Cross Island Line (CRL) Phase 2 Environmental Impact Study (EIS) – Turf City and Holland Plain

Non-Technical Summary

Land Transport Authority's Objectives

With the vision to strengthen the connectivity and resilience of the land transport network in Singapore to support a car-lite nation, LTA has set off with an ambitious journey with one of the key targets being the expansion of the rail network to about 360km by 2030. This means connecting eight in 10 households to within 10 minutes of a train station. With a 360km rail network, Singapore will have a total rail length that is longer than major cities such as Tokyo or Hong Kong today and be on par with London and New York City.

As part of the vision, LTA's eighth MRT line, the Cross Island Line (CRL) will be Singapore's longest fully underground line at more than 50 kilometres long. It will serve existing and future developments in the eastern, western, and north-eastern corridors, connecting major hubs such as Jurong Lake District, Punggol Digital District and Changi region.

When operational, it will have the highest number of interchange stations, with almost half the stations on the line being linked to existing rail stations. This means more alternative travel routes to reach the desired destination. More than 100,000 households will benefit from CRL, and common recreational spaces such as Changi Beach Park and Bishan-Ang Mo Kio Park will also become accessible by public transport.

(Sources: LTA. Cross Island Line. 8 March 2021 & LTA. Upcoming Projects. Updated on 5 January 2022)

Overview

The proposed Cross Island Line (CRL) will be constructed in three phases. The first phase of the CRL is currently in the early stages of construction. This Environmental Impact Study covers the second phase of the CRL where a section of the alignment passes through a few vegetated areas. This report focuses specifically on the environmental impacts arising from the construction and operation of the stretch of CRL2 rail alignment and associated worksites from Turf City to Holland Plain, on the following nearby forested areas: Site I and II (forested area adjacent to Fairway Quarters), Site III (forested area within racecourse oval), Site IV (forested area adjacent to Rail Corridor) and Site V (forested area at Holland Plain).

Whilst not part of the Turf City and Holland Plain Study Area, Eng Neo Avenue Forest is a forested area located in close proximity to Site I and II (Turf City), while Clementi Forest is a forested area located adjacent to Site IV and V (Holland Plain). Whilst the focus of this report is on Turf City and Holland Plain (Sites I to V), the close proximity of adjacent project sites, means that the baseline findings of those Projects have some relevance to this report as well, particularly in relation to biodiversity, which is able to move across sites. It should therefore be noted that the focus of this report is on Sites I to V, all of which are located nearby CR14 and CR15 worksites. The relevant baseline and study findings of EIS (Windsor and Eng Neo Avenue Forest) and EIS (Clementi Forest and Maju Forest) are discussed in completeness, in respective reports; nonetheless, the findings from these studies are referenced in this report, where appropriate, to allow for a holistic discussion, where necessary.

This Document

This Document presents a Non-Technical Summary (NTS) of the findings from the Environmental Impact Study (EIS) conducted as a part of the CRL Phase 2 (CRL2) alignment for an impact assessment on the biological environment and hydrology during both construction and operational phases.

This NTS and the EIS of this Project exclude the alignment portions within the Central Catchment Nature Reserve (CCNR) which was covered under the *Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line* (hereinafter referred to as "CCNR EIA") gazetted by LTA on the 2 September 2019.

Scope and Objective of EIS

The **Scope of the EIS** covers the construction and operational impacts on the environment from above and below ground (i.e., biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise, and ground-borne vibration). Additionally, where the impacts were deemed to be "Significant" or "Moderate/Major", appropriate mitigation measures were also recommended, along with the proposed Environmental Monitoring and Management Plan (EMMP) to manage these impacts.

The **Objective of the EIS** is to present an assessment of the potential environmental impacts arising from and associated with, the construction and operation of CRL Phase 2 (CRL2) from Turf City to Holland Plain, on the forested areas identified in the vicinity of the Project for its biodiversity value (i.e., Site I to Site V)). These identified forested areas along the alignment have formed the biodiversity Study Area for this report. The study of pre-construction environmental baseline conditions along this route was conducted and included as part of the EIS.

The Project

Project Location and Components

In this Project, vegetated sites i.e., **Site I, II, III, IV and V** were identified as the Biodiversity Study Area as shown in Error! Reference source not found., which could potentially be impacted by the activities along the CRL2 alignment as listed below:

- Pre-construction activities: include road and utilities diversion works, site and tree clearance, temporary worksite establishment, monitoring instruments installation;
- Ground improvement works: expected at the worksite with launch/retrieval shaft to ensure water tightness between the interface of the soil and the face of launch/retrieval shafts;
- Construction of shafts –vent shafts associated with station boxes will be constructed adjoining the two main stations;
- Construction of stations includes construction of two underground stations, viz. CR14 in the Turf Club area and CR15 near current Alberts Park Station; and
- Tunnelling: Tunnel Boring Machine (TBM) will be launched from the CR14 worksite towards CR15 and pulled back to CR14. There will be no retrieval shaft at CR15.

Upon completion of the construction works, the worksites will undergo reinstatement and landscaping, eventually becoming CR14 and CR15 stations. Periodic maintenance works will be required once the MRT rail, stations and facility buildings are operational.

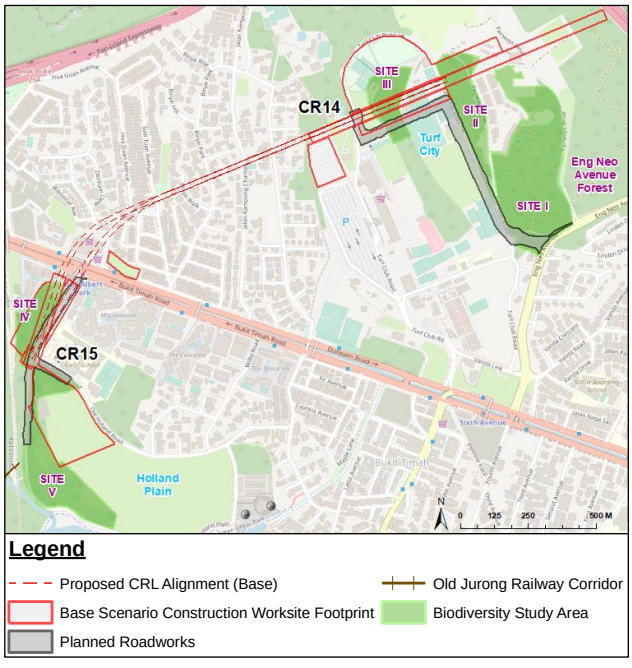


Figure 1 Project Location (Base Scenario)

Environmental Consultation Process and Stakeholders Engagement

Prior to the commissioning of the EIS, an Environmental Consultation Process was undertaken by LTA with the relevant technical Agencies (i.e., MPA, SFA, NEA, NParks), as well as MND/URA, to confirm the scope of the EIS of the Project which was then documented in the form of an Inception Report for approval from the relevant Agencies.

As the EIS progressed, members of Nature Groups were also engaged throughout the study process to share the EIS findings, as well as to discuss design optimisation/mitigation measures and any other key biodiversity issues related to this Project. This has enabled potential impacts to be captured on time and recommendations to be incorporated into the preliminary design to avoid or mitigate environmental impacts.

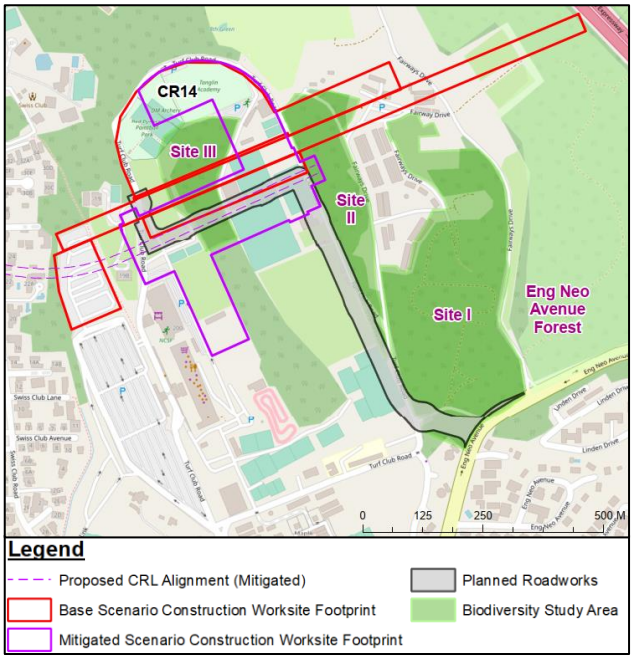


Figure 2 Design Optimisation of CR14

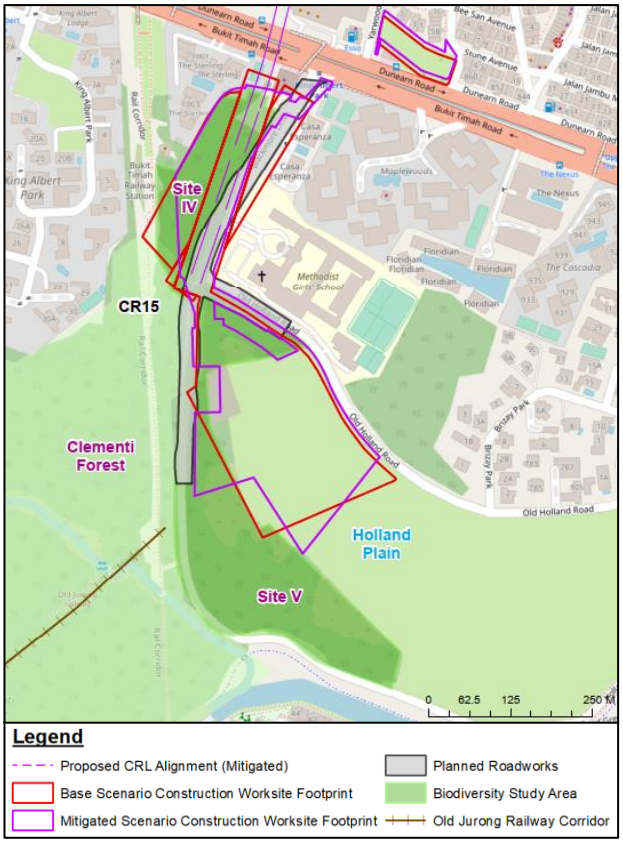


Figure 3: Design Optimisation of CR15

Environmental Impact Mitigation through Design Optimisation

Extensive engagements were made with internal and external stakeholders to discuss alternatives to reduce environmental impacts during the EIS process, including the design optimisation of worksites as a method of Impact Avoidance/ Elimination. Therefore, this was assessed as mitigated scenarios in the EIS.

The key optimisations comprised altered worksite layouts and a significant reduction in worksite area for both CR14 and CR15 worksites (see **Figure 2** and **Figure 3**).

This optimisation has greatly helped in reducing encroachment into the Biodiversity Study Area, preventing further fragmentation, hence minimizing impacts to the ecologically sensitive receptors in Sites I to V.

Overview of Assessment Methodology

The assessment was undertaken by identifying the Study Area, categorizing the sensitive receptors within Study Area, followed by the prediction and evaluation of impacts, and then the recommendation of mitigation measures and EMMP where relevant. The environmental impacts studied were direct impacts on biodiversity, or indirectly via other environmental aspects such as air quality, noise quality, vibration, hydrology and water quality and soil and groundwater.

Definition of Study Area and Identification of Sensitive Receptors

The Study Area, defined as a representative area covering the construction/ operational footprint of the Project, was used for the assessment of environmental impacts. The Study Area identified for each environmental parameter varies based on the relevant legislation or international guidelines as shown in **Figure 4** to **Figure 7** below.

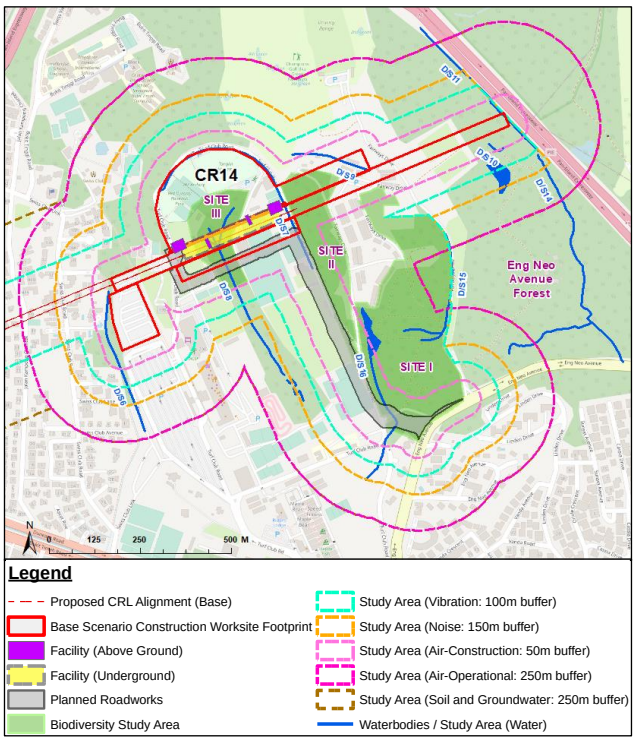


Figure 4: Study Area of CR14 (Base Scenario)

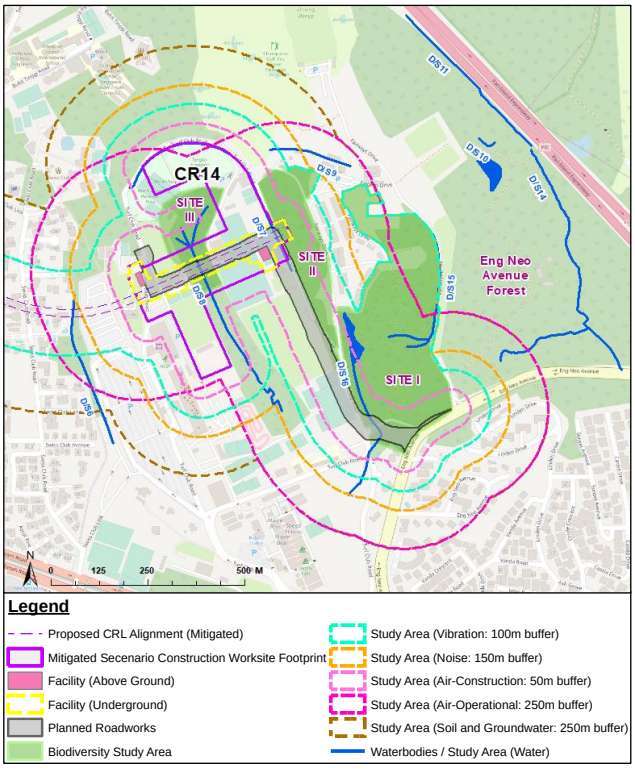


Figure 5: Study Area of CR14 (Mitigated Scenario)

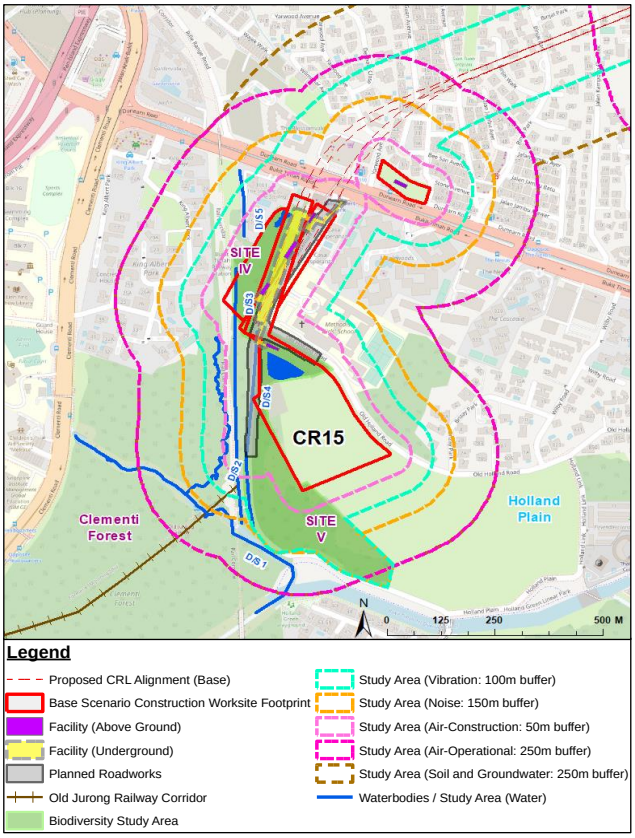


Figure 6: Study Area of CR15 (Base Scenario)

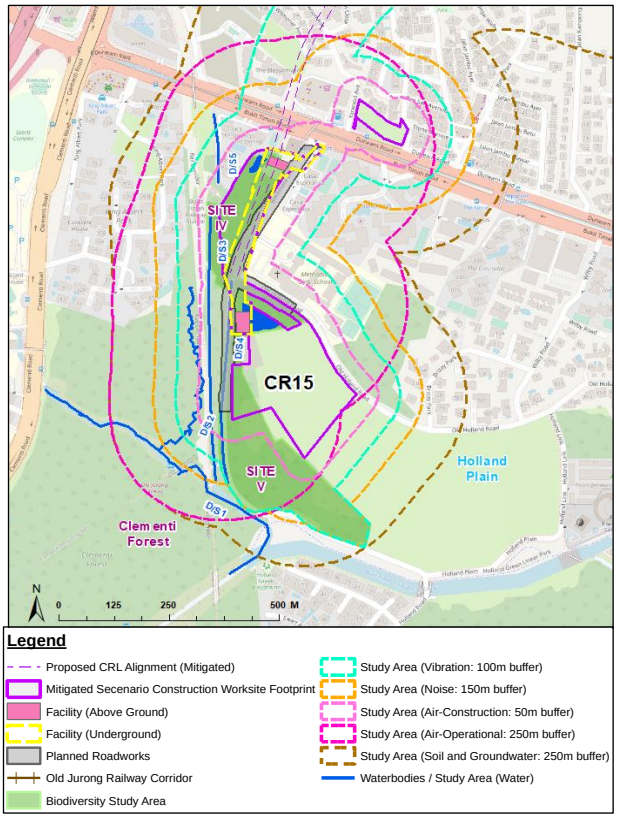


Figure 7: Study Area of CR15 (Mitigated Scenario)

The assessment criteria for each parameter were also established based on similar sources of local and international guidelines or precedent reports and are detailed in the EIS.

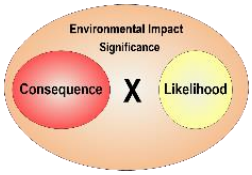
The sensitive receptors identified for this EIS were mainly flora and fauna or their habitats within the biodiversity Study Area nearby the construction worksites, i.e., Sites I to IV. The ecologically sensitive receptors were classified into Priority 1, 2 and 3, which were defined differently within each environmental discipline (viz., air, noise, vibration, hydrology and surface water quality, and soil and groundwater) and detailed in the EIS.

Baseline Data Collection

To establish the baseline conditions of the Study Area, pre-construction environmental baseline data were collected from both primary sources (e.g., on-site water sampling, air, noise and vibration monitoring, site reconnaissance survey) and secondary sources (e.g., review of available environmental surveys, soil and groundwater baseline reports, publicly available data such as maps and weather data from online databases, existing literature, books, etc.).

Prediction and Evaluation of Impact

Impacts were evaluated based on their Significance, which is a measure of the weight that should be given to each impact in decision making and if it warrants impact management. It was assessed with consideration of two main factors: Impact Consequence and Likelihood of Occurrence.



Impact Consequence is a function of a range of considerations including impact spread, impact duration, impact intensity and nature, legal and guideline compliance. Likelihood of Occurrence refers to how likely an event would occur during the Project's construction and operational phases, which considers the probability of the event happening as well as duration of the event.

In general, a simple risk-based matrix was used for summation of Impact Consequence and Likelihood of Occurrence as shown in **Figure 8**. The full definitions of impact assessment terms and methodology were detailed in the EIS.

Consequence / Likelihood	Imperceptible	Very Low	Low	Medium	High
Unlikely/ Remote	Negligible	Negligible	Negligible	Negligible	Negligible
Less Likely/ Rare	Negligible	Negligible	Minor	Minor	Minor
Possible/ Occasional	Negligible	Minor	Minor	Moderate	Moderate
Likely/ Regular	Negligible	Minor	Moderate	Moderate	Major
Certain/ Continuous	Negligible	Minor	Moderate	Major	Major

Figure 8: Impact Significance Matrix (General)

Impact Mitigation, Monitoring and Management

The mitigation, monitoring and management approach was defined in line with the NParks Biodiversity Impact Assessment (BIA) 2020, and the international risk assessment guidelines adopted in Singapore, as shown in **Figure 9**.

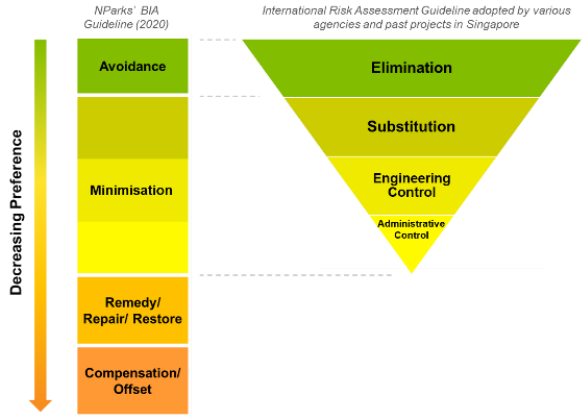


Figure 9: Mitigation Hierarchy

Baseline Environment

Both primary and secondary sources of information were used to establish the baseline conditions in the surrounding areas of this Project.

Other than secondary sources, on-site field surveys and monitoring works were conducted to establish the baseline conditions of:

- Biodiversity
- Hydrology and Surface Water Quality
- Air Quality
- Airborne Noise
- Ground-borne Vibration

The baseline data review for Soil and Groundwater was carried out via secondary source only, i.e., from the findings of Historical Land Use Survey (HLUS) as well as site investigations recorded in a separate study.

Biodiversity

A few forested areas in the vicinity of the Project worksites were identified as biodiversity Study Areas in the EIS: Sites I, II and III, near Eng Neo Avenue Forest (19.7 ha) and Sites IV and V, near Clementi Forest (10.2 ha). Field surveys were conducted from September–December 2021 at Sites I–V.

Sites I, II and III near Eng Neo Avenue Forest

Sites I, II and III near Eng Neo Avenue Forest collectively comprise seven habitat types, namely (1) native-dominated secondary forest, (2) abandoned-land forest, (3) mixed forest, (4) waste woodland, (5) scrubland and herbaceous vegetation, (6) managed vegetation, and (7) waterbody. The remaining areas are occupied by infrastructure (e.g., concrete roads and sand pathways that are now used by horses, abandoned buildings, water pump rooms, multiple concrete culverts and drains).

A total of 270 and 128 plant species were recorded in Sites I & II, and Site III, respectively. Of these, 54 and 17 species are of conservation significance in the two respective areas. The floristic assemblage is largely native. Many species found in the native-dominated secondary forest can also be found in the CCNR and are less commonly encountered in other secondary forests in Singapore. Some species associated with older forests, which are even rare in Nee Soon Swamp Forest (NSSF), were also recorded in the Study Area. This has contributed to the high overall native species richness at the site, a feature characteristic of late-successional forests in Singapore. Nationally threatened specimens are widespread and occur in high numbers, and large parent trees also occur in the Study Area.

The field assessment documented 197 species, dominated by birds (71 species) and butterflies (38 species). A total of 15 species of conservation significance were recorded, scattering across the Study Area. These

species, such as the globally threatened straw-headed bulbul (*Pycnonotus zeylanicus*) and red junglefowl (*Gallus gallus*), were generally distributed throughout the Study Area, with recorded more in Sites I and II than in Site III. Notably, the Sunda pangolin (*Manis javanica*) was recorded throughout Sites I and II. The forest-dependent Sunda colugo (*Galeopterus variegatus*) was also found in Site I.

Along the waterbodies, only the waterbody in Site I, D/S16, recorded a fish species of interest, the common walking catfish (*Clarias cf. batrachus*). The waterbody at Site III recorded mainly non-native fish, alongside common amphibians and odonates.

Given the site's proximity to the Central Catchment Nature Reserve and Eng Neo Avenue Forest, the entire Study Area provides important forest connectivity between the larger forest patches to the north and to the east (Eng Neo Avenue Forest), which allows for the dispersal of flora and fauna. The native-dominated secondary forest and mixed forest in particular, were found to be rich in plant species of conservation significance, while the Sunda pangolin (*Manis javanica*) was found to be utilising the entire Study Area.

Hence, the majority of the Study Area, i.e., all contiguous vegetated areas of Sites I and II, consist of native-dominated secondary forest, mixed forest, abandoned-land forest and scrubland and herbaceous vegetation, as well as the native-dominated secondary forest in Site III are regarded as of high ecological value. The waterbodies (D/S15 and D/S16) are also included as part of the areas of high conservation value (**see Figure 10).**

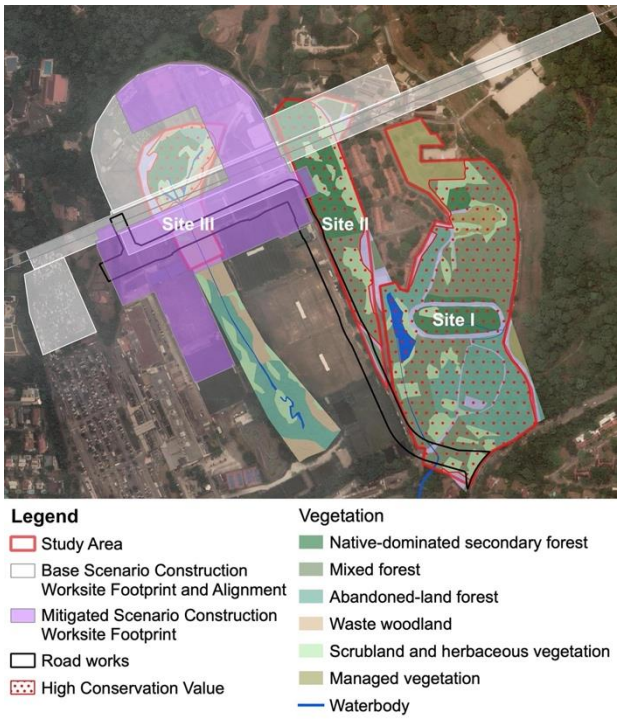


Figure 10: Areas of High Conservation Value at Sites I, II and III

Figure 11: Examples of Biodiversity Species at Sites I, II and III

Sites IV and V, near Clementi Forest

Sites IV and V near Clementi Forest collectively comprise seven habitat types, namely (1) native-dominated secondary forest, (2) abandoned-land forest, (3) waste woodland, (4) scrubland and herbaceous vegetation, (5) managed vegetation, (6) freshwater marsh, and (7) waterbody. The remaining areas are occupied by infrastructure. A total of 229 plant species were recorded, of which 17 are of conservation significance.

A total of 160 species were recorded during surveys of fauna, of which most were dominated by birds (71 species) and odonates (29 species). Of these, 11 species are of conservation significance. These include the globally Critically Endangered straw-headed bulbul (*Pycnonotus zeylanicus*), nationally Critically Endangered ruddy kingfisher (*Halcyon coromanda*), and nationally Endangered red-wattled lapwing (*Vanellus indicus*). Other noteworthy findings include the Sunda pangolin (*Manis javanica*) recorded at Site V.

One of the key findings is the freshwater marsh, an extensive patch of wetland which occupies approximately 3% of Sites IV and V. The aquatic plants that inhabit the marshland and the mature trees that surround the area contribute to the uniqueness of the habitat, which is also is an especially good site for odonate species not easily found elsewhere in Singapore. The odonate assemblage is made up of up to 21 species, including marsh-specialists like the crenulated spreadwing (*Lestes praemorsus*) and the nationally Endangered restless demon (*Indothemis limbata*).

Additionally, the extensive patch of scrubland in Site V is one of the last remaining locations for a variety of native pitcher plant species (and the associated fauna) outside

the nature reserves in Singapore. Dominated by the resam fern (*Dicranopteris linearis*), the vegetation is one of the most important habitats for *Nepenthes* species in Singapore, which are carnivorous pitcher plants that attract and capture animal prey. Large populations of up to four native *Nepenthes* species occur here, of which two are nationally threatened and one is a rare native hybrid.

The carnivorous plants are also associated with important and rare fauna, such as specialist crab spiders that inhabit pitcher plants, and a resident butterfly species, the pitcher blue (*Virachola kessuma deliochus*). The butterfly caterpillar host plants are the nationally Common *N. gracilis* and Vulnerable *N. rafflesiana*, both of which have been recorded in this area. This butterfly species is rare, and its distribution restricted to the host plant distribution.

The close proximity of Sites IV and V to the CCNR and the adjacent Clementi Forest, allows the former to serve as additional refugia for rare or forest-dependent species. Records of important terrestrial fauna such as the globally and nationally Critically Endangered Sunda Pangolin (*Manis javanica*) and rare pitcher plant hybrids suggest the importance of these sites as habitats for flora and fauna. The native-dominated secondary forest patches, the freshwater marsh, and the scrubland and herbaceous vegetation where the pitcher plants were found are all regarded as areas of high ecological value and recommended for conservation (see **Figure 12**).

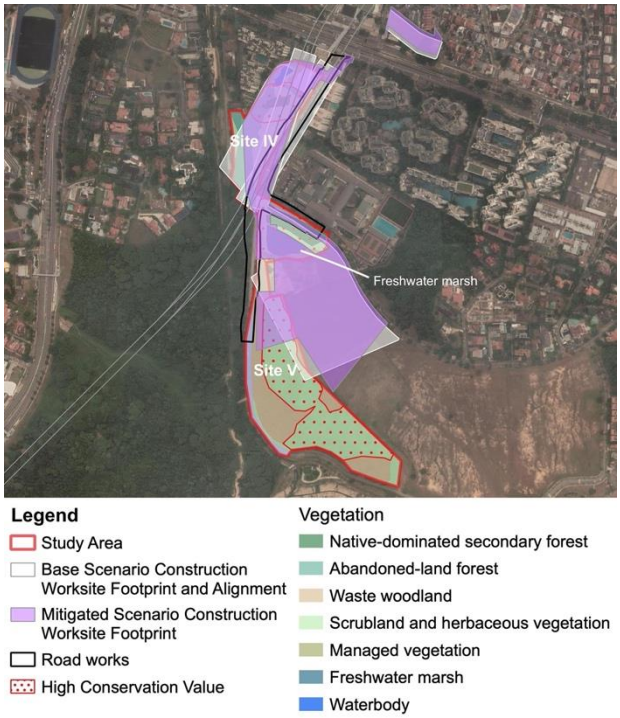


Figure 12: Areas of High Conservation Value at Sites IV and V

Figure 13: Examples of Biodiversity Species at Sites IV and V

Hydrology and Surface Water Quality

The hydrological baseline survey aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data, site survey as well as PUB water catchment map, water catchment areas within Turf City mainly contribute to the three (3) watercourses, and Holland Plain contributes to three (3) watercourses and numerous waterbodies (see **Figure 14** and **Figure 15**). Water from the identified drains/streams in Turf City eventually flow to Marina Reservoir, while the identified drains/streams/waterbodies in Holland Plain flows into Pandan Reservoir, both of which store water for drinking water purpose. Furthermore, a naturalised stream (i.e., D/S16) in Site I & II and a freshwater marsh in Site V (**Figure 14)** are located within areas of high ecological conservation values, supporting surrounding ecological systems.

To study the baseline water quality within the identified drains/streams, two (2) dry and/or one (1) wet weather samples were taken from each of the eight (8) water quality stations at the watercourses from Turf City and Holland Plain. Water samples were tested for both physical and chemical parameters relevant to the sustenance of aquatic life including temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), turbidity, total suspended solids (TSS), Biochemical Oxygen Demands (BOD_5), chemical oxygen demand (COD), total phosphorous (TP), orthophosphates (PO_4-P), total nitrogen (TN), and nitrates (NO_3-N). Results were compared with both NEA discharge guidelines in Singapore and identified international criteria for aquatic life. The international criteria include guidelines/ criteria from United Nations Economic Commission for Europe,

United States Environmental Protection Agency, Australian & New Zealand, Canada, Philippines and Malaysia.

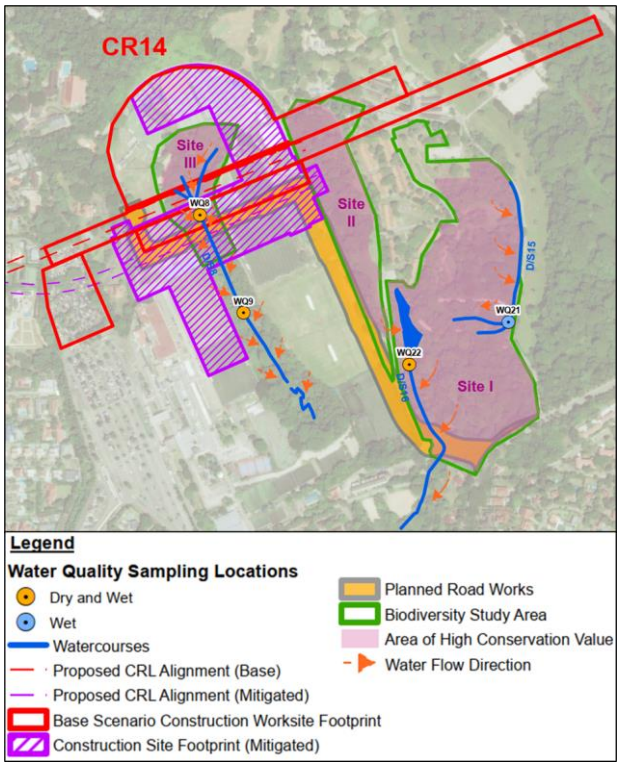


Figure 14: Water Sampling Locations at Sites I, II and III

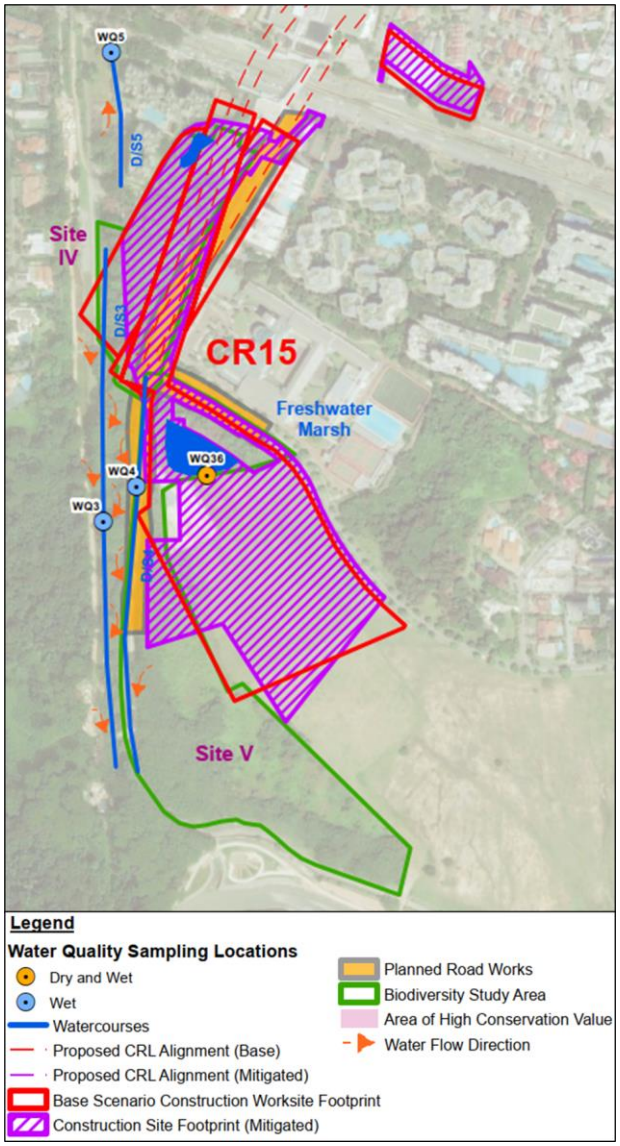


Figure 15: Water Sampling Location at Sites IV and V

Turf City: Site I, II and III

At Site I and II, ephemeral concrete drain (D/S15) and perennial naturalised stream (D/S16) were identified and sampled accordingly. The water quality of both watercourses was within or close to most of the parameter criteria except for relatively high turbidity and TSS during wet weather. This might be due to the flushing of solids from urban areas and vegetation. Despite the variation in water quality, this watercourse was found to support aquatic life and has a high ecological value. Furthermore, there were sightings of freshwater fishes during the time of dry weather water quality survey as well.

At Site III, the perennial man-made earth drain (D/S8) in Site III had water quality that is suitable to support aquatic life. However, the earth drain was considered to be of low ecological value due to frequent human disturbance due to its proximity to recreational and sports facilities (Section 7.4.1).

Holland Plain: Site IV and V

At Site IV, stormwater runoff during wet weather in ephemeral earth drain (D/S3) was found to have a low pH value, which exceeds the range in NEA guidelines (i.e., pH 6 – pH 9). Given its earth bank conditions, the low pH may be due to the presence of humic acid from decomposing forest debris flushed down from the surrounding vegetation by the runoff. The water quality in ephemeral concrete drain (D/S5) was well within the NEA guidelines for all water quality parameters.

At Site V, the water quality in ephemeral concrete drain (D/S5) was also well within the NEA guidelines for all water quality parameters. The freshwater marsh had relatively poor water quality, as compared to the aquatic life criteria, which indicates that the marsh has unfavourable conditions for aquatic life during dry weather. However, the marsh was found to support an ecosystem of conservation significant biodiversity, which include marsh-specific odonates and birds (Section 7.4.2).

Soil and Groundwater

Soil and groundwater impact assessment was carried out qualitatively based on the HLUS study findings, previously carried out soil and/ or groundwater studies within Study Area and construction waste information.

Soil profile underneath both Turf City and Holland Plain Area generally consists of sandy silt. Furthermore, sandy clay, sand and silty sand was observed at Turf City Area, while gravelly clay, silty to clayey sand were additionally observed at Holland Plain Area.

Metals (i.e., arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel and zinc) and Total Petroleum Hydrocarbons (TPH) were detected in majority of soil samples at both areas. These detections were all below their respective DIVs, with the exception of detected concentration of arsenic in near-surface soil sample collected west from Site III. However, risk-based assessment showed that the reported concentration of arsenic is below the screening level does not present an unacceptable risk to the health of future construction workers via dermal contact and incidental ingestion. Reported concentrations of vanadium were below their indicative levels of severe contamination as per Dutch Standards. The Dutch Intervention Values (DIV) as defined in the Dutch Environmental Guidelines Soil Remediation Circular, indicate when the functional parameters for the soil and groundwater for humans, plants and animals are seriously impaired or in danger of being so. As such, and in the lack of national guidelines/ criteria regarding soil and/ or groundwater quality, the DIVs are referenced in the latest Code of Practice for Pollution Control by the NEA, Guideline on Environmental Baseline Study published by JTC as well as Environmental Site Assessment Guidelines published by SLA. Detections of manganese and fecal coliforms were also reported in soil samples. Photoionization detector (PID) readings were up to 12.1 parts per million (ppm) at Turf City Area and up to 2.6 ppm at Holland Plain Area, both indicating negligible concentration of VOCs. No visual or olfactory evidence of contamination of soil was noted during field activities

The average groundwater level at Turf City Area ranged from +11.23 mRL to +33.76 mRL. Groundwater depth within CR14 worksite ranged from 0.23 m below ground level (m bgl) to 12.63 m bgl. The average groundwater level at Holland Plain Area ranged between +10.44 mRL to +21.76 mRL with groundwater observed from 1.18 m bgl to 3.9 m bgl.

The calculated velocity of groundwater is 0.29 m per year at Turf City Area with inferred groundwater flow direction generally being westwards, towards Site III where the lowest groundwater levels were observed. The calculated groundwater velocity at Holland Plain Area is 0.64 m per year and the inferred groundwater flow direction is generally towards the northeast area within Site IV. No data was available for Site V, but based on the topography, it is likely that the groundwater flow direction will be generally towards the southern area. It should be noted that the groundwater seepage velocity varies depending on the varying clay, silt and sand contents at a specific location and should be used as a general guide only.

Based on the physicochemical parameters assessed, the groundwater beneath the Turf City and Holland Plain Area can be described as generally acidic. Furthermore, the presence of non-aqueous phase liquid (NAPL) was not observed during well development and sampling events.

Parameters, such as barium and TPH were detected in all of the groundwater samples collected in the Turf City area (i.e., the northern part of Site II and Site III and their vicinity). Additionally, detections of arsenic, antimony, chromium, molybdenum and zinc were detected in the majority of the samples, while cobalt, copper, lead and mercury were detected in a limited number of samples. These detections were all below their respective DIVs. Additionally, the groundwater samples collected at the CR14 worksite, and its vicinity were also analysed for concentrations of TN, TP, faecal coliforms and vanadium.

Groundwater analytical results for samples collected in the Holland Plain area (i.e., Site IV) showed detections of metals such as barium, chromium, lead, molybdenum and zinc as well as TPH. Beforementioned metals were detected in majority of the groundwater samples, with exception of molybdenum which was detected only in one sample (below its DIV). The concentrations of the remaining metals were also all below their respective DIVs, with the exception of lead which reported exceedances of its DIV in two samples, collected in south part of Site IV. However, risk-based assessment showed that the reported concentrations of lead are well-below screening levels and do not present unacceptable risk to health of future construction workers via dermal contact and incidental ingestion.

The groundwater samples were also tested for and compared to parameters defined in the NEA Trade Effluent Discharge limits for controlled watercourse, watercourse and public sewer. The majority of the parameters detected were below their respective trade effluent discharge limits (exception being pH value [in 2 samples], COD [in 1 sample], TSS [in 2 samples], sulphate [in 1 sample], arsenic [1 sample], iron [in 2 samples] and manganese [in 1 sample], all in Turf City Area).

Air Quality

In order to assess the current baseline air quality in the Study Area, secondary air monitoring data from the concurrent study[1] conducted in close proximity to Site I Site II and Site III has also been analysed (see **Figure 16)**. Ambient air quality was conducted at 2 locations for 1 week, ranging from 14.6 – 24.9 µg/m^3 and 7.7 – 16.4 µg/m^3 for PM_{10} and $PM_{2.5}$ concentration respectively. Both are in compliant to Singapore Ambient Air Quality Long Term Targets.

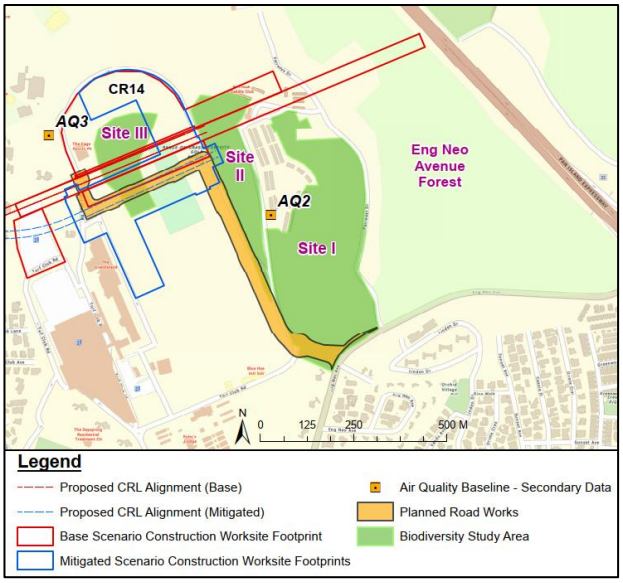


Figure 16: Air Baseline Monitoring in the vicinity of Site I, Site II and Site III[2]

Primary baseline air quality data were also collected from the monitoring locations in the vicinity of Site IV and Site V (see **Figure 17**) from 25 February – 3 March 2020 and 6 – 13 July 2022 respectively. Particulate matters (PM_{10} and $PM_{2.5}$) were measured for 1 week unattended to collect the ambient air quality data within the Study Area. At Site IV and Site V, the average daily PM_{10} and $PM_{2.5}$ concentration ranged from 20.6 – 36.0 µg/m^3 and 10.2 – 21.7 µg/m^3 respectively. Both are in compliant to Singapore Ambient Air Quality Long Term Targets.

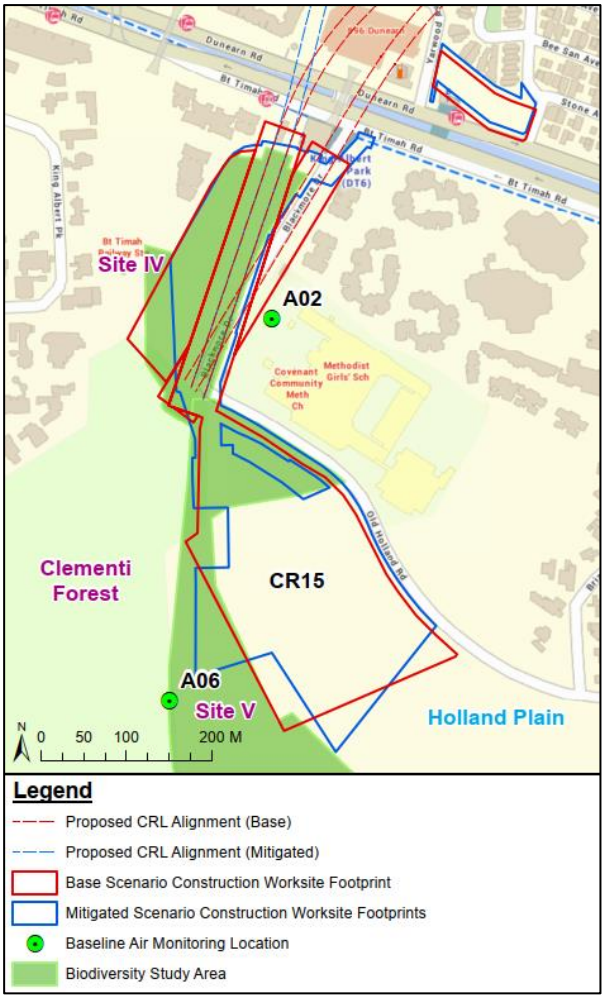


Figure 17: Air Baseline Monitoring in the vicinity of Site IV and Site V

All pollutant concentrations were found to be within the Singapore Ambient Air Quality Long Term Targets (i.e., 50 µg/m^3 and 25 µg/m^3, respectively for PM_{10} and $PM_{2.5}$).

Airborne Noise

Baseline noise monitoring was carried out at nine (9) locations, in the vicinity of the proposed worksite area as part of this study at both CR14 and CR15 sites. Additional five (5) monitoring locations are secondary sources extracted from other concurrent studies as baseline references. The Norsonic 131 Sound Level Meter was used to record the baseline noise levels over time periods of 12 hours (long term), 1 hour, 15 minutes and 5 minutes (short term) at each location. As advised by NParks, these pre-construction baseline served as the criteria for ecologically sensitive receptors and the predicted noise levels were assessed by no-worse-off than baseline. This is generally much more stringent than NEA's noise criteria for human receptors.

Four (4) noise monitoring locations were set within/ near Site I, Site II and Site III respectively (see **Figure 18**) to study the baseline noise level. The average baseline noise

[1] [R-6] URA. Environmental Baseline Survey (EBS) for Former Turf Club (Bukit Timah Planning Area) Draft Final Report (URA/T/20/052). 25 May 2021.

levels for weekday were recorded at $L_{eq(12hours)}$ 47-57 dB(A) and $L_{eq(5mins)}$ 45-56 dB.

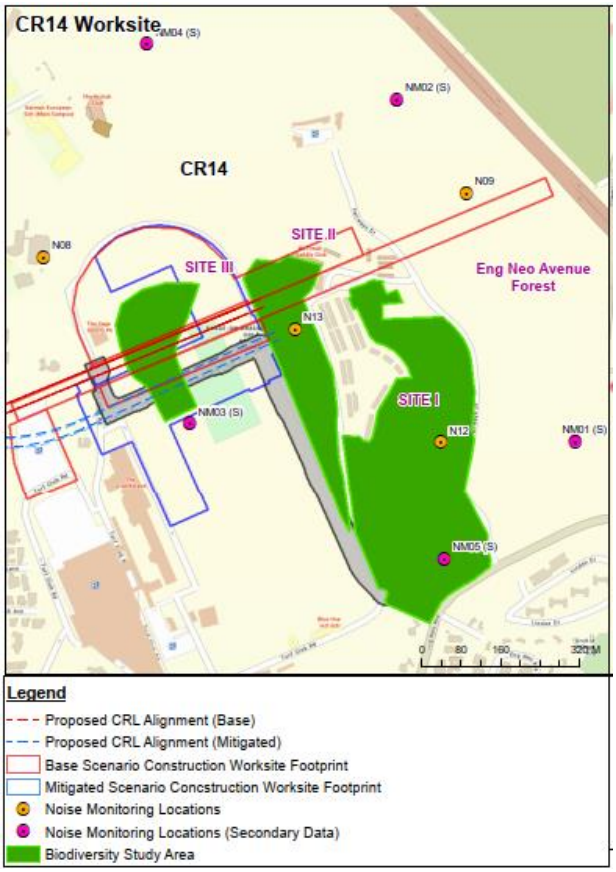


Figure 18: Noise Baseline Monitoring in the vicinity of Site I, Site II and Site III

The average noise level measured at Site IV and Site V (see **Figure 19**) for weekday were $L_{eq(12hours)}$ 51-75 dB(A) and $L_{eq(5mins)}$ 49-73 dB.

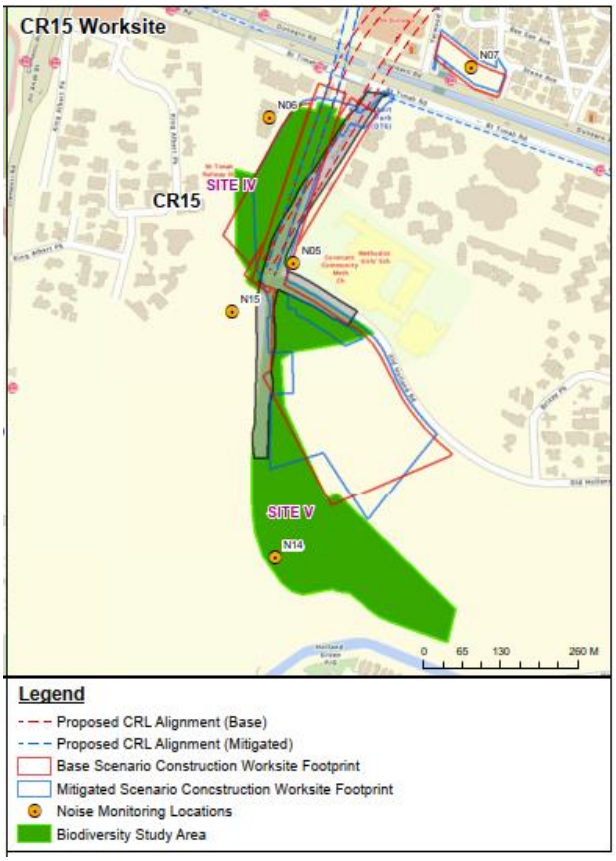


Figure 19: Noise Baseline Monitoring in the vicinity of Site IV, and Site V

Ground-borne Vibration Baseline

Baseline vibration monitoring was conducted at four (4) locations within Turf City and Holland Plains Area (i.e., VM1 to VM4 in **Figure 20**).

Baseline monitoring was carried out in the vicinity of the proposed worksite area as part of this study at both CR14 and CR15 sites.

The baseline vibration monitoring results show that the 99th percentile baseline vibration level [peak particle velocity (PPV)] were 0.09 mm/s for Site I and II, 0.16 mm/s for Site III, and 0.27 mm/s for Sites IV and V. Since there are no standardised vibration criteria for fauna, the step increment in human response[3] was referenced, and the baseline vibration results were subsequently used to develop an assessment criterion that meets the Project's requirements.

[3] According to BS5228-2: 2009+A1:2014, the Code of Practice for Noise and Vibration Control on Construction and Open Sites, human response refers to the vibration levels that produce an effect or consequence of human perception and disturbance.

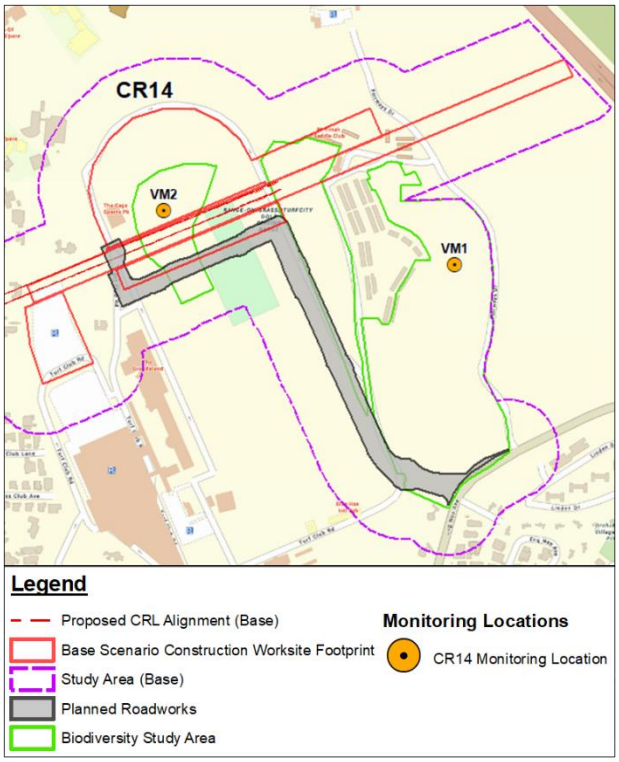


Figure 20: Vibration Baseline Monitoring at Turf City

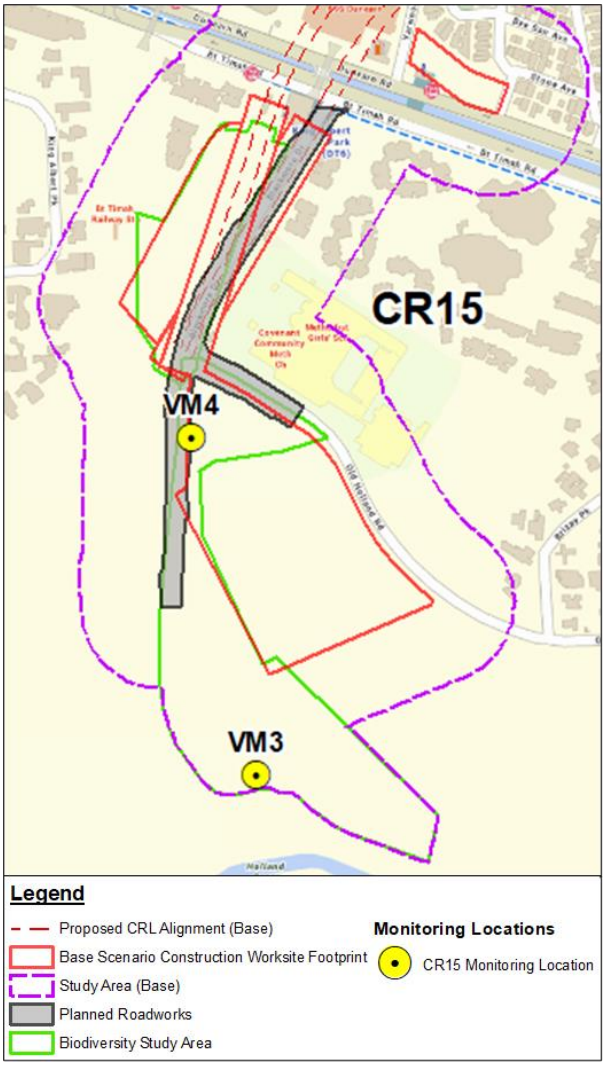


Figure 21: Vibration Baseline Monitoring at Holland Plain

Minimum Controls

Minimum controls are non-site-specific measures which comprise of common best site practices mandatory for implementation at all construction worksites, as well as basic practices required under local regulations and guidelines. As per the impact assessment methodology, minimum control measures were considered as the basis of impact prediction and evaluation. In other words, minimum controls were sometimes known as upstream mitigation measures integrated as part of the initial impact assessment before the additional mitigation measures being proposed during the residual impact assessment later in the EIS process.

Key Minimum Controls in Construction Phase

A list of minimum control measures was summarised for each assessed environmental parameter in the EIS, in which some key examples for construction phase are:

- Prepare Safety Operational Procedures (SOPs) and Emergency Response Plans on site, which include Noise Management Plan (NMP), Erosion Control Measures (ECM) plan, Air Pollution Control Plan (APCP) and other plans (e.g., for chemical storage and handling, waste storage and handling, etc.) to avoid and minimise environmental impacts. A review of Noise Impact Assessment (NIA) was suggested if there are changes to Project activities or worksite design which differs from that in the EIS;
- Engage arborists, flora and fauna specialists to clearly mark out the Tree Protection Zones, plants with conservation value, wildlife or nesting structures that are being active before the start of works;
- Engage a qualified erosion control professional (QECP) to formulate and implement ECM plan (e.g., install silt fences along site hoarding) in accordance with PUB requirements to eliminate risk of discharging construction wastewater into natural stream, where the robust ECM plan will include but not limited to:
  - Practice due diligence in proper handling and storage of all construction wastes including hazardous wastewater (e.g., oily wastewater, thinners, solvents, paints from surface run-off and machinery), as well as ensure proper disposal by authorized dealers or licensed waste collectors;
  - Install CCTV monitoring including Silty Imagery Detection System (SIDS) at the public drains to monitor surface run-off discharge to these drains;

  - Include ECM tanks/ponds prior to discharge of treated effluent (only storm water runoff); treated water to be tested prior to discharge;
  - Adequate drainage, cut off drains, sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater and storm runoff separately.
- Design and implement proper Earth Retaining Stabilizing Structures to limit impact from unstable slopes and groundwater settlement;
- Implement Reduce, Reuse and Recycle hierarchy for solid waste and wastewater generated onsite;
- Avoid placing food waste in bins situated outside of worksite to avoid human-wildlife conflict. Where site staff take breaks outside, all waste must be disposed in the bins provided. This potential issue will be included within the biodiversity toolbox talk; and
- Adopt construction method and use construction equipment that generates less noise, dust and vibration, which includes but not limited to the following, where applicable:
  - Construct paved access roads where possible before starting work on site;
  - Implement dust control measures such as dust screens, hessian mulch and water suppression systems;
  - Reduce the number of operating powered mechanical equipment (PME) used. The operating schedule will also be optimised to minimise intermittent noises from machines;
  - Equipment emitting directional noise, to be directed away from ecologically sensitive receptors;
  - Conduct dilapidation studies, careful selection of low noise and vibratory equipment/ trucks;
  - Apply noise abatement measures, include covering PMEs with acoustic shed/enclosure, applying silencers or mufflers on equipment, etc.

Key Minimum Controls in Operational Phase

Similarly, some key examples of minimum controls for the operational phase include but not limited to:

- Permanent drainage systems should be design in accordance with the requirements in PUB's Code of Practice on Surface Water Drainage.
- Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc., as well as eventual discharge of treated water;
- Ensure no trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land;
- Proper handling, storage and disposal of hazardous and non-hazardous new or used chemicals during operational process. Provide spill kit where necessary;
- Heavy maintenance works and noisy equipment delivery should be kept within the daytime (9am to 5pm). This will only be allowable beyond these hours, only in the instance of an emergency; and
- Acoustic treatment for equipment to meet noise level limit at site boundary where necessary.

Impact Assessment Findings

Overview of Impact Assessment

In short, the impact of all assessed environmental parameters in the EIS was first evaluated based on the base scenario worksite, along with the consideration of minimum controls as the basis. Thereafter, additional mitigation measures (including mitigated scenarios of worksites) were provided for Moderate and Major impacts and incorporated as part of the residual impact assessment, where relevant.

Biodiversity

Table 1: Summary of Biodiversity Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls[1]	Residual Impact Significance with Mitigation Measures (if required) [1]
Construction Phase		
Site I	4 Major 5 Moderate 1 Minor	3 Major 4 Moderate 3 Minor
Site II	Mostly Major	Mostly Moderate
Site III	Mostly Major	Mostly Moderate
Site IV	3 Major 3 Moderate 4 Minor	3 Major 3 Moderate 4 Minor
Site V	Major	Major
Operational Phase		
Site I	1 Major 4 Moderate 2 Minor	0 Major 1 Moderate 6 Minor
Site II	Mostly Major	Mostly Moderate
Site III	Mostly Major	Mostly Moderate
Site IV	1 Major 3 Moderate 3 Minor	1 Major 0 Moderate 6 Minor
Site V	Major	Major

[1]For each impact type on habitat, flora and fauna receptors, the highest impact significance for that impact type is reported

Areas of high conservation value were identified at Sites I–V during baseline studies. Following the mitigation hierarchy, design optimisation was applied to further avoid or minimise impact to ecologically sensitive receivers. Where such impact could not be avoided, minimisation and compensatory measures were applied.

In the base scenario, the most substantive impact to the habitats from construction phase at Sites I to III is Major. Site clearance will result in the removal of approximately 3.83 ha of forest and 46% of a waterbody within the Study Area. The habitats that would be affected are native-dominated secondary forest, mixed forest, waste woodland, and D/S8 waterbody.

Likewise for Sites IV and V, the most substantive impact to the habitats from construction phase is Major as well. Site clearance will result in the removal of approximately 4.44 ha of forest and a waterbody within the Study Area. The affected habitats are native-dominated secondary forest, abandoned land forest, scrubland and herbaceous vegetation, freshwater marsh, and the waterbody (pond). Loss of vegetation either results in a large loss of the aforementioned habitats (more than 90%), or the habitats affected are of priority 1

Details of other recommended mitigation measures for the construction phase, include but are not limited to, transplanting/harvesting tree species of conservation significance if existing specimen are to be cleared, wildlife shepherding via direction clearance of vegetation, pre-felling fauna inspections, and road calming measures. Recommended mitigation measures are included in the EIS to further minimise the biodiversity impacts of the Study Area.

By implementing the recommended mitigation measures detailed in the EIS report, the overall impact significance of habitat degradation during the construction phase at Sites I, II and III will be reduced to Moderate. Optimisation of the worksite to become smaller would halve the expected habitat clearance. Hence, the resulting impact significance for most habitats under Mitigated Scenario is reduced.

For Sites IV and V, however, the overall impact significance of habitat loss during the construction phase is still Major due to the small difference between the base and mitigated worksite footprint – a result of limited land constraints and land use plan.

During the operational phase, negative impacts on habitats at Sites I, II and III were estimated to be negligible to minor. This was assessed in terms of habitat degradation (trampling or pollution) because the developed area is intended for people to visit but not live in. The development also involves relatively small building infrastructure compared to surrounding areas. This is likewise for Sites IV and V as well.

Details of other recommended mitigation measures relating to the operational phase (e.g., conduct regular site inspections to ensure mitigating measures are effective, implementing wildlife friendly night lighting, and ensuring any replanted habitats closely mimic the composition of adjacent habitats etc.) are included in the EIS to further minimise the biodiversity impacts of the Study Area.

Hydrology and Surface Water Quality

Table 2: Summary of Hydrology and Water Quality Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Negligible to Major	Minor to Moderate
Site II	Negligible to Major	Minor to Moderate
Site III	Minor to Moderate	Minor to Moderate
Site IV	Negligible to Minor	Negligible to Minor
Site V	Minor	Minor
Operational Phase		
Site I	Negligible to Major	Minor
Site II	Negligible to Major	Minor
Site III	Minor to Moderate	Minor
Site IV	Negligible to Minor	Negligible to Minor
Site V	Minor	Minor

During the construction phase, the potential sources of hydrology and surface water quality impacts are mainly from construction activities, such as surface run-off during site clearance, wastewater from concrete batching plant, spoil generation, improper handling during storage and disposal of solid wastes and liquid wastes, accidental spill and leaks during the use and storage of chemical substances, etc.

During the operational phase, the potential sources of hydrology and surface water quality impacts are mainly from stormwater run-off which contains pollutants built-up in the new developed area during heavy rain events, increased runoff peak flow that drains into the stream or drains during storm events, as well as reduced baseflow (i.e., sub-surface water discharge) due to a change in land use of the new development.

The CRL2 design team has optimised the CR14 and CR15 worksites, station entrances and vent shafts to reduce the adverse impacts on surrounding biodiversity. Both the base scenario and mitigated scenarios during construction and operational phases were assessed, and the latter was presented as below.

During construction phase, the mitigated scenario construction worksite and planned road works would cause Moderate hydrological impacts on earth drain D/S8 and Major hydrological and water quality impacts on

naturalised stream D/S16. As such, mitigation measures were proposed, such as flow diversion or culvert construction (subject to the Contractor's design at a later stage) to connect the upstream and downstream of earth drain D/S8 and the discharge of treated runoff into drain D/S8 to maintain its existing flow (i.e., runoff is treated to meet NEA Trade Effluent Discharge Limits). For stream D/S16, it was recommended to install the box culvert to ensure continuous perennial flow of the stream and flow diversion (i.e., follows PUB's Code of Practice on Surface Water Drainage) prior to culvert integration. Therefore, this reduced the impact significance of hydrological and water quality impacts to the range of Minor to Moderate.

During the operational phase, the mitigated station entrance and vent shafts for the CR14 station were found to have Moderate hydrological impacts on earth drain D/S8 and Major hydrological impacts on naturalised stream D/S16. Given that the abovementioned mitigation measures are in place during the operational phase, the hydrological impacts to the watercourses during the operational phase were reduced to Minor.

For the rest of the watercourses, the impact on hydrology and surface water quality was assessed to cause only Negligible to Minor impacts during both construction and operational phases with consideration of the minimum control measures (e.g. effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage, appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector, etc.). Hence, no additional management or mitigation measures were required.

Soil and Groundwater

Table 3: Summary of Soil and Groundwater Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Minor	Minor (see Note 1)
Site II	Minor	Minor (see Note 1)
Site III	Minor	Minor (see Note 1)
Site IV	Minor	Minor (see Note 1)
Site V	Minor to Moderate	Minor to Moderate
Operational Phase		
Site I	Minor	Minor (see Note 1)
Site II	Minor	Minor (see Note 1)
Site III	Minor	Minor (see Note 1)
Site IV	Minor	Minor (see Note 1)
Site V	Minor	Minor (see Note 1)
Note: 1 - The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.		

The potential impacts on soil and groundwater of historical and current land use as well as activities associated with the construction and operational phases of the Project were discussed by using the information from historical land use surveys, construction waste information and other best available data. The soil and groundwater impact study was carried out qualitatively based on the findings from the HLUS study and the previous soil and/ or groundwater investigation studies.

The soil and groundwater within the project site were identified as Priority 3 sensitive receptors, as they were not expected for direct sensitive uses (e.g., agricultural/ irrigation/ drinking water purposes) and not directly extracted for industrial uses, therefore not posing unacceptable risks. Streams that support habitats and/ or species of high conservation significance and which are partly supported by groundwater were identified as Priority 2 sensitive receptors. The potential sources of soil and groundwater impact during construction were expected to be mainly from pre-construction activities (e.g. site clearance, levelling, land grading works) and main construction activities of this Project such as tunnelling activities, which may cause decreased groundwater baseflow feeding into the streams, potential contamination from toxic chemical waste used or generated on site, improper management of excavated soil and extracted groundwater, as well as potential leakage from improper handling of hazardous chemical/substances on site.

The potential sources of soil and groundwater impact during operational phase are expected to be mainly from maintenance of the alignment and stations with potential contamination from toxic chemical waste used or generated, as well as potential leakage from improper handling of hazardous chemical/substances within the operational footprint of the Project.

Minimum control measures for soil and groundwater which are commonly implemented in Singapore have been included in this section. Regular inspection and workers' training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site.

Hence, the significance of potential sources of soil and groundwater impacts during construction and operational phases such as toxic chemical waste generation and improper handling of hazardous chemicals/substances and soil and groundwater was assessed to be **Minor** to the sensitive receptors and no further mitigation measures

were required for CRL2 Project. The significance of groundwater baseflow reduction to identified waterbodies was assessed to be Minor, with the exception of impact on Freshwater Marsh on which it was assessed to be Moderate.

Air Quality

Table 4: Summary of Air Quality Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Moderate to Major	Minor
Site II	Moderate to Major	Minor
Site III	Moderate to Major	Minor
Site IV	Moderate to Major	Minor
Site V	Moderate to Major	Minor
Operational Phase		
Site I	Minor	Minor (see Note 1)
Site II	Minor	Minor (see Note 1)
Site III	Minor	Minor (see Note 1)
Site IV	Minor	Minor (see Note 1)
Site V	Minor	Minor (see Note 1)

Note:

1. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.

Air quality impacts from the construction and operation of the proposed Project were assessed on air sensitive receptors (ASRs) in the vicinity of the Project site. Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the earthworks, construction and trackout activities. During the operational phase, emissions from vehicle exhaust due to increased traffic in the vicinity of the proposed development are identified as the predominant air emission source.

Air quality impact assessment for construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to this, a 50 m Study Area was considered for earthworks, construction and trackout activities due to ecological sensitive receptors in the vicinity of the worksites. Dust generated during construction works can have adverse effects on vegetation restricting photosynthesis, respiration and transpiration. Furthermore, it can lead to phytotoxic gaseous pollutants penetrating the plants. The overall effect can be a decline in plant productivity.

The results of the assessment showed that unmitigated impacts were assessed as Moderate to Major across all construction worksites analysed and have the potential to affect the receptors near the construction worksite area unless mitigation measures are put in place. This is mainly because of the large extent of the construction worksite located very close to or within the areas with flora, fauna and habitat with high ecological value. By implementing the recommended mitigation measures, the residual impact significance was anticipated to be reduced to **Minor**.

The key air quality control and mitigation measures include but are not limited to the development of an air pollution control plan, dust control measures on site, site hoarding, planning of dust-causing activities-location and timing, and reinstating land upon completion of works among several others. The mitigation measures are also applicable for the access road construction at CR14 and CR15 worksites. The worksite option with a smaller footprint (i.e., Mitigated Scenario) was preferred. A smaller construction footprint would reduce the potential air quality impact on the neighbouring receptors.

Air quality impacts were also qualitatively weighed during the operational phase. Fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the Project was expected. It was assumed that all new vehicles met their Euro emission standard. Furthermore, there is currently a large traffic volume along the PIE (CR14) and Bukit Timah Road and Dunearn Road (CR15). The buffer from some green areas which will not be disturbed as part of the Project will also help in terms of providing cleaner air from the impact of the vehicles. For immediate localized road traffic to and from the stations may see some increase.

With the information assessed at this stage, the air quality impact derived from the proposed development was anticipated to be Minor during the operational phase. No mitigation measures are required during the operational phase as no significant air quality impact was expected from the Project's operation.

Airborne Noise

Table 5: Summary of Airborne Noise Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Minor- Major	Minor to Major[1]

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Site II	Minor- Major	Minor to Major[1]
Site III	Minor- Major	Moderate to Major[1]
Site IV	Minor- Major	Minor
Site V	Major	Minor to Major[1]
Operational Phase		
Site I	Negligible	Negligible[2]
Site II	Negligible	Negligible[2]
Site III	Negligible	Negligible[2]
Site IV	Negligible	Negligible[2]
Site V	Negligible	Negligible[2]

Note:

1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevated area which cannot be blocked by the proposed noise barrier. Due to the sensitive receptor in Site III being close proximity to the construction worksite, both pre and post-mitigated scenarios were "Major" impact significance. Since the remaining area of Site III during post-mitigated scenarios are higher than pre-mitigated scenario, the area of major impact significance looks greater than the pre-mitigated scenario.
2. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same.

Noise impact assessment was carried for the construction and operational phases of the proposed worksites for the Project.

For the classification of receptor sensitivity to airborne noise, auditory sensitivity of the respective species was used to assign receptor priority. Species that use sound for communication, foraging and breeding or are known to have their behaviours disrupted by sound were assigned Priority 1 status for auditory sensitivity. Species that are less affected by airborne noise but are of Conservation Significance were assigned Priority 2. Species that are less affected by airborne noise and are not of Conservation Significance were assigned Priority 3. Habitat sensitivity map was used for this project as basis to decide the probability of a finding of species in the area, and for this assessment. The noise Study Area are Site I, Site II, Site III, Site IV, Site V and the area within the 150m from construction worksites.

The noise levels generated from the equipment used during construction phase was predicted using Sound PLAN ver 8.2. Topography played an important role in noise propagation and were included in this assessment.

A quantitative assessment at the noise sensitive receptors (within the Study Area) was carried out and compared with the stipulated Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008. Based on the impact evaluation, mitigation to reduce airborne noise impacts were recommended for the affected ecological noise sensitive receptors. The criteria selected for noise impact assessment was a very stringent "no worse off than average baseline" criteria in this Project owing to its proximity to a nature reserve.

The study on construction noise impact to the noise sensitive receptors focused on three (3) different construction scenarios for CR14 worksite and two (2) different construction scenarios for CR15 worksite. Three (3) different construction scenarios for CR14 worksite were, Scenario 1: Cut and cover works and associated activities; Scenario 2: TBM works; and Scenario 3: Construction of station entrances where construction noise impacts to the sensitive receptors were assessed. It is to be noted that impacts on higher elevation receptors such as bird species are likely able to find alternative habitats in the surroundings for reasons more than just noise, including increased human presence, light, noise and other activities also. Therefore, the predicted noise levels with construction noise impact more on fauna near the ground level up to 1.5m height, hence, the predicted levels at this height were assessed in more details.

For the CR14 worksite Scenario 1 (Cut and cover works and associated activities), Scenario 2 (TBM works) and Scenario 3 (Construction of station entrances) for construction phase, base scenario results showed impact significance of Minor to Major at Site I, Site II and Site III.

For the CR15 worksite Scenario 1 (Cut and cover works and associated activities) to Scenario 2 (Construction of station entrances) for construction phase, base scenario results showed impact significance of Minor to Major at Site IV and Major at Site V.

During operational phase, the potential impacts would arise from the ACMV (Air-Conditioning and Mechanical Ventilation) noise at the facility buildings and traffic noise from the neighbouring public roads and new access road to the biodiversity Study Area (i.e., Site I, Site II, Site III, Site IV, Site V).

For the purpose of ACMV noise, a "no worse off than average baseline" criteria was imposed at the boundary of ventilation shaft buildings and shall form a mandatory requirement when this is designed and built at a later stage as design engineering develops in the next phase. Note that a separate study for the facility or ventilation buildings was conducted by another professional party under a separate contract. It was understood from the separate study that the ACMV noise at boundary is expected to meet the *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* and/or the stringent criteria as proposed in this EIS. For the

qualitative assessment on traffic noise, as there is a new access road for these CR14 and CR15 MRT stations, the routine traffic near Site I to Site III for the CR14 worksite and near Site IV to Site V for CR 15 worksite are expected to be much higher than the recent traffic. Therefore, the noise from the traffic from the new access road shall dominate the noise levels. Due to the lack of information at this juncture of reporting, assessment, minimum controls and mitigation will be provided by the appointed Noise Consultant during the prelim design stage and in accordance with *Technical Guideline for Land Traffic Noise Impact Assessment*.

In absence of specialist traffic study, therefore there shall be no evaluation conducted from traffic noise in operational noise in this report; however, with current knowledge as above at this stage, the variations can only be speculated as described. Overall, the airborne noise impact during operational phase was evaluated to be Negligible.

Mitigation measures were proposed and considered during the residual noise impact assessment, which include but not limited to:

- Design optimisation to reduce footprint of CR14 and CR15 worksites (see **Figure 2** and **Figure 3**);
- 5m and 8m high noise barriers around the boundary of CR14 worksite;
- A noise barrier, at least 8m in height, should be placed around the boundary of the CR15 worksite, the noise barrier at the CR15 worksite is being studied for human impact. The height and extent of the barrier may change once the study is completed; and
- Administrative measures including
  - To avoid early morning day time noisy activities between 7 to 9 am as far as possible on site to reduce impact to avifauna;
  - Works will be halted immediately, and mitigation measures adjusted to prevent future occurrence of roadkill incidents upon any observed signs of fauna seen trying to dash onto the road; and
  - To avoid above-ground night works after 7pm for all non-safety critical activities.

Overall, the ground level and low-height noise sensitive receptors benefit significantly from the noise barrier, however receptors at top of the trees may not benefit from noise barriers since noise travels with the line-of-sight principle. The worst-case assumptions on construction equipment usage, period of usage, and more conservative approach for barrier heights were used in this stage to inform the worst impacts predicted in these locations of highly sensitive nature. Notwithstanding the above, when the design is more firmed up in detailed design phase, an optimisation of noise models with more realistic use of equipment and area of worksite shall be used to redefine the noise impacts at a later stage by the Contractor as well.

Following the residual impact assessment with all the recommended mitigation measures, the residual airborne noise impact assessment above, the proposed 5m and 8m noise barriers at CR14 worksite will be beneficial by reducing the area of major impact significance significantly from 3.9 hectares (Base Scenario) to 1 hectares (Post Mitigated scenario) at Site I, from 2.6 hectares (Base Scenario) to 1.8 hectares (Post Mitigated scenario) at Site II and from 0.2 hectares (Base Scenario) to less than 0.1 hectares (Post Mitigated scenario) at Site III respectively.

Based on the residual airborne noise impact assessment above, the proposed 8m noise barriers at CR15 worksite will be beneficial by reducing the impact significance and area of major impact significance from Major (Base Scenario) to **Minor** (Post Mitigated scenario) at Site V, and the area of major impact significance significantly from 2.1 hectares (Base Scenario) to 0.4 hectares (Post Mitigated scenario) at Site V. In any case, the receptors which are found at the height immediately next to the construction site are likely to have a straight line of sight despite a noise barrier, therefore the benefit of barrier is unlikely to occur for avian and arboreal species at that height; impact significance, therefore, remains major. Since the residual impact significance was Major, portable noise barrier were highly recommended close to the noisy equipment/ activities and no night works after 7pm for all non-safety critical activities since the site is next to the sensitive receptors.

Ground-borne Vibration

Table 6 Summary of Ground-borne Vibration Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Negligible to Moderate	Negligible to Moderate[1]
Site II	Negligible to Moderate	Negligible to Major[2]
Site III	Negligible to Moderate	Negligible to Major[2]
Site IV	Negligible to Minor	Negligible to Minor[3]
Site V	Negligible to Minor	Negligible to Minor[3]
Operational Phase		
Site I	Minor[4]	Minor[4]
Site II	Minor[4]	Minor[4]
Site III	Minor[4]	Minor[4]
Site IV	Minor[4]	Minor[4]
Site V	Minor[4]	Minor[4]
Note:		

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
1. Construction activities such as bulldozing produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate. 2. Construction activities such as rock breaking and excavation is only required in the mitigated scenario, which produces high PPV levels and impact significance at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate. 3. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.		

This EIS had taken a range of approaches based on minimal data available in literature at the time of writing the EIS for the study's comprehensiveness.

Based on the review of the proposed construction activities for this Project, an assessment was carried out for the ground-borne vibration impact for rock breaking and excavation, tunnel boring, bulldozing and vibratory compaction works on the identified biodiversity Study Area.

High amplitude vibratory compactors and rock breaking and excavation activities produced vibration levels exceeding 5 mm/s. Hence the activities were screened for partial burrow collapse. During these activities, there is a risk that the vibration causes impacts on the structural integrity of the animals' habitat, such as burrows. The study recommends mitigation measures to limit the construction activities such that impact intensity remains below the levels for structural impacts.

Another potential impact on fauna is change to behaviour during their day-to-day activities, such as communication, breeding and foraging habits within their home range. The potential impact intensity experienced by the fauna was evaluated based on the predicted vibration levels and the impacted area within the biodiversity Study Area or species-specific home range information from literature, such as mouse deer and pangolin. At Turf City, some Priority 1 and 2 ecological receptors (e.g., the Red-legged crake, Red junglefowl and Long-tailed parakeet) may potentially also be impacted during the breeding season. Typically, birds and animals may move away from instantaneous and short duration works like rock breaking and excavation as well as the passing of the tunnel boring machine but are likely to return to their original activity soon after the works are completed. However, continuous vibration monitoring and fauna behaviour monitoring (using camera traps and specialists' observation) during these critical construction phases was recommended to study the actual impact. For piling activities that may last for a more extended period (i.e., a few months), it is advisable to control the vibration levels to practical levels to minimise the size of the impacted area. For example, a bored pile technique should be used when required during the daytime.

LTA predicted ground-borne vibration levels due to train operation in a separate study. The study assesses the vibration impacts on sensitive ecological receptors. The assessment results show that minimum control measures are sufficient to mitigate the ground-borne vibration impacts on the sensitive receptors at Turf City and Holland Plain. The overall impact significance is **Minor**.

Environmental Monitoring & Management Plan (EMMP)

Overview

An EMMP was proposed to monitor and manage environmental impacts of the construction and operational phases associated with the Project. The EMMP also aimed to provide an overall picture of the potential roles and responsibilities required during each phase of the Project. The coverage of the proposed EMMP involved environmental parameters that were assessed in this EIS study, namely biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise and ground-borne vibration. The EMMP details how recommended mitigation measures prepared for the impact assessment are to be implemented and specifies recommended monitoring measures to assess the effectiveness of the mitigation measures.

EMMP for Construction Phase

The proposed EMMP before and during the construction phase follows the *General LTA's Safety, Health and Environment (SHE) Specifications* guidance document. Additional contract-specific EMMP includes the following, but not limited to:

- Flora and fauna monitoring and management programme, e.g., conduct pre-site clearance inspection (including pre-felling tree inspections) to minimise fauna injury and mortality during site clearance, monitoring of vegetation along the hoarding line for unauthorized vegetation clearance and forest edge effects, enact wildlife response plan when trapped/dead/dangerous animals are encountered around or within the worksite, etc.

Figure 22: Example of Flora Monitoring Along Hoarding

- Inspect hoarding and perimeter drains daily to ensure no discharge of untreated surface runoff and no clogging;
- Perform site inspection during heavy storm event to ensure no flooding;
- Install necessary instrumentations to monitor changes in groundwater level during construction;
- Perform online real-time monitoring for TSS, as well as conduct in-situ water quality monitoring for the remaining in-situ parameters (i.e., Temperature, pH, Conductivity, TDS and DO) at discharge points of construction sites (suggested monthly) and at the sensitive stream/drains (suggested bi-weekly at D/S16) throughout construction period;
- Perform ex-situ water quality monitoring for all the ex-situ parameters (i.e., BOD_5, COD, Total Nitrogen, Nitrate, Total Phosphorus, Orthophosphate, Oil and Grease Total, Oil and Grease (HC), Lead, Zinc, Mercury, Total Alkalinity, TOC, NH4-N, *Enterococcus*), at discharge points of construction sites (suggested monthly) and at the sensitive stream/drain (suggested bi-weekly at D/S16) if discharging into public drains;
- Perform monthly monitoring of in-situ and ex-situ parameters at the newly created freshwater marsh during the construction phase of CR15 entrance at Site V;
- Perform monitoring of PM_{10} and $PM_{2.5}$ at Site I, II, III, IV and V, 1 week prior to site clearance averaged over 1-day period; and continuous monitoring of dust deposition in mg/m^2/day during construction phase averaged over 4-week period;
- Perform pre-construction airborne noise monitoring of $L_{eq(12\ hours)}$, $L_{eq(1\ hour)}$, and $L_{eq(5\ min)}$ prior to site clearance and continuous monitoring at the Forested Area Adjacent to Fairway Quarters, throughout the construction period;
- The Contractor will control construction vibration levels using best available techniques (BAT) for rock breaking and excavation and vibratory compactors.
- The Contractor will ensure that the vibration levels for any construction activities at Turf City and Holland Plain (excluding the worksite area) do not exceed PPV, 8 mm/s;
- Identifying burrows before the start of construction and monitoring burrow collapse during construction activities;
- Monitor for any fauna behaviour (e.g., dashing onto road) resulting in road-kill incidents, for at least thirty (30) minutes after rock breaking events; and;
- Erect temporary barriers (i.e., water barriers) along Turf Club Road, Fairways Drive and Eng Neo Avenue (if there are no hoardings for existing construction works present) during rock breaking and tunnel boring activities. In addition, hoardings must be included at the worksites, and canvas sheets must be added onto existing railings along Eng Neo Avenue.

EMMP for Commissioning/ Operational Phase

The proposed EMMP during commissioning/ operational phase include but not limited to:

- In general, the Operator/ Contractor will perform regular site inspection and environmental audit during the commissioning phase, especially on:
  - Drainage system within and in the vicinity of the facility building, especially during heavy storm event
  - Log of waste generation and condition of storage of hazardous chemicals
- Regular site inspections for both flora and fauna in the initial commissioning phase to be conducted to evaluate any impact from the development;
- Prepare Compliance Report after the scheduled audit; and
- Schedule and perform monitoring for biodiversity, water quality, ground-borne vibration, and airborne noise against the criteria specified in the EIS.

The detailed lists of EMMP for construction and operational phases are provided in the EIS.

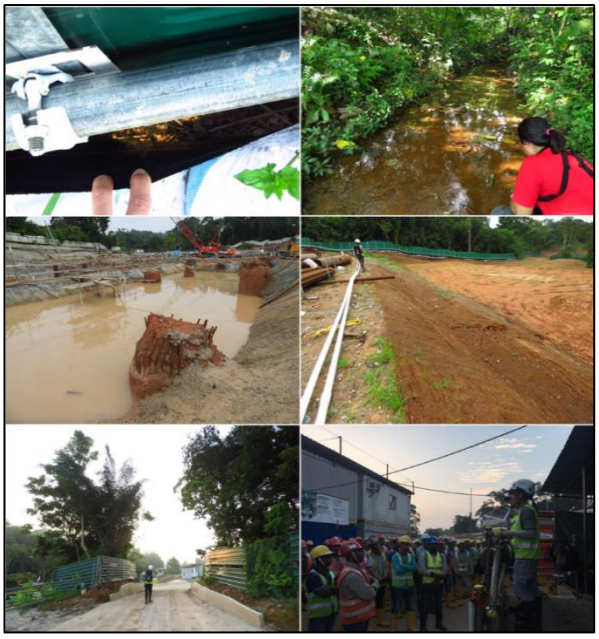


Figure 23: Examples of photographs showing monthly monitoring and inspection on-site

Conclusion

The EIS was carried out based on the relevant local and international guidelines. Minimum controls were formed by referring to these guidelines and the common best practices in the industry, incorporated as the basis of impact assessment. Where the implementation of minimum controls was insufficient to alleviate any significant environmental construction or operational impacts (with "Moderate" to "Major" impacts), additional general and Project-specific mitigation measures were further proposed in consultation with LTA to mitigate the potential environmental impacts to as low as reasonably practicable. The summary of unmitigated impact significance and potential residual impact significance of the assessed environmental aspects for both construction and operational phases are presented in the following table.

Table 7: Summary of Impact Assessment

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase			
Site I	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology & Surface Water Quality	Negligible to Major	Minor to Moderate (see Note 6)
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Moderate (see Note 2)
Site II	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology & Surface Water Quality	Negligible to Major	Minor to Moderate (see Note 6)
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major (see Note 3)
Site III	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology & Surface Water Quality	Minor to Moderate	Minor to Moderate (see Note 6)
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Moderate to Major (see Note 1 and Note 5)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major (See Note 3)
Site IV	Biodiversity	Minor to Major	Minor to Major
	Hydrology & Surface Water Quality	Negligible to Minor	Negligible to Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor
	Ground-borne Vibration	Negligible – Minor (see Note 4)	Negligible – Minor (see Note 4)
Site V	Biodiversity	Minor to Major	Minor to Major

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Hydrology & Surface Water Quality	Minor	Minor
	Soil & Groundwater	Minor - Moderate	Minor - Moderate (see Note 7)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Minor- Major (see Note 1)
	Ground-borne Vibration	Negligible – Minor (see Note 4)	Negligible – Minor (see Note 4)
Operational Phase			
Site I	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology & Surface Water Quality	Negligible to Major	Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Minor	Minor (see Note 4)
	Airborne Noise	Negligible	Negligible (see Note 4)
	Ground-borne Vibration	Minor (see Note 4)	Minor (see Note 4)
Site II	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology & Surface Water Quality	Negligible to Major	Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Minor	Minor (see Note 4)
	Airborne Noise	Negligible	Negligible (see Note 4)
	Ground-borne Vibration	Minor (see Note 4)	Minor (see Note 4)
Site III	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology & Surface Water Quality	Minor to Moderate	Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Minor	Minor (see Note 4)
	Airborne Noise	Negligible	Negligible (see Note 4)
	Ground-borne Vibration	Minor (see Note 4)	Minor (see Note 4)
Site IV	Biodiversity	Mostly Moderate/Minor	Mostly Minor
	Hydrology & Surface Water Quality	Negligible to Minor	Negligible to Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Minor	Minor (see Note 4)
	Airborne Noise	Negligible	Negligible (see Note 2)
	Ground-borne Vibration	Minor (see Note 4)	Minor (see Note 4)
Site V	Biodiversity	Mostly Moderate/Minor	Mostly Minor
	Hydrology & Surface Water Quality	Minor	Minor
	Soil & Groundwater	Minor	Minor (see Note 4)
	Air Quality	Minor	Minor (see Note 4)
	Airborne Noise	Negligible	Negligible (see Note 4)
	Ground-borne Vibration	Minor (see Note 4)	Minor (see Note 4)

Note:

1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevated area which cannot be blocked by the proposed noise barrier.
2. Construction activities such as bulldozing produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
3. Construction activities such as rock breaking and excavation is only required in the mitigated scenario, which produces high PPV levels and impact significance at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
4. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.
5. The area of moderate impact significance is less than 0.1 hectares and this is due to close proximity of Site III with station

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
entrance worksite during Post-Mitigated Scenario than Base Scenario. 6. Water Quality impacts at Site I and Site III was assessed to be Moderate impact significance, as the proposed road will cross existing major stream in Site I and the proposed CR14 worksite likewise for earth drain in Site III, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the watercourses are in the immediate vicinity of the construction site 7. Construction of entrance of CR15 will occupied the freshwater marsh, and its impact on groundwater drawdown in the vicinity cannot be avoided.		

A few of the key proposed monitoring, management or mitigation measures which are worth highlighting, including but not limited to:

Impact mitigation through design optimisation (Avoidance of Impact)

- CR14 Worksite
  - Partial relocation of the construction worksite to reduce encroachment into sites I, II and III; and,
  - The worksite footprint required for construction activities is reduced to as minimal as reasonably practicable, minimising impact to surroundings.
- CR15 Worksite
  - Partial relocation of the construction worksite to reduce encroachment into sites IV and V; and,
  - The worksite footprint required for construction activities is reduced to as minimal as reasonably practicable, minimising impact to surroundings.

The above are achieved through extensive design coordination to optimise the tunnel ventilation requirements.

Additional mitigation for residual impact during construction phase after design optimisation (Minimisation of Impact):

- Implementation of site-specific biodiversity mitigation measures at CR14:
  - Construct new culvert with a continuous barrier along Fairways Drive Road for wildlife crossing;
- Implementation of site-specific biodiversity mitigation measures at CR15:
  - Construct new marsh to replace existing marsh before any CR15 construction works are carried out in existing marsh;
- Implementation of proposed noise barriers on site to reduce construction noise impact;
- Avoid peak breeding seasons (May to July) for tree-felling activities, where possible;
- Above-ground works not critical for safety reasons will only be allowed from Mondays to Saturdays (i.e., avoiding works on Sunday and public holidays) from 7am to 7pm. However, noisy activities (e.g., piling, excavation) will only be allowed from 9am to 5pm. If night works are essential, suggest to:
  - Prevent areas from being artificially lit, only install lighting where necessary;
  - Limit duration of lighting, avoid peak nocturnal fauna activity;
  - Reduce trespass of lighting and change spectrum of lighting;
  - Setting dark buffers, illuminance limits and zonation;
  - Species-specific strategy;
  - Reduce operating power mechanical equipment to minimum;
- The construction worksites and road works should not obstruct the flow of naturalised stream D/S16 and earth drain D/S8, so as to ensure the perennial flow is maintained. If flow diversion is required, the contractor shall provide diversion of affected sections of these watercourses prior to the start of construction. The diversion should follow PUB's Code of Practice on Surface Water Drainage. Discharge treated runoff;
- Treated runoff (i.e., treated to meet NEA Trade Effluent Discharge Limits) may be discharged into earth drain D/S8 to maintain its existing flow;
- Heavy maintenance works and noisy equipment delivery should be kept within the daytime (9am to 5pm) during operational phase, as much as possible;
- Control construction vibration levels using best available techniques (BAT) and ensure that the vibration levels for any construction activities at Sites I to III and Eng Neo Avenue Forest do not exceed PPV, 8.0 mm/s;
- Appoint Ecologist and Environmental Officer to survey for burrows before any construction activities. Camera traps should be deployed to assess any fauna activity if burrows are detected within the Biodiversity Study Areas. If no burrows or fauna activity is detected, construction works are allowed to be continued;
- During rock breaking and excavation for the CR14 Station, Ecologist shall monitor for any fauna

behaviour (e.g., dashing onto the road) resulting in roadkill incidents for at least thirty (30) minutes after the event. In addition, during these construction activities, Ecologists will be present to observe fauna movements. In the instance that fauna is observed trying to dash onto the road, construction activities will be immediately suspended, and mitigation measures should be applied to prevent such an event. Whilst fencing will be erected to limit instances of this occurring, monitoring post-event in case fauna which can evade or climb said fencing enter the road; and,

- Before the construction activities commence, a 1.4 km long temporary barrier (e.g., water-filled barrier of 1 m height) shall also be set up at specific locations along Turf Club Road, Fairways Drive and Eng Neo Avenue. Hoardings must be included at the worksites, and canvas sheets must be added onto existing railings (130 m long) along Fairways Drive to cover holes on the railings. These will potentially mitigate roadkills due to the impacted fauna trying to dash onto a road during the construction activities.

Overall, the assessment findings demonstrated that the optimised designs of CR14 and CR15 worksites were beneficial to minimise the direct impacts on the identified Biodiversity Study Area and Sites I, II, III, IV and V.

A robust EMMP is provided in EIS, detailing the environmental monitoring and management plans to review the effectiveness of the proposed mitigation measures during the construction and operational phases.