EQOs, target levels, monitoring and management measures that are recommended for the project.

7.1 Environmental Quality Objectives

Based on the evaluation criteria provided in Section 6, the proposed Environmental Quality Objectives (EQOs) for this project, under the base Masterplan option, are as follows:

No more than **MODERATE IMPACT** to:

- Young Secondary Forest

No more than **MINOR IMPACT** to:

- Freshwater Swamp Forest
- Birds
- Reptiles and Amphibians
- Mammals and Bats
- Residents

No more than **SLIGHT IMPACT** to:

- Central Catchment Nature Reserve
- Scrubland / Grassland
- Naturalised Stream
- Businesses

NO IMPACT to:

- Freshwater Organisms
- Odonates
- Recreational Users
- Springleaf Nature Park
- Lower Seletar Reservoir

Assuming that the reduced Tree Cottages alternative masterplan option is adopted, the proposed EQO for young secondary forest can be made more stringent, to no more than **MINOR IMPACT**.

7.2 Environmental Management and Monitoring Plan

7.2.1 Purpose of Environmental Management and Monitoring Plan

The Environmental Management and Monitoring Plan (EMMP) is the primary measure to ensure overall compliance with the EQOs, particularly during construction.

The objectives of the EMMP are:

1. To ensure compliance with the mitigation measures identified in the EIA
2. To set out roles and responsibilities for the parties involved
3. To monitor the Project's actual environmental impacts so that, if necessary, corrective actions can be taken and the necessary modifications can be made to the Project in time

7.2.2 Construction EMMP Roles and Responsibilities

The Developer(s) will be responsible for the detailed design in accordance with the Design Guidelines and will engage Construction Contractor(s) to undertake the development of the Springleaf Precinct. The Contractor(s) will need to ensure the EMMP is implemented and compliance is maintained during the construction works. The responsibility for maintenance of the Sensitive Biodiversity Areas, Buffer Zones and other public lands will likely remain with NParks, PUB and LTA. Enhancement works and maintenance of the public lands and parks will need to be assigned to the appropriate Public Land Developer(s).

The construction and development works may be staged between Parcels 1a/1b and 2 and the public lands. The Developers and Contractors may be different and timing of construction may potentially occur years apart. All of them will have very different responsibilities for specific mitigations. It is not yet possible to fully elaborate the responsibilities of the various parties. Currently, all mitigation measures have been defined as Developer's responsibility which will need to be further defined once the arrangements are clear. The EMMP requirements stipulated will generally be applicable to each of the work packages and the respective Developers will be responsible for ensuring implementation in and around their own sites.

The Contractor shall engage a full-time Environmental Manager (EM) and Environmental Control Officer (ECO). The ECO shall be registered with the Commissioner of Public Health and discharge the duties set out in the Code of Practice for ECO and advise the Contractor in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; and earth control measures and silt control.

The Contractor shall also be responsible to appoint the Qualified Erosion Control Professional (QECP), Earth Control Measures Officer (ECMO), Pest Control Officer (PCO), Public Relations Officer (PRO), Flora Specialist/Arborist, Wildlife Management Officer (WMO), laboratory/vendor, and waste collectors to implement all the EMMP requirements.

The Contractor shall be responsible to appoint qualified personnel (e.g. Fire Safety Manager, QECP, Traffic Management Specialist, etc) to prepare fire protection plan, flood

protection plan, and traffic management plan, and obtain all necessary approvals from relevant government agencies and stakeholders for the plans.

The Site Environmental Control Plan (SECP) shall be prepared by the Environmental Control Officer (ECO). The Client's ECO is responsible to obtain all necessary approvals for the SECP from relevant parties.

The SECP shall provide details of Earth Control Measures (ECM), Earth Management Plan (EMP), Soil Erosion Management (SMP), which will be prepared and provided by the (QECP). The Plan shall depict graphically the activities, including sequence of work, type and duration for each phase of construction activities. The QECP is responsible to obtain all necessary approvals for the ECM, EMP and SMP from relevant parties, e.g. Public Utilities Board (PUB). The ECM Inspection Plan shall be prepared and provided by the ECM Officer (ECMO).

The Contractor shall prepare a Noise Management Plan (NMP) outlining but not limited to the following: comparison charts between baseline monitoring results and anticipated noise emission levels; machinery and plant to be utilised on site as well as the noise emission levels; sequence of work and construction methods involved, indicating anticipated noise levels accompanying each type of activity; proposed noise mitigation measures along with the estimated noise reduction levels; scheduling of works demonstrating consideration of noisy activities.

The Contractor shall provide a detailed Vibration Management Plan (VMP) that clearly demonstrates the vibration attenuation for each specific equipment in similar ground conditions.

The Vector Control Plan (VCP) shall be prepared and provided by the ECO and appointed licensed Pest Control Operator (PCO). The Client is responsible to obtain all necessary approvals for the VCP from relevant parties, e.g. NEA.

The Grievance Management Plan (GMP) shall be prepared by the Public Relation Officer (PRO). The PRO is responsible to obtain all necessary approvals for the GMP from relevant parties, e.g. Project Owner.

The Hoarding Construction Plan (HPD) shall be prepared by the Contractor. The Contractor is responsible to obtain all necessary approvals for the HPD from relevant parties, e.g. Project Owner.

Details of Site Lighting Plan (SLP) for night works shall be prepared by the Contractor. The Contractor is responsible to obtain all necessary approvals for the SLP from relevant parties, e.g. NParks.

Details of chemical management shall be prepared by the ECO including type and estimate amount of chemicals to be stored and used for the Project, and storage arrangements and procedures.

Details of waste management shall be prepared by the ECO including type and estimate amount of waste to be generated, waste storage, reduce, reuse, recycling and disposal arrangements and procedures.

An Emergency Response Plan to be established, trained and tested to rapidly respond to emergency events such as oil spills. Oil spill clean-up kits to be kept on site.

The Contractor shall prepare detailed specification, design, layout, methodology, equipment, personnel, fabrication, installation, operation and maintenance for all pollution

control measures (i.e. air, noise, water and wastewater, ECM, soil and sediment, groundwater, and waste management) that will be deployed.

The Contractor shall prepare detailed specification, design, layout, methodology, equipment, personnel, fabrication, installation, operation and maintenance for tree and flora protection, planting, pruning, removal and transplantation.

The Contractor shall prepare detailed specification, design, layout, methodology, equipment, personnel, fabrication, installation, operation and maintenance for wildlife shepherding, and fauna protection measures including site lighting for nightworks, prevention of fauna encroachment, rescue of trapped fauna, record keeping of fauna encroachment, trap or kill in the work site, monitor and ensure temporary fauna hoarding is properly maintained.

Monitoring shall include ambient air quality, airborne noise, wastewater discharge quality monitoring, and all requirements by relevant agencies. Contractor shall have overall responsibility for preparation, submission, and obtaining approval for SECP, Fortnightly Environmental Control Report, ECM Plan, VCP, and their implementation. The Contractor shall also be responsible and conduct ambient air quality, airborne noise, wastewater discharge quality, vector control, sediment quality and waste management monitoring and conduct the necessary environmental inspections, trainings and toolbox talks.

Prior to beginning any construction work, the ECO to provide all construction personnel with biodiversity awareness training. The training is to educate staff on the ecological importance of the site, how to identify key flora and fauna, and how to handle wildlife encounters. Training of Contractor personnel and monthly toolbox briefing for construction personnel and sub-contractors will be to educate workers on fauna response during work. Workers on site should be educated on behaviours of the macaques and snakes to reduce human-wildlife conflict.

7.2.3 Construction Staging

In order to minimize loss of habitat, construction footprints must remain as small as reasonably possible. This is particularly important for developments within the Tree Cottages area in Parcel 1b (SHG). Care must be taken to phase the construction to:

1. Reduce the amount of land required for clearing; and
2. To develop infrastructure in such a way that the starting and the end points of construction are at the point of entry.

This is illustrated in Figure 7-1 with an example development of six hypothetical Tree Cottages: Unit 1 through to Unit 6 (A). The first unit to be developed would be Unit 2. Access roads from the point of entry (Unit 1) as well as the area to construct Unit 2 would be cleared (B). Note that forest being cleared is for the footprint of the actual building and road (light brown) as well as a buffer around the building and access road (dark brown) to allow movement of heavy vehicles. Once Unit 2 is completed, access roads and construction footprint for Unit 3 can commence (C). This process is repeated sequentially for Units 4-6 and Unit 1 (D-G), where only the access roads and the construction footprints are cleared. Once Unit 6 has been developed, the buffer areas for the buildings and the roads can be reforested (H) with trees as per the appropriate planting characteristics.

While the example provided is for a hypothetical set of Tree Cottages, the same principles are applied to other construction activities, such as laying down of pipelines. Land clearance for pipelines require large buffers (up to 2 m for a 900 mm diameter pipeline). In

such circumstances, tree roots must be avoided to prevent structural and long-term health damage on trees.

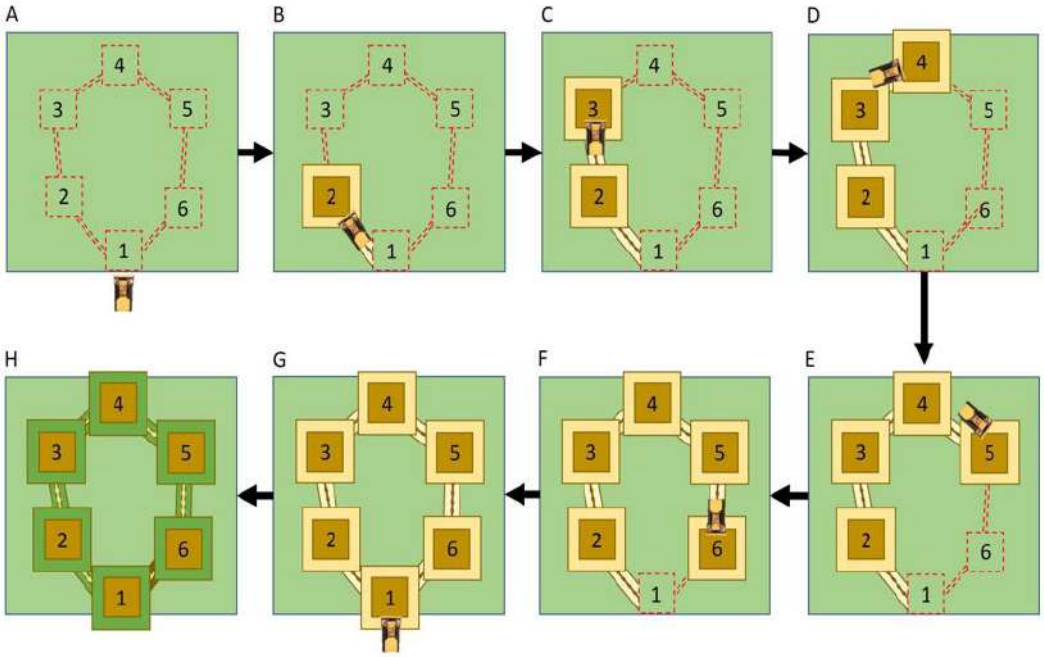


Figure 7-1 Construction phasing for a hypothetical set of units in the Tree Cottages. Light green area is the Springleaf Forest; red dotted lines are areas where the units and access roads will be as per design plans; dark brown areas are infrastructure (buildings, fire engine access); light brown areas are buffer areas; dark green is reforestation (image credit: Arborculture Pte Ltd)

7.2.4 Implementation Agents Roles and Responsibilities

The proposed Springleaf Precinct Master Plan relies on avoidance, minimisation and restoration mitigation efforts within the private development areas to reduce impact levels as well as offsets largely within the adjacent public lands to ensure optimum environmental outcomes. There will be a delicate balance in the environmental management of the different land use types and the interface between these land uses.

For the implementation and sustained success of the proposed Springleaf Precinct Master Plan there are many different organisations and parties that must commit to and enact an ethos towards caring for and conserving nature. On top of this, both public education and outreach as well as cues for care are required to cultivate environmental stewardship. Figure 7-2 presents an overview of the roles and responsibilities of the implementation agents for the execution of EMMP during construction stage.

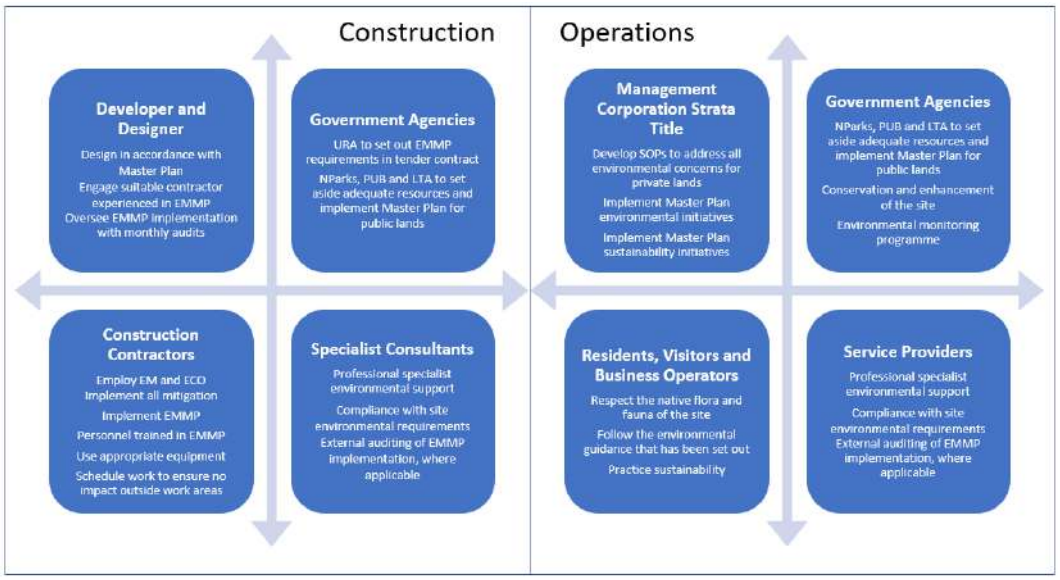


Figure 7-2 Overview of Implementation Agent Roles and Responsibilities

7.2.5 Environmental Audits

Depending on the phase, the Developer(s) or MCST will be responsible for regular environmental audits of the EMMP. Such environmental audits will likely be combined with other elements of the Project implementation, such as health, safety and regulatory compliance. Where audit findings highlight a non-conformance, there will be an immediate investigation and appropriate corrective action taken. All environmental audits will be clearly documented and filed internally.

As a minimum the following environmental audit schedule is recommended:

- At least weekly site inspections by the ECO to confirm good housekeeping and site management practices, including: hoarding; signage; toolbox talks; suitable waste management procedures; and emergency response procedures are in place.
- At least monthly environmental audits of the construction sites by Environmental Manager with specialists such as Environmental Consultant, Arborist and/or WMO. Any non-compliances should be documented and followed up through an action tracker.

7.2.6 Grievance Management

The Developer(s) will establish a grievance management process to ensure that any complaints or feedback received from stakeholders are appropriately recorded, investigated, and resolved where required throughout the Project. The main components of the grievance process will include:

- Prompt acknowledgement and response to stakeholder complaints, keeping them informed of the progress and outcomes
- Accurate records of complaints, investigations and outcomes are maintained
- Resolution within a specified timeframe (proposed four weeks)
- An escalation mechanism in the event that grievance cannot be resolved by the Developer(s) within the specified timeframe
- Assign responsibility and accountability to individual(s) such as Public Relations Officer (PRO) within the Developer(s) for administering the grievance procedure

- Government Agencies to be kept informed of complaints, where required.

7.2.7 Management of Change

Change is an inevitable part of projects and therefore managing and reviewing change during the execution phase of a project is an important factor in project success. Deviations from the scope of work might occur during the project execution.

The overall aim of the EMMP is to ensure that environmental management is implemented, and its performance monitored. This means there must be scope for corrective action to be taken if required. It may be necessary to make modifications to the EMMP over the course of the Project when:

- Unanticipated environmental impacts are identified that require additional mitigation
- When mitigation proposed proves ineffective or unable to be implemented
- When the Project changes in a way that is substantially different to that described in the EIA (e.g., internal changes initiated by the project team, external changes initiated by the client; or external changes that are a result of third-party stakeholders)

The overall responsibility for the Management of Change to the EMMP during construction and operation phase rests with the Developer(s) and MCST respectively. The Developer(s) and MCST shall carry out the Management of Change to the EMMP in consultation with the relevant specialists and/or technical agencies where required.

The steps for managing change to the EMMP are as follows:

- Identify and describe unanticipated impacts, ineffective mitigation or changes in the Project construction or operation that require updates to the EMMP
- Suggest mitigation to manage the identified issues
- Concerns/issues could, for example, be highlighted in site inspection reports or progress calls with the Developer(s) on an ongoing basis
- Review and update the EMMP in consultation with the relevant specialists and/or technical agencies
- Record recommended corrective action in a Minute of Meeting.

7.2.8 Environmental Monitoring

Monitoring shall be undertaken by the Contractor as part of the Construction EMMP, and where relevant carried through into operations. Table 7-1 provides recommendations on the types of monitoring that should be implemented, but this is not necessarily an exhaustive list.

Table 7-1 Environmental monitoring requirements

Aspect	Objective	Monitoring Parameters	Method	Locations	Frequency
Terrestrial Flora	Monitor tree protection zones	TPZ hoarding must be intact Tree physiological health and vigour should not decline No mechanical damage to trees that may impair stability	Visual inspections at construction sites to ensure tree conditions have not deteriorated; check that integrity of the TPZ has not been compromised; verify no mechanical damage to trees has occurred; and monitor for edge effects at new forest edge. Includes inspection of trees condition, review of construction practices, recommendations and reporting with photos.	Conservation significant species 2 to 5 m from access routes	Monthly
Terrestrial Fauna	Monitor fauna presence To set long term targets for increasing biodiversity across the Springleaf	Identify types of animals around construction site, and within the Significant Biodiversity Areas Record activities if possible	Transect and point count surveys. The monitoring should be coordinated with NParks and integrated into a long term biodiversity monitoring strategy for the site.	Checking of development boundary, erosion control blanket and erosion control tanks for any fauna activity	Monthly, starting six months prior to construction commencing until completion
	Prevent human-wildlife conflict	Number of occurrences	Carry out awareness training with site team to record any incidents	Throughout the work area	Daily monitoring and record-keeping with monthly reporting
Noise	Noise levels	Leq 12 hrs	Class 1 Sound Level Meters with valid calibration certificate shall be used. Automatic short messaging system (SMS) alert shall be sent when noise levels exceed maximum permitted noise levels.	Install and maintain at least five (5) sensors around development boundary or at sensitive receptor sites	Real-time, starting at least seven (7) days before commencement of construction until completion

Aspect	Objective	Monitoring Parameters	Method	Locations	Frequency
Vibration	Vibration levels	Peak particle velocity, acceleration and displacement	Vibration Meters with valid calibration certificate shall be used. Automatic short messaging system (SMS) alert shall be sent when vibration levels exceed maximum permitted vibration levels.	Install and maintain at least three (3) sensors around development boundary or at sensitive receptor sites	Real-time, starting at least seven (7) days before commencement of construction until completion
Air Quality	Dust	$PM_{2.5}$ and PM_{10}	The Contractor shall be responsible to supply, install and maintain dust monitoring sensors with valid calibration certificate.	Install and maintain at least three (3) sensors around development boundary or at sensitive receptor sites	Real-time, starting at least seven (7) days before commencement of construction until completion
Chemical Inventory	Chemical tracking	Hazardous chemicals	The Contractor to track the volumes of chemicals stored and used within the site.	Chemical storage site	Daily
Groundwater	To monitor the water table	Water levels	The Contractor shall install at least five (5) boreholes to a depth of at least 2 m below the water table.	Within Springleaf, particularly in the proximity of the Significant Conservation Areas.	Weekly readings of water levels in each well starting at least one (1) month before commencement of construction until completion.
Effluent Streams	To monitor discharge concentrations	Turbidity	The Contractor shall install a “live” monitoring system for turbidity. The “live” monitoring system shall be monitored by CCTV. The system shall include SMS “alert” feature when allowable limits are exceeded.	At every final discharge point	Real-time, starting at least seven (7) days before commencement of construction until completion
Waste Inventory	Waste tracking	Solid waste	The Contractor to track the volumes of waste produced, stored and sent for disposal.	Waste storage site	Daily
Vectors	Reduce pathogen risks	Pests	Visual monitoring (presence / absence)	Work site	Daily

7.3 Environmental Aspects and Impacts Register

The Environmental Aspects and Impacts Register (EAIR) forms an addendum to the EMMP, as a practical document that can be tracked and updated throughout each phase of the work. Together the EMMP and EAIR will serve as a reference for implementing appropriate mitigation measures and monitoring procedures during project construction and operational phase. It provides the basis for more detailed Plans, Method Statements or Standard Operating Procedures. The document is designed to be updated and amended by the appointed Construction Contractor as additional information becomes available through the design process and government agencies consultation. Implementation will typically include the engagement of qualified specialists, subcontractors, and service providers to supply labour, equipment and professional services for the environmental management and monitoring works, in compliance with the standards, guidelines and procedures prescribed in Section 2.

Table 7-2 Environmental Aspects and Impact Register

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
***Note: D=Design, C=Construction, O=Operation**									
1.	D	**All environmental aspects**	• Apply 'light-touch' development principle whereby areas that are degraded and heavily impacted will be developed sensitively while forested areas such as Parcel 1b (within mature secondary forest) will have dwellings built 9m above ground to reduce disturbance on the forest floor.	URA	Design review to ensure the development principle is in place	Prior to start of construction works	NIL	NIL	NIL
2.	C & O		• Monitoring of the physical (noise, water, light, air) and biological (flora and fauna) should be done with accordance to the EMMP recommendations. • Any significant deviations from the baseline parameters of the site should trigger adjustments to management of the site to reverse or reduce impacts i.e., implement adaptive management measures to review and change (if and where necessary) mitigation measures.	All Developers	EMMP implementation audits	Monthly during construction	Mitigation measures outlined in this EMMP	Location outlined in this EMMP	• Monthly EMMP Implementation Audit Report • Minutes of any meeting conducted during construction and operation in relation to EMMP implementation and corrective actions

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
				MCST		Annually during operation			
3.	D & O		• The establishment of the Sustainability Education Centre is an opportunity to be a one-stop centre for resident education of the natural space around the development. An extension of community education will be focused living responsibly within the development	URA	Design review to ensure this development is in place	NIL	NIL	NIL	NIL
				All Developers	"As built" review of construction to ensure that the centre has been built and served as per design and functionality requirements				
4.	D, C & O	**Stakeholder Engagement**	• Establish a grievance process to ensure that any complaints received from stakeholders throughout the Project, are appropriately recorded, investigated, and resolved where required.	All Developers MCST	Grievance process in place	Ongoing throughout all phases	Number of complaints received	Around and within vicinity of work areas	Grievance records
5.	D & C	**Habitat loss-disturbed biodiversity**	• Housing Developers to minimize the construction footprint, construction of development, particularly for the Tree Cottages, should be planned in such a way that the land that needs to be cleared is only for the buildings and roads to be constructed.	URA NParks	Design review to ensure the retainment of Core Conservation Area and Significant Conservation Area, and conduct habitat enhancement	Prior to start of construction works	NIL	NIL	NIL

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			• Retain both Core Conservation Area and Significant Conservation Area; strictly no construction works within these areas. • Park Developer to ensure that there is no development within Freshwater Swamp Forest and development limited to raised paths and wildlife hides in habitats utilized by grazing fauna e.g., Sambar Deer. • Creation of artificial habitats as part of habitat enhancement efforts: • Park Developer to provide roosting habitats for bats under SLE • All Developers to provide bee hotels throughout the site for native bees • All Developers to provide swales for dragonfly biodiversity in development (ABC features) • Housing Developers to provide butterfly gardens in the development	Developers	Site personnel inspections	Daily	Verifying works are within permitted work area	Within project site	EMMP Implementation Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
6.	C		• Maintain the services of a qualified arborist and/or horticulturalist to monitor and provide ongoing advice and management of all retained and planted flora within the Project area • As much as possible, saplings of native flora species should be salvaged from areas marked for development to be transplanted to areas marked for afforestation. • Establish nursery prior to sapling salvaging, felling of trees, and construction. This will be followed by salvaging native plant saplings in development sites. • Plant nursery should be located within the development site to reduce movement and stress onto saplings. • Native plants in the nursery will be monitored for survival rate to inform the quantity of saplings available for landscaping and reforestation, e.g., how many more saplings of certain species need to be ordered in. • Where disease outbreaks are identified, the arborist and/or horticulturalist must advise of measures to manage any outbreaks. Measures can include using selected	Developer Arborist	Tree and flora inspection	Fortnightly during construction or when trees observed to show signs of stress	• Live Crown Ratio Recovery • Die Back from tips (in 3 months) • Diseases • Edge effects on retained trees in the project area • Location of vegetative barriers and corridors, pathways adjacent to TPZ and size of vegetation patches planted	Trees retained within Tree Protection Zones/planted within the contract boundary; Trees within the buffer zones	Tree and Flora Inspection Report
				Developer Horticulturist	Nursery maintenance	Monthly during construction	• Checklist: • Maintaining plant inventory and health list • Misting • Watering	Nursery	Maintenance Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			insecticides/fungicides to control outbreaks; reduction of stressors (dust, water etc.). The plant may be removed or quarantined if it poses a threat to surrounding individuals. • Pathways will be constructed outside the Tree Protection Zone (TPZ) (developed in accordance with NParks TPZ guidelines) of each tree identified for retention, to avoid soil compaction and root damage. Advice will be obtained from the Arborist on the requirements for the construction of paths within the vicinity of trees.				• Application of root hormones/ liquid fertilizer for saplings and trees • Forking and weeding • Application of slow released fertilizers		
7.	D	**Human-wildlife conflict**	• Development parcels will have low-impact kelong-style walls built to ground to exclude larger fauna (i.e. Wild Boar and Sambar deer) from the development. • Access holes within the wall approximately 1.5, 2, or 3 m above ground will allow access to climbing fauna (squirrels, pangolins, snakes, other reptiles, etc.). • Boardwalks within proposed buffer area to be raised to reduce possibility of large mammals such as Sambar Deer and Wild Boar from reaching and using the bridge. This will also deter humans from straying off the	URA NParks	Design review to ensure the large-mammal filtering fence structures are included in design	Prior to start of construction works	NIL	NIL	NIL

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			path, thus protecting themselves and preventing them from entering Core Conservation Area.						
8.	C & O		• Prior to site clearing, the entire construction site is to be hoarded, and to consult NParks (Wildlife Management & CCNR) for site specific wildlife shepherding or removal plan based on the carrying capacity of the area • Erect hoarding and barriers progressively to prevent fauna from entering project site. The hoarding will be erected first along Upper Thomson Road and Mandai Road side of the development to encourage fauna movement inwards towards refuge areas in the centre. The hoarding will be removed sequentially from first the inner area outwards then towards the roads following completion of the construction works and carefully to prevent damage to vegetation within development areas, and to prevent exposure of fauna to risks. • Wildlife shepherding to be conducted properly and in sequence according to Wildlife Shepherding Plan approved by NParks to shepherd animals from construction zones. Trees that require felling will undergo pre-	Developer Ecologist	Wildlife shepherding plan	Prior to start of construction works/closure of project perimeter hoardings	• Species requiring relocation within the Project component area. • Habitat features such as hollow trees, pangolin dens, nests and roosts. • Record all habitat features observed using a GPS.	Land areas that required to be cleared	Wildlife shepherding records
				Developer Ecologist	Pre-felling & Post-felling inspections	Before/during/ after tree felling activities	Presence of wildlife on trees to be felled	Trees to be felled	Pre-felling and post-felling inspection records

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			felling surveys to ensure fauna are not within trees before being felled • Immediately upon any dead or injured animal encounter, construction activities in that immediate area shall stop and the Developer Environmental Management Team shall be notified. No attempt shall be made by construction staff to handle the animal. Wildlife handlers and veterinarians are to be informed to attend to the animal as soon as practicable. Construction activities in the immediate area may resume only after notice has been received from the Developer Management that it is safe to continue with the work. • Prior to wildlife shepherding activities, undertake a training with all involved personnel so that they are aware of their roles and responsibilities; measures to deal with injured wildlife; occupational health and safety requirements; and requirements regarding the prohibition of hunting/catching/taking of fauna and flora. Refresher training is to occur with new employees. • Monkey guarding should be used as a means to manage wild populations of macaques within	Developer	Grievances process in place	Ongoing throughout all phases	Number of complaints received	Around and within vicinity of work areas	Grievance records
				Developer	Site personnel inspections	Daily during construction	• Presence of wildlife and/or trapped wildlife within the project site • Ensure erected hoardings follow the agreed hoarding plan and in good condition	Within project site and all fencing enclosures	EMMP Implementation Report
				Developer Ecologist	Wildlife inspections	Monthly during construction	Presence and detection rate of main species group and species of conservation interest	Within project site	Monthly Wildlife Inspection Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			the development. Other wildlife, such as snakes, pangolins, or palm civets, should be managed by responsible wildlife management vendors (e.g., ACRES or NParks Animal Response Centre) or NParks approved pest control vendors that are allowed to handle wildlife. • Interpretive signs and signage throughout the development can be used as tools for education and encourage responsible living within the development. • Signage throughout the development play an important role in reminding residents of responsible behaviour to prevent wildlife encounters or what to do when encountering wildlife					
9.	C & O	**Fauna mortality from roadkill/ machinery kill/hoarding strikes**	• Implement a speed limit and post the speed limit on signs at regular intervals along vehicle access routes. Install speed bumps at appropriate locations. • Ensure that all vehicle strikes are investigated and that gaps in mitigation measures that may have led to the death/injury are identified, and appropriate changes made to the mitigation strategy. • Such investigations will make use of information from camera traps	Developer	Site personnel inspections	Daily during construction	• Presence of wildlife and/or trapped wildlife within the project site • Roadkill/machinery kill frequency • Ensure erected hoardings follow the	Within project site	Daily Inspection Report, Wildlife Incident Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			to determine whether there are patterns in animal appearance. Roadkill register and investigation will be maintained and continued during operation.				agreed hoarding plan and in good condition • Installation of signs and speed bumps		
10.	D & C	**Fragmented fauna connectivity**	• Rope bridges over Sungei Seletar will improve connectivity between the northern and southern Significant Conservation Areas for arboreal animals, while wooden logs or tree trunk from felled trees will be used by terrestrial animals across the stream. • Connectivity between Springleaf and adjacent forest areas (NSSF/CCNR, Springleaf Nature Park) will be enhanced through targeted reforestation or revegetation of corridors, such as the SLE underpass with Sungei Seletar, buffer zones, and areas within the developed parcels • Plant shade-resistant native flora underneath SLE to increase ground cover and connectivity for small and medium fauna • Cargo net rope crossing under and around SLE to facilitate movement of arboreal fauna between CCNR and Springleaf	NParks	Design review to ensure canopy and ground-level connectivity is maintained	Prior to start of construction works	NIL	NIL	NIL
				NParks Park Developer Ecologist	Wildlife inspections	Monthly during construction	Presence and detection rate of main species group and species of conservation interest	Within project site	Monthly Wildlife Inspection Report
				NParks Park Developer	Site personnel inspections: To monitor if there is disturbance to canopy or ground-level connectivity due to the presence of construction equipment.	Daily during construction	Obstruction to connectivity	Within project site	Daily Inspection Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			• As pedestrian bridges across Upper Thomson Road are proposed, the roof of the bridges can be used to plan native flora to aid in connectivity and movement of small fauna from Springleaf/CCNR/NSSF to the forests across Upper Thomson Road. • Modification of SLE underpass and parallel PUB drain and fencing/railing by removing or modify fencing/railings and covering drains.						
11.	D & C	**Potential degradation of flora and fauna habitat by invasive species**	**<u>Fauna</u>** • Develop a drop structure within the Sg Seletar channel under the SLE flyover where it will have minimal ecological impact due to a lack of primary production and minimal riparian growth. This will significantly reduce likelihood of invasive fish and crustaceans dispersing upstream into the NSSF and beyond **<u>Flora</u>** • All flora and grasses used for planting will be from native indigenous stock or non-native species that are not listed as weed or invasive species or have a low seeding rate. Grasses planted will consist of a range of	NParks PUB	Design review to ensure the appropriate infrastructure is in place to reduce likelihood of invasive fish and crustaceans	Prior to start of construction works	NIL	NIL	NIL
				Developer	Tree and flora inspection	Fortnightly	Presence of weed/ invasive species infestation	Within Project site	Tree and Flora Inspection Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			heights, included mown and freely sprouting areas. • Due diligence will be conducted on suppliers to ensure that the trees are obtained by legal means and are able to be exported/imported to Singapore. All imported trees will be inspected and/or undergo quarantine if required to reduce the chance of transmission of weeds and soil pathogens. • Ensure material imported into the Project area will be checked for contamination from weed/invasive species seeds/vegetative matter at source. This is particularly important for imported building materials, such as clay and soil. Source site will be inspected to determine presence of weed/invasive species. Where weed or invasive species are identified, alternative supply sources or decontamination will occur before the material is transported to site. • Weed and invasive species will be cleared from the Project area progressively and will be separated and transported to an appropriate disposal location. Transport will occur within a covered vehicle to ensure seed/vegetative matter does not dislodge. All vegetative matter	Developer	Opportunistic sightings by construction personnel	Daily			EMMP Implementation Report
				Developer	Due diligence check on tree suppliers	Due diligence prior to using all suppliers of planting stock	Provenance of planted stock	NIL	NIL

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			and seeds will be rendered inert at the disposal location through incineration at a licensed waste disposal facility. Herbicides may be used to render any stumps/root systems inert. The cleared area will be inspected on a monthly basis to detect any seedlings of invasive species. These seedlings will be killed using herbicide or removed by hand weeding. Any seedlings or vegetative matter that may sprout will be disposed of at a licensed waste management facility						
12.	O		**Fauna** • Encourage responsible pet ownership (indoor cats, dogs on leashes) and enforce a "no release" policy of invasive species (e.g., ornamental fish, red-eared sliders) into ABC Water features or surrounding forest. **Flora** • To reduce possibility of invasive flora and chemical pollutants from entering the Significant Conservation Areas during storm events, certain non-native flora and chemical pollutants (e.g., fertilizers, pesticides) shall not be used within the development during operations	Developer MCST	Inspection	Quarterly	Presence of invasive species	NIL	NIL
13.	C	**Change in wildlife behaviour,**	• Window decals, reducing reflectivity, grills, reduce reflective	Developer	Light monitoring	During night works	Light intensity: Light levels should target to	Vegetated areas and habitats that	Light monitoring records

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
		including nocturnal/diurnal behaviour	window aspect on dominant flight path direction. Decals or matted UV screens on window panels can drastically reduce the likelihood of bird collision. • The construction working hours is restricted to 8 am to 6 pm. • Approval for night works is to be obtained from relevant technical agencies prior to commencement of works after construction hours. **Lighting Management** • Lighting will be directed away from vegetated areas and habitats. Upward and directional lighting will be avoided. Lighting into unintended areas will be avoided. • Where lighting is required to be installed for safety and security purposes, regulatory requirements will be followed. All lighting locations shall be submitted to Developer for approval as part of submission of Site Utilisation plan. • Reduce the duration of nocturnal lighting sources by using a timer or movement-based sensor system to turn off lights. • Where permanent lights are employed, ensure that darker passages between lights exist for sensitive fauna to pass.				be as close to baseline levels during a moonless night as possible	are close to these light sources	

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			Automatic dimming to reduce lighting intensity will also be considered. • Avoid illumination that has a high UV component. • Avoid broad spectrum lights. • Installation of light fittings to reduce nocturnal light impacts on habitats in vegetated areas and habitats outside contract area that are close to these night light sources.						
14.	D & C	**Edge effects on habitats**	• Establish 30m buffer around the Core Conservation Area and Significant Conservation Area • New buildings and infrastructure to be sufficiently setback from the Freshwater Swamp Forest with appropriate spatial buffers considering topography and ecology. • Planting along the entire stretch of western boundary, next to SLE (through various approaches including the Miyawaki method of afforestation) to enhance the range of habitat connectivity within the site. • Additional buffer for planting along the north boundary to reinforce the forest character along this edge.	Developer	Tree and flora inspection: To monitor the edges of vegetation exposed to newly constructed buildings, enclosures and other facilities.	Monthly during construction	Condition of vegetation, reflection from built structures	Forest edges beside project components and built structures	Tree and Flora Inspection Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			• Where newly exposed forest edges are exposed following clearing and where impacts to vegetation are evident, e.g., vegetation shows signs of drying out, artificial shading and/or a sprinkler system will be installed to improve moisture differentials around forest edges.						

15.	C	**Generation of dust impacting human and biodiversity receptors**	**<u>Site Utilization and Construction Works Planning</u>** • Minimise the area of exposed ground, and the volume of soil and construction material handled at any one time by properly scheduling the construction activities (such as demolition works, earthworks and building construction). • Cleared vegetation in particular at sloped areas shall be covered with mulch or erosion control blankets to control erosion of exposed soil. Re-vegetate exposed ground as soon as possible to stabilise surfaces and minimise re-entrainment of dust and potential for erosion of waste spoil to watercourses. **<u>Dust Suppression</u>** • Ensure the availability of water for dust suppression. • Dust suppression methods such as misting during demolitions works in dry conditions. • Water suppression during earth handling at exposed areas. • On days with no rain, watering of dry exposed grounds will be conducted twice per day with watering trucks. Additional round of watering will be implemented on drier months.	Developer	Site walkover	Daily	• Dust generation sources and surface erosion • Spoil, spillage, and general housekeeping. • Presence of mud or dirt on public road entrances • Condition and positioning of tarpaulin covers • Height of stockpiles relative to surrounding hoardings • Vehicular/machinery smoke emissions	All worksite areas, in particular where land clearance, earthworks and building construction are ongoing	EMMP Implementation Report

			Stockpiles and Wastes Management • Minimize volume of spoil stockpiled with potential for dust generation and erosion/runoff, schedule removal of spoil from the Development area or waste material by licensed third party at least once every 5 days. Vehicles used to transport spoil will have tarpaulin securely covering load. • Stockpiles that are not in used, in particular during dry periods, shall be covered with well-maintained tarpaulin, keeping at a maximum height of 2 m. • Ensure any spoil/earth spillage onto the haulage routes are cleaned up immediately and undertake proper housekeeping of the construction site, as well as roadways linked to the entrances of the worksites at the end of each day to ensure that roadways, vehicle wheels and equipment tracks are clear of dust or mud, and that appropriate barriers, tarpaulin covers/erosion blankets have been repaired and/or reinstated. • Cement packaging should not be shaken vigorously to empty the contents as the cement dust will be entrained in the air. Proper disposal of the used packaging into refuse containers will prevent the cement from discharging into the air.						

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
16.	C	**Increased vehicle/equipment emissions resulting in lower air quality**	**<u>On-site Vehicles and Machinery Management</u>** • All vehicles and machinery upon entry and exit of the site shall be cleaned at the bunded wheel washing bay to remove any dust, sediments, seeds, plant, weeds pathogens or contaminating material. • All vehicles and equipment are not to be left idling when not in use and will be periodically checked during maintenance and inspection to ensure emissions are within the prescribed exhaust emission and noise limits. • Avoid use of diesel- or petrol-powered generators by using mains electricity or battery powered equipment where possible, and if safety concerns shall be overcome. • All equipment and machinery used at the construction worksites are to be maintained and operated in a manner such that it does not give rise to smoke emissions or leakage of fuel/oil to ground and will comply with the Environmental Protection and Management (Vehicular Emissions) Regulations. All large vehicles with power output over 37 kW are to have exhaust after-treatment systems installed.	Developer	Ambient air quality monitoring against Singapore ambient air quality target for 24- hour PM10 and PM2.5, i.e., 50 µg/m^3 and 37.5 µg/m^3. If exceeding target level, review of suppression techniques and construction plan will be undertaken and additional measures put in place to alleviate elevated dust levels, e.g., reduce the number of dust generating activities being undertaken	Continuous monitoring during construction	24-hour PM10 and PM2.5	One location upwind and one location downwind of construction worksites	EMMP Implementation Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			Traffic Management • Implement a speed limit and post the speed limit on signs at regular intervals along vehicle access routes. Install speed bumps at appropriate locations. • Minimize traffic delays caused by movement of construction vehicles by planning transport route and transport period that avoid congested areas. This will apply for major deliveries of construction materials, large cast of concrete or during excavation works. Queuing or parking of vehicles outside the construction work area, both before the construction work area opens and during work hours is to be monitored to not more than two (2) vehicles at one time.						

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
17.	C	**Increase ambient noise and vibration level impacting human and biodiversity receptors**	**<u>Equipment and Machinery Management</u>** • Proper selection of quiet models of construction equipment i.e., generators, rebar cutting machine, excavators. • Undertake spot checks of construction equipment to ensure that equipment is operating within its noise specification. In the event of an exceedance, ascertain if exceedance is due to the improper operation of the construction equipment. In the event of repeated and significant exceedances (i.e., more than 3 dB(A)), the construction equipment shall be earmarked for maintenance. • Where technically feasible, use earth retaining and stabilising structures for the proposed underground works, such as diaphragm walls, contiguous piles or secant bored piles that could eliminate the need for percussive piling, e.g., sheet-piling. **<u>Noise and Vibration Reduction Measures</u>** • Utilise noise attenuation devices such as noise barriers to absorb and direct noise away from the Core Conservation Area and Significant Conservation Area adjacent to and beyond the	Developer	Site walkover	Daily	Presence of noisy behaviour / equipment Structural integrity of acoustic barriers	All worksite areas, in particular where land clearance, earthworks and building construction are ongoing	EMMP Implementation Report
				Developer	Noise monitoring in accordance with Annex C & D of the Singapore Standard SS602:2014 to ensure compliance against limits in the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations and <55 dBA	Continuous monitoring during construction	LAeq 5min, LAeq 1hr and LAeq 12hr	Within the Core Conservation Area	EMMP Implementation Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			Contract boundary and prevent a direct line of sight between the Contract area and adjacent forested areas. • Conduct noisy works (piling and demolition activities in particular) only within specific work hours so as to minimize disturbances • Acoustic barriers will be maintained along the boundary between the construction work area and the existing residential. • Erect noise barriers of at least STC 20 around smaller worksites where noisy activities to be carried out over a short-term period, e.g., concrete or road breaking • Install rubber lining within demolition chutes and enclose the façade of the demolition worksite directed towards nearby receptors with acoustic curtains, where possible • Limit the number of equipment operating concurrently on site or switch to a quieter model where applicable. • Assessments to identify any noisy equipment which requires noise control such as mufflers and sound absorbers will be carried out.		at Core Biodiversity Area and Significant Biodiversity Area				

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			• Where sensitive areas or receptors are in proximity, a line will be saw cut on the concrete on floors or appropriate location to break transmission of vibrations. • Preferred demolition method shall be saw cutting, brought down to ground level prior to full demolition of structural elements. This generates the least vibration and noise. **Toolbox Briefing** • Ensure all workers are trained in noise-reduction behaviours such as reducing the drop height of materials and turning off equipment and vehicle engines when not in use. • Daily toolbox briefings should include reminders on the need to implement noise-reduction behaviours					
18.	D	**Increase site runoff and discharges resulting in lower surface water quality**	• The overriding intent is to protect and not degrade the fragile and sensitive biodiversity of the Freshwater Swamp Forest as an important gateway guardian to the NSSF which Singapore's last primary freshwater swamp forest • Integrate WSUD/ABC engineering to divert or disperse water runoff safely to avoid changing the hydrological input and output of swamp forests and to create	URA PUB NParks	Design review to ensure ABC design features are integrated in the design	Prior to start of construction works	NIL	NIL	NIL

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			productive and biodiverse water features and drainage lines. • ABC swales running along the 30m buffer as a protective moat around the Core Conservation Area and Significant Conservation Area to intercept run-off from the parcels on higher ground: ➢ Art pond (retention pond) to contain filtered and cleansed water from ABC Water design features (treatment elements). It is integrated with communal and leisure amenities and a littoral edge to encourage water cleansing plants ➢ Bio-retention swale to channel, filter, and cleanse runoff. The cleansed and filtered runoff will be conveyed to bio-retention pond and collected by sub-soil pipes to channel to downstream waterway and swamp forest ➢ Bio-retention pond to detain, filter and cleanse runoff. Runoff is cleansed as it percolates downwards and will be collected by installed sub-soil pipes to channel to downstream waterway and swamp forest. The filtered and cleansed runoff allows to						

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						Frequency	Parameters	Location	Reporting Requirements
			recharge to surrounding soil via soak away system ➢ Vegetated swale to reduce the flow velocities and to filter runoff that channels to downstream waterway and swamp forest						
19.	C		**General Requirement** • A TSS meter and CCTV camera should be installed at the entrance to any public drains on-site. This is to ensure that parameters of any discharged water are below allowable limits for discharge to public drainage or watercourse, or within permissible levels in any approval letter. • A Silt Imagery Detection System (SIDS) which uses image analytics technology to detect silt discharge and CCTV downtime will be installed at public drains to monitor treated rainwater discharges to ensure that the discharge is not silty. • The used water from the washing bay should be collected and then be re-used in the washing facility or disposed of after being treated by ECM. • Concrete trucks and other equipment should be washed out to prevent concrete from hardening within. This washout	Developer	Visual inspections	Daily and monthly	Check along boundary to ensure silt fence in good condition Check bund wall height at least 300mm high and are in good condition Check perimeter drain to ensure no blockage/ damaged/diverted Ensure discharge to public drain are cleaned. Check for any exposed soil	Within the project site Drains along project boundary Discharge points	Inspections records/ EMMP Implementation Report
					CCTV monitoring of ECM discharge	Continuously throughout construction	30 mg/L TSS	ECM discharge point	EMMP Implementation Report
					Surface water quality survey	Monthly	Environmental Protection and Management (Trade Effluent) Regulations	Sungei Seletar	EMMP Implementation Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			should not be discharged directly into any drainage system but collected as wastewater for treatment. **<u>Site Clearance</u>** • Cleared vegetation in particular at sloped areas shall be covered with biodegradable erosion control blankets to control erosion of exposed soil. • Re-vegetate exposed ground as soon as possible to stabilise surfaces and minimise erosion of waste spoilt to watercourses. • All stockpiles and worksite entrances shall be located as far as practically possible from waterbody. • Minimize the volume of spoil stockpiled that have potential for dust generation and erosion/runoff, schedule removal of spoil from the project site or waste material by licensed third party at least once every 5 days. • All stockpiles, temporary or permanent, and exposed earth surfaces are maintained below a maximum height of 2 m and covered within 3 hours of non-usage or immediately during rain with well-maintained canvas sheets or tarpaulin.					

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						Frequency	Parameters	Location	Reporting Requirements
			Earth Control Measures (ECM) Plan • No construction works shall commence without adequate ECM facilities to ensure no discharge containing TSS in concentration greater than the prescribed limits throughout the project, especially during the site clearance stage. • Before construction work commences, ECM proposal duly designed and endorsed by appointed Qualified Erosion Control Professional (QECP) shall be submitted to PUB in accordance with PUB requirements, and copied to the Developer as follows: ➢ Construction activities are phased and scheduled (such as land clearance, earthworks) to minimise the area of ground exposed and the volume of soil and construction material handled at any one time ➢ Exposed surfaces will be minimised according to the construction activities in each phase ➢ Effective sediment control facilities (including storage						

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						Frequency	Parameters	Location	Reporting Requirements
			and treatment facilities) will be implemented ➢ At high risks areas (e.g., adjacent to setback zone), extra ECM measures, such as the installation of double-layered silt fences shall be put in place to prevent silty water discharge ➢ Perimeter hoarding shall be sealed with concrete on both sides of the footing to minimise silty water discharge ➢ A Clearance Certificate from PUB shall be obtained to commence earthworks ➢ The ECM Plan shall provide for the design of ECM of all phases of construction on site ➢ QCEP shall incorporate all relevant requirements into the ECM design and plan • Earth Control Measures Officer (ECMO) shall ensure that the implementation, maintenance, and inspection of ECM are in accordance with the QECP's design. The ECMO shall also monitor the effectiveness of ECM throughout the various stages of construction: ➢ Regular inspections along boundary to ensure silt fences in good condition					

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						Frequency	Parameters	Location	Reporting Requirements
			➢ Immediate action to replace any damaged silt fence • During construction works, revise and resubmit the ECM proposals, where necessary, according to each phase of the construction activities. **Spill Management and Response Plan** • Equipment such as generator sets and diesel day tank to be bunded to capture and control oil, grease and other spills. • All diesel storage to be contained and with capacity of at least 115% or more than the volume of diesel storage • All chemicals used during construction activities shall be properly stored in designated containers and location and bunded concrete paved area far away from any water bodies. All chemicals must be properly labelled. • A maximum depth of spilled fluids within each containment area to be 20 mm. Exceedance of 20 mm mark will necessitate removal of spills within the bunded storage. • Ensure equipment and machinery are placed on flat ground such that the spill tray is level.					

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			• All spill containment facilities and spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Spill control measures (leaks from machinery and equipment; spills as a result of accidental damage to other underground structures uncovered during excavation works etc.) include the following: • Provide spill kits in case of a leak or spill of a chemical within the contract boundary. • Training for all staff in spill response measures. • All spills must be cleaned within the same day or immediately under wet weather conditions • Spill management kits will be provided at worksites (composition will depend on the type of hazardous materials to be used, but likely include rags, sands, eyewash, protective gloves etc.), one (1) for each Zone, in particular at where hazardous materials, equipment and machinery will be stored and used. • All spill containment facilities and spill trays shall be regularly maintained to prevent rain from					

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			washing out the pollutive substances. • All accidental spillages and trade effluent discharges shall be notified immediately to the Developer Environmental Management Team, investigated, and reported to the relevant authorities. **Waste Management** • All waste onsite shall be kept in designated waste containers and bunded concrete paved area. All the waste shall be collected at least every 5 days by licensed waste collector. No waste shall be disposed outside designated waste bins and on unpaved ground or any water bodies. • Ensure portable sanitary facilities provided within Contract Boundary are located far away from any water bodies and managed by licensed waste collector. • Adequate number of portable sanitary facilities to be provided according to relevant regulations and managed by a licensed third party. • Ensure any spoil/earth spillage onto the haulage routes are cleaned up immediately.					

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			Toolbox Briefing • Ensure all workers undertake proper housekeeping of the construction site, as well as roadways linked to the entrances of the worksites at the end of each day; to ensure that roadways, vehicle wheels and equipment tracks are clear of dust or mud, and the appropriate barriers, tarpaulin covers/erosion blankets have been repaired and/or reinstated.						
20.		**Impacts on the existing groundwater elevation and flow**	• Pumped dewatered groundwater shall not be disposed to the ECM treatment plant. Discharge shall either be to temporary storage tanks for removal by third party licensed wastewater collector; or to a temporary treatment system prior to discharge to a discharge point agreed with PUB. • Discharge of pumped dewatered groundwater from excavations to the NSSF or Freshwater Swamp Forest is not encouraged. • Monitor the groundwater levels at the locations determined as required via geotechnical design. There shall be thresholds in place for each borehole based on the baseline monitoring of the typical range in groundwater levels and if the water table drops below then response measures such as	Developer	Monitoring of groundwater levels	Monthly	Groundwater level	Designated standpipe locations	EMMP Implementation Report

S/N	Phase*	Environmental Impact	Mitigation Measures	Party Responsible for Ensuring Action Implementation	Means of Verification	Monitoring			
						Frequency	Parameters	Location	Reporting Requirements
			groundwater recharge shall be considered. • Limit potential groundwater drawdown and subsequent water level impacts during any excavation e.g., use recharge wells as necessary during excavations. The method to limit groundwater drawdown shall be provided as part of the EMMP and extent determined by geotechnical design. • For all locations with excavation of depth near or deeper than groundwater level, an environmental baseline borehole shall be installed in the middle of the area where excavation will be carried out and the groundwater and soil of each locations be tested against the Dutch Intervention and Target Standards.						

8 Assessment Summary and Residual Impacts

DHI has identified, predicted and evaluated potential residual impacts associated with the project construction. A residual impact is the impact that is predicted to remain after mitigation measures have been designed into the intended activity.

8.1 Construction Phase

Figure 8-1 and Figure 8-2 present the predicted construction phase non-mitigated and mitigated cases respectively for Impact Significance as translated from Environmental Scores following the RIAM methodology. Following mitigation measures, for the base proposed Springleaf Precinct Master Plan the residual impact significance of loss of flora and fauna from young secondary forests is predicted to be Moderate Negative (Figure 8-2). Residual Impact Significance was lower than Minor Negative for all predicted impacts, when the alternative proposed Springleaf Precinct Master Plan option was taken into consideration.

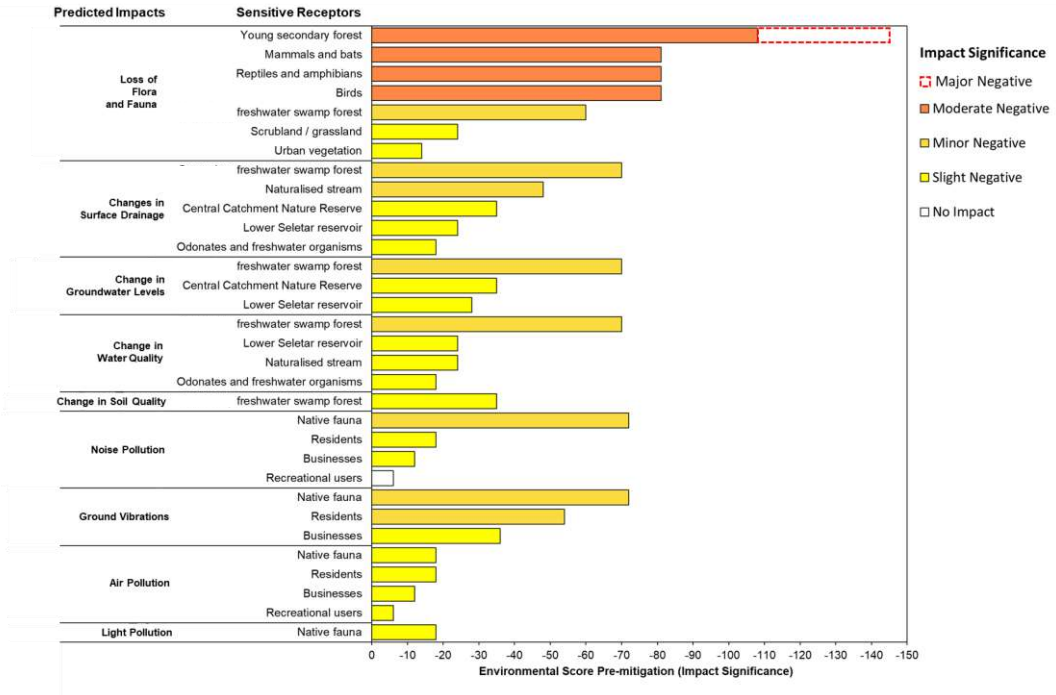

Figure 8-1 Visual summary of predicted Impact Significance as translated from Environmental Scores following the RIAM methodology, for construction phase impacts prior to mitigation measures. The dashed bar represents the increase in Environmental Score (Impact Significance) should the base masterplan with five additional forest cottages be adopted. *Note: Environmental Scores are displayed on a reversed horizontal axis. Environmental Scores of 0 are classified as "No Impact".*

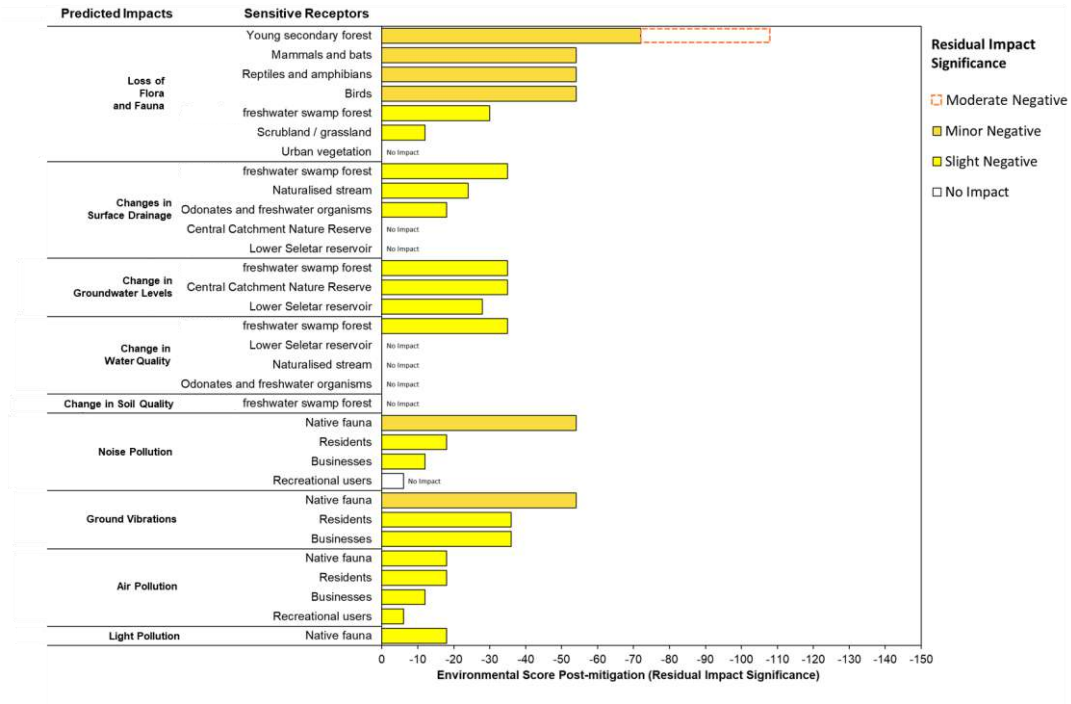

Figure 8-2 Visual summary of predicted Impact Significance as translated from Environmental Scores following the RIAM methodology, for construction phase impacts after mitigation measures, i.e. Residual Impact Significance. The dashed bar represents the increase in Environmental Score (Residual Impact Significance) should the base masterplan with five additional forest cottages be adopted. *Note: Environmental Scores are displayed on a reversed horizontal axis. Environmental Scores of 0 are classified as "No Impact".*

8.2 Post Construction Phase

Figure 8-3 and Figure 8-4 present the predicted post-construction phase non-mitigated and mitigated cases respectively for Impact Significance as translated from Environmental Scores following the RIAM methodology. Following mitigation measures, the base proposed Springleaf Precinct Master Plan has residual impact significance of loss of ecosystem functions and forest edge effects within young secondary forests predicted to be Moderate Negative (Figure 8-4). Residual Impact Significance was lower than Minor Negative for all predicted impacts when the alternative proposed Springleaf Precinct Master Plan option is adopted. Notably, the proposed mitigation measures were expected to result in several positive impacts (Figure 8-4).

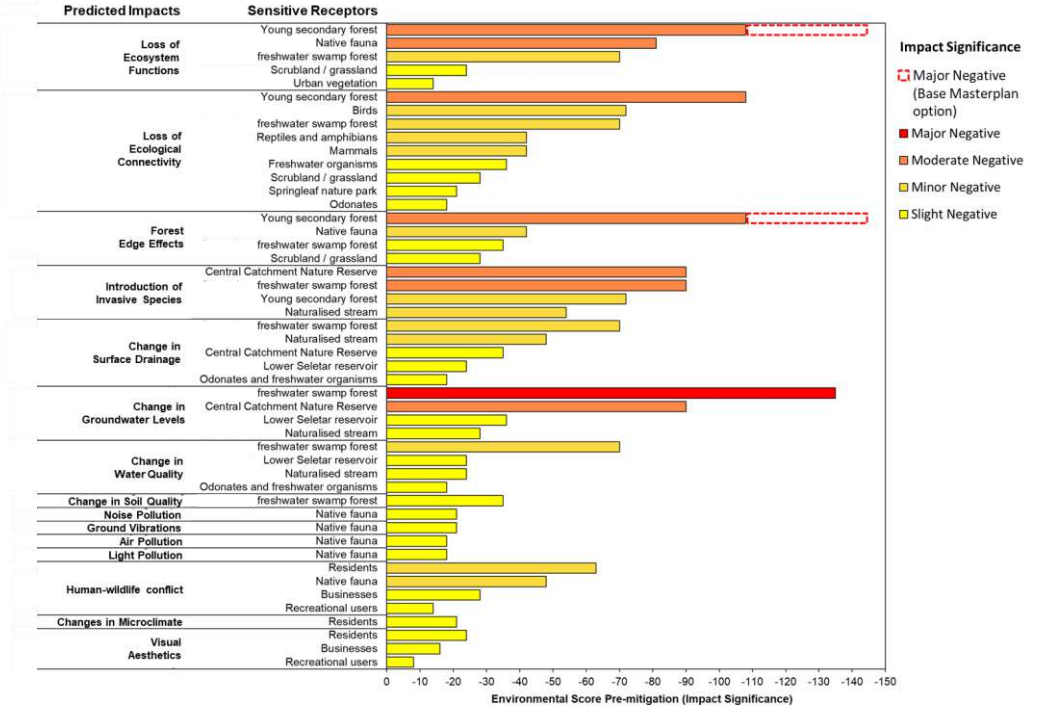

Figure 8-3 Visual summary of predicted Impact Significance as translated from Environmental Scores following the RIAM methodology, for post-construction phase impacts prior to mitigation measures (top). The dashed bar represents the increase in Environmental Score (Impact Significance) should the base masterplan with five additional forest cottages be adopted. *Note: Environmental Scores are displayed on a reversed horizontal axis. Environmental Scores of 0 are classified as "No Impact".*

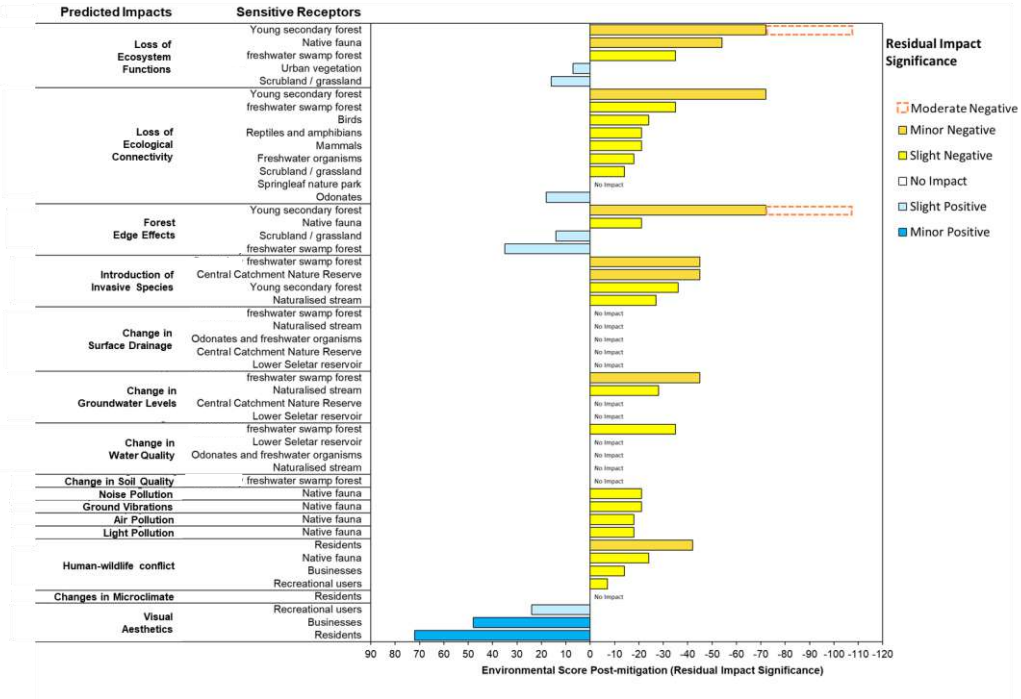

Figure 8-4 Visual summary of predicted Impact Significance as translated from Environmental Scores following the RIAM methodology, for post-construction phase impacts after mitigation measures, i.e. Residual Impact Significance (bottom). The dashed bar represents the increase in Environmental Score (Residual Impact Significance) should the base masterplan with five additional forest cottages be adopted. *Note: Environmental Scores are displayed on a reversed horizontal axis. Environmental Scores of 0 are classified as "No Impact".*

9 Conclusions

Vegetation covers 56% of Singapore's total land area: 27% is actively managed (parks, gardens, lawns, etc.) and 29% is spontaneous vegetation. Primary lowland dipterocarp forest and freshwater swamp forest cover only 0.28% and is confined to the Bukit Timah and Central Catchment Nature Reserves (Yee et al. 2011). Any additional loss of Singapore forest can not only be detrimental to biodiversity and ecosystem functions but also the local community who have deep connections to these natural areas.

The Springleaf Precinct is situated in a strategic position between the Central Catchment Nature Reserve and Upper Seletar Reservoir to the west, and Springleaf Nature Park and Lower Seletar Reservoir to the east. It provides critical local hydrological and ecological connectivity. The conservation value of the biodiversity within the Springleaf site is relatively high, especially the core area of the freshwater swamp as a high portion of the flora and fauna are found only within the Springleaf site and the NSSF, and not anywhere else in Singapore (NUS, 2018).

Any land development project will inevitably create some site disturbance. However, the significance of these impacts can be controlled to a level considered acceptable through the planning and implementation. The proposed Springleaf Precinct Master Plan is guided by the BSUD Framework, which provides a systematic and rational approach for optimal integration of ecology and biodiversity in the proposed Springleaf Precinct Master Plan design. The proposed Springleaf Precinct Master Plan proposes the construction and longer term running of the development will follow a 'light touch' approach to achieve the delicate balance between preservation of nature and human intervention. Impacts to habitats and associated biodiversity will be minimised, safeguarding the inherent character of nature.

The proposed Springleaf Precinct Master Plan proposes development parcels in the north and south of the site. The proposal focuses development on land which is already disturbed ground and in areas with less ecologically sensitive areas. A key priority in the proposed Springleaf Precinct Master Plan design is to protect the Significant Conservation Areas.

One of the most defining characteristics of the proposed Springleaf Precinct Master Plan is the amount of area retained as green or landscaped land. At least 72.4% of the existing green area is maintained and potentially more (approximately 0.26 ha more) if the final number of Tree Cottages is reduced by five and substituted with two Forest Towers in the alternative masterplan. Compared to other residential developments in Singapore or internationally this is exceptional. For comparison, the US EPA mentions that, depending on the densities, open space requirements should be between 35-50% of which half should be green space maintained in a natural, undisturbed condition (US EPA, 2018). This outcome has been achieved through positioning the high-rise towers on a smaller footprint concentrated at locations that in some cases are already disturbed and far from the ecologically sensitive epi-centre (ie. at Parcels 1a/1b and 2) as an optimal way to meet the targeted dwelling units with minimal land take. The high-rise towers yield a total of 1,468 units (73.4% of target units), with a building footprint of about 3% of the total site area.

A new housing type, i.e. the Tree Cottages, is proposed within the secondary forest zone, consisting of low-rise buildings on stilts. The building height of the Tree Cottages will be controlled to ensure buildings lie beneath the tree canopies of the mature trees. This approach leaves much of the ground, including the existing topography, in its existing state. This potentially enables a shared habitat model, where wildlife continues to have access on ground, and humans predominantly stay at the common 'new ground' level at about 9 m above ground. Communal facilities can be introduced at a minimum 3 m from ground, to provide a safe and unencumbered zone for recreation. Residents can come to ground, with

the awareness of the possibility of encountering wildlife. The clear benefit of this approach is that less space is partitioned from the wildlife and fauna can continue to roam freely and feed within the shared area.

High-rise towers will be designed as Forest Towers, infused with vertical greening. The minimum area of common green decks (maintained by MCST) to be provided is an average of at least 20% of the building floor area. These decks will have maintenance access and form part of the common zone to be maintained by MCST, for consistency and sustainability of the greenery.

Apart from the base proposed Springleaf Precinct Master Plan option, an alternative option where the number of Tree Cottages is halved from 10 to 5, yielding a total of 160 dwelling units, has been evaluated (elaborated in Section 4.2.1.1). The reduction in total dwelling units can be compensated by introducing two additional towers in the north, within Parcel 2, which can accommodate an additional 224 units. In this reduced Tree Cottage option, there is an opportunity to increase the size of the Core Conservation Area and hence retain more of the existing green area and further minimise potential disturbances to the sensitive freshwater swamp forest habitat.

The existing urbanised areas (and disturbed ground) on site would be transformed into high quality public spaces, in a green setting reflecting the forested nature of the site. A landscape planting guide provides strategic guidelines on landscape strategy for each development parcel, to ensure the landscape signature of the site is retained. New habitat will be created, enabling residents to be close to nature.

ABC Waters features play an integral role in flood mitigation, water quality improvement and biodiversity enhancement. The aim is to maintain similar hydrological processes across the site and in particular to minimise any changes in the water table, to avoid broader scale impacts. Modelling results predict that the design achieves this through maintaining a high proportion of green or landscaped land (30-80% depending on the parcel) and ensuring that even paved areas utilise porous materials where practicable (at least 10-15% depending on the parcel). Stormwater will be treated by ABC Waters features and encouraged to exfiltrate back to the ground for recharging of the groundwater during storm events.

Tree planting at targeted areas of the site will be done to create green corridors to be used by different fauna. The proposed Springleaf Precinct Master Plan distinguishes between Native (plants native to Singapore) and Non-Native species. Native plants which are found within Springleaf site are classified as Signature species. The purpose of this distinction is to focus the planting predominantly on keeping the Landscape Signature species. The Signature, Native and Non-Native species are carefully zoned and graded across the site, with Native and Signature species focused on areas closest to the Significant Biodiversity Areas.

Access into the Significant Conservation Areas will be restricted. In particular, the Freshwater Swamp Forest will be entirely conserved and the fringes will be reinforced through native plantings to increase biodiversity and connectivity with NSSF. Public access is limited to the eastern fringe areas where elevated boardwalks within the 30 m buffer zone enable appreciation of the natural setting with minimal impact on existing ecology of the site. The boardwalk connects the two new public parks, i.e. the P.O. Park in the north and to the Woodland Art Park south of Sg. Seletar. Look-out towers at strategic locations offer glimpses of the swamp forest and riparian corridor. An on-ground trail for guided walks is proposed in the north within the 30 m buffer zone which will provide one of the best opportunities in Singapore to get close to the unique swamp forest habitat.

Residents who choose to live here will be part of a community committed to sustainable living. Various design elements incorporated within the development, such as the Sustainability Education Centre sited within the Red House, will help reinforce the message and facilitate active stewardship in the community.

Through the RIAM assessment the following predictions were made for impacts without any mitigation, assuming that the base proposed Springleaf Precinct Master Plan option is adopted:

- Construction phase impacts - 1 Major, 3 Moderate, 8 Minor and 19 Slight Negative Impacts.
- Post-construction phase impacts - 3 Major, 5 Moderate, 13 Minor and 27 Slight Negative Impacts.

Significant impacts, those rated as major or moderate, relate to potential impacts on the Young Secondary Forest, Native Fauna and the Central Catchment Nature Reserve included:

- Loss of flora and fauna
- Loss of ecosystem functions
- Loss of ecological connectivity
- Forest edge effects
- Introduction of invasive species
- Change in groundwater levels

However, the proposed Springleaf Precinct Master Plan has put forward detailed proposals to mitigate against these types of impacts. Section 6 presents a series of mitigation measures split between avoidance, minimisation, restoration and offsets that are designed to bring the impacts down to acceptable levels. Some of the mitigation measures designed toward protecting the sensitive receptors, that will provide consequential benefits, include:

- Protection of the Significant Conservation Areas and establishing 30 m buffer zones as a further layer of protection.
- Dwelling units planned within existing urbanised or disturbed ground areas as far as possible, rather than high value forest.
- Tree Cottages and walkways raised on stilts, to avoid impact on the forest ground, within the secondary forest zone.
- Safeguarding as much greenery as possible within the development sites, by requiring conservation of mature trees and the endangered/critically endangered tree species, as well as implementing a landscape planting guide to maintain the green/forested character of the site.
- Connectivity between Springleaf and adjacent forests enhanced through targeted reforestation or revegetation of corridors, such as the SLE underpass and Sungei Seletar riparian vegetation, buffer zones, as well as areas within the developed parcels.

With mitigation in place predicted residual impacts, assuming that the base proposed Springleaf Precinct Master Plan option is adopted, are reduced as follow:

- Construction phase impacts – 1 Moderate, 5 Minor and 18 Slight Negative Impacts.
- Post-construction phase impacts – 2 Moderate, 6 Minor and 19 Slight Negative Impacts; and 6 Slight and 2 Minor Positive Impacts.

Three Moderate residual impacts are still identified after mitigation is integrated. These all related to the Young Secondary Forest and involve loss of flora and fauna, loss of ecosystem functions, and forest edge effects. However, assuming a scenario where the alternative proposed Springleaf Precinct Master Plan option with reduced number of Tree

Cottages, these Moderate Negative residual impacts reduce to Minor Negative impact, given that the area of secondary forest clearance will be minimised and around the periphery with more conservation-significant flora species will be retained. The size of the Core Conservation Area can also be expanded, giving more protection to the sensitive freshwater swamp forest habitat. The buffer zones will then be shifted southward of the Core Conservation Area, and potentially its width can be increased too. The final locations of the remaining Tree Cottages and supporting infrastructure would need to be carefully surveyed at implementation stage. Considerable planning effort should also be committed into reducing these impact levels to as low as reasonably practicable utilising both innovative and proven design and mitigation approaches.

The proposed Springleaf Precinct Master Plan has put in place detailed guidelines for the development parcels at design, construction and inhabitation stages, to manage impacts within the private parcels. Targeted enhancements critical to the success of the proposed Springleaf Precinct Master Plan are predominantly in the public domain. Within the development parcels impacts can be reduced through implementation of the recommended avoidance, minimisation and/or restoration mitigation measures but not entirely eliminated. However, there can be some counterbalance by introducing offsets outside the development parcels. These offsets include afforestation; replacement of invasive flora species with endemic species; improvements to connectivity between forested areas; and increased accessibility, recreational amenity and visual aesthetics. It is predicted that these offsets can lead to positive outcomes in terms of ecological connectivity, ecosystem function, edge effects and visual aesthetics and they should be implemented before or in tandem with the parcel developments.

To achieve the best possible outcomes there will need to be broad commitment by different organisations and parties including the Developer, Designer, URA, NParks, PUB, LTA, Construction Contractor, Specialist Consultants, Service Providers, MCST, Residents, Business Operators and Visitors to enact an ethos towards caring for and conserving the nature on site. On top of this, both public education and outreach are recommended to cultivate environmental stewardship.

For developments within ecologically sensitive sites, the proposed Springleaf Precinct Master Plan can set a new benchmark in the way that it will retain the natural green and forested character of the site. The Springleaf development also aims to be a model for sustainable living, contributing positively to the national effort to instil environmental responsibility and stewardship. The proposed Master Plan is aimed at offsetting 100% of its operational carbon emissions, leveraging on the extensive greenery on site as a carbon sink to achieve carbon neutrality.

It is anticipated that Springleaf Precinct will be developed in stages, enabling feedback and assessment of earlier stages to inform and shape later phases of development. Parcel 1 is expected to be developed first, followed by Parcel 2. Sufficient time should be allowed between the different stages of development, to enable close monitoring of outcomes of the key strategies and assumptions.

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11 Appendices

Appendix A

Table 2.6.1. List of 51 mammal species of probable occurrence at Springleaf Forest with their status and conservation status. Status: RC = Restricted and Common, RR = Restricted and Rare, VT = Visitor, WC = Widespread and Common, WR = Widespread and Restricted, WU = Widespread and Uncommon. Conservation Status: NL = Not Listed, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered. Bold indicates species recorded during the biological impact assessments (Rajathurai, 2011; Rajathrai, 2013).

Family	*Species*	Common Name	Status	Local status (SRDB)	Global status (IUCN)
Suidae	*Sus scrofa*	Wild Pig	WC	NL	LC
Tragulidae	*Tragulus kanchil*	Lesser Mousedeer	RR	CE	LC
Felidae	*Prionailurus bengalensis*	Leopard Cat	RR	CE	LC
Viverridae	*Arctogalidia trivirgata*	Three-striped Palm Civet	RR	CE	LC
Viverridae	*Paradoxurus musangus*	Common Palm Civet	WU	NL	LC
Mustelidae	*Lutrogale perspicillata*	Smooth-coated Otter	RR	CE	VU
Emballonuridae	*Emballonura monticola*	Lesser Sheath-tailed Bat	WR	CE	VU
Emballonuridae	***Saccolaimus saccolaimus***	**Pouch-bearing Bat**	**WC**	**NL**	**LC**
Emballonuridae	*Taphozous melanopogon*	Black-bearded Tomb Bat	WR	EN	LC
Hipposideridae	*Hipposideros bicolor*	Bicoloured Leaf-nosed Bat	RR	NL	LC
Megadermatidae	*Megaderma spasma*	Malayan False Vampire	RR	CE	LC
Molossidae	*Cheiromeles torquatus*	Naked Bulldog Bat	RR	CE	LC
Nycteridae	*Nycteris tragata*	Southeast Asian Hollow-faced Bat	RR	CE	NT
Pteropodidae	***Cynopterus brachyotis***	**Lesser Dog-faced Fruit Bat**	**WC**	**NL**	**LC**
Pteropodidae	*Cynopterus sphinx*	Short-nosed Fruit Bat	RR	VU	LC
Pteropodidae	*Eonycteris spelaea*	Cave Nectar Bat	WU	NL	LC
Pteropodidae	*Macroglossus minimus*	Common Long-tongued Nectar Bat	RR	VU	LC
Pteropodidae	*Penthetor lucasi*	Dusky Fruit Bat	RR	EN	LC
Rhinolophidae	*Rhinolophus lepidus*	Glossy Horseshoe Bat	RC	NL	LC
Rhinolophidae	*Rhinolophus luctus*	Woolly Horseshoe Bat	RR	CE	LC
Rhinolophidae	*Rhinolophus trifoliatus*	Trefoil Horseshoe Bat	RR	CE	LC
Vespertilionidae	*Kerivoula hardwickii*	Hardwicke's Woolly Bat	RR	CE	LC
Vespertilionidae	*Murina suilla*	Brown Tube-nosed Bat	RR	CE	LC
Vespertilionidae	***Myotis adversus***	**Grey Large-footed Myotis**	**WC**	**NL**	**LC**
Vespertilionidae	***Myotis muricola***	**Whiskered Myotis**	**WC**	**NL**	**LC**
Vespertilionidae	*Pipistrellus javanicus*	Javan Pipistrelle	WU	NL	LC
Vespertilionidae	*Pipistrellus stenopeterus*	Narrow-winged Pipistrelle	WR	NL	LC
Vespertilionidae	***Scotophilus kuhlii***	**Asiatic Lesser Yellow House Bat**	**WC**	**NL**	**LC**
Vespertilionidae	*Tylonycteris pachypus*	Lesser Bamboo Bat	RR	CE	LC
Vespertilionidae	*Tylonycteris robustula*	Greater Bamboo Bat	WC	NL	LC
Cynocephalidae	*Galeopterus variegatus*	Malayan Colugo	RC	NL	LC
Manidae	***Manis javanica***	**Sunda Pangolin**	**WR**	**CE**	**CE**
Cercopithecidae	***Macaca fascicularis***	**Long-tailed Macaque**	**WC**	**NL**	**LC**
Cercopithecidae	***Presbytis femoralis***	**Banded Leaf Monkey**	**RR**	**CE**	**NT**
Loridae	***Nycticebus coucang***	**Sunda Slow Loris**	**RR**	**CE**	**VU**
Hystricidae	***Hystrix brachyura***	**Malayan Porcupine**	**RR**	**CE**	**LC**
Muridae	***Maxomys rajah***	**Rajah Spiny Rat**	**RR**	**EN**	**VU**
Muridae	***Mus musculus***	**House Mouse**	**WC**	**NL**	**LC**
Muridae	***Rattus annandalei***	**Annandale's Rat**	**RC**	**NL**	**LC**

Muridae	***Rattus exulans***	**Polynesian Rat**	**WU**	**NL**	**LC**
Muridae	***Rattus norvegicus***	**Brown Rat**	**WC**	**NL**	**LC**
Muridae	***Rattus tanezumi***	**Oriental House Rat**	**WC**	**NL**	**LC**
Muridae	***Rattus tiomanicus***	**Malaysian Wood Rat**	**WC**	**NL**	**LC**
Sciuridae	***Callosciurus notatus***	**Plantain Squirrel**	**WC**	**NL**	**LC**
Sciuridae	***Hylopetes spadiceus***	**Red-cheeked Flying Squirrel**	**RR**	**CE**	**LC**
Sciuridae	***Iomys horsfieldii***	**Horsfield's Flying Squirrel**	**RR**	**CE**	**LC**
Sciuridae	***Rhinosciurus laticaudatus***	**Shrew-faced Ground Squirrel**	**RR**	**CE**	**NT**
Sciuridae	***Sundasciurus teniuis***	**Slender Squirrel**	**RC**	**NL**	**LC**
Tupaiidae	***Tupaia glis***	**Common Treeshrew**	**WC**	**NL**	**LC**
Soricidae	***Crocidura malayana***	**Malayan Shrew**	**RR**	**NL**	**LC**
Soricidae	***Suncus murinus***	**House Shrew**	**WC**	**NL**	**LC**

Table 2.6.2 List of fish recorded by Rajathurai (2011) from Springleaf Forest

No.	Common name	Scientific name
1	Einthoven's Rasbora	*Rasbora einthovenii*
2	Two-spot Rasbora	*Rasbora elegans*
3	Saddle Barb	*Systomus banksi*
4	Harlequin Rasbora	*Trigonostigma heteromorpha*
5	Spotted Eel-Loach	*Pangio muraeniformis*
6	Hasselt's Leaf Catfish	*Silurichthys hasselti*
7	Longnose Little Warty Catfish	*Parakysis longirostris*
8	Common Walking Catfish	*Clarias batrachus*
9	Malayan Pygmy Halfbeak	*Dermogenys collettei*
10	Malayan Forest Halfbeak	*Hemirhamphodon pogonognathus*
11	Common Guppy	*Poecilia reticulata*
12	Buff-backed Spiny Eel	*Macrognathus maculatus*
13	Marbled Gudgeon	*Oxyeleotris marmorata*
14	East Asian River Goby	*Rhinogobius giurinus*
15	Asian Climbing Perch	*Anabas testudineus*
16	Peacock Bass	*Cichla orinocensis*
17	Crescent Betta	*Betta imbellis*
18	Malayan Forest Betta	*Betta pugnax*
19	Malayan Pikehead	*Luciocephalus pulcher*
20	Forest Snakehead	*Channa lucius*
21	Common Snakehead	*Channa striata*

Appendix B – Draft Technical Report 01: Landscape and Ecology

Appendix B: BIODIVERSITY CONSERVATION GUIDELINES (DESIGN, CONSTRUCTION, INHABITATION)

1.1 Biodiversity Conservation Guidelines (Design)
1.2 Biodiversity Conservation Guidelines (Construction)
1.3 Biodiversity Conservation Guidelines (Inhabitation)
1.4 BSUD Actions Implementation Timeline

1.1 BIODIVERSITY CONSERVATION STRATEGIES: DESIGN

1.1.1 Retain northern Significant Conservation Area and southern Core Conservation Area

BSUD Principle(s): Maintain and introduce habitat

Type of Mitigation: Mitigation

The Core Conservation Area was identified for conservation for its landscape and biodiversity values. The primary habitat Core Conservation Area is a freshwater swamp forest, a rare habitat in Singapore that has been reduced to 0.4% land cover from 5% land cover. This habitat is also the most floristically rich area of the Springleaf Forest, having an abundance of native CR species and several individual tree species that are unique to this habitat. Finally, although fauna appear to utilize different habitats throughout the Springleaf Forest to different extents, a majority of fauna groups appeared to utilize the freshwater swamp forest more than other habitats throughout the forest.

The Significant Conservation Area in the NHG was also identified as an area of conservation. While secondary forest patches are common habitat in Singapore, this habitat is abundant in flora that were unique to only this habitat within the Springleaf Forest. Further, this habitat is a significant habitat for mammals, reptiles, and birds; indeed, mammal abundance in this area appears to be on par with the freshwater swamp forest, while reptiles use this habitat for natural processes (foraging, hunting, mating, etc.).

No development shall be undertaken within the Core Conservation Area and the Significant Conservation Area. Further, a 30 m buffer will be designated around these areas where only limited development can be undertaken. For more details on what developments can occur within the buffers, see 1.1.2 Establish Screening Buffers.

1.1.2 Establish Screening Buffers

BSUD Principle(s): Minimize threats and human disturbances; Improve potential for positive human-nature interactions

Type of Mitigation: Mitigation & Enhancement

While Core Conservation Area and Significant Conservation Area are identified to be retained, they are prone to edge effects if not given sufficient protection. Buffers are the most efficient means of protecting forest fragments as they absorb and reduce impacts from surrounding development. Such buffers need to be wide and sufficiently dense in order to provide sufficient protection for the internal forest fragments.

The buffer for both the Significant Conservation Area and the Core Conservation Area will be 30 m wide and encircle each protected area in order to mitigate impacts of the new development. These buffers must be identified and demarcated prior to development and left intact to mitigate impacts of the development. This buffer will establish a strip of forest between surrounding human-built environments and the Significant Conservation Area and Core Conservation Area and protect these areas from human impacts. As the development progresses (e.g. two years after development commence), salvaged saplings can be planted within Screening Buffer to intensify the greenery or repair any tree gaps that existed in the buffer due to damages, for example those caused by inclement weather or animals.

It is important that no construction activities are done in Screening Buffer except for boardwalk/stepping stones. These boardwalks and stepping stones must allow public access through the buffers, but not to enter the Significant Conservation Area or the Core Conservation Area.

While the Core Conservation Area and Significant Conservation Area require Screening Buffers to mitigate impacts of new development, additional Screening Buffers need to be established to protect other areas of the Springleaf Forest from impacts of human-environments that are already there (e.g. Upper Thomson Road, SLE). This measure would be considered an enhancement as it is developing protections for the Spring- leaf Forest against pre-existing human-built environments.

Information on the importance of forest trails for outreach and education are found in Forest Trails under section 1.3.1 Community education and stewardship.

For guidelines on plantings required to strengthen Screening Buffers, see section 1.1.3.2 Tree Planting Methods for Springleaf Forest and 1.1.8 Planting characteristics and palettes.

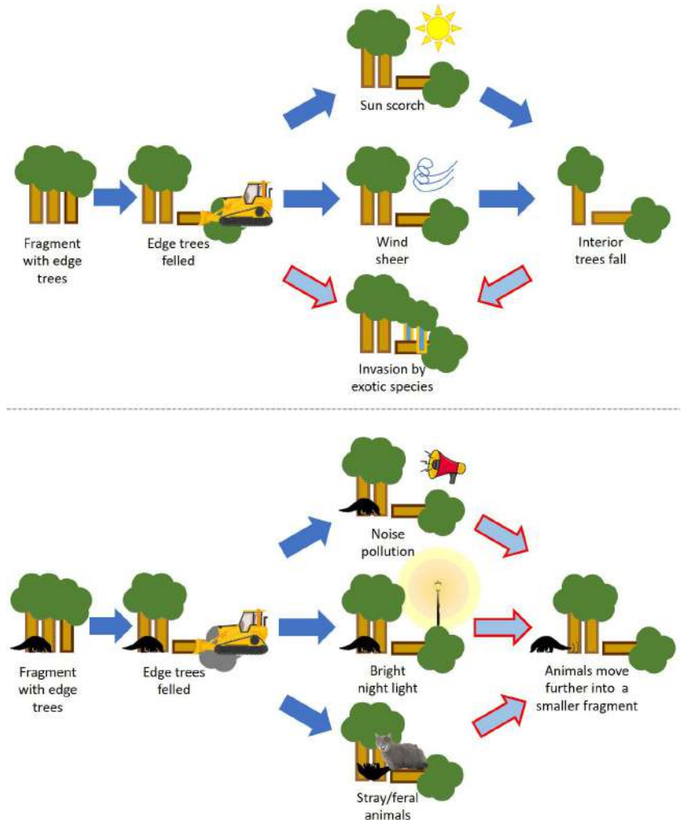

Figure 1.1.3a Different edge effects for both flora (top) and fauna (bottom). Removal of edges can result in interior trees becoming damaged from sun scorch, weakened by wind shear and invaded by competing invasive plants. Damaged trees from sun scorch and trees weakened by wind sheer can fall, exposing more interior habitat to invasion and damage. Removal of habitat at edges can increase disruptions to behaviour by human light, noise, and result in fauna becoming predated by feral animals. These, on top of other impacts not listed here, can result in fauna becoming displaced or leaving edge habitats.

1.1.3 Targeted tree planting

BSUD Principle(s): Facilitate dispersal; Minimize threats and human disturbances; Facilitate natural ecological processes

Type of Mitigation: Mitigation & Enhancement (see section 1.1.3.3 Areas for Planting below)

1.1.3.1 Purposes of Tree Planting

There are four purposes to tree planting within the development parcels and Springleaf Forest:

<u>Connectivity</u>

Tree planting at targeted areas of the site can create green corridors to be used by different fauna. Trees that create a closed and contiguous canopy create connectivity for arboreal animals. Planting trees create forest patches in between fragments, which create stepping stones for birds that need to cross large empty spaces between habitats. Planting trees to connect different fragments with a forest corridor provides cover for forest-dependent terrestrial animals to move through between fragments.

<u>Buffer</u>

Buffers are green walls that separate sensitive habitat from development projects as well as hard landscapes. Buffers with sufficient widths and appropriate densities are able to shield sensitive habitats from human impacts by reducing air pollution, tampering noise, preventing invasions by feral animals or invasive plants, or providing sufficient shade from human-made lights.

<u>Strengthen Edges</u>

Forest edges are the interface between two habitats; forest (interior) and an open habitat (exterior, such as a low-density woodland or grassy plains). Portions of a forest edge that have gaps open the interior sensitive habitat to a multitude of different edge effects. Tree planting in gaps at forest edges between habitats can strengthen the boundaries of the forest and make them resilient to invasion from adjacent habitats (Figure 1.1.3a).

<u>Creating Habitat</u>

Tree planting can provide habitat to different flora (e.g. climbers and orchids) and fauna (e.g. birds and squirrels). Planting trees within gaps of a forest or in forest edges provides additional habitat for forest-dependent species, but doing so in development areas provides habitats within the development. This also brings nature closer to residents and people, which can instill a sense of stewardship and care for the environment if people have the opportunity to view and appreciate wildlife.

1.1.3.2 Tree Planting Methods for Springleaf Forest

Two methods of tree planting for the purposes of afforestation (creating forest at places with no existing tree cover) and reforestation (replenishing an existing forest) within the Springleaf Forest will be used. While both planting methods use same species selection, they differ in planting density, site suitability and planting goals.

Miyawaki Afforestation

The Miyawaki afforestation method is a rapid restoration method that is appropriate for restoring small areas of degraded forests and wastelands with no existing tree cover. The first distinguishing feature of the Miyawaki method is that flora species chosen are usually “climax” species, i.e. species that would be typical of an end-successional forest (Miyawaki, 1993). As a multitude of climax species can be chosen and planted, high flora diversity is achieved very early in the process. The second feature is that trees are planted at extremely high density, up to 3 trees/m2. The purpose of this high-density planting of climax species is to achieve a climax forest within a short period of time while allowing the crown canopy to quickly close and reduce landscape maintenance need such as weeding and watering.

Miyawaki afforestation method had been applied to sites with high precipitation such as India, Malaysia, and South America with proven success, allowing quick environmental restorations of strongly degraded areas and mitigating Urban Heat Island effect (Schirone et al. 2010). In Singapore, while Miyawaki afforestation method had not been explicitly tested, the core idea of Miyawaki afforestation (dense planting to achieve rapid canopy closure) had been supported by trial findings at Chestnut Nature Park (Chua, 2021).

In Singapore, climax species with local germplasm can be challenging to procure. Further, many local forest species prefer shaded cool environments and will not survive growing in unshaded open areas. Therefore, the Springleaf Forest uses a modified Miyawaki method by using “framework species" that are found within the Springleaf Forest rather than climax species in view of the local forest ecology. In particular, tree species found locally on Springleaf forest that are fast growing, have high survival rate, and bear fleshy fruits regularly to encourage rapid canopy formation in open areas and seed dispersion throughout Springleaf. Because of the high density of trees required for the Miyawaki method, the saplings will be planted through a nucleation-like planting scheme, interspersed as “island forests” throughout the development and Springleaf Forest, covering approximately 0.4 ha. Trees within the nuclei are expected to eventually spread, connect and form contiguous forest patches. Certain areas within the development will use the Miyawaki method as well to quickly grow trees and cover walls (e.g. the MRT).

Miyawaki afforestation will prioritize using salvaged saplings within construction footprints in the final development design. To achieve a Miyawaki forest:

1. The site within which the trees are planted must be cleared of herbaceous, non-native weedy vegetation (e.g., grass) Trees should be planted when they are between 3 and 4 m tall
2. Trees must be planted at a density of 3 trees/m2
3. Tree species within each square meter should be randomly selected
4. Placement of trees within each square meter and throughout the site should not be orderly (i.e., trees should not be planted in rows and columns)
5. Management of the site is required, primarily focused on providing sufficient water to the trees and clearing the site of grass or weeds During periodic management, any leaf litter that develops should be left on the floor
6. After three years of intensive management, trees should be left alone for natural selection processes to take over

Framework Species Method

The framework species method is conducted at areas with existing tree cover (compared to Miyawaki afforestation which is done in places with no existing tree cover). It can be conducted in larger areas compared to Miyawaki afforestation method as it requires a lower planting density (a 100×100 m area would require 30,000 trees with the Miyawaki method). The hallmark feature of the framework species method is the use of "framework species”, a selected range of 20-30 species designated for planting. These selected species are meant to re-establish the natural mechanisms of forest regeneration and accelerate biodiversity recovery. For Springleaf, we chose fast-growing, fruit-bearing trees with high survival rate that can attract fauna for seed dispersal. As the seeds are deposited and additional trees grow, existing forests can expand and close canopy gaps. This prevents weeds from growing and allows young, shade-tolerant late-successional forest species to grow in understorey. In essence, these first 20-30 selected species provide the “framework” with which a forest can grow (see Goosem and Tucker, 2013 for an overview of the method).

The framework species method is ideal for larger secondary forest patches within the Springleaf Forest, especially where the crown canopy is dominated by exotic species. It is also suitable for repairing or intensifying Screening Buffers protecting sensitive habitats. The framework species saplings should be planted randomly across sites, averaging approximately 1.8 meters away from each other (this comes to an approximate average tree density of 0.3 trees/m2), and the planting density can be further reduced in areas with some established trees. As the native framework saplings grow and produce fruits, they can increase the number of native saplings at understorey and eventually replace the exotic species on site.

The exact species to use must be in keeping with the landscape signature and the planned planting signature of specific zones. For guidelines on plant palettes used and definition of landscape signature, see section 1.1.8 Planting characteristics and palettes.

Location	Specific areas within location	Purpose	Intervention Type	Implementing Party (Public/Private)	FSM	MA	Other
Screening Buffer	1. South of Parcel 2	Buffer	Mitigation	Private	✓	✓	
	2. Surrounding Parcel 1a and 1b	Buffer	Mitigation	Private	✓		
	3. Adjacent SLE	Buffer	Enhancement	Public	✓		
	4. Adjacent Mandai Road	Buffer	Enhancement	Public	✓		
	5. Adjacent Upper Thomson Road Culvert	Buffer	Enhancement	Public	✓	✓	
	6. South-eastern corner of Springleaf	Buffer	Enhancement	Private	✓	✓	
Development Parcels	7. Parcels 1a, 1b, and 2 except South-eastern corner of Springleaf	Habitat; Connectivity	Mitigation	Private	✓		✓
Grassy Woodlands	8. Entire habitat except eastern portion	Habitat; Connectivity; Strengthen edges	Enhancement	Public	✓		
Sungei Seletar	9. Both sides of Sungei Seletar except for eastern portion near Upper Thomson Road	Habitat; Connectivity; Strengthen edges	Enhancement	Public	✓		
Swamp Forest and Ecotone	10. Adjacent to SLE	Strengthen edges	Enhancement	Public		✓	
SLE Underpass	11. Sungei Seletar	Connectivity	Enhancement	Public			✓
	12. Upper Thomson Road	Connectivity	Enhancement	Public			✓

Table 1.1.1 Location and specific areas within aforementioned locations where tree planting occurs. The type of measure (mitigation or enhancement) for each tree planting is provided. Cells with ticks under Framework Species Method (FSM) and Miyawaki Afforestation (MA) indicate the method to be used for these specific areas. Planting methods other than FSM and MA are highlighted in Other; the reader is encouraged to read the specific sections for details on planting methods. Implementing party indicates whether the government/state (public) or the land developer (private) are meant to carry out the tree planting .

1.1.3.3 Areas for Planting

The areas targeted for planting in the Springleaf Forest and in the development are for specific functions and satisfy either mitigation measures or are habitat enhancements. The following subsections will identify the location of areas for planting, whether they fulfil impact mitigations or habitat enhancements, and if they utilize Miyawaki afforestation methods or the framework species method. Table 1.1.1 summarizes the information while Figure 1.1.3b shows locations of where Miyawaki forests and tree plantings are. The reader is encouraged to read on for further details.

Screening Buffers

Screening buffers are located at the interface between human-built environments and the natural environments. Buffers that are enhancements would be those that buffer Springleaf Forest from existing urban environments (e.g. Upper Thomson Road, SLE). Buffers that are mitigations are for those that would buffer the sensitive environment from new developments, such as the one planned around Significant Conservation Area and Core Conservation Area.

Within Development Parcels

Tree planting within development parcels are mitigation measures as they are an attempt to replace habitats that may have been cleared for development. As planting within development parcels are dependent on the placement of infrastructure, planting within these parcels is driven by landscape architecture and design.

However, Miyawaki nucleations are possible within areas of development, such as the north- and south-eastern portions of the development. These would serve the purpose of providing stepping stones for birds where there previously were no forests or trees. Miyawaki nucleations also provide a visible barrier that cue birds to slow their flight speed, rather than flying into a building and becoming victims of bird strike. As a majority of bird strikes occur between 6 and 9 m above ground, buildings taller than Miyawaki nucleations would not be of major concern. In either case, buildings will have green walls, which will also cue birds to slow their flight speed.

Grassy Woodlands

The grassy woodlands in the northern division is dominated by a grassy understory and a non-native dominated crown (Rain trees *Samanea saman*, African tulip trees *Spathodea campanulata*, and Albizia trees *Falcataria moluccana*). Because natural successional pathways can take several decades to complete, the process can be hastened with a framework species method. As this is providing additional habitat for fauna by quickening successional pathways, this can be considered a habitat enhancement measure.

Although the crown is dominated by non-native species, it is imperative that these large trees are not felled. They not only provide important functions for fauna, such as roosting habitats, but also provide shade to the understorey. This function serves two purposes: the first is to block sunlight from reaching weedy plants in the understorey, thus not allowing them to grow. The second is to provide shade for shade-tolerant native species while they are saplings, which will be planted with the framework species method. These non-native trees must be allowed to continue to persist until they naturally die, by which time the native understory will have developed into the new canopy for the site.

Planting of grassy woodlands is to be concurrent with tree planting for either side of Sungei Seletar. This is to ensure that the forest in the Significant Conservation Area extends to Sungei Seletar and provides connectivity opportunities for Malayan colugos (see Either Side of Sungei Seletar).

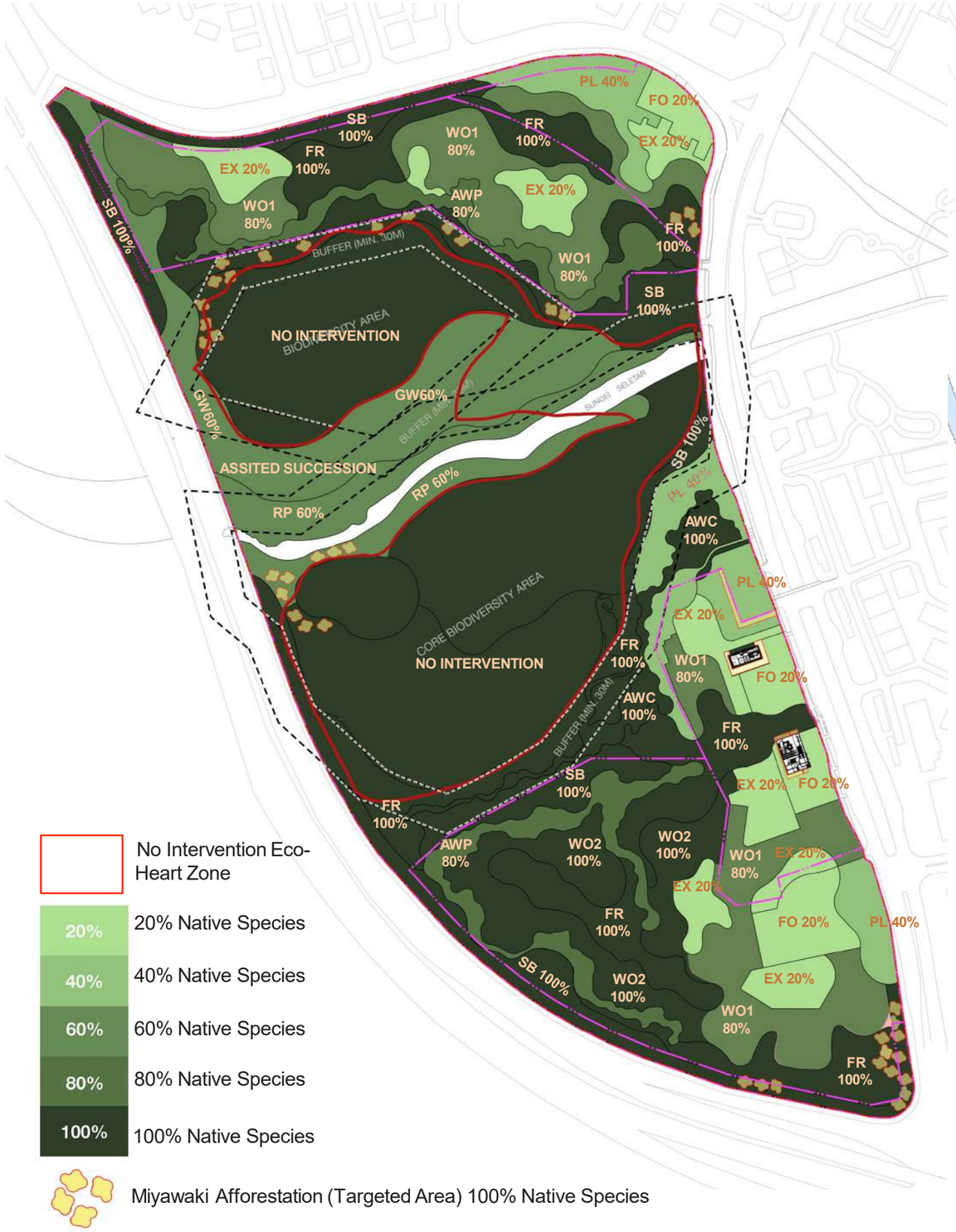

Figure 1.1.3b Location of Miyawaki afforestation targeted areas (left) and tree plantings as labelled in Table 1.1.1 (right) (Map credit: STX Landscape Architects).

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Figure 1.1.3c. Malayan Colugo, or the Flying Lemur, is an otherwise common arboreal gliding mammal throughout Singapore that is in abundance in the NGH but not in the areas south of Sungei Seletar.

Figure 1.1.3d. SLE underpass adjacent to Sungei Seletar. The ground is hard-packed with sparse vegetation cover .

Not all portions of the grassy woodlands will undergo tree planting (and subsequent habitat change). The baseline study found that the grassy woodlands was possibly important for reptile fauna as a basking site for reptiles that resided and foraged within the Significant Conservation Area. To maintain the function of the habitat for reptiles, a patch of this habitat in the south-eastern corner of NLG will remain as grassy woodlands. Maintaining this habitat as grassy woodlands will also maintain a heterogeneous landscape mosaic of different habitats throughout Springleaf Forest.

Either Side of Sungei Seletar

The Significant Conservation Area was identified as a significant habitat for Malayan colugo (Figure 1.1.3c). However, it is unusual that Malayan colugo were limited to the northern habitat, as the Malayan colugos tend to be fairly well distributed wherever there are mature, straight trees in forests throughout Singapore. Given that such trees are available in the Core Conservation Area as well as the NHG, it is likely that Malayan colugos are fragmented and isolated to the Significant Conservation Area and thus unable to reach the habitats in the southern division of Springleaf Forest. As recommended in the baseline survey, efforts must be made to connect the northern and southern divisions of Springleaf.

As Malayan colugos glide between trees, canopy rope ladder bridges would be an inappropriate means of encouraging movement between the northern and southern divisions for them (canopy rope ladder bridges are still important for other arboreal animals. See section 1.1.5 Improve or establish connectivity). However, planting trees on either side of Sungei Seletar will create tall, straight trees that can provide Malayan colugos the necessary natural corridors to glide over Sungei Seletar (once a forest is established between the Significant Conservation Area and Sungei Seletar). This will give them the opportunity to colonize the southern division of Springleaf Forest, which has an abundance of large and straight trees.

The portion of Sungei Seletar that cuts through Springleaf Forest is approximately 400 m. The framework species method is recommended for the banks of Sungei Seletar because the tree density required for the Miyawaki method would result in a high number of trees required. Further, trees should be planted in such a way that their roots have enough space to grow within soil. In other words, tree roots should not be penetrating out of the banks of Sungei Seletar and over the river once the trees reach maturity.

Swamp Forest and Ecotone Edges

Edges of the swamp forest and ecotone, particularly those adjacent to the SLE, are floristically poor with several gaps. These areas have the potential to be points of invasion into the forested habitat, but can be strengthened to prevent this. As the SLE is already impacting the environment, planting trees in this area would be considered a habitat enhancement. Further, because the area is small, this is an opportunity to use the Miyawaki nucleation forests.

SLE Underpass (Sungei Seletar)

The space underneath the SLE and around Sungei Seletar is hard-packed ground with very little vegetation cover (Figure 1.1.3d). This is because the SLE aboveground makes it difficult for water to reach any planting beds that would be underneath it, while also preventing sunlight from reaching any plants that would be planted here. The resulting sparse vegetation may be unattractive to forest-dependent fauna which seek refuge within a vegetated patch. This area would also use a framework species approach, but the species used must be shade tolerant. A plant palette has been developed for this area, which can be found in Planting Palette for SLE underpass.

Prior to planting, the site must be prepared. The ground must be tilled to soften it, and nutrients must be inserted to make the soil viable. It is not necessary nor recommended to use fertilizers due to the proximity of Sungei Seletar. Instead, compost can be added to the softened soil and replenish the nutrients necessary for plant growth.

Planting in this area would encourage the movement of animals where there previously was no movement before. Because this corridor is in response to an already existing human-built environment (SLE), this can be considered as a habitat enhancement measure.

SLE Underpass (Upper Thomson Road)

The space underneath the SLE and adjacent to Upper Thomson Road has low-shrub streetscape. However, this space is an opportunity to enhance the Springleaf Forest by creating a stepping stone for birds between CCNR/NSSF and the Springleaf Forest. Vegetation needs to be shade tolerant, but the space between the lanes of the SLE will allow more light and water to reach the planted vegetation. *Ardisia elliptica* and *Leea indica* are recommended to be planted in this zone due to their small size and attractiveness to birds.

It is important to follow the plant palette as closely as possible. While there is a need to plant native flora, it must consider that road users need to be able to see on-coming traffic. Hence, vegetation used cannot be too high to impede visibility.

1.1.3.4 Anticipated Outcomes of Targeted Tree Planting

Species lists for plants to be salvaged are not provided as there is no certainty in the final list of species (i.e. if a species is not on the species list encountered by the topographical surveyor, it does not mean that the species does not occur there). An example of such a discrepancy was the absence of *Barringtonia racemosa* in the topographical survey, despite that it had been identified in the baseline. Instead, guidelines for criteria to salvage plants can be found in section 1.2.6 Harvesting and transplanting native plant saplings/climbers. That being said, it is expected that the species list should be similar to that recorded in baseline report and landscape signature list as defined in Section 1.1.8.

A detailed plan/survey is not available as it is subject to changes in final design, but where saplings will be planted will be based on a hierarchy of priority sites that require tree planting based on the need to fulfill ecological functions to mitigation impacts or enhance habitats. This hierarchy of priorities can be found in section 1.1.8 Planting Characteristics and Palettes. Specific guidelines on protecting trees on site are found in section 1.2.9 Tree protection. The general principles of reforestation actions are as below:

- Large trees not obstructing building footprints will be retained on site as much as possible, and thus will not be transplanted for reforestation purpose at all.
- Small native saplings (girth ≤ 30 cm) within construction footprint, FEA, and those within a 2 m buffer of construction footprints and FEA will be salvaged to an onsite nursery to be used for reforestation, afforestation and/or landscaping purposes depending on species.

The salvaged saplings used for reforestation purposes will be (1) planted using Miyawaki Method at designated areas, or (2) planted using Framework Species Method at areas that have existing secondary forest canopy (as per Figure 1.1.3b).

Once planting is completed, the final outcome (i.e. 20-30 years after planting) would be a closed canopy throughout the Springleaf Forest, such that:

- Edges of Core Conservation Area and Significant Conservation Area strengthened such that there are no gaps in the tree line, making these habitats more resilient to invasion from invasive flora
- The forests in the NLG and SLG have extended to the banks of Sungei Seletar, allowing connectivity across Sungei Seletar for birds and Malayan colugos
- A patch of grassy woodlands maintained to maintain a habitat mosaic and heterogeneity across the Springleaf Forest for edge specialists to utilize
- Screening buffers with no gaps in the tree line in between Springleaf Forest and current/future developments, blocking out dust, light, and noise
- A vegetated space underneath the SLE at Sungei Seletar, allowing movement of small fauna between NSSF/CCNR and Springleaf
- A vegetated space underneath the SLE at Upper Thomson Road, providing stepping stones for birds to cross underneath the SLE at Upper Thomson Road between Springleaf and NSSF/CCNR

It is important to reiterate a point: to state that the tree planting will result in a net positive benefit to Springleaf Forest would be premature. Careful monitoring of the entire forest over several decades after development completion is the only way to determine if these impact mitigations and habitat enhancements have worked.

1.1.4 Water-sensitive urban design

BSUD Principle(s): Facilitate natural and ecological processes

Type of Mitigation: Mitigation

As the development occurs adjacent to a wet freshwater swamp forest, urban design must be sensitive to the aquatic ecosystems found there. Technical meetings with the Public Utilities Board (PUB) have highlighted concerns that directing surface runoff away from the swamp and into the drains on Upper Thomson Road will overload the drain systems, becoming a flood risk for the upcoming MRT station. PUB have strongly suggested that surface runoff be directed into the swamp forest instead.

The baseline study highlighted concerns of the swamp forest becoming too dry, thus unable to support the biodiversity within the site (fish and crustaceans specifically). This means that flood risk goals match well with biodiversity conservation objectives. However, water must still be managed properly.

Surface runoff from site is managed through a network of Active, Beautiful, Clean Waters (ABC Water) features within the development parcels. While these are meant to clean the water before they enter the water table or becoming surface runoff, the water cannot be too clean; the swamp forest had substantially high levels of total nitrogen, and water that is too clean will leach nutrients from the soil, making it unable to support the rich biodiversity in the swamp forest. Water that is filtered through the ABC Water features should be sufficiently clean while still capable of supporting swamp forest biodiversity.

Aquatic plants within all water features must be selected carefully. Aquatic plants that are suitable for horticultural purposes are hardy and fast-growing, which can make them weedy and suitable for invasion. Some aquatic plants to avoid include but are not limited to: Water hyacinth (*Pontederia crassipes*), Water lettuce (*Pistia stratiotes*), Giant Salvinia (*Salvinia molesta*), cocoyam (*Colocasia esculenta*), Waterthyme (*Hydrilla verticillata*), Peacock water hyacinth (*Eichhornia azurea*), Mosquitoferns (*Azolla pinnata*), Stream Bog Moss (*Mayaca fluviatilis*), Primrose Willow (*Ludwigia octovalvis*), Water primrose (*Ludwigia hyssopifolia*)

It is also imperative that the ornamental freshwater fish **are not used in any water features within the development.** For the same reasons as horticultural aquatic plants, fish species normally selected for ponds are easy to keep alive, which makes them potentially invasive in ecosystems. In circumstances where a storm event results in overflow from the development into the swamp forest, fish might also be washed down to the swamp forest as well.

Location	Type	Fauna Group	Measure
Sungei Seletar	BAI (canopy rope ladder bridge)	Arboreal	Enhancement
	BAI (raft bridge; log bridge)	Terrestrial	Enhancement
	HCC	Bird; Colugo	Enhancement
Grassy woodlands	HCC	Terrestrial; arboreal	Enhancement
Upper Thomson Road	BAI (canopy rope ladder bridge)	Arboreal	Enhancement
	HCC	Bird	Enhancement
SLE Underpass (Sungei Seletar)	HCC	Terrestrial	Enhancement
		Arboreal	Enhancement
		Bird	Enhancement
SLE Underpass (Upper Thomson Road)	BAI (canopy rope ladder bridge)	Arboreal	Enhancement
	HCC	Bird	Enhancement
Screening buffers (south-eastern and north-eastern Springleaf Forest)	HCC	Birds	Enhancement
Towers	BAI + HCC (greening of tower blocks)	Birds	Enhancement
Drain and railing parallel to SLE	None, see below	Terrestrial	Enhancement
Development parcels	See section 2.5.3.3 Areas for Planting	Arboreal/Terrestrial/Bird	Mitigation

Table 1.1.2 Location of specific connectivity strategies: built animal infrastructure (BAI) or habitat connectivity corridors (HCC)
*For details on connectivity across Upper Thomson Road, see section *1.1.5.5 Wildlife Crossing*

Figure 1.1.5b Canopy rope ladder bridge that allows movement of arboreal animals across spaces separated by a river or a road (left). Location of where the infrastructure could be installed along Sungei Seletar, marked in red circle (right)

1.1.5 Improve or Establish Connectivity

BSUD Principle(s): Facilitate dispersal
Type of Mitigation: Mitigation & Enhancement (see Table 1.1.2)

Some guidelines have been briefly covered with regards to connectivity for tree planting (See section 1.1.3 Targeted tree planting). This section will consolidate information on ecological connectivity, with some additional strategies.

There are two types of connections that can be developed to connect fragmented habitats: habitat connectivity corridors and animal built infrastructure (Figure 1.1.5a). Habitat connectivity corridors are connections between fragments that are developed through planting of flora. Over time, a flora community will develop within this corridor and provide cover, closed canopy, an understory, and leaf litter on the forest floor. This will become attractive spaces for fauna to use as corridors to move between fragmented habitats. Habitat connectivity corridors are suitable when habitats are fragmented in a human-impact landscape mosaic (e.g., forests fragmented within an area where the majority of the surface area is agriculture or built environment).

Built animal infrastructure are engineering solutions to connect fragmented habitats. Animal crossings across an expressway (e.g., the animal crossing at BKE) are one such example, but still require habitat connectivity corridors on them; animals do not find a bare, concrete bridge safe to cross, and likely will not use them if it is not covered in vegetation. Other built infrastructure can be canopy rope ladder bridges across tree crowns (Figure 1.1.5b). This type of animal infrastructure allows arboreal animals such as squirrels and monkeys to move across rivers or roads.

A summary of strategies for improving or maintaining connectivity is provided in Table 1.1.2. The sections below will focus on the development of canopy rope ladder bridges, raft bridges, log bridges, and towers while also providing guidelines on improving connectivity with regards to the railing and drain running parallel to the SLE. Guidelines on habitat connectivity corridors with regards to tree planting can be found in 1.1.3 Targeted Tree Planting.

Only one of each built animal infrastructure needs to be developed and installed to establish connectivity across Sungei Seletar. Location for the built animal infrastructures should be as far away from Upper Thomson Road and the SLE as possible, so any location along Sungei Seletar between the SLE and Upper Thomson Road should be sufficient (i.e. anywhere from 130-220 m from the SLE along Sungei Seletar towards East) (Figure 1.1.5b). It is not necessary to provide exact locations for where these infrastructure are to be installed, but endangered trees along Sungei Seletar in figure 1.1.3b must not be impacted.

It is worth mentioning that connections over Upper Thomson Road are focused on arboreal and avifauna connectivity. The low-rise residences across Upper Thomson Road from Springleaf are likely to have a high abundance of stray cats. Any built animal infrastructure that allows animals to connect to forests from Springleaf into Springleaf Nature Park and surrounding forests are likely to be used by cats to enter Springleaf Forest. While cats will likely be removed by natural means, they can cause significant damage and loss of animal life prior to that. As such, connectivity for terrestrial fauna will be focused between Springleaf and CCNR/NSSF.

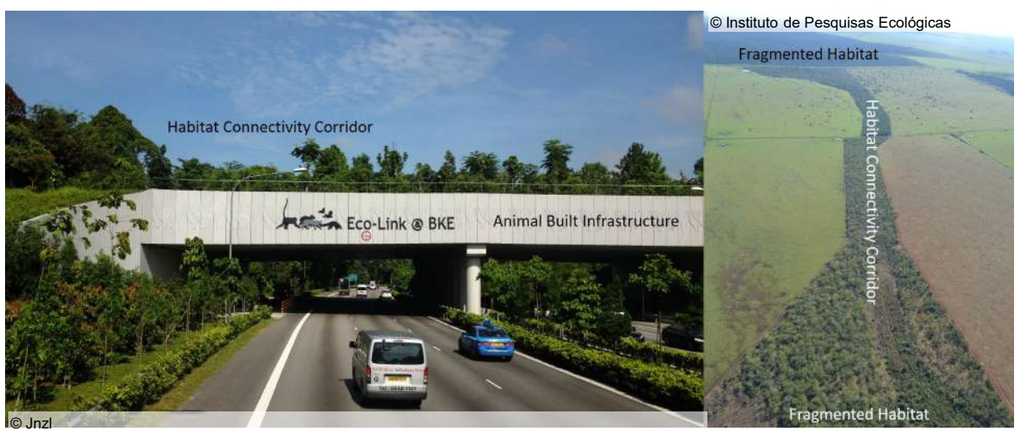

Figure 1.1.5a Habitat connectivity corridors (left) connecting fragmented habitats within an agriculture landscape. Animal built infrastructure (right) over the BKE connecting the CCNR and BTNR. Note that the animal crossing over the BKE itself is an animal built infrastructure, but requires a habitat connectivity corridor to provide cover.

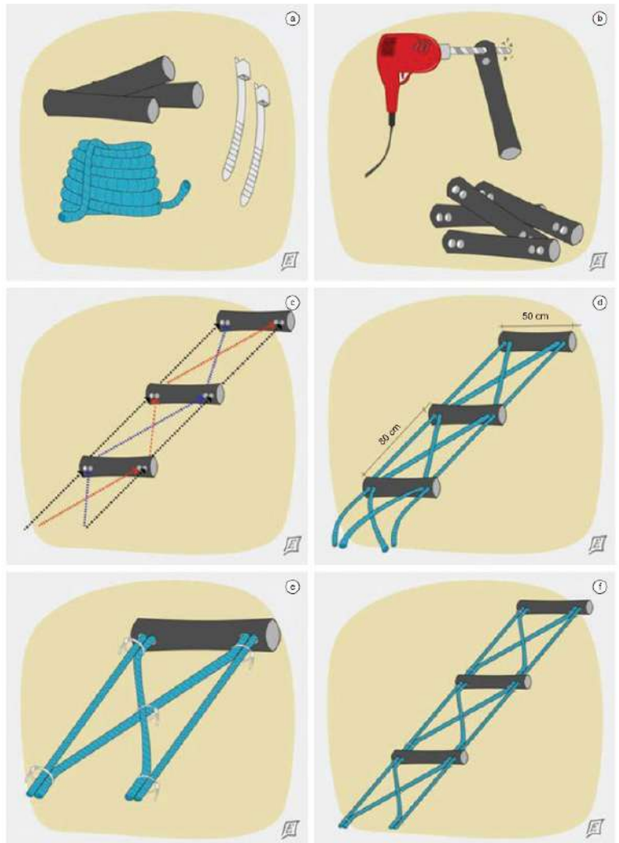

Figure 1.1.5c Diagram of canopy rope ladder bridge specifications (from Teixeira et al., 2013).

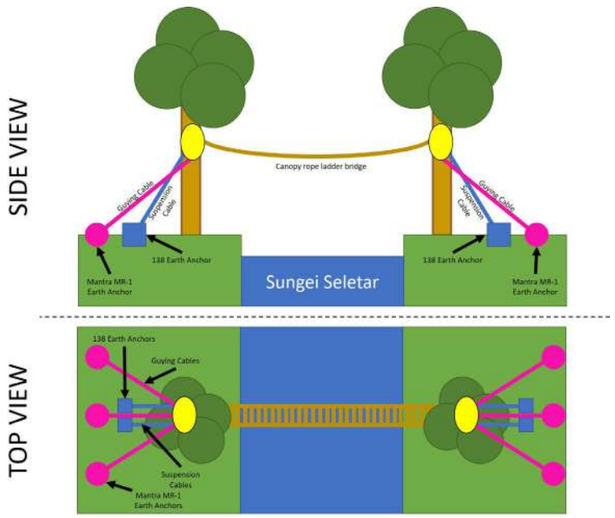

Figure 1.1.5d Diagram of stabilization requirements for trees that hold up the canopy rope ladder bridge.

1.1.5.1 Canopy rope ladder bridge

Canopy Rope Ladder Bridge Specification

A canopy rope ladder bridge is, as the name implies, a ladder made of two pairs of 12 mm ropes with rubber hose rungs (Teixeira et al., 2013). One pair of ropes run through the edges of the ladder and are always parallel to each other, while the other pair create an “X” between each rung (Figure 1.1.5c). Points where ropes cross or come into contact with one another are held together by cable ties to prevent rungs from moving up and down the ladder.

1. A 70 mm diameter hose is cut into 500 mm pieces
2. Four holes are drilled through the hose, two on each side of the rung. Holes must be wide enough to thread through a 12 mm nylon fiber rope
3. The outer ropes are threaded through the outer rungs in a straight line
4. The inner ropes are threaded through the inner rungs in a zig-zag pattern
5. Points where the ropes cross or are in close contact (at the rungs and the “X” in the center” are secured with cable tie to prevent the rungs from slipping up and down the ladder

While the lengths of the ropes will vary depending on the length of the bridge, there are two important considerations to keep in mind:

- The ropes used to create the “X” pattern must be at least 1.2 times the length of the parallel ropes
- Ropes must have an excess of approximately 10-20 m on either end to securely fasten the ladder to the tree. Length of excess will vary on the size of the trees
- The distance between the end rungs and the tree should be between 50-100 mm

Canopy rope ladder bridges across Sungei Seletar are more-or-less straightforward, but installing at the SLE underpass adjacent to Upper Thomson Road is trickier due to the traffic and the ladder drooping low between suspension points. Poles should be installed from Springleaf Forest to CCNR through the SLE underpass to suspend the canopy rope ladder bridge. Poles must be high enough to ensure that the lowest point of the canopy rope ladder should be more than 4 m above ground.

Tree Stabilizing Guidelines

Trees are hardy organisms but their growth and structure are dependent on the stresses they were exposed to while they were developing. Hence, a tree that did not grow to bear additional weight would suddenly be strained if a canopy rope ladder was suspended from it and a group of animals (e.g. 10 monkeys) jump and move about on the said rope bridge.

However, with careful arboricultural techniques, trees can be supported to bear the weight of crossing animals (Figure 1.1.5d). The exact specification (cable diameters and length) will vary depending on the species, so the contracted arborist (see section 1.2.5 Guidelines for native plant salvaging timeline and personnel) should assist in the exact specifications once a crossing point is selected.

In general, the listed components are recommended:

- Two (2) 138 Earth Anchors per tree (total 4)
- Three (3) Manta MR-1 Earth Anchors per tree (total 6)
- Two (2) suspension cables per tree to be secured to the tree and attached to 138 Earth Anchors (total 4)
- Three (3) guying cables per tree to be secured to the tree and attached to Mantra MR-1 Earth Anchors (total 6)
- 4T Pulley system to secure guying cables, suspension cables, and canopy rope ladder bridge to the trees

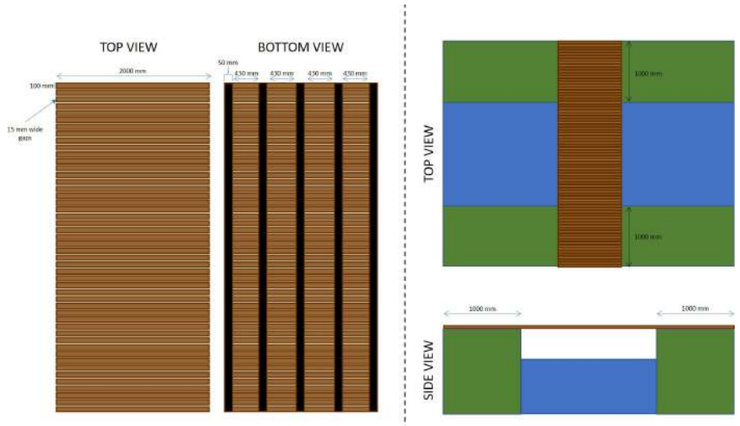

Figure 1.1.5e Specifications of the raft bridge. Left: Dimensions of each log used for the raft bridge as well as maximum gaps between logs. Right: Amount on either side of the bridge that must be on solid ground.

Figure 1.1.5f Drain and railings running alongside the SLE on the western bounds of Springleaf Forest

1.1.5.2 Raft Bridge

A raft bridge that crosses Sungei Seletar will be used by large terrestrial animals (sambar deer and wild boar) to travel between the northern and southern divisions of Springleaf Forest. Therefore, the raft bridge must be able to support the weight of these animals (avg. weight sambar deer: 240 kg; wild boar: 100 kg). Specifications for the raft bridge can be found below, while a diagram of specifications can be found in Figure 1.1.5e:

- Raft bridges must be at least 2000 mm wide, while length must be long enough to (i) cross the width of the river and (ii) have at 1000 mm of each end of the bridge on solid ground
- 12 mm nylon thread must be used to lash woods together to ensure long-term durability
- Direction of wooden logs lashed together must be perpendicular to the direction of the bridge
- Wooden logs used as the platform of the bridge must have a diameter of at least 100 mm and must have a length of 2000 mm
- Five (5) support logs with a diameter of 50 mm must run parallel to the direction of the bridge to support the wooden logs
- Support logs must be long enough to (i) cross the width of the river and (ii) have at least 1000 mm of each end of the bridge on solid ground
- Support logs must be spaced at approximately 430 mm from each other
- Spaces between lashed logs must be no greater than 15 mm to reduce the chances of fauna having their forelimbs fall through gaps
- While it is encouraged to use wood that is within the vicinity (e.g., trees that are felled for development), the wood must be durable enough to withstand the elements and forces of nature and be resistant to rot and decay. In such circumstances, Bakau wood is an ideal choice for such bridges
- Bridges must be secured on site without the use of high-impact engineering methods, such as (but not limited to) concrete.

1.1.5.3 Log bridge

The log bridge can simply be any tree that was felled during the construction phase. Such logs can be up to 200 mm in diameter. Species used should not be soft woods (e.g., Albizia *Falcataria moluccana* or African tulip tree *Spathodea campanulata*).

1.1.5.4 Railing and drains parallel to SLE

A drain runs along the length of the western boundary of Springleaf Forest parallel to the SLE and is bounded with railings on either side of the drain (Figure 1.1.5f). While this was once a way of preventing humans from falling into the drain, it provides a barrier to movement for terrestrial fauna that cannot climb over the railing or cannot climb out of the drain if they fell in.

In order to enhance connectivity between Springleaf and NSSF, the railing should be removed and the drain should be covered.

1.1.5.5 Towers

Towers within the Masterplan are designed to be built in the very north and southern extents of Springleaf Forest. These areas are along the corridors for birds through Springleaf Forest when moving between CCNR/NSSF and Sungei Khatib Bongsu. This can pose a problem for birds, particularly with respect to bird strikes.

However, the towers can be covered with greenery to block the window glass, causing birds to slow their flight speed before reaching the towers. These walls of greenery can also provide birds with a resting spot as they attempt to cross Upper Thomson Road. What is worth mentioning is there is an absence of vegetation at the very southern tip of the Springleaf Forest, so vegetation on the towers will be an enhancement to bird connectivity between CCNR/NSSF and Sungei Khatib Bongsu. This will make the towers a BAI as well as an HCC.

Woody climbers are recommended as flora to use on the towers. However, plants to be used for the buildings may not necessarily be native as there are very few native woody climbers that can withstand direct sun exposure. There are simple ways to mitigate the risk of invasion by these non-native climbers though: simply ensuring they do not bear fleshy fruits make them unattractive to birds as a source of food, while using woody vines that cannot be wind dispersed prevents seeds from being blown great distances into the Springleaf Forest or even the CCNR.


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Figure 1.1.5g Fence flashing as used here is usually used to deter invasive predators (e.g. feral cats) from entering protected areas. Such fences have been used to prevent western swamp tortoises in protected areas within Western Australia from leaving their protected areas and into specific adjacent properties (residential).

1.1.5.6 Wildlife Crossing

Sambar deer have been sighted crossing Upper Thomson Road into Tagore Forest from the southeastern corner of Springleaf, indicating that this is an important point of connectivity. It is very likely that when site clearance and construction works begin in Springleaf, there will be more movement of sambar deer and other fauna, e.g. megafauna such as wild boar and smaller fauna such as palm civets, across Upper Thomson Road. This will increase the likelihood that an animal may be struck by vehicles moving on Upper Thomson Road or as vehicles exit or enter the SLE. It is not only important for ecological and conservation purposes, but for the safety of road users, to ensure these animals are not struck.

There are two means of preventing the collision of fauna on Upper Thomson Road, each of which will be detailed below. Each option will provide the advantages and disadvantages to these methods, concluding with a recommendation regarding the wildlife crossing.

Wildlife Crossing

In order to allow continued connectivity between Springleaf Forest and Tagore Forest, a wildlife crossing can be constructed that crosses Upper Thomson Road and runs parallel to the SLE. One other wildlife crossing has been constructed over the BKE connecting Bukit Timah Nature Reserve (BTNR) and the Central Catchment Nature Reserve (CCNR), known as the Eco-Link @ BKE, while another is currently under construction connecting the forests divided by Mandai Lake Road. The Eco-Link @ BKE has seen success with the crossing of several small animals such as pangolins, palm civets, and several species of birds and bats. Of note are the mouse deer, which have only been known to be within CCNR. However, there have been sightings of mouse deer within BTNR, whose presence may explained by the Eco-Link @ BKE (National Parks Board 2016). It is worth noting that Tagore Forests are substantially larger than the forests in Springleaf. Further, these forests are under the jurisdiction of the Ministry of Defence, where human trespassers face severe punishment; this is enough to deter members of public from entering this site and allow fauna to remain undisturbed.

Constructing a wildlife crossing is no small undertaking, and it may be for naught in the future. The Eco-Link@BKE cost $12 million and took two years to construct (Chua 2017). While plant palettes can be similar to those recommended within this document, it is an extra cost in terms of maintenance, at least for the initial years until the habitat connectivity corridor is fully established. Further, Tagore Forest is fragmented from forests around Lower Seletar Reservoir, but there are no other forests that megafauna would be able to utilize northeast of Yishun Dam. Since Tagore Forests are subject to detailed planning for residential land use as per the 2019 Master Plan (Urban Redevelopment Authority 2019); any connectivity into Tagore Forest would only have short-term benefits.

Fence Springleaf Forest

The second option would be to cut off connectivity between the two forests for terrestrial fauna entirely. If fauna are not allowed to access the road, then the concerns of road collisions have been addressed. Fencing would need to have a mesh size that is sufficiently small enough to prevent the movement of even smaller animals (piglets, mouse deer, tortoises) from passing through the fence (75 mm mesh size). Animals that can climb, such as pangolins, palm civets, and monitor lizards, could be prevented from climbing with the installation of 50 cm wide flashing on the fences (Figure 1.1.5g); this change from vertical to horizontal surfaces may prove too difficult for some animals to cross over, thus preventing animals from crossing. For more details on specifications of this fence, see section 3.3.5 of the main report: the recommended fencing is similar to that of Tree Cottage exclusion fence; a low-impact barrier of min 1.8m height, extended 1.5m below ground to keep out large animals but still allow passage of smaller animals through.

There are ecological concerns with preventing movement of animals between forests. Megafauna that were initially allowed to move between these fragments would suddenly have a smaller area to roam, pushing them to exit the forests at other points and become a road collision risk in those areas. Smaller fragments have also been associated with lower species richness of amphibians within Singapore (Bickford et al. 2010). Having lower species richness reduces the number of functional groups within an ecosystem, which can impact the functioning of the system and the ecosystem benefits humans gain from them. The cessation of genetic material between fragments endangers resilience of populations within those fragments (Li et al. 2015).

Concluding Remarks Connecting Tagore and Springleaf Forest

A wildlife corridor is a serious undertaking that must keep long-term goals in mind. Ensuring connectivity into Tagore Forest would have short-term benefits to large and small fauna alike, but given the reserved land-use change of Tagore Forest in the future, the investment of a multi-million dollar wildlife crossing is short-sighted. The simpler solution of simply preventing animals from crossing Upper Thomson Road is the most cost-effective solution that considers long-term goals. Further, fencing the southeastern corner of Springleaf Forest would then encourage megafauna to utilize the possible Shared Habitat zone and move into the CCNR via NSSF.

Figure 1.1.6 Two options for an exclusion fence for the Tree Cottages area. Colors indicate the areas where certain fauna are allowed to enter (Map credit: STX Landscape Architects)

1.1.6 Human-wildlife interaction

BSUD Principle(s): Increase potential for positive human-wildlife interaction

Type of Mitigation: Mitigation

Parcel 1b is marked for development for the Tree Cottages, which is guided by the “light touch” principle. One action from this principle is to ensure that units are built at least 9 m above ground. This would allow the areas below the Tree Cottages to remain vegetated and provide habitat for fauna, but also allow fauna to move freely underneath the Tree Cottages.

There is considerable concern about access below the Tree Cottages to large terrestrial fauna, namely wild boar. There have been several recent incidents of injuries sustained from wild boar encounters in Pasir Ris and Punggol in early 2021, which has raised the proposal of excluding wild boar from the space underneath the Tree Cottages to ensure residents can descend to ground without the possibility of being injured during an encounter. Wild boar would be excluded from the space underneath the Tree Cottages by a fence, but is porous enough to allow smaller fauna (e.g., pangolins, palm civets) to move through it. However, ecological considerations for excluding large fauna from habitat must be considered as well (Figure 1.1.6). The options below will explore these ecological considerations in greater detail through the perspective of BSUD.

1.1.6.1 Total Exclusion

Total exclusion from the space underneath the Tree Cottages is to the extent of the Tree Cottages as well as the Fire Engine Access (FEA). Because the FEA does not reach the boundary of the Springleaf Forest, wild boar are still able to move through a small Screening Buffer along the length of the forest.

A study published in 2018 on the movement and activity centers of wild boar determined that their populations in Singapore have not reached carrying capacity (Koh et al., 2018). In other words, los[illegible] of habitat will not result in a sudden crash of their populations. However, the low wild boar population in Singapore may be due to the fact that food resources and space are limited.

Springleaf Forest and the forests surrounding it might be important. The same study found that the eastern portion of the CCNR (where Springleaf Forest is located) had high wild boar activity (Koh et al., 2018), possibly because the availability of food resources for them in this area is high. While the area where the exclusion may occur is approximately 2 ha, it is not clear how it may impact wild boar populations given that the overall area may be important to them. Recent encounters with wild boars in Pasir Ris and Punggol are examples of how wild boar react to habitat loss. So, while an exclusion fence may result in reduced or no wild boar encounters within the development, encounters in the surrounding areas may occur.

If encounters do not occur, there is a chance that fauna may run onto roads and become roadkill victims. Incidents of roadkill along Mandai Road and Mandai Lake Road, including pangolins and sambar deer, increased during the development of the new Wildlife Reserves Singapore properties. Wildlife experts agreed that loss of habitat associated with those developments have displaced several individuals, some of which were struck by vehicles as they attempted to find new areas.

It is also important to note that while wild boars are excluded, the exclusion fence will also prevent sambar deer from utilizing the habitat. This means that two large, wide-ranging animals are excluded from certain areas and habitats and may suffer the consequences of being excluded (negative human-wildlife interactions, roadkill).

While there are areas of Springleaf forest where habitat enhancements are taking place and it could be argued that increasing habitat quality makes up for the loss of habitat; this, however, is not the case. A useful analogy would be a residential 5-room flat (four bedrooms, a living room, kitchen, and two bathrooms). If a living room was removed from the five-room flat, habitat to the resident inside the flat is lost. Beds could be replaced with higher quality beds and bathrooms could undergo renovations to improve the overall quality of life, but these do not make living in this flat any better, only just a bit more tolerable. In the same way, removing habitat by way of an exclusion fence at the Tree Cottages but improving habitat elsewhere would not make the overall Springleaf Forest habitat any better, but only just a bit more tolerable that habitat had been lost.

1.1.6.2 No Exclusion

Not excluding wild boars from the area underneath the Tree Cottages would allow wild boars and sambar deer to roam freely underneath the units. Given that a majority of Parcel 1a is already heavily degraded and developed, the amount of area available to wild boar and sambar deer would not have changed.

The limitations of not excluding large fauna means that it may not be safe for residents to descend the ground. Even if there are designated trails, the very fact that wild boar and sambar deer are able to roam freely increases the potential for negative human-wildlife interactions to occur. This places greater emphasis on the importance of “Cues to Care” (section 1.2.1 Community education and stewardships) within the development to relay information on appropriate behaviours in the circumstance they encounter a wild boar or sambar deer.

Excluding people from a particular habitat can create a sense of detachment from the habitat. This sense of detachment could result in people not being instilled with a sense of stewardship for their environment (Hahn, 2021). Indeed, a fundamental principle in protected area management is allowing people (residents, public, or otherwise) to experience nature in a controlled manner that is not impactful to the environment so that they can cultivate a sense of stewardship from being immersed in this natural setting (Newsome et al., 2013).

It is possible to allow people to come as close to ground as possible without being on a ground. A walkway 3 m above the ground could allow people to be immersed with the environment while distancing themselves from the large fauna. This allows both fauna and people to be safe, and thus creates a positive human-nature interaction.

Not allowing people to ground may not fulfil development goals, however. Air space cannot be sold separately from ground space, and limitations on use of the land limits commercial viability. There may also be residents who insist on being able to go to ground and use the land.

[redacted] Continued land use change and exclusions will result in the continued extinction of species (Chisholm et al., 2018) and impact on humans elsewhere as animals are displaced, so each remaining natural area then becomes increasingly important. This is not to say that residents of the development cannot enjoy the space underneath the Tree Cottages, but it must be done with a healthy respect for nature and observing from a distance can still allow residents to appreciate nature in a safe manner.

While both options are given to be exercised, it is strongly recommended that the No Exclusion option is exercised.

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Figure 1.1.7a Popcorn ceiling increase the amount of texture on the SLE Underpass, allowing bats to possibly colonize this area.

1.1.7 Habitat creation

BSUD Principle(s): Maintain or introduce habitat; Facilitate natural ecological processes

Type of Mitigation: Mitigation & Enhancement

Creating habitats within the Springleaf Forest and within the development parcels can be both a mitigation measure as well as an enhancement to the habitat. Creating habitat within the development can replace habitat that may have been lost during the land clearing and construction, and hence are considered mitigation measures. Habitats developed outside the development area and within the Springleaf Forest would be an enhancement as they provide habitat resources that are in addition to what is naturally occurring.

Habitat guidelines are provided for four fauna groups that can benefit humans with the ecosystems services they provide. These are bats, dragonflies and damselflies, butterflies, and bees.

1.1.7.1 Bats

Bats found in Springleaf provide two important ecosystem services: pest control and seed dispersion. Biological pest control by bats is an important ecosystem service that humans enjoy, particularly with respect to mosquito populations. Seed dispersal by bats is important for ensuring forests can continue to grow, reducing ambient temperatures and maintaining hydrological processes. While some biodiversity actions attempt to fulfil this function (see section 1.1.3 Targeted tree planting), bats can continue the work once trees are planted. Thus, maintaining bat populations within the Springleaf Forest are not only important for biodiversity conservation, but for the better standard of living for residents within the development.

The baseline study highlighted that bat densities within the Springleaf Forest were low. While this is not unusual for Singapore, it is due to significant habitat loss of its previous range. Of conservation significance is the Lesser Bamboo Bat, a species that relies on bamboo stands for roosting and possibly an important pest controller within forests surrounding their roosting bamboo. With development in the Springleaf Forest, it is imperative to identify where bamboo stands are in order to protect them and the surrounding forests as a mitigation measure. As the size of the home range of a bamboo bat is unknown, as much intact forest surrounding bamboo needs to be protected as possible.

Habitats for other bat species can be made as an enhancement opportunity. A large colony of cave-nectar bats have established a long-term colony under a major expressway in Singapore (Leong and Chan, 2011). The reason they persist within this habitat is that it is adjacent to the CCNR, where their foraging demands are met. Because this colony of bats primarily feed on nectar, they are an important pollinator of plants, thus play an important role in the continued survival and persistence of forests.

The SLE underpass is an opportunity to develop potential habitat for bats. While it is not guaranteed that cave-nectar bats will establish a colony, any other species of bats can still perform other important ecosystem services for the development. However, the ceiling of the SLE is smooth, and therefore provides no grip for bats to hang on to when they are roosting. It is recommended that, in order to potentially establish a bat habitat here, the walls are given a texture. This can be done by simply spraying a mixture of drywall or plaster onto the ceiling of the underpass to create a textured “popcorn ceiling” (Figure 1.1.7a). This texture provides them grips to hold onto while they rest during the day.

While this does not guarantee the establishment of a colony, creating a habitat which can be used certainly increases the likelihood than if there was nothing done.

1.1.7.2 Dragonflies and Damselflies

Permanent water bodies within the development parcels can be habitats for dragonflies and damselflies (collectively termed odonates). Odonates are voracious hunters that can act as pest controllers during both their aquatic nymph stage and their aerial adult stage, so are a welcome addition to any urban development.

However, not all odonates are made equal. Odonates seen in urban environments are generalist species and can quickly invade sensitive habitats and displace forest-dependent species when forests are disturbed by development in vicinity. As one of the BSUD objectives is to conserve the Core Conservation Area and the associated biodiversity within it, care must be taken to ensure that generalist odonates do not invade the sensitive freshwater swamp habitat.

Generalist odonates in Singapore tend to spread into habitats that are forest edges, open areas with less riparian canopy cover, high water temperatures, and streams with deep channels (Cai et al., 2018). Hence, any permanent water body near the Core Conservation Area must maintain a closed canopy to reduce the ambient and stream water temperature of the site. The waterbody should be as far away from forest edges as possible to reduce the chances that a generalist odonate will be able to reach the waterbody. In circumstances where water bodies are not far from forest edges, a strong Screening Buffer is recommended. This also emphasizes why forest edges need to be strengthened.

These are general ecological guidelines to managing invasion by generalist odonates. For a specific planting characteristic scheme to fit within the landscape architecture of the development parcel, the reader is encouraged to see section 1.1.8 Planting characteristics and palettes.

1.1.7.3 Butterflies

Butterflies were identified to be abundant in both the northern and southern parcels in equal measure, so developments on both sides of the Springleaf Forest will incur a loss of butterfly habitat in the form of resting sites and food. However, additional habitats within the development parcels can help to mitigate these impacts. This can be achieved by planting native flowering plants throughout the development parcel.

For specific guidelines on plants to use within the development parcels, the reader is encouraged to see section 1.1.8 Planting characteristics and palettes. As the planting palettes consider the landscape signature of Springleaf Forest, it is important to ensure that the planting palettes are followed as closely as possible. This is to maintain the landscape signature of Springleaf Forest so that the biodiversity can make the seamless transition within the development area.

1.1.7.4 Bees

Bees are seeing world-wide extinctions due to pesticide use and climate change. This is of major concern to human populations as bees are an important pollinator for many of the foods we eat. While large-scale agriculture is not practiced in Singapore, wild bee populations are important pollinators of flowering forest species, and hence ensure the persistence of these floral communities. Humans benefit from these intact ecosystems for large-scale temperature control, mitigating the impacts of a warming climate, and for our water security. Given that Singapore is a small country, any mitigations or enhancements to bee populations can have a significant impact on biodiversity conservation and comfortable living for human populations.

The National Parks Board (NParks) recently installed a series of bee hotels in several parks throughout Singapore. The bee hotels are designed to be small to ensure that solitary bees inhabit them, as opposed to more aggressive social bees and wasps that need to protect their queen.

Bee hotels are also simple to make and easy to install. NParks has provided online videos on how to create bee hotels (National Parks Board, 2020), but the steps are summarized here.

Figure 1.1.7b Different types of bee hotels that can be made

1. Create a wooden box that has a depth of 80 mm, 150 mm tall, and 110 mm wide with only one open side
2. Gather thin bamboos with diameters of 5-10 mm and cut them into the length of the depth of the box. Once cut, sand down the edges to reduce any sharp edges
3. Fill the wooden box with the cuts of bamboo, ensuring that the bamboo openings are facing outward
4. If a wooden box is unavailable, simply lash together bamboo sticks into a circle with a diameter of 160 mm with a 12 mm nylon thread securely
5. Hang the bee hotel or place the bee hotel on a platform in a protected area at a height of approximately 1 m
6. Placement of the bee hotel should be in an area that is protected from strong winds and heavy rainfall. It should also be in a shaded space so that the bees do not overheat. Ensure that the opening of the bee hotel has a clearing of approximately 500 mm
7. The bee hotels should be located in areas where there are plants that flower at least for most of the year, even if it is different species flowering at different times
8. Locations can be within development parcels to mitigate impacts of lost habitat, while those outside the development and within the Springleaf Forest can enhance habitat by providing additional habitat

The fundamental principle of a bee hotel is that it (i) remains small to dissuade swarming bee species from using it, (ii) each unit within the hotel is small to just fit a bee (5 mm to 10 mm diameter), and (iii) it is placed somewhere about 1 m off the ground. Other than that, there are many shapes, containers, and even colors that a bee hotel can come in; the limits are the imagination (Figure 1.1.7b).

Much like butterflies, bees require flowers to survive, and planting native flowering plants throughout the development parcel can provide additional food resources for them. For specific guidelines on plants to use within the development parcels, the reader is encouraged to see section 1.1.8 Planting characteristics and palettes. Recall that the planting palettes consider the landscape signature of Springleaf Forest. So as with butterflies, it is important to ensure that the planting palettes are followed as closely as possible to maintain the landscape signature of the site.

Figure 1.1.8a Planting Characteristics of Springleaf (top) with map legends (right) (Map credit: STX Landscape Architects)

1.1.8 Planting characteristics and palettes

BSUD Principle(s): Maintain and introduce habitat; Minimize threats and human disturbances; Facilitate dispersal

Type of Mitigation: Mitigation

The landscaping of public and private domains within Springleaf consists of several plant palettes. Plant palettes are the list of species assembled based on different criteria and purpose driven by the BSUD biodiversity objectives of improving habitats, facilitating flora and fauna dispersal and minimizing human disturbances towards forest. The three important concepts behind creation of Springleaf plant palettes are Landscape Signature, Native vs. Non-native Species, and Planting Characteristics.

1.1.8.1 Landscape Signature

Landscape Signature is defined as the collection of native flora species (trees, palms, shrubs, climbers, and ferns) that currently exist on site. Based on this definition, if a species (e.g., *Adinandra dumosa*) is naturally found in Singapore but not locally found in Springleaf, it is considered native but not part of Springleaf Landscape Signature.

1.1.8.2 Native vs. Non-native Species

Native species are those species that exist in an area as a result of natural processes, i.e., no human intervention. The inverse of this, then, would be that non-native species are those species that exist in an area because of human intervention. For example, Rain trees *Samanea saman* are naturally found in South America, but have been brought to Singapore, this makes rain trees non-native species in Singapore.

1.1.8.3 Planting Characteristics

Planting Characteristics are landscaping concepts that guide the species assemblage to be planted in different zones (Figure 1.1.8a). The percentage of landscape signature, non-native, and native species to be used in each planting characteristics are provided in Table 1.1.3 and Figure 1.1.8b.

Figure 1.1.8b Planting Zone Design Guides with percentage of native species to be planted in each Planting Characteristics, and expected broad habitat of Springleaf post development as result of the Planting Zone Design Guides. (Map credit: STX Landscape Architects)

Given uncertainty of the final number of salvaged saplings available, the exact percentages of salvaged and purchased Landscape Signature species and quantity may fluctuate. However, the priority of using salvaged saplings for different planting characteristics must be as follows:

1. Miyawaki Afforestation Targeted Area (MA)
2. Screening Buffer (SB)
3. ABC Water Design Features within 30m Buffer (AWC)
4. ABC Water Design Features within Development Parcels (AWP)
5. Woodlands in Low Rise Areas (WO2)

This means that given a limited quantity of salvaged saplings, the salvaged saplings must be prioritized for Miyawaki Afforestation Targeted Area, followed by Screening Buffers. If there are still salvaged saplings available after the aforementioned two Planting Characteristic zones are completed, the saplings should then be prioritized for AWC, followed by AWP and finally WO2.

If there are not enough salvaged saplings for any planting characteristic zone, for example at AWP because the salvaged saplings had been exhausted in other prioritized planting characteristic zones, additional saplings can then be ordered from external nurseries.

The selection of plant forms (trees, shrubs, palms. ferns, and climbers) for each Planting Characteristics should be more or less homogeneous across different plant groups (Landscape Signature/Native non-Landscape Signature/ Exotic). For example, in Exotic (Ex) Planting Characteristics, it is not recommended to assign all the 80% exotic species exclusively as trees, while the 20% native flora exclusively as ferns, and so on.

Zone	Non-native species%	Native Species (A)	Landscape Signature (Purchased) (B)	Landscape Signature (Salvaged) (C)	Total Native Species % (A) + (B) + (C)
FO	80	20	-	-	20
EX	80	20	-	-	20
PL	60	30	10	-	40
GW	40	40	20	-	60
RP	40	20	40	-	60
AWP	20	20	40	20	80
WO1	20	20	30	30	100
AWC	-	20	20	60	100
WO2	-	-	40	60	100
SB	-	-	-	100	100
FR	-	-	-	100	100
MA	-	-	-	100	100

Table 1.1.3 Percentage of non-native, native, and landscape signature species to be used in each plant- ing zone. Landscape signature species are divided into two groups: those that are salvaged and those that are purchased. Planting zones are

(1) Formally Ordered (FO)
(2) Exotic (EX)
(3) Parkland/Grassy Parkland (PL)
(4) Grassy Woodland (GW)
(5) Riparian Waterway (RP)
(6) ABC Water Design Feature within Development Parcels (AWP)
(7) Woodlands in High Rise Areas (WO1)
(8) ABC Water Design Features within 30 m Buffer Area (AWC)
(9) Woodlands in Low Rise Areas (WO2)
(10) Screening Buffer (SB)
(11) Secondary Forest (FR)
(12) Miyawaki Afforestation Targeted Areas (MA).

1.2 BIODIVERSITY CONSERVATION STRATEGIES: CONSTRUCTION

Section 1.2 provides detailed guidelines for developers to conserve flora and fauna in Springleaf Forest in order to minimize environmental impacts of development during construction phase, where land clearing for storage areas, building footprints, piling, and some degree of tree felling are expected. It is important to highlight that in this masterplan, most of the building designs are targeted within disturbed areas, and care has been taken to ensure that the alignment of buildings (e.g. Tree Cottages) minimize the need to fell any large trees. The masterplan building design, when combined with the guidelines outlined in Section 1.2, are expected to result in minimum loss of fauna and flora. In addition, most of the native saplings (Common to CR status) will be salvaged and transplanted to other areas within Springleaf for reforestation/afforestation/landscaping purposes.

While there have been great lengths to ensure that the construction and building of the development within and around an ecologically sensitive site is as low-impact as possible, different buildability scores and targets would need to be reviewed for a completely different set or scores or targets. This is due to the fact that current construction methods used in urbanized areas would not be suited for the Springleaf site. For examples, a shared habitat could be an entirely new category to indicate that a particular area of the development is shared between faun and humans, where humans will stay on a raised platform and fauna are allowed to roam freely underneath.

While detailed list of affected mature trees/sapling species/fauna is not available subject to future changes in final building design, the general principles of flora and fauna conservation actions are as below:

(1) Wildlife must be shepherded out of designated construction zones, and trees must be checked for the presence of nests or fauna before being felled and any construction work begins. The details are provided in section 1.2.1 to 1.2.3

(2) Small native saplings within these sites will be salvaged: building footprints, Fire Engine Access (FEA), anticipated construction staging grounds/workspace and storage areas, piling sites, and each of their respective 2 m buffer. The salvaged saplings will be transplanted to an on-site nursery and be allocated for reforestation/afforestation and/or landscaping purposes depending on species. Miyawaki afforestation method will be used for afforestation targeted sites, while Framework Species Method will be used to facilitate reforestation such as infilling gaps in existing secondary forests and strengthening screening buffers. Details of native plant salvaging and reforestation methods are provided in section 1.1.3.2 and 1.2.5 to 1.2.8.

(3) Transplanting large trees are costly and often negatively affect tree health and structure. Therefore, large trees not obstructing building footprints will be retained on site to prevent transplanting. Tree protection measures for the remaining mature trees on site are provided in 1.2.9.

(4) The construction operations should adopt biodiversity sensitive approaches to reduce disturbance to wildlife as listed in sections 1.2.4, 1.2.10 and 1.2.11

(5) Any land required for *ad hoc* land clearance in the midst of construction stages will need to be inspected for native saplings, native mature trees, and fauna. Mitigation measures for flora and fauna will need to be conducted prior to any land clearance as per 1.2.1 to 1.2.11.

It is of crucial importance that developers follow these guidelines closely to minimize construction impacts on site. Developer's contract clauses should be written in manner to ensure strict compliance to the Biodiversity Conservation Strategies. In addition, it is important that the developer appoint an ISA-certified arborist at all-time, and not have the arborist be appointed by Construction Contractors to prevent conflict of interest.

1.2.1 Wildlife Management Officers

BSUD Principle(s): Minimize threats and human disturbances; Improve potential for positive human-nature interactions

Type of Mitigation: Mitigation

The Wildlife Management Officers (WMOs) are key members of the development team, particularly in development projects that are occurring on or adjacent to sites of significant biodiversity. Their main role is to ensure that fauna biodiversity values are managed on the construction site in a manner that ensures the fauna and construction personnel are safe during the entire construction process.

The WMO must satisfy a strict set of criteria as well as be able to fulfil their duties to the safety of personnel and biodiversity on site due to the sensitivity of adjacent habitats, the wide range of fauna groups that may require management on the development site, and the need to fulfil biodiversity objectives as per BSUD ("light touch"). This section outlines these criteria and responsibilities.

1.2.1.1 Personnel Requirements

Given the wide range of variable biology, ecology, and behaviour between and within fauna groups, it is not sufficient nor is it likely that a single person has the breadth and depth of knowledge required to manage all fauna groups in a responsible and safe manner. Therefore, three WMOs are required for the duration of the development to handle the three main fauna groups often encountered on site: mammals, reptiles, and birds.

A tender for the WMOs must be awarded to subcontractors who display evidence of substantial wildlife management experience (see below). This is to ensure their reports remain independent and that their assessments reflect uninfluenced fauna management on the development site. It is recommended that they are provided access to the site to carry out their responsibilities (see below) as and when necessary and determined by the WMO.

The Mammal WMO must satisfy **all** criteria:

- At least a degree in ecology, conservation biology, or a relevant *and* related degree
- Satisfies **any one** of the following:
    - is a first-author of *at least* one (1) scientific article in a peer-reviewed journal focused on local or regional mammal ecology or biology
    - is a co-author of *at least* two (2) scientific articles in peer-reviewed scientific journals focused on local or regional mammal ecology or biology
    - has made significant contributions to *at least* three (3) technical reports, which includes (but are not limited to):
        - Environmental Impact Assessments (EIAs)
        - Environmental Management Monitoring Programmes (EMMPs)
        - species recovery action plans
- Satisfies **any one** of the following:
    - at least one (1) year of experience in conducting EIAs or EMMPs
    - at least two (2) years of experience supervising or reviewing EMMPs
- Has participated, successfully passed, and has updated certification for **all** the following courses:
    - *Animal Management Professional Certification Programme - Intermediate Elective Module - Mammals* and all necessary prerequisite courses
    - *Animal Management Professional Certification Programme - Intermediate Elective Module - Wildlife Management in Developments* and all necessary prerequisite courses

- Has updated vaccinations for Influenza, Rabies, Tetanus (Boostrix), and Japanese Encephalitis

The Reptile WMO must satisfy **all** criteria:

- At least a degree in ecology, conservation biology, or a relevant *and* related degree
- Satisfies **any one** of the following:
  - is a first-author of *at least* one (1) scientific article in a peer-reviewed journal focused on local or regional reptile ecology or biology
  - is a co-author of *at least* two (2) scientific articles in peer-reviewed scientific journals focused on local or regional reptile ecology or biology
  - has made significant contributions to *at least* three (3) technical reports, which includes (but are not limited to):
    - Environmental Impact Assessments (EIAs)
    - Environmental Management Monitoring Programmes (EMMPs)
    - species recovery action plans
- Satisfies **any one** of the following:
  - at least one (1) year of experience in conducting EIAs or EMMPs
  - at least two (2) years of experience supervising or reviewing EMMPs
- Has participated, successfully passed, and has updated certification for **all** the following courses:
  - *Animal Management Professional Certification Programme - Intermediate Elective Module - Reptiles* and all necessary prerequisite courses
  - *Animal Management Professional Certification Programme - Intermediate Elective Module - Wildlife Management in Developments* and all necessary prerequisite courses
- Has updated vaccinations for Influenza, Rabies, Tetanus (Boostrix), and Japanese Encephalitis
-

The Bird WMO must satisfy **all** criteria:

- At least a degree in ecology, conservation biology, or a relevant *and* related degree
- Satisfies **any one** of the following:
  - is a first-author of *at least* one (1) scientific article in a peer-reviewed journal focused on local or regional reptile ecology or biology
  - is a co-author of *at least* two (2) scientific articles in peer-reviewed scientific journals focused on local or regional reptile ecology or biology
  - has made significant contributions to *at least* three (3) technical reports, which includes (but are not limited to):
    - Environmental Impact Assessments (EIAs)
    - Environmental Management Monitoring Programmes (EMMPs)
    - species recovery action plans
- Satisfies **any one** of the following:
  - at least one (1) year of experience in conducting EIAs or EMMPs
  - at least two (2) years of experience supervising or reviewing EMMPs
- Has participated, successfully passed, and has updated certification for *Animal Management Professional Certification Programme - Intermediate Elective Module - Wildlife Management in Developments* and all necessary prerequisite courses
- Has updated vaccinations for Influenza, Rabies, Tetanus (Boostrix), and Japanese Encephalitis

1.2.1.2 Responsibilities of the WMOs

- Conduct Wildlife Orientation workshops for construction staff to ensure staff are able to recognize different fauna groups, where they can be found, basic animal behaviours, what to do when they encounter them, and determining which snake species are venomous or not
- Respond to instances where wildlife was encountered on site and carry out removal if necessary
- Manage human-wildlife interactions and encounters
- Record all instances of wildlife road strikes and road kills for all fauna groups, or bird strikes on buildings within the development for birds
    - Road strikes and roadkill that occur on Upper Thomson Road, SLE (where and if appropriate), Mandai Road, and other roads that can be sensibly linked to the development on Springleaf for all fauna groups should be recorded.
    - Information recorded must include (but is not limited to):
        - GPS location of strike
        - date and time of strike
        - species
        - male/female/unknown
        - adult/subadult/juvenile/neonate
        - the response to the strike (e.g., specimen collected by museum, animal alive and transported to healthcare facility)
        - report instances to relevant agencies
        - If more than one animal was struck, a separate record should be created for each individual
- Conduct wildlife shepherding exercises, including shepherding of terrestrial fauna and pre-felling surveys of trees for arboreal animals
- Carry out recommended EMMP, including surveys and data collection, data preparation, data analysis (if any), data visualizations, reporting, and submission
- Monitor wildlife populations for deviations from the baseline and enforce modifications to the daily operations to reverse or reduce impact

Such courses do not cover every circumstance a development manager may face. For such extraordinary circumstances, development managers may require the services of a wildlife management contractor to carry out necessary management. It must be stated that **pest control companies are not and are never appropriate vendors to manage and handle wildlife**. Recent media coverage has shown that pest control companies are in fact poorly equipped to handle wildlife in a manner that is safe for them, the residents, and the animals themselves.

Should the development wish to engage a wildlife management vendor, the vendor must satisfy **all** requirements:

- Have at least five (5) years of experience where a significant portion of their portfolio is focused wild fauna, including but not limited to:
    - Raptors, owls and other birds of prey
    - Wild boar
    - Pythons, monitor lizards, and other large reptiles
- Have at least two (2) years of experience in wildlife shepherding exercises for development projects
- Be certified and have updated licenses for the following courses:
    - *Animal Management Professional Certification Programme - Basic Module*
    - *Animal Management Professional Certification Programme - Intermediate Elective Module - Mammals*
    - *Animal Management Professional Certification Programme - Intermediate Elective Module - Reptiles*

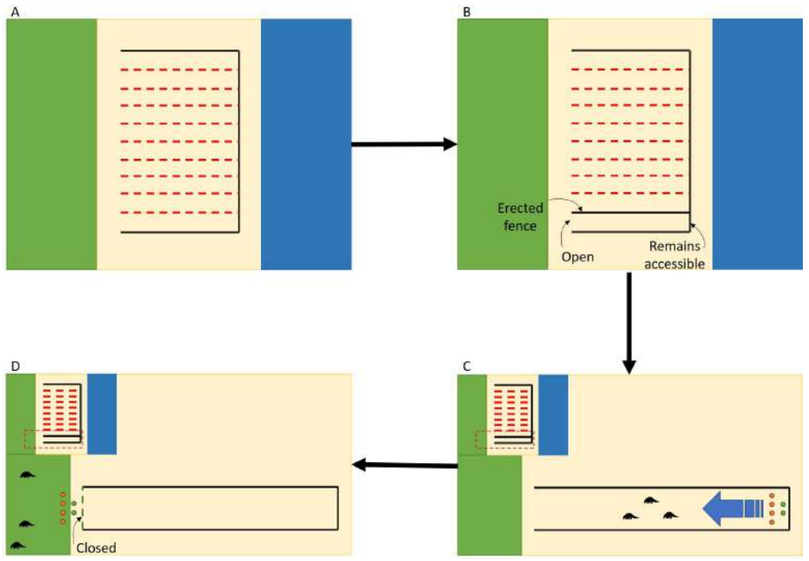

Figure 1.2.2a The wildlife shepherding process. (A) A fence (black) is erected around the site marked for construction, but with one side facing a forested area (green). Plans for subsections (red dashed lines) are made. (B) A fence is erected for subsection but remains open to the forest, with the opposite side accessible to staff. (C) Personnel (orange) line up and move down the subsection and are trailed by WMOs (green) and fauna are herded out of the subsection. (D) Once staff reach the outside of the subsection and all animals are out, the subsection is closed. The process continues for the rest of the subsections.

1.2.2 Wildlife Shepherding

BSUD Principle(s): Minimize threats and anthropogenic disturbances;
Improve potential for positive human-nature interactions

Type of Mitigation: Mitigation

Wildlife shepherding is a means of moving fauna out of construction zones in a systematic manner or waiting for fauna to move on their own. This is a common practice for construction projects in Singapore due to the high biodiversity of fauna found in the tropics. The guidelines provided here are just a few ways of moving fauna from construction sites; it is imperative that prior to tree felling, the contracted WMOs survey the site to determine the method that suits the needs of Springleaf Forest.

The sections below are divided into guidelines for removing different fauna groups based on their habitats: terrestrial fauna (mammals and reptiles) and fauna found in trees that require felling (mammals, reptiles, birds).

1.2.2.1 Wildlife shepherding for terrestrial fauna

Wildlife shepherding is typically done by a line of personnel moving down a fenced subsection of the construction area. Any reptile or mammal encountered is brought to the attention of the respective WMO, who takes the appropriate steps to remove the animal from site, if necessary. Once all fauna are removed from this subsection, the section is fenced off, and the process is repeated again for other sections until the entire construction zone is cleared.

There are important considerations to account for prior to conducting the shepherding exercise: The direction animals need to go if they can move (typically towards the direction of forested areas) How many subsections are required within the construction zone and where these subsections are Which subsections must be shepherded first, and which subsections must be subsequently cleared.
The amount of personnel available for each wildlife shepherding exercise. This will oftentimes determine how wide each subsection is as personnel must be separated by a maximum distance of 1.5 m.

Time required to shepherd wildlife can be found in Table 1.2.1.

The abovementioned items must be planned prior to the shepherding exercise to ensure that site is cleared of animals in a systematic manner. If planning is not done correctly, fauna can be trapped within the construction zone. The following steps briefly describe the wildlife shepherding process, with illustrations available in Figure 1.2.2a.

1. The construction site needs to be fenced along the boundary, but only one side remains open. Typically, this side faces the forested area.
2. The first subsection is then selected for shepherding. A fence is erected such that it creates a third wall between two parts of the boundary fence. One side of the fencing must remain open, while the opposite side can swing open and be accessible to personnel
3. The swinging fence is accessed by personnel and remains closed. Personnel form a line perpendicular to the longest side of the subsection with approximately 1.5 m between each personnel
4. As a single line, the personnel move down the subsection, checking a 1 m cone in front of them for wildlife
5. The wildlife manager trails behind them to ensure that personnel stay within 1.5 meters from each other.
6. Any large wildlife encountered should be highlighted to the wildlife manager, who will carry out the necessary actions to remove the animal
7. In most cases, particularly with sambar deer, wild boar and large moving reptiles (cobras, monitor lizards), fauna will move away from an approaching line of humans
8. If fauna do not move, such as large pythons and some turtles, these need to be moved responsibly and only by the WMO except in extraordinary circumstances when the WMO requires the help of additional personnel
9. Once the line of personnel has reached the opening, the subsection can be closed
10. The process is repeated again for each subsection until the entire construction zone is cleared.

Fauna encountered	Fauna Group	Window period
Colugo	Mammal	24 hours
Raptor	Bird	24 hours
Nesting raptors	Bird	5 days
Pangolin	Mammal	5 days
Monitor lizards	Reptile	24 hours
Long-tailed macaques	Mammal	24 hours

Table 1.2.1 The window period given to the specific animals to leave the tree

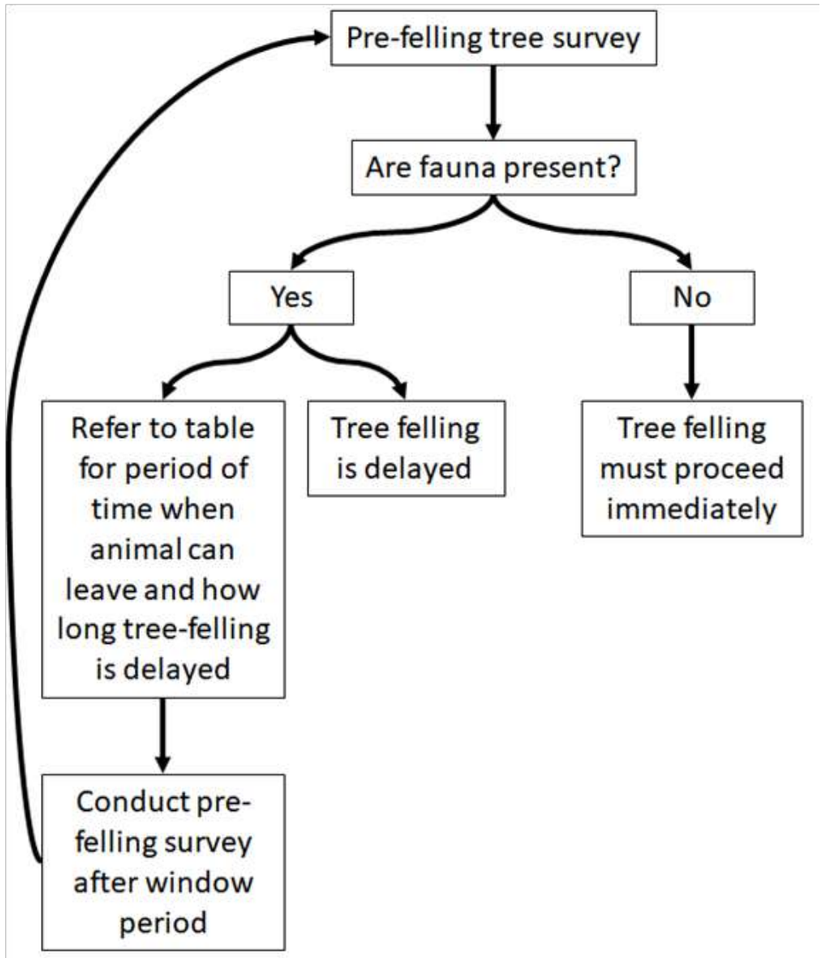

Figure 1.2.2b Decision process and actions when fauna are found in a tree earmarked for tree felling.

1.2.2.2 Pre-felling tree surveys for arboreal fauna (mammals, reptiles, and birds)

Pre-felling tree surveys are conducted to determine if fauna are currently inhabiting any trees earmarked for felling. A decision tree chart is provided to determine whether trees can be felled or not in Figure 1.2.2b, while Table 1.2.1 provides the period of time when an animal can leave. Tree felling protection zones must also be inspected prior to felling; any fauna found within this zone must be removed by the respective WMO.

Table 1.2.1 is a non-exhaustive list of animals that are possibly encountered on trees. For animals that are encountered which are not on the list, the WMO will determine the appropriate window period.

In summary, the WMOs will conduct pre-felling tree surveys for their respective fauna groups. Fauna found in trees must trigger a delay in tree felling to allow the animal time to leave. Trees are surveyed again after a specified amount of time, derived from the normal behaviour of that animal. Once trees are declared to be free of visible or observable fauna, the tree must be felled immediately while no animals are on them.

If there is a delay of more than 12 hours, tree felling must be delayed once more and trees must be surveyed again to see if any new animals have inhabited it within 12 hours.

When the tree felling is to be conducted, the WMOs shall assist the supervisor, banksman, and foreman to ensure that the tree felling protection zone (established as per section 1.2.9) is free of fauna activities. Should any fauna activities be present, the respective WMO shall perform the necessary fauna removal.

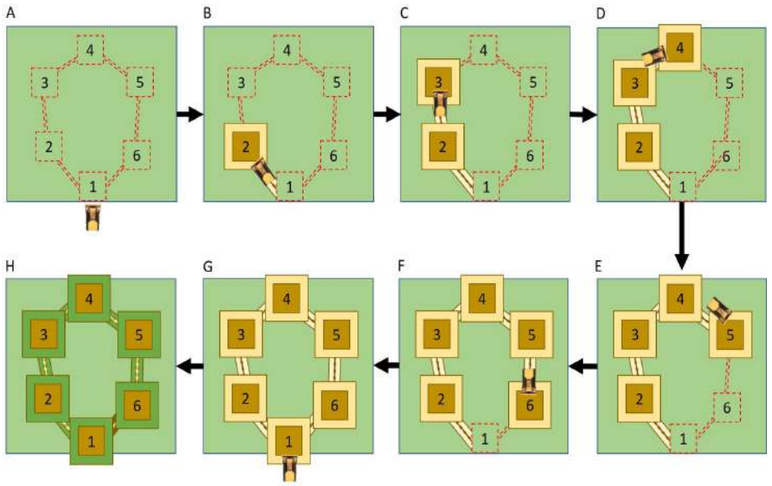

Figure 1.2.3 Construction phasing for a hypothetical set of units in the Tree Cottages. Light green area is the Springleaf Forest; red dotted lines are areas where the units and access roads will be as per design plans; dark brown areas are infrastructure (buildings, Fire Engine Access); light brown areas are buffer areas; dark green is reforestation.

1.2.3 Monitoring and adaptive management

BSUD Principle(s): Minimize threats and anthropogenic disturbances
Type of Mitigation: Mitigation

Monitoring refers to collecting environmental data in areas outside the development to determine if any substantial deviations to the physical and biological environment are a result of development practices. Adaptive management, then, refers to the immediate changes to development practices to reverse or reduce the deviations. Specific requirements for monitoring programs are outlined within the EMMP portion of the EIA or an EMMP program developed from a subcontracted environmental consultant.

As the specific biological and environmental parameters to monitor would only be available within the EMMP recommended in the EIA or are developed by an EMMP consultant, the following guidelines for this section are only:

1. Ensure that the monitoring program outlined by the EMMP are closely adhered to
2. Monitoring results must always be compared to the findings from the baseline study
3. Any deviations, such as loss of biodiversity or reduced encounter frequency of certain species, from the baseline that can be linked to activities from the development must trigger changes in development operations to reduce or reverse these deviations

1.2.4 Minimize construction footprint

BSUD Principle(s): Minimize threats and human disturbances
Type of Mitigation: Mitigation

In order to minimize loss of habitat, construction footprints must remain as small as reasonably possible. This is particularly important for developments within the Tree Cottages area in Parcel 1b (SHG). Care must be taken to phase the construction to:

1. reduce the amount of land required for clearing; and
2. to develop infrastructure in such a way that the starting and the end points of construction are at the point of entry.

Point 2 can be illustrated in Figure 1.2.3 with an example development of six hypothetical Tree Cottages: Unit 1 through to Unit 6 (A). The first unit to be developed would be Unit 2. Access roads from the point of entry (Unit 1) as well as the area to construct Unit 2 would be cleared (B) Note that forest being cleared is for the footprint of the actual building and road (light brown) as well as a buffer around the building and access road (dark brown) to allow movement of heavy vehicles. Once Unit 2 is completed, access roads and construction footprint for Unit 3 can commence (C). This process is repeated sequentially for Units 4-6 and Unit 1 (D-G), where only the access roads and the construction footprints are cleared. Once Unit 6 has been developed, the buffer areas for the buildings and the roads can be reforested (H) with trees as per the appropriate planting characteristics.

While the example provided in Figure 1.2.3 is for a hypothetical set of Tree Cottages, the same principles are applied to other construction activities, such as laying down of pipelines. Land clearance for pipelines require large buffers (up to 2 m for a 900 mm diameter pipeline). In such circumstances, tree roots must be avoided to prevent structural and long-term health damage on trees. Details and guidelines on establishing proper tree protections for trees during construction are outlined in section 1.2.9 Tree Protection.

Time	Process	Description	Personnel required
Approximately 9 months before site clearance	On-site nursery established	Set up on-site native plant nursery at a suitable area with enough personnel and capacity to accommodate at least 1500 number of saplings	Nursery Manager
	Tree assessments	Perform Visual Tree Assessment (VTA) and establish Tree Protection Zone (TPZ) for trees that are to remain on site. Produce tree assessment report that serves as the benchmark for subsequent monthly monitoring.	Arborist
	Tag native flora saplings	Tag, identify and take photos of native species saplings suitable for transplanting within building footprints, Fire Engine Access (FEA) areas and 2 m buffer zones enveloping building footprints and NEA	Native Flora Specialist
Approximately 6 months before site clearance	Root ball sizing	Determine root ball size of the tagged native species saplings	Arborist
	Screening Buffer demarcation	Identify and demarcate Screening Buffers around development parcels and at forest edges	Developer
	Salvaging	Salvage and transplant tagged saplings to on- site native plant nursery	Native Flora Specialist, Nursery Manager
	Maintenance	Maintain the saplings to ensure at least 70% of the saplings survive in first six months after transplanting	Nursery Manager
	Preliminary inventory: landscaping	Tally species and quantity of salvaged saplings to create a basic saplings inventory for final landscaping planting	Native Flora Specialist, Nursery Manager
6 months after site clearance	Final inventory of Salvaged Saplings	Tally the remaining species and quantity of salvaged saplings and update the saplings inventory	Native Flora Specialist, Nursery Manager
	Tree planting plan	Use the updated sapling inventory to plan for the final landscaping and reforestation of developed area	Landscape Architect
Throughout construction after site clearance	Ad-hoc adaptive management	Shall the developer require ad-hoc land clearance, the land needs to be surveyed by Native Flora Specialist to identify native existing trees to be retained and saplings to be salvaged before any site clearance commence	Native Flora Specialist, Nursery Manager
Approximately 2 years after site clearance	Tree planting: Miyawaki Afforestation	Plant salvaged saplings at assigned Miyawaki plots when there are enough saplings achieving 3-4m height	Nursery Manager, Arborist, Landscape Contractor
	Tree Planting: Framework Species Method	Plant salvaged saplings at damaged Screening Buffer zones to repair buffers. Plant salvaged saplings at screening buffers with exotic canopies to increase native saplings at understorey and gradually phase out exotic species.	Nursery Manager, Arborist, Landscape Contractor
Towards end of construction	Pruning of saplings for development parcels	Perform structural pruning for salvaged saplings to be planted close to buildings and developed areas	Arborist
	Prioritizing	Prioritize salvaged saplings for landscape planting plans. Order additional plant stocks should the developed areas require more stocks than the native sapling nursery can provide, or require other non-native species for built areas	Landscape Architect, Landscape Contractor
	Sapling inspection	Ensure saplings planned to be planted in developed areas are of satisfactory condition	Nursery Manager, Arborist
	Tree planting: Development parcels	Plant all remaining salvaged saplings to respective areas as planned and coordinated by Landscape Architect	Landscape Architect, Landscape Contractor

It is imperative to follow this guideline closely in order to reduce the amount of habitat cleared. If such guidelines are followed diligently, all EN and CR trees within the SHG can be retained. Trees within construction footprints and a 2 m buffer around these footprints will be salvaged if they have a girth of less than 30 cm (see section 1.2.6 Harvesting and transplanting native plant saplings/climbers for more details on salvaging criteria). These trees were not surveyed during the topological survey, nor were they captured within the baseline study, so a quantifiable amount is not possible at the time of write. All other trees will unfortunately be removed.

Note that with this construction sequence starting at Unit 1 and ending at Unit 1, land in between the Tree Cottages did not need to be cleared unnecessarily. Further, the buffers around each building are replanted with trees as a means of regaining habitat that was previously lost. This is in line with the second biodiversity objective: adopting a “light touch” principle.

1.2.5 Native plant salvaging timeline and personnel

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Biodiversity Sensitive Urban Design (BSUD) is the key principle that shapes the development concept and informs environmental mitigation actions of Springleaf Masterplan. In line with BSUD, salvaging native species saplings during pre-construction stages and incorporating them into subsequent landscaping stages of the development site can minimize threats and human disturbances by preserving native species biodiversity, maintain habitats and more importantly, to conserve the local gene pool and germplasm of the original forests.

1.2.5.1 Overview of tree and flora management plan and timeline

Table 1.2.2 shows the estimated timeline for tree and flora works within the proposed Springleaf development. Personnel involved in different stages is also specified. While the exact time frame may vary, it is important that the developer and the awarded construction contractor follow the sequence of processes to maximize protection for trees to be retained on site as well as for native saplings.

Do note that while there are two years of waiting period for salvaged sapling species and therefore two years of waiting period for planting characteristic zones that only uses salvaged saplings (such as Screening buffer and Miyawaki Afforestation zones), other planting zones that allow planting of some non-salvaged plants has the flexibility of being planted at any time since commencement of construction activities. For example, if protective moats need to be built in early stage of development, plantings at AWC and AWP can commence at least partially since AWC allows at least 40% of non-salvaged saplings and AWP allows at least 80% of non-salvaged saplings.

Table 1.2.2 Tree works and native plant salvaging processes required at different stages of development

1.2.5.2 Native Plant Salvaging Personnel requirements

To salvage native forest species from the development site successfully, it is crucial to accurately identify local forest species (saplings, shrubs, trees) and maintain a high survival rate of the salvaged saplings. The plant salvaging team that is engaged are therefore required to show evidence that demonstrates their expertise in local flora, arboriculture, nursery management, and sapling transplanting. The plant salvaging team will consist of Native Flora Specialist, an Arborist, and a Nursery Manager. All three personnel do not need to come from the same company. The Native Flora Specialist and Arborist can be the same person provided the person fulfils the criteria for both positions.

The Native Flora Specialist must meet ***any one*** of the criteria below:

- Published as first author for one publication, or as co-author for two publications or more. Accepted publications include botany/forest ecology-related books, and/or botany/forest ecology research papers from local journals such as Garden's Bulletin Singapore/ Nature in Singapore
- At least one (1) year of experience in conducting either of the following in secondary forests, primary forests and/or mangroves:
  - flora baseline surveys
  - forest ecology research
- Collected and submitted voucher specimen(s) of native plant species with traceable collection ID and collectors name at local herbariums (SING, SINU herbarium)

The Arborist must meet **all** the criteria below:

- ISA-certified with at least three (3) years of working experience in landscape industry
- Have experience writing tree assessment report for development projects
- Have experience coordinate sapling transplanting for development projects

The Nursery Manager must meet **all** the criteria below:

- At least two (2) years of working experience in transplanting saplings and cuttings from development sites while maintaining a high survival rate of saplings (>70%)
- Have enough personnel capacity to take care of up to 2000 number of transplanted saplings/cuttings

Figure 1.2.5 Examples of on-site nursery

1.2.5.3 Responsibilities of Plant Salvaging Team

Native Flora Specialist

- To work with Arborist to identify species of Trees to be Protected during pre-construction tree assessment
- To work with the Nursery Manager to identify, tag and transplant native plant saplings from designated construction site during site clearance stage
- To categorize and assist nursery to arrange the salvaged native plant saplings based on local conservation status (Least Concern [LC], VU, EN or CR)
- To establish an inventory list with species and quantity information of the salvaged species and, with assistance from the Arborist, advice the developer the species suitable for forest restoration efforts, and species suitable for developed area planting (e.g., condominium, shophouses)
- With assistance from the Arborist, to plan reforestation planting within a 10 m buffer from the SLE and/or other designated reforestation/afforestation/biodiversity enhancement areas
- Should native species saplings from other countries of origin are ordered to meet native species planting demands from development, the Native Flora Specialist must inspect the species of these nursery stock and verify if the correct species is received

Arborist

- To perform pre-construction tree assessment for Trees to be Protected within construction site with assistance from Native Flora Specialist to identify native forest species
- Advise the appropriate size of Tree Protection Zones (TPZs) for Trees to be Protected within construction site
- Ensure developers establish TPZs and perform necessary mitigations for trees to be retained on construction site
- To assist Native Flora Specialist and Landscape Architect to provide planting recommendations to developers for both developed area and reforestation/afforestation area
- To assist Native Flora Specialist in planning planting density and planting area within forest restoration area, and oversee planting of such saplings
- To assist WMOs with the installation of tree support systems and canopy rope ladder bridge across Sungei Seletar, including selecting appropriate trees for use
- To coordinate with developers for other landscape planting requirements

Nursery Manager

- To establish an on-site nursery within the Springleaf development parcel with sufficient personnel and facilities to maintain salvaged saplings (Figure 1.2.5)
- With assistance from Native Flora Specialist, to salvage native plant saplings from designated construction footprints before site clearance
- To provide all material, equipment, and labour required for the maintenance of salvaged saplings
- To maintain high survival rate (>70%) of salvaged saplings until end of the construction stage when the saplings can be transplanted
- To adhere to best management practice in the industry for nursery operations and transplanting throughout development period
- To provide salvaged saplings to be planted at developed areas and designated forest restoration areas

Figure 1.2.6 Example of a tagged native plant sapling with unique tag number

1.2.6 Harvesting and transplanting native plant saplings/climbers

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

1.2.6.1 Setting up on-site nursery

Before site clearance, an on-site nursery has to be established within the Springleaf development site at zones that are the last to be developed, such as the zones designated for future community gardens. As the land designated for future community gardens are mostly degraded grassy areas located within development parcel (private domain), this on-site nursery is to be carried out by nursery manager under developer, and minimum land clearing is expected. The Nursery Manager should ensure the on-site nursery has enough personnel and space to handle at least 2000 number of saplings. The nursery should be sealed with an irrigation system installed. If the nursery is located in areas with full sun exposure, the Nursery Manager must ensure there are measures in place to provide areas with indirect sunlight (e.g., shade cloth) where the light is between 60-90 Photosynthetic Active Radiation (PAR) and maintain at least 85% humidity (e.g., misting) depending on the growth requirements of saplings. The temperatures within the nursery should not exceed 30° Celsius. The daily monitoring of the environmental conditions must be taken and documented as a record.

Throughout the development duration, the Nursery Manager must be responsible for sapling maintenance. Should any personnel changes of the Nursery Manager occur, the leaving personnel must prepare a manual providing instructions and operating procedures for sapling care to the personnel taking over.

1.2.6.2 Salvage and transfer saplings to on-site nursery

Before site clearance, the Native Flora Specialist shall identify, take photos of, and tag native tree, shrub, climber, fern, and palm saplings with local conservation status of LC, VU, EN and CR with unique tag numbers (Figure 1.2.6). The tagged saplings should be in healthy and vigorous condition, free from dead wood, bruises, or other root or branch injuries. They should also be free from insect and/or disease infestation. Only saplings with a girth of 0.3 m or less are to be tagged and harvested. If the species is not known, samples should be sent to herbarium to confirm species. The root ball size of saplings will be determined in consultation with the Arborist.

If any fruits of species with local conservation status of EN and CR are observed during salvaging, the Native Flora Specialist should collect the fruits and seeds and consult with Native Plant Centre personnel (located at Pasir Panjang Nursery) whether these fruits and seeds should be submitted to Native Plant Centre. If a plant (e.g., climber) cannot be transplanted in full, cuttings of 1-1.2 m should be made and propagated. The cuttings shall be placed in a sealed plastic bag with water to maintain humidity.

Epiphytes and ferns can be collected and tied to a fern slab or, in cases where the epiphyte or fern is attached to fallen branches or log, the epiphyte or ferns can be collected together with the branch or log. Transportation of transplanted epiphyte or ferns need to be done with proper care to reduce transportation shock to the saplings/plants.

Tree pruning should be minimal, using appropriate sharp tools that are wiped clean before each cutting to remove dead branches and defective branches prior to being transplanted. The tree saplings should be watered well 24 hours prior to trenching if the ground is dry. The Nursery Manager should subsequently arrange personnel to salvage the tagged saplings.

There shall be sufficient support installed prior to trenching to ensure that trees do not move. Trenching will be performed manually around the outer edge of the designated root ball size. The root balls will be wrapped and secured with geotextile and polythene wraps. Tree saplings will then be lifted from the secured root ball and loaded onto the transport vehicle.

Secure tree saplings firmly onto the transport vehicle and cover the sapling crown with tarp netting prior to transporting. Covering the tree crown with tarp nettings will help to reduce transpiration pull and protect the saplings from wind burn.

In the nursery site, tree saplings will be unloaded from the transport vehicle, lifting the sapling from the secure root ball. Damaged plant material will be rejected upon arrival at the nursery. The saplings will then be placed into the bags or containers in the nursery site. After placing the tree sapling into the polythene bag, remove the geotextile/polythene wraps and backfill the

Regime	Frequency	Material
Watering	Daily, except for the rainy days	Non potable water 5L for trees <0.1m in girth and at least 30L for trees >0.3m in girth
Fertilization	Fortnightly	E.g. Fish kelp, humic acid, high EC molasses
Pesticide	As and when required	As the site is near swamp forest, synthetic chemicals shall not be used (see Table 1.2.6 for pesticides to not use). Use organic certified solutions instead
Mulching	Once a month	Mulch should have a minimum thickness of 20 mm, should be an approved friable, odour-free high grade mature compost or an approved mix, with C:N ratio between 12:1 and 25:1. Mulch pH must be between 5.5 to 7.
Weeding	Once a week	Weeding should be done manually and before mulching
Pruning	As and when required	Clean cutters. Cutters must be wiped clean in between cuts.

Table 1.2.3 Maintenance regimes with required frequency and materials

space/gaps with clean approved soil mix. Staking support shall be provided as and when necessary to keep the plant upright. The saplings shall be placed with adequate spacing from one another in a semi-shade shelter in temporary nursery sites. Cuttings from climbers shall be dipped into growth hormone and inserted into a container with a mixture of sand and soil. Individual saplings shall be salvaged from site, transported, and placed in the temporary nursery site within a day.

The Nursery Manager and Native Flora Specialist shall tally the total number of salvaged saplings and provide an inventory consisting at least the tag number, photo and species of each salvaged sapling. The Nursery Manager and Native Flora Specialist shall also arrange the saplings by their chosen criteria, such as by scientific Latin name, by local conservation status, by plant form, and so on.

1.2.7 Growth and maintenance of harvested and transplanted saplings/climbers

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

The newly harvested saplings will be watered and maintained by the Nursery Manager until the saplings have sufficiently established. The transplanted climbers and epiphytes are to be placed under shade until they have established and sprouting of young leaves occur. Once each tree has been transplanted, daily maintenance activities should begin. The Nursery Manager should provide all material, equipment and labours required for the maintenance of salvaged saplings. Sufficient space between salvaged saplings should be provided such that the saplings have room to advance in size. Table 1.2.3 outlines the maintenance regime.

Attention must be given to pesticide use. As the site is close to a freshwater swamp forest, special considerations are given for pesticides. See section 1.2.10 Biodiversity-sensitive insect pest control practices.

To ensure good form and structure of the harvested saplings, it is recommended to carry out formative pruning on the harvested tree saplings in accordance with ANSI A-300 pruning standards (ISA).

Manual weeding should be carried out regularly for the harvested saplings. All weeds should be removed before mulching. Regular mulching should be applied to all harvested saplings at the receiving site. The mulch used should be friable, odour-free high grade mature composts.

1.2.8 Survival rate monitoring and incorporating salvaged saplings/climbers into development landscaping plan

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Three months after the transfer of salvaged saplings to the on-site nursery, the Nursery Manager shall tally the remaining saplings and estimate the survival rate of each species as an effort to improve industry knowledge of survival rate of native species. With the final list of surviving saplings, the Native Flora Specialist and Arborist shall inform the contracted Landscape Architect the remaining species and the quantity of salvaged saplings available for reforestation, afforestation and/or landscaping purposes. The Landscape Architect shall refer to the Springleaf Masterplan and relevant appendices in Technical Report to design the planting scheme for the development site.

In general, more native species should be used in sites closer to the Core Conservation Area, and the detailed priority hierarchy of Planting Characteristics are provided in Section 1.1.8. The planting scheme should prioritize and use all the salvaged saplings available before ordering an additional quantity of saplings. If saplings of native species are to be ordered from other countries of origin, the Native Flora Specialist must inspect the saplings to ensure saplings are of correct species. The Nursery Manager should ensure satisfactory handover of salvaged saplings at the end of the development contract period, particularly for saplings that will be planted in built zones.

The criteria of satisfactory saplings include (but are not limited to):

- Saplings are in good health and free from injury with good taper
- Saplings of tree species can be self-supporting and planted without staking (with the exception of climber and shrub)
- Saplings of excurrent species should have a defined central leader with apical bud intact
- Root crown must be at the surface of the rootball
- When shaking or handling the unsupported rootball at least 90% of the soil volume must remain intact
- Rootball is shaved or pruned if girdling root is observed within planting bag

Girth	Recommended TPZ (radius)
<0.5m	1 m
>0.5m but less than 1m	2 m
>1m but less than 1.5m	3 m
>1.5m but less than 2m	4 m
>2m	5 m
Fig trees and Trees with Critically Endangered status	Prescribed individually by Arborist on a case-by-case basis

Table 1.2.4 Tree Protection Zone (TPZ) size required for different girth range

Figure 1.2.9a Example of a Tree Protection Zone (TPZ)

1.2.9 Tree protection

BSUD Principle(s): Minimize threats and human disturbances
Type of Mitigation: Mitigation

Arborist plays an important role in preserving tree health and minimizing construction impact on trees throughout development stages. It is important that the Arborist be given all assistance to maintain absolute professional integrity. The developer shall appoint an arborist at all times and not have the Arborist be appointed by Construction Contractors (though they may choose to engage their own Arborist if needed). This is to minimize conflict of interest and ensure that the tree care recommendations and tree assessment findings of Arborist is not compromised by needs of Construction Contractors.

1.2.9.1 Setting up Tree Protection Zone (TPZ)

To protect existing trees, the Arborist shall establish a Tree Protection Zone (TPZ) for each tree to be retained on site, and the contractor shall ensure that the proposed site access and machinery do not encroach into established TPZs. Table 1.2.4 outlines the recommended TPZ dimension. Figure 1.2.9a provides an example of TPZ. TPZ size varies depending on tree size. In general, the remaining space should be sufficient for implementation of design and required infrastructure. Shall the contractor require ad-hoc space for design and infrastructure in the midst of construction, the area should be surveyed for native trees to be retained on site and native saplings to be salvaged to on-site nursery before any clearance.

A 1.8 m height fencing shall be installed around trees with girth between 0.5 and 1 m as a demarcation of TPZ (Figure 1.2.9a). Shorter fencing can be installed for trees less than 1 m in girth upon approval by the Arborist. The fencing material shall be of rigid and firm material such as plywood or corrugated zinc sheets. The TPZ shall not be removed under any circumstances.

No equipment or materials of any kind or any size shall be placed within the TPZ. If any materials spill into TPZ, the spillage should be cleaned up immediately and the Arborist and site manager must be informed. The developer shall notify Arborist immediately if trees to be retained are damaged, and the contractor that damaged the tree shall make good of the damage at their own cost. If the tree suffers from substantial damage as determined by the Arborist, the contractor will be liable to replace the tree of the same species and size, or to pay for full cost incurred in the replacement by the developer.

Tree Health	TPZ Condition
Foliage color (Normal, Chlorotic, Necrotic)	TPZ barriers installed/good condition
Foliage density (Normal, Sparse)	Evidences of illegal encroachment
Leaf size (Normal, Small)	Evidences of damage to tree
Epicormic shoots (Yes, No)	Evidences of toxic splash
Twig dieback (Yes, No)	Evidence of illegal compaction
Wound wood roll development (Good, Average, Poor, None)	Evidences of materials storage
Vigor (Good, Average, Poor)	Evidences of machinery, equipment and vehicle storage
Pests/Diseases (Yes, No)	

Table 1.2.5 Parameters to take note during monthly inspections

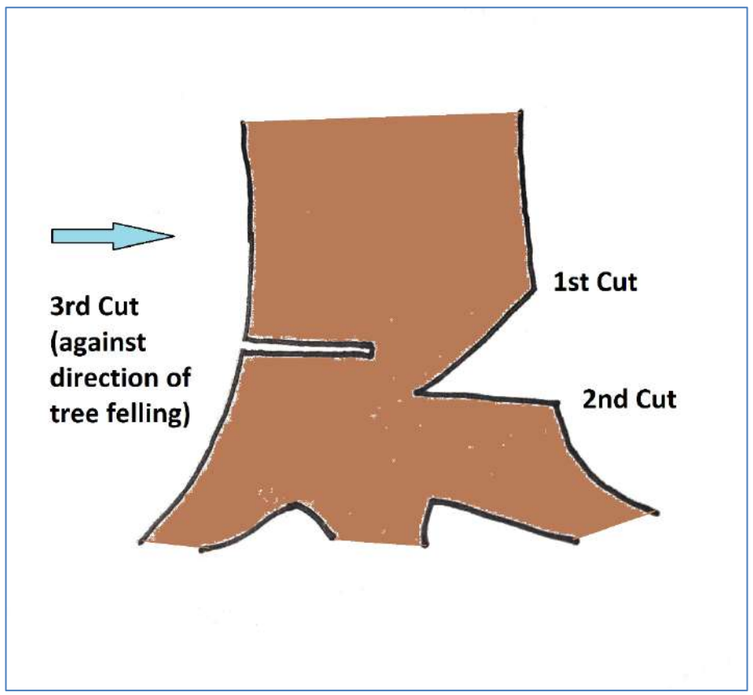

Figure 1.2.9b Example of a notch cut

1.2.9.2 Assessment and Monitoring of Trees to be Protected

Before any construction activity begins, the arborist shall perform pre-construction tree assessment for trees at proposed development site. Based on site observation, construction drawing and design, the Arborist shall produce tree assessment report recording tree information such as site photos, species, height, girth, crown spread, tree health, form, structure, site observations and assessment on whether the tree will be affected by proposed development footprint, and if so, what are the recommended mitigation measure to construction impact on trees. If the tree species is uncertain, the Arborist shall seek assistance from the Native Flora Specialist to identify the species. This tree assessment report will then serve as record of pre-development tree condition, and the Arborist will have to refer to this report as benchmark when performing monthly monitoring for trees.

Tree pruning such as crown cleaning, formative pruning, structural pruning, or crown thinning will be the first line of mitigation measures. Tree Support Systems such as Tree Guying and Root Anchoring must be considered if the tree is deemed to be susceptible to wind throw.

The Arborist shall also conduct monthly inspections of trees to be protected. The monthly inspection report will cover 2 main aspects: (i) Current tree health and (ii) The TPZ condition. Table 1.2.5 presents criteria to be reflected in the monthly inspection report. Photos of each tree are to be included in the monthly inspection report. In addition, past or current maintenance activities will be reflected in the monthly inspection report (such as Last Tree Pruning Date) during the contract period.

1.2.9.3 Tree Felling within Forested Areas

Before felling trees, the Arborist must ensure native saplings have already been tagged, identified by Native Flora Specialist and transplanted into on-site nursery by Nursery Manager and the nursery workers. The Arborist must also survey, identify, and confirm the Trees to be Protected the surrounding area and establish a tree felling protection distance based on site condition and tree crown spread. Tree felling protection barriers should be set up using Rebar 13 and wrapped with highly visible materials such as orange netting and red & white tape. If any tree to be felled is located within the barrier, the tree contractor shall consult the Arborist on how to remove these trees and whether the grub is to be removed.

The trees to be felled shall be inspected for any fauna as per section 1.2.2 Wildlife Shepherding. Such trees will be marked with red & white tape and no tree felling operation shall be carried out within 5 m from the said tree until further instruction.

Before commencing tree felling works, the supervisor, banksman, and foreman shall scout the area a final time to ensure that the tree felling protection zone is clear of human activities, while WMOs will inspect the tree felling protection zone if the site is free of wildlife activities. Once the areas are cleared, the banksman will signal the excavator operator to commence work for trees felling. The excavator operator will first clear off the shrubs and small trees (<5m height) to create a clear line of sight for the whole area and to keep away blind spot areas which are blocked by small trees or tall shrubs. The excavator operator shall operate cautiously and fell all small trees and shrubs in a controlled manner, aware of the location of the other trees to be protected.

When opening is completed, the excavator operator will clear off small trees and shrubs along the path into the site so as to demark the area that they are supposed to work within. When the paths are cleared, the operator will then move inward to fell trees within the area. If the operator faces a tree with height between 5 and 7 m, they will clear off shrubs in the surrounding area so that the foreman can move closer to the tree. The recommended tree cutting method will be the notch cut (Figure 1.2.9b). The foreman shall determine the direction of falling and ensure the tree does not land on any property, cause injury, or damage nearby Trees to be Protected. To avoid trees leaning to an unintended direction when performing a third cut, the excavator will assist to prevent fall back and guide the tree to fall into the intended direction. Once the tree has been felled, the tree cutter shall cut the tree trunk into shorter lengths for easier loading during clearing of the debris from site.

If the tree has a height greater than 7 m, the tree height has to be reduced by using a lorry crane to perform crown reduction first. Before the lorry crane can enter the site, the construction contractor has to prepare proper access for the lorry crane to enter the site and access the tree location. The construction contractor must ensure that the access ground is firm enough to allow the lorry crane to deploy its outrigger. When the access is ready, the construction contractor will then mobilize the lorry crane to enter the site to reduce tree height to 7 m in order to adopt the notch cut method for trees less than 7 m in height.

Compound name	Effect	Source
2,4-Dichlorophenoxyacetic acid	Possibly alter microbial soil communities with continued exposure	Chinalia et al., 2007
Abamectin	Lethal to certain freshwater aquatic organisms	Novelli et al., 2011
Chlorpyrifos	Can be a potential danger to aquatic organisms, particularly fish.	Bhatnagar et al., 2016; Giddings et al., 2014; van Wijngaarden et al., 1993
Cypermethrin	Causes toxicity in fish and soil microbia	Ullah et al., 2018; Tejada et al., 2014
Esfenvalerate	Physiological impacts on fish. Odonates susceptible to toxicity. Aquatic habitats are susceptible if they are downhill from premises that use this	Bjergager et al., 2011; Geist 2007; Beketov 2004;
Malathion	Harmful effects on tropical freshwater systems and associated biodiversity	Stoler et al., 2017; Rico et al., 2011
Methomyl	Lethal to a widely tolerant species of frog	Trachantong et al., 2017
Permethrin	Permethrin is highly toxic to fish and other animals that live in either salt water or fresh water. Permethrin is low in toxicity to birds, but some aerosol products made with permethrin may also contain other ingredients that can harm birds if they inhale it. Permethrin is highly toxic to bees and other beneficial insects.	CCME 2006
Propoxur	Lethal to earthworms and fish	Ogeleka et al., 2016
Pyrethrin	Impact on a wide variety of aquatic-dependent fauna groups (fish, birds, amphibians, aquatic mammals)	Ali et al., 2011;
Resmethrin	Found to be lethal to bees	Mackenzie and Winston, 1989

Table 1.2.6 List of chemicals to not be used within the development, their effects, and study that determined these effects.

1.2.10 Biodiversity-sensitive insect pest control practices

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Pesticide use has resulted in landscape-scale changes to biodiversity. Bees and butterflies have received substantial media coverage due to pesticide-driven population crashes and have received significant public support for their ecological importance as pollinators. This is an ecosystem service that humans directly benefit from with food and ensuring flora communities continue to grow (thus reducing ambient air temperature). However, other species necessary for functional and healthy ecosystems are also faced with damage from pesticide use. For example, fungi are required to break down dead matter (dead trees or fauna) and return nutrients into the soil. These are used by trees to continue growing. As rain in the tropics can leach nutrients from the soil, fungi are necessary for the constant recycling of nutrients into the soil to maintain flora communities.

While the National Environment Agency (NEA) maintains a list of registered pesticides that can be used, the literature suggests that some chemical compounds on the list have adverse effects on the environment. A full list of these chemicals is found in Table 1.2.6. Chemicals listed here **shall not be used** on the premises of the development as the impact on the sensitive adjacent habitat is likely to be significant.

This list is correct as of 2021. However, facilities managers must stay abreast of the literature concerning the impacts of pesticides on the environment. A new study may be published that indicates that the impact of another NEA-registered pesticide could be substantial. As new science is published, this list may change, and facilities managers must ensure that pesticides that may impact the environment are added to this list.

A common means of pest control is through fumigation. Fumigation converts liquid pesticides into an aerosol, which can be sprayed into the air. While this allows pest controllers to apply the pesticide in inaccessible areas (e.g., drains), it is this feature that allows the pesticides to reach deep into forested areas through wind dispersion. This activity has previously wiped out an entire heronry of Black-crowned night herons in Sungei Khatib Bongsu. Therefore, in order to mitigate impacts by pesticides, fumigation **must not be used** within the development.

Mosquitoes are a serious and legitimate concern in Singapore, but it is important to note that intact and healthy ecosystems will provide pest control ecosystem services that can tamper mosquito populations. For example, bats are able to provide biological control of pest populations. Because some bat species eat a variety of insects, the impacts of fumigation can have indirect effects on bats should they consume resistant insects that are covered with pesticides. This would then cause bat populations to plummet, leaving less bats to provide these ecosystem services and more intensive human pest control measures. If the suggestions for bat habitat creation in section 1.1.7 Habitat creation are carried out, bats that colonize this habitat can substantially help maintain pest populations within the development.

1.2.11 Biodiversity-sensitive construction operations

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Impact mitigations for construction works for humans (e.g., sound barriers, fencing and barricade) are normal practices and enforced in Singapore. However, due to the sensitive nature of landscape values surrounding the Springleaf development, additional measures are needed to reduce the impact on the habitat. The Environmental Impact Assessment will recommend a set of mitigation measures for different aspects of the construction, but certain measures will be outlined here.

1.2.11.1 Stipulated time for works

Many of the fauna found on site are nocturnal (active at night) or crepuscular (active at dawn and dusk), so works must only commence after 0800HRS and end at 1700HRS.

1.2.11.2 Construction lighting

While time for works must be limited between 0800HRS to 1700HRS, lighting throughout the construction site may be necessary as a security measure. In such a circumstance, lights operating at night should be:

- of low wavelengths and narrow spectrum, e.g. low pressure sodium 18W pointed downwards instead of sideways or upwards
- kept to the boundary between construction site and human habitation (e.g., streets) as opposed to boundaries between construction site and the forest
- Pointed to ensure that beams are pointed into the construction site if lights are needed at forest boundary, and kept at a maximum height of 8m
- kept at a minimum distance of 25 m between lights

1.2.11.3 Sound barriers towards the forest

While sound barriers may be erected between the construction site and human habitation, sound barriers should be erected between the construction site and the forest to reduce the impact of noise on the environment.

1.2.11.4 Storage of chemicals and fuel

Chemical and fuels should be stored near the roadside or at the furthest point away from the forest boundary, whichever is further. Storage of chemicals or fuels on site should be on slopes that slope away from the forested area.

1.2.11.5 Slope stabilizer

Slopes, particularly slopes that face down towards the freshwater swamp, must be stabilized to reduce erosion risk

1.2.11.6 Drainage away from the forest

The sites marked for construction are on the higher elevations, and construction activities may result in surface runoff draining to the swamp forest. Appropriate drainage must be established to ensure that surface runoff does not travel down to the swamp.

1.2.11.7 Bury fencing and barricades

To reduce the possibility of wild boar entering the construction site, fencing should be buried 0.5 to 1 m into the ground.

1.3 BIODIVERSITY CONSERVATION STRATEGIES: INHABITATION

1.3.1 Community education and stewardship

BSUD Principle(s): Improve potential for positive human-nature interactions

Type of Mitigation: Mitigation

Public education and outreach, as well as engagement between residents and the surrounding biodiversity is key to the success of positive human-nature interactions (Cooper et al., 2007). Public education and outreach can be both passive (e.g., interpretive panels, signages) or active (e.g., seminars, guided walks). Public engagement, on the other hand, involves public and residents directly with conservation efforts within the development, giving residents a sense of stewardship with the surrounding biodiversity.

The bookend of public education, outreach, and engagement would be “Cues to Care”. Cues to care are calls to actions that residents can do to make an impact towards biodiversity conservation. These are essentially a response to what residents can do to ensure that all the information they learned was worth the time to obtain it. Actions can be as simple as promoting responsible behaviour, while others can be what residents can do should they encounter wildlife within the development.

Both public education and outreach as well as cues for care are required to cultivate environmental stewardship. Further, these strategies are more effective than top-down approaches such as enforcement, and should be utilized by development operators during inhabitation (Doremus, 2003). Such a strategy is key to reducing the impact residents have on the surrounding Springleaf Forest. The following guidelines are some example avenues for how these opportunities can be exploited. This is a non-exhaustive list, and planners should use the following guidelines as inspiration for developing new and novel ways of outreach, education, and engagement.

1.3.1.1 Sustainable Education Center

A central hub for sustainable living has been designed into this Masterplan document. The purpose of the Sustainable Education Center was to promote sustainable living with the residential community within the development (reduce water or electricity use, growing their own food, etc.), but can be a central hub of information for biodiversity and conservation as well.

An example of such a hub is the Bukit Timah Nature Reserve (BTNR) Visitor Centre. This visitor centre acts as a one-stop centre for visitors to learn about the conservation values within BTNR. These conservation values refer to landscape, flora, and fauna values that can be found on site. Such a visitor centre is important as visitors to BTNR are restricted to trails within the forest to ensure that sensitive flora species are not trampled on by visitors, but also allows cryptic and sensitive animals (such as mouse deer or pangolins) to find refuge away from heavily visited areas. While such a visitor management strategy is necessary for protected area management, it means that visitors to BTNR may not be able to view the full range of biodiversity, either because they are inaccessible or because they were not detected during their visit. The visitor centre gives visitors a chance to learn about the conservation values on site, even if visitors were not able to see them during their visit. With recent renovations in 2016, the visitor centre has several interpretive panels that are more interactive and engaging (puzzles, touch screens, video montages, etc.).

Given that an education center is included in the Masterplan for Springleaf, it provides an opportunity to mimic these features to showcase the conservation values within the Springleaf Forest. While the secondary forests are of good quality in terms of the presence of threatened flora and fauna and forest structure, the habitat that is worth showcasing is the freshwater swamp forest. As mentioned previously, such habitat is rare in Singapore, with the largest and only protected forest patch in NSSF. Showcasing that the development was designed sensitively with respect to this and other habitats within Springleaf Forest will not only be a selling point for the development, but residents can feel proud to be staying in a development that was sensitive and respectful to these habitats.

As this is a central hub of information for sustainable living, Cues to Care for biodiversity conservation are married very well with actions that residents can take for sustainable living. The following are examples of how such pairings can be made, and should be treated as inspiration for planners to develop other ways to couple sustainable living and biodiversity conservation:

- Waste management and recycling information can be coupled with encouraging residents to ensure their rubbish bins and trash cans are securely fastened to not allow Long-tailed macaques from reaching discarded rubbish

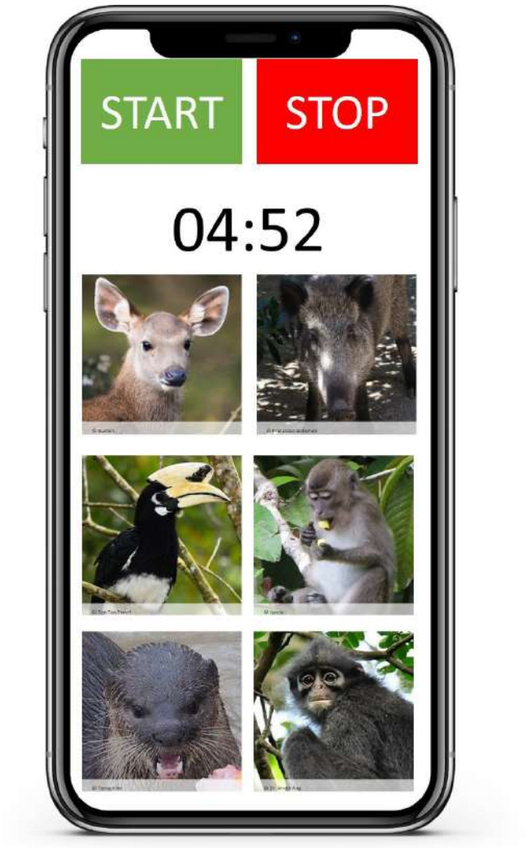

Figure 1.3.1a An example of an app that can be used for data collection by residents within the development. Residents could tap START or STOP to begin and end their transect. When they see an animal, they simply tap on the photo of the animal they see.

- Residents can make their own bee hotels and place them in their home and community farms if residents are encouraged to grow their own food. This will create habitat for solitary bees to rest or lay their eggs, thus increasing pollination potential within the adjacent forests
- Carbon-reduction strategies such as only using lights when needed can be tied in with efforts to reduce human lighting within the development to not impact natural behaviors of fauna (e.g., disrupting sleeping activities of birds, moth attracted by lights without pollinating flowers, etc.)

Planners should make use of new technologies (touch screens, reactive projectors) to keep education panels engaging. However, certain aspects can be maintained as analogue, such as puzzles and simple games. Create opportunities to learn through play, as ideas and concepts are retained faster and longer if learning experiences are fun and engaging (Roussou, 2003). High-resolution images collected from the site should be used to showcase different conservation values in Springleaf Forest, such as the swamp forest, cryptic fauna, and dramatic trees found throughout the site. While the Exhibition Hall from BTNR was used in this example, planners and designers should look to other well-designed hubs for information. Such examples are:

- Sungei Buloh Wetland Reserve Wetland Centre
- Sungei Buloh Visitor Centre

1.3.1.2 Citizen Science

Monitoring and adaptive management is important during the operations of the development so that operation managers can adapt operations to ensure their impacts on biodiversity are limited, reduced, or reversed. While the bulk of the data that is used must come from scientifically rigorous monitoring programs within the forest, residents within the development can take part at an opportunistic, ad hoc capacity. While there are limitations to citizen science data due to collectors not having the necessary background in rigorous data collection, carefully planned programs can yield data that gives important information (Brown and Williams, 2019).

A very simple example would be for residents to collect data along a designated, already built path (e.g., the walkway between the Tree Cottages) within a development within a certain time window (e.g., 6:00 pm to 7:00 pm). Residents can be asked to record data on specific fauna of interest to the development, such as fauna important for wildlife management (Long-tailed macaques, wild boar, sambar deer) or fauna of conservation significance (pangolins, mouse deer). Such data is already valuable as it is consistent both in terms of space (the walkway between Tree Cottages) and time (6:00 pm to 7:00 pm). This makes such data more robust for analysis.

Data collection in this example can be simple as well (Figure 1.3.1a). Residential-specific applications on smartphones are common practice for managers to obtain feedback from residents or for residents to get information such as time of events or maintenance notices. Such an app can also be utilized for citizen science projects by residents. Residents can input information such as when they started and ended their survey. Data recording can be as simple as tapping on a photo of fauna that are of interest to the operation managers. What makes this mode of data collection useful is that data on the resident recording the data and the time when the saw specific fauna can also be collected. Such high-resolution information is already needed for some complex models.

Citizen science is clearly a Cue to Care in itself. It is an activity that engages residents to contribute to management and operations of the development by providing useful and valuable data on fauna of interest. Citizen science itself is a public education and outreach strategy as well as enabling residents to identify fauna to a reasonable level of accuracy. It would not be difficult for the app to provide additional information on each fauna species during the survey, or to even play sounds the animals make (especially for birds).

Figure 1.3.1b Guided walks are an opportunity for an experienced nature guide (individual on the far right with black bag) to give an engaging education experience where participants walk away with more information about the biodiversity of their development than when they started but with a new sense of stewardship

1.3.1.3 Forest Trails

The Masterplan has included design guidelines for trails within the buffer zones of the Core Conservation Area and the Significant Conservation Area. While these areas are within the public realm, it is recommended that these trails are developed sensitively as per the design recommendations of this Masterplan.

The creation of forest trails in the buffer are strategies for protected area management (Newsome et al., 2013). It allows the public a controlled glimpse into these sensitive habitats. This is particularly important for the freshwater swamp forest; as the only other freshwater swamp forest is in NSSF, some people have attempted to enter it illegally in order to experience this rare habitat. However, there are impacts on the habitat that include trampling sapling trees of threatened species, disturbing sensitive fauna, and polluting aquatic environments. While there are impacts on the habitat, there are several hazards within an intact forest that could result in serious injury or death, such as tree fall, deadwood, holes, venomous snakes, and serious encounters with large fauna (sambar deer or wild boar). Allowing trails into a sensitive habitat allows the public and residents to experience this sensitive habitat, thus satisfying their curiosity from having to enter another freshwater swamp habitat illegally.

Trails within the buffer areas should be opportunities for public education. Interpretive signs can be placed and interspersed along the trail to provide educational information about the habitat. These can also be opportunities to include Cues to Care, such as encouraging visitors to keep plastic bags and food inside their bags to decrease the chances of a negative human-wildlife interaction (such as with wild boar or long-tailed macaques). Interpretive signs also provide an opportunity to showcase the design features of the development that were sensitive to the surrounding conservation values.

1.3.1.4 Guided Walks

Guided walks are a classic form of outdoor education and outreach programs (Figure 1.3.1b). This involves residents registering for a guided walk by a guide who shares their knowledge of local conservation values. Guided walks can be conducted within the development and be exclusive to residents only. The walkways between the Tree Cottages provide the perfect opportunity for such guided walks as this would be within a secondary forest. Assuming that developers and planners fully adopt the “light touch” principle, this forest should remain fairly intact once the development is completed. If large fauna such as wild boars and sambar deer are allowed to roam freely beneath the tree cottages, it provides material and content for the guide to provide information for residents from a safe distance.

These guided walks can also be done at forest trails within the buffer. While these are not within the development parcels and remain in the public realm, development managers can still engage a guide to take residents through the buffers. This is a prime opportunity for residents to learn about the freshwater swamp forest from an experienced and knowledgeable guide.

While this serves as a public education and outreach strategy, there are opportunities for Cues to Care. Guides should be allowed to weave and create their performance in a way that works for the individual guide, and this may mean that their guides are punctuated with Cues to Care or the guide can end with a dramatic and emotional Cue to Care. However, a Cue to Care should be specified in whoever is engaged.

Development managers are encouraged to explore themed guided walks as well. While a single generalist guide can provide great coverage of several topics, guides who are specialists within a certain discipline can provide excellent depth to resident participants during the walks. For example, the Jane Goodall Institute (Singapore) provides guided walks to participants for primates of Singapore. Their walks are geared to exposing Singaporeans to the diversity of primates within Singapore, but also to changing notions that some species, particularly Long-tailed macaques, are a nuisance, thus satisfying public education and Cues to Care. The Herpetological Society of Singapore is another group of enthusiasts who are specifically interested in amphibians and reptiles (collectively known as herpetofauna). Like the Jane Goodall Institute (Singapore), they provide guided walks to show Singaporeans the vast herpetofauna biodiversity in Singapore, but also provide Cues to Care by changing the notion held by several Singaporeans that all snakes are to be afraid of.

Figure 1.3.1c Interpretive sign in a nature reserve that provides information of a particular attraction

Figure 1.3.1d An example of a behavioral reminder signage by NParks

Guides can be engaged by the development managers and do not necessarily need to be development staff themselves. Such guides are available as freelancers, but can also be available via a contract from a company or through non-government organizations, societies, and charities. Guidelines on a guide or several guides are kept general to allow for competition from various vendors, but all guides **must meet all** of the following requirements:

- Have at least 2 years of guiding experience in Singapore
- Have demonstrated evidence of their knowledge on local biodiversity in Singapore with at least two (2) contributions to guides, books, chapters, or technical reports on local biodiversity Singapore
- If themed guided walks are the goal, guides must have demonstrated evidence of their knowledge through **any one** of the following:
- At least one (1) first-author publication of a scientific article in a scientific journal on flora/fauna groups of their chosen discipline
- At least two (2) contributions to guides, books, chapters, technical reports, or sighting contributions on local biodiversity in Singapore

While such requirements may be unusual, demonstrating and verifying experience and knowledge are necessary to ensure that the information and knowledge shared to residents is correct and comes from an expert of their discipline.

1.3.1.5 Signage

Signages throughout the development could either be interpretive signs or behavioral reminders. Interpretive signs are generally geared towards educational content, while behavioral reminders are to remind residents of certain behaviors that reduce the possibility of negative human-nature interactions.

Interpretive signages can contain educational content (Figure 1.3.1c), particularly information that is specific to the Springleaf forest. Placement of where the interpretive signs are could provide specific information. For example, signage near trees of conservation could have information about the species of tree (cultural uses, ecological importance, interactions with other species, conservation status), while signage near water features, bee hotels, or flower beds could describe the different species of dragonflies, bees, and butterflies often found in those areas and how they are important for the local ecosystems.

Behavioral reminder signages are to remind residents to adopt behaviours that reduce negative human-nature interactions (Figure 1.3.1d). Such signs have been used by NParks for various fauna groups such as otters, wild boars, and feral dogs. Such signages can be used within the development. Below is a list of possible behavioural reminders that the development could adopt. This list is non-exhaustive, and development managers should brainstorm other behaviors they would want residents specifically for human-nature interactions.

- Signages for “Dos and Don’ts” for
  - Dog walking (pick up after your dog, keep dog on a leash, etc)
  - Wild boar encounters
  - Long-tailed macaque encounters
  - Sambar deer encounters
- Proper waste management (keeping bins secure, throw waste in designated bins)
- Reduce noise at night when walking through development
- Do not use aerosol pesticide outside their homes

Figure 1.3.1e Tree planting could be an activity carried out by committees developed by residents as a way of ensuring continued ecosystem function of the Springleaf Forest

Figure 1.3.1f As with warning signs for areas with high bear activity, warnings signs within the Springleaf development could be produced to warn residents of sambar deer and wild boar.

1.3.1.6 Environmental Stewardship

Environmental stewardship implies that users of a particular environmental resource take it upon themselves to be responsible for its maintenance and care. Indeed, Bennett et al. (2018) defines environmental stewardship, particularly at a local level, as:

> *The actions taken by individuals, groups or networks of actors, with various motivations and levels of capacity, to protect, care for or responsibly use the environment in pursuit of environmental and/or social outcomes in diverse social-ecological contexts.*

While this definition is all encompassing and great efforts can be spent unpacking this definition (Bennett et al. 2018), this section will focus on two components of local environmental stewardship within the context of Springleaf Forest and the development: "to protect [and] care" for the environment and "responsibly use the environment."

<u>Care For the Environment</u>

Care for the environment can come in the form of lifestyle choices or in the form of actively doing their part for the environment. Lifestyle choices would be related to residents' day-to-day life. For example, if residents wish to have a picnic in some parts of their property, they ensure that everything they brought with them is taken back out, which includes biological and non-biological waste (e.g. food wrappers, banana peels, or apple cores). Such efforts require capacity that residents would be able to invest in as these are small, management, and inclusive.

In circumstances where residents may have greater capacity (such as funding or governance within the development), they could form committees similar to "Friends Of" groups that take on the responsibility and care of the environment. Such committees can organize larger scale efforts to care for the environment. Citizen science projects (section 1.3.1.2 Citizen Science) that can contribute to monitoring and adaptive management (section 1.3.4 Monitoring and Adaptive Management) could be managed by such committees. Should such committees or volunteers be made up of ecologists and conservationists, interpretation of results can be more meaningful and contributions to adaptive management policies within the development can be grounded and supported by science.

A "Friends of Springleaf" group could also organize development-wide activities in a post-pandemic world, such as days where residents remove environmental weeds from the environment. This can ease maintenance required (section 1.3.7 Maintenance of Ground Level at Tree Cottages for Habitat Quality), especially if ecologists and conservationists make up some portion of the volunteers; it is possible such individuals would be able to contribute to weed management plans to ensure that weeds on site are managed effectively without the use of chemical herbicides. These same volunteers could also guide planting exercises for areas within or around the development that require additional planting to strengthen ecological functions.

<u>Responsible Use of the Environment</u>

In the context of Springleaf Forest, responsible use of the environment refers to the residents use of the different trails within and around the development. This can be divided into two broad components: responsible use of trails and responsibility of risks.

Forest trails can be a management problem if people do not stay on the trail. This can result in trampling of endangered flora saplings, destruction of nesting sites for sensitive fauna, soil compaction, and trail widening. Responsible use, then, would refer to the residents use of the trails in a manner that these impacts are reduced. To that regard, the solution is simply to ensure that residents stay on trails. Signages (section 1.3.1.5 Signages) are key to this, as this would be a low-cost tool to help achieve the goal of responsible trail use. More information can be provided within the Sustainable Education Centre, especially with regards to the environmental impacts of going off the trail within Springleaf Forest.

Responsibility of risks is an important component, particularly if the Shared Habitat model is adopted (section 1.1.6 Human-wildlife Interaction). Much like hiking through woods with cougars and bears, residents who wish to descend to the forest below the Tree Cottages must be made aware of the inherent risks of entering a forest where wild animals roam freely and accept such risks. Signages also play a crucial role with this, but residents can be told up-front during purchase of a dwelling unit within the development.

1.3.2 Biodiversity-sensitive pesticide practices

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Once the development is operational and begins accepting residents into the development, pest control practices must transition from construction phase into inhabitation phase. Guidelines for this section are the same as Section 1.2.10 Biodiversity-sensitive insect pest control practices, and the reader is strongly encouraged to use those guidelines for inhabitation.

1.3.3 Responsible wildlife management and human-wildlife interaction

BSUD Principle(s): Improve potential for human-wildlife interactions

Type of Mitigation: Mitigation

Just as human-wildlife interactions must be managed during the construction phase, so too do these interactions need to be managed during the inhabitation phase. However, guidelines during the inhabitation phase need not be as stringent as the construction phase; impacts during the construction phase are of a much greater magnitude than those in the inhabitation phase.

While residents play an important role in how they respond to wildlife, strategies for resident-specific behavior have been covered in section 1.3.1 Community education and stewardship. In this section, wildlife management and human-wildlife interaction will be focused on guidelines for development managers.

Development managers need to be trained in animal handling in order to manage break-ins by different fauna groups. Such courses and certifications are available by NParks, with certification lasting three years. Furthermore, different courses cover different fauna groups, with the basic module covering birds.

Development managers must have participated, successfully passed, and ensured continued renewal of their license in the following courses:

- *Animal Management Professional Certification Programme - Basic Module*
- *Animal Management Professional Certification Programme - Intermediate Elective Module - Mammals*
- *Animal Management Professional Certification Programme - Intermediate Elective Module - Reptiles*

Just as with WMOs, the courses cannot predict all possible circumstances that a trained facilities manager can be prepared for, so facilities managers can engage wildlife management contractors as per 1.1.1 Wildlife Management Officers.

1.3.4 Monitoring and adaptive management

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Monitoring and adaptive management is not only conducted during the construction period. Given that the success of enhancement and mitigation measures can only be detected over long timescales (20-30 years), monitoring during the construction stage must continue into the inhabitation stage.

Guidelines for monitoring and adaptive management have been provided in section 1.2.3 Monitoring and adaptive management and shall be used during the inhibition stage. All methods of data collection, such as time of day when surveys are carried out, transect locations, and camera trap and acoustic bat station locations, should be the same. This would allow direct comparisons between the construction phase and inhabitation phase as methods have been consistent over time.

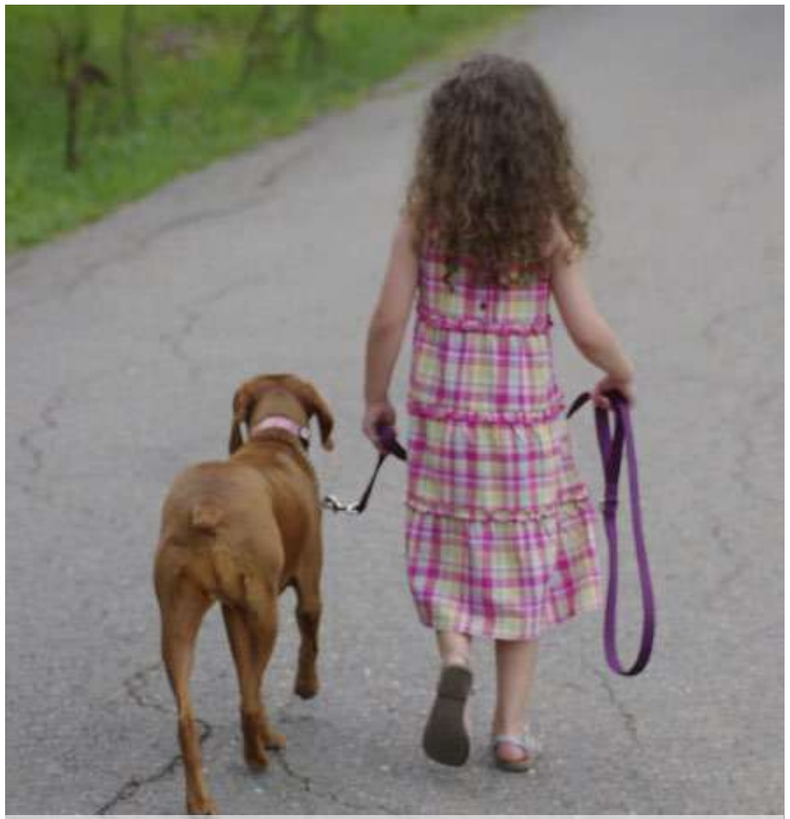
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Figure 1.3.5a. Residents must ensure that their pets are kept on leashes when they take them out for walks within the premises.


© Juhan Sonin


© Sadiah Jaffar

Figure 1.3.5b. Cats can be particularly destructive to native biodiversity if allowed to freely roam. If cats are allowed to roam, they must be on a lead with the owner holding onto the lead at all times. If not taken out, cats must be kept indoors at all times.

1.3.5 Responsible pet ownership

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

A major impact that residents can have on the surrounding habitats can come from their animal companions. Pets can vary in how they impact the environment, but all can have the same magnitude if not managed properly. Cats, for example, have had devastating impacts on wildlife in Australia. Invasive aquatic species, such as fish or red-eared sliders, can dominate aquatic systems and displace or eradicate sensitive native species.

The impacts of pets can also be on the pets themselves. While roaming pet cats can greatly impact their environment, they can also be eaten by local wildlife, such as pythons. Dogs that are allowed to walk off the lead can chase animals that can defend themselves. Consequences can be painful, such as with a porcupine (which Singapore has), but they can be fatal if a dog decides to chase and harass a venomous snake such as a King cobra or a Black-spitting cobra. While released aquatic pets can cause damage to the environment, up to 90% of released aquatic pets die within the first few days of being released as they are unable to adapt to the wild habitats. The reader must bear in mind that while ecosystems must be protected, the welfare and safety of the pets themselves is just as important a priority.

The following guidelines are how pets must be managed within the development.

- Dogs must be kept on the lead at all times while they are within the development and outside the residents' unit (Figure 1.3.5a)
- Cats must never be allowed to roam within a development at any time of day unless on a leash and with the owner holding the leash (Figure 1.3.5b)
- Owners must immediately clean up after their dogs defecate
- Aquatic pets, such as red-eared sliders or pet fish, must never be released into any permanent water body within the development (they could wash into the swamp forest during an overflow event from a strong storm)
- Pet birds must not be allowed to fly freely within the development

Figure 1.3.6a Lights can be installed with different wavelengths, such that white lights (top) could be used during the daytime, while warm lights (bottom) can be used at night time (after 7:00 pm)

1.3.6 Light Management

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

Artificial light at night is known to negatively impact the health, behaviour, and ecology of insects (Perkin et al. 2014; Owens & Lewis 2018), birds (Moaraf et al. 2020), and bats (Lewanzik & Voigt 2014; Stone et al. 2015). Reducing or eliminating lights from natural areas is beneficial to the local ecosystem but are not in keeping with human needs of a sense of safety within a built environment. This section attempts to develop that balance between human needs for illumination in dark areas and the ecological needs to maintaining ecosystem function in two areas within a development: inside residents' homes and outside residents' homes.

1.3.6.1 Inside Residents' Homes

Light from inside homes can impact the behaviour and ecology of insects, bats, and birds if light escapes into the surrounding environment. Light from resident homes can be managed in three ways:

<u>Install Lights Altering Wavelengths and Intensities</u>

Lighting systems that allow for the same fixture to toggle through different wavelengths of light and have changing intensities are currently available on the market. This provides residents with the option to change the intensity or colors of their lights within their homes to one that is of lower impact. Full spectrum light mimicking daylight can be used during the daytime, and narrow-spectrum, low-wavelength lights (orange lights) can be used at night (Figure 1.3.6a).

<u>Window Design</u>

Windows can use tinted glass to reduce intensity of light that leaves the windows. This has the additional benefit of reducing light and heat that enters the house from the external environment. Windows can also be installed with window louvers, which residents can be reminded to use at certain times of the day.

<u>Adopt Low-impact Light Regimes</u>

Adopting certain lighting regimes should not be enforced onto residents. However, the use of an in-development app used by residents (see section 1.3.1.2) could be used to provide residents reminders to adopt certain regimes that are ecologically low impact. Any combination of the following regimes can be adopted after 7:00 pm:

- Only turn on lights in rooms where there are people in them
- Turn off lights after 9:30 pm to 6:00 am
- Reduce the intensity of lights
- Change light color from white to orange
- Close or set window louvers ajar

1.3.6.2 Outside Residents' Homes

Light outside homes but within the development parcels are necessary for residents' sense of security, and hence the option of avoiding lights altogether is not an option. As it has been shown that lights of any intensity have impacts on animals (Stone et al. 2015), recommendations here are impact mitigations (Figure 1.3.6b).

Light Direction

Lights should not be allowed to permeate into adjacent forests. Lights should have screens that point down towards the ground. For lighting within the Tree Cottages, lights should only be directed towards the walkways, while light permeating into the surrounding environment is reduced as much as possible.

Wavelengths and Intensity

Lights used should be low-wavelength lights (orange) to reduce the emittance of wavelengths associated with green and blue lights. Light intensity should be as low as practically possible.

There is the possibility of automating the intensity of light to gradually reduce over time to a certain lumen/lux by 11:00 pm. Again, the lumen/lux in which lighting is reduced to should be as low as practically possible.

Distance Between Sources

Light sources should be no closer than 25 m from each other. This is to reduce the amount of continuous light in between light sources, thus reducing the overall collective intensity of lights from footpaths. Space between light bulbs should be dark to allow bats to fly in the spaces between lights.

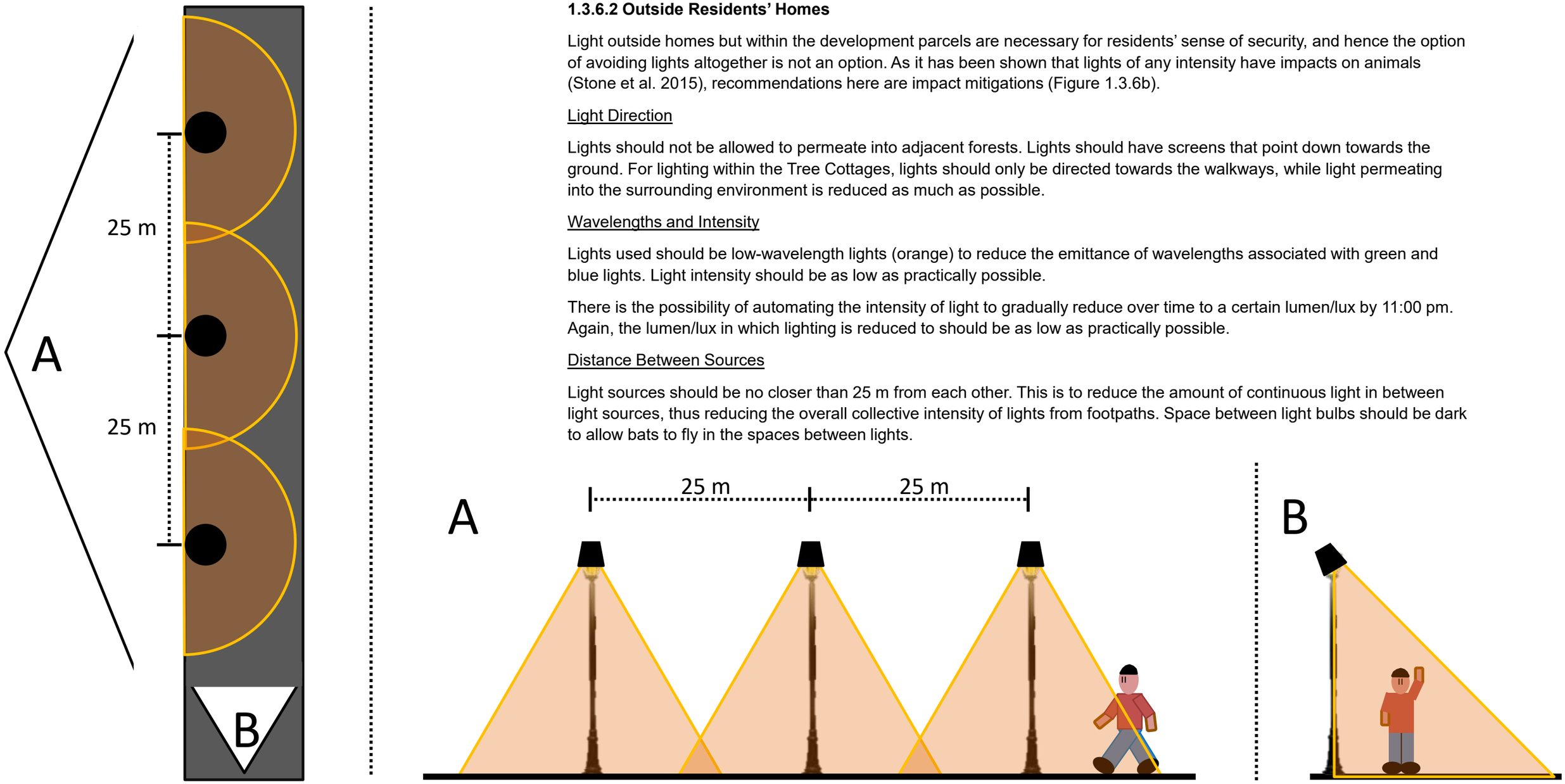

Figure 1.3.6b. Aerial view of lights along a pathway (left) with point-of-view from point A (centre) and point B (right). LEFT: Black circles are lights; orange translucent circles with yellow outlines are extents of lights; grey rectangle is pathway. Light sources should be spaced at a minimum of 25 m apart from each other. Light sources should have shades that point downwards, allowing for some aerial areas between light sources to be dark and allow bats to fly in between them. Lights should be pointed down and illuminate only the path. Lights should not be allowed to spill off the path and into the surrounding habitat.

Scientific Name	Common Name
Acacia auriculiformis	Acacia Tree
Asystasia gangetica ssp micrantha	Chinese Violet
Cecropia pachystachya	Ambay
Clidemia hirta	Koster's Curse
Dioscorea sansibarensis	Zanzibar Yam, Batman Plant
Falcataria moluccana	Albizia
Leucaena leucocephala	Lead Tree
Manihot carthaginensis	False Tapioca
Mikania micrantha	Mile-a-minute
Piper aduncum	Spiked Pepper
Pipturus argenteus	Australian Mulberry
Spathodea campanulata	African Tulip

Table 1.3.1 List of common invasive plants that should be cleared in Tree Cottages understorey

1.3.7 Maintenance of Ground Level at Tree Cottages for Habitat Quality

BSUD Principle(s): Minimize threats and human disturbances

Type of Mitigation: Mitigation

The ground level underneath the Tree Cottages is for the purposes of fauna habitat (which fauna is dependent on which fencing regime in section 1.1.6) and for flora to continue to grow in the forest. Given that this is a natural area, maintenance of the area should be limited to only removing invasive weeds and saplings (Figure 1.3.7, Table 1.3.1). Removal of invasive and non-native plants should be mechanical rather than chemical. In other words, the use of herbicides at ground level underneath the Tree Cottages should not be used under any circumstance; only removal by hand. Fungicide should not be used in this area as well; the maintenance of fungal communities is essential to the cycling of dead matter in the forest and giving plants access to nutrients released by fungi.

Grass cutters should not be used in this area so as to not unintentionally injure or kill any fauna that may be hiding in the understory. Tree pruning should be minimized (i.e. strictly no topping) to ensure that understorey is shaded and deter growth of invasive plants underneath Tree Cottages.

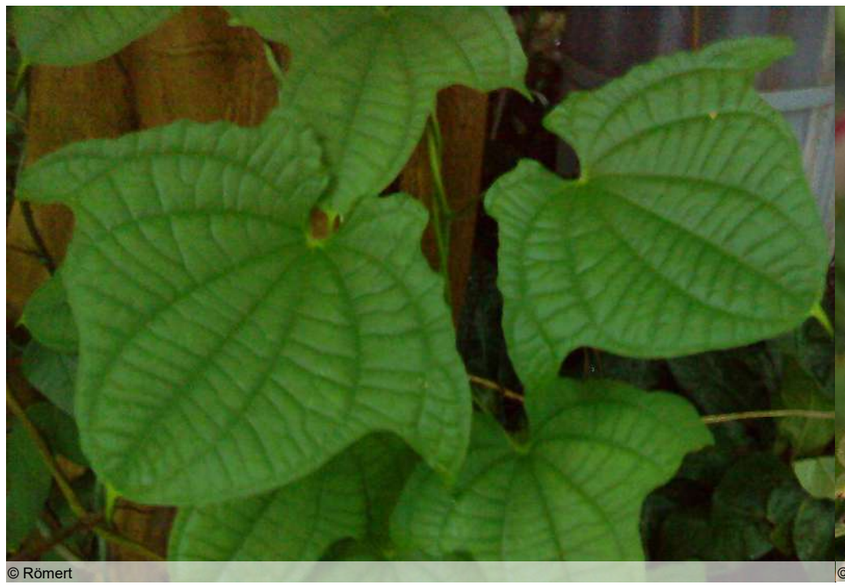

Figure 1.3.7 Left: Zanzibar yam, an invasive plant that can quickly take over gaps within the forest and smother out native flora. Center: *Spathodea campanulata* or African Tulip Tree is a non-native tree species that can invade natural areas as their seeds are weed dispersed. Right: *Mikania micrantha* or mile-a-minute vine grows quickly and can quickly smother plants present on site.

1.4 BSUD ACTIONS IMPLEMENTATION TIMELINE

The BSUD actions provided in sections 1.1 to 1.3 are provided in the order of the lifecycle of the development. The order in which these actions take place is just as crucial as the BSUD actions themselves. Table 1.4.1 gives an overview of when important BSUD actions must occur, particularly with respect to when construction begins and ends. The more detailed breakdown of Native Flora Salvaging and Tree Protection processes can be found in Table 1.2.2.

Time from Site Clearance	BSUD Actions Milestone	Description	Implementing parties (Private/Public)	Implementing personnel
1 year before	Artificial connectivity	Artificial connectivity (canopy rope ladder bridges, log bridges, and raft bridges) should be established 1 year before site clearance to allow fauna to condition to their use * Artificial connectivity could be carried out by government, or delegated to private developer as a contract option	Public*	Wildlife Management Officer
9 months before	Establish on-site nursery	Set up on-site native plant nursery at a suitable area with enough personnel and capacity to accommodate at least 1500 number of saplings	Private	Nursery Manager
	Tag native flora saplings	Native flora specialist should begin tagging, photographing and identifying native saplings that are within construction footprints and within a 2 m buffer of these footprints	Private	Native Flora Specialist
	Tree assessments	ISA-certified arborist to conduct visual tree assessments of trees with a girth greater than or equal to 1 m to establish necessary TPZ/RPZs and produce a tree assessment report that serves as benchmark for future monthly monitoring.	Private	Arborist
6 months before	Salvaging, maintenance and preliminary inventorying of affected saplings	Salvaging of native plants found on site that are within any construction footprint, with root ball size determined by Arborist. Salvaged saplings should be transplanted to on-site nursery and be maintained to ensure 70% of the saplings survive in first six months after transplanting. Species and quantity of saplings should be tally to create preliminary saplings inventory.	Private	Native Flora Specialist, Nursery Manager, Arborist
	Screening buffer demarcation	Screening buffers should be identified and demarcated. No construction/storage activities are allowed within Screening Buffer except for stepping stone/boardwalk constructions	Private	Developer
2 months before	Shepherding	Shepherding of animals out of construction areas	Private	Wildlife Management Officer
	Fencing	Fencing should be established in area where wall to ground will be to prevent animals from entering. Fencing should reach Sungei Seletar to prevent animals from entering Upper Thomson Road	Private	Developer
1 month before	Pre-felling arboreal fauna surveys	Trees that need to be felled must be inspected for arboreal fauna. Arboreal animals found in trees must be given time to leave the tree before the tree is felled. Tree to be inspected again after period when animal should have left.	Private	Wildlife Management Officer
Throughout construction and inhabitation	Monitoring and adaptive management	Monitoring of the physical (e.g., noise, water, light, air) and biological (e.g., flora assemblages, changes in fauna populations and behaviour) environment should be done with accordance to the EMMP to determine if the operations of the development have adverse impact on the biodiversity. Any deviations from baseline parameters should trigger adjustments to management and operations to reverse or reduce impacts Shall the developer require ad-hoc land clearance, the land needs to be surveyed by Native Flora Specialist to identify native existing trees to be retained and saplings to be salvaged before any site clearance commence.	Private	Environmental engineer/Environmental Control Officer, Native Flora Specialist, Nursery Manager
6 months after	Final sapling inventory	A final inventory of saplings within the on-site nursery that survived should be conducted so as to determine how many saplings are available for planting and to determine how many other saplings (of the same species assemblage as Springleaf) need to be ordered in.	Private	Native Flora Specialist, Nursery Manager
	Development of tree planting plan in and outside Springleaf Development Areas	Based on final saplings inventory, the Landscape Architect shall use the final saplings inventory to plan for final landscaping and reforestation of screening buffers, Miyawaki Targeted Areas, and other Planting Characteristics at Developed areas with assistance from Native Flora Specialist.	Private	Landscape Architect, Native Flora Specialist
Approximately 2 years after	Tree planting: Public domains	Once saplings reach 3-4 m in height, saplings can be planted in areas targeted for reforestation and repair screening buffers following Landscape Architect and Native Flora Specialist's guidance. Miyawaki Afforestation Method will be used at designated Miyawaki Afforestation Target Area, while Framework Species Method will be used at Screening Buffer areas. *Planting could be carried out by government after collecting stocks from on-site nursery, or planting could be delegated to private developer as a contract option.	Public*	Landscape Contractor
			Private	Landscape Architect, Native Flora Specialist
Towards end of construction	Tree planting: private developed parcels	Remaining salvaged saplings available after public domain planting can be planted into the developed parcels when construction is completed following design by Landscape Architect. Additional saplings may be ordered to make up the shortfall between salvaged sapling quantity and required planting quantity, but ordered native saplings should be inspected by Native Flora Specialist to ensure correct species. The saplings should be inspected by Nursery Manager to be of satisfactory quality, and structurally pruned by landscape technician under supervision of Arborist to ensure good form	Private	Landscape Architect, Landscape Contractor, Native Flora Specialist, Nursery Manager, Arborist

Table 1.4.1 Implementation timeline for major BSUD activities before and during the construction period