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7.4 Assessment of Ecological Value

Habitats and species within the Study Areas were assessed for their ecological value based on the criteria described in Table 7-42 (habitat), Table 7-43 (plant species), and Table 7-44 (faunal species) (EPD, 2011). Habitats and species accorded with higher ecological value were regarded of greater importance for conservation relative to other habitats and species, respectively, within the Study Areas. The assessment was carried out using biodiversity baseline findings for each Study Area.

Each key biodiversity receptor was sub-categorised into their respective Priority Sensitivity Levels: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least) as shown in Table 6-1. The habitats/species with high ecological value are categorised as Priority 1 and habitats/species with low ecological value are categorised as Priority 3, while habitats/species with moderate ecological value are categorised as Priority 2.

Table 7-42 Criteria for Assessing the Ecological Value of Habitats

Criterion	Description
Naturalness	Degree to which the habitat is modified or disturbed owing to human activities, i.e., man-made, naturalised and natural. This is indicated by species composition in terrestrial habitats. A man-made habitat is created; a naturalised habitat is dominated by exotic plant species; a natural habitat is dominated by native plant species. In an aquatic habitat, it is indicated by the extent of human modification or disturbances. A man-made habitat is created; a naturalised habitat is modified by human actions; a natural habitat is largely pristine and not affected by human actions.
Size	Amount of physical space occupied by the habitat. Larger habitats usually have a greater carrying capacity and thus a higher ecological value.
Rarity	Extent to which the habitat occurs locally. The less common the habitat, the higher its rarity. Rare habitats are usually more difficult to create due to the need for specific conditions and thus making them less commonly occurring.
Ecological Linkage	Proximity of the habitat to other habitats. The value of a habitat increases if it lies in close proximity and/or links functionally to a high valued habitat type.
Native Species	Number of native floral and faunal species and specimens in the habitat. A habitat with higher number of native species and/or more individuals of these species has higher ecological value.
Species of Conservation Significance	Number of species of conservation significance or other faunal species of value, and number of individuals of these species in a habitat. A habitat with higher number of these species and/or more individuals of these species has higher ecological value.

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

- High ecological value: Species of conservation significance
- Medium ecological value: All other native species
- Low ecological value: Exotic and cryptogenic species

Species that were tentatively assigned medium (all other native species) or low (exotic and cryptogenic species) ecological value were then evaluated individually based on the criteria listed in Table 7-43. The evaluation of individual species served to either maintain or raise the pre-assigned ecological value. The following paragraphs detail how each criterion was considered in the evaluation.

Association with important fauna (native, exotic, and cryptogenic species): The ecological value of plant species that directly support the growth and survival of important fauna at one or various life cycle stages were raised to high, irrespective of plant species origin, cultivation intensity and effects, as well as national distribution. Examples of such plant species include caterpillar host plants for rare butterfly species and bamboos that are refugia for nationally threatened bamboo bats. The ecological value of plant species without associations with important fauna was maintained at the original level, i.e., medium or low.

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

National distribution (non-cultivated native species only): The ecological value of non-cultivated native plant species with restricted national distribution—i.e., largely found in certain forest patches in Singapore or offshore islands, such as the primary and old growth secondary forests of the CCNR—was raised from the original medium level to

high. On the other hand, that of non-cultivated plant species which are nationally widespread—i.e., occur at several secondary forest patches throughout Singapore—was maintained at the medium level.

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

Table 7-43 Criteria for Assessing the Ecological Value of Plant Species

Criterion	Definition
Conservation Significance	Listed as nationally threatened, i.e., Vulnerable, Endangered, Critically Endangered, or Extinct, and are considered of conservation significance in this study
Cultivation Intensity And Effects	Cultivated previously or presently—for various purposes such as reforestation, landscaping, species reintroduction, commercial sale, etc—and populations of relics and/or escapees are present/absent in forests
National Distribution	Extent of spread and/or occurrence at one or multiple forest patches in Singapore
Association With Important Fauna	Directly associated with the survival of important fauna at one or various life cycle stages

Table 7-44 Criteria for Assessing the Ecological Value of Faunal Species

Criterion	Definition
Conservation Significance	Listed as globally and/or nationally threatened and/or rare
Distribution	Global and/or national extent of spread of the species population. Species with restricted extent of spread are more susceptible to impacts, thus have higher ecological value
Rarity	Frequency at which the species occurs globally or locally. Rarer species have higher conservation significance, thus ecological value.

7.4.1 Eng Neo Avenue Forest

The ecological value of five terrestrial habitats, two waterbody habitats, 282 plant species and 233 faunal species present within Eng Neo Avenue Forest were assessed.

7.4.1.1 Habitats

The ecological value of five terrestrial habitats and two waterbody habitats observed at Eng Neo Avenue Forest was assessed. Only one terrestrial habitat and one waterbody habitat was assessed to be of high ecological value, while the remaining habitats consist of three terrestrial habitats of moderate ecological value and one of low ecological value. The remaining waterbody habitat was considered of moderate ecological value. A summary of ecological value assessment of each receptor is shown in Table 7-45.

i. Native-dominated Secondary Forest (High Ecological Value; Priority 1)

The native-dominated secondary forest occupies 1.8 ha (4.6%), making it one of the smaller within Eng Neo Avenue Forest. Although having the smallest total area, it is a hotspot for late-successional secondary forest species. Many species found in these areas can also be found in the CCNR (Wong et al., 1994) and are less commonly encountered in other secondary forests in Singapore. Some species associated with older forests which are rare even in the NSSF were also recorded in the Study Area.

High floral faunal richness in terms of native and conservation significant species richness was observed within this habitat type. This includes species such as the critically endangered Sunda pangolin (*Manis javanica*) and records of restricted species such as the Sunda colugo (*Galeopterus variegatus*) and glossy horseshoe bat (*Rhinolophus refulgens*).

ii. Waste Woodland (Moderate Ecological Value; Priority 2)

Waste woodland occupies 13.1 ha (33.4%), making it the most expansive vegetation type within Eng Neo Avenue Forest. This is a commonly encountered habitat in Singapore – where areas were cleared or highly disturbed in the past. Usually, this vegetation type is considered easily created and commonly encountered. Though observed in patches across Study Area, it is still contiguous with other vegetation type, making it high value in providing ecological linkage for species utilising the Study Area. Additionally, due to the higher than usual presence of plant species of conservation significance in this vegetation type, it has been accorded a higher rarity level. Many of these species can be found in the CCNR (Wong et al., 1994) and are less commonly encountered in other secondary forests in Singapore.

iii. Scrubland and Herbaceous Vegetation (Moderate Ecological Value; Priority 2)

The scrubland and herbaceous vegetation occupy 12.2 ha (31.1%), making it the second largest vegetation type in Eng Neo Avenue Forest. This is a common habitat as it mostly occupies the scattered patches within the forest where temperature and light levels are higher; and because of that, it is contiguous with other vegetation type, making it high value in providing ecological linkage for species utilising the Study Area.

It has intermediate numbers of average native floral species richness, but low numbers of average conservation significant floral species richness recorded, while intermediate average native faunal species richness and average conservation significant faunal species richness was recorded.

iv. Abandoned-land Forest (Moderate Ecological Value; Priority 2)

The abandoned-land forest occupies 10.8 ha (27.6%) within Eng Neo Avenue Forest, making it the third largest vegetation type in Eng Neo Avenue Forest. The abandoned-land forest exists in large patches distributed across the Study Area and is contiguous with other vegetation type. Thus, it provides high value in ecological linkage in providing floral and faunal species to disperse or move across the Study Area. Subsequently, the abandoned-land forest habitat is uncommon in Singapore as many forests have been largely disturbed and/or cleared to give way for development.

The forest harbours the highest native floral richness and the second highest conservation significant floral species, while faunal species recorded low average native faunal species richness but high average conservation significant faunal species richness. These forest-dependent species include the malesian frog (*Limnonectes malesianus*) and common palm dart (*Telicota colon stinga*).

v. Managed Vegetation (Low Ecological Value; Priority 3)

The managed vegetation occupies 0.3 ha (0.8%), making it the smallest vegetation type within Eng Neo Avenue Forest. The managed vegetation is located on the forest edges and comprise mainly of planted trees that are exotic species. This is a very common habitat in Singapore, represented by managed lawns, as well as small community gardens—a make-up typical of urban parks in Singapore. Most of these areas observed in Eng Neo Avenue Forest are managed lawns, open and turfed with grass. A relatively low average of native and conservation significant faunal species richness was observed.

vi. Waterbody (D/S14; High Ecological Value; Priority 1)

A natural stream system (1.0 km) runs across the south eastern part of Eng Neo Avenue Forest, which does not reside within the worksite. Such natural stream habitats are uncommon in Singapore. The waterbody appears to be connected to a larger water source that runs outside of the Study Area; thus, ecological linkage for aquatic species is considered to be present.

The stream is characterised with mainly abandoned-land forest vegetation, which has a high native plant species richness and intermediate conservation significant plant species richness. Several species with restricted distribution, such as the malesian frog (*Limnonectes malesianus*), were recorded. It is also an important habitat for the common walking catfish (*Clarias* cf. *batrachus)* which has seen local population decline in recent years.

vii. Waterbody (Anaerobic pond; Moderate Ecological Value; Priority 2)

The large pond with 0.04 ha in the central part of the Study Area appears to support uncommon aquatic species those have adapted to using the pond and marsh habitat. This includes the uncommon slaty-breasted rail *(Lewinia striata*) which is possibly using the marsh habitat surrounding the pond. The presence of sapphire flutter (*Rhyothemis triangularis*) observed frequently observed along the old gravel road is possibly also attributed to this pond. Additionally, breeding was observed here for the dragonfly, emperor (*Anax guttatus*). Only two flora species of conservation significance, *Oncosperma sp.* and *Cayratia trifoli*, were recorded. Such a habitat though in poor condition and is not linked to any larger waterbody, is a natural and uncommon habitat that appears to support uncommon species; thus should be considered of medium ecological value.

Table 7-45 Habitat Ecological Assessment Table for Eng Neo Avenue Forest

Criterion	Native-dominated Secondary Forest	Waste Woodland	Scrubland and Herbaceous Vegetation	Abandoned-land Forest	Managed Vegetation	Waterbody (D/S14 Stream)	Waterbody (Anaerobic Pond)
Ecological value	High	Moderate	Moderate	Moderate	Low	High	Moderate
Naturalness	Natural	Naturalised	Naturalised	Natural	Man-made	Natural	Natural
Size in hectares (% of Study Area)	1.8 (4.6%)	13.1 (33.4%)	12.2 (31.1%)	10.8 (27.6%)	0.3 (0.8%)	0.9 km	0.9 ha
Rarity	Rare	Common	Common	Uncommon	Common	Uncommon	Uncommon
Ecological linkage	High	High	High	High	Low	Medium	Low
Native species richness	Flora: high Fauna: high	Flora: low Fauna: N.A.	Flora: intermediate Fauna: intermediate	Flora: high Fauna: low	Flora: N.A. Fauna: low	Flora: N.A. Fauna: low	Flora: N.A. Fauna: N.A.
Conservation significance species richness	Flora: high Fauna: high	Flora: intermediate Fauna: N.A.	Flora: low Fauna: intermediate	Flora: intermediate Fauna: high	Flora: N.A. Fauna: intermediate	Flora: N.A. Fauna: low	Flora: N.A. Fauna: N.A.

Table 7-46 Average Conservation Significance and Native Faunal Species Richness for Each Habitat at Eng Neo Avenue Forest

Habitat Type	Number of Sampling Points	Average Native Species Richness	Average Conservation Significant Species Richness
Native-dominated Secondary	1	22	4
Abandoned-land forest	3	8.67	3
Scrubland and herbaceous vegetation	9	14.22	3
Managed vegetation	13	10.46	2
A1_Stream	6	0.5	0

7.4.1.2 Plant Species

Two hundred and eighty-two species at Eng Neo Avenue Forest were assessed for their ecological value. From the assessment, 95 species have high ecological value, 80 species have medium ecological value, and 107 have low ecological value. The list of species is available in Appendix R1.

Only seven species initially accorded with medium or low ecological value were raised to high following assessment. One of these is the exotic bamboo species, *Bambusa vulgaris*, which could be utilised by nationally threatened bamboo bats. Out of the six bamboo clusters present in Eng Neo Avenue Forest, five were found to have bamboo bats residing in them during roost emergence surveys. Retaining the bamboo clusters would ensure the continued survival of the nationally threatened faunae. Hence, this species was considered of high ecological value even though it is not native to Singapore. The other six species of which the ecological value was raised from medium to high are listed as Common in Chong et al. (2009). These species, though nationally Common, are often found to be widespread only within the nature reserves; they are not commonly encountered in other secondary forests of Singapore and known to be not cultivated locally. These include *Calophyllum ferrugineum*, *Gluta wallichi*, and *Pleocnemia irregularis*. Their presence in the forests of Eng Neo Avenue Forest suggests that the Study Area could serve as an additional refugium for these species with restricted national distribution. Hence, they should, too, be considered of high conservation value.

Ten other species of high ecological value are figs, a keystone plant group that plays an important role in ensuring the health of entire ecosystems. Of the ten, two are of conservation significance, i.e., the nationally Critically Endangered *Ficus glandulifera* and *F. villosa*. The remaining seven fig species consists of six native common species, one exotic species (*F. hispida*), and one cryptogenic species (*F. benjamina*). All other species of high ecological value are nationally threatened and considered of conservation significance.

7.4.1.3 Faunal Species

Of the 233 faunal species evaluated for their ecological value, 15 were of high value as they were considered of conservation significance. This list includes three butterfly, eight bird, two non-volant mammal and one bat species. Species of interest that require additional mitigation measures include the Sunda colugo (*Galeoopterus variegatus*). The criteria for determining species of conservation significance is described in Section 7.2.2.3. The list of species is available in Appendix R1.

7.4.2 Sites I and II

The ecological value of five terrestrial habitats, two waterbody habitats, 270 plant species and 165 faunal species present within Sites I and II was assessed.

7.4.2.1 Habitats

The ecological value of five terrestrial habitats and two waterbody habitats observed at Sites I and II was assessed. Only two terrestrial habitats were assessed to be of high ecological value. Two remaining terrestrial and two waterbody habitats were assessed to be of moderate ecological value and one terrestrial habitat was assessed to be of low ecological value. A summary of ecological value assessment of each receptor is shown in Table 7-47.

i. Native-dominated Secondary Forest (High Ecological Value; Priority 1)

The native-dominated secondary forest occupies 2.8 ha (16.7%), making it one of the smaller habitats within Sites I and II but still a medium-sized habitat. The native-dominated secondary forest patches within the Study Area were found to be hotspots for late-successional secondary forest species. Many species found in these areas can also be found in the CCNR (Wong et al., 1994) and are less commonly encountered in other secondary forests in

Singapore. Some species associated with older forests, which are rare even in the NSSF, were also recorded in the Study Area.

High floral and faunal richness in terms of native and conservation significant species richness was observed within this habitat type. This includes species such as the critically endangered Sunda pangolin (*Manis javanica*) and records of restricted species such as the Sunda colugo (*Galeopterus variegatus*) and glossy horseshoe bat (*Rhinolophus refulgens*).

ii. Mixed Forest (High Ecological Value; Priority 1)

The mixed forest occupies 5.1 ha (30.5%), making it the largest habitats within Sites I and II. The mixed forest was found to be of high floral and faunal richness in terms of conservation significant species. Notably, the critically endangered Sunda pangolin (*Manis javanica*) and restricted Sunda colugo (*Galeopterus variegatus*) were found within this habitat type.

Due to its large size, it is contiguous with other vegetation types and especially the high ecological value native-dominated secondary forest, making it high value in providing ecological linkages for species utilising within the Study Area, as evident also by the array of conservation significant fauna species sighted within this habitat type. In addition, the mixed forest within this Study Area also houses a large number of large and other plant specimens of value, including bamboo clusters in which resident bamboo bats (*Tylonycteris sp.)* were found. Many of the large trees found within this Study Area also host rare epiphytes, with this habitat considered high value in terms of large and other plant specimens of value richness.

iii. Scrubland and Herbaceous Vegetation (Moderate Ecological Value; Priority 2)

The scrubland and herbaceous vegetation occupy 2.7 ha (16.2%), making it the second smallest vegetation type in the Study Area. This is a common habitat as it mostly occupies the scattered patches within the forest where temperature and light levels are higher; and because of that, it is contiguous with other vegetation type, making it high value in providing ecological linkage for species utilising the Study Area.

It has intermediate numbers of average conservation significant floral and faunal species richness recorded and low numbers of large and other plant specimens of value recorded within its habitat.

iv. Abandoned-land Forest (Moderate Ecological Value; Priority 2)

The abandoned-land forest occupies 3.0 ha (18.1%) within the Study Area, making it the second largest vegetation type within Sites I and II. The abandoned-land forest exists in large patches distributed across the Study Area and is contiguous with other vegetation type. Thus, it provides high value in ecological linkage in providing floral and faunal species to disperse or move across the Study Area. Subsequently, the abandoned-land forest habitat is moderately uncommon in Singapore as many forests have been largely disturbed and/or cleared to give way for development.

The forest harbours medium numbers of conservation significant floral and faunal species, and medium numbers of large plants and other specimens of value.

v. Managed Vegetation (Low Ecological Value; Priority 3)

The managed vegetation occupies 1.4 ha (8.4%), making it the smallest vegetation type within the Study Area. The managed vegetation is located on the forest edge and comprise mainly of planted trees that are exotic species. This is a very common habitat in Singapore, represented by managed lawns, as well as small community gardens—a make-up typical of urban parks in Singapore. The managed vegetation observed in Sites I and II consist of turf grass with horse paddocks used by the neighbouring Saddle Club. A low number of conservation significant floral species richness was found within the Study Area, and no faunal species of conservation significant were observed onsite.

vi. Waterbody (D/S15; Moderate Ecological Value; Priority 2)

A partially concretised stream system (0.46 km) runs across the eastern part of the Study Area, which does not reside within the worksite. Such natural stream habitats are uncommon in Singapore. The waterbody appears to be connected to a larger water source that runs from outside of the Study Area; thus, ecological linkage for aquatic species is considered to be present.

The stream is located within the native-dominated secondary forest, which has a high conservation significant plant and animal species richness.

vii. Waterbody (D/S16; Moderate Ecological Value; Priority 2)

A natural stream system (0.36 km) runs down the western part of the Study Area; the southern section of the stream will intersect with a temporary access road that will be built to provide access to the worksite. Such natural stream habitats are uncommon in Singapore. The waterbody appears to be connected to a larger water source downstream outside of the Study Area; thus, ecological linkage for aquatic species is considered to be high.

The common walking catfish (*Clarias cf. batrachus*) was also sighted at two points within the stream – given that this aquatic species has seen local population decline in recent years, the sighting of it indicates that this stream is an important habitat for this species.

Table 7-47 Habitat ecological assessment table for Sites I and II

Criterion	Native-dominated Secondary Forest	Abandoned-land Forest	Mixed Forest	Scrubland and Herbaceous Vegetation	Managed Vegetation	Waterbody (D/S15)	Waterbody (D/S16)
Ecological value	High	Medium	High	Medium	Low	Medium	Medium
Naturalness	High	Medium	Medium	Medium	Low	Medium	Medium
Size in hectares (% of Study Area)	Medium 16.7% (2.8 ha)	3.0 ha (18.1%)	5.1 ha (30.5%)	2.7 ha (16.2%)	1.4 ha (8.4%)	0.46 km	0.36 km
Rarity	High	Medium	High	Low	Low	Medium	Medium
Ecological linkage	High	High	High	High	Low	Medium	High
Conservation significance species richness	High Flora: High Fauna: High	Medium Flora: Medium Fauna: Medium	High Flora: High Fauna: High	Medium Flora: Medium Fauna: Medium	Low Flora: Low Fauna: Low	Low Flora: Low Fauna: Low	High Flora: Low Fauna: High
Large and other plant specimens of value species richness	Medium	Medium	High	Low	Low	NA	NA

7.4.2.2 Plant Species

A total of 270 plant species were assessed for their ecological value at Sites I and II. Among these species, 70 are of high value, 79 of medium value, and 121 of low value. Five species had their ecological value raised after assessment. Three species were raised from low to high ecological value, while the other two species from medium to high value.

All the three plants species that were raised from low to high ecological value are exotic species. Two of these are bamboo species, namely, *Bambusa vulgaris* and *Thyrsostachys siamensis*. Nationally threatened bamboo bats (*Tylonyecteris* sp.) are known to reside within bamboo internodes and roost for long hours. As such, bamboo clusters could be potential roost sites for the threatened fauna. In this Study, bamboo bats were recorded during bat roost emergence surveys (see Section 7.3.3.3.12), thus keeping bamboo clusters is important in ensuring the survival of the bats. Additionally, it is essential to conserve bamboo clusters in the Study Area to safeguard the local bamboo bat populations at large that are continually facing threats of habitat loss. Therefore, while non-native in origin, the association bamboo clusters with bamboo bats make species of the former of high ecological value.

The remaining species that had its ecological value raised from low to high is *Aristolochia acuminata*. This climber is the host plant for the nationally threatened common birdwing (*Troides helena cerberus*), which was recorded in the Study Area too (see Section 7.3.3.3.5). As the caterpillar host plant for the threatened butterfly species, specimens of the former play an important role in allowing the butterflies to complete their life cycle stages and hence ensuring the continued persistence of the population. Therefore, the climber species has been accorded high ecological value even though it is non-native in origin.

The two species that had their ecological values raised from medium to high are native, namely, *Ardisia sanguinolenta* and *Campnosperma auriculatum*. Although these two species are listed as nationally Common, they are not known to be cultivated in local streetscapes and have restricted distributions locally, where they occur more commonly in old-growth secondary forests and/or forest reserves in the CCNR, BTNR and NSSF. Therefore, these species found in the forest fragments in Sites I and II have been accorded high ecological value given that they do not occur in most other forest fragments in Singapore.

7.4.2.3 Faunal Species

Of the 165 faunal species evaluated for their ecological value, 13 were of high value as they were considered of conservation significance. This list includes three butterflies, seven birds, two non-volant mammal and one bat species. Species of interest that require additional mitigation measures include the Sunda colugo (*Galeoopterus variegatus*). The list of species is available in Appendix R2.

7.4.3 Windsor

The ecological value of five terrestrial habitats (including Windsor Nature Park), three waterbody habitats, 325 plant species and 229 faunal species present within Windsor were assessed.

7.4.3.1 Habitats

The ecological value of five terrestrial habitats (including Windsor Nature Park) and three waterbody habitats observed at Windsor was assessed. Two terrestrial habitats and all the waterbodies were assessed to have high ecological value, while all the remaining terrestrial habitats were of moderate ecological value, except one that was of low ecological value. A summary of ecological value assessment of each receptor is shown in Table 7-48.

i. Native-dominated Secondary Forest (High Ecological Value; Priority 1)

The native-dominated secondary forest occupies 0.9 ha (3.0%) within Windsor. It has a relatively high native species richness with an average of 43 flora species were recorded per vegetation plot. Notably, it has the highest number of conservation significant plant species (33 species; 95 individuals) across the three vegetation types assessed. Although having the smallest total area of all spontaneous vegetation types present, it is a hotspot for late-successional secondary forest species. Many species found in these areas can also be found in the CCNR (Wong et al., 1994) and are less commonly encountered in other secondary forests in Singapore.

Intermediate native species richness, mostly consisting of birds and butterflies were recorded within this habitat type. Despite the low numbers of conservation significant faunal species, because of its high ecological linkage to adjacent habitat types such as abandoned-land forest and scrubland vegetation, the native-dominated secondary forest habitat will also be important in supporting the records of rare and restricted species recorded in the adjacent habitats. It includes the Sunda colugo (*Galeopterus variegatus*) and flying squirrels that were recorded multiple times in the abandoned-land forest adjacent to it.

ii. Abandoned-land Forest (Moderate Ecological Value; Priority 2)

The abandoned-land forest occupies 7.7 ha (26.1%) within Windsor. It has high ecological linkage with other habitat types intersperse within it. Across the four vegetation types assessed, it has an intermediate richness in native plant species, with an average of 36 native flora species recorded per plot, and a high number of conservation significant plant species (30 species; 98 individuals).

Despite of having the second largest habitat type within Windsor, low and intermediate native faunal species richness (mostly dominated by birds) and faunal species of conservation significance respectively, was observed. Faunal species of conservation significance include Horsefield's Flying Squirrel (*Iomys horsfieldii*).

iii. Scrubland and Herbaceous Vegetation (Moderate Ecological Value; Priority 2)

The scrubland and herbaceous vegetation occupy 0.9 ha (2.6%) in Windsor. Most patches are interspersed within the abandoned-land forest, with varying degree of disturbances; some patches were exotic dominated while others were solely occupied by short herbaceous plants and grasses. No vegetation plot sampling was conducted and therefore floral native species richness was not reported. It has the least number of conservation significant plant species recorded (6 species; 8 individuals) across the three vegetation types assessed within Windsor.

It has high faunal native richness but a low richness of faunal species of conservation significance, some of which are rare or restricted. However, considering its interspersed nature within the contiguous abandoned-land forest patch, it will also support the rare and restricted species recorded there and should be considered of medium ecological value too.

iv. Managed Vegetation (Moderate Ecological Value; Priority 2)

The managed vegetation occupies 2.8 ha (9.4%) in Windsor. Most of the patches are located on the periphery of the Study Area, conferring it low ecological linkage. No vegetation plot sampling was conducted and therefore floral native species richness was not reported but floral native richness is expected to be low as such habitats are common and relatively easy to recreate.

Though, expected faunal species are generally expected to be low. Yet, intermediate native and conservation significant species richness was observed. This could be due to 1. proximity of Windsor Nature Park to this habitat, resulting in spill over of species from the better Windsor Nature Park habitat, and 2. the managed vegetation are areas that are more open, allowing more species to be seen and thus recorded. Therefore, ecological value of managed vegetation is medium instead of low.

v. Windsor Nature Park (High Ecological Value; Priority 1)

Almost half of Windsor Study Area consists of Windsor Nature Park (16.4 ha; 55.2%). No vegetation plot sampling was conducted due to permit restrictions. Windsor Nature Park has been considered under the NParks Nature Conservation Masterplan which aims to "regenerate the secondary forests in Nature Parks buffering the two Nature Reserves"; native species are actively introduced and planted, exotic species are concurrently weeded out and removed. With active forest restoration efforts, the vegetated landscape of Windsor Nature Park is thus, expectedly, a mix of managed and natural vegetation.

Intermediate native species richness was recorded within this habitat type with high conservation significant richness. This includes rare and forest-dependent species like *Draco melanopogon* and *Nycticebus coucang*. More importantly, it has high ecological linkage with the CCNR, which accounts for the high conservation significant richness observed.

vi. Waterbody (Streams within the Northern Forest Fragment, D/S26 and D/S27; High Ecological Value; Priority 1)

Two natural stream systems D/S26 and D/S27 run within the eastern part of the Northern Forest Fragment, which do not reside within the worksite. Such natural stream habitats are uncommon in Singapore. D/S26 and D/S27 waterbodies are connected upstream to a culvert under Thomson Road and downstream to the main stream within Windsor Nature Park respectively. This provides connectivity for aquatic species thus is important in ecological linkage.

The stream is characterised with mainly abandoned-land forest vegetation, which has an intermediate native plant species richness and high conservation significant richness. It has intermediate faunal species native and conservation significant richness, including records of several species with restricted distribution, such as the *Betta pugnax*. It is also an important habitat for the common walking catfish (*Clarias* cf. *batrachus)* which has seen local

population decline in recent years. The survival of the catfish is dependent on the continued existence of the streams in the site and the presence of vegetation along stream banks.

vii. Waterbody (Stream within Windsor Nature Park, D/S13; High Ecological Value; Priority 1)

A natural stream system (1.0 km) runs across Windsor Nature Park, which does not reside within the worksite. Such natural stream habitats are uncommon in Singapore. The waterbody is connected to the streams in the Northern Forest Fragment via a culvert under Island Club Road and provides connectivity for aquatic species thus is important in ecological linkage. It has high and intermediate faunal species native and conservation significant richness respectively. This includes records of several species with restricted distribution, such as the Malayan forest betta (*Betta pugnax)*.

Table 7-48 Habitat Ecological Assessment Table for Windsor

Criterion	Native-dominated Secondary Forest	Abandoned-land Forest	Scrubland and Herbaceous Vegetation	Managed Vegetation	Windsor Nature Park	D/S26 and D/S27 Waterbody	D/S13 Waterbody
Ecological value	High	Moderate	Moderate	Moderate	High	High	High
Naturalness	Natural	Natural	Naturalised	Man-made	Naturalised	Natural	Natural
Size (% of Study Area)	0.9 ha (3.0%)	7.7 ha (26.1%)	0.9 ha (3.0%)	2.8 ha (9.4%)	16.4 ha (55.2%)	0.31 km	0.68 km
Rarity	Rare	Uncommon	Common	Common	Uncommon	Rare	Rare
Ecological linkage	High	High	Medium	Low	High	High	High
Native species richness	Flora: high Fauna: intermediate	Flora: intermediate Fauna: low	Flora: NA Fauna: high	Flora: NA Fauna: intermediate	Flora: NA Fauna: intermediate	Flora: intermediate Fauna: intermediate	Flora: NA Fauna: high
Conservation significance species richness	Flora: high Fauna: low	Flora: high Fauna: intermediate	Flora: low Fauna: low	Flora: NA Fauna: intermediate	Flora: NA Fauna: high	Flora: high Fauna: intermediate	Flora: NA Fauna: intermediate

Table 7-49 Average Conservation Significance and Native Species Richness for Each Habitat at Windsor

Habitat Type	Number of Sampling Points	Average Native Species Richness	Average Conservation Significant Species Richness
Windsor Nature Park	15	12.13	2.4
Abandoned-Land Forest	10	10.7	2.3
Scrubland And Herbaceous Vegetation	2	12.5	1
Managed Vegetation	3	10.67	2
D/S26_Stream	3	3	1.67
D/S27_Stream	2	5	2
D/S13_Stream	5	5.6	1.8

7.4.3.2 Plant Species

All 325 plant species recorded at Windsor, including Windsor Nature Park, were evaluated for their ecological value. Sixty-five species were assessed to be of high ecological value, while 136 and 124 were assessed to be of medium and low ecological value, respectively. The list of species is available in Appendix R3.

The ecological value of three exotic species was raised from low to high, while that of eight non-cultivated native common species was raised from medium to high. The former are *Bambusa heterostachya*, *Bambusa multiplex*, and *Bambusa vulgaris*, bamboo species that could be utilised by nationally threatened bamboo bats. During surveys of bat roost emergence at three bamboo clusters situated within the proposed worksite areas in the Northern Forest Fragment, bamboo bats were not recorded. Nonetheless, the plants could still be potential roosting

sites, especially since bamboo bats are likely to be present in the nearby forests of the CCNR and may move beyond the forest reserves into the Study Area. In addition, other bamboo clusters found outside the proposed worksite areas in the Northern Forest Fragment and Windsor Nature Park may also have bamboo bat colonies; some clusters were found to have slits along the internodes suitable for bamboo bats to enter and exit. This conjecture, however, could not be confirmed as surveys at those clusters were not carried out. The seven non-cultivated native common species, of which the ecological value was raised from medium to high, have restricted national distribution, i.e., they are more commonly found in the CCNR. They include *Eurya acuminata*, *Friesoldielsia latifolia*, and *Santiria apiculata*. It is uncommon for such species to be found in other secondary forests of Singapore, such as the one in the Northern Forest Fragment. Hence, it is important to conserve these species in the Study Area as they may be propagules that have arrived from the nature reserves.

Out of the remaining 54 species of high ecological value, six are figs, which are considered keystone plants in Singapore. Five of these are native common *Ficus* species, while the remaining one is cryptogenic. All other species of high ecological value are nationally threatened and considered of conservation significance.

7.4.3.3 Faunal Species

Of the 229 faunal species evaluated for their ecological value, 27 were of high value as they were considered of conservation significance. This list includes five odonate, two butterfly, two amphibian, five reptile, seven bird and five non-volant mammal species. Species of interest that require additional mitigation measures include the Sunda colugo (*Galeoopterus variegatus*). The criteria for determining species of conservation significance is described in Section 7.2.2.3. The list of species is available in Appendix R3.

7.5 Areas of High Conservation Value

The assessment of habitat and species ecological value was used to identify areas of high conservation value. Areas of high conservation value within the Study Areas are of highest priority and should be kept untouched as much as possible. Any development within these areas are likely to result in major to moderate impacts. A 30-m buffer was placed around some of these features to further safeguard these features from habitat degradation and reduce the impacts of edge effects. It is important to note that other areas of medium or low conservation value also contribute towards the ecological integrity of the Study Area and should be preserved as well.

7.5.1 Eng Neo Avenue Forest

Areas of high conservation value at Eng Neo Avenue Forest are (Figure 7-115):

i) All waterbodies (D/S14 and Anaerobic Pond): Waterbodies have an inherent importance in sustaining the basis of life for a range of other common/rare faunal species residing within the Study Area. Furthermore, waterbodies are uncommon habitats in Singapore. Stream associated floral and faunal species were observed along and around the stream. Although the anaerobic pond is disturbed and in poor condition, it provide habitats for some uncommon odonate species that has adapted to use it, such as the emperor (*Anax guttatus*) and sapphire flutterer (*Rhyothemis triangularis*).

ii) Northern forest patch consisting of native-dominated secondary forest, waste woodland and anaerobic pond: The native-dominated secondary forest consists late-successional secondary forest species with a cluster of threatened plant species. The forest patch between the native-dominated secondary forest and stream provides an important connectivity between the northern and southern part of the Study Area, to allow the dispersal of floral and faunal species. Several faunal species of conservation significance and forest-dependent species were also recorded here. Examples are the Sunda colugo (*Galeopterus variegatus*), Sunda pangolin (*Manis javanica*), Wagler's pit viper (*Tropidolaemus wagleri*) and red-necked bronzeback (*Dendrelaphis kopsteini*). Together with the anaerobic pond, it is about 13.5 ha.

7.5.2 Sites I and II

Areas of high conservation value at Sites I and II are (Figure 7-116):

i) All waterbodies (D/S15 and D/S16): Waterbodies have an inherent importance in sustaining the basis of life for a range of other common/rare faunal species residing within the Study Area. Furthermore, waterbodies are uncommon habitats in Singapore, especially natural and naturalised stream-types such as those found within the Study Area. Stream associated floral and faunal species, including the species of interest, common walking catfish (*Clarias cf. batrachus*), were observed along the stream.

ii) The majority of the Study Area consisting of native-dominated secondary forest, mixed forest, abandoned-land forest, and some managed vegetation and scrubland and herbaceous vegetation patches. The entire Study

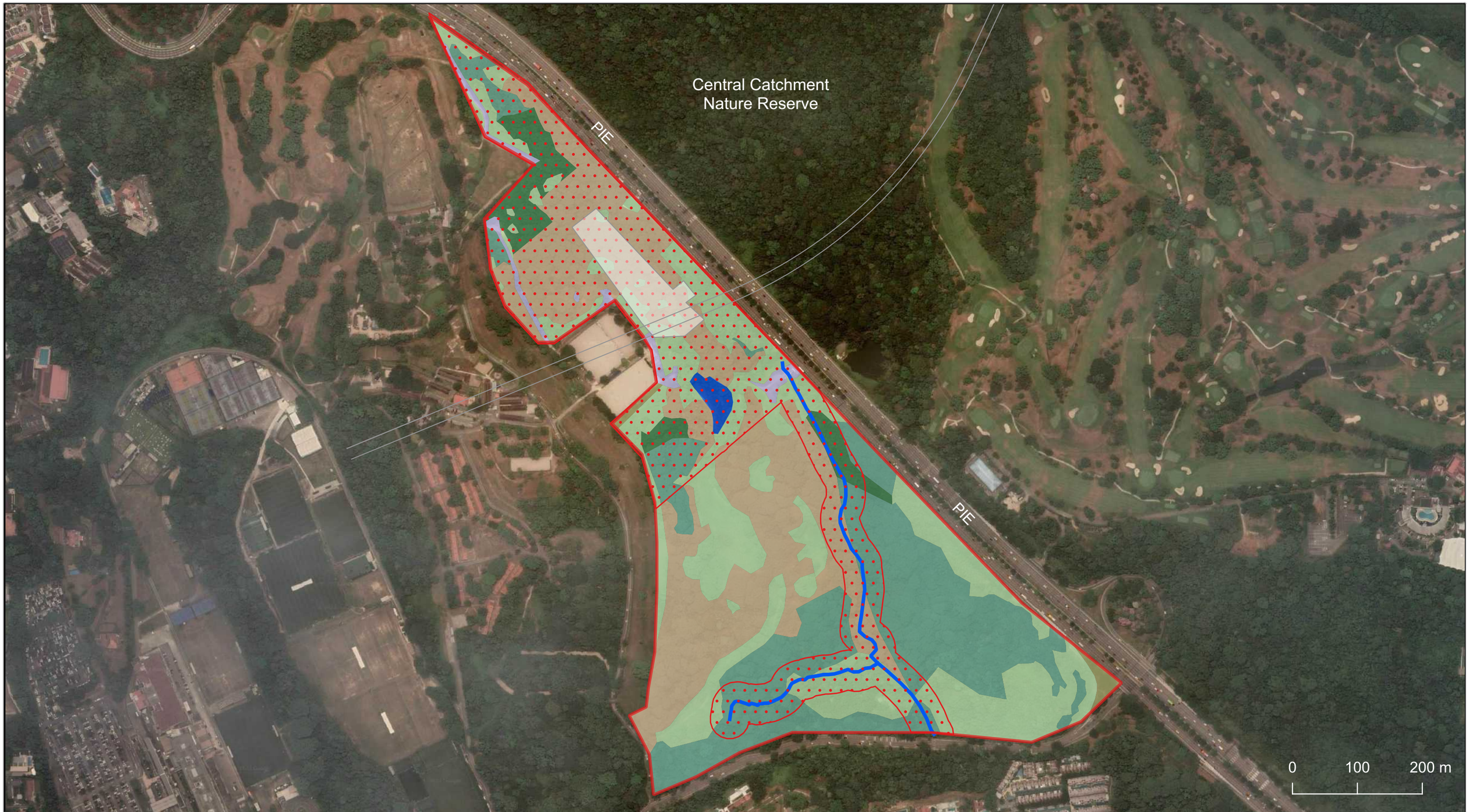
Area provides important forest connectivity between the larger forest patches to the north and to the east (Eng Neo Avenue Forest), allowing the dispersal of floral and faunal species. The native-dominated secondary forest and mixed forest in particular, were found to contain late-successional secondary forest species and be rich in floral species of conservation significance, some of which are species rarely found outside of CCNR. These two forest types and the abandoned-land forest habitat also recorded a high number of large tree specimens, many of which host trees to rare epiphytes. Several faunal species of conservation significance and forest-dependent species were also recorded here, such as the straw-headed bulbul (*Pycnonotus zeylanicus*), Sunda pangolin (*Manis javanica*) and Sunda colugo (*Galeopterus variegatus*), which were found to be utilising the entire Study Area.

7.5.3 Windsor

Areas of high conservation value at Windsor are (Figure 7-117):

i) Windsor Nature Park (including D/S13 waterbody): It is home to many floral and faunal species of conservation significance. The contiguity with the CCNR, a key biodiversity hotspot in Singapore, allows opportunity for forest-dependent species to disperse from the Reserves to the Windsor Nature Park. Windsor Nature Park together with D/S13 waterbody is approximately 16 ha.

ii) Northern Forest Fragment (including D/S26 and D/S27 waterbodies): It provides a potential connection for floral and faunal species between Windsor Nature Park and Lower Peirce forest to the north. Several faunal species of conservation significance and forest-dependent species were also recorded – Sunda slow loris (*Nycticebus coucang*), Horsfield's flying squirrel (*Iomys horsfieldii*), Sunda colugo (*Galeopterus variegatus*), lesser mousedeer (*Tragulus kanchil*), golden-eared rough-sided frog (*Pulchrana baramica*) and blue Malayan coral snake (*Calliophis bivirgatus*). Notably, it is important to the Raffles' banded langur as it provides habitat connectivity for the langurs to move between the northern and southern part of CCNR. The Northern Forest Fragment together with D/S26 and D/S27 waterbody is approximately 12 ha.



Legend

- Study Area
- Worksite and alignment (Base)
- Areas of high conservation value

Vegetation

- Native-dominated secondary forest
- Abandoned-land forest
- Waste woodland
- Scrubland and herbaceous vegetation
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

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Figure Title :
AREAS OF HIGH CONSERVATION VALUE AT ENG NEO AVENUE FOREST

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Legend

- Study Area
- Worksites, access roads and alignment (Mitigated)
- Area of high conservation value

Vegetation

- Native-dominated secondary forest
- Mixed forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

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Figure Title :
AREAS OF HIGH CONSERVATION VALUE AT FORESTED AREA ADJACENT TO FAIRWAYS QUARTERS

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Legend

- Study Area
- Vegetation
  - Native-dominated secondary forest
  - Abandoned-land forest
  - Scrubland and herbaceous vegetation
  - Managed vegetation
  - Others - infrastructure
  - Windsor Nature Park
  - Waterbody
- Boardwalk
- Worksite and alignment
- High Conservation Value

N

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Figure Title :
**AREAS OF HIGH CONSERVATION VALUE
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7.6 Identification of Biodiversity Sensitive Receptors

Potential impacts to biodiversity arising from construction (Section 3.2) and operational (Section 3.3) activities are assessed in this section.

The two main categories of impacts are (1) direct, i.e., impacts to habitats and species within the worksites, and (2) indirect, i.e., impacts to habitats and species outside the worksites but within the impact zone.

Impact zones for habitat and plant receptors are defined as areas within 150 m and 30 m from worksites of the proposed development respectively. This is to primarily account for edge effects in forests adjacent to worksites, based on studies that found edge effects affecting vegetation up to 150 m from forest boundaries (Paton, 1994; Murcia, 1995; Didham, 1997; Laurance and Bierregaard, 1997). The impact zone for faunal receptors is the Study Area boundary as most fauna are mobile throughout the Study Area.

Table 7-50 List of Ecological Impacts

Receptor	Impact type	Description	Impact category
Construction Phase			
Habitats	Loss of vegetation	Direct removal of vegetation (with extensive underground root systems that protect against soil erosion) to create space for construction activities	Direct
	Habitat degradation	Improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in forest hydrology	Indirect
	Change in species composition	Formation of forest edge habitats that favour the growth of certain exotic plants and fauna, and accidental introduction of exotic species from construction materials (such as soil with seeds or bio-degradable erosion blankets with insect eggs)	Indirect
Plant Species	Mortality	Direct removal of vegetation to create space for construction activities	Direct
	Impediment to seedling recruitment	Pollution of habitats from improper disposal of construction waste and accidental release of hazardous materials (such as construction slurry, paint, and/or solvents)	Indirect
	Competition from exotic plant species	Formation of forest edge habitats that favour the growth of certain exotic plants and accidental introduction of exotic species from construction materials (such as soil with seeds)	Indirect
	Decline in plant health and survival	Changes in microclimatic conditions (i.e., dust, noise, and light, temperature, and humidity) and hydrology	Indirect
Faunal Species	Loss of/reduction in habitats and food sources	Direct removal of vegetation to create space for construction activities	Direct
	Injury or mortality	Collisions with machineries, entrapments in construction materials (such as non-biodegradable erosion control blankets) and structures (such as exposed pits or drains), and accidental kills by construction personnel	Direct
	Loss of ecological connectivity for faunal movement	Habitat fragmentation from the removal of vegetation	Indirect
Operational Phase			
Habitat	Change in plant species composition	Long-term changes in light, temperature, and humidity in habitats surrounding facility structures	Indirect
	Habitat degradation	Trampling on vegetation and pollution from increased human traffic	Indirect
Plant Species	Mortality	Stealing/poaching of plants by humans	Direct
	Competition from exotic plant species	Accidental and/or intentional release of exotic plants by humans	Indirect

Receptor	Impact type	Description	Impact category
Faunal Species	Collisions with buildings (birds only)	Distorted perceptions of reflective surfaces on buildings as flyways, greenery, and/or water	Direct
	Loss of ecological connectivity for faunal movement	Habitat fragmentation from the removal of vegetation	Indirect
	Injury or mortality	Navigation failures into the wrong areas and entrapment in facility structures	Indirect

7.6.1 Construction Phase

7.6.1.1 Eng Neo Avenue Forest

The base scenario of A1-W2 launch shaft worksite will be constructed using the cut and cover construction method within an area in Eng Neo Avenue Forest, estimated to be about 1.5 ha. Vegetation clearance is expected in scrubland and herbaceous vegetation and waste woodland habitat type, 0.35 ha (2.9%) and 1.14 (8.7%) respectively.

Five terrestrial habitat types, one waterbody and 6 floral species are likely to be impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during construction phase within Eng Neo Avenue Forest is shown in Table 7-51.

Table 7-51 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in Eng Neo Avenue Forest during Construction Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Direct Impact (% of total habitat type within Study Area)	Indirect Impact (% of total habitat type within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	N.A.	Approximately 1.04 ha (56.8%)
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	N.A.	Approximately 0.16 ha (1.5%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value 2	Approximately 0.35 ha (2.9%)	Approximately 2.58 ha (21.2%)
	Waste Woodland	Priority 2 Area of High Conservation Value	Approximately 1.14 ha (8.7%)	Approximately 4.38 ha (33.3%)
	Managed Vegetation	Priority 3	N.A.	Approximately 0.10 ha (34.5%)
	Anaerobic Pond	Priority 2 Area of High Conservation Value	N.A.	0.29 ha (96.7%)

Legend

- Study Area
- Worksite and alignment (Base)
- 150m Impact Zone

Vegetation

- Native-dominated secondary forest
- Abandoned-land forest
- Waste woodland
- Scrubland and herbaceous vegetation
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

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Figure Title :
**THE IMPACT ZONE 150 M
FROM THE WORKSITE IN
ENG NEO AVENUE FOREST**

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7.6.1.2 Sites I and II

The mitigated scenario of A1-W2 launch shaft will be constructed using the cut and cover construction method on managed vegetation and surrounding built-up areas at and close to Sites I and II. The worksite is 5.12 ha, with 1.81 ha residing of Sites I and II. Clearance of vegetation is expected for 75% (1.05 ha) of managed vegetation, 18.6% (0.5 ha) of scrubland and herbaceous vegetation, and a small percentage (0–5%) of the native-dominated secondary forest, mixed forest and abandoned-land forest.

Five terrestrial habitat types and three plant species are likely to be impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during construction phase within Sites I and II is shown in Table 7-52.

Table 7-52 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in Sites I and II During Construction Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Direct Impact (% of total habitat type within Study Area)	Indirect Impact (% of total habitat type within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	Approximately 0.044 ha (1.6%)	Approximately 1.27 ha (44.1%)
	Mixed Forest	Priority 1 Area of High Conservation Value	Approximately 0.25 ha (4.9%)	Approximately 3.38 ha (66.7%)
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	Approximately 0.0046 ha (0.2%)	Approximately 0.85 ha (26.7%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.50 ha (18.6%)	Approximately 1.82 ha (66.7%)
	Managed Vegetation	Priority 3	Approximately 1.05 ha (75.0%)	Approximately 0.36 ha (28.6%)
	D/S15 stream	Priority 2 Area of High Conservation Value	N.A.	Approximately 0.009 ha (20.5%)
	D/S16 stream	Priority 2 Area of High Conservation Value	N.A.	Approximately 0.29 ha (76.9%)

Legend

- Study Area
- Worksites, access roads and alignment (Mitigated)
- 150m Impact Zone

Vegetation

- Native-dominated secondary forest
- Mixed forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

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THE IMPACT ZONE 150 M FROM THE WORSKITE IN FORESTED AREA ADJACENT TO FAIRWAYS QUARTERS

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7.6.1.3 Windsor

The base scenario of A1-W1 launch/retrieval shaft worksite will be constructed using methods such as pilling, rock breaking and excavation within the forest fragments north of the Windsor Nature Park (outside of the Park), estimated to be about 1.5 ha. Vegetation clearance is expected in native-dominated secondary forest, abandoned-land forest, scrubland and herbaceous vegetation and managed vegetation habitat type, approximately 0.22 ha (24.44%) and 0.99 (12.86%), 0.07 ha (7.78%) and 0.28 ha (10.00%) respectively. While no construction works are planned within Windsor Nature Park.

Five terrestrial habitat types, one waterbody and 20 plant species are likely to be impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during construction phase within Windsor for the two worksite options are shown in Table 7-53.

Table 7-53 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in Windsor during Construction Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Direct Impact (% of total habitat type within Study Area)	Indirect Impact (% of total habitat type within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	Approximately 0.22 ha (24.44%)	N.A.
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	Approximately 0.99 ha (12.86%)	Approximately 1.24 ha (15.58%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.07 ha (7.78%)	Approximately 0.06 ha (6.67%)
	Managed Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.28 ha (10.00%)	Approximately 0.87 ha (31.07%)
	Windsor Nature Park	Priority 1 Area of High Conservation Value	N.A.	Approximately 4.87 ha (29.70%)
	D/S13 stream	Priority 1 Area of High Conservation Value	N.A.	0.39 km

Legend

- Study Area
- 150m Impact Zone

Vegetation

- Native-dominated secondary forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Managed vegetation
- Others - infrastructure
- Windsor Nature Park
- Waterbody
- Boardwalk
- Worksite and alignment

N

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Figure Title :
THE IMPACT ZONE 150-M FROM THE WORKSITE IN WINDSOR

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7.6.2 Operational Phase

7.6.2.1 Eng Neo Avenue Forest

During operational phase, the A1-W2 launch shaft worksite will be converted into a facility building in base scenario.

Five terrestrial habitat types and one waterbody are likely to only be indirectly impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during operational phase within Eng Neo Avenue Forest is shown in Table 7-54.

Table 7-54 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in Eng Neo Avenue Forest during Operational Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Indirect Impact (% of Total Habitat Type within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	Approximately 0.20 ha (11.10%)
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	Approximately 0.64 ha (5.90%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value 2	Approximately 1.4 ha (11.50%)
	Waste Woodland	Priority 2 Area of High Conservation Value	Approximately 5.11 ha (38.90%)
	Managed Vegetation	Priority 3	N.A.
	Anaerobic Pond	Priority 2 Area of High Conservation Value	0.02 ha (100%)

7.6.2.2 Sites I and II

During operational phase, the optimised A1-W2 launch shaft worksite (shifted out into Sites I and II from Eng Neo Avenue Forest) which originally planned to be converted into a facility building in base scenario, will now planned to be reinstated to only supporting underground rail-passing in mitigated scenario where no above-ground structure is expected.

Five terrestrial habitat types and two waterbodies are likely to be indirectly impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during operational phase within Sites I and II is shown in Table 7-55.

Table 7-55 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in the Sites I and II During Operational Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Indirect Impact (% of Total Habitat Type Within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	Approximately 1.27 ha (44.1%)
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	Approximately 3.38 ha (66.7%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.85 ha (26.7%)
	Mixed Forest	Priority 1 Area of High Conservation Value	Approximately 1.82 ha (66.7%)
	Managed Vegetation	Priority 3	Approximately 0.36 ha (28.6%)
	D/S15 stream	Priority 2 Area of High Conservation Value	Approximately 0.009 ha (20.5%)
	D/S16 stream	Priority 2 Area of High Conservation Value	Approximately 0.29 ha (76.9%)

7.6.2.3 Windsor

During operational phase, the worksite for A1-W1 will be converted to a facility building in the base scenario.

Five terrestrial habitat types and one waterbody are likely to be impacted, while all faunal species recorded are expected to be indirectly impacted as well, as most fauna are mobile throughout the Study Area.

A summary of the key biodiversity receptors impacted during operational phase within Windsor for the two worksite options are shown in Table 7-56.

Table 7-56 Key Biodiversity Habitat Receptors Likely to Experience Direct and Indirect Impacts in Windsor during Operational Phase

Category	Key Biodiversity Receptor	Priority Level and Other Relevant Status	Indirect Impact (% of total habitat type within Study Area)
Habitat	Native-dominated Secondary Forest	Priority 1 Area of High Conservation Value	N.A.
	Abandoned-land Forest	Priority 2 Area of High Conservation Value	Approximately 1.24 ha (15.58%)
	Scrubland and Herbaceous Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.06 ha (6.67%)
	Managed Vegetation	Priority 2 Area of High Conservation Value	Approximately 0.87 ha (31.07%)
	Windsor Nature Park	Priority 1 Area of High Conservation Value	Approximately 4.87 ha (29.70%)
	D/S13 stream	Priority 1 Area of High Conservation Value	0.39 km

7.7 Minimum Control Measures

This section lists biodiversity-specific minimum controls commonly implemented in Singapore for similar construction and operational activities. These are assumed to be implemented for the purpose of the impact assessment. Minimum controls for each potential impact occurring from the construction and operational phases are listed in Table 7-57. Since work activities/methods are largely similar across the Study Areas, all minimum control measures proposed are applicable to all worksites and utility diversion works. Therefore, it will be examined across all Study Areas by development phases (i.e. construction and operational phase). These measures should be proposed in tandem with that proposed for other environmental receptors (i.e. hydrology, noise, etc).

7.7.1 Construction Phase

Main construction activities that would likely occur at all worksites include vegetation clearance for worksite and excavation for levelling ground, followed by above and below ground construction. Piling and TBM tunnelling will likely occur as well. With these work activities anticipated, the related minimum control measures are listed down in Table 7-57.

Table 7-57 Minimum Control Measures for the Construction Phase

Work activities	Minimum controls	Worksite
Vegetation Clearance	Trees that are to be retained within worksite would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in accordance with NParks guidelines. Before vegetation removal, pre-felling fauna inspection should be conducted by an Ecologist to identify wildlife or nesting structures that are being actively used such as bird nests, tree hollows, burrows, and bamboos clusters. Soil erosion control measures are to be executed once vegetation has been removed and soil is exposed as described in Section 8 under Hydrology and Surface Water Quality and Section 9 under Soil and Groundwater.	All
Excavation	Implement soil erosion control measures as described in Section 8 under Hydrology and Surface Water Quality. Implement dust control measures as described in Section 10 under Air Quality.	All

Work activities	Minimum controls	Worksite
	Implement noise barrier as described in Section 11 under Airborne Noise.	
Above and Below Ground Construction	Proper storage of materials that are likely to leech harmful chemicals and fuel-powered equipment away from waterbodies or sensitive habitats as described in Section 9 under Soil and Groundwater (and Waste).	All
Pilling And; TBM Tunnelling Along Alignment	Ensure noise levels are within approved limits as described in Section 11 under Airborne Noise. Ensure vibration levels are within approved limits as described in Section 12 under Ground-borne Vibration.	All
General	Installation of hoarding to delineate worksite. Put in place wildlife management protocol with an approve wildlife management Contractor in accordance to Section 10 of Wildlife Ac Fogging is not recommended. To implement preventive measures against mosquito breeding by removing sources of stagnant water or water-bearing receptacles. E.g., • Providing well-maintained pitched roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, ensure effective drainage flow. • Daily checks by Environmental Manager on site.	All

7.7.2 Operational Phase

Regular and/or ad-hoc maintenance works are the main operational activities that would likely occur at all Study Areas. Operational activities are not expected to result in significant impacts. As facility buildings will become new sources of disturbance to the surrounding forest, daily operational works and regular maintenance works during the operational stage can be incorporated to minimise/reduce disturbances.

7.8 Assessment of Ecological Impacts

In this section, ecological impacts to key biodiversity receptors within Eng Neo Avenue Forest and Windsor will be assessed according to the base scenarios for proposed worksites. Ecological impacts to Sites I and II will only be assessed in Section 7.10 in the mitigated scenario.

7.8.1 Construction Phase

In this section, key biodiversity receptors identified are evaluated against potential sources of impacts based on the impact intensity of work activity (refer to Table 6-6) and likelihood of impact occurring (refer to Table 6-7).

The two assumptions made in defining the levels of impact intensity and likelihood for habitat receptors during the construction phase are:

1. Habitats within 30 m from the worksites are assumed to experience the greatest extent of edge effects, although some studies have shown that edge effects could be up to 150 m (refer to Section 7.6 for the definition of the impact zone).

2. The likelihood of habit degradation [i.e., improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in forest hydrology] is presumed to be Less Likely for all habitat receptors, based on the assumption that all minimum controls are adequately and properly implemented.

Table 7-58 Definitions of Each Level of Impact Intensity for All Three Impact Types during Construction for Habitat Receptors

Impact Type	Negligible	Low	Medium	High
Loss of vegetation	The habitat does not overlap with the worksites	≤ 10% of the habitat overlaps with the worksites	10–40% of the habitat overlaps with the worksites	³ 40% of the habitat overlaps with the worksites
Habitat degradation	The habitat does overlap with areas 30 m from the worksites	≤ 10% of the habitat overlaps with areas 30 m from the worksites	10–40% of the habitat overlaps with areas 30 m from the worksites	³ 40% of the habitat overlaps with areas 30 m from the worksites
Change in species composition				

Table 7-59 Definitions of Each Level of Likelihood for All Three Impact Types during Construction for Habitat Receptors

	Loss of Vegetation	Habitat Degradation	Change in Species Composition
Unlikely/Remote	The habitat does not overlap with the worksites	N.A.	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the forest)
Less Likely/ Rare	N.A.	N.A. (see assumption above)	Formation of scrubland edges in scrubland areas only
Possible/ Occasional	N.A.	N.A.	Formation of some forest and scrubland edges in a mix of managed vegetation, scrubland and forested areas
Likely/ Regular	N.A.	N.A.	Formation of new forest edges (i.e., complete clearance within forested areas)
Certain/ Continuous	The habitat overlaps with the worksites	N.A.	N.A.

The definitions for impact intensity and likelihood for faunal species at construction phase are presented below.

Table 7-60 Definitions of Level of Impact Intensity for All Three Impact Types during Construction for Faunal Species Receptors

Impact Type	Negligible	Low	Medium	High
Loss of/ reduction in habitats and food sources	No loss of original habitat	– Loss of <10% of original habitat;	– Loss of 10–40% of original habitat;	– Loss of >40% of original habitat;
Injury or mortality	Negligible susceptibility to roadkills	Species with low susceptibility to injury/mortality from construction activities (large vehicles, excavation, piling, etc): – Volant species (e.g., odonates, butterflies, highly volant birds, raptors and bats) – Pelagic species (marine context), ability to swim/crawl away quickly from danger (most fishes, crabs, shrimp) Low susceptibility to roadkills	Species that are mobile but possibly susceptible to injury/mortality from construction activities (large vehicles, excavation, piling, etc): – Amphibious aquatic species – All amphibians – Mammals: squirrels, shrews – Species (marine context) with ability to swim/crawl away but not very quickly (slow moving marine creatures, worms) Possibly susceptible to roadkills	Species with high susceptibility to injury/mortality from construction activities (large vehicles, excavation, piling, etc): – Less volant birds – Reptiles (snakes) – Mammals: Pangolin, long-tailed macaque, otter – Sessile species (marine context) cannot swim away (coral, anemone), move extremely slowly (echinoderms, molluscs, seahorses) – Birds, specifically migratory species
Loss/reduction of ecological connectivity for faunal movement	– Not dependent on connected and forested habitats for dispersal and able to traverse urban infrastructures;	– Slightly dependent on connected and forested habitats for dispersal and adaptable to traverse urban infrastructures if needed;	– Dependent on connected and forested habitats for dispersal;	– Highly dependent on connected and forested habitats for dispersal;

Table 7-61 Definitions of Each Level of Likelihood for All Three Impact Types during Construction for Faunal Species Receptors

Impact Type	Unlikely/Remote	Less likely/Rare	Possible/ occasional	Likely/Regular	Almost certain/ Continuous
Loss of/ reduction in habitats and food sources	Impact is not expected to happen during the construction phase of the project	Impact is not likely to happen during the construction phase of the project	Impact could possibly happen or known to occur during the construction phase of the project	Impact is a common occurrence during the construction phase of the project	Impact is a continual or repeated process during the construction phase of the project
Injury or mortality					
Loss/reduction of ecological connectivity for faunal movement					

Following the assessment of ecological values for all plant species (Section 7.4), some were selected for the assessment of ecological impacts. The selection was based on the following: (1) species with specimens of conservation significance, large specimens, and/or other specimens of value found inside and within 30 m from the proposed worksite area, (2) keystone species, which are only the *Ficus* species in this study, (3) species associated with important fauna, and (4) species that make up ≤ 1% of the total number of specimens of conservation significance. The selected species receptors were then evaluated based on impact intensity and likelihood, which eventually gives impact significance.

The various levels of impact intensity and likelihood for each impact type during the construction phase were specifically defined for plant species receptors.

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

1. Habitats within 30 m from the worksites are assumed to experience the greatest extent of edge effects, though some studies have shown that edge effects could be up to 150 m. The effects of forest edges may be experienced by species more sensitive to microclimatic changes more than 30 m away from the worksites; which are considered during species-specific impact evaluations.
2. For tree/strangler species that are not bamboos or of conservation significance (i.e., native common or exotic species), and hence do not have count data, total specimen count was taken from arboricultural survey data. Note that the area for arboricultural surveys is a subset of the entire Study Area. For species with zero counts (i.e., were not recorded during arboricultural surveys), it is assumed that the intensity of impacts of work activities on them is negligible. The impacts, however, were still considered specifically for each species during evaluation.
3. For native common or exotic climbing fig species/species associated with important fauna that do not have count data from both floristic and arboricultural surveys, it is assumed that the intensity of impacts of work activities on them is negligible since most of these species are expected to be widespread. The impacts, however, were still considered specifically for each species during evaluation (e.g., *Ficus heteropleura* and *Ficus punctata*).

Table 7-62 Definitions of Each Level of Impact Intensity for All Four Impact Types during the Construction Phase for Plant Species Receptors

	Negligible	Low	Medium	High
Mortality	No plant specimens of this species are within the worksites	Less than 50% of all plant specimens of this species are within the worksites	More than or exactly 50% of all plant specimens of this species are within the worksites	All plant specimens of this species are within the worksites
Impediment to Seedling Recruitment	No specimens of this species are within 30 m from the worksites	Less than 50% of all plant specimens of this species are within	More than or exactly 50% of all plant specimens of this	All specimens of this species are within 30 m from the worksites
Competition from Exotic Species				

	Negligible	Low	Medium	High
Decline in Plant Health and Survival		30 m from the worksites	species are within 30 m from the worksites	

Table 7-63 Definitions of Each Level of Likelihood for All Four Impact Types during the Construction Phase for Plant Species Receptors

	Mortality	Impediment to Seedling Recruitment	Competition from Exotic Species	Decline in Plant Health and Survival
Unlikely/Remote	No plant specimens of this species are within the worksites	Plants are epiphytes and/or do not grow on soil	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the forest)	
Less Likely/ Rare	N.A.	N.A.	Formation of very little forest edges in managed vegetation only	
Possible/ Occasional	No count data/locations of specimens of this species is available, but specimens could possibly be within the worksites	Plants that grow on soil and whose dispersals are not restricted, i.e., they disperse via wind, water, and/or terrestrial fauna	Formation of little forest edges in scrubland areas only	
Likely/ Regular	N.A.	N.A.	Formation of some forest edges in a mix of managed vegetation, scrubland and forested areas	
Certain/ Continuous	Plant specimens of this species are within the worksite	Plants that grow on soil whose dispersals are restricted owing to environmental factors and/or growth strategies (e.g, bamboos that propagate via underground rhizomes and ground orchids)	Formation of new forest edges (i.e., complete clearance within forested areas)	

7.8.1.1 Eng Neo Avenue Forest

7.8.1.1.1 *Habitats*

The most substantive impact to the habitats from construction phase at Eng Neo Avenue Forest is of minor significance. During construction phase, site clearance will result in removal of 1.5 ha (constituting 3.83% of the Study Area). Worksite consists of two habitat type, both with moderate ecological value - waste woodland forest making up the larger proportion (1.14 ha; refer to Table 7-51 for area directly impacted by construction works) and scrubland (0.35 ha).

The impact intensity of habitat degradation for scrubland and herbaceous vegetation and waste woodland vegetation is deemed to be medium because as mentioned above, construction activities still include construction methods such as pilling and excavation. The likelihood differs for different habitat type depending on the proximity of habitat to worksite; because the scrubland and herbaceous vegetation and waste woodland vegetation are adjacent to the worksite, likelihood of habitat degradation is possible. However, habitats slightly further from worksite such as the anaerobic pond are less likely to experience habitat degradation. This assessment nonetheless results in impact significance of minor for all habitat types.

Subsequently, after the clearance of worksite, loss of connectivity impact could potentially occur. After site clearance, only an approximately 50-m width strip of forest is left connecting the north and south of the Study Area. This 50-m width would be exposed to impacts such as habitat degradation and changes in species composition. Furthermore, it is also exposed to disturbances such as noise and dust from the traffic along the eastern (PIE) side. With impacts putting pressure on both side of this forest strip, the forest might not be able to exist overtime, which might eventually result in Study Area becoming fragmented.

Changes in species composition are also expected to occur with the presence of new forest edge. The spatial extent of exposed forest edge differs for different habitat types, depending on the proximity of the habitat to the

worksite. The scrubland and herbaceous vegetation and waste woodland vegetation have the largest spatial extent of exposed forest and therefore impact intensity is rated at medium, while native-dominated secondary forest has least/almost no exposed edges would have an impact intensity of low. Coupled with likelihood of possible and less likely, depending on the proximity of habitat to worksite, all habitats adjacent to worksite are expected to experience negligible to minor significance from changes in species composition impacts.

Habitat degradation and changes in species composition impacts were not evaluated for managed vegetation habitat type as all the habitats within Study Area have been cleared for worksite.

Summary of impact evaluation for the habitat at Eng Neo Avenue Forest can be found in Appendix R1.

7.8.1.1.2 *Plant Species*

A total of 67 plant species recorded from Eng Neo Avenue Forest were selected for the assessment of ecological impacts. The significance of the impacts is major for four species, moderate for another four species, and minor for the remaining 59 species (Appendix R1).

All four species likely to experience major impacts are of high ecological value.

1) Of these, three (*Dysoxylum cauliflorum*, *Hornstedtia scyphifera* var. *scyphifera*, and *Hoya diversifolia*) are likely to experience major impacts as a result of mortality. All or more than 50% of all specimens of each species were found to be located within the construction worksite in Eng Neo Avenue Forest, giving an impact intensity of high or medium, respectively. Since it is almost certain that these specimens will be removed as site clearance is carried out for construction, the impact of mortality on these species is, thus, major.

2) The fourth species, *Cratoxylum maingayi*, is likely to experience major impacts as a result of competition from exotic species and decline in plant health and survival. All specimens of this species recorded at Eng Neo Avenue Forest are located within 30 m from the construction worksite, giving an impact intensity of high. As the habitats expected to be cleared for construction in Windsor are a mix of managed vegetation and forested areas, it is likely that some forest edges will be formed as a result of the clearance. Assuming that forest edge effects are the greatest in habitats within 30 m from the cleared areas, all the specimens of this species would experience competition from exotic species as the formation of forest edge habitats favours the growth of certain exotic plants. Additionally, changes in microclimatic conditions at forest edges may also cause a decline in plant health and survival of the specimens. As such, the impacts of competition from exotic species and decline in plant health and survival on these species are major.

The four species likely to experience moderate impacts are also of high ecological value. Two of these (*Amphineuron opulentum* and *Ficus variegata*) are likely to experience moderate impacts as a result of mortality as some (< 50%) of all specimens of each species were found to be located within the construction worksite, giving an impact intensity of low. Given that the likelihood is 'almost certain', the impact significance is, thus, moderate. The other two species (*Ficus benjamina* and *Strophanthus caudatus*) are likely to experience moderate impacts as a result of competition from exotic species and decline in plant health and survival as some (< 50%) of all specimens of each species are located within 30 m from the construction worksite, giving an impact intensity of medium and subsequently, an impact significance of moderate. Detailed air quality impact on plant species was also conducted and discussed in Section 10.

Majority (59 out of 67) of the plant species are likely to experience minor impacts as a result of impediment to seedling recruitment, competition from exotic species, and decline in plant health and survival. None or few (< 50%) of all specimens of each species were found to be within 30 m from the construction worksite, giving an impact intensity of negligible or low, respectively. Nonetheless, there is still a possibility that seedling recruitment of these species may somewhat be impeded as a result of construction activities, such as pollution from improper disposals and/or accidental release of construction waste, or the plants may face competition from exotic species as forest edges are formed. Hence, the resulting impact significance is minor.

7.8.1.1.3 *Faunal Species*

A total of 16 faunal species recorded from Eng Neo Avenue Forest were selected for the assessment of ecological impacts. The overall significance of the impacts is major for three species, moderate for six species, minor for six species and negligible for one species. Species of conservation significance or interest that are most impacted by the proposed worksites are the birds and non-volant mammals. Impacts in the form of disturbances from noise, light and vibration are also expected. Impacts of these disturbances to fauna are unclear, but may affect communication with other individuals. Refer to Section 11.7.1 and Section 12.7 for the ecological impact assessment of vibration and noise respectively, to fauna.

The detailed evaluation of impact significance to each species is shown in Appendix R1.

i) Butterflies

Both the common rose (*Pachliopta aristolochiae asteris*) and common birdwing (*Troides helena cerberus*) were recorded within the worksite. Though there is expected to be some habitat loss, impact on these species is deemed to be minor. This is because they are now considered moderately common as its host plant is frequently planted in the urban landscape and also observed in multiple locations across the Study Area.

ii) Birds

As some habitat loss is expected, the loss of ecological connectivity and injury/mortality from the construction of worksite are of minor impact significance for most of the bird species. However, species that rely on contiguous forests such as the thick-billed green pigeon (*Treron curvirostra*), rusty-breasted cuckoo (*Cacomantis sepulcralis*), straw-headed bulbul (*Pycnonotus zeylanicus*) and red-legged crake (*Rallina fasciata*) are expected to have moderate to major impacts from the loss of connectivity. In terms of injury/mortality, ground-dwelling species such as the red junglefowl (*Gallus gallus*) and red-legged crake have a moderate impact significance as they are unable to move away from construction activities as easily.

iii) Non-volant mammals

The Sunda pangolin (*Manis javanica*) species has been recorded from the nature reserves and degraded forest fragments in Singapore. Notably, Singapore is a global stronghold for the species and is crucial in contributing to the conservation of pangolin populations globally. Yet, habitat loss, degradation and fragmentation, and road kills threaten the viability of the national population. The worksite results in loss of small area of habitats. Based on distribution records, it seems to be using the entire Study Area. Loss of connectivity between the south and north portions of the Study Area might result in detrimental impacts to the pangolins using this area. Subsequently, the increased presence of vehicles may contribute to the increased incidence of roadkills due to the lack of safe wildlife crossings. Due to its conservation status nationally and globally, the loss of any individual would be significant. As habitat loss and mortality of fauna are permanent and irreversible, the impact intensity is considered medium to high, and the overall impact significance is moderate.

Although not a species of conservation significance, the Sunda colugo (*Galeopterus variegatus*) is a species of interest requiring additional mitigation measures and was observed within the worksite. Colugos are able to glide between tall trees, and suitable gliding spots are important for this species. Colugos are known to show fidelity to the trees that it uses, thus are susceptible to construction impacts. The worksite represents a loss of habitat and connectivity, as well as potential of injury/mortality for this species. Hence, impact intensity is expected to be high and the overall impact significance is moderate. Furthermore, impacts of disturbances to this species is unknown. It is a nocturnal species and will be subjected to disturbances from noise and light during the construction phase. The noise impact assessment for fauna is provided in Section 11.7.

iv) Bats

The cave nectar bat (*Eonycteris spelaea*) is expected to have moderate impact from the loss of ecological connectivity as it relies on contiguous forests, while still being able to exploit planted urban streetscapes outside its roosting site. A highly volant and nectarivorous generalist, habitat loss and injury/mortality for this species is of low impact significance.

Though some habitat loss is expected, the loss of ecological connectivity and injury/mortality from the construction of worksite is of negligible impact significance for the bamboo bats (*Tylonycteris* sp.) as none of their habitat are expected to be impacted.

7.8.1.2 Sites I and II

7.8.1.2.1 *Habitats*

Worksite does not overlap with habitats within Sites I and II. Therefore, impacts to the habitats from construction phase at A1-W2 is considered Negligible.

7.8.1.2.2 *Plants Species*

Worksite does not overlap with areas within Sites I and II. Therefore, impacts to the flora species within Site II and III from construction phase at A1-W2 is considered Negligible.

7.8.1.2.3 *Faunal Species*

A total of 14 faunal species recorded from Sites I and II were selected for the assessment of ecological impacts. The overall significance of the impacts is moderate for two species, minor for 11 species and negligible for one species.

The detailed evaluation of impact significance to each species is shown in Appendix R2. For all species, loss or reduction in habitats and food sources at Sites I and II has a negligible impact significance because the worksite does not overlap with areas within Sites I and II.

i) Butterflies

The most substantial impact significance on the butterfly species is minor as they are less susceptible to injury/mortality from construction activities and loss of connectivity.

ii) Birds

The straw-headed bulbul (*Pycnonotus zeylanicus*) and red-legged crake (*Rallina fasciata*) are species that highly depend on contiguous forests, and is hence expected to have a moderate impact from the loss of connectivity. For other species, impact due to injury/mortality and loss of connectivity is of minor impact significance.

iii) Non-volant mammals

Given that the Sunda pangolin (*Manis javanica*) has been recorded across Sites I and II, and Eng Neo Avenue Forest, the loss of connectivity between the south and north portions of Eng Neo Avenue Forest might result in detrimental impacts to the pangolins using this area. Moreover, the increased presence of vehicles may contribute to the increased incidence of roadkills due to the lack of safe wildlife crossings. As a result, the pangolin is expected to have moderate impacts from the loss of connectivity and from injury/mortality.

iv) Bats

Though some habitat loss is expected, the loss of ecological connectivity and injury/mortality from the construction of worksite is of negligible impact significance for the bamboo bats (Tylonycteris sp.) as none of their habitat are expected to be impacted.

7.8.1.3 Windsor

7.8.1.3.1 *Habitats*

The most substantive impact to the habitats from construction phase at Windsor is of major significance and is a result of vegetation loss. During construction phase, site clearance will result in removal of 1.5 ha (constituting 5.05% of the Study Area). Worksite consists of four habitat type, with high ecological value native-dominated secondary forest making up the largest proportion (0.22 ha; refer to Figure 7-126 for area directly impacted by construction works). Lower ecological value habitat type such as the managed vegetation habitat (low ecological value; priority 3) would still experience moderate impacts significance from the loss of vegetation.

The impact intensity of habitat degradation for abandoned-land forest is deemed to be minor because the work activities are relatively small-scale. However, the likelihood of habitat degradation impact differs for different habitat type depending on the proximity of habitat to worksite, because the abandon-land forest is adjacent to the worksite, likelihood is higher than the rest of the habitats not adjacent to worksite. Therefore, with minor intensity and likelihood of possible, the most substantive impact significance from habitat degradation impact would be minor to the abandon-land forest. While Windsor Nature Park and the D/S13 stream that resides within Windsor Nature Park is situated across Island Club Road, habitat degradation is considered less likely to occur at Windsor Nature Park and D/S13 stream.

Changes in species composition are also expected to occur with the presence of new forest edge. Intensity is co-related to the spatial extend of exposed forest edge while the likelihood differs for different habitat type depending proximity of habitat to worksite. Clearing of 1.5 ha for worksite within the native-dominated secondary forest would result in formation of a new edge that will be susceptible to changes in species composition; likelihood of impact occurrence is possible as this new edge now resides adjacent to the worksite. Therefore, with minor intensity and likelihood of possible, the most substantive impact significance from changes in species composition impact would be minor to the abandon-land forest. Habitat degradation and changes in species composition impacts were not evaluated for native-dominated secondary forest habitat type as all the habitat within Study Area has been cleared for worksite.

Summary of impact evaluation for the habitat at Windsor can be found in Appendix R3.

7.8.1.3.2 *Plant Species*

A total of 43 plant species recorded from Windsor were selected for the assessment of ecological impacts. The significance of the impacts is major for 10 species, moderate for 10 species, and minor for 23 species (Appendix R3).

Of the 10 species likely to experience major impacts, are of high ecological value likely to experience major impacts as a result of mortality.

1) The ten species likely to experience major impacts as a result of mortality are five nationally Vulnerable tree species (*Aporosa benthamiana*, *Elaeocarpus nitidus*, *Glochidion zeylanicum* var. *zaylanicum*, *Guioa oubescens*, and *Palaquium obovatum*), one nationally Critically Endangered climber species *Strophanthus caudatus*, three *Ficus* species (*F. benjamina*, *F. fistulosa*, and *F. microcarpa*), and one bamboo species Bambusa *multiplex*. All or more than 50% of all specimens of each species were found to be located within the A1-W1 worksite at base scenario in Windsor, giving an impact intensity of high or medium, respectively. Since it is almost certain that these specimens will be removed as site clearance is carried out for construction, the impact of mortality on these species is, thus, major.

Of the 10 species likely to experience moderate impacts, nine are of high ecological value while one is of medium ecological value (*Cyrtophyllum fragrans*).

1) The former nine are likely to experience moderate impacts as a result of mortality. The impacts for these species were assessed to be moderate for reasons similar to that of the ten species likely to experience major impacts; instead of having all or more than 50% of all specimens of each species located within the A1-W1 worksite at base scenario, there were only less than 50% of all specimens of each species found to be inside the worksite. This gives an impact intensity of the medium level. As such, the impact of mortality on these species is moderate.

2) The only species likely to experience moderate impacts as a result of competition from exotic species and decline in plant health and survival is the native common species *Cyrtophyllum fragrans*. All specimens of this species recorded at Windsor are located within 30 m from the A1-W1 worksite at base scenario, giving an impact intensity of high. As the habitats expected to be cleared for construction in Windsor are a mix of managed vegetation and forested areas, it is likely that some forest edges will be formed as a result of the clearance. Assuming that forest edge effects are the greatest in habitats within 30 m from the cleared areas, all the specimens of this species would experience competition from exotic species as the formation of forest edge habitats favours the growth of certain exotic plants. Additionally, changes in microclimatic conditions at forest edges may also cause a decline in plant health and survival of the specimens. As such, the impacts of competition from exotic species and decline in plant health and survival on these species is moderate.

Twenty-two out of 23 species likely to experience minor impacts are of high ecological value, while one (the exotic tree species *Pterocarpus indicus*) is of low ecological value. They are likely to experience minor impacts as a result of impediment to seedling recruitment, competition from exotic species, as well as decline in plant health and survival. The impact intensity of all three impact types is negligible or low for all species (except *Pterocarpus indicus*) since none or less than 50% of the specimens are located within 30 m from the proposed worksite, respectively. As such, the impacts are minor for all three types of impact. As for *Pterocarpus indicus*, the impact intensity is medium as more than 50% of all specimens of this species are located within 30 m from the proposed. Being an exotic species of low ecological value, however, lowered the overall impact significance to minor as well.

Detailed air quality impact on plant species was also conducted and discussed in Section 10.

7.8.1.3.3 *Faunal Species*

A total of 27 faunal species recorded from Windsor were selected for the assessment of ecological impacts. The overall significance of the impacts is major for five species, moderate for 15 species and minor for seven species.

Species of conservation significance or interest that are most impacted by the proposed worksites are the arboreal mammals. The worksite likely impacts a canopy connection at the eastern end of the worksite, which is important for arboreal fauna which requires it to move between forest patches. Examples are the Sunda slow loris (*Nycticebus coucang*) and Raffles' banded langur (*Presbytis femoralis femoralis*). Gliding arboreal mammals, namely the Sunda colugo (*Galeopterus variegatus*) and Horsfield's flying squirrel (*Iomys horsfieldii*). Major impact significance is expected for these species, except the colugo with a moderate impact significance. These are also subject to impacts from loss of habitat and connectivity, as well as disturbances in the form of light, noise and vibration from

night works. The impact assessment in terms of noise and vibration for ecologically sensitive receptors in Windsor is provided in Section 11.7 and Section 12.7 respectively.

Bird species impacted are likely able to find alternative habitats in the surroundings. However, impacts in the form of disturbances from noise, light and vibration are also expected. Impacts of these disturbances to fauna are unclear, but may affect communication with other individuals. Refer Section 11.7.1 and Section 12.7 for the ecological impact assessment of vibration and noise respectively, to fauna.

As stream habitats are not directly impacted by the worksites (refer to Section 8.7.1), the overall impact significance for most aquatic species is considered negligible or minor. This is with the exception of the dryad (*Pericnemis stictica*) which was observed within the worksite. Its impact significance is moderate

The detailed evaluation of impact significance to each species is shown in Appendix R3.

v) Odonates

The Malayan grisette (*Devadatta argyoides*) and blue-spotted flatwing (*Podolestes orientalis*) are aquatic species, so any changes to the aquatic habitat including hydrology, will be detrimental. However, these species were recorded in the streams outside of the proposed worksites, and outside of the impact zone. It is assumed that the species will not be affected by habitat loss or habitat degradation. It is also assumed that there is no change in hydrology to the stream. The impact intensity is negligible. Since it is less likely to occur, the overall impact significance is negligible.

On the other hand, the dryad (*Pericnemis stictica*) is recorded once within the forested area of the worksite. This species is known to breed in water-filled bamboo stumps. Given that this species is likely able to use other surrounding habitats, the impact intensity is considered medium. Given that impact is likely to occur, overall impact significance is moderate.

vi) Butterflies

The detached dart (*Potanthus trachala tytleri*) and common birdwing (*Troides helena cerberus*) have host plants that can be found extensively elsewhere. As they are volant and likely able to find alternative habitats within or adjacent to the Study Area, only negligible or minor impacts are expected.

vii) Freshwater decapod crustaceans and fish

The freshwater prawn (*Macrobrachium malayanum*), Malayan forest betta (*Betta pugnax*) and common walking catfish (*Clarias* cf. *batrachus*) are aquatic species so any changes to the aquatic habitat including hydrology, will be detrimental. However, these species were recorded in the streams outside of the proposed worksites. It is assumed that the species will not be affected by habitat loss or habitat degradation. It is also assumed that there is no change in hydrology to the stream. However, the streams lie within the 150 m impact zone and may be subjected to disturbances from vibration. Although impact intensity is high, it is considered less likely to occur, and the overall impact significance is minor.

viii) Amphibians

The cinnamon bush frog (*Nyctixalus pictu*) and golden-eared rough-sided frog (*Pulchrana baramica*) are species that utilise aquatic habitat; any changes to aquatic habitats including hydrology, will be detrimental. However, these species were only recorded through auditory calls along Windsor Nature Park's trail, outside of the proposed worksites. It is assumed that the species will not be affected by habitat loss or habitat degradation. It is also assumed that there is no change in hydrology to the stream. However, the streams lie within the 150 m impact zone and may be subject to disturbances from vibration. Although impact intensity is high, it is considered less likely to occur, and the overall impact significance is minor.

ix) Reptiles

All snakes were recorded within Windsor Nature Park, outside of worksite boundary, with the exception of the nationally Endangered black-headed collared snake (*Sibynophis melanocephalus*). It was observed dead on road along the western end of Island Club Road. Like all snakes, these are susceptible to roadkill accidents and therefore impact significance is assessed to be major (with high intensity and likely likelihood).

The Asian softshell turtle (*Amyda cartilaginea*) is a rare and restricted species that was recorded along the Windsor Nature Park stream; any changes to aquatic habitats including hydrology, will be detrimental. It is assumed that the species will not be affected by habitat loss or habitat degradation. It is also assumed that there is no change in

hydrology to the stream. However, the streams lie within the 150 m impact zone and may be subjected to disturbances from vibration. Although impact intensity is high, it is considered less likely to occur, and the overall impact significance is minor.

x) Birds

This red junglefowl (*Gallus gallus*) has adapted to disturbed habitats such as parklands and is increasingly more widespread. They may be able to use alternative habitats around the Study Area. Therefore, impacts to this species are considered minor for loss of habitat. However, as a ground-dwelling species, it is expected to have a moderate impact significance as it is more susceptible to injury/mortality from construction activities, like the red-legged crake (*Rallina fasciata*).

No nesting records were observed for the changeable hawk-eagle (*Nisaetus cirrhatus*) and it was observed on camera trap outside of the proposed worksites. It has adapted to disturbed habitats such as parklands and is increasingly more widespread. They are likely able to use alternative habitats around the Study Area. Hence the impact intensity is expected to be low and overall impact significance is moderate.

xi) Non-volant mammals

The Raffles' banded langur (*Presbytis femoralis femoralis*) was not recorded during our field assessment. However, it was recorded by ERM (2020). Ang & Jabbar (2020) highlighted the importance of canopy connections as it provides habitat connectivity for this species to cross between the northern and southern part of CCNR. This species is shy and known to exhibit habitual crossings at existing locations. A group of langurs were observed crossing from the Northern Forest Fragment to Windsor Nature Park (Ang & Jabbar, 2020), likely via canopy connections. Therefore, canopy connections along Island Club Road are important for this species. The worksite thus represents a loss of habitat and connectivity for this species. This species is considered nationally Critically Endangered and globally Near Threatened. Hence, impact intensity is considered high and overall impact significance is major.

The Horsfield's flying squirrel (*Iomys horsfieldii*) is a nocturnal arboreal fauna that is rare. This species was observed within the worksite. Flying squirrels are able to glide between tall trees, but canopy connections are important for arboreal fauna to cross between forest patches. It was not observed to use any canopy connections along the Island Club Road, but they remain important for this species. Due to the lack of other canopy connections and suitable gliding spots for this species along the Island Club Road, the canopy connection at the worksite is likely important. The worksite thus represents a loss of habitat and connectivity for this species and hence impact intensity is expected to be high and the overall impact significance is major.

The Sunda slow loris (*Nycticebus coucang)* is a nocturnal arboreal fauna that is rare. It is unable to glide and requires canopy connections to move between forest patches. During our field assessment, it was only recorded within Windsor Nature Park. However, it was documented within the worksite by ERM (2020). It was not observed to use any canopy connections along the Island Club Road, but they remain important for this species. Due to the lack of other canopy connections and suitable gliding spots for this species along the Island Club Road, the canopy connection at the worksite is likely important. The worksite thus represents a loss of habitat and connectivity for this species and hence impact intensity is expected to be high and the overall impact significance is major.

The Sunda pangolin (*Manis javanica*) species has been recorded from the nature reserves and degraded forest fragments in Singapore. Notably, Singapore is a global stronghold for the species and is crucial in contributing to the conservation of pangolin populations globally. Yet, habitat loss, degradation and fragmentation, and road kills threaten the viability of the national population. The presence of infants also suggests a breeding population in the Study Area. The worksite would result in a major loss of habitat for the species. Nonetheless, it is also able to cross the Island Club Road but the increased presence of vehicles may contribute to the increased incidence of roadkills due to the lack of safe wildlife crossings. Due to its conservation status nationally and globally, the loss of any individual would be significant. As habitat loss and mortality of fauna is permanent and irreversible, the impact intensity is considered high and the overall impact significance is major.

Although not a species of conservation significance, the Sunda colugo (*Galeopterus variegatus*) is a species of interest requiring additional mitigation measures and was observed within the worksite. Colugos are able to glide between tall trees, and suitable gliding spots are important for this species. Colugos are known to show fidelity to the trees that it uses, thus are susceptible to construction impacts. The worksite represents a loss of habitat and connectivity, as well as potential of injury/mortality for this species. Hence, impact intensity is expected to be high and the overall impact significance is moderate. Furthermore, impacts of disturbances to this species is unknown. It is a nocturnal species and will be subjected to disturbances from noise and light during the construction phase. The noise impact assessment for fauna is provided in Section 11.7.

During our field assessment, the lesser mousedeer (*Tragulus kanchil*) was only recorded within the Northern Forest Fragment, which lies outside of the 150 m impact zone of the worksite. However, it was also recorded within the Windsor Nature Park by ERM (2020). The mousedeer is shy in nature. It is expected to be subjected to partial habitat loss and connectivity impacts. For vibration impacts, it is anticipated that individuals of the lesser mousedeer would experience minor to moderate impacts after adopting the recommended mitigation measures, see Section 12 (Ground-borne vibration).

Additionally, as most of the non-volant mammal species are nocturnal, they are likely be subjected to disturbances from noise and light during the construction phase. The noise impact assessment for fauna is provided in Section 11.7.

7.8.2 Operational Phase

The various levels of impact intensity and likelihood for each impact type during the operational phase were specifically defined for plant species receptors.

Table 7-64 Definitions of Each Level of Impact Intensity for Two Impact Types during Operational Phase for Habitat Receptors

Impact type	Negligible	Low	Medium	High
Habitat degradation	Developed area is not accessible to public.	Developed area is not designed with the intention for the public to use or visit, but may increase human accessibility to the surrounding natural habitats.	Developed area is designed for members of the public to visit (e.g., parks with boardwalks)	Developed area is designed for large groups of people to live in in the long-run (e.g., residential estates)
Change in species composition	Development footprint is temporary and/or operational activities are fully underground (e.g., train alignment)	Development footprint is permanent and small relative to the size of the surrounding habitats (i.e., ⩽ 10%)	Development footprint is permanent and medium-sized relative to the size of the surrounding habitats (i.e., 10-40%)	Development footprint is permanent and large-sized relative to the size of the surrounding habitats (i.e., ≥40%)

Table 7-65 Definitions of Each Level of Likelihood for Two Impact Types during Operational Phase for Habitat Receptors

	Habitat Degradation	Change in Species Composition
Unlikely/Remote	Development is largely green (e.g., Thomson Nature Park)	Surrounding natural habitats are not accessible to public
Less likely/Rare	Development involves the building of urban infrastructures but will be heavily landscaped (e.g, Gardens by the Bay)	Surrounding natural habitats are less accessible and public use is restricted/controlled
Possible/Occasional	Development involves the building of infrastructure that are designed to release heat (e.g., ventilation shafts)	Surrounding natural habitats are accessible and have some infrastructure for the public to use, such as boardwalks (but people can still stray off track)
Likely/Regular	Development involves the building of extensive pavements, structures, and other infrastructures with surfaces that absorb and retain heat (e.g., residential estate)	Surrounding natural habitats are easily accessible and do not have infrastructure for the public to use, such as boardwalks (but people can still stray off track)
Certain/ Continuous	N.A.	N.A.

Table 7-66 Definitions of Each Level of Impact Intensity for Both Impact Types during the Operational Phase for Plant Species Receptors

Impact Type	Negligible	Low	Medium	High
Mortality	No plant specimens of this species could get stolen	Less than 50% of plant specimens of this species could get stolen (i.e., most plant species)	More than or exactly 50% of all plant specimens of this species could get stolen (i.e., orchids)	All plant specimens of this species could get stolen (i.e., pitcher plants)
Competition from Exotic Species	Only native species are planted (assume so for all projects by the NParks)	Exotic species listed as 'Cultivated Only' are planted	Exotic species listed as 'Casual' are planted (assume so for projects by the LTA, HDB, and/or other agencies)	Exotic species listed as 'Naturalised' are planted

Table 7-67 Definitions of Each Level of Likelihood for Both Impact Types during the Operational Phase for Plant Species Receptors

	Mortality	Competition From Exotic Species
Unlikely/Remote	Species not known to have been stolen before	Original vegetation mostly retained with no new landscaping
Less Likely/ Rare	N.A.	N.A.
Possible/ Occasional	Flowering species known to have been stolen before	Some original vegetation retained with some new landscaping (e.g., Springleaf Precinct, Rifle Range Nature Park)
Likely/ Regular	N.A.	N.A.
Certain/ Continuous	"Charismatic species" known to be stolen most of the time (i.e., pitcher plants and orchids)	Original vegetation mostly cleared with new large-scale landscaping (e.g., Tengah Forest Town)

Table 7-68 Definitions of Each Level of Impact Intensity for Two Impact Types during Operational Phase for Faunal Species Receptors

Impact Type	Negligible	Low	Medium	High
Injury or Mortality	Operation activities cause no injuries/deaths to the species.	Extent of injuries/ mortality arising from operation activities is low OR Species is able to move away from danger in operation activities relatively easily: – Volant species (e.g., odonates, butterflies, non-ground-dwelling birds, raptors and bats) – Pelagic species (marine context), ability to swim/crawl away quickly from danger (most fishes, crabs, shrimp) Low susceptibility to roadkills, poaching	Extent of injuries/ mortality arising from operation activities is medium OR Species is not able to move away from danger in operation activities very easily: – Amphibious aquatic species – All amphibians (frogs, lizards) – Mammals: squirrels, shrews – Species (marine context) with ability to swim/crawl away but not very quickly (slow moving marine creatures, slow swimming fishes, worms, snails)	Extent of injuries/mortality arising from operation activities is high – Has small population size – Birds, specifically migratory species OR Species is unable to move away from danger in operation activities easily: – Ground-dwelling birds – Reptiles (snakes) – Mammals: Pangolin, long-tailed macaque, otter – Sessile species (marine context) cannot swim away (coral, anemone), move extremely slowly (echinoderms, molluscs, seahorses)

Impact Type	Negligible	Low	Medium	High
		and/or collision with buildings	Possibly susceptible to roadkills, poaching and/or collision with buildings	High susceptibility to roadkills, poaching and/or collision with buildings
Loss of Ecological Connectivity for Faunal Movement	– Not dependent on connected and forested habitats for dispersal and able to traverse urban infrastructures;	– Slightly dependent on connected and forested habitats for dispersal and adaptable to traverse urban infrastructures if needed;	– Dependent on connected and forested habitats for dispersal;	– Highly dependent on connected and forested habitats for dispersal;

Table 7-69 Definitions of Each Level of Likelihood for Two Impact Types during Operational Phase for Faunal Species Receptors

Impact Type	Injury or Mortality	Loss of Ecological Connectivity for Faunal Movement
Unlikely/Remote	Impact is not expected to happen during the operational phase of the project	
Less Likely/Rare	Impact is not likely to happen during the operational phase of the project	
Possible/ Occasional	Impact could possibly happen or known to occur during the operational phase of the project	
Likely/Regular	Impact is a common occurrence during the operational phase of the project	
Certain/ Continuous	Impact is a continual or repeated process during the operational phase of the project	

7.8.2.1 Eng Neo Avenue Forest

7.8.2.1.1 *Habitats*

During the operational stage, only habitat degradation impact and changes in species composition impacts are expected to occur. Similar to the construction phase, likelihood depends on the proximity of receptors to, in this case, operational footprint. Operational footprint is much smaller than construction footprint as the area not used will be reinstated to managed vegetation (assuming to be turfed). Therefore, the habitats that used to be adjacent to worksite are not adjacent to operational footprint anymore.

Habitat degradation appears to be less likely to occur because of the 1. habitats will probably not be directly adjacent to station access as the reinstated area becomes a Buffer for these habitats, 2. public are not legally allowed to enter these adjacent habitats and pollute them and 3. operational works are at a much lower intensity than construction phase. Therefore, intensity of habitat degradation is deemed to be low; together with likelihood of less likely, impact intensity is at minor.

Species composition is likely to change for habitats that were once adjacent to worksite at the construction phase because a forest edge which has been exposed will almost always favour the growth of certain exotic plants and fauna and is more susceptible to accidental/purposeful (from humans) introduction of exotic species. Therefore, assessment remains as status quo from construction phase – minor impact significance.

Habitat degradation and changes in species composition impacts were not evaluated for managed vegetation habitat type as all the habitat within Study Area has been cleared during construction phase.

Summary of impact evaluation for the habitat at Eng Neo Avenue Forest can be found in Appendix R1.

7.8.2.1.2 *Plant Species*

A total of 67 plant species recorded from Eng Neo Avenue Forest were selected for the assessment of ecological impacts. The significance of the impacts is moderate for all 67 species, all of which are of high ecological value (Appendix R1).

The species are likely to experience moderate impacts as a result of competition from exotic plant species. It is assumed that casual species, i.e., species that “do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence” (Chong et al., 2009), would be planted as part of

landscaping efforts during the operational phase, giving an impact intensity of the medium level. This is a possible event as some original vegetation are expected to be retained, with some others cleared and replaced with landscaping. Hence, the impact of competition from exotic species is moderate.

7.8.2.1.3 *Faunal Species*

As the facility building during the operational phase is small and short, the most substantial impact on faunal species due to building collision, injury/mortality and loss of connectivity is minor.

7.8.2.2 Sites I and II

7.8.2.2.1 *Habitats*

Worksite does not overlap with habitats within Sites I and II. Therefore, impacts to the habitats from operational phase at A1-W2 is considered Negligible.

7.8.2.2.2 *Plant Species*

Worksite does not overlap with areas within Sites I and II. Therefore, impacts to the flora species within Site II and III from operational phase at A1-W2 is considered Negligible.

7.8.2.2.3 *Faunal Species*

As the facility building during the operational phase is small and short, the most substantial impact on faunal species due to building collision, injury/mortality and loss of connectivity is minor.

7.8.2.3 Windsor

7.8.2.3.1 *Habitat*

At the operational stage, only habitat degradation impact and changes in species composition impacts are expected to occur. Similar to the construction phase, likelihood depends on the proximity of receptors to, in this case, operational footprint. Operational footprint is much smaller than construction footprint as the area not used will be reinstated to managed vegetation (assuming to be turfed). Therefore, the habitats that used to be adjacent to worksite are not adjacent to operational footprint anymore.

Habitat degradation appears to be less likely to occur because of the 1. habitats will probably not be directly adjacent to station access as the reinstated area becomes a Buffer for these habitats, 2. public are not legally allowed to enter these adjacent habitats and pollute them and 3. operational works are at a much lower intensity than construction phase. Therefore, intensity of habitat degradation is deemed to be low; together with likelihood of less likely, impact intensity is at minor.

Species composition is likely to change for habitats that were once adjacent to worksite at the construction phase because a forest edge which has been exposed will almost always favour the growth of certain exotic plants and fauna and is more susceptible to accidental/purposeful (from humans) introduction of exotic species. Therefore, assessment remains as status quo from construction phase – moderate impact significance.

Habitat degradation and changes in species composition impacts were not evaluated for managed vegetation habitat type as all the habitat within Study Area has been cleared during construction phase.

Summary of impact evaluation for the habitat at Windsor can be found in Appendix R3.

7.8.2.3.2 *Plant Species*

A total of 43 plant species recorded from Windsor were selected for the assessment of ecological impacts. The significance of the impacts is moderate for 41 species and minor for the remaining two species (Appendix R2).

The 41 species are likely to experience moderate impacts as a result of competition from exotic species. All 41 species are of high ecological value. It is assumed that casual species, i.e., species that “do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence” (Chong et al., 2009), would be planted as part of landscaping efforts during the operational phase, giving an impact intensity of the medium level. This is a possible event as some original vegetation are expected to be retained, with some others cleared and replaced with landscaping. Hence, the impact of competition from exotic species is moderate.

The last two species are likely to experience minor impacts as a result of competition from exotic species. They are the native common tree species *Cyrtophyllum fragrans* of medium ecological value and the exotic tree species *Pterocarpus indicus*, which has low ecological value. Nonetheless, they could still face competition from other exotic species planted as part of landscaping efforts. Hence, the impact of competition from exotic species is minor.

7.8.2.3.3 *Faunal Species*

At the operational stage, ecological connectivity is expected to remain as in construction phase before spontaneous vegetation and over a long time restore the connectivity that has been lost. Assuming no mitigation measures applied, major impact from loss of connectivity in the construction phase to faunal species would extend into the operational phase. However, the intensity of mortality from roadkill is expected to be reduced resulting in minor impact significance. Subsequently, impacts from collisions with the facility building are of negligible impact significance as the infrastructure is relatively small and short.

Ecological impacts to fauna are assessed to be negligible to minor from vibrations (see Section 12.7) and noise (see Section 11.7) generated during operational phase (respectively).

7.9 Recommended Mitigation Measures

In this section, mitigation measures for the Project are discussed. Mitigation measures are implemented in the following order: (1) avoidance (elimination), (2) minimisation (substitution, engineering controls and administrative controls), and (3) compensation and enhancement. Avoidance of the impact is first attempted. If avoidance is not possible, the construction impacts will be minimised. Finally, if habitat loss must occur, compensation and enhancement of remaining/nearby habitats will be suggested as a form of impact mitigation.

It is important to note that the successful implementation of mitigation measures requires the commitment of Contractors, arborists, and biodiversity specialists. Some of the major concerns around this proposed Project include habitat loss, habitat connectivity and potential fauna mortality.

7.9.1 Mitigation at Design Phase

Although impacts only occur downstream (i.e., construction phase onwards), the design stage is of paramount importance. The design can significantly influence the extent of impacts, as the structural design will dictate the location of structures, construction methods and the intensity of impacts caused during the construction and operational phases.

7.9.1.1 Eng Neo Avenue Forest

7.9.1.1.1 *Avoidance (Elimination)*

- It is recommended to shift the A1-W2 worksite away from Eng Neo Avenue Forest as it is currently situated on areas of high conservation value. Furthermore, the shift is recommended to avoid fragmenting the forest into two, resulting in significant impacts to loss of connectivity for both floral and faunal species.
- To mitigate biodiversity impacts on to ecological valuable habitats, LTA has agreed to shift construction works, completely removing A1-W2 worksite from Eng Neo Avenue Forest (Figure 7-121).

A

B

Eng Neo
Avenue Forest

Site II

Site I

Site I

0 100 200 m

Legend

- Study Area
- Worksite and alignment

Vegetation

- Native-dominated secondary forest
- Mixed forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Windsor Nature Park
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	JW	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**(A) CURRENT A1-W2 AND (B)
RECOMMENDED DESIGN SHIFT IN A1-W2**

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JW	JAG	JAG	7 - 121	-	1 of 1
	Drawn JW	Date JUN 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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7.9.1.2 Sites I and II

As part of the main mitigation measure, the base worksite in Eng Neo Avenue Forest has been shifted to Sites I and II. This mitigation worksite has been designed to avoid areas of high conservation value within Sites I and II as much as possible, resulting in mitigated worksite scenario presented in Figure 7-121.

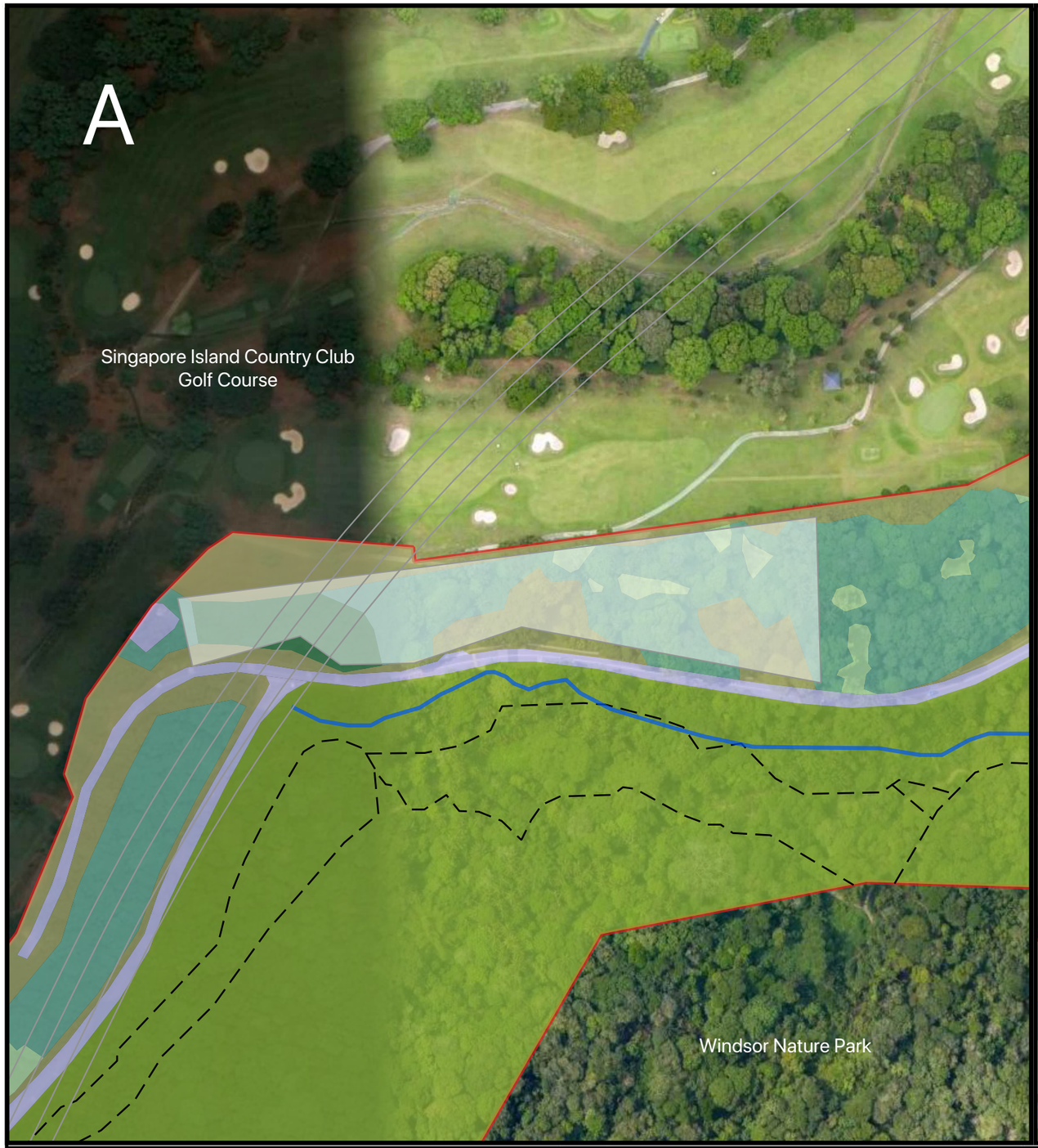
Subsequently, as there is no facility building at the operational phase, mitigation at the design phase is not applicable here.

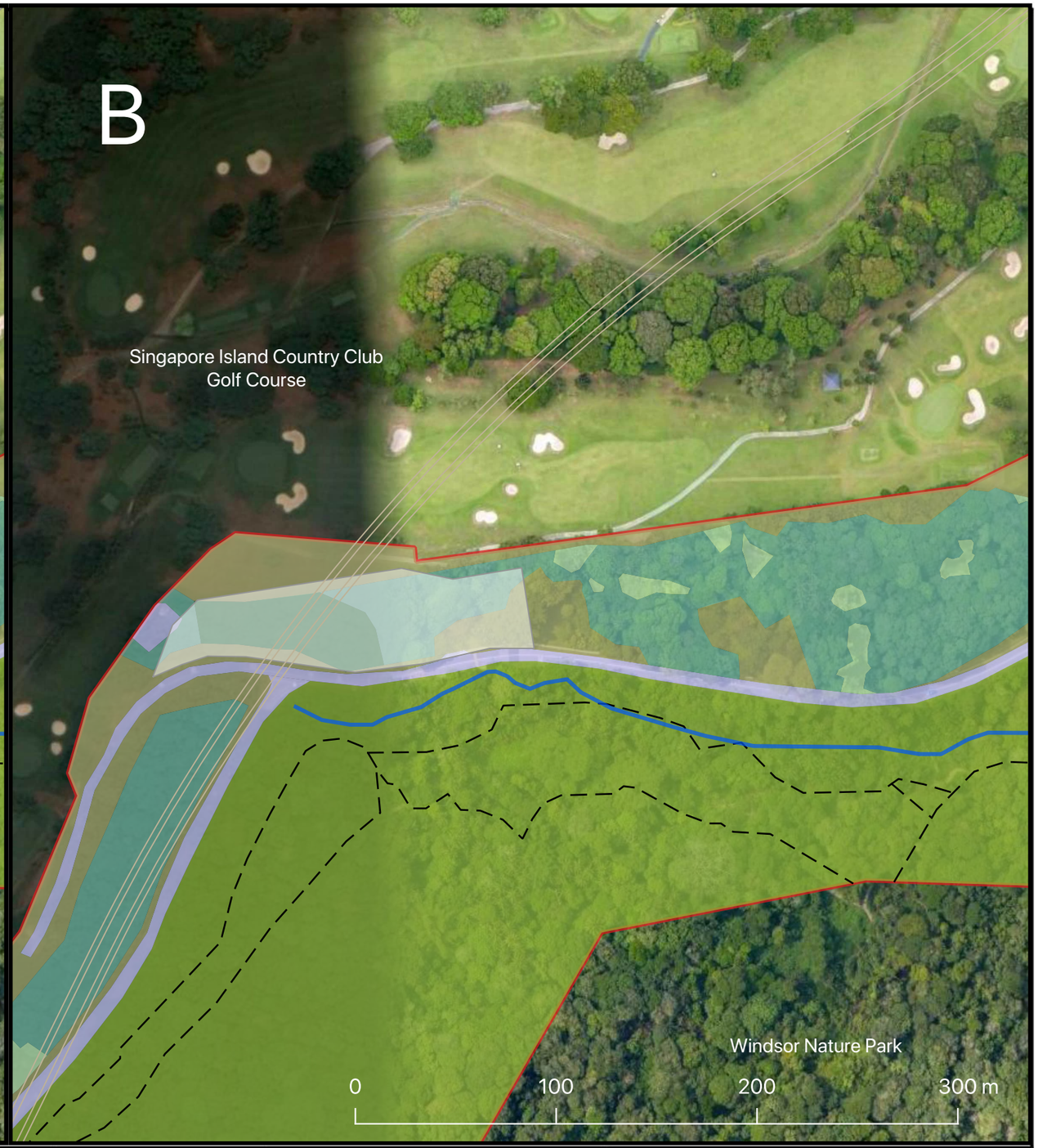
7.9.1.3 Windsor

7.9.1.3.1 *Avoidance (Elimination)*

- To prevent fauna entrapment, facility building should have no opening where fauna can be trapped. Alternatively, the perimeter of the facility building can be fenced up to prevent fauna entry. Propose fencing should ensure that the lower sections are covered to prevent fauna (such as snakes and pangolins) moving under the fence. The covered sections should also be smooth to prevent fauna (such as pangolins) from climbing over and bridging the fence. The proposed fencing design should also not have razor or sharp blades at the top to prevent injuring arboreal wildlife such as colugos. The covered sections should be at least 0.5-m to 1-m tall. Refer Figure 7-122 to as an example.
    - Currently, the worksite is situated on areas categorised as high conservation value and along at least one canopy connection (Figure 7-117). It is recommended to
        - Shift the A1-W1 worksite away from canopy connection
        - Optimise worksite to avoid clearing high conservation value habitats such as the native-dominated secondary forest.
    - To mitigate biodiversity impacts on the canopy connection and ecological valuable habitats, LTA has agreed to shift construction works away from the canopy connection and optimise the worksite, reducing worksite by more than half the original size (0.8 ha) (Figure 7-123).

Figure 7-122 Example of Proposed Fencing for Perimeter of Facility Building at A1-W1





Legend

- Study Area

Vegetation

- Native-dominated secondary forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Managed vegetation
- Others - infrastructure
- Windsor Nature Park
- Waterbody
- Boardwalk
- Worksite and alignment

N

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	SS	EIS (Windsor and Eng Neo Avenue Forest)	JAG	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
(A) CURRENT A1-W1 WORKSITE AND (B) RECOMMENDED DESIGN SHIFT IN A1-W1

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SS	JAG	JAG	7 - 123	-	1 of 1
	Drawn SS	Date JUN 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

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7.9.1.3.2 *Minimisation (Substitution)*

- Bird collision can be reduced by substituting certain aspects of the building design with bird-friendly building design. Bird-friendly building design can significantly reduce the incidences of bird collisions, especially for higher storeys that are above tree canopy height. Although the proposed facility building does not appear to be higher than two storeys, because of the proximity of these buildings to forested areas, bird collisions are still possible. Some recommendations are stated here (Sheppard & Phillips, 2015):
    - Minimise the quantity or surface area of glass. This could be achieved by reducing the amount of glass façade or installing a decorative cladding over the glass façade so that the reflections on the glass facades are broken up.
    - Incorporate features that increase the visibility of glass (including mirrored and non-mirrored reflective glass, and transparent glass) or dampen reflections to reduce the appearance of clear passage to sky or vegetation. Possible strategies include film e.g., CollidEscape; http://www.collidescape.org), angled glass, interior or exterior shades, decals, fenestration patterns, grilles, sunshades, screens, blinds, and netting. Exterior shades confer the freedom of choosing to only use it during periods where bird collisions are expected to be most frequent, such as during the migratory seasons.
    - When decals or patterns are added to increase the visibility of the glass, it is advised that the pattern should be as dense as possible as it will appear more clearly as a solid object to birds and thus be more effective (Green Development Standard, 2007). For example, for WindowAlert decals, it is recommended for decals to be 5cm apart horizontally and 10-cm apart vertically (FLAP, n.d.).
    - Avoid interior vegetation near windows as birds may confuse this with exterior vegetation and fly towards them.
    - Avoid planting vegetation close to glass so that reflection of vegetation does not confuse birds, which may fly into the building. If there are sides which are close to the natural vegetation, the façade should have shades installed or netting that are a short distance away from the glass to prevent birds from crashing into it.
    - Buildings should not have courtyards or corridors that are enclosed by glass as these may confuse birds to fly through.

7.9.1.3.3 *Minimisation (Engineering Controls) / Enhancement*

- Given that the development will still be near existing forest, it is important that the development is as green as possible. Besides making it aesthetically more pleasing, doing so might facilitate the movement of fauna between green patches and might enhance biodiversity if implemented properly. This can be done via landscaping and planting on the reinstated areas.
- On the ground, considerations for increasing connectivity include:
    - Plant keystone flora such as fig trees. These trees have uncoordinated fruiting periods but fruit abundantly when in season. Fig trees are important food source for avian fauna and small mammals. In addition, planting of flowering plants will attract the pollinators such as butterflies, bees, wasps and improve ecological processes.
    - Increase vertical vegetation structures (i.e., ground cover, shrub, understorey, and canopy layers) and forms (e.g., epiphytes, shrubs, ferns, trees).
    - It is recommended that only native plant species are planted because they are genetically representative of the region's biodiversity and higher conservation value.
    - Select a diversity of flowering and fruiting plant species to include butterfly and bird attracting plant species. The planting palette should be planned for continuous flowering and fruiting throughout the year to provide food and improve ecological processes. However, planting location of bird attracting species should take into consideration bird collisions recommendations.
    - Prioritise intensive greening along streets or in areas with low disturbances (e.g., low traffic volumes and speeds, low human activities).

7.9.2 Mitigation in Construction Phase

Mitigation measures stated here should be relevant for all the Study Areas and enforced if applicable. Most of the mitigation measures stated have overlapping and cascading effects on other impacts. For example, by reviewing the construction footprint primarily reduces working space and the need for vegetation removal. Subsequently, this would also reduce other potential impacts such as habitat degradation, flora mortality, and the loss of/reduction in habitats and food sources for fauna etc. Therefore, the relevant mitigation measures proposed should be implemented as good practice even if the impacts were evaluated as insignificant (i.e. Negligible or Minor).

7.9.2.1 Flora

7.9.2.1.1 *Avoidance (Elimination)*

- Ensure there are no works and disturbances to areas outside of worksite, especially into areas of high conservation value as shown in Section 7.5 (Eng Neo Avenue Forest – Figure 7-115, Sites I and II – Figure 7-116 and Windsor – Figure 7-117). This includes prohibiting workers access to Windsor Nature Park for any reasons.

- Ensure any associated slope stabilisation and grading works will not impact topography of areas outside worksite and, water quality and hydrology of the waterbodies within the Study Area; this includes Windsor Nature Park for any reasons. The proposed 30-m buffer to waterbodies and areas of high conservation value should be observed at all times (Eng Neo Avenue Forest – Figure 7-115, Sites I and II – Figure 7-116 and Windsor – Figure 7-117).

- Consider engaging arborists, flora and fauna specialists to clearly mark out areas and plants with conservation value before the start of works. This would minimise the working space, reduce the disturbance to adjacent forested areas and eliminate the need of removing specimens of value and plants of conservation significance as much as possible. It is important to conserve large trees and fruit trees as they serve important ecological processes and, provide habitat and food for faunal species. This includes trees with active bird's nest.

- To eliminate the need of removing bamboo clusters found within worksites as they are found to be potential roosting sites for the Critically Endangered bamboo bats (*Tylonycteris spp.*). Proper Tree Protection Zones (TPZs) should be established to ensure proper conservation of these bamboo clusters. For more information, refer to the Bamboo Bats in Section 7.9.4.

7.9.2.1.2 *Minimisation (Substitution, Engineering and Administrative Controls)*

- Transplant or harvest trees/saplings of conservation significance instead if they have to be cleared, e.g., the *Plegmariurus carinatus* on a rain tree (*Samanea saman*) near the Riders' Cafe.

- Erect Tree Protections Zones to prevent encroachment of construction activities and excessive vegetation clearance around retained trees or areas (if any).

- Conduct regular inspections to ensure the Contractor's compliance and identify any impacts to the adjacent forest areas.

7.9.2.2 Fauna

7.9.2.2.1 *Avoidance (Elimination)*

- It is recommended to avoid felling trees and clearing vegetation during the peak bird breeding season (March to July).

7.9.2.2.2 *Minimisation (Substitution, Engineering and Administrative Controls)*

- Wildlife shepherding via directional clearing should be adopted over the usual site clearance (Figure 7-124). This entails clearing the site from built up areas towards forested refuge areas to avoid trapping ground-dwelling mammals within the site. Additionally, it is crucial to ensure that hoarding be set up along worksite boundary adjacent to the road (if any) to prevent fauna from being displaced onto the road during the wildlife shepherding. This should be planned and overseen by an Ecologist.

- Pre-felling fauna inspection should be conducted before felling any trees or removing any vegetation. This should be planned and overseen by an Ecologist.

- Noisy work activities should only be allowed from 0900–1700-h.

- Above-ground works not critical for safety reasons should be avoided to prevent disturbance to nocturnal fauna; recommended to restrict working hours to 0700–1900-h. Animals perceive light differently from humans. Any level of artificial light above that of moonlight masks the natural rhythms of lunar sky brightness and thus, can disrupt patterns of foraging, mating, as well as the circadian rhythm (Voight et al., 2018). Artificial lighting at night (ALAN) can disorient birds, bats and insects, altering their behaviour that results in them being more vulnerable to predation and other risks (Blackwell et al., 2015). For example, ALAN may repel light-adverse bats from lit areas and restrict their use of commuting or feeding space. If night-time works are essential, it is recommended to adopt the following framework:

    1. Prevent areas from being artificially lit, where lighting should only be installed when necessary.
    2. Limit the duration of lighting, where peak nocturnal fauna activity is avoided.
    3. Reduce the trespass of lighting. This can be done via the use of a minimal number of luminaires, at low positions in relation to the ground, directed and shielded to provide the least amount of spill to adjacent habitats while achieving the necessary lighting levels for working safely (Figure 7-125 and Figure 7-126). Accessories such as baffles, hoods or louvres can be used to reduce light spill and direct it only to where it is needed (ILP, 2018).
    4. Change the spectrum of lighting. Lights with reduced or filtered blue, violet and ultra-violet wavelengths should be used. Short wavelength light (blue) scatters more readily in the atmosphere and therefore contributes more to sky glow than longer wavelength light. Furthermore, most wildlife is sensitive to short wavelength (blue/violet) light. Therefore, as a general rule, only lights with little or no short wavelength (400–500 nm) violet or blue light should be used to avoid unintended effects. Where wildlife is sensitive to longer wavelength light (e.g. some bird species), consideration should be given to wavelength selection on a case by case basis. It is also recommended that warm colour temperature light sources to be employed preferably at <2,700 Kelvin.
    5. Setting dark buffers, illuminance limits and zonation.
    6. Species-specific strategy.

- Subsequently, if night-time works are essential, noise impacts from night work would need to be kept to the minimal as well. Measures should be adopted as specified in Section 11.8.
- Multiple roadkill accidents have occurred along Fairways Drive at Eng Neo Avenue Forest and Island Club Road at Windsor. It is recommended to adopt road calming measures such as speed bumps, coupled with other mitigation measures such as restriction on speed of vehicles and working time (Figure 7-127). This can include sequencing of trucks leaving the worksite to reduce the number of trucks on the road at one time and the possible use of tri-axle trucks with larger capacity to reduce number of trips. Measures stated here should also be applicable to the work access road located adjacent A1-W2 worksite at Sites I and II.
- Retain ground cover for as long as possible before removal. When ground cover is removed, earth control measures (ECM) are to be in place. Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes, with reference to specification in Appendix BB.
- Train site personnel on biodiversity awareness and actions to take when encountering wildlife.
- Ensure good housekeeping controls such as provision of wildlife proof bins and eating areas.
- Execute fauna response—as specified in Appendix K—and rescue protocol when fauna is found on-site.
- Monitor the water quality and aquatic faunal community in retained streams and streams adjacent to the construction areas.
- Ensure silt fences or other silt control measures along the site hoarding are installed and maintained properly.
- Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies.
- Engage a Qualified Erosion Control Professional (QECP) to formulate and implement ECM plan in accordance with PUB requirements.
- Implement dust control measures such as dust screens and water suppression systems as specified in Section 10.8.

- Implement acoustic barriers to reduce noise pollution outside worksites as specific in Section 11.8.
- Conduct regular site inspections to ensure the Contractor's compliance and to identify potential fauna entrapments.
- Carry out monitoring of vibration, noise and light levels (see Section 13.6.1.3) with regards to the estimated densities, occupancy or site usage (as directed by Engineer) of mousedeer and pangolins during construction stage to understand actual impact to these species.

FORESTED AREA ADJACENT TO FAIRWAYS QUARTERS

Site II

Site I

0 100 200 m

WINDSOR

0 100 200 m

Legend

- Study Area
- Worksite and alignment (Mitigated)
- Boardwalk
- Direction of clearance

Vegetation

- Native-dominated secondary forest
- Mixed forest
- Abandoned-land forest
- Scrubland and herbaceous vegetation
- Windsor Nature Park
- Managed vegetation
- Waterbody
- Others (infrastructure)

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement :
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Land Transport Authority — We Keep Your World Moving

Project Title :
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Figure Title :
SHOWING DIRECTION OF CLEARING AT (A) FORESTED AREA ADJACENT TO FAIRWAYS QUARTERS AND (B) WINDSOR

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
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Figure 7-125 Low Level Bollards Directed Downwards and Shielded to Limit Lighting to Only the Area Intended

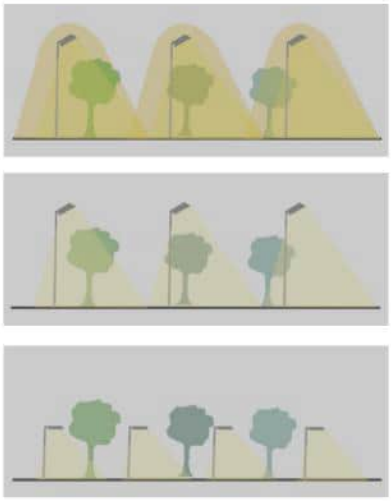

Figure 7-126 Combined Effect of Shielded Luminaires and Short Poles on Reducing Light Trespass. First Picture—Unshielded Luminaires, Second—Luminaires with Shield, Third—Shielded Luminaires on Short Poles Which Cut-Off Light Trespass and Keep Adjacent Areas Dark.

Figure 7-127 Examples of Road Calming Measures that Can be Implemented at Eng Neo Avenue Forest and Windsor

7.9.3 Mitigation in Operational Phase

Mitigation measures stated here should be relevant for all the Study Areas and enforced if applicable. However, most of the strategies for avoidance (elimination) and enhancement should have been considered during the design phase. Minimisation (substitution, engineering controls and administrative controls) would be the most applicable at the operational phase.

7.9.3.1 Flora

- Areas not used should be returned to earth ground and replanted if possible. Planting scheme should be as similar to forest composition to adjacent forest, if not as native as possible. Other than minimising edge effects, it can serve as a natural barrier to light, noise, and dust to reduce disturbance. As a general guide, 400 trees should be replanted for every hectare to be reinstated.

- Conduct regular site inspections at least during the first six (6) months of the commissioning phase to ensure that proposed planting/mitigating measures are effective and to identify any impacts to the adjacent forest areas.

7.9.3.2 Fauna

- Specific to Windsor, the idea of reforestation on the eastern portion of the Northern Forest Fragment is recommended. This adopts the recommendation from Dr Andie to help improve the continuous forest connectivity between Lower Peirce Reservoir Park in the north and Windsor Nature Park in the south for the Raffles' banded langur and other arboreal animals can move within CCNR particularly across the gap in SICC (Ang and Jabbar, 2019). However, there are a few challenges that needs to be consider:

    1. From Windsor leading up to Lower Peirce Reservoir, it is important to take note that vegetation along Upper Thomson Road is sparse (only 15m at its widest) and would not make a good/attractive green corridor for fauna to utilise. At least a 30-m wide vegetation strip is recommended. This would require reforesting about 15-m of SICC's land (Figure 7-128).

    2. Further down from the thin strip of vegetation along Upper Thomson Road, before reaching Lower Peirce Reservoir, bridging over Kallang river canal is required (Figure 7-129).

    3. It is recommended that conservation significant floral species harvested within worksite be replanted in this area if suitable.

    4. More importantly, there is a need for inter-agencies to work together due to the different land ownership. It should be noted that this is not a project that can be conducted by LTA alone, in-depth discussion is expected across agencies for such a recommendation to be feasible.

- Conduct regular site inspections at least during the first six (6) months of the commissioning phase to ensure that proposed mitigating measures are effective and to identify any impacts to the adjacent forest areas. Key species such as the straw-headed bulbul (*Pycnonotus zeylanicus*), Sunda pangolin (*Manis javanica*) and the Sunda colugo (*Galeopterus variegatus*) should be monitored. This will contribute to evaluating the actual impact of the developments. Please refer to Section 13.6.1.3 for monitoring of mousedeer and pangolin activity levels in relation to vibration, noise and light levels.

Figure 7-128 Area Suggested by Dr Andie to Reforest. Red Box Indicated Windsor Study Area (including Worksite). (Source: Ang And Jabbar, 2019).

Figure 7-129 Thin Strip of Vegetation along Upper Thomson Road and Canal that Needs to be Bridged Over

7.9.4 Mitigation Measures for Specific Fauna

Several threatened faunal species have been recorded at multiple Study Areas. These include the straw-headed bulbul (*Pycnonotus zeylanicus*), Sunda pangolin (*Manis javanica*) and the arboreal mammals such as Sunda colugo (*Galeopterus variegatus*), Raffles' banded langur (*Presbytis femoralis femoralis*), Horsfield's flying squirrel (*Iomys horsfieldii*). Broadly, mitigation measures to protect threatened faunal species include retaining habitats and food sources, maintenance/enhancement of ecological connectivity and promotion of wildlife-friendly building design. The mitigation measures for specific faunal species are listed below and should be applied at areas where they are recorded, on top of general mitigation measure that have been mentioned in the section above.

Straw-headed bulbul

- Retain fruit and fig trees, which are known food sources. Some examples are *Leea indica*, *Bridelia tomentosa*, *Clausena excavata*, *Dillenia suffruticosa* and *Ficus spp.* (LCKNHM, 2020b).
- Include fruit and fig trees (known food sources) as part of the native planting palette when replanting the area in the operational phase.

Sunda pangolin

- Retain large trees (≥ 0.5cm DBH) and fallen logs which are known to be used by the pangolin for their natal dens (Lim & Ng, 2007).
- If their habitat is fragmented, it is recommended to construct an underpass such as a culvert. Pangolins are known to have a wide distribution range, to prevent roadkill and facilitate the pangolin's movement, culverts have been proven to be useful in maintaining ground connectivity for this species. It has been observed at Old Upper Thomson Road and Rifle Range Road, where they have been recorded to be using the culverts. This allows them to safely cross the roads, restoring/enhancing the connectivity between the populations on either side of the road. As pangolins have been recorded at both Eng Neo (Eng Neo Avenue Forest, Sites I and II) and Windsor, this mitigation measure is applicable to both areas.
- Culvert at Windsor:
    1. Records of pangolins across Windsor Study Area (Northern Forest Fragment and Windsor Nature Park) from the field survey, suggest the use of a passing under Island Club Road that seems to be a drain made for the purpose of connecting waterflow from the Northern Forest Fragment to Windsor Nature Park stream (Figure 7-120) by pangolins. As currently the underground passing is slightly exposed, more vegetation can be provided on both sides subject to authority's approval, but the planting should not be too dense and still allow light to pass through without affecting the flow capacity of the culvert.
    2. *Melastoma malabathricum*, *Cyathea latebrosa*, *Blechnum orientale*, *Ficus alba*, *Ficus fistulosa* and *Dillenia suffruticosa* are some of the recommended plants to be used for enhancement planting. Planting (subject to authority's approval) should start from the forest edge (this includes both the Northern Forest Fragment and Windsor Nature Park side) towards the culvert and should also be carried out 5 m from the side of the culvert.
    3. In addition, a barrier should be installed along the length of the road to "lead" pangolins to the culvert so that they do not cross the roads and potentially end up as roadkill. Barriers should be at least 0.5 m and up to 1 m in height, with an overhang and made of a smooth material to prevent pangolin from scaling it (Figure 7-132). This will also be useful to minimise roadkill of snakes
- Culvert at Sites I and II:
    1. Records of pangolins across Eng Neo, particularly Sites I and II, suggest that the pangolins are crossing the Fairways Drive Road. To prevent roadkill incidents at construction phase, it is recommended to install a culvert along the Fairways Drive Road between Sites I and II (Figure 7-131).
    2. In addition, a barrier should be installed along the length of the road to "lead" pangolins to the culvert so that they do not cross the roads and potentially end up as roadkill (Figure 7-131). Barriers should be at least 0.5 m and up to 1 m in height, with an overhang and made of a smooth material to prevent pangolin from scaling it (Figure 7-132). This will also be useful to minimise roadkill of snakes.

- Culverts and road calming measures proposed here would also mitigate for mortality and/or injury roadkill impacts on other ground-dwelling faunal species such as snakes, civets, long-tailed macaques (*Macaca fascicularis*), wild pigs (*Sus scrofa*), and the less mousedeer (*Tragulus kanchil*).

Figure 7-130 Underground Passing under Island Club Road at Windsor

Figure 7-131 Location of Culvert and Barrier along Fairways Drive Road

> **Fencing design options.** (*Left*) On US Highway 441, Florida, a concrete barrier wall with lip limits access to roadways. (*Right*) Metal flashing is designed to funnel animals, especially reptiles and amphibians, to a highway crossing grate (photos by Marcel Huijser).

Figure 7-132 Recommended Barrier Design to be Implemented along Fairways Drive Road

(Source: Green Infrastructure Design For Transport Projects, Asian Development Bank 2019)

Raffles' banded langur

- The Raffles' banded langur specifically requires canopy connection to from place to place and this includes crossing from the Northern Forest Fragment (on the SICC side) to Windsor Nature Park across Island Club Road. Therefore, it is of utmost importance that this feature is provided along the Island Club Road. If canopy connections are disturbed, compensatory measures such as a rope bridges may replace its function (Figure 7-133). Refer to Appendix S for specifications of proposed rope bridge.

- Due to the optimisation of the worksite at mitigated phase, existing canopy connection will not be lost. However, to safeguard this important canopy connectivity between the Northern Forest Fragment (on the SICC side) to Windsor Nature Park, three rope bridge locations have been proposed along Island Club Road (Figure 7-134). The bridges should be a hybrid between a rope ladder and ropeway to accommodate for the different arboreal mammals and their movement behaviour – rope ladders for langurs and macaques, and ropeways for slow lorises. Glider poles should also be integrated to function as vertical poles that act as artificial trees to provide launching and landing points for arboreal and gliding species like colugos, as well as for securing the arboreal rope bridge. It is important to note that locations are tentative and have to be refined before placement with the Contractor and engineer on site; including design of the rope bridges.

- Refer to Table 7-70 for justification behind each rope bridge location. These proposed locations would still require LTA and technical agencies such as NParks to finalise prior to construction of the rope bridges.

- Rope bridges proposed here would also mitigate for the loss of ecological connectivity along Island Club Road, and for other non-gliding mammals which uses canopy connection such as the long-tailed macaque (*Macaca fascicularis*).

- Retain trees known to be their food source such as rubber tree (*Hevea brasiliensis*), *Adinandra Dumosa* and fruits like rambutan (*Nephelium lappaceum*) (Ang 2010).

Sunda slow loris

- The Sunda slow loris also specifically requires a contiguous forest and complete canopy connection to move around, including the crossing from the Northern Forest Fragment (on the SICC side) to Windsor Nature Park across Island Club Road. Unlike the langurs and macaques, slow lorises cannot leap from tree to tree and can only walk hand over hand along branches. Therefore, it is of utmost importance that this feature is accounted for and provided along the Island Club Road. If canopy connections are disturbed, compensatory measures such as rope bridges (ropeway) may replace its function.

- Due to the optimisation of the worksite at mitigated phase, existing canopy connection will not be lost. However, to safeguard the important canopy connectivity between the Northern Forest Fragment (on the SICC side) to Windsor Nature Park, three rope bridge locations have been proposed (Figure 7-134). The bridges should be a hybrid between a rope ladder and ropeway to accommodate for the different arboreal mammals and their movement behaviour – rope ladders for langurs and macaques, and ropeways for slow lorises. Glider poles should also be integrated to function as vertical poles that act as artificial trees to provide launching and landing points for arboreal and gliding species like colugos, as well as for securing the arboreal rope bridge. It is important to note that locations are tentative and have to be refined before placement with the Contractor and engineer on site; including design of the rope bridges.
- Refer to Table 7-70 for justification behind each rope bridge location. These proposed locations would still require LTA and technical agencies such as NParks to finalise prior to construction of the rope bridges.
- Rope bridges proposed here would also mitigate for the loss of ecological connectivity along Island Club Road, and for other non-gliding mammals which uses canopy connection such as the long-tailed macaque (*Macaca fascicularis*).
- Retain or plant trees known to be their food source in the region such as *Acacia decurrens*, *Prunus polystachya*, *Calliandra calothyrsus* (Fransson 2008). However, their diet in Singapore is still not specifically known.

Table 7-70 Justification of Rope Bridge Locations

Rope Bridge Location	Justification	Photos
RB_01	Raffles banded langurs, Sunda colugos, flying squirrels and Sunda slow lorises have been sighted along this stretch, indicating the potential use of the stretch (refer to Section 7.3.4.3.11). There is currently no canopy connection. However, existing site condition of the canopy has potential for a natural canopy to form if not for the constant pruning of trees. By placing one here, this can act as an enhancement measure to improve connectivity along this stretch. Existing landscape is a line of planted coconut trees running parallel to the road which can act as poles for the bridge (i.e. no poles are needed for the rope bridges; rope bridges will be attached directly to the trees).	 

Rope Bridge Location	Justification	Photos
RB_02	Location proposed is existing canopy connection. However, it is pruned regularly. By placing a rope bridge nearby, helps to ensure a permanent connection for arboreal mammals.	 
RB_03	Currently, landscape on either side of the road is relatively open. Rope bridge must be accompanied by enhancement planting.	 

Figure 7-133 Raffles' Banded Langur Using Rope Bridges at Old Upper Thomson Road

Desmond Lee/Facebook - https://www.straitstimes.com/singapore/environment/sighting-of-endangered-monkeys-using-rope-bridge-to-cross-road-gives-hope

Legend

- Study Area
- Worksite and alignment (mitigated)

Vegetation

- Native-dominated secondary forest
- Abandoned-land forest
- Waste woodland
- Scrubland and herbaceous vegetation
- Managed vegetation
- Waterbody
- Others (infrastructure)

- Boardwalk
- Canopy connections
- Proposed rope bridge stretch
- Tentative rope bridge location

N

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Land Transport Authority
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Figure Title :
PROPOSED LOCATIONS WHERE ROPE BRIDGES CAN BE PLACED ALONG ISLAND CLUB ROAD

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Bamboo Bats

Translocation of specific species may be considered as a last measure if the original habitats cannot be retained. However, these measures are not considered to lower the impact significance of the works as the success rate of the translocation exercise cannot be secured. Many environmental factors have to be considered and cannot be pre-determined. For example, the sex and number of individuals captured for the translocation exercise, finding similar habitat conditions which provide food and refuge for the species translocated and existing populations in the receptor sites, the stress that translocated individuals face and whether the individuals translocated return to the original habitats which are meant to be cleared.

Figure 7-135 Photos Showing the Prototype of an Example Bat Internode Roost that Bamboo Bats Will be Translocated to

7.10 Residual Impacts

Impacts evaluated to have major and moderate significance in Section 7.6 were addressed with appropriate mitigation measures to help reduce the impact as much as possible. However, the significance of certain impacts such as site clearance (resulting in vegetation and habitat loss) remains as major because it is a permanent and irreversible impact that cannot be mitigated. Hence, the greatest impact significance of proposed developments at some of the Study Areas are still expected to be major/moderate.

Due to the shifting of the A1-W2 worksite out of Eng Neo Avenue Forest into another forested site—Sites I and II—the evaluation of construction and operational impacts on habitat, flora and faunal receptors within the Sites I and II has been included under the residual impact assessment in this section. The evaluation includes the assumption that appropriate mitigation measures have been put in place to help reduce impact as much as possible.

7.10.1 Construction Phase

7.10.1.1 Eng Neo Avenue Forest

7.10.1.1.1 *Habitats*

The most substantive Base Scenario impact significance of the proposed development during the construction phase is expected to be Minor (refer to Section 7.8.2.1). After mitigation measures are applied, the overall impact significance of habitat degradation during the construction phase will be reduced to **Negligible**. This includes the impact assessment to the managed vegetation where initially was to be cleared for worksite before worksite optimisation. Though majority impact significance levels are already at a relatively low level, it is still recommended to adopt the mitigation measures where applicable. Refer to Table 7-71 for residual impact significance after application of mitigation measures during the construction phase.

Table 7-71 Residual Impact Significance after the Implementation of Proposed Mitigation Measures at Eng Neo Avenue Forest during the Construction Phase

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
Loss of Vegetation	Native-dominated Secondary Forest (Priority 1)	Negligible	Based on latest preliminary design plans, worksite has been shifted outside of Eng Neo Avenue Forest Study Area. Therefore, no habitats will experience vegetation loss impacts.	Negligible
	Abandoned-land Forest (Priority 2)	Negligible		Negligible
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor		Negligible
	Waste Woodland (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 3)	Minor		Negligible
	Anaerobic pond (Priority 2)	Negligible		Negligible
Habitat Degradation	Native-dominated Secondary Forest (Priority 1)	Minor	Monitor the water quality and aquatic faunal community in retained streams and streams adjacent to the construction areas. Retain ground cover for as long as possible. When ground cover is removed, erosion control measures are to be in place. Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. Engage a qualified erosion control professional to formulate and implement ECM plan in accordance with pub requirements. Conduct regular inspections to ensure the Contractor's compliance and identify any impacts/unnecessary clearance in adjacent forest areas. Conduct regular biodiversity surveys to monitor the flora and faunal community in retained and forest adjacent to the construction areas. Applying the above mitigation strategies together with design recommendations, impact significance can be reduced from moderate/major to negligible/minor for Mitigated Scenario.	Negligible
	Abandoned-land Forest (Priority 2)	Minor		Negligible
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor		Negligible
	Waste Woodland (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 3)	NA		Negligible
	Anaerobic pond (Priority 2)	Minor		Negligible
Change In Species Composition	Native-dominated Secondary Forest (Priority 1)	Minor	Conduct regular inspections to ensure the Contractor's compliance and identify any impacts/unnecessary clearance in adjacent forest areas. Conduct regular biodiversity surveys to monitor the flora and	Negligible
	Abandoned-land Forest (Priority 2)	Minor		Negligible

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor	faunal community in retained and forest adjacent to the construction areas. Applying the above mitigation strategies together with design recommendations, impact significance can be reduced from moderate to minor for Mitigated Scenario.	Negligible
	Waste Woodland (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 3)	NA		NA
	Anaerobic pond (Priority 2)	Minor		Negligible

7.10.1.1.2 *Plant Species*

For the 67 plant species recorded from Eng Neo Avenue Forest and selected for the assessment of ecological impacts, the most substantive impacts during the construction phase before mitigation measures were theoretically implemented are Major for four species, moderate for another four species, and Minor for the remaining 59 species (Appendix R1). Following the implementation of mitigation measures, the most severe impacts reduce to **Minor** for 65 species and **Negligible** for two species.

Majority (65 out of 67) of the plant species are likely to experience minor impacts as a result of impediment to seedling recruitment. Aside from *Bambusa vulgaris* (which propagates via underground rhizomes), all other 64 species are flowering seed plants that grow on soil and whose dispersal modes are not restricted. There is a possibility that seedling recruitment of these species may somewhat be impeded as a result of construction activities, such as pollution from improper disposals and/or accidental release of construction waste. None of all specimens belonging to each of the 65 species, however, were found to be inside nor within 30 m from the proposed construction worksite in Eng Neo Avenue Forest under the mitigation plan. As such, the impact of impediment to seedling recruitment on these species is minor.

The two species likely to experience negligible impacts from all four impact types are *Goniophlebum percussum* and *Hoya diversifolia*, both of which are epiphytic and were not found to have any specimens inside nor within 30 m from the proposed mitigated worksite.

The severity of impacts has reduced substantially as the proposed worksites are shifted out of the Study Area, which is ideal as it means minimal disturbance would be caused to the existing plant communities. It is ideal that the residual impact significance is reduced to the lowest level for most.

7.10.1.1.3 *Faunal Species*

The most substantive Base Scenario impact significance from Eng Neo Avenue Forest during the construction phase is major resulting from the loss of ecological connectivity for forest-dependent birds such as the thick-billed green pigeon (*Treron curvirostra*) and straw-headed bulbul (*Pycnonotus zeylanicus*). Non-volant mammals such as the Sunda colugo (*Galeopterus variegatus*) and Sunda pangolin (*Manis javanica*) are also expected to have moderate impacts from the loss of habitat, injury/mortality and loss of connectivity. After mitigation measures, in particular the shift of worksite outside of Study Area, impacts have largely been reduced to **Negligible** during construction and operational phases.

7.10.1.2 Sites I and II

This section presents the residual impacts of the proposed construction for A1-W2 following the theoretical implementation of mitigation measures, the key of which is the shifting of the entire worksite out of Eng Neo Avenue Forest to near/around the Sites I and II.

7.10.1.2.1 *Habitats*

The most substantive significant impact on habitats is the direct loss of vegetation. Habitats assessed to sustain **Moderate** impacts are Native-dominated Secondary Forest, Mixed Forest, Scrubland and Herbaceous Vegetation, and Managed Vegetation with 1.6%, 4.9%, 18.6% and 75.0% of each respective habitat to be cleared during construction. Majority of land use change will therefore occur in Managed Vegetation, a habitat of low ecological

value. Impact significance is **Negligible** for Abandoned-land Forest as only 0.2% will be cleared, and for Waterbody (D/S15 and D/S16) which not be impacted directly.

Vegetation loss is expected to form new forest edges in the Native-dominated Secondary Forest thereby resulting in a change in species composition. However, with adequate EMMP the significance on this impact type is **Minor**. The change in species composition is also **Minor** for Mixed Forest due to formation of forest and scrubland edges in a habitat that is already a mosaic of managed vegetation, scrubland and forested areas. The impact significance is **Minor** for Waterbody (D/S16) as construction would increase accessibility hence the potential for exotic species introduction either deliberately or inadvertently. With the formation of scrubland edges, the change in species composition is **Minor** for Scrubland and Herbaceous Vegetation. No forest edge is expected to form at Abandoned-land Forest, Managed Vegetation and Waterbody (D/S15) due to the distance from the worksite to these habitat types so the impact is **Negligible**.

Since majority of all the habitat types are outside and within the 150m buffer from worksite, the impact significance of habitat degradation is either **Minor** or **Negligible.**

7.10.1.2.2 *Plant Species*

A total of 102 plant species recorded from Sites I and II were assessed for the ecological impacts from construction activities. None of these species will experience major impacts from mortality, competition from exotic species, impediment to seedling recruitment and decline in health from construction activities. However, some plant species will still experience moderate to negligible impact significance (Appendix R2).

1) Nine species are likely to experience **Moderate** impact significance from mortality due to construction. They are (1) *Acacia mangium*, (2) *Alstonia angustiloba*, (3) *Alstonia scholaris*, (4) *Bridelia stipularis*, (5) *Ficus benjamina*, (6) *Ficus microcarpa*, (7) *Ficus variegata*, (8) *Guioa pleuropteris*, and (9) *Litsea firma*. Ten species are likely to experience **Moderate** impacts from seedling impairment as they are medium to high value and more than 50% of the individuals were found within 30 m from the construction site. They are (1) *Bambusa vulgaris*, (2) cf. *Dibridsonia conferta*, (3) *Cyclosorus polycarpus*, (4) *Endospermum sp*. (5) *Ficus barteri*, (6) *Ficus religiosa*, (7) *Litsea elliptica*, (8) *Sterculia parviflora*, (9) *Timonius wallichianus* and (10) *Thyrsostachys siamensis*.

All other species will only experience **Minor** to **Negligible** impact significance from competition from exotic species and decline in health as the area outside the construction boundary are currently scrubland or land allocated for sports recreation (e.g., tennis court).

7.10.1.2.3 *Faunal Species*

Habitats of all assessed fauna species will only be affected minimally, hence impact significance from loss of/reduction in habitats and food sources is **Negligible.** The only exception is the endangered Formosan swift butterfly whose Scrubland and Herbaceous Vegetation habitat will be cleared partially. Nevertheless, other pockets of scrubland in the area will be unaffected rendering the impact as **Minor**.

Injury or mortality during construction is **Negligible** for most assessed fauna mainly because either their habitat is minimally affected or being mobile, they can move away from worksite. However, the Sunda pangolin is susceptible to roadkill and the arboreal Sunda colugo to construction activities if the species enters the worksite. With appropriate EMMP, the impact significance on these mammals can be reduced to **Minor**.

Since the worksite does not increase distance between forest patches and waterbodies are not affected, the impact from loss of ecological connectivity for faunal movement is **Negligible for** most assessed fauna except four species. The three butterflies (Formosan swift, *Arhopala amphimuta amphimuta* and Common birdwing) could be separated between Sites I and II by the road hoarding. However, host plant of the two former species is found throughout the Study Area, while Common birdwing is a strong flier therefore the impact significance is **Minor**. Impact intensity from loss of ecological connectivity is high for Sunda pangolin but as the species is known to traverse between disconnected habitats using culverts, the impact significance is **Minor**.

7.10.1.3 Windsor

7.10.1.3.1 *Habitats*

The most substantive Base Scenario impact significance of the proposed development during the construction phase is expected to be Major (refer to Section 7.6.1.3). After mitigation measures are applied, the overall impact significance of habitat loss during the construction phase is expected to reduce to **Moderate** mainly due to reduced size of new optimised worksite. While the significance of the other residual impacts has been reduced to **Minor**.

Refer to Table 7-72 for residual impact significance after application of mitigation measures during the construction phase.

Table 7-72 Residual Impact Significance after the Implementation of Proposed Mitigation Measures at Windsor during the Construction Phase

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
Loss of Vegetation	Native-dominated Secondary Forest (Priority 1)	**Major**	By adopting the optimisation of worksite (Section 7.9.1.3.1), there would be more than half reduction in habitat clearance (due to a smaller worksite), resulting in moderate impact significance for Mitigated Scenario.	**Moderate**
	Abandoned-land Forest (Priority 2)	**Major**		Minor
	Scrubland and Herbaceous Vegetation (Priority 2)	**Major**		Minor
	Managed Vegetation (Priority 2)	**Major**		Minor
	Windsor Nature Park (Priority 1)	Negligible		Negligible
	D/S13 Waterbody (Priority 1)	Negligible		Negligible
Habitat Degradation	Native-dominated Secondary Forest (Priority 1)	NA	Monitor the water quality and aquatic faunal community in retained streams and streams adjacent to the construction areas. Retain ground cover for as long as possible. When ground cover is removed, erosion control measures are to be in place. Practise due diligence in proper storage and handling of machinery to prevent leaching of oil or harmful materials such as bentonite slurry. Store and handle harmful materials well away from water bodies. Engage a qualified erosion control professional to formulate and implement ECM plan in accordance with PUB requirements. Conduct regular inspections to ensure the Contractor's compliance and identify any impacts/unnecessary clearance in adjacent forest areas. Conduct regular biodiversity surveys to Monitor the flora and faunal community in retained and forest adjacent to the construction areas. Applying the above mitigation strategies together with design recommendations, impact significance can be reduced from moderate/major to negligible/minor for Mitigated Scenario.	NA
	Abandoned-land Forest (Priority 2)	**Moderate**		Minor
	Scrubland and Herbaceous Vegetation (Priority 2)	**Moderate**		Minor
	Managed Vegetation (Priority 2)	**Moderate**		Minor
	Windsor Nature Park (Priority 1)	Minor		Minor
	D/S13 Waterbody (Priority 1)	Minor		Minor
Change In Species Composition	Native-dominated Secondary Forest	NA	Adopting a smaller worksite, would also result in a smaller area of adjacent forest edge being affected by edge effects.	NA

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
	(Priority 1)		Conduct regular inspections to ensure the Contractor's compliance and identify any impacts/unnecessary clearance in adjacent forest areas. Conduct regular biodiversity surveys to monitor the flora and faunal community in retained and forest adjacent to the construction areas. Applying the above mitigation strategies together with design recommendations, impact significance can be reduced from moderate to minor for Mitigated Scenario.	
	Abandoned-land Forest (Priority 2)	**Moderate**		Minor
	Scrubland and Herbaceous Vegetation (Priority 2)	**Moderate**		Minor
	Managed Vegetation (Priority 2)	**Moderate**		Minor
	Windsor Nature Park (Priority 1)	Minor		Minor
	D/S13 Waterbody (Priority 1)	Minor		Minor

7.10.1.3.2 *Plant Species*

For the 43 plant species recorded from Windsor and selected for the assessment of ecological impacts, the most severe impacts during the construction phase before mitigation measures were theoretically implemented are Major for 11 species, Moderate for nine species, and Minor for 23 species (Appendix R3). Following the implementation of the proposed mitigation measures, i.e., the optimised worksite is used, the most severe impacts is **Major** for six species (down from 11), **Moderate** for 11 species (instead of nine), and **Minor** for 26 species (instead of 23).

The three species for which the impacts are reduced from Major to **Minor** are (1) *Elaeocarpus nitidus*, (2) *Ficus fistulosa*, and (3) *Strophanthus caudatus*. All the specimens of these species in Windsor were found within the A1-W1 the worksite, which resulted in high impact intensity as a result of mortality. However, none of these specimens are within the optimised worksite, which reduced the impact intensity as a result of mortality from high to negligible. Hence, the impact significance was correspondingly reduced to **Minor**.

7.10.1.3.3 *Faunal Species*

The most substantive impact significance from Windsor during the construction phase is **Major** (Section 7.8.1.1.3) resulting from the loss of connectivity for mammals such as the Sunda slow loris (*Nycticebus coucang*) and Raffles' banded langur (*Presbytis femoralis femoralis*) (Appendix R3). After mitigation measures are applied (i.e. optimised worksite is adopted) ecological connectivity would be avoided and impact can be reduced. Additionally, compensation and habitat measures such as dedicated animal crossing would help mitigate for any disturbance (if any) to the existing canopy connectivity. Together with the reduction of worksite, work activities generating ground borne noise and vibration and the need for night works would also be reduced significantly. This plan also means that a substantial daily movement of truck loads carrying excavated spoil as well as TBM segments from TBM launch/ retrieval would also be avoided on a daily basis during construction. This would not only greatly reduce the noise and vibration disturbances generated, it would also reduce the potential of vibration and most definitely would help with reduction of road kills accidents along Island Club Road. Implemented together with other standard mitigation measures, impact significance was mostly reduced to **Minor**, with some still at **Moderate** for six mammals species and one odonate species – primarily due to the loss of habitat and connectivity due to construction of A1-W1.

7.10.2 Operational Phase

7.10.2.1 Eng Neo Avenue Forest

7.10.2.1.1 *Habitats*

The most substantive Base Scenario impact significance of the proposed development during the operational phase is expected to be Minor. After mitigation measures are applied, the significance of the residual impacts has been reduced to Negligible. Refer to table below for residual impact significance after application of mitigation measures during the operational phase.

Table 7-73 Residual Impact Significance after the Implementation of Proposed Mitigation Measures at Eng Neo Avenue Forest during the Operational Phase

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
Habitat Degradation	Native-dominated Secondary Forest (Priority 1)	Minor	Due to optimisation of A1-W2, at the operational stage there would be no above-ground structures or regular and ad-hoc maintained works. Therefore, impact significance would be reduced to Negligible.	Negligible
	Abandoned-land Forest (Priority 2)	Minor		Negligible
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor		Negligible
	Waste Woodland (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 3)	NA		NA
	Anaerobic pond (Priority 2)	Minor		Negligible
Change In Species Composition	Native-dominated Secondary Forest (Priority 1)	Minor	Due to optimisation of A1-W2, at the operational stage there would be no above-ground structures or regular and ad-hoc maintained works. Therefore, impact significance would be reduced to Negligible.	Negligible
	Abandoned-land Forest (Priority 2)	Minor		Negligible
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor		Negligible
	Waste Woodland (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 3)	NA		NA
	Anaerobic pond (Priority 2)	Minor		Negligible

7.10.2.1.2 *Plant Species*

For the 67 plant species recorded from Eng Neo Avenue Forest and selected for the assessment of ecological impacts, the most severe impacts during the operational phase before mitigation measures were theoretically implemented is Moderate for all 67 species (Appendix R1). The species are likely to experience Moderate impacts as a result of competition from exotic plant species.

Following the implementation of mitigation measures, the impacts on all 67 plant species would, theoretically, be reduced to **Negligible** for both impact types. By using native planting palettes, it would reduce the impact intensity (and subsequently, the impact significance) of competition from exotic plant species to **Negligible**.

7.10.2.1.3 *Faunal Species*

The most substantive Base Scenario impact significance from Eng Neo Avenue Forest during the construction and operational phases is **Negligible** (Section 7.8.1.1.3) as the worksite lies outside of the Study Area boundary. It remains as negligible during construction and operational phases.

7.10.2.2 Sites I and II

7.10.2.2.1 *Habitat*

During operation there is no above-ground facility building except for an access road that was constructed for the construction phase which may increase accessibility to surrounding natural habitats. Thus, habitat degradation impact significance is expected to be **Minor** for most habitat types and **Negligible** for Managed Vegetation.

Impact significance of change in species composition is **Minor** for Native-dominated Secondary Forest, Mixed Forest and Scrubland and Herbaceous Vegetation. This is due to Increased accessibility to these habitats which may result in the introduction of new species. Given that public access and use in Abandoned-land Forest, Managed Vegetation and Waterbody (D/S15 and D/S16) will be restricted during operation, the impact significance is therefore **Negligible**.

7.10.2.2.2 *Plant Species*

A total of 102 plant species recorded in Sites I and II were assessed.

All the species are likely to experience **Minor** impacts as a result of mortality and competition from exotic plant species. For competition from exotic plant species, it is assumed that if casual species, i.e., species that "do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence" (Chong et al., 2009), are planted as part of landscaping efforts during the operational phase, an impact intensity of the medium level is expected due to competition between these casual species and native species found within the Study Area. This is an unlikely event as original vegetation is expected to be retained. Therefore, the impact of competition from exotic species is **Minor**. For mortality, most plants are expected to experience low impact intensity as less than 50% of the plant species are anticipated to be stolen, except for the *Bulbophyllum vaginatum*, for which more than 50% of the plant species are anticipated to be stolen due to it being an orchid. The likelihood of this occurring is expected to be "Less likely", in part because public access to Sites I and II is not expected to increase due to the operational works, since there is no operational worksite present in the area.

7.10.2.2.3 *Faunal Species*

For all assessed fauna, the only substantive impact during operation is potential injury or mortality to the Sunda pangolin due to presence of a new permanent road. The impact significance is **Minor** with appropriate mitigation measures to reduce roadkill incidents. Collision with buildings (assessed only for birds) is **Negligible s**ince there are no above-ground facility buildings. Loss of ecological connectivity for faunal movement is also **Negligible** as the cleared area does not increase distance between forest patches, construction hoarding will be removed, and waterbodies (D/S15 and D/S16) are not affected. Moreover, the Vulnerable Bamboo bat (*Tylonycteris* sp.) is found only in Site I bamboo cluster hence unlikely to utilise Site II.

7.10.2.3 Windsor

7.10.2.3.1 *Habitats*

The most substantive Base Scenario impact significance of the proposed development during the operational phase is expected to be Moderate. After mitigation measures are applied, the significance of the residual impacts has been reduced to **Negligible** to **Minor**. Refer to Table 7-74 for residual impact significance after application of mitigation measures during the operational phase.

Table 7-74 Residual Impact Significance after the Implementation of Proposed Mitigation Measures at Windsor during the Operational Phase

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
Habitat Degradation	Native-dominated Secondary Forest (Priority 1)	NA	At the operational stage, not much habitat degradation impacts will be experienced by the habitats present. Impacts will mainly come from the regular and ad-hoc	NA

Impact Type	Receptor	Base Scenario Impact Significance	Mitigation Measures	Mitigated Scenario Impact Significance
	Abandoned-land Forest (Priority 2)	Minor	maintained works. As long as minimum controls and mitigation measures mentioned in Section 7.9 are applied, impact significance would remain at minor.	Negligible
	Scrubland and Herbaceous Vegetation (Priority 2)	Minor		Negligible
	Managed Vegetation (Priority 2)	Minor		Negligible
	Windsor Nature Park (Priority 1)	Minor		Minor
	D/S13 Waterbody (Priority 1)	Minor		Minor
Change In Species Composition	Native-dominated Secondary Forest (Priority 1)	NA	At the commissioning phase, the following should be adopted: Conduct regular inspections (at least 6 months) to identify any impacts/unnecessary clearance in adjacent forest areas. Conduct regular biodiversity surveys (at least 6 months) to monitor the flora and faunal community in retained and forest adjacent to the construction areas. Applying the above mitigation strategies together with design recommendations, impact significance can be reduced from moderate to minor for Mitigated Scenario.	NA
	Abandoned-land Forest (Priority 2)	Moderate		Minor
	Scrubland and Herbaceous Vegetation (Priority 2)	Moderate		Minor
	Managed Vegetation (Priority 2)	Moderate		Negligible
	Windsor Nature Park (Priority 1)	Minor		Negligible
	D/S13 Waterbody (Priority 1)	Minor		Negligible

7.10.2.3.2 *Plant Species*

For the 43 plant species recorded from Windsor and selected for the assessment of ecological impacts, the most substantive impacts during the operational phase before mitigation measures were theoretically implemented are Moderate for 41 species and Minor for the remaining two species. Following the implementation of mitigation measures, the impact significance reduces to **Minor** for 41 species and **Negligible** for the remaining two species. These species were originally likely to experience moderate impacts as a result of competition from exotic plant species. The impact significance, however, could be reduced if native planting palettes are used for landscaping during the operational phase. This would reduce the impact intensity, and subsequently, the impact significance, of competition from exotic plant species to **Minor/Negligible**.

7.10.2.3.3 *Faunal Species*

The most substantive Base Scenario impact significance of the proposed development during the highest operational phase is expected to be **Moderate** due to the loss in ecological connectivity, injury/mortality, and collisions with buildings (birds only). After mitigation measures are applied, the overall impact significance is expected to reduce to **Minor** for birds, reptiles and mammals.

7.11 Cumulative Impacts from Other Major Concurrent Developments

This section assessed the cumulative impacts from major concurrent developments in the vicinity of the Study Areas. Cumulative impacts have been discussed qualitatively based on the similar impact evaluation approach final impact significance definition in Section 6.4.2.3.

7.11.1 Construction Phase

7.11.1.1 Eng Neo Avenue Forest

No concurrent major development in the vicinity.

7.11.1.2 Sites I and II

The CR14 project identified in Section 3.4.1 will have overlapping construction timeline with construction of A1-W2 and is planned to be allocated within less than 150 m away from A1-W2.

Impacts to habitats and flora: Construction of the nearby CR14 could potentially have cumulative impact in terms of habitat degradation, impediment to seedling recruitment and possibly decline in plant health and survival on the remaining habitats and flora within Sites I and II. These impacts are indirect and assessed to be of **insignificant** increase relative to impacts from A1-W2 as the surrounding area between the two projects are already rather urbanised and fragmented.

Impacts to fauna: Unlike impacts to habitats and flora, impacts from CR14 is assessed to be of **significant** increase in impacts. Despite area being rather urbanise and fragmented, baseline results have indicated that these fragmented habitats are still being utilised by sensitive fauna receptors such as the pangolins. Cumulative impacts include loss of/reduction in habitats and food source, and loss of ecological connectivity for faunal movement. Subsequently, work activities at proposed future development as pilling, rock breaking and excavation can further increase noise and vibration impacts for fauna. Refer to Section 11 and Section 12 respectively, for further assessment of cumulative impacts of noise and vibration impacts on fauna

7.11.1.3 Windsor

PUB works at BKSR identified in Section 3.4.1 is part of a larger project with construction duration of at least three years. Of this specifically, two phases are of concern, 1. the permanent and reinstatement Works at PUB Shaft 4 (S4), and 2. the pipelaying within BKSR that will overlap with construction timeline of A1-W1. The reinstatement period of PUB BKSR Shaft 4 overlaps with the construction timeline of A1-W1 for at least three months and is planned to be allocated within A1-W1 worksite. While the pipelaying works will be done outside of A1-W1. PUB BKSR will commencing works before construction of A1-W1 and will end six months into A1-W1 construction during the site clearance and excavation phase.

Impacts to habitats and flora**:** BKSR worksite is a subset of A1-W1 worksite. After BKSR works are complete, part of their worksite will be reinstated while another part will be taken over by A1-W1 to be used as a storage facility. Subsequently, though dust impacts would be cumulative here, it can be mitigated with administrative measures (Section 10.8.1.1). In terms of impacts to habitat and floral species, there should be **insignificant** increase relative to impacts from A1-W1.

Impacts to fauna: Though there is only six months of overlap, work activities at the reinstatement stage can still generate disturbance to faunal species. Additionally, BKSR have two other shaft locations before and after this worksite (shaft 4) along Island Club Road ongoing. Increased activity along Island Club Road not only contributes to disturbances to fauna, it can also potentially result in increased roadkill accidents and loss of ecological connectivity between the northern forest and Windsor Nature Park. Similarly, though dust impacts would be cumulative here, it can be mitigated with administrative measures (Section 10.8.1.1), resulting in only small contributions to cumulative dust impact at A1-W1 worksite. In term of noise impact assessment (Section 11.10.1.1), due to the minimum overlap as well as construction area difference, the BKSR project is expected to have negligible to small contributions to cumulative noise impact at A1-W1 worksite. Therefore, the assessment is that BKSR worksite will result in **significant** increase in impacts to fauna residing within Windsor, when both noise and dust impacts are considered together.

7.11.2 Operational Phase

7.11.2.1 Eng Neo Avenue Forest

No concurrent major development in the vicinity.

7.11.2.2 Sites I and II

The CR14 project identified in Section 3.4.1 will allocated within less than 150 m away from Sites I and II at the operational phase. Additionally, the development is expected to consist of MRT facilities and other supporting amenities.

Impacts to habitats and flora: Presence of vicinity transport infrastructure development could potentially have cumulative impact in terms of habitat degradation, mortality and competition from exotic plant species on the remaining habitats and flora within Sites I and II. These impacts are mainly due to the expected increase in human traffic in the general area due to presence of the vicinity transport infrastructure development. The impacts are indirect and assessed to be **insignificant** as the surrounding area between the two projects are already rather urbanised and fragmented.

Impacts to fauna: Unlike impacts to habitats and flora, impacts from CR14 is assessed to have **significant** increase in impacts. Despite of area being rather urbanise and fragmented, baseline results have indicated that these fragmented habitats are still being utilised by sensitive fauna receptors such as the pangolins. Cumulative impacts include (1) loss of ecological connectivity for faunal movement due to presence of MRT facilities and other supporting amenities; building development could potentially result in bird collision if bird-friendly building design is not implemented, and (2) injury and mortality to fauna due to increase human and vehicular traffic can lead to human-wildlife conflicts and roadkill accidents, respectively.

7.11.2.3 Windsor

At the operational stage, no above ground structures are expected from BKSR project. Only ad-hoc and/or regular maintenances are expected to occur.

Impacts to habitats and flora: Assuming that maintenance works does not result in increased light, noise and vibration levels, and significance tree/habitat loss, the impacts are assessed to be **insignificant**.

Impacts to fauna: Similarly, assuming that maintenance works does not result in increased light, noise and vibration levels, and significance tree/habitat loss, the impacts are assessed to be **insignificant**.

7.12 Summary of Key Findings

7.12.1 Design Optimisation (Introduced as Mitigated Scenario)

Optimisation of A1-W2 Worksite at Eng Neo Avenue Forest

With the original worksite of A1-W2 as base scenario that takes up an area of 15,000 m^2 and sits within ecologically sensitive Eng Neo Avenue Forest Study Area. Worksite within Eng Neo Avenue Forest could also potentially cause significant impacts to connectivity as the site clearance for the worksite would eventually leave only a thin strip of forest connecting the north and south of Eng Neo Avenue Forest. Work activity would also be closer and therefore more intense to the fauna residing within Eng Neo Avenue Forest. Therefore, the shift of worksite out of Eng Neo Avenue Forest is recommended to avoid these significant impacts. With this shift in worksite, impacts are mostly reduced to minor and negligible within Eng Neo Avenue Forest.

Optimisation of A1-W1 Worksite at Windsor

With the original worksite of A1-W1 as base scenario that takes up a bigger area of 15,000 m^2 and sits along a canopy connection, the biodiversity impact towards the ecologically valuable habitats and faunal species would be greatly affected. Therefore, a shift is recommended to avoid direct impact to the canopy connection, especially for the arboreal mammals. While the optimisation of the worksite would help to reduce habitat loss to ecologically valuable habitat within Study Area.

Aside from the direct benefits of adopting an optimised worksite at A1-W1, other significant impacts have been reduced due to the optimised worksite includes the reduced need for night works, reduction in noise and vibration generated from work activated such as TBM and potential roadkill accidents along Island Club Road. The efforts of LTA with regards to optimisation of A1-W1 has significantly reduce impact significance to the biodiversity within Study Area at Windsor.

7.12.2 Eng Neo Avenue Forest

Eng Neo Avenue Forest was previously connected to the CCNR but fragmented by the construction of Pan-Island Expressway in the 1960s. While it is unlikely for non-volant species from the CCNR to cross the PIE and reach the Study Area, there remains a chance of expecting rare species here.

Eng Neo Avenue Forest is characterised by five vegetation types. Waste woodland as well as scrubland and herbaceous vegetation dominate the site. Three patches of native-dominated secondary forest present occupy 5% of the Study Area. A total of 284 plant and species groups from 89 families were recorded. The floristic assemblage is largely native (60.2% native species). Many species found in the native-dominated secondary forest in Eng Neo Avenue Forest can also be found in the CCNR and are less commonly encountered in other secondary forests in Singapore. Interestingly, some species associated with older forests which are rare even in the NSSF are 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. Eighty species of plants of conservation significance were recorded and mostly distributed within the native-dominated secondary forest.

The faunistic field assessment recorded 233 species with more than half of the recorded assemblage dominated by bird and butterfly species. This includes one bird species that was not listed as probable species. A total of 15 species of conservation significance were recorded, although they were distributed across the Study Area with no distinct hotspot. Some notable records include the globally Critically Endangered straw-headed bulbul (*Pycnonotus zeylanicus*) and globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*). The Study Area therefore, supports local populations of fauna conservation significance, and other forest-dependent fauna and/or species of restricted distribution that are increasingly threatened by habitat loss. Although not of conservation significance, Eng Neo Avenue Forest also supports thriving populations of fiery coraltail (*Ceriagrion chaoi*) and painted bronzeback (*Dendrelaphis pictus*), with significant numbers observed. Along the waterbodies, records of the species of interest common walking catfish (*Clarias* cf. *batrachus*) were made, showing value of this forest stream. The anaerobic pond, although is not an optimal habitat, can provide habitats to marsh-associated or aquatic species that can adapt to it. The waterbodies were hence also regarded as high ecological value.

The most substantive impact from the construction phase at Eng Neo Avenue Forest is of major significance to habitats, floral and faunal species. By adopting the shift and optimisation of A1-W2 worksite, vegetation and habitat loss is not necessary anymore, reducing permanent impacts from vegetation and habitat loss to negligible. It is also worthy to note that the Nature Groups were engaged, and the outcome was positive – they were supportive of the relocation of worksite A1-W2 out of Eng Neo Avenue Forest. Other impacts such as loss of habitats and food sources and loss of ecological connectivity for faunal species were also be reduced to **Negligible**.

During the operational phase, the most substantive impact from the operational phase at Eng Neo Avenue Forest is of moderate significance to habitats, floral and faunal species. After application of mitigation measures, moderate impact significance was reduced to **Negligible**.

Subsequently, **negligible** cumulative impacts incurred as there are no concurrent major development in the vicinity.

7.12.3 Sites I and II

Due to its proximity to Eng Neo Avenue Forest, which was previously connected to the CCNR but fragmented by the construction of Pan-Island Expressway in the 1960s, there remains a chance of expecting rare species here.

Sites I and II are characterised by five vegetation types. Mixed forest (5.1 ha, 30.5%) dominates the site, followed by abandoned-land forest (3.0 ha, 18.1%). Three patches of native-dominated secondary forest present occupy 16.7% (2.8 ha) of the Study Area. A total of 270 plant and species groups from 89 families were recorded. More than half of the floristic assemblage is native (51.5%, 139 native species). Many species found in the native-dominated secondary forest in Sites I and II can also be found in the CCNR and are less commonly encountered in other secondary forests in Singapore. Interestingly, some species associated with older forests which are rare even in the NSSF are 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. Fifty-five species of plants of conservation significance were recorded and mostly distributed within the native-dominated secondary forest and the mixed forest.

The faunistic field assessment recorded 165 species with more than half of the recorded assemblage dominated by bird and butterfly species. This includes one bird and one bat species that were not listed as probable species. A total of 13 species of conservation significance were recorded, distributed across the Study Area with no distinct hotspot. Some notable records include the nationally Endangered changeable hawk-eagle (*Nisaetus cirrhatus*), the nationally Vulnerable bamboo bat (*Tylonycteris* sp.), and the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*), which was found throughout the Study Area. The Study Area, therefore, supports local populations of fauna conservation significance, and other forest-dependent fauna and/or species of restricted distribution that are increasingly threatened by habitat loss. Along the waterbody D/S15, notable records of the common walking catfish (*Clarias* cf. *batrachus*) were made, showing value of this forest stream. The other

waterbody D/S14, although it did not show any records of fauna species of conservation significance, is also regarded as of high ecological value due to the increasing loss of stream habitats within Singapore and its location within the native-dominated secondary forest.

The most substantive impact from the construction phase at Sites I and II is of Moderate significance to habitats and floral and faunal species due to the shifting and optimisation of A1-W2 worksite into Sites I and II. Permanent impacts due to loss of vegetation and change in species composition is expected to be Moderate for the native-dominated secondary forest, mixed forest, scrubland and herbaceous vegetation, and managed vegetation. Moderate impact due to mortality and impediment to seedling recruitment is also expected for some floral species. No faunal species are expected to sustain Major or Moderate impact in the construction phase due to the distance of the worksite from key fauna-supporting habitats.

During the operational phase, the most substantive impact is of **Minor** significance to habitats, floral and faunal species, due to the lack of an operational above-ground facility within the Study Area.

Subsequently, **significant** cumulative impacts incurred from the concurrent major development in the vicinity.

7.12.4 Windsor

Windsor consists of Windsor Nature Park and a Northern Forest Fragment. Once a rubber plantation that was subsequently abandoned, the Windsor Nature Park has since been designated as a green buffer for the Central Catchment as Windsor Nature Park. It is contiguous with the CCNR to its west, therefore, assemblage of the Study Area is expected to overlap with that of the CCNR, including rare native species.

Windsor Nature Park alone occupies more than half the Study Area in Windsor, while the remaining area is largely abandoned-land forest and managed vegetation. Two patches of native-dominated secondary forest in the Northern Forest Fragment occupy 3% of the Study Area, with the northern patch being comparatively more species-rich in both the canopy and understorey layers. Scrubland and herbaceous vegetation also occupy 3% of the Study Area. A total of 329 plant species and species groups belonging to 103 families were recorded at Windsor (including Windsor Nature Park). The site is dominated by a native floristic assemblage (59.9% native species), overlapping with that of CCNR. With constant and steady rates dispersal of propagules from the nearby CCNR and Windsor Nature Park, together with successful seedling recruitment, this forested area in the Northern Forest Fragment may eventually develop into primary forest overtime if left undisturbed. Only 49 species, however, were considered of conservation significance. All threatened species found exclusively in Windsor Nature Park were hence excluded from the list of species of conservation significance. Some of the rarer species of conservation significance include *Rourea asplenifolia*, *Gironniera subaequalis*, *Rourea fulgens*, and *Baccaurea sumatrana*. Majority of the specimens and clusters were found within the larger continuous forested patch north of Windsor Nature Park. Many species were observed to be restricted to the northern native patch in Windsor, some of which with only records of one specimen, such as the *Enkleia malaccensis* and *Elaeocarpus rugosus* tree. At least 200 individuals and clusters of specimens of conservation significance were recorded at the Northern Forest Fragment alone. The specimens are mostly concentrated within the two native-dominated patches, but are also scattered throughout the abandoned-land forest between the two native patches. Beyond these areas, the distribution of specimens of conservation significance occurs at low concentrations.

The faunistic field assessment recorded 229 species with more than half of the recorded assemblage dominated by bird and butterfly species. This includes one butterfly species not listed as a probable species. Higher richness was recorded at the entrance of Windsor Nature Park and Northern Forest Fragment. A total of 26 species of conservation significance were recorded, although they were distributed across the Study Area with no distinct hotspot. Some notable records include the nationally Vulnerable tiny sheartail (*Microgomphus chelifer*), as well as the nationally Endangered Horsfield's flying squirrel (*Iomys horsfieldii*) and lesser mousedeer (*Tragulus kanchil*). Along the waterbodies, richness of aquatic fauna was generally low but observed to be higher within the Windsor Nature Park. Notable records of aquatic fauna, such as the freshwater prawn (*Macrobrachium malayanum*) and gold-ringed cat snake (*Boiga melanota*) were made, showing value of the forested streams. Nevertheless, the forested stream within the Northern Forest Fragment provides habitats to native aquatic fauna such as the Malayan forest betta (*Betta pugnax*) and blue-spotted flatwing (*Podolestes orientalis*). On the other hand, the pond at the entrance of Windsor Nature Park comprised largely non-natives possibly released by park users.

Unlike other sites, Windsor is also characterised by rare arboreal fauna which is usually restricted to the nature reserves. Examples are the Sunda slow loris (*Nycticebus coucang*) and Raffles banded langur (*Presbytis femoralis femoralis*) which are nationally Endangered and Critically Endangered respectively. Canopy connections along the Island Club Road serve as important crossing points for arboreal fauna requiring connected vegetation to move. Notably, the Northern Forest Fragment is considered of importance to the Raffles' banded langur as it provides habitat connectivity for the langurs to move between the northern and southern part of CCNR. Tall trees within the

Study Area is also important to allow gliding arboreal fauna to move between trees. The Study Area supports local populations of fauna of conservation significance, and other forest-dependent fauna and/or species of restricted distribution that are increasingly threatened by habitat loss. This is especially so for Windsor which is contiguous with the CCNR. While the Northern Forest Fragment is fragmented from Windsor Nature Park by the Island Club Road, many species are able to cross the road and use the habitats there, and it may be seen as an extension of the Windsor Nature Park.

Within the worksites, 41 individuals and clusters of specimens of conservation significance were found. Three bamboos were also found but no bamboo bats were recorded. Notable records of species of conservation significance from past and existing studies include the Horsfield's flying squirrel (*Iomys horsfieldii*), Sunda slow loris (*Nycticebus coucang*) and Raffles banded langur (*Presbytis femoralis femoralis*). Windsor Nature Park, native-dominated secondary forest and all natural waterbodies (D/S13, D/S26 and D/S27) are also regarded as high ecological value.

The most substantive impact from the construction phase at Windsor is of **Major** significance to habitats, floral and faunal species. Adopting optimised worksite would directly reduce the major impact from vegetation loss in habitats to **Moderate**; and also reduces major loss of ecological connectivity to faunal species. It is also worthy to note that the Nature Groups were engaged, and the outcome was positive – they were supportive of the reduction in size of A1-W1 out of Eng Neo Avenue Forest.

During the operational phase, the most substantive impact from the operational phase at Windsor is of **Minor** significance to habitats, floral and faunal species. After application of mitigation measures, moderate impact significance was reduced to **minor/negligible**.

Subsequently, significant cumulative impacts incurred as from the concurrent major development in the vicinity.

Table 7-75 Summary of Biodiversity Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls[2]	Residual Impact Significance with Mitigation Measures (if required)[1]
Construction Phase		
Eng Neo Avenue Forest	Habitats: Minor Flora: Major Fauna: Major	Habitats: Negligible Flora: Negligible Fauna: Negligible
Site I and Site II	Habitats: Negligible Flora: Negligible Fauna: Moderate	Habitats: **Moderate** Flora: **Moderate** Fauna: Minor
Windsor	Habitats: Major Flora: Major Fauna: Major	Habitats: **Moderate** Flora: **Major** Fauna: **Moderate**
Operational Phase		
Eng Neo Avenue Forest	Habitats: Minor Flora: Moderate Fauna: Negligible	Habitats: Negligible Flora: Negligible Fauna: Negligble
Site I and Site II	Habitats: Negligible Flora: Negligible Fauna: Minor	Habitats: Minor Flora: Minor Fauna: Minor
Windsor	Habitats: Moderate Flora: Moderate Fauna: Moderate	Habitats: Minor Flora: Minor Fauna: Minor

Sensitive Receptor	Impact Significance with Minimum Controls[2]	Residual Impact Significance with Mitigation Measures (if required)[1]

Note:

1. Biodiversity: Major impact still exists due to the irreversible loss of vegetation and habitats during site clearance in construction phase (Sites I and II: mortality and impediment to seedling recruitment for two flora species - Alstonia angustiloba and Thyrsostachys siamensis; Windsor: mortality for six flora species - *Bambusa multiplex, Cyrtophyllum fragrans, Ficus benjamina, Glochidion zeylanicum var. zeylanicum, Guioa pubescens, Palaquium obovatum*).
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. Note that this does not indicate that impacts are completely eliminated.

8. Hydrology and Surface Water Quality

8.1 Introduction

This section includes the assessment of hydrology and surface water quality within the Study Area, as well as the prediction and evaluation of the impacts from the Project's construction and operational phases on the hydrology of the Study Area and the water quality of the impacted watercourses (refer to Figure 8-1). Results from the site surveys were analysed and used to establish the baseline conditions to assess the subsequent changes due to construction and operational activities associated with the Project. Sensitive receptors were identified and classified according to the sensitivity categorisation defined in Section 6.2.2. Potential sources of impact from the Project that could affect the identified sensitive receptors and the minimum controls put in place to reduce them were also described to allow for impact prediction. Thereafter, an impact evaluation was carried out to assign significance to predicted impacts and where necessary, mitigation measures were proposed. An EMMP was also developed to specify methods and measures to be included during construction, commissioning and operation of the Project which are necessary to reduce the environmental impacts to minimal levels (see Section 13).

The scope of work of the hydrological and surface water quality impact assessment consisted of:

- Reviewing of data provided by the Client to understand the topographic characteristics of the Study Area;
- Conducting site reconnaissance survey for a better understanding of the Study Area's topography, hydrology, land cover and existing watercourses with their properties (i.e. locations, water flow conditions and bank characteristics);
- Identifying sampling locations for in-situ and ex-situ water quality analysis of existing watercourses located within the Study Area;
- Carrying out hydrological and surface water quality impact analysis to assess the potential impacts of the Project during construction and operational phases; and
- Proposing EMMP to mitigate potential impacts of the Project during construction, commissioning and operational phases.

B: Windsor

Singapore Island Country Club
(Island Location)

A1-W1

DIS12

DIS13

Windsor

0 50 100 200 M

C: CR13 Retrieval Shaft & Peirce Secondary School

Worksite at
Peirce Secondary School

CR13
Retrieval Shaft

0 50 100 200 M

A: Eng Neo Avenue Forest

A1-W2

DIS9

DIS11

DIS10

DIS14

Anaerobic
Pond

Site II

DIS15

DIS16

Site I

Eng Neo
Avenue
Forest

0 150 300 600 M

A

B

C

0 500 1,000 2,000 M

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Area of High Conservation Value
- Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Project Title :
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Figure Title :
STUDY AREA FOR THE HYDROLOGY AND SURFACE WATER QUALITY IMPACT ASSESSMENT

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8.2 Methodology and Assumption

8.2.1 Baseline Hydrology and Surface Water Quality Study

The activities performed as part of the baseline assessment included the following:

- To assess the accessibility of the watercourses within the Study Area;
- To verify the information collected from the available topographic survey and satellite images;
- To identify and map out the location of existing watercourses within the Study Area;
- To determine the drain and stream flow conditions and bank characteristics; and
- To assess current surface water quality conditions in existing watercourses within the Study Area.

8.2.1.1 Desktop Assessment

Desktop research aided in determining the location of existing watercourses within the Study Area. The topographic survey data provided by LTA as well as the catchment map (i.e. defines the areas which contributes water flow to existing reservoirs) from PUB website [W-19] were used to support the findings of the hydrological survey. The information, used for the desktop assessment, comprised of publicly available data from government and technical agencies, existing publicly available data (e.g. online satellite images), as well as published books, relevant articles, and other online sources.

8.2.1.2 Hydrological Baseline Assessment

The hydrological survey was conducted by casual exploration methods to identify and outline existing major streams and watercourses within the Study Area. The existing conditions of the watercourses such as stream bank characteristics (e.g. natural bank or artificial bank), were identified based on visual observations and professional experience. Using the topographic survey data provided by the Client, ArcGIS was used to overlay with this Project alignment and worksites to support the hydrological survey. Catchment analysis based on topographic data and catchment map from PUB website [W-19] was carried out to identify the water sources and to ascertain the runoff flow direction within the site.

A Global Positioning System (GPS) device was used to track the hydrology survey route. The GPS data was then synchronised with the photos taken on-site to identify the exact location of identified watercourses.

8.2.1.3 Water Quality Baseline Assessment

As mentioned in the section above, major watercourses present in the Study Area were identified during site surveys. Suitable locations were selected within the identified watercourses for collection of water samples in order to assess the baseline in-situ and ex-situ water quality of existing watercourses within the Study Area. The baseline conditions of the surface water quality at the Study Area were then established.

The water quality sampling locations were subsequently identified based on preliminary hydrological findings during site reconnaissance. Generally, two (2) dry weather (normal conditions) and one (1) wet weather (after a storm event) samples will be collected from each water quality station. Dry-weather conditions are defined as after a continuous 48-hour period of no-rain, and wet-weather conditions are defined as a rainfall event having more than 10mm of rainfall, with samples to be collected within two (2) hours after the rain stops.

Water samples were collected at thirteen (13) water quality stations along the streams or roadside drains from Eng Neo Avenue Forest and Windsor as detailed in Figure 8-2 and Table 8-1. The assessment of baseline water quality conditions was conducted by analysing primary sampling data (this Study) from seven (7) water quality stations and secondary baseline data of concurrent study carried out by AECOM in the vicinity from another six (6) water quality stations.

Based on hydrology findings, in Eng Neo Avenue Forest, stations WQ11 and WQ12 were selected to capture water quality within D/S10 and D/S11, respectively, which receive water from A1-W2 worksite as well as the corresponding Project footprint. WQ11A was selected to capture the water quality in the Anaerobic Pond. Although the surface runoff from the proposed development is not likely to reach the Anaerobic Pond based on site observation and topographic data analysis, water quality was sampled here to support biodiversity findings of this Project. Station WQ10 was selected to capture the water quality of watercourse D/S9 which located at north of Site I and Site II. Stations WQ21 and WQ22 in Site I and Site II were also selected to capture the water quality of the concrete drain and stream (e.g. D/S15 and D/S16) which near to A1-W2 worksite.

In Windsor, station WQ13 was selected to capture the water quality within the natural stream D/S13 of Windsor Nature Park which receives stormwater discharge from roadside drain D/S12. This roadside drain (D/S12) captures water from A1-W1.

Secondary water quality baseline sampling data of Eng Neo Avenue Forest from the concurrent study carried out by AECOM in the vicinity were reviewed and all the baseline findings for the areas were included in this report. In the concurrent study carried out by AECOM in the vicinity, stations WQ23, WQ24, WQ25, WQ26 and WQ28 were selected to capture the water quality at upstream, midstream and downstream of the major natural stream (D/S14), while WQ27 was selected to capture the water quality of the tributary feeding into the natural stream (D/S14) in this Study.

In the vicinity of Worksites at Peirce Secondary School and CR13 retrieval shaft, there are only roadside concrete drains surrounding the worksites, which are similar as the concrete roadside drains identified at other sites and receiving mainly storm runoff. Hence, no water quality samples were taken from Worksites at Peirce Secondary School and CR13 retrieval shaft.

In-situ water quality parameters assessed in this Study were all measured using a calibrated multi-parameter digital sensor (YSI ProDSS) with USEPA approved testing methods for water quality parameters and included:

- Temperature;
- pH;
- Salinity/Conductivity;
- Total Dissolved Solids (TDS), and
- Dissolved Oxygen (DO).

The ex-situ parameters analysed by Marchwood Laboratory Services Pte Ltd (MLS) are listed as below:

- Turbidity;
- Total Suspended Solids (TSS);
- Biochemical Oxygen Demand (BOD5);
- Chemical Oxygen Demand (COD);
- Total Nitrogen (TN);
- Nitrate (NO3-N);
- Total Phosphorus (TP);
- Orthophosphate (PO4-P);
- Ammoniacal Nitrogen (NH4-N);
- Total Organic Carbon (TOC);
- Enterococcus; and
- Lead (Pb).

B: Windsor

Singapore Island Country Club
(Island Location)

A1-W1

D/S12

WQ13

D/S13

Windsor

0 50 100 200 M

C: CR13 Retrieval Shaft & Peirce Secondary School

Worksite at
Peirce Secondary School

CR13
Retrieval Shaft

0 50 100 200 M

A: Eng Neo Avenue Forest

D/S11

A1-W2

WQ12

WQ11

WQ23

D/S9

WQ10

D/S10

WQ24

WQ11A

Anaerobic
Pond

WQ25

Site II

D/S15

WQ26

Eng Neo
Avenue
Forest

WQ27

WQ21

D/S14

WQ22

WQ28

Site I

D/S16

0 150 300 600 M

C

B

A

0 500 1,000 2,000 M

Legend

Water Quality Sampling Locations
- Dry and wet
- Wet

Waterourses

Proposed CRL Alignment (Base)

Base Scenario Construction Worksite Footprint

Area of High Conservation Value

Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Figure Title :
**WATER QUALITY SAMPLING LOCATION
WITHIN THE STUDY AREA**

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JAC	NHT	JAG
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Table 8-1 Rationale for the Selection of Water Quality Sampling Locations

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Project Footprint	Justification (refer to Figure 8-2)
WQ10	At concrete drain D/S9	A1-W2 (construction worksite area)	To capture the baseline water quality within drain D/S9 receiving water from worksites A1-W2. The drain was observed to be completely dry during dry weather and is unlikely to support an ecosystem of biodiversity conservation significance. Samples were collected during wet weather to understand existing water quality condition of runoff from forest. This runoff will ultimately flow to Marina Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply.
WQ11	At earth drain D/S10	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the baseline water quality within earth drain D/S10 receiving water from worksites A1-W2. The drain was observed to be completely dry during dry weather and is unlikely to support an ecosystem with biodiversity conservation significance. Samples were collected during wet weather to understand the existing water quality condition of runoff from forest. This runoff will ultimately flow to Marina Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. Runoff collected from the drainage system within the A1-W2 facility (if any) will be diverted to Marina Reservoir.
WQ11A	Anaerobic Pond in Eng Neo Avenue Forest	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the baseline water quality of Anaerobic Pond in the Eng Neo Avenue Forest. Although the surface runoff from the proposed development is unlikely to flow into the Anaerobic Pond (determined based on site observation and topographic data analysis), water quality was sampled here to support biodiversity findings of this Project (refer to Section 7.5.1).
WQ12	At roadside drain D/S11	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the baseline water quality within roadside drain D/S11 receiving water from worksites A1-W2. The drain was observed to be completely dry during dry weather and is unlikely to support an ecosystem of biodiversity conservation significance. Samples were collected during wet weather to understand existing water quality of runoff from forest. Part of water of the drain will flow to MacRitchie Reservoir and another part of water will flow to Marina Reservoir based on detailed drainage plan shared by PUB, which serves as a raw water source for treated drinking water supply.
WQ13	At natural stream D/S13 which also receives stormwater discharge from roadside drain D/S12	A1-W1 (construction worksite area)	To capture the baseline water quality within natural stream D/S13 receiving stormwater discharge from roadside drain D/S12 which captures water from worksite A1-W1. The natural stream D/S13 flows within

[7] The sampling locations are shown in Figure 8-2.

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Project Footprint	Justification (refer to Figure 8-2)
			the Windsor Nature Park which supports biodiversity of conservation significance (refer to Section 7.5.3).
WQ21	Roadside concrete drain at upstream of D/S15 which located near the edge of the forested area of Site I	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of runoff from forested areas of Site I and nearby urban areas (i.e. road) before it discharges back into forested area of Site I. It is not supporting an ecosystem of biodiversity conservation significance but has relatively high ecological value as it is within the native-dominated secondary forest (refer to Section 7.5.2).
WQ22	Naturalised stream D/S16 located in forested area of Site I	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of naturalised stream D/S16 flowing south, through Site I. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.2).
WQ23	Discharge outlet and upstream of stream D/S14 in the south of Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the receiving runoff from drain D/S10 and D/S11 as well as surrounding forested area. The stream D/S14 also connects to the other side of PIE through underground culvert as per PUB's suggestion. Based on existing topographic data, water flows from CCNR side to Eng Neo Avenue Forest side as the invert level of underground culvert is lower on Eng Neo Avenue Forest side, then discharges to the south through Eng Neo Avenue Forest. This stream discharge will ultimately flow to Marina Reservoir. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).
WQ24	Midstream of stream D/S14 in the Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the stream D/S14 flowing south, through Eng Neo Avenue Forest. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).
WQ25	Midstream of stream D/S14 in the Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the stream D/S14 flowing south, through Eng Neo Avenue Forest. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).
WQ26	Midstream of stream D/S14 in the Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the stream D/S14 flowing south, through Eng Neo Avenue Forest. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Project Footprint	Justification (refer to Figure 8-2)
WQ27	Tributary feeding into stream D/S14 in the Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the tributary feeding into the stream D/S14 near south of Eng Neo Avenue Forest. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).
WQ28	Discharge outlet at the south of the stream D/S14 in the Eng Neo Avenue Forest.	A1-W2 (construction worksite area) A1-W2 (operation stage)	To capture the water quality of the stream D/S14 discharging out of Eng Neo Avenue Forest. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).

8.2.2 Water Quality Baseline Assessment Criteria

During construction phase, the locations of the construction worksites can potentially impact the hydrology and water quality of existing watercourses. During operational phase, increased urbanised area and human activities may lead to increased surface runoff and waste management practices (such as littering). Hence, any watercourses that are directly impacted by the proposed development were included in the impact assessment.

The baseline water quality of the watercourses located within the Study Area was analysed against the NEA Trade Effluent Discharge limits for controlled watercourses [R-26]. This comparison could be used to determine whether the existing baseline water quality of the watercourses within the Study Area complies with NEA limits or has already exceeded these limits. However, the NEA Trade Effluent Discharge limits does not provide criteria for the preservation and growth of aquatic life locally. To assess whether the water quality along the identified streams is suitable for aquatic life, certain parameters were compared to the water quality criteria for aquatic life from other countries including United Nations Economic Commission for Europe [R-19], United States Environmental Protection Agency [R-20], Australian & New Zealand [R-27], Canada [R-28], Philippines [R-17], and Malaysia [R-29], which provides guidelines for the protection of aquatic life. The relevant limits and guidelines for water quality parameters were summarised in Table 8-2; however, where no guidelines exist, the monitored results would be considered as the baseline.

Table 8-2 Water Quality Guidelines and Criteria

Parameter	NEA Trade Effluent Discharge Limits[a]	International Water Quality Criteria for Aquatic Life[b]
pH	6 - 9	6.5 - 9
Temperature (°C)	45	-
Salinity (PSU)/Conductivity (µS/cm)	-	-
Total Dissolved Solids, TDS (mg/L)	1,000	1,000
Dissolved Oxygen, DO (mg/L)	-	> 4.0
Turbidity (NTU)	-	50
Total Suspended Solids, TSS (mg/L)	30 SDA: 50[e]	50
Biological Oxygen Demand, BOD_5 (mg/L)[d]	20	3
Chemical Oxygen Demand, COD (mg/L)	60	25
Total Phosphorous, TP (mg/L)	-	Eutrophic limit: 0.075 mg/L
Orthophosphate, PO_4-P (mg/L)	0.65 (equivalent to 2 as PO_4)	0.033 (equivalent to 0.1 as PO_4)
Total Nitrogen, TN (mg/L)	-	Eutrophic limit: 1.5 mg/L
Nitrate, NO_3-N (mg/L)	4.52 (equivalent to 20 as NO_3)	10 (equivalent to 44 as NO_3)

Parameter	NEA Trade Effluent Discharge Limits[a]	International Water Quality Criteria for Aquatic Life[b]
Ammonium Nitrogen, NH_4-N (mg/L)	-	0.5
Total Organic Carbon, TOC (mg/L)	-	-
Lead, Pb (µg/L)	100	Acute LOEL[c]: 82 Chronic LOEL[c]: 3.2

Note:

a. NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse.

b. The sources of international water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-19], United States Environmental Protection Agency [R-20], Australian & New Zealand [R-27], Canada [R-28], Philippines [R-17], and Malaysia [R-29]

c. LOEL – Lowest Observed Effect Level

d. BOD_5 is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material per litre of sample during 5 days of incubation at 20 °C.

e. The limit value is for TSS discharge into storm water drainage system (i.e. ECM discharge) which referred from Sewerage and Drainage (Surface Water Drainage) Regulations.

8.2.3 Prediction and Evaluation of Impact Assessment

Qualitative and analytical methods were applied to assess hydrological and water quality impacts of the development construction and operational phases.

The hydrological impact study will provide an understanding of the impact of construction/operational activities on hydrological conditions of the site, such as the potential land use changes of the site which can lead to an increase in peak flow discharge, a reduction in dry weather flow or even a change in the stream alignment of the impacted watercourse.

The water quality impact study will provide an understanding of potential impact of construction/operational activities on the water quality of the existing watercourses within/surrounding the site using analytical methods.

8.3 Potential Sources of Hydrology and Surface Water Quality Impacts

This section discusses the potential environmental impacts arising from the construction and operational phases of the Projects.

8.3.1 Construction Phase

Nearby watercourses can be potentially exposed to contamination due to the activities taking place during the Project's construction phase. The sources that could potentially impact on the nearby freshwater quality and quantity include, but are not limited to, those listed in Table 8-3.

Table 8-3 Potential Hydrology and Water Quality Impacts during the Construction Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, concrete	• Runoff from exposed soil surface, earth work areas, utilities diversion, soil stockpiles; • Stormwater/groundwater pumped out from excavated areas; • Release of grouting and cement materials; • Runoff from dust suppression sprays. • Wastewater generated from concrete batching plant;	Hydrology: • Increased stormwater peak flow contributions to the channel can lead to increased water levels and subsequent flood to the surrounding areas adjacent to the stream/drain due to the land use change from land clearance; • Alteration of dry weather flow of the watercourse can impact on downstream aquatic habitats; • Stormwater runoff from exposed and unstable slopes may cause soil erosion; and • Potential groundwater drawdown due to dewatering process during tunnelling activities (its

Activity	Potential Source of Impacts	Potential Associated Impacts
batching plant, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)	• Elevated suspended solids (e.g. silt and sediment) in site runoff due to heavy rain; • Spoil generation, handling and transport; • Heavy rain during construction; and • Wastewater generated from tunnelling activities	impact will be assessed in Section 9 – soil and groundwater) Water contamination: • Wastewater from construction activities can contain elevated levels of suspended solids which can lead to increased turbidity and sedimentation rates in the watercourses, etc; • Wastewater from construction activities can contain high levels of oil, grease, and other chemical substances (e.g. calcium hydroxide) therefore contaminating the watercourses; • Alteration of pH due to runoff generated from concrete batching plant; • Inappropriate storage and disposal of wastewater will generate contaminated runoff and pollute nearby watercourses (e.g. improper discharge of tunnelling wastewater, concrete batching plant wastewater and domestic sewage); • Solid waste generated can lead to elevated levels of suspended solids entering watercourses via runoff or improper handling/disposal. It can also block the temporary drains which can lead to localised flooding and mosquito breeding; and • Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination; • Contaminated stormwater due to improper storage/disposal/transport of chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances (e.g. calcium hydroxide) in the nearby watercourses; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil and grease in the nearby watercourses.
Storage and disposal of solid wastes	Improper handling, transfer, storage, and disposal of spoil and solid waste (e.g. TBM spoil, excavated earth, construction debris).	
Storage and disposal of liquid wastes	• Improper management of sewage effluents from on-site; and • Inappropriate discharge of domestic sewage and poor maintenance of the portable chemical toilet, storage tanks and septic tanks (e.g. overflow or overload); and • Inappropriate discharge of wastewater generated from tunnelling activities	
Use and storage of chemical substances, and refuelling activities	• Improper handling, transfer, and storage of chemical substances; • Accidental spill and leaks; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment.	

8.3.2 Operational Phase

Watercourses can potentially be exposed to contamination due to the activities taking place during the Projects' operational phase. The sources that could potentially impact on nearby surface water quality and quantity include but are not limited to the ones listed in Table 8-4.

Table 8-4 Potential Hydrology and Water Quality Impacts during the Operational Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Stormwater Runoff Generation	• Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to the streams; • Increase of runoff peak flow draining to the stream	Hydrology: • Increased stormwater peak flow contributions to the channel and blockage of channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain;

Activity	Potential Source of Impacts	Potential Associated Impacts
	or drain during storm events due to the increase in urbanised area; • Accidental events (e.g. fires); and • Reduce the baseflow (sub-surface water discharge) due to the change in land use of the new development.	• Alteration of dry weather flow of the watercourse can lead to impacts on downstream aquatic habitats; and • Stormwater runoff from exposed and unstable slopes may cause soil erosion. Stormwater Quality: Elevated suspended solids (e.g. silt and sediment) and pollutants in the watercourses (e.g. heavy metals and nutrients from human activities including accidental events).

8.4 Identification of Hydrology and Surface Water Quality Sensitive Receptors

Receptor screening for surface water was conducted within the Biodiversity Study Area for both construction and operational phases (Figure 8-1). Based on site observations, the sensitive receptors for surface water were same for both construction and operational phases. The criteria detailed in Table 6-1 were used to determine the sensitivity of the surface water receptors presented in Table 8-5.

Table 8-5 Classification of Hydrology and Water Quality Sensitive Receptors Identified within the Study Area for Both Construction and Operational Phases

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Concrete drain D/S9	The concrete drain is a freshwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), be used for drinking supply.	Priority 1
Earth Drain D/S10	The earth drain is the upstream of a freshwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), be used for drinking supply. Any proposed discharge from A1-W2 facility building (if available) will be diverted to Marina Reservoir.	Priority 1
Concrete Drain D/S11	The concrete drain is a freshwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	Part of surface water will discharge into MacRitchie Reservoir and another part of surface water will discharge to Marina Reservoir (refer to Figure 4-10), to be used for drinking supply.	Priority 1
Concrete Drain D/S12	The concrete drain is a freshwater public drain. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), be used for drinking supply.	Priority 1
Natural Stream D/S13	The natural stream is a freshwater stream that discharges into public drains. Observations from the site	The surface watercourses is supporting ecosystems of biodiversity conservation significance (refer to Figure 8-1) and eventually will discharge into	Priority 1

Sensitive Receptor	Description	Water Use	Sensitivity Classification
	walkover included presence of aquatic life.	Marina Reservoir (refer to Figure 4-10), used for drinking supply.	
Stream D/S14	The upstream is a freshwater earth drain. The midstream is natural stream with dense vegetation. Downstream is a concrete discharge outlet. Observations from the site walkover included presence of aquatic life.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), be used for drinking supply. Any proposed discharge from A1-W2 facility building (if available) will be diverted to Marina Reservoir.	Priority 1
Concrete Drain D/S15	The concrete drain is freshwater public drains. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), used for drinking supply.	Priority 1
Naturalised Stream D/S16	The natural stream is a freshwater stream that discharges into public drains. Observations from the site walkover included presence of aquatic life.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), used for drinking supply.	Priority 1
Minor roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13	The concrete drains are freshwater public drains. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-10), used for drinking supply.	Priority 1

8.5 Baseline Hydrology and Surface Water Quality

As mentioned in Table 6-2, this report presents the hydrology and water quality findings of the field assessments collected from February 2020 to November 2021, including secondary baseline data of concurrent study carried out by AECOM in the vicinity.

8.5.1 Hydrological Conditions in the Study Area

Based on site reconnaissance and review of secondary data from the concurrent study carried out by AECOM in the vicinity, a few streams and drains were identified in the vicinity of Study Area as shown in Figure 8-3. This consists of three (3) natural stream/mostly-natural streams (D/S13, D/S14 and D/S16), one (1) man-made earth drain (D/S10), four (4) concrete drains (D/S9, D/S11, D/S12 and D/S15) and one (1) pond (Anaerobic Pond). The runoff flowing into the upstream of drain D/S15 has been surveyed before it flows to the earth drain at further downstream of D/S15 in the forested area.

The surveyed topographic data was used to generate elevation and slope maps, and subsequently overlaid with surface watercourses using ArcGIS software as shown inFigure 8-3, Figure 8-4, Figure 8-6 and Figure 8-7.

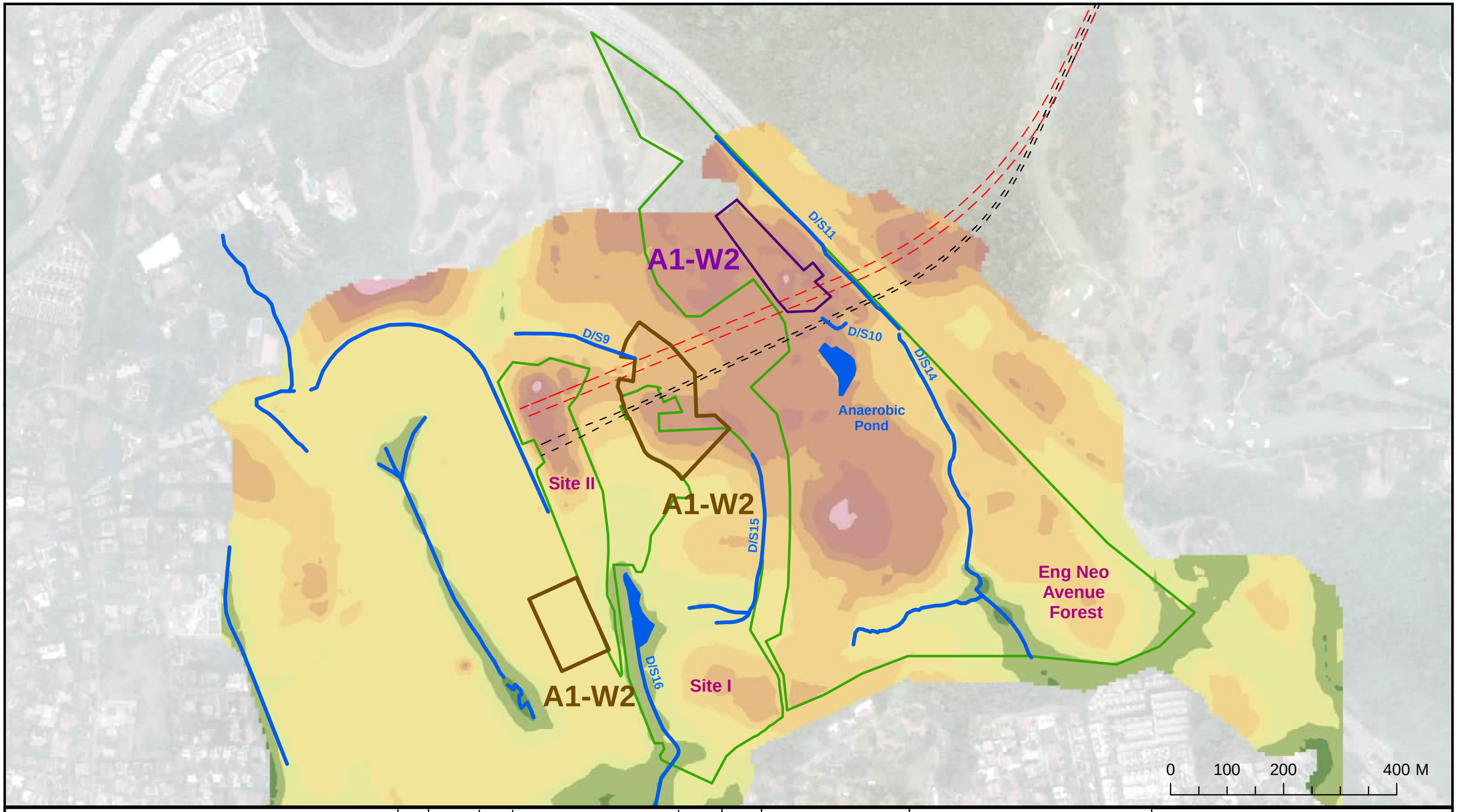
Eng Neo Avenue Forest has the relatively higher overall elevation and undulating terrain based on existing topographic data (Figure 8-3). The two (2) highest points within the Eng Neo Avenue Forest are located near the centre and south of the A1-W2 base scenario worksite footprint, approximately at 46 mSHD. The southwestern hill decreases in elevation towards the east and south of the site. It can be observed that the natural stream (D/S14)

was formed along a valley, between areas with higher elevations (Figure 8-3) and has relatively steep slopes on either bank (Figure 8-4). A man-made earth drain D/S10, a concrete drain D/S11 as ephemeral watercourses, and the Anaerobic Pond is located at areas with comparatively lower elevations, and thus collect runoff during storm events. The Anaerobic Pond found near to earth drain D/S10 (Figure 8-3), however, based on site observation, the surface runoff from proposed development is unlikely to reach this Anaerobic Pond. Based on Figure 8-3, the A1-W2 mitigated scenario worksite footprints will be located at north of Site I and the southwest of Site II. The elevation decreases from northeast to southwest at Site I while the elevation decreases from northwest to southeast at Site II. Ephemeral drain D/S9 found at lower elevation at the north of Site I. An elongated zone of low elevation is located just outside of the western boundary of Site I. Given the comparatively lower elevation of this zone, it is unsurprising that a perennial naturalised stream (D/S16) presented in this area. Similarly, an ephemeral concrete drain (D/S15) is located at areas with relatively lower elevations and conducts runoff from the surrounding vegetation and urban area during storm events.

Based on generated elevation and slope analysis for Eng Neo Avenue Forest, Sites I and II, catchment delineation was conducted to further understand catchment characteristics of the Study Area. In the vicinity of A1-W2 worksite footprint, it is divided into five (5) catchment areas based on Figure 8-5. Catchment C2 feeds into the natural stream (D/S14) in Eng Neo Avenue Forest. A1-W2 base scenario worksite footprint is located at Catchment C3 and the catchment basically contributes into the ephemeral man-made earth drain (D/S10), concrete drain (D/S11) and Anaerobic Pond. Based on hydrological analysis, the surface runoff from earth drain (D/S10) and concrete drain (D/S11) will discharge to upstream of stream D/S14 and the stream D/S14 connects to the other side of PIE through underground culvert. It is understood that the runoff of roadside drains along PIE near the Eng Neo Avenue Forest could be separated into 2 categories: the runoff of northern roadside drains will flow to CCNR and the runoff of southern roadside drains will flow to Marina Reservoir based on the detailed drainage plan shared by PUB. As in similar findings based on existing topographic data, stream D/S14 connects to the southern roadside drains. The water flows from CCNR side to Eng Neo Avenue Forest side as the invert level of underground culvert is lower on Eng Neo Avenue Forest side, then discharges to the south through Eng Neo Avenue Forest and end up to Marina Reservoir. At Site I and Site II, the A1-W2 mitigated scenario worksite footprint will be located in Catchment C4 and Catchment C5. The runoff from Catchment C4 generally contributes to ephemeral concrete drain (D/S15) and perennial concrete drain (D/S16), with water flowing to south of the catchment. while the runoff from Catchment C5 contributes to concrete drain D/S9 at north of Site I. The other catchment, such as Catchment C1 contributes to roadside drains within its respective catchment area..

Based on the elevation and slope analysis at surroundings of A1-W1 worksite footprint (Figure 8-6), higher terrain is found at the southwest of Windsor area and the elevation decrease towards east area. A1-W1 is located in minor undulating terrain. It can be observed that the natural stream (D/S13) was formed along a valley, between areas with higher elevations (Figure 8-6) and has relatively steep slopes on either bank (Figure 8-7). In the vicinity of A1-W1, the main natural stream D/S13 with perennial flow is located within the Windsor Nature Park with envisioned high ecological conservation values (refer to Section 7.5.3). As recorded in Table 8-6, D/S13 has estimated length of 680 m and is covered by dense vegetation. It receives water from Windsor and surrounding urban area towards the east, with an estimated flow velocity of 0.15 m/s during dry weather conditions. D/S12 is a roadside concrete drain with ephemeral flow running along the boundary of A1-W1. It collects surface runoff from the Singapore Island Country Club (SICC) and subsequently discharge to the natural stream D/S13 through an underground culvert structure within the Catchment C1 (refer to Figure 8-8).

The Worksites at Peirce Secondary School and CR13 are located within a well-developed urban area with mostly flat terrain and minor roadside concrete drains. Surface runoff from these worksites will likely flow into surrounding roadside concrete drains.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area

Note:
Site I and II: Forested area adjacent to Fairways Quarters

Elevation (mSHD)

- <10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- >50

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :
Elevation map of the Vicinity of A1-W2

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date JUN 2022

Figure No. : 8 - 3 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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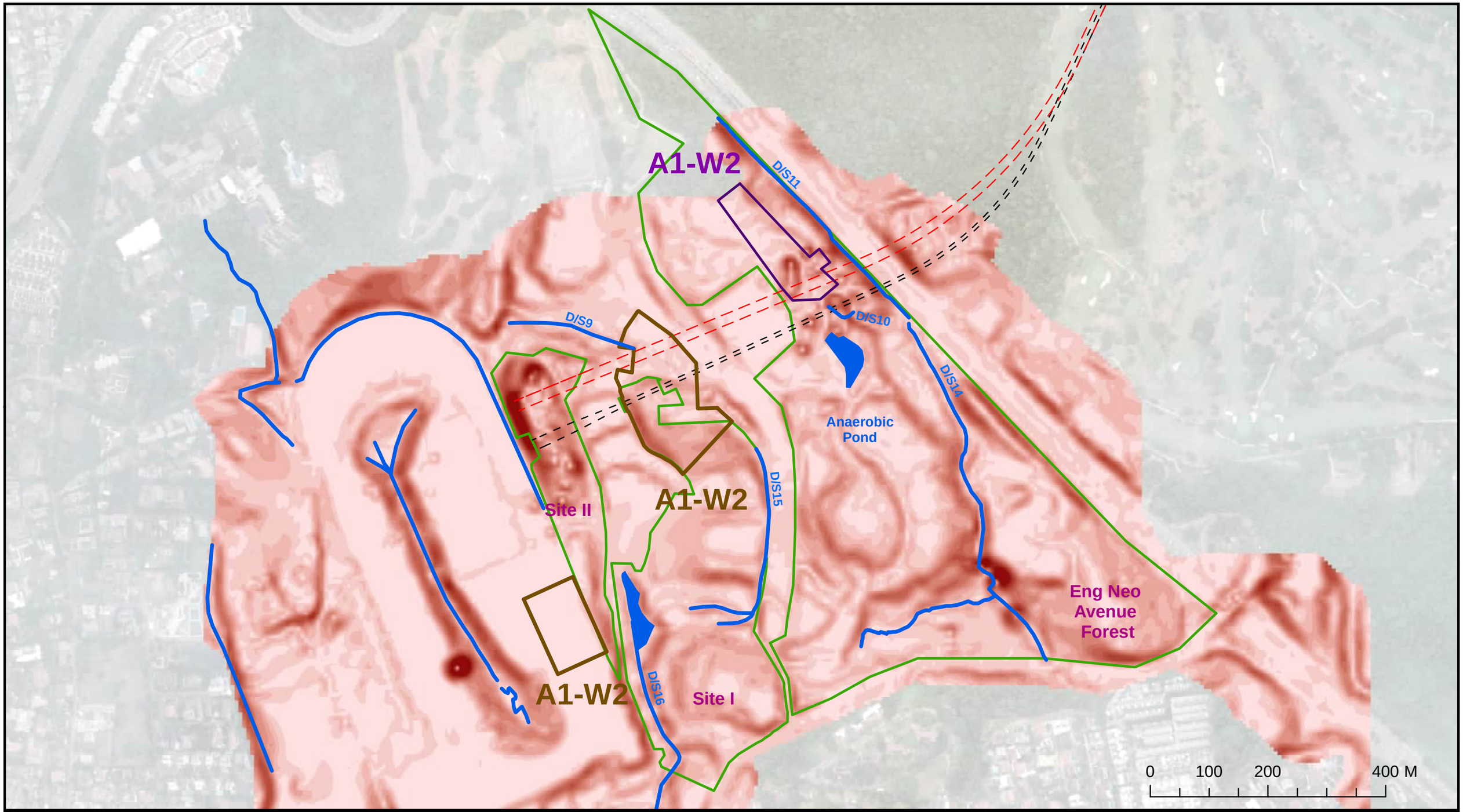

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area

Slope (%)

< 5	35 - 40
5 - 10	40 - 45
10 - 15	45 - 50
15 - 20	50 - 55
20 - 25	55 - 60
25 - 30	> 60
30 - 35	

N

Note:
Site I and II: Forested area adjacent to Fairways Quarters

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-	JUN 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :
Slope map of the Vicinity of A1-W2

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date JUN 2022

Figure No. :	Rev.	Sheet
8 - 4	-	1 of 1

CAD File Name : NA | A3

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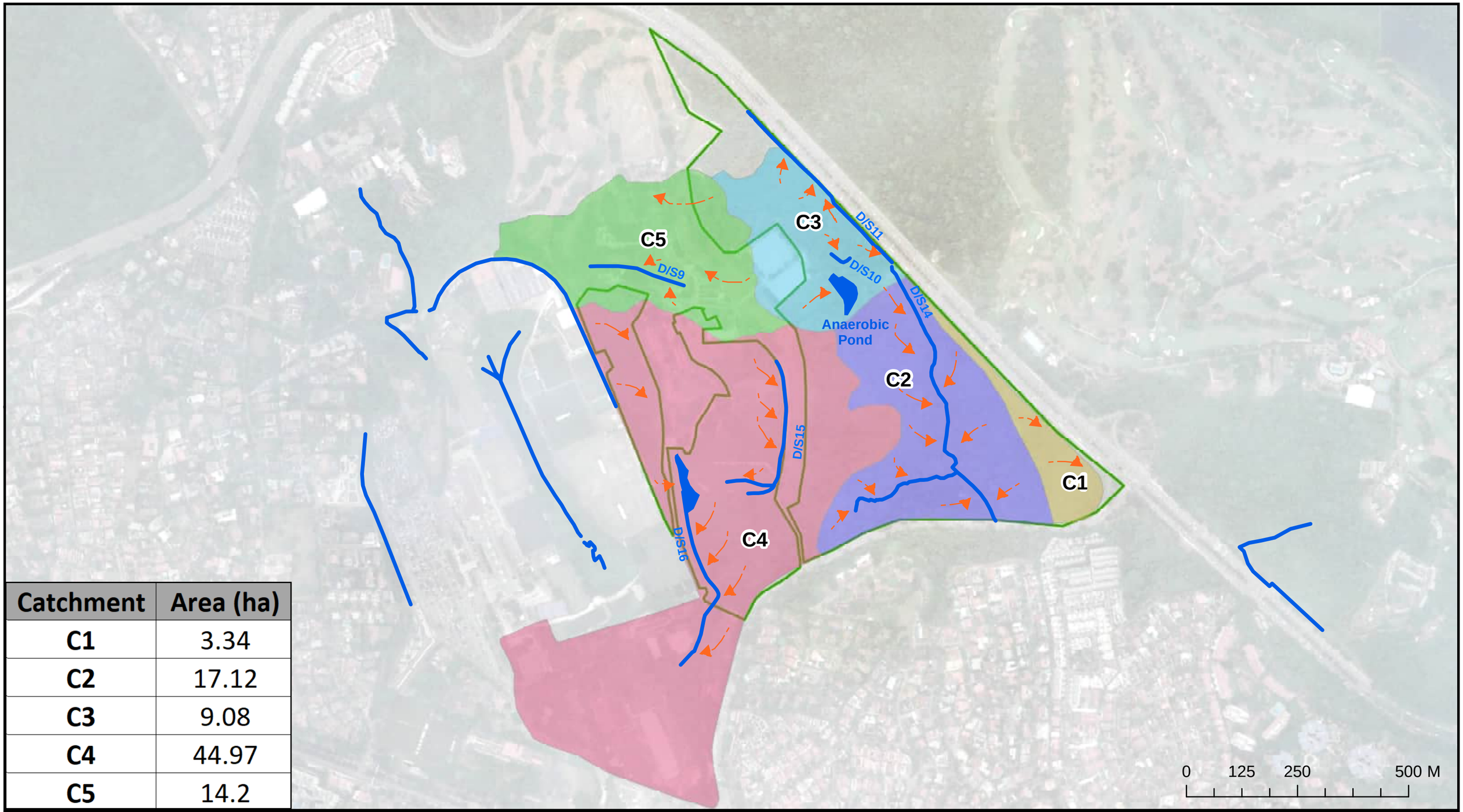

Catchment	Area (ha)
C1	3.34
C2	17.12
C3	9.08
C4	44.97
C5	14.2

Legend

- Watercourses
- Biodiversity Study Area
- Water Flow Direction

Catchment

- C1
- C2
- C3
- C4
- C5

N

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :

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ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :

Catchment Map of the Vicinity of A1-W2

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn: JAC	Date: JUN 2022

Figure No. : 8 - 5 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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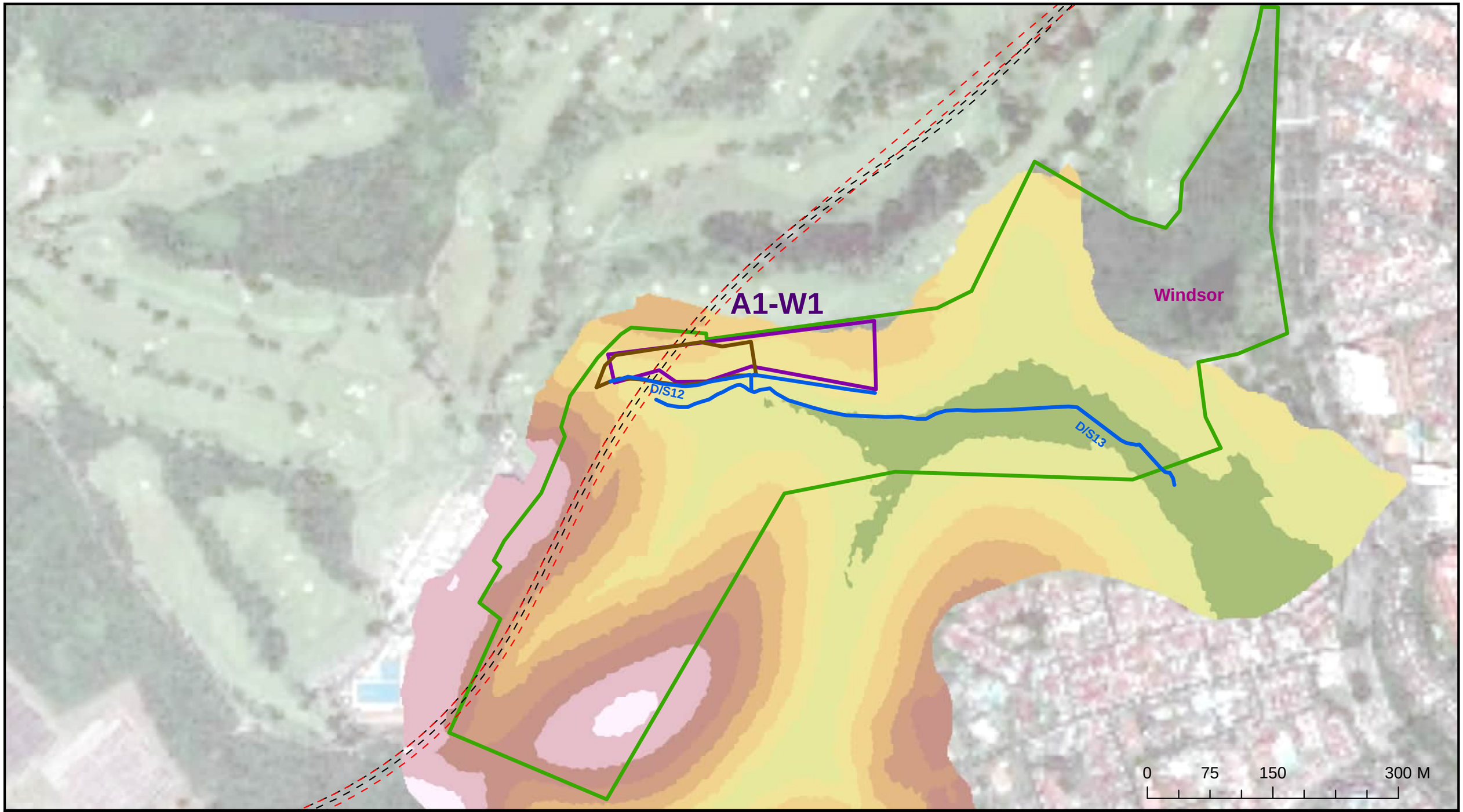

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area

Elevation (mSHD)

- <10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- >50

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :

Elevation map of the Vicinity of A1-W1

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn: JAC	Date: MAR 2022

Figure No. : 8 - 6 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

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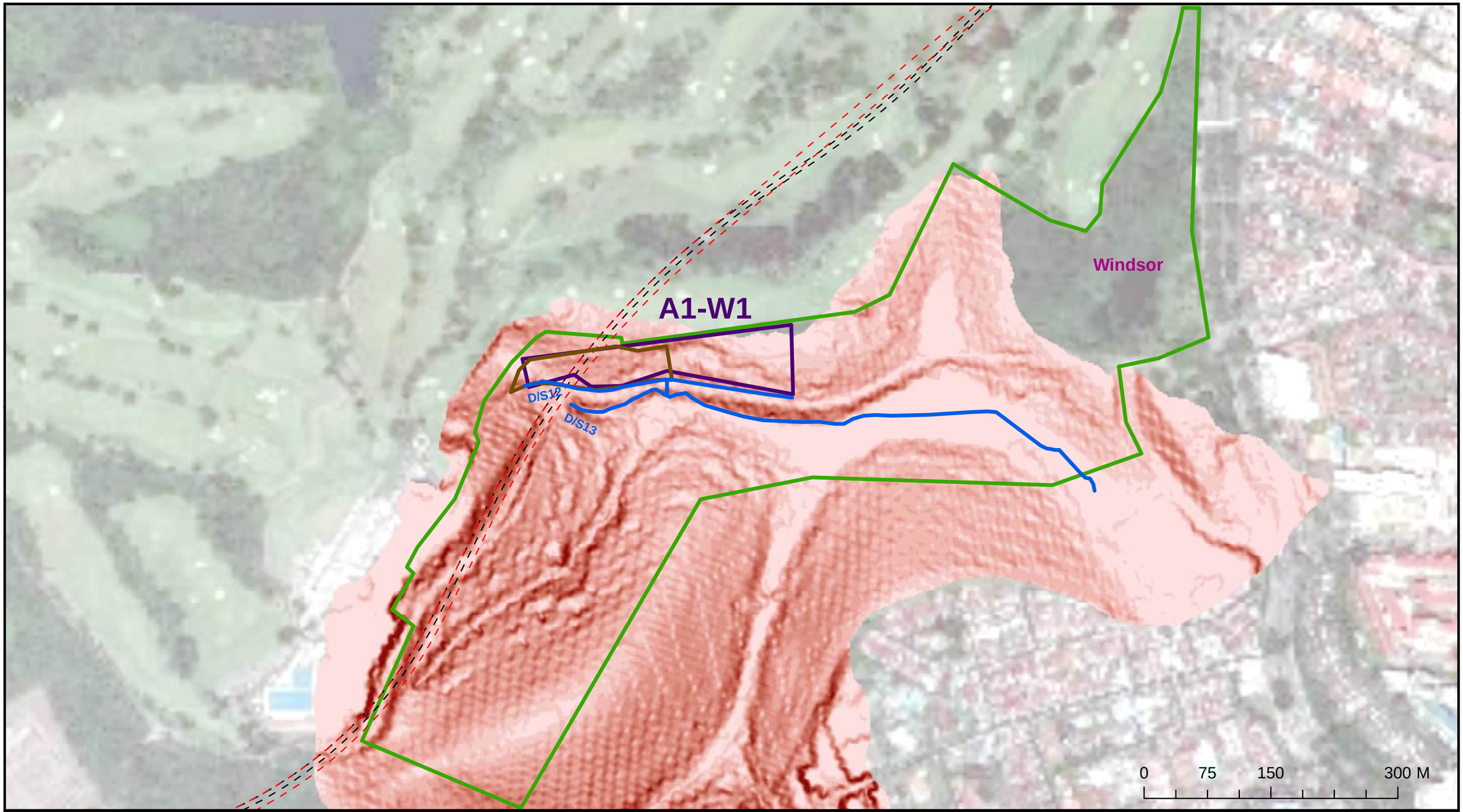

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area

Slope (%)

<5	35 - 40
5 - 10	40 - 45
10 - 15	45 - 50
15 - 20	50 - 55
20 - 25	55 - 60
25 - 30	> 60
30 - 35	

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :

Slope map of the Vicinity of A1-W1

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn: JAC	Date: MAR 2022

Figure No. : 8 - 7 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

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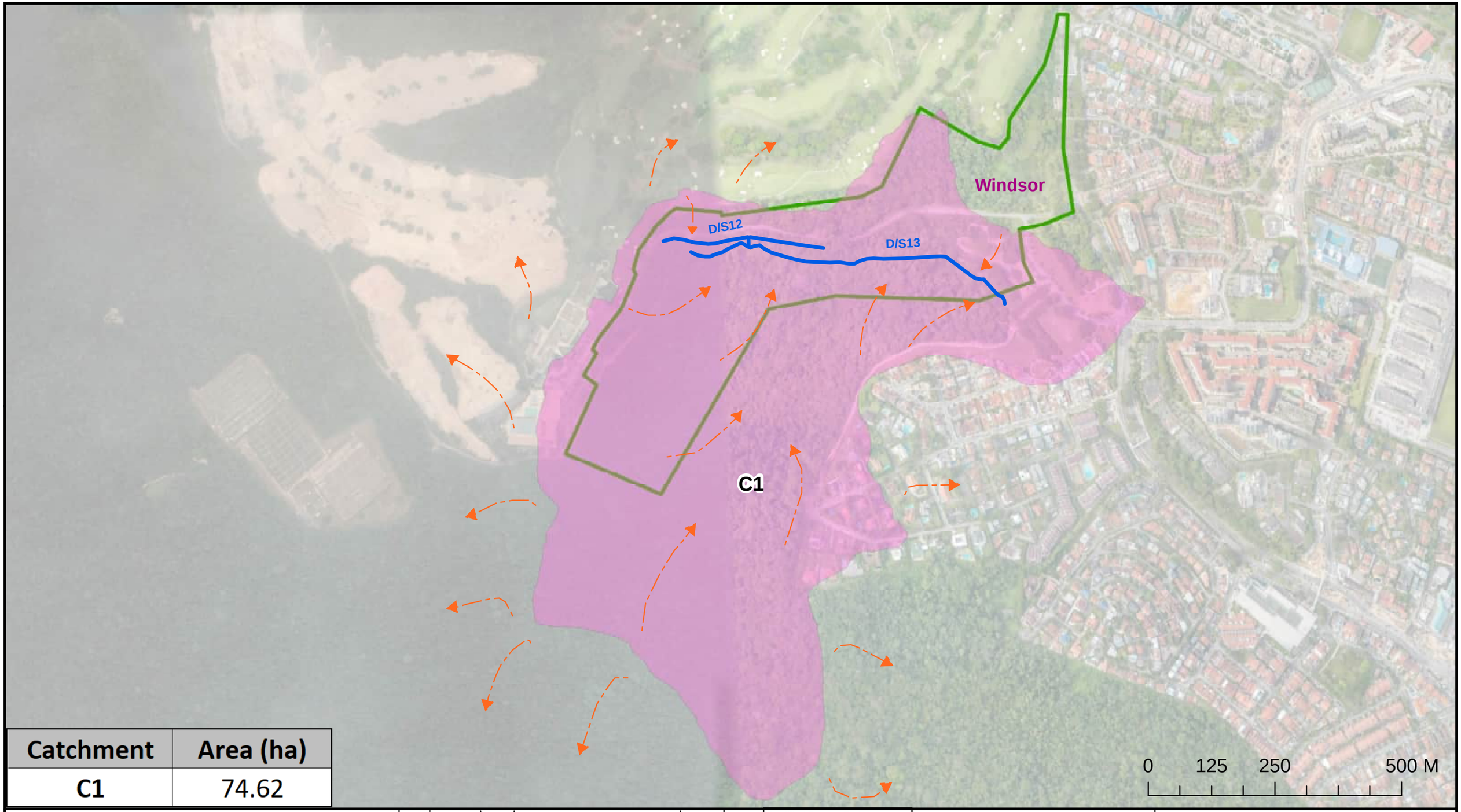

Catchment	Area (ha)
C1	74.62

Legend

- Watercourses
- Biodiversity Study Area
- Water Flow Direction

Catchment

- C1

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

Consultant : AECOM

Client: Urban Redevelopment Authority

Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)

Figure Title :

Catchment map of the Vicinity of A1-W1

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date MAR 2022

Figure No. : 8 - 8 | Rev. - | Sheet 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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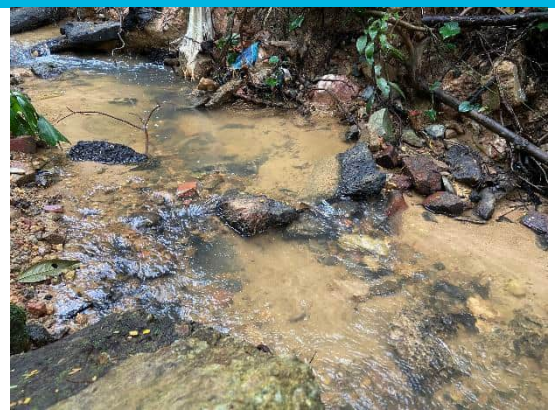
Table 8-6 Description of Watercourses with its Water Quality Sampling Points within the Study Area

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
D/S9	Concrete roadside drain with artificial banks	• Originates from runoff from urbanised area • Ephemeral flow during wet weather condition only **During dry weather condition:** Almost no flow **During wet weather condition:** • Slow wet weather flow observed (estimated at 0.1 m/s) • Water had approximated less than 1 cm flow depth with width of 8 cm along the drains, at time of survey	**WQ10** During Dry Weather  During Wet Weather 
D/S10	Earth drain covered by dense vegetation Estimated drain length is 70 m	• Originates from runoff from Eng Neo Avenue Forest and saddle club • Ephemeral flow during wet weather condition only **During dry weather condition:** Almost no flow **During wet weather condition:** • Almost stagnant wet weather flow observed • Water had approximately 1-5 cm in depth with width of 30 - 100 cm, at time of survey	**WQ11** During Dry Weather  During Wet Weather 
		During wet weather condition:	**WQ11A**

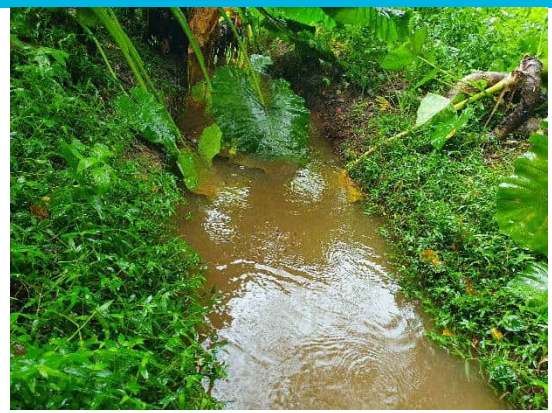
Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
Anaerobic Pond in Eng Neo Avenue Forest	Fully covered by green algae and filled with shrubs and bushes	Stagnant anaerobic pond observed	During Dry Weather 	During Wet Weather 
D/S11	Concrete roadside drain with artificial banks	• Originates from runoff from forest in Eng Neo Avenue Forest and urban area • Ephemeral flow during wet weather condition only **During dry weather condition:** Almost no flow **During wet weather condition:** • Slow wet weather flow observed (estimated at 0.1 m/s) • Water had approximate 1 cm flow depth with width of 10 cm along the drains, at time of survey	**WQ12** During Dry Weather 	During Wet Weather 
D/S13	Natural stream with earth banks, covered by dense vegetation	• Originates from Windsor Nature Park and northern forest fragment • Perennial flow **During dry weather condition:**	**WQ13** During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
	Estimated stream length is 680 m	• Slow water flow (estimated at 0.15 m/s) • Approximately 2 - 9 cm in depth with width of 30 - 100 cm varying along the streams, at time of survey **During wet weather condition:** • Slow wet weather flow (estimated 0.31 m/s at the main stream) • Water had approximate 10 - 20 cm depth with 60 – 120 cm width varying along the streams, at time of survey	 
D/S14	Upstream of D/S14 (WQ23) is a waterbody with earth banks. The midstream (WQ24, WQ25, WQ26) is a natural stream with dense vegetation. The tributary that feeds into the natural stream (WQ27) is a natural stream	• Originates from surrounding vegetation in Site A • Perennial flow **During dry weather condition:** <u>Upstream (WQ23):</u> • Almost no flow as stagnant • Approximate 1 m water depth and width of 5 - 5.5 m at time of survey <u>Midstream</u> (WQ24): • Stagnant • Approximate 25 - 30 cm water depth and width of 3.3 – 3.6 m at time of survey <u>Midstream</u> (WQ25): • Slow water flow observed of approximately 0.13 m/s	**WQ23 (upstream)** During Dry Weather  During Wet Weather  **WQ24 (midstream)** During Dry Weather During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
	with dense vegetation. The downstream is a concrete discharge outlet (weir) (WQ28). Estimated stream length is 673 m.	• Approximate 10 cm water depth and width of 1 m at time of survey • Water was clear and has no odour <u>Midstream</u> (WQ26): • Slow water flow observed of approximately 0.17 m/s • Approximate 8 - 20 cm water depth and width of 70 – 80 cm at time of survey • Water was clear and has no odour <u>Tributary</u> (WQ27): • Slow water flow observed of approximately 0.02 m/s • Approximate 5 cm water depth and width of 80 cm at time of survey • Water was clear and has no odour <u>Downstream</u> (WQ28): • Fast water flow observed of approximately 1 m/s • Approximate 5 cm water depth at time of survey and width of water flow is 40 cm • Water was clear and has no odour **During wet weather condition:** <u>Upstream (WQ23):</u> • Almost stagnant	  **WQ25 (midstream)** During Dry Weather  During Wet Weather  **WQ26 (midstream)** During Dry Weather During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
		• Approximate 1.1 m water depth and width of 5 – 5.8 m at time of survey Midstream (WQ24): • Slow water flow observed of approximately 0.03 m/s • Approximate 15 - 20 cm water depth and width of 3.4 - 3.7 m at time of survey Midstream (WQ25): • Slow water flow observed of approximately 0.5 m/s • Approximate 5 -10 cm water depth and width of 1 - 1.5 m at time of survey • Water was clear and has no odour Midstream (WQ26): • Slow water flow observed of approximately 0.5 m/s • Approximate 10 - 25 cm water depth and width of 1 m at time of survey • Water was clear and has no odour Tributary (WQ27): • Slow water flow observed of approximately 0.1 m/s • Approximate 5 - 10 cm water depth and width of 1 m at time of survey • Water was clear and has no odour Downstream (WQ28): • Fast water flow observed of approximately 1 – 1.5 m/s • Approximate 20 cm water depth at time of survey and width of water flow is 40 cm	  **WQ27 (tributary feeding into D/S13))** During Dry Weather  During Wet Weather  **WQ28 (downstream)** During Dry Weather During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		• Water was clear and has no odour		
D/S15	Concrete roadside drain with artificial banks Length of drain is estimated to be 286 m	• Originates from stormwater runoff from forested area north of Site I • Ephemeral flow **During dry weather condition:** Almost no flow **During wet weather condition:** • Slow water flow observed of approximately 0.12 m/s • Approximately 12 cm water depth and width of 39 cm at time of survey • Water was clear and has no odour	**WQ21** During Dry Weather 	During Wet Weather 
D/S16	Naturalised stream and surrounded by dense vegetation	• Originates from surrounding vegetation in Site I, waterlogged area upstream and a discharge outlet discharging flow from forested areas east of Site I. Flows	**WQ22** During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
	Estimated drain length is 433 m	south of Site I, and out of the Study Area • Perennial flow **During dry weather condition:** • Slow water flow (estimated at 0.037 m/s) • Approximate 50 - 56 cm water depth and width of 85 - 86 cm at time of survey • Water was clear and has no odour **During wet weather condition:** • Slow surface water flow observed, approximately 0.18 m/s • Approximate 76 cm water depth and width of 90 - 95 cm at time of survey • Water was clear and has no odour		

8.5.2 Water Quality Conditions in the Study Area

Both in-situ and ex-situ water quality analyses were conducted for all water quality stations. The water quality sampling dates for two (2) dry weather events and one (1) wet weather event for in the Study Area is shown in Table 8-7. The sampling dates of the baseline water quality surveys for the concurrent study carried out by AECOM in the vicinity are provided in Table 8-8. Note that a greater number of water quality parameters were tested in the concurrent study than this Study, including Ammoniacal Nitrogen (NH_4-N), Total Organic Carbon (TOC), *Enterococcus* and Lead (Pb).

Only stations located at perennial streams/drains (i.e. WQ13, WQ22, WQ23, WQ24, WQ25, WQ26, WQ27 and WQ28) were sampled during dry and wet weather conditions, while stations located at ephemeral streams/drains (i.e. WQ10, WQ11, WQ12 and WQ21) were only be sampled during wet weather conditions. Besides, one (1) water sample was collected from WQ11A during wet weather to support biodiversity findings in the Anaerobic Pond in Eng Neo Avenue Forest.

The water quality results are presented in Table 8-9 with photos shown in Table 8-10, and were assessed against guidelines listed in Table 8-2. The laboratory results for surface water quality parameters were also included in Appendix L. This comparison supports the impact assessment as the streams/drains within the Study Area were found to flow into area of ecological conservation values and public watercourses, and it allows for an assessment of whether the existing water quality is in compliance with the identified limits. If there are no guidelines defined for any of the water quality parameters, the monitored results will be considered as the minimum criteria. It should be noted that the water quality of any water generated from the Project's activities during both construction and operational phases should be treated to comply with the NEA allowable limits for discharge into a controlled watercourse prior to discharge.

Generally, two (2) dry weather (normal conditions) and one (1) wet weather (after a storm event) samples were collected from each water quality station (e.g. WQ13, WQ22, WQ23, WQ24, WQ25, WQ26, WQ27 and WQ28). Some of the watercourses (i.e. D/S9, D/S10, D/S11 and D/S15) in the Study Area were only sampled during storm event only as there was no flow or were mostly dry during dry weather condition. Hence, only wet weather samples were collected at WQ11, WQ12 and WQ21. Besides, one (1) water sample was collected from WQ11A during wet days to support biodiversity findings in Anaerobic Pond located in the Eng Neo Avenue Forest. Dry weather conditions are defined as after a continuous 48-hour period of no-rain, while wet-weather conditions are defined as a rainfall event having more than 10mm of rainfall, with samples to be collected within three (3) hours after the rain stops. A total of twenty-nine (29) samples were collected for this Study as shown in Table 8-7 and Table 8-8.

Table 8-7 Water Quality Monitoring Schedule for this Study

Sampling Event / Sampling Location	Dry Weather				Wet Weather		
	5 Feb 2020	17 Mar 2020	16 Nov 2021	26 Nov 2021	26 Aug 2020	3 Sep 2020	30 Dec 2021
Eng Neo Avenue Forest							
WQ11 (D/S10)	-	-	-	-	Sampled	-	-
WQ11A (Anaerobic Pond)	-	-	-	-	Sampled	-	-
WQ12 (D/S11)	-	-	-	-	Sampled	-	-
Windsor Nature Park							
WQ13 (D/S13)	Sampled	Sampled	-	-	-	Sampled	-
Site I and Site II							
WQ10 (D/S9)	-	-	-	-	-	Sampled	-
WQ21 (D/S15)	-	-	-	-	-	-	Sampled

Sampling Event / Sampling Location	Dry Weather				Wet Weather		
	5 Feb 2020	17 Mar 2020	16 Nov 2021	26 Nov 2021	26 Aug 2020	3 Sep 2020	30 Dec 2021
WQ22 (D/S16)	-	-	Sampled	Sampled	-	-	Sampled
Note: "-" indicates that sampling was not conducted on the corresponding date.							

Table 8-8 Water Quality Monitoring Schedule for Secondary Data Collected for the Concurrent Study Carried out by AECOM in the Vicinity

Sampling Event / Sampling Location	Dry Weather		Wet Weather
	13 October 2021	16 November 2021	5 October 2021
Eng Neo Avenue Forest			
WQ23	Sampled	Sampled	Sampled
WQ24	Sampled	Sampled	Sampled
WQ25	Sampled	Sampled	Sampled
WQ26	Sampled	Sampled	Sampled
WQ27	Sampled	Sampled	Sampled
WQ28	Sampled	Sampled	Sampled

Table 8-9 Surface Water Quality Results

Parameter		WQ11 (D/S10)	WQ11A (Anaerobic Pond)	WQ12 (D/S11)	WQ23 (D/S14)	WQ24 (D/S14)	WQ25 (D/S14)	WQ26 (D/S14)	WQ27 (D/S14)	WQ28 (D/S14)	WQ10 (D/S9)	WQ21 (D/S15)	WQ22 (D/S16)	WQ13 (D/S13)	Average	NEA Trade Effluent Discharge Limits[a]	Criteria for Aquatic Life[b]
Site		Eng Neo Avenue Forest										Site I and Site II		Windsor Nature Park			
Waterbody type		Ephemeral, natural	Pond	Ephemeral, concrete	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Ephemeral, concrete	Ephemeral, concrete	Perennial, naturalised	Perennial, natural			
pH	Dry Average	-	-	-	7.9	8.1	8.2	8.7	8.3	8.1	-	-	8.2	6.8	8.0	6 - 9	6.5 - 9
	Wet	7.3	7.1	7.1	7.2	7.6	7.5	8.2	8.0	8.3	6.9	8.7	8.7	6.5	7.7		
Temperature (˚C)	Dry Average	-	-	-	28.3	27.3	26.7	26.8	26.3	26.5	-	-	27.0	26.6	26.9	45	-
	Wet	26.5	28.6	27.2	27.7	26.6	26.4	26.2	25.5	25.9	28.1	26.6	26.8	27.0	26.7		
Conductivity (µS/cm)	Dry Average	-	-	-	225	326	350	363	647	400	-	-	260	122	337	-	-
	Wet	607	204	372	288	349	358	372	623	426	621	65	131	229	335		
Salinity (PSU)	Dry Average	-	-	-	0.10	0.15	0.16	0.17	0.31	0.19	-	-	0.12	0.06	0.16	-	-
	Wet	0.28	0.09	0.17	0.13	0.16	0.17	0.17	0.30	0.20	0.28	0.03	0.06	0.10	0.16		
Total Dissolved Solids, TDS (mg/L)	Dry Average	-	-	-	137	203	220	228	409	252	-	-	163	77	211	1,000	1,000
	Wet	383	124	232	178	220	226	236	401	272	381	41	82	144	212		
Dissolved Oxygen, DO (mg/L)	Dry Average	-	-	-	2.4	1.6	3.4	7.3	4.6	4.1	-	-	3.7	6.5	4.2	-	> 4.0
	Wet	4.7	1.0	6.3	2.2	3.0	3.6	7.8	6.3	6.8	6.5	7.9	6.6	6.2	5.2		
Turbidity (NTU)	Dry Average	-	-	-	48.4	44.9	39.4	36.8	38.5	42.3	-	-	49.4	32.0	41.5	-	50
	Wet	2.5	36.0	1.4	43.0	29.4	29.2	31.6	33.2	33.6	7.1	148.3	98.2	3.8	40.8		
Total Suspended Solids, TSS (mg/L)	Dry Average	-	-	-	6.8	13.2	3.8	3.9	1.3	4.5	-	-	4.1	7.8	5.7	30	50
	Wet	16.7	118.0	<1.0	7.4	6.1	3.4	18.8	9.4	6.9	8.7	70.5	28.0	3.2	24.0		
Biochemical Oxygen Demand, BOD_5 (mg/L)	Dry Average	-	-	-	2.2	2.4	1.6	1.1	1.2	1.7	-	-	1.5	1.9	1.7	20	3
	Wet	<1.0	60.0	1.4	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	6.7	2.8	4.0	1.7	5.8		
Chemical Oxygen Demand, COD (mg/L)	Dry Average	-	-	-	22.5	23.0	17.5	9.0	12.5	18.0	-	-	8.0	2.5	14.1	60	25
	Wet	9.0	244.0	19.0	18.0	23.0	28.0	48.0	53.0	40.0	Not Tested	37.0	32.0	8.0	44.9		
Total Phosphorus, TP (mg/L)	Dry Average	-	-	-	0.05	0.08	0.08	0.10	0.11	0.11	-	-	0.05	0.19	0.10	-	Eutrophic Limit: 0.075
	Wet	0.28	0.12	0.24	0.05	0.07	0.08	0.11	0.11	0.09	Not Tested	0.03	0.04	0.08	0.11		
Orthophosphate as PO_4-P (mg/L)	Dry Average	-	-	-	0.04	0.06	0.07	0.08	0.08	0.07	-	-	0.04	0.06	0.06	0.65	0.033
	Wet	0.12	0.07	0.10	0.04	0.06	0.06	0.07	0.07	0.06	Not Tested	0.03	0.04	0.06	0.07		
Total Nitrogen, TN (mg/L)	Dry Average	-	-	-	0.7	0.9	1.2	1.2	1.4	1.1	-	-	0.7	0.7	1.0	-	Eutrophic Limit: 1.5
	Wet	0.5	1.4	1.2	0.7	0.7	1.1	1.0	1.1	1.0	Not Tested	1.9	1.0	0.9	1.0		
Nitrate as NO_3-N (mg/L)	Dry Average	-	-	-	0.2	0.04	0.05	0.6	0.9	0.7	-	-	0.3	0.2	0.4	4.52	10
	Wet	0.1	< 0.005	0.8	0.3	< 0.005	0.01	0.4	0.05	0.6	Not Tested	1.4	0.6	0.4	0.4		
	Dry Average	-	-	-	0.29	0.57	0.97	0.30	0.27	0.12	-	-	0.21	Not Tested	0.39	-	0.5

Parameter		WQ11 (D/S10)	WQ11A (Anaerobic Pond)	WQ12 (D/S11)	WQ23 (D/S14)	WQ24 (D/S14)	WQ25 (D/S14)	WQ26 (D/S14)	WQ27 (D/S14)	WQ28 (D/S14)	WQ10 (D/S9)	WQ21 (D/S15)	WQ22 (D/S16)	WQ13 (D/S13)	Average	NEA Trade Effluent Discharge Limits[a]	Criteria for Aquatic Life[b]
Site					Eng Neo Avenue Forest							Site I and Site II		Windsor Nature Park			
Waterbody type		Ephemeral, natural	Pond	Ephemeral, concrete	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Perennial, natural	Ephemeral, concrete	Ephemeral, concrete	Perennial, naturalised	Perennial, natural			
Ammoniacal Nitrogen as NH_4-N (mg/L)	Wet	Not Tested	Not Tested	Not Tested	0.10	0.02	0.59	0.48	0.27	0.20	Not Tested	0.07	0.02	Not Tested	0.22		
Total Organic Carbon, TOC (mg/L)	Dry Average	-	-	-	2.35	3.27	3.52	3.54	4.73	3.32	-	-	1.93	Not Tested	3.24	-	-
	Wet	Not Tested	Not Tested	Not Tested	2.46	3.42	3.73	3.81	5.64	4.38	Not Tested	7.62	6.15	Not Tested	4.65		
***Enterococcus* (CFU/100mL)**	Dry Average	-	-	-	395	360	285	160	425	805	-	-	295	Not Tested	389	-	-
	Wet	Not Tested	Not Tested	Not Tested	1,200	1,500	2,100	1,800	1,900	2,300	Not Tested	40,000	89,000	Not Tested	17,475		
Lead, Pb (µg/L)	Dry Average	-	-	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	-	< 0.5	Not Tested	< 0.5	100	Acute LOEL: 82
	Wet	Not Tested	Not Tested	Not Tested	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	Not Tested	2.06	2.55	Not Tested	0.58		

Note:
a. NEA Trade Effluent Discharge Limits are for controlled watercourses.
b. The sources of water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-19], United States Environmental Protection Agency [R-20], Australian & New Zealand [R-27], Canada [R-28], Philippines [R-17], and Malaysia [R-29].
c. Red values mean data exceeding the NEA limits; Blue values mean data exceeding the aquatic life criteria; Purple values mean data exceeding both NEA limits and aquatic life criteria.
d. <1 means lower than 1 mg/L of level of detection limit, etc.
e. "-" indicates samples were only collected for wet weather conditions, thus dry weather data were not available.
f. "Not Tested" indicates that the LTA's EIS baseline data did not test for the particular water quality parameter.

Table 8-10 Water Quality Photos at Each Sampling Station

Water Sampling Station	During Dry weather	During Wet weather
Eng Neo Avenue Forest		
WQ11		
WQ11A		
WQ12		
WQ23		

Water Sampling Station	During Dry weather	During Wet weather
WQ24		
WQ25		
WQ26		
WQ27		

Water Sampling Station	During Dry weather	During Wet weather
WQ28		
Site I and Site II		
WQ10		
WQ21		
WQ22		
Windsor Nature Park		

Water Sampling Station	During Dry weather	During Wet weather
WQ13		

As described in Section 8.5.1, some drains/streams in the Study Area had ephemeral flow and it is unlikely that such ephemeral drains/streams will have any aquatic life. Hence, water quality data at these ephemeral watercourses were compared with NEA discharge limits. Besides the NEA criteria for trade effluent discharge regulations into controlled watercourses, in cases of watercourses in a natural ecosystem, baseline water quality should be compared to international water quality standards for aquatic watercourses in order to assess its appropriateness to support aquatic life. Hence, the water quality in the Study Area is described as below.

Overall, the water quality from Anaerobic Pond and natural stream in Eng Neo Avenue Forest, perennial natural stream in Windsor Nature Park, ephemeral concrete drain and perennial naturalised concrete drain in Site I were found to correlate well with the identified ecological significance of each watercourse. Earth drain D/S10 (WQ11) and concrete drain D/S11 (WQ12) in Eng Neo Avenue Forest as well as ephemeral drains, D/S9 (WQ10) and D/S15 (WQ21) in Site I had relatively good water quality but was not assessed for its ecological significance due to its ephemeral conditions. Generally, stormwater runoff from this Study Area has relatively good water quality but may have elevated TSS. Natural stream and naturalised drains may have elevated nutrient levels, but aquatic life may have adapted to such conditions. The detailed water quality conditions are included in the following sections. As shown in Figure 8-9, water temperature across the water quality stations during dry and wet weather conditions ranged from 25.5 ˚C – 28.3 ˚C, which below the NEA limit of 45˚C.

8.5.2.1 Eng Neo Avenue Forest

At Eng Neo Avenue Forest, a total of nine (9) water quality stations were sampled. These stations are located along the man-made earth drain (WQ11), concrete drain (WQ12), Anaerobic Pond (WQ11A) and natural stream (WQ23, WQ24, WQ25, WQ26, WQ27 and WQ28).

During wet weather, the water quality of stormwater runoff collected in man-made earth drain (WQ11) and concrete drain (WQ12) was found to be within the NEA discharge limits for all tested water quality parameters (i.e. pH, temperature, Total Dissolved Solids [TDS], Total Suspended Solids [TSS], Biochemical Oxygen Demand [BOD_5], Chemical Oxygen Demand [COD], Orthophosphate [PO_4-P] and Nitrate [NO_3-N]). This indicates that the runoff from northern areas of Site A had relatively good water quality. These watercourses were ephemeral and thus were not assessed for their ecological value.

The Anaerobic Pond had elevated TSS (i.e. 118 mg/L), BOD_5 (i.e. 60 mg/L) and COD (i.e. 244 mg/L) concentrations, which exceeded their respective aquatic life criteria (i.e. 50 mg/L, 3 mg/L and 25 mg/L, respectively) by a great margin. These three parameters are correlated, and their exceedances were likely due to the Pond's stagnant water condition (i.e. which leads to accumulation) as well as the presence of dense green algae on water surface and rotten wood in the pond that were observed during time of survey (refer to photos of WQ11A in Table 8-10). Total Phosphate (TP) and orthophosphate (PO_4-P) were found to be present at high levels that exceeded the eutrophic limit, indicating that the Pond is eutrophicated. This corroborates with the observation of dense green algae at the water surface at time of survey. Furthermore, Anaerobic Pond (WQ11A) had extremely low Dissolved Oxygen, DO (i.e. 1 mg/L), indicating that the conditions are likely unfavourable for aquatic life, given its anaerobic condition. The low DO may be the result of the eutrophication occurring in the Pond as well as the decomposition of the rotten wood. The water quality in this Pond is consistent with the biodiversity findings as there were no aquatic life with high ecological value found inside the Pond at the time of biodiversity survey. However, the Pond has some ecological value as it can still support the surrounding bird species.

The natural stream was sampled at the upstream (WQ23), midstream (WQ24, WQ25 and WQ26) and downstream (WQ28), as well as at the tributary that feeds into this natural stream (WQ27). Generally, the pH and temperature did not fluctuate much in the natural stream, ranging from 7.2 – 8.7 and 25.5 – 28.3 ˚C. The pH values were consistent with a previous study, which showed that the pH generally ranged from 4 to 9 for drains and streams in Singapore [P-4]. The conductivity of water is strongly dependent on the number of ions available to participate in the conduction process. This parameter is positively correlated to TDS and salinity, which measures the total amount of organic and inorganics present in the waterbody and the amount of salts dissolved in water, respectively. The highest value measured for conductivity, salinity and TDS were 647 µS/cm, 0.31 PSU and 409 mg/L, respectively, which confirmed prevalence of freshwater, given that the seawater generally has conductivity of around 3.31×10^6 µS/m [P-64], salinity of around 35 PSU [P-108], and TDS of around 35,000 mg/L [W-50]. The measured DO concentration was found to be relatively low at upstream and midstream (WQ23, WQ24 and WQ25) which was below the aquatic life criteria (i.e. 4 mg/L) for both dry and wet weather, indicating the conditions may be unfavourable for aquatic life. Decomposition of organic matter from forest vegetation in low flowing natural streams surrounded by vegetation, can usually result in depletion of DO in the natural stream. However, despite the low DO, there were freshwater fishes observed near WQ23 and WQ25 along the natural stream (refer to Section 7.3.2.4.7). To support this observation, a previous study has shown DO below 4 mg/L among Singapore natural streams, indicating that freshwater aquatic life may have adapted to such low DO environment in Singapore [P-5]. With the exception of the samples at WQ23 (i.e. 0.05 mg/L for wet and dry weather conditions) and a wet weather sample at WQ24 (i.e. 0.07 mg/L), all water quality stations along the natural stream in Eng Neo Avenue Forest (ranging from 0.08 – 0.11 mg/L) was found to have exceeded the TP eutrophic limit (i.e. 0.075 mg/L). Similarly, PO_4-P exceeded the aquatic life criteria at all stations. Ammoniacal Nitrogen (NH_4-N) had exceeded midstream during dry weather (i.e. WQ24 and WQ25) and wet weather (i.e. WQ25) conditions. The relatively high nutrient levels of nitrogen and phosphorus is typical of forest stream conditions, which is aligned with AECOM's past studies in other forested areas in Singapore. These nutrients are likely to be contributed by the breakdown of organics and detritus (e.g. dead leaves) from the surrounding vegetation. According to the biodiversity findings (see Section 7.3.2.4.7), freshwater fish of conservation value such as the common walking catfish (*C. cf. batrachus*) and and ghost shrimp (i.e. *Channa striata)* were found along this natural stream, which may imply that aquatic life may have adapted to such high nutrient conditions. As such, it can be concluded that the baseline water quality of the natural stream (WQ23 – WQ28) in Site A was still likely to be suitable for aquatic life. This supports biodiversity findings in Section 7.4.1, which considers this natural stream to be of high ecological value.

8.5.2.2 Site I and Site II

At Site I, three (3) water quality stations were sampled at the ephemeral concrete drains (i.e. D/S9 and D/S15) and perennial stream (i.e. D/S16). During wet weather, drain D/S15 had TSS levels of 70.5 mg/L that exceeded the NEA guidelines (i.e. 30 mg/L). This high TSS levels was likely due to the runoff originating from soil, vegetated and urbanised areas which may have contributed the TSS into the watercourse. The BOD_5 level at drain D/S9 (i.e. 6.7 mg/L) was exceeded aquatic life criteria (i.e. 3 mg/L) during wet weather, potentially because the drain D/S9 received the stormwater runoff from the surrounding horse barn in Bukit Timah Saddle Club which could consist of high organic substances.

The perennial stream D/S16 (WQ22) in Site I was within most of the aquatic life criteria on dry weather conditions, with a slight exceedance in PO_4-P levels. It is noted that the water quality in this drain is greatly impacted after storm events. During wet weather, elevated BOD_5, turbidity, *Enterococcus* and lead (Pb) were observed in the concrete drain (WQ22). Turbidity level in the concrete drain (WQ22) was at 98.2 NTU, which exceeded the aquatic life criteria (i.e. 50 NTU). This may be due to the flushing of solids from urban areas and vegetation. It could also because of the turbulent effects resulting in the increased flow in the drain, leading to suspension of solids in the drain during wet weather sampling. These suspended solids may have likely contributed to the increased BOD_5 levels of 4.0 mg/L in the drain as well, which exceeded the aquatic life criteria of 3 mg/L. A 300 times increase in *Enterococcus* counts from 295 CFU/100 ml to 89,000 CFU/100 ml during wet weather shows that the storm runoff flowing into the drain likely contained human or animal faecal matter, implying a possible contamination source from the adjacent/ upstream urban areas outside of Site I. Although Pb concentrations during dry and wet weather (i.e. below the detection limit and 2.55 µg/L, respectively) were lower than the NEA limits and aquatic life criteria, it is of note as the increased concentrations could be due to the contamination of runoff from anthropogenic activities in the vicinity of Site I. Despite the relatively poor water quality during wet weather in this perennial stream D/S16, biodiversity survey findings have shown that there is aquatic life within this watercourse. Furthermore, there were sightings of freshwater fishes during the time of dry weather water quality survey as well. Like other natural streams, nutrient levels of PO_4-P were found to have exceeded the aquatic life criteria during dry and wet weather, suggesting possible unfavourable conditions for aquatic life. However, as mentioned above, aquatic life could have adapted to such elevated nutrient conditions.

8.5.2.3 Windsor

During dry and wet weather conditions, the water quality of surface runoff collected in perennial natural stream (WQ13) was found to be within the NEA discharge limits for all tested water quality parameters (i.e. pH, temperature, Conductivity, Salinity, Turbidity, TDS, DO, COD, BOD_5,TSS, TN and NO_3-N). This indicates that the runoff had relatively good water quality.

TP and PO_4-P concentrations at WQ13 were found to have exceeded the aquatic life criteria (i.e. 0.075 mg/L of TP eutrophic limit of and 0.033 mg/L of PO_4-P). However, the overall baseline water quality of the natural stream in Windsor Nature Park was still likely to be suitable for aquatic life. This supports biodiversity findings in Section 7.4.3, which considers this natural stream to be of high ecological value.

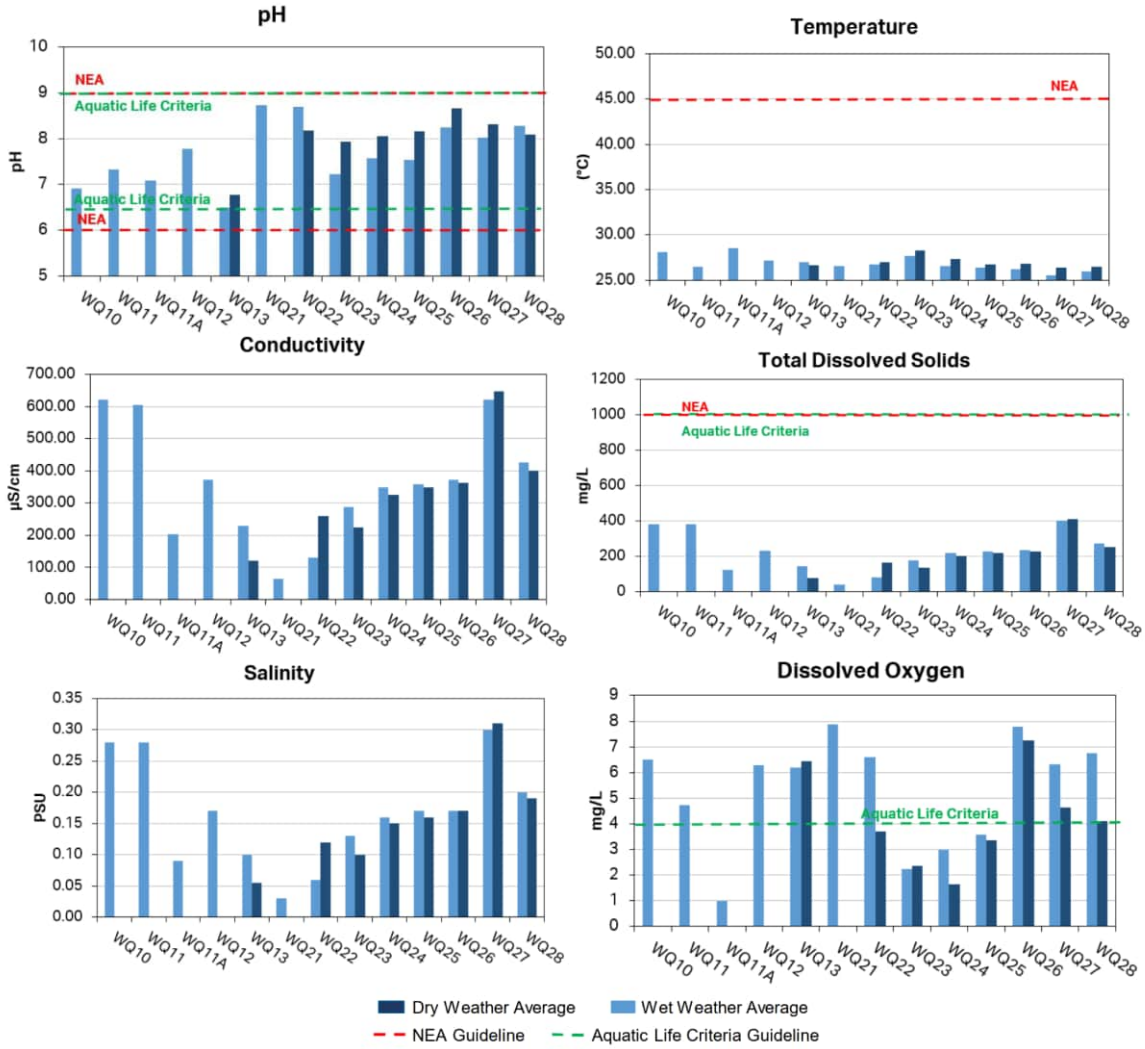


Figure 8-9 Average Monitoring Results of In-situ Parameters for Dry and Wet Weather Conditions

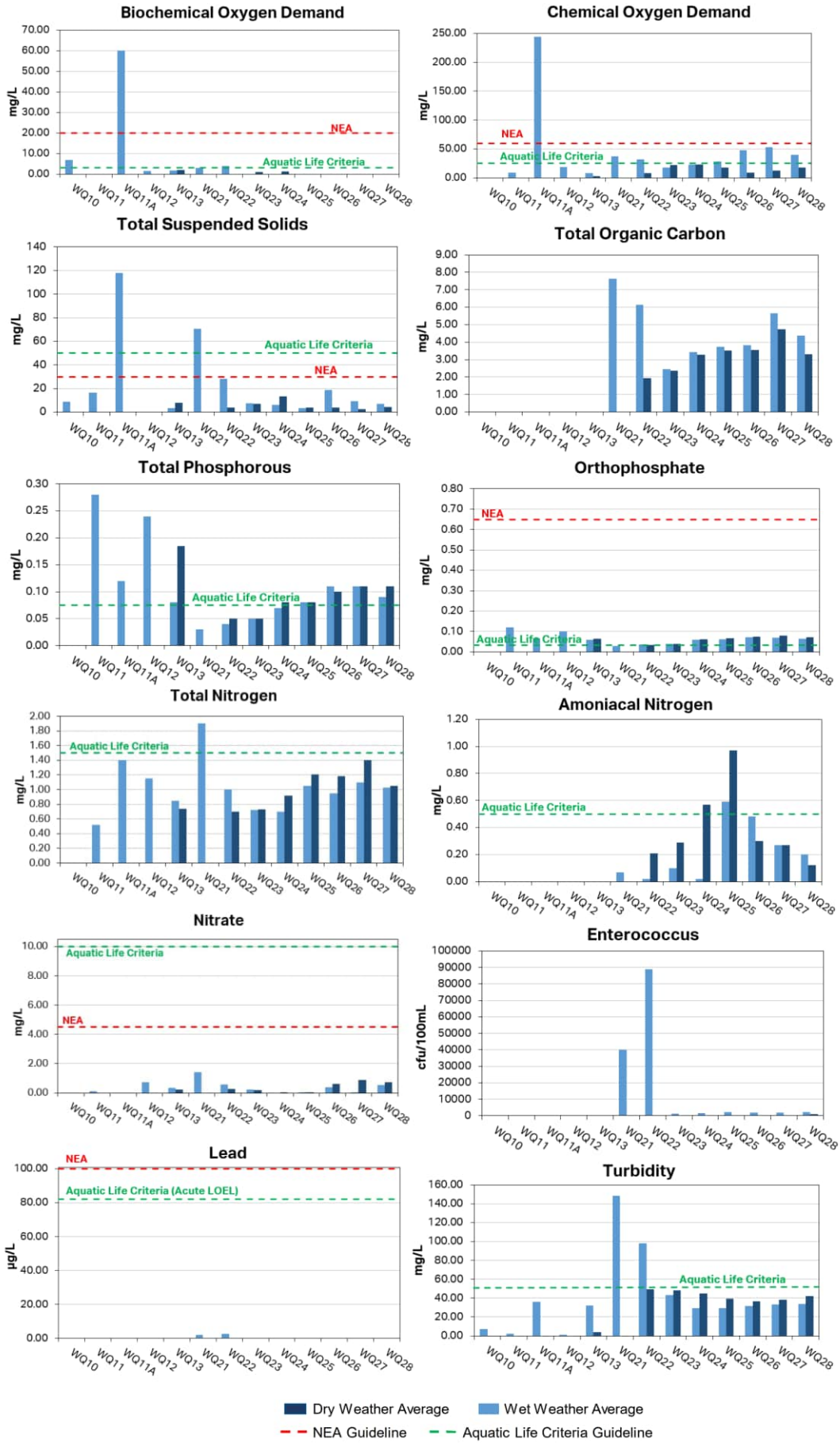


Figure 8-10 Average Monitoring Results of Ex-situ Parameters for Dry and Wet Weather Conditions

8.6 Minimum Control for Potential Impacts

This section proposes minimum controls, or standard practices, commonly implemented in Singapore for similar construction and operation activities, that have been assumed to be implemented for the purposes of impact assessment.

8.6.1 Construction Phase

Table 8-11 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.1 for construction phase.

Table 8-11 Minimum Controls during the Construction Phase Applicable to Hydrology and Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Solid & Toxic Waste Generation	Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)	• Development of a Standard Operation Procedure (SOP) for safe handling, transfer, storage and disposal of solid waste; • Effective ECM and monitoring implemented as required in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses, etc.; • Implementation of CCTV including SIDS at the public drain to monitor the surface runoff discharges from the sites as per the Public Utilities Board of Singapore's (PUB) circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site; • Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area; • All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.); and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.
Liquid Effluent Generation and Stormwater Runoff	Construction wastewater resulting from site clearance, excavation, tunnelling etc.	• A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works; • No unmanaged discharge of wastewater stream permitted; • Reduce, reuse, and recycle hierarchy principle to be applied to wastewater on-site; • Regular audits on environmental management procedures will be carried out on site; • No hazardous liquids to be sent to the detention pond/tank; • Hazardous wastewater, such as oily water, thinners, solvents, or paints should be stored on hard stand, under shelter with a kerb around the storage area. The wastewater should be removed for treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste; • Containment pond/kerbs will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site and potential fire-fighting wastewater. Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purpose;

Environmental Parameter	Activity	Minimum Control

		• ECM tanks/ponds will be designed in sufficient capacity to hold the turbid stormwater prior to treatment at the ECM facility;
		• Temporary storage volumes should be provided for overflow situations. Temporary storage with sufficient capacity will capture any expected additional volumes to ensure untreated wastewater is not released to watercourses unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations;
		• A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the containment pond/kerbs where 'Good Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the containment pond/kerbs checked at least daily to ensure proper functionality;
		• Daily record volume of wastewater, as well as volumes of sludge and other produced wastes;
		• Contractor will need to seek approval from relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site;
		• It is noted that no TBM dewatering facilities, grout handling and cement plants are allowed at this worksite at Windsor Nature Park;
		• The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited (e.g. natural streams within Windsor Nature Park and Eng Neo Avenue Forest);
		• Tunnel washing effluent should be discharged to containment pond/kerbs that manually collected by operator assigned private wastewater collector to be transferred to wastewater treatment plant;
		• The containment pond/kerbs, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits;
		• Adequate drainage, cut-off drains sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater (e.g. concrete batching, wash water, etc.) and stormwater runoff separately through detailed design for capture and treatment in the containment pond/kerbs. Where applicable (e.g. in the vicinity of liquid storage or refuelling areas), this infrastructure will include oil-water separators to capture inadvertent spills or leaked oils or greases;
		• Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following:
		  • EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and
		  • Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of the containment pond/kerbs, or any other wastewater discharge location/equipment.
		• Regular and dedicated procedures for the inspection and maintenance of wastewater (i.e. trade effluent) collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc.;
		• Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses; and
		• A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management;

Environmental Parameter	Activity	Minimum Control

		• Surface runoff from the A1-W1 worksite will be treated with ECM system before discharge to the nearby watercourses along the Island Club Road with the following measures:
		  • Routine monitoring and maintenance of the ECM treatment plant-related equipment; and
		  • Spare pumps, piping and other ancillary equipment will be stored at the worksite for redundancy to enable prompt replacements/repairs are made to allow for smooth operation of the ECM system at all times.

	Storage and disposal of domestic liquid wastes	• Provision of portable toilets and on-site septic tank; • Regular cleaning of the portable toilets and clearing of sanitary waste; • Appropriate location of toilet facilities away from any nearby watercourses; • Inspections and audits to ascertain the hygienic conditions onsite; • The toilet facilities will be placed at least 30 m away from any nearby watercourse; • Training of workers on the best practices to contribute in environmental protection; and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector regardless the wastes to be disposed off-site or discharged to public sewer.
	Storage and disposal of construction solid wastes	• Surface Water Drainage, to be endorsed by a QECP and submitted to PUB; • Implementation of the ECM plan before the start of any construction work; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses (i.e. canals, drains, streams), etc. • Implementation of CCTV including a SIDS at the public drain to monitor the surface runoff discharges from the sites as per the PUB circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Runoff within, upstream of, and adjacent to the worksite will be effectively drained away without causing flooding in the vicinity; • Manholes should always be adequately covered and temporarily sealed; • Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored onsite; • Coverage of temporary/open storage of excavated materials; • All vehicles should run via wheel washing process before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor; and • Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land.
	Stormwater Runoff Generation	Stormwater Quality: • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-

Environmental Parameter	Activity	Minimum Control
		off drain, turbidity curtains for works adjacent to watercourses (i.e. canals, drains, streams), etc.; • Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design for capture and treatment at ECM tanks/ponds before discharge into surface watercourses; • 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.; and • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses. Hydrology: • Runoff within, upstream of, and adjacent to the worksite will be effectively drained away without causing flooding in the vicinity; • Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks/ponds within the Study Area. Detention tanks/ponds can capture stormwater during heavy storm events to reduce the peak runoff. • Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS) to be included in detailed design engineering for the construction stage; and • The design engineers for detailed design may need to ensure that Earth Retaining Stabilisation structures (ERSS) are proposed when the site is cleared and excavated. Concurrently the ECO must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability.
Improper Management of Chemical Substances	Use, storage and disposal of chemical substances Refuelling activities	• Development of SOP for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate fully sheltered storage area with storage volume to be 110% of the largest volume of chemical substances to be stored (kerb up and enclosed on at least 3 sides, covered and with adequate ventilation); • Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically; • Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593; • Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages; • Consignment notification/tracking system and transport emergency response plan for transport of toxic waste; and • Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.

8.6.2 Operational Phase

Table 8-12 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.2 for operational phase.

Table 8-12 Minimum Controls during the Operational Phase Applicable for Hydrology and Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Stormwater Runoff	Stormwater Runoff Generation	Stormwater Quality: • Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment before discharge into watercourses; • 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.; and • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. Hydrology: • Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention ponds/tanks within the Study Area. Detention ponds/tanks can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; • Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; and • Geotechnical aspect of the site's slope stability (such as ERSS) will be included in detailed design engineering for the operational stage.

8.7 Prediction and Evaluation of Hydrology and Surface Water Quality Impacts

8.7.1 Construction Phase

As described in Sections 8.3 and 8.6, three (3) major sources of hydrology and surface water quality impacts were identified, including solid & toxic waste generation, liquid effluent and stormwater runoff, as well as management of chemical substances. Among them, liquid effluent and stormwater runoff may have impact on both hydrology and surface water quality in the vicinity of Study Area, while the other two (2) sources tend to have more impact on surface water quality. Following sections present the prediction and evaluation of hydrology and surface water quality impacts during the construction phase.

8.7.1.1 Solid & Toxic Waste Generation (Water Quality)

In Eng Neo Avenue Forest, drain D/S10, drain D/S11 and stream D/S14 are located outside the construction worksite (Figure 8-3). The quantity of solid and toxic waste stored on site (e.g. chemical waste, construction debris, etc.) is expected to be limited and will be periodically disposed of by licensed waste management Contractors as stipulated as a minimum control measure, and thus it is likely that limited solid and toxic waste will be discarded into the drain D/S10 and drain D/S11 before the runoff discharge to upstream of stream D/S14. Hence, based on the Impact Consequence Matrix as in Table 6-6, the impact intensity would be Medium and its consequence would is also expected to be Medium as these watercourses are Priority 1 sensitive. For stream D/S14, since it has high ecological value based on biodiversity findings (refer to Section 7.4.2.1), the impact intensity would consider High and its impact consequence would be High based on the Impact Consequence Matrix as in Table 6-6. The discharge of suspended solids into drain D/S10, drain D/S11 and stream D/S14 is expected to be limited, since the implementation of ECM tanks/ponds within the construction site will allow for the sedimentation and thus removal of these suspended particles. Water soluble parameters such as TDS, nutrients, heavy metals, etc. will be monitored and the treatment targeting these parameters will be put in place before the effluent is released into the watercourses. By providing that all minimum control measures detailed in Table 8-11 are in place and precautionary management controls are implemented on site (such as regular inspection, housekeeping and training of workers), the likelihood of occurrence would be Regular, resulting in Moderate impact significance for drain D/S10 and drain D/S11 and Major impact significance for stream D/S14 according to Table 6-8. Since watercourses of D/S9, D/S15

and D/S16 are located away from the construction worksite, the impact intensity of solid and toxic waste on watercourses of D/S9, D/S15 and D/S16 would be Negligible and the consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Once effective ECM and monitoring are implemented as required in the Code of Practice on Surface Water Drainage, the impact likelihood on watercourses of D/S9, D/S15 and D/S16 would be Rare and the impact significance would be Negligible according to Table 6-8.

At A1-W1 worksite, any spill and leakage of solid and toxic waste generated from construction site will have High impact intensity on the natural stream of D/S13 inside Windsor Nature Park due to its high ecological importance (refer to Section 7). As stream D/S13 was also Priority 1 sensitive receptors, the impact consequence would also be High based on Table 6-6. However, provided that all minimum control measures detailed in Table 8-11 are in place and precautionary management controls are implemented on site especially the additional measures proposed at A1-W1 (such as routine monitoring and maintenance of ECM treatment plant, etc.), it was assessed to be Rare likelihood that spills or runoff from the waste stored on site would reach any watercourse outside of construction worksite. Therefore, the significance will be Minor at A1-W1 worksite based on Table 6-8.

In the vicinity of Worksites at Peirce Secondary School and CR13 retrieval shaft, the roadside drains of the area are categorised as Priority 1 sensitive receptor. The impact intensity for the roadside drains would be Medium. The solid and toxic waste generation during the construction phase would also lead Medium consequence on those roadside drains based on Table 6-6. However, the implementation of CCTV including SIDS will monitor the flow to prevent waste generated at those roadside drains and could bring Rare likelihood on the roadside drains. Hence, resulting in Minor significance on the roadside drains based on Table 6-8.

8.7.1.2 Liquid Effluent and Stormwater Runoff Generation (Hydrology and Water Quality)

8.7.1.2.1 *Hydrology*

Land use modification due to land clearing during the construction phase may affect existing hydrology condition of Study Area. Due to the land use changes with less vegetation and exposed earth, it may lead to increased surface runoff volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains. With minimum controls as mentioned in Table 8-11, installation of temporary storage volumes can prevent overflow situations at site. Temporary storage with sufficient capacity will capture any additional volumes that may be expected due to proposed construction site. Flooding can be minimised at streams and drains if they will not be occupied as CCTV will be implemented at existing drain to monitor the surface runoff discharges from the sites.

At A1-W2, the worksite is located in the forested area of Eng Neo Avenue Forest. Hence, the catchment area for drain D/S10, drain D/S11 and stream D/S14 could be affected significantly due to the changes on land use and the proposed worksite almost occupied the whole centre section of the Eng Neo Avenue Forest. The impact intensity on watercourses of D/S10 and D/S11 would be Medium with minimum controls in place before the runoff from drain D/S10 and drain D/S11 discharge to stream D/S14. As the drain D/S10 and drain D/S11 are Priority 1 sensitive receptors, their impact consequence would be Medium based on Table 6-6. For stream D/S14, since it has high ecological value based on biodiversity findings (refer to Section 7.4.2.1), the impact intensity would consider High and consequence would be High based on the Impact Consequence Matrix as in Table 6-6. With Regular likelihood of flooding occurrence, the impact significance on the watercourses in Eng Neo Avenue Forest such as drain D/S10 and drain D/S11 would become Moderate as well as Major for stream D/S14 based on Table 6-8. Since watercourses of D/S9, D/S15 and D/S16 are located out of the forested area of Eng Neo Avenue Forest, the land use change may not affect the catchment area which the drains located at, the impact intensity would be Negligible and the impact consequence would be Very Low based on the Impact Consequence Matrix as in Table 6-6. With Rare likelihood of flooding occurrence on watercourses of D/S9, D/S15 and D/S16 due to the land use change, the impact significance on the watercourses of D/S9, D/S15 and D/S16 would be Negligible according to Table 6-8.

At A1-W1, the existing forest area will be removed during construction phase, leading to slighted increase surface runoff and reduced baseflow at the worksite area. As described in Table 8-11, treated surface runoff will be discharged to stream D/S13 with additional minimum controls, such as routine monitoring and maintenance of ECM treatment plant, etc. With such minimum control methods, the existing baseflow from the SICC side flowing to the natural stream D/S13 through underground culvert structure crossing Island Club Road could be lesser in reduction. According to the hydrological baseline surveys during dry weather conditions, the existing baseflow (Figure 8-11, B) from upstream of D/S13 itself was estimated as 0.0075 m^3/s, while the baseflow (Figure 8-11, A) from SICC to D/S13 was estimated as 0.0003 m^3/s (equivalent to only 4% of 0.0075 m^3/s). This indicated that the baseflow contribution from the SICC to the natural stream through this underground culvert is relatively small. In addition, D/S13 is much longer within the Windsor Nature Park than the drain along SICC, indicating the catchment area of D/S13) would also be much larger than the catchment area of the A1-W1 worksite area (as shown in Figure 8-8).

Hence, the reduced catchment area due to at A1-W1 worksite could be minor compared with the larger catchment of D/S13. Therefore, the construction activity would have Low impact intensity. As a Priority 1 sensitive receptor, stream D/S13 would expect Low impact consequence based on Table 6-6. Although the likelihood of such impact is assessed to be Continuous as stream D/S13 with perennial flow would have slightly reduced catchment area throughout the construction period, the impact significance could still be Minor based on Table 6-8.

Figure 8-11 Water Flow Conditions in the Natural Stream D/S13 of Windsor Nature Park.

As the Worksites at Peirce Secondary School and CR13 will only occupy existing empty space or worksite for construction works in the highly urbanised area, with the minimum controls as described above, liquid effluent and stormwater runoff generated from site would have Negligible impact intensity on the hydrology of surrounding roadside drains. As the roadside drains are all Priority 1 receptors, the consequence of hydrology impact would be Very Low based on Table 6-6. With Rare likelihood of flooding, the impact significant becomes Negligible for all the surrounding roadside drains based on Table 6-8.

8.7.1.2.2 *Water Quality*

Liquid effluents generated from the construction activities commonly include extracted groundwater, sanitary discharges, and stormwater runoff from exposed and unstable slopes. For sanitary discharges, portable toilets will be installed as part of the minimum control provided by the Project and sanitary effluents from portable toilets will be collected every week by the appointed Contractor for disposal. Management controls are also expected to be implemented, such as regular inspection and housekeeping. To avoid additional stormwater runoff flowing from site's unstable slope to adjacent forested slopes during the construction phase, it is also recommended that geotechnical aspect of slope stability should be well-planned before the construction.

In Eng Neo Avenue Forest, drain D/S10, drain D/S11 and stream D/S14 are located outside the construction worksite (Figure 8-3). With proper application of the minimum controls described in Table 8-11, such as the implementation of containment pond/kerbs to hold the wastewater generated from construction activities, impacts to the surface water quality from the construction site surface runoff can be reduced. For the extracted groundwater as part of tunnelling wastewater, contractor will need to seek approval from relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. The turbid stormwater runoff generated from construction site will be channelled to ECM tanks/ponds. Hence, the impact intensity on water quality of drain D/S10 and stream D/S11 would be Medium before the runoff from drain D/S10 and drain D/S11 discharge to stream D/S14. Subsequently, the impact consequence would also be Medium as both drain D/S10 and drain D/S11 are Priority 1 sensitive receptors based on Table 6-6. For stream D/S14, since it has high ecological value based on biodiversity findings (refer to Section 7.4.2.1), the impact intensity would consider High and consequence would be High based on the Impact Consequence Matrix as in Table 6-6. Other minimum controls, such as putting in place regularly and dedicated procedures for inspection and the maintenance of wastewater collection and storage would reduce the likelihood to Regular for drain D/S10, drain D/S11 and stream D/S14. Thus, the impact significance on drain D/S10 and drain D/S11 would be Moderate while on stream D/S14 would be Major based on Table 6-8. Due to watercourses of D/S9, D/S15 and D/S16 are located away from the construction worksite, the impact intensity of liquid effluent and stormwater contamination on watercourses of D/S9, D/S15 and D/S16 would be Negligible and the consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix

as in Table 6-6. With a Rare impact likelihood of liquid effluent contamination on watercourses of D/S9, D/S15 and D/S16, the impact significance would be Negligible according to Table 6-8.

At A1-W1 worksite, any spill and leakage of untreated liquid effluent and stormwater generated from construction site with contaminants could have High impact intensity on the natural stream of D/S13 inside Windsor Nature Park due to its high ecological importance. Hence, the consequence would also be High as stream D/S13 was a Priority 1 sensitive receptor. However, provided that all minimum control measures detailed in Table 8-11 are in place and precautionary management controls are implemented on site especially the additional measures proposed at A1-W1 (such as routine monitoring and maintenance of ECM treatment plant, etc.), it was expected to be Rare likelihood that spills or runoff from the waste stored on site will reach any watercourse outside of construction worksite. Therefore, the significance would be Minor at A1-W1 worksite based on Table 6-8.

In the vicinity of Worksites at Peirce Secondary School and CR13 retrieval shaft, the roadside drains of the area are categorised as Priority 1 sensitive receptor. The impact intensity for the roadside drains will be Medium with minimum controls in place. The liquid effluent and stormwater runoff generated during the construction phase would also lead to Medium consequence on those roadside drains based on Table 6-6. However, equipped with the spill clean-up kits at the ECM tanks/ponds and containment pond/kerbs, it could prevent the generated stormwater runoff and liquid effluent flowing into the roadside drains and the likelihood on the roadside drains would be Rare, and thus resulting in Minor significance on the roadside drains based on Table 6-8.

8.7.1.3 Improper Management of Chemical Substances (Water Quality)

Chemical substances will be stored on concrete surfaces with containment bunds or on spill control palettes. Moreover, SOP is expected to be developed to ensure the proper handling, transfer and storage of these substances, which will also contribute to reduce the frequency and impact of chemical spillage.

In Eng Neo Avenue Forest, drain D/S10, drain D/S11 and stream D/S14 are located outside the construction worksite (Figure 8-3). The minimum control measures described in Table 8-11 such as periodically conducting lead detection tests will be implemented accordingly. Hence, the impact intensity of potential contamination from chemical substances would be Medium and the impact consequence would also be Medium for drain D/S10 and drain D/S11 according to Table 6-6 before the runoff from drain D/S10 and drain D/S11 discharge to stream D/S14. For stream D/S14, since it has high ecological value based on biodiversity findings (refer to Section 7.4.2.1), the impact intensity would consider High and consequence would be High based on the Impact Consequence Matrix as in Table 6-6. The likelihood of occurrence of a spill leading to runoff into the watercourses (i.e. D/S10, D/S11 and D/S14) would be Regular, resulting in Moderate impact significance for drain D/S10 and drain D/S11 as well as Major impact significance for stream D/S14 based on Table 6-8. Due to watercourses of D/S9, D/S15 and D/S16 are located away from the construction worksite, the impact intensity on watercourses of D/S9, D/S15 and D/S16 would be Negligible and the consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. With a Rare impact likelihood of water quality contamination due to improper chemical substances management on watercourses of D/S9, D/S15 and D/S16, the impact significance would be Negligible according to Table 6-8.

At A1-W1 worksite, any spill and leakage of chemical substances generated from construction site with contaminants would have High impact intensity on the natural stream of D/S13 inside Windsor Nature Park due to its high ecological importance. Hence, the impact consequence would also be High for stream D/S13 (Priority 1 sensitive receptor) according to Table 6-6. However, provided that all minimum control measures detailed in Table 8-11 are in place and precautionary management controls are implemented on site especially the measures proposed at A1-W1 (such as routine monitoring and maintenance of ECM treatment plant, etc.), it would be Rare that chemical substances could reach any watercourse outside of construction worksite. Therefore, the impact significance was assessed to be Minor at A1-W1 worksite based on Table 6-8.

In the vicinity of Worksites at Peirce Secondary School and CR13 retrieval shaft, the roadside drains of the area are categorised as Priority 1 sensitive receptor. The impact intensity for the roadside drains would be Medium. The liquid effluent and stormwater runoff generated during the construction phase would also lead to Medium consequence on those roadside drains according to Table 6-6. However, with a proper emergency response plan and training for handling chemical substances, the likelihood would be Rare on the roadside drains. Hence, it would result in Minor significance on the roadside drains based on Table 6-8.

Table 8-13 Summary of Impact Evaluation during Construction Phase

Potential Source of Impact	Receptor Sensitivity[8]	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
Solid & Toxic Waste Generation (Water Quality)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S14)	Eng Neo Avenue Forest	High	High	Regular	Major
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	High	High	Rare	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	Medium	Medium	Rare	Minor
Liquid Effluent Generation and Stormwater Runoff (Hydrology)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S14)	Eng Neo Avenue Forest	High	High	Regular	Major
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	Low	Low	Continuous	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	Negligible	Very Low	Rare	Negligible

[8] Receptor locations are shown in Figure 8-2.

Potential Source of Impact	Receptor Sensitivity[8]	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
Liquid Effluent Generation and Stormwater Runoff (Water Quality)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S14)	Eng Neo Avenue Forest	High	High	Regular	Major
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	High	High	Rare	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	Medium	Medium	Rare	Minor
Improper Management of Chemical Substances (Water Quality)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S14)	Eng Neo Avenue Forest	High	High	Regular	Major
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	High	High	Rare	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	Medium	Medium	Rare	Minor

8.7.2 Operational Phase

As described in Section 3.1.2, A1-W1 worksite will be converted to permanent facility buildings at the time of operation. The Worksites at A1-W2, CR13 and Peirce Secondary School will have only permanent underground structures without housing any facilities, thus no impact assessment was carried out at the roadside drains surrounding these areas.

8.7.2.1 Stormwater Runoff Generation (Hydrology and Water Quality)

8.7.2.1.1 *Hydrology*

The increase in stormwater runoff peak flow and soil erosion may occur due to land use change of Study Area during operation stage. Due to the land use changes (i.e. reduced vegetation surface cover and reduced pervious area), it may lead to increased surface runoff volume and there an increased water level in existing channels, which can result in subsequent flooding of surrounding areas adjacent to the streams and drains.

Located within the Eng Neo Avenue Forest, the proposed facility buildings at A1-W2 will result in a major change in the existing catchment of drain D/S10, drain D/S11 and stream D/S14 as it largely blocks the water flowing from northwest to southeast. Hence, during operational phase, the impact intensity on drain D/S10 and drain D/S11 would be Medium. As drain D/S10 and drain D/S11 are Priority 1 sensitive receptors, the impact consequence would be Medium based on Table 6-6. For stream D/S14, since it will receive runoff from drain D/S10 and D/S11 at its upstream and it has high ecological value based on biodiversity findings (refer to Section 7.4.2.1), the impact intensity would be High and the impact consequence would also be High, as assessed based on the Impact Consequence Matrix as in Table 6-6. The likelihood of flooding due to heavy storm events would be Occasional, resulting in Moderate impact significance on drain D/S10, drain D/S11 and stream D/S14, as assessed based on Table 6-8. Due to watercourses of D/S9, D/S15 and D/S16 are located far away from the A1-W2 facility building, the impact intensity on watercourses of D/S9, D/S15 and D/S16 would be Negligible and the consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. With a Rare impact likelihood of hydrological change on watercourses of D/S9, D/S15 and D/S16, the impact significance would be Negligible according to Table 6-8.

The proposed permanent location of A1-W1 facility building will be located to the north of natural stream D/S13 as shown in Figure 8-13. The amount of stormwater runoff flowing into stream D/S13 may be altered slightly due to the minor change in land use. With proper minimum control applied such as installation of detention tanks to hold stormwater at site (refer to Table 8-12) to prevent surface runoff overflow and flooding on stream D/S13, the impact intensity would be Low. Hence, according to Table 6-6, the impact consequence was Low as stream D/S13 is Priority 1 sensitive receptor. The likelihood of occurrence of such heavy storm events would be Occasional. Hence, the impact significance on stream D/S13 was assessed as Minor based on Table 6-8.

8.7.2.1.2 *Water Quality*

Stormwater runoff generated from the development site typically has good water quality with negligible contaminants. With proper application of the minimum controls described in Table 8-12, (e.g. ABC water design approach for capture and treatment before discharge into surface water and regular dedicated procedures for the inspection and maintenance of stormwater systems, etc.), the impact intensity of potential contamination from stormwater runoff would be Negligible for freshwater receptors. As all the freshwater receptors are Priority 1, the impact consequence of the watercourses due to the potential contamination was classified as Very Low based on Table 6-6. Although the likelihood of normal storm event was expected to occur Occasionally for drain D/S10, drain D/S11, stream D/S13 and stream D/S14, the overall significance of stormwater runoff impact to water quality was assessed to be Minor impact based on Table 6-8. With a Rare impact likelihood of water quality contamination on watercourses of D/S9, D/S15 and D/S16 during operational phase, the impact significance would be Negligible according to Table 6-8.

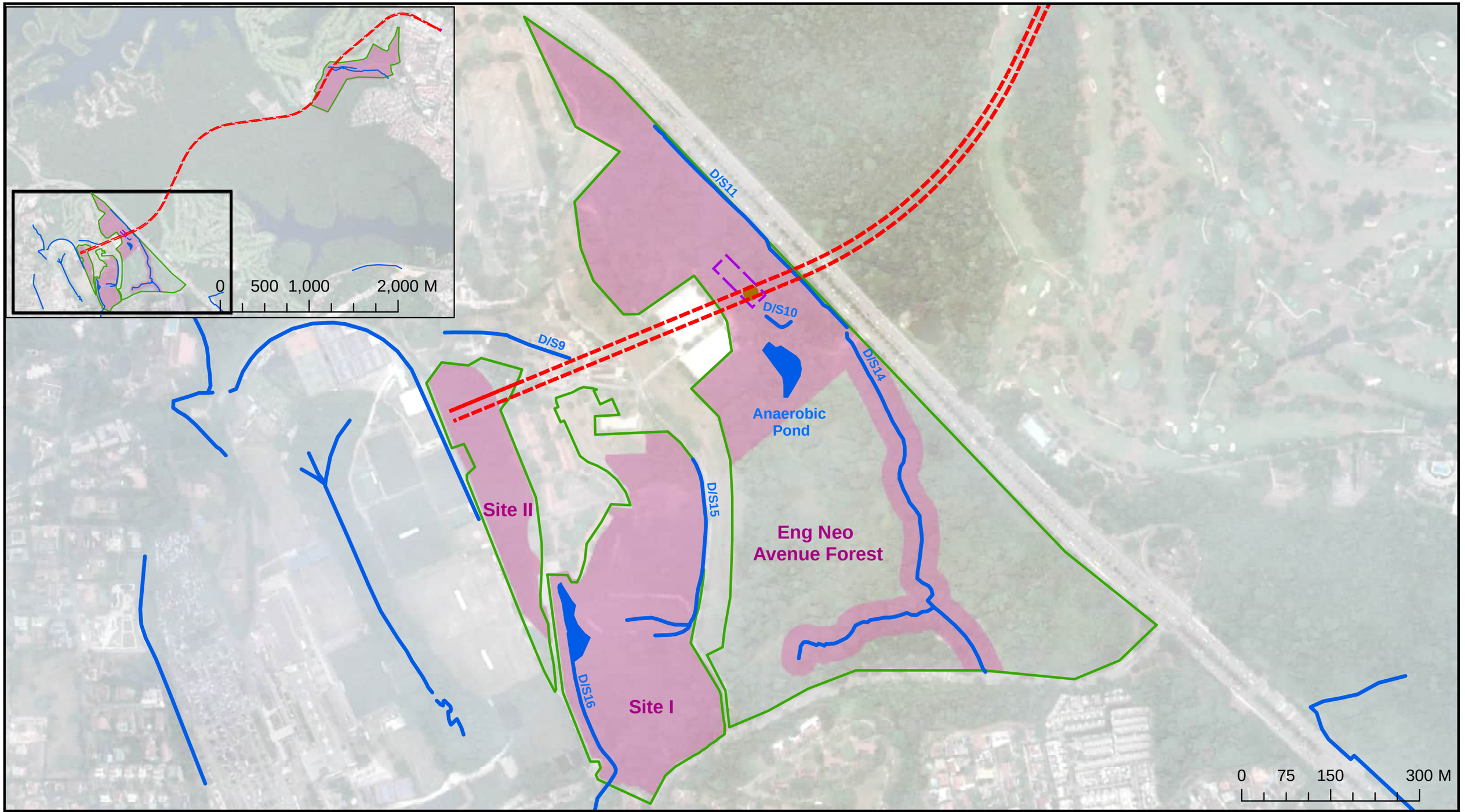
Table 8-14 Summary of Impact Evaluation during Operational Phase

Potential Source of Impact	Receptor Sensitivity	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
Stormwater Runoff (Hydrology)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Medium	Medium	Occasional	Moderate
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Medium	Medium	Occasional	Moderate

Potential Source of Impact	Receptor Sensitivity	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
	Priority 1 (D/S14)	Eng Neo Avenue Forest	High	High	Occasional	Moderate
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	Low	Low	Occasional	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	N.A.			
Stormwater Runoff (Water Quality)	Priority 1 (D/S10)	Eng Neo Avenue Forest	Negligible	Very Low	Occasional	Minor
	Priority 1 (D/S11)	Eng Neo Avenue Forest	Negligible	Very Low	Occasional	Minor
	Priority 1 (D/S14)	Eng Neo Avenue Forest	Negligible	Very Low	Occasional	Minor
	Priority 1 (D/S9)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S15)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)	Sites I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S13)	Windsor	Negligible	Very Low	Occasional	Minor
	Priority 1 (Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	None	N.A.			

Note:

1. N.A. – Not applicable as the worksites at CR13 and Peirce Secondary School will have only permanent underground structures without housing any facilities.



Legend

- Watercourses
- Proposed CRL Alignment (Underground)
- A1-W2 Underground Structures (Base Scenario)
- A1-W2 Above-ground Structures (Base Scenario)
- Biodiversity Study Area
- Area of High Conservation Value

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
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Consultant : AECOM

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Project Title :
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Figure Title :
SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF A1-W2 FACILITY BUILDING DURING OPERATION

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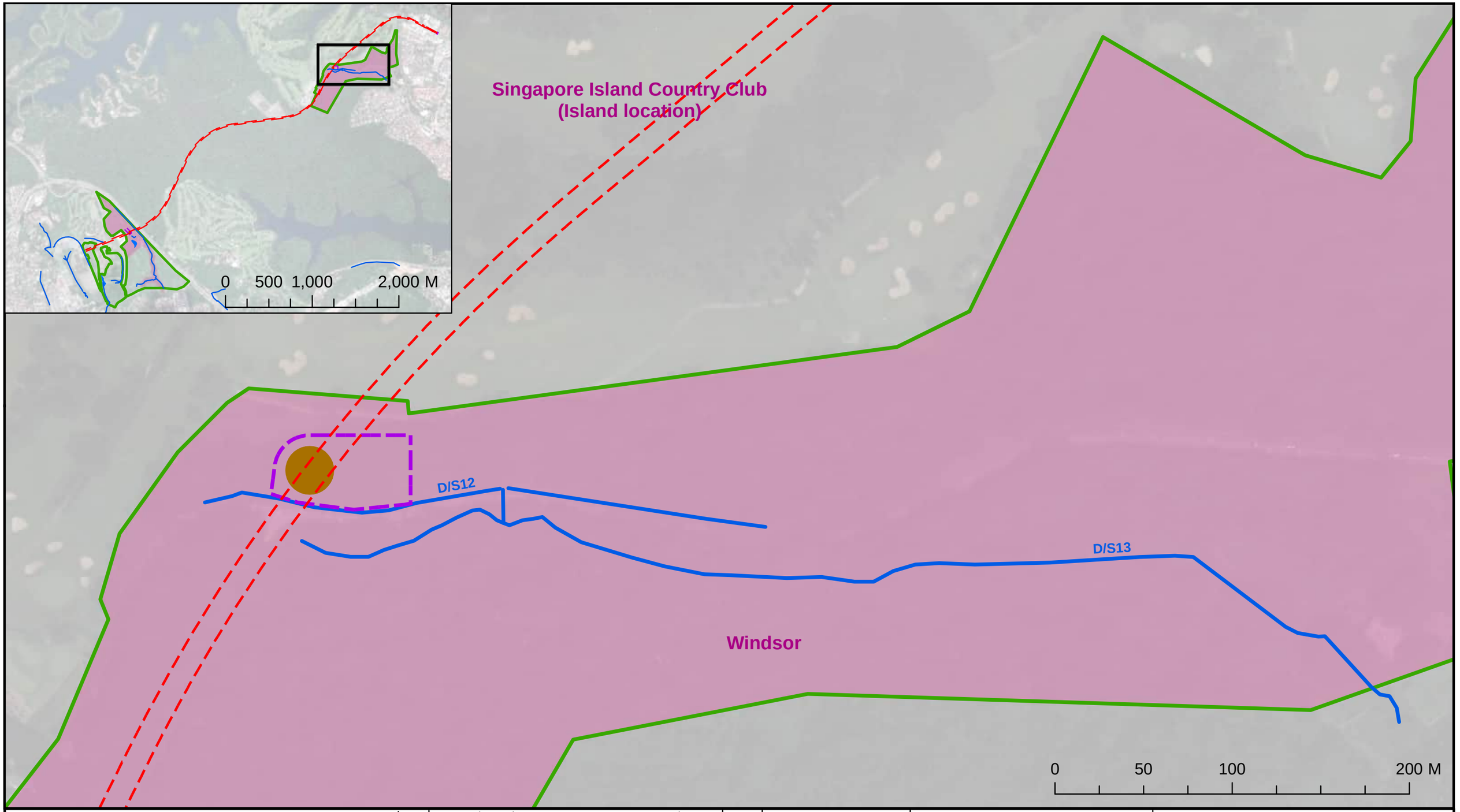

Legend

- Proposed CRL Alignment (Underground)
- A1-W1 Underground Structure (Base Scenario)
- A1-W1 Above-ground Structure (Base Scenario)
- Watercourses
- Biodiversity Study Area
- Area of High Conservation Value

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(WINDSOR AND
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Figure Title :

SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF A1-W1 FACILITY BUILDING DURING OPERATION

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8.8 Recommended Mitigation Measures

In this section, mitigation measures are proposed to further minimise the adverse impacts on the sensitive receptors that were assessed to have an impact significance of Moderate or Major.

8.8.1 Construction Phase

8.8.1.1 Elimination/Avoidance

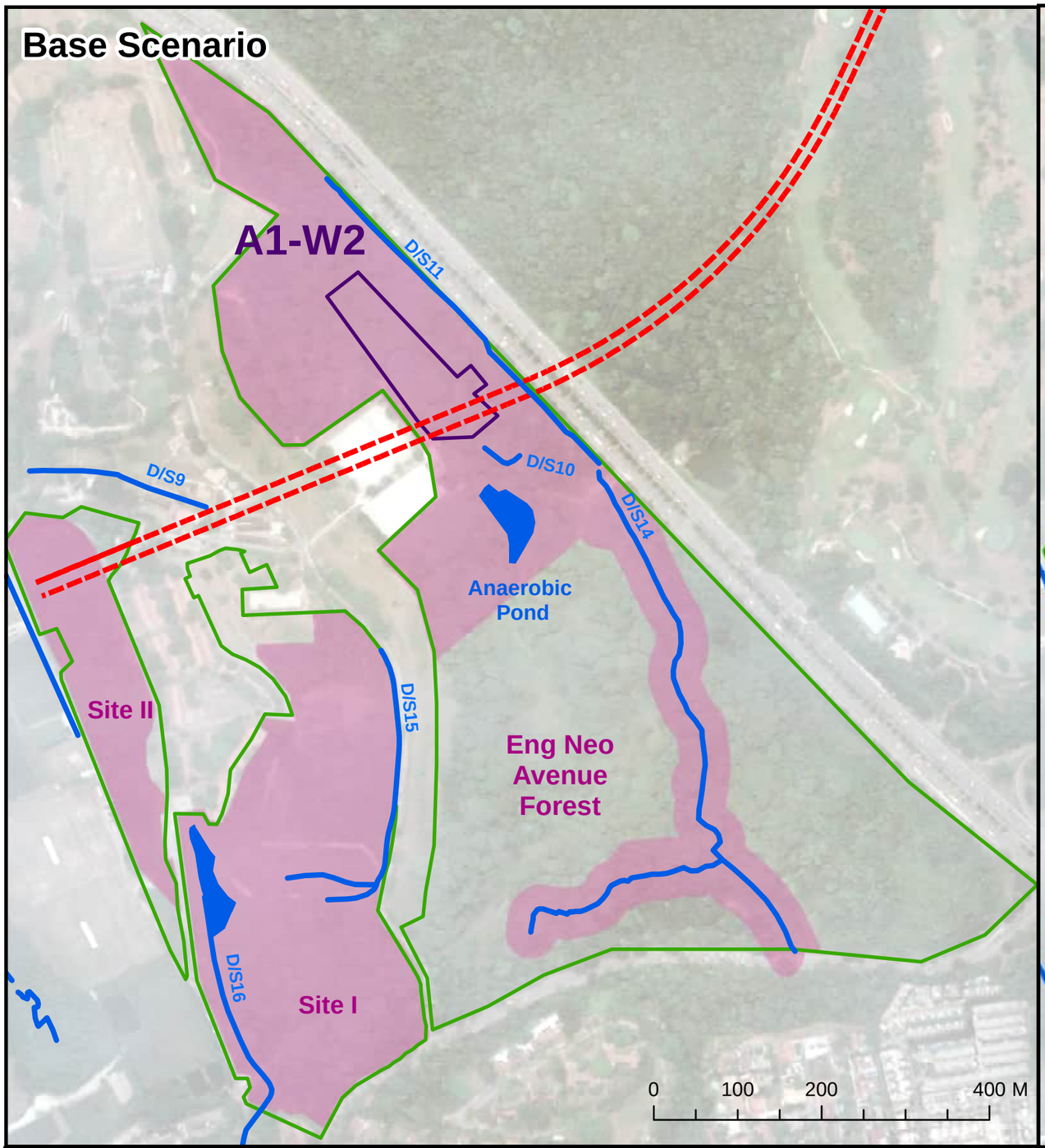
As shown in Table 8-13, even with minimum controls implemented, the proposed construction activities were assessed to have Moderate impacts on water quality and hydrological condition of drain D/S10 and drain D/S11 as well as Major impact on stream D/14 in the Eng Neo Avenue Forest. In addition, the biodiversity findings from Section 7 shows that the A1-W2 worksite could pose Major impact on the biodiversity of Eng Neo Avenue Forest, which has high ecological importance. Hence, it was recommended to shift the A1-W2 worksite outside of Eng Neo Avenue Forest to preserve the forest area of Eng Neo Avenue Forest as much as possible. In order to achieve this, LTA relocated the A1-W2 worksite to the existing Bukit Timah Saddle Club, which is an existing urbanised area located outside of the Eng Neo Avenue Forest. No expansion works from existing urbanised area towards the surrounding forest area will be expected (Figure 8-14). With such relocation of A1-W2 worksite, the impact significance on hydrology and water quality of watercourses of D/S10, D/S11 and stream D/S14 would become Negligible. As shown in Figure 8-14, the mitigated scenario construction worksite footprint will be connected with a temporary access road along Sites I and II. The temporary access road will encroach into the downstream portion of stream D/S16. To ensure continuous perennial flow of stream D/S16, a box culvert will be constructed at the section of the affected drain before the start of temporary road construction. However, this will cause Major impact on the hydrology and water quality of stream D/S16 with High intensity and Regular likelihood of occurrence.

Prior to box culvert integration in the drain D/S16, it is recommended to have flow diversion as additional mitigation measure. The flow diversion will seek for PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage [R-22] to ensure the proposed diversion cater for sufficient flow capacity during construction phase. Any storm discharge from the worksites to the diverted drain requires to meet the guideline of NEA Trade Effluent Discharge Limits if applicable. The recommended additional mitigation measures will help to reduce to Moderate impact on drain D/S16 with Medium impact intensity and Occasional likelihood of occurrence.

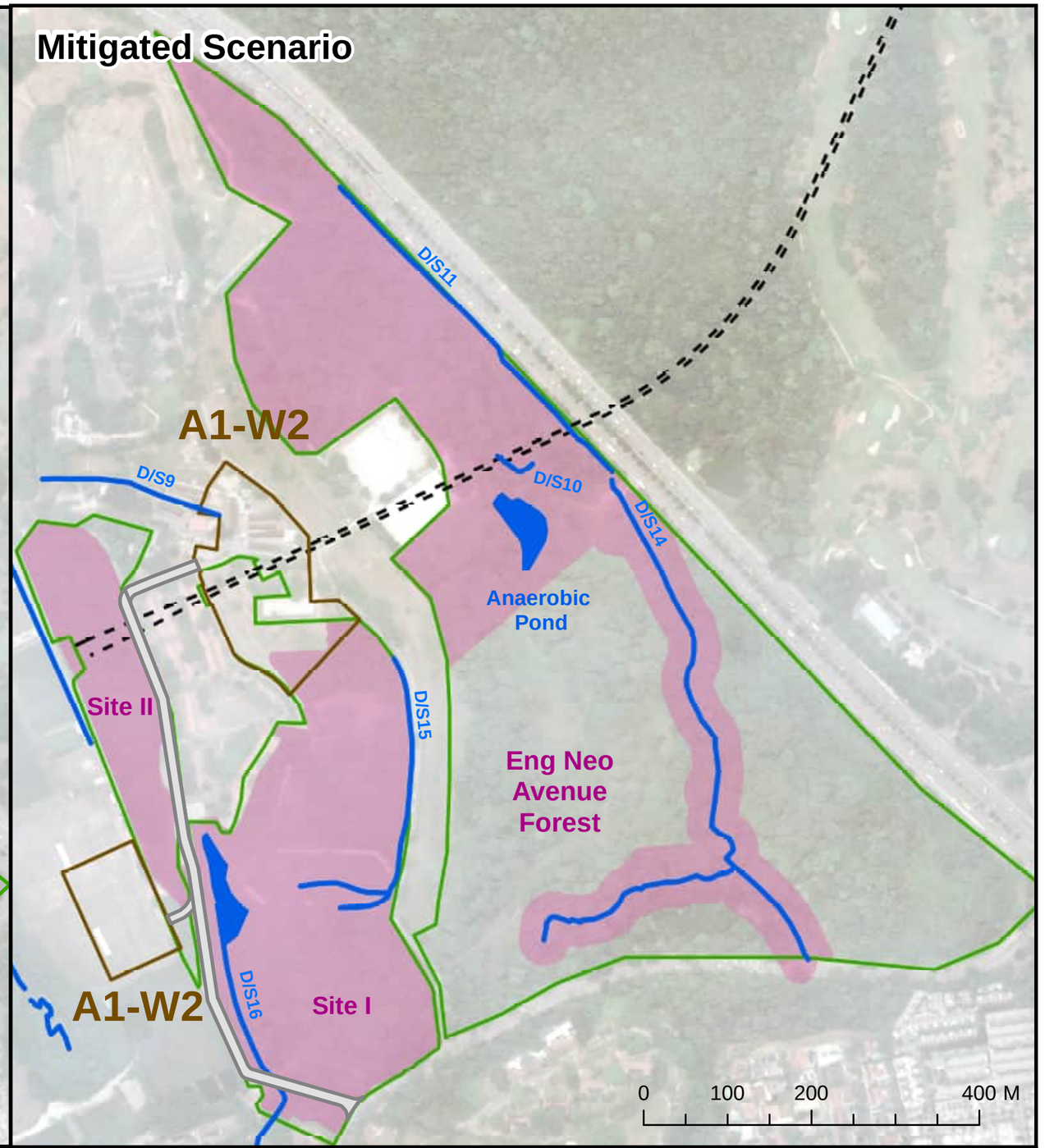
The impact significance on hydrological and water quality impacts on the rest of the watercourses were assessed Negligible to Minor with minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction plans are required.

Nevertheless, it is noted that LTA had further reduced the area of the A1-W1 worksite to significantly reduce adverse impact on surrounding biodiversity (refer to Section 7 and Figure 8-15). This worksite in the mitigated scenario has also helped to further reduce its hydrology and water quality impact on the surrounding watercourses due to its smaller worksite.

Base Scenario



Mitigated Scenario



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- A1-W2 Temporary Access Road
- Biodiversity Study Area
- Area of High Conservation Value

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF A1-W2 WORKSITE WITH WATERCOURSES NEARBY DURING CONSTRUCTION PHASE

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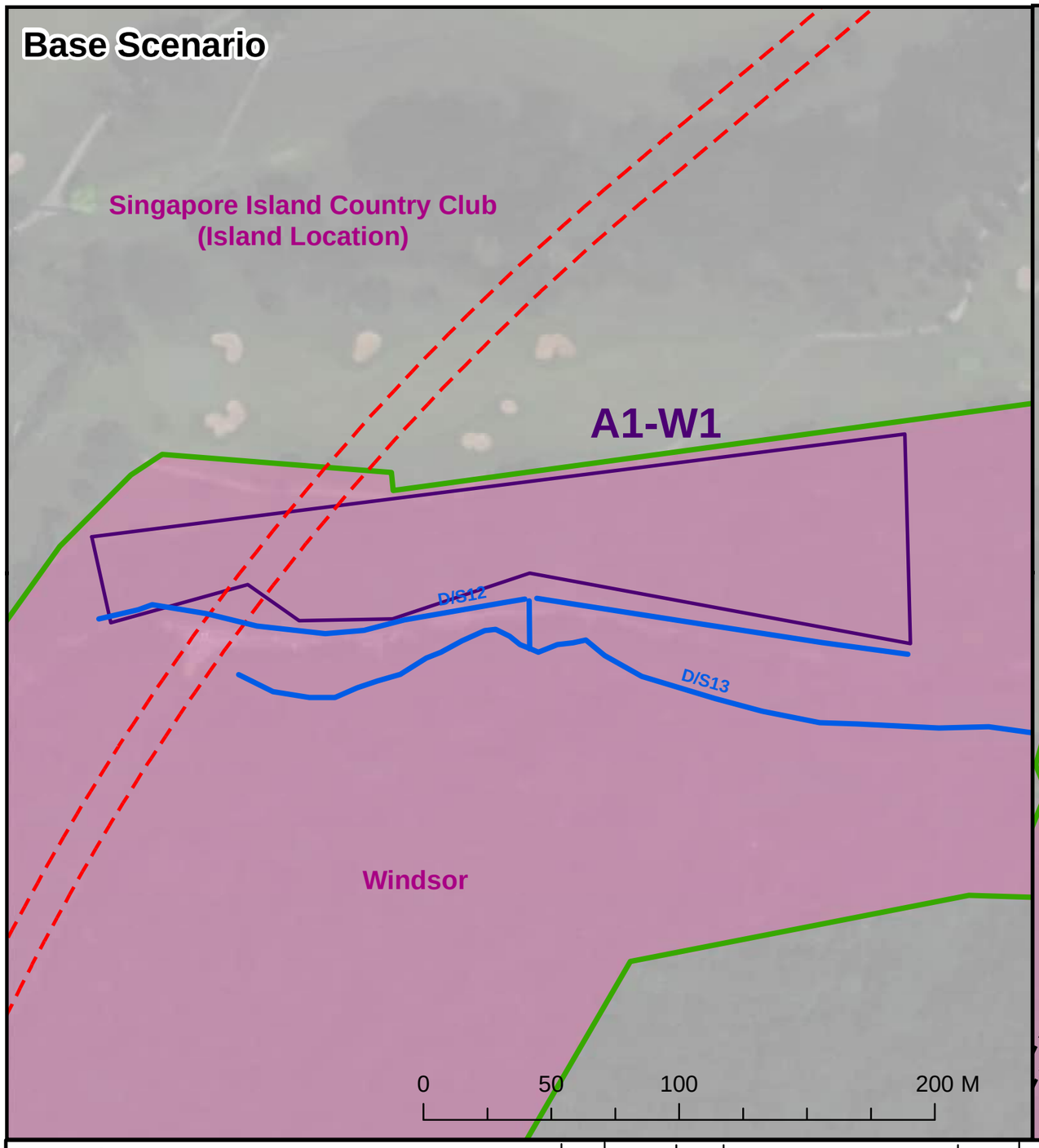

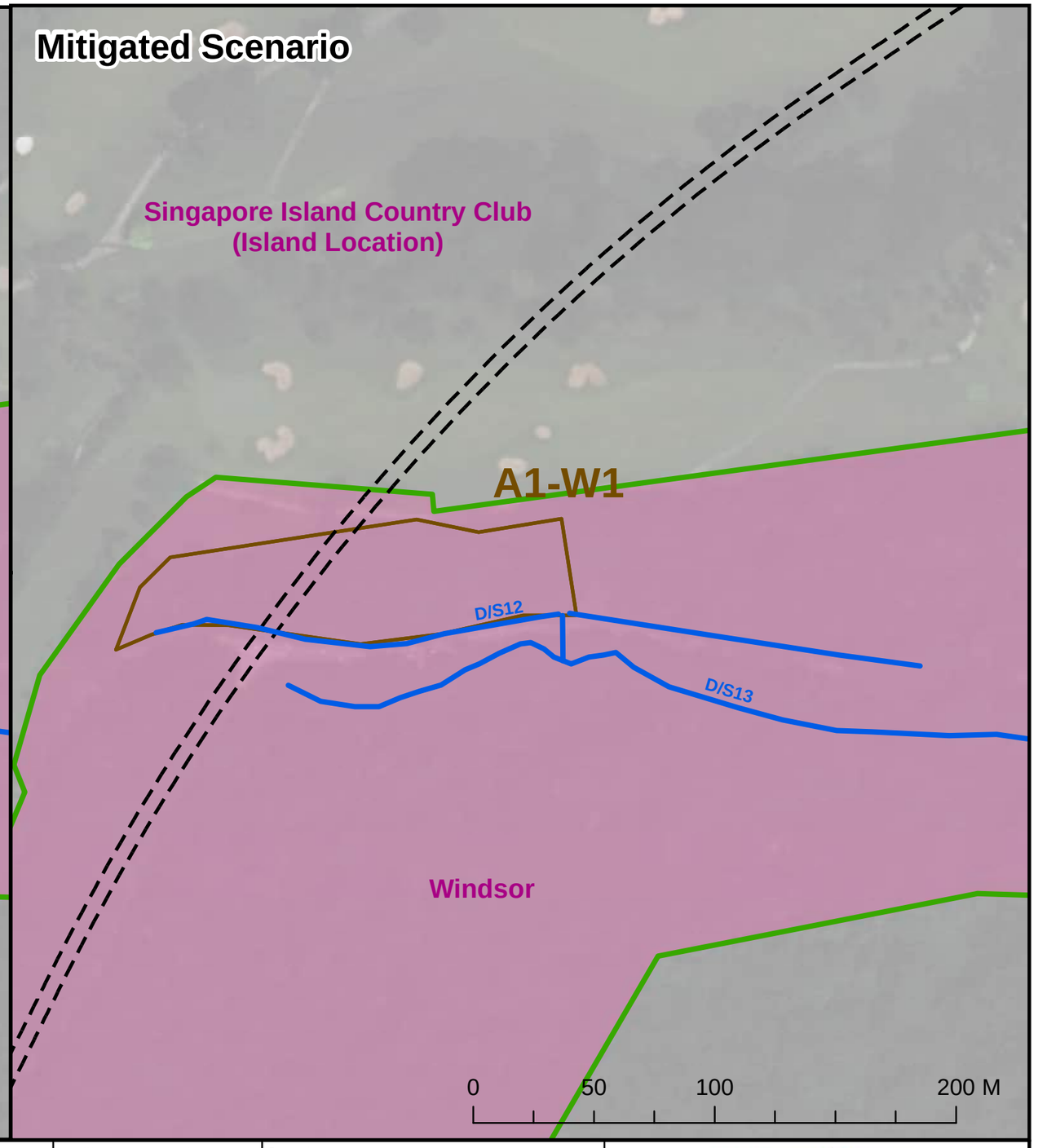

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Area of High Conservation Value

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Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF A1-W1 WORKSITE WITH WATERCOURSES NEARBY DURING CONSTRUCTION PHASE

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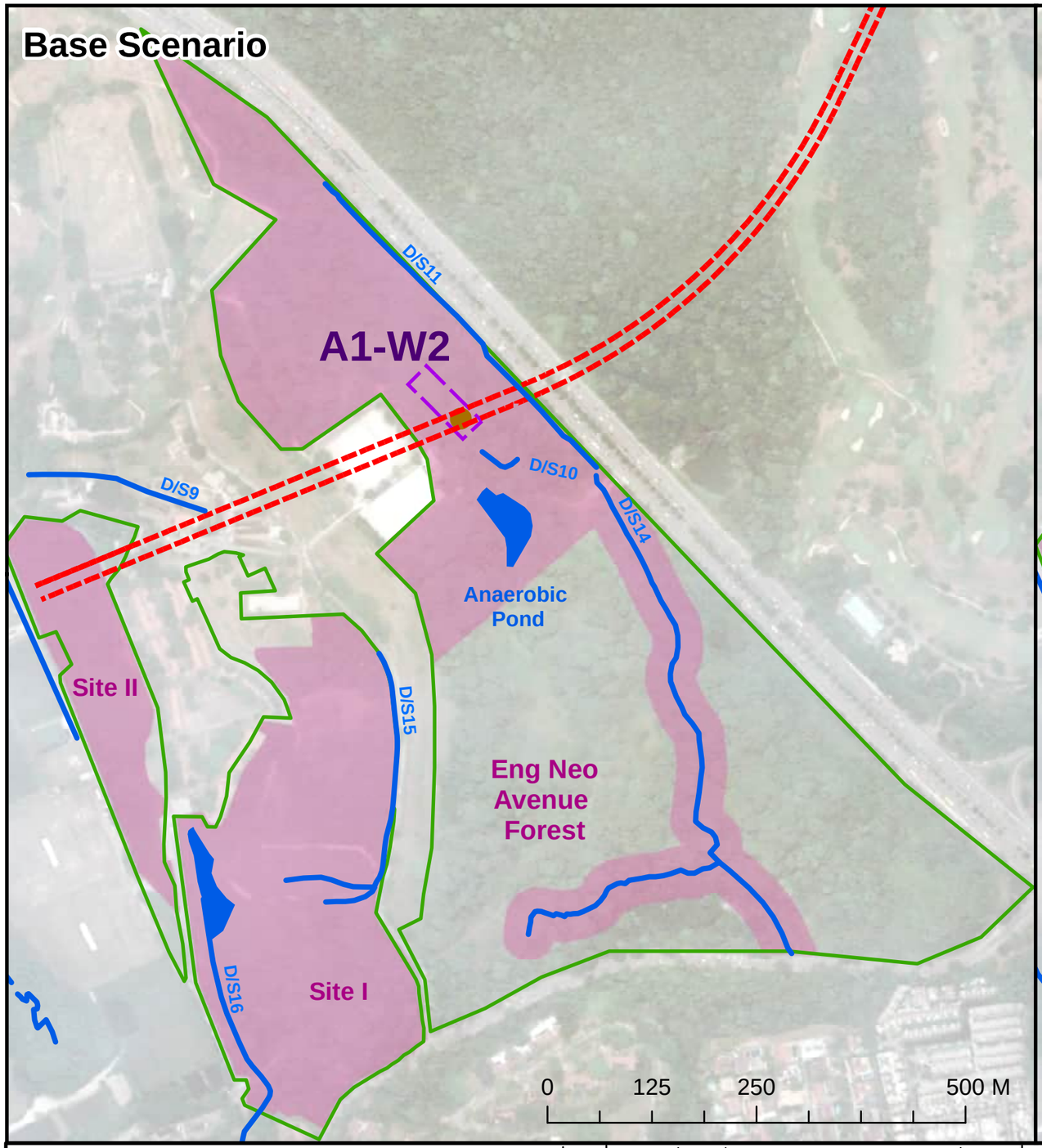
8.8.2 Operational Phase

8.8.2.1 Elimination/Avoidance

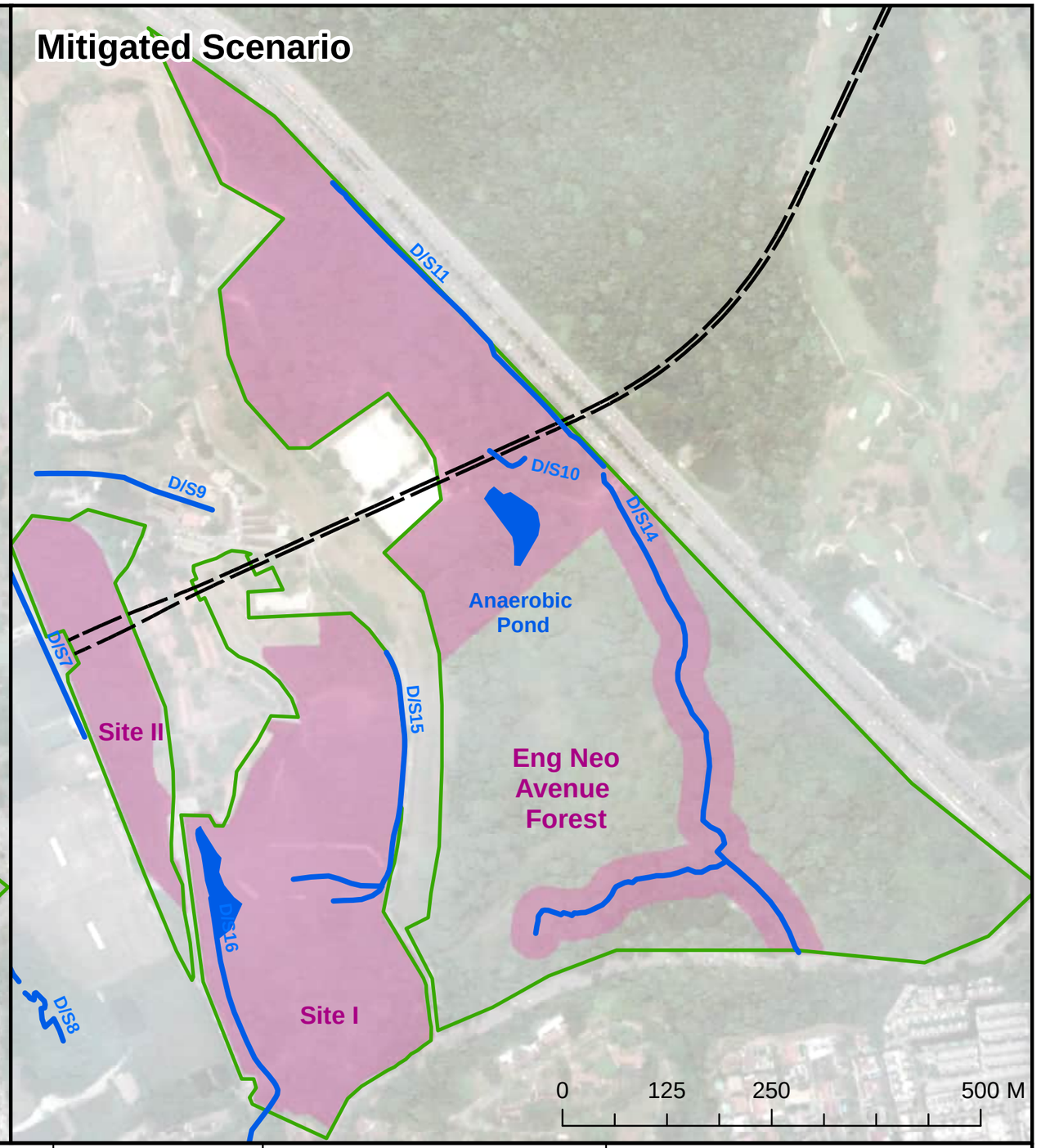
As shown in Table 8-14, the proposed operational activities were assessed to have Moderate impacts on hydrology of drain D/S10, drain D/S11 and stream D/S14 within Eng Neo Avenue Forest, although with implemented minimum controls. In addition, the biodiversity findings from Section 7 shows that the A1-W2 facility building could pose Major impact on the biodiversity of Eng Neo Avenue Forest, which has high ecological importance. Hence, it was recommended to shift the A1-W2 facility building outside of Eng Neo Avenue Forest to preserve the forest area of Eng Neo Avenue Forest as much as possible. As described in Section 3.1.2, the A1-W2 facility building was removed and thus reduced the hydrological impact on watercourses during operational phase (refer to Figure 8-16) as described in Section 3.1.2, the impact on hydrology of drain D/S10, drain D/S11 and stream D/S14 would become Negligible. And since there is no facility building will be located in the vicinity of drain D/S15 and stream D/S16 during operational phase, the impact significance on hydrology and water quality of drain D/S15 and stream D/S16 would remain as Negligible.

The hydrological and water quality impacts on the rest of the watercourses were assessed to be Minor, when considering the implemented minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the operational plans are required.

Base Scenario



Mitigated Scenario



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- A1-W2 Underground Structures (Base Scenario)
- A1-W2 Above-ground Structures (Base Scenario)
- Biodiversity Study Area
- Area of High Conservation Value

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Figure Title : **COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF A1-W2 FACILITY BUILDING WITH WATERCOURSES NEARBY DURING OPERATIONAL PHASE**

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8.9 Residual Impacts

A residual impact assessment has been undertaken as there is Moderate or Major impact significance on sensitive receptors were assessed. With the implementation of the recommended mitigation measures in conjunction with the identified minimum controls as mentioned in previous sections, the impact intensity of the hydrology and water quality residual impact on the watercourses in the Eng Neo Avenue Forest could be reduced to Negligible for both construction and operational phases. Thereafter, the impact significance on the relevant watercourses might thus be reduced to Negligible with Unlikely likelihood of occurrence.

Although watercourses of D/S9, D/S15 and drain D/S16 have Negligible impact from base scenario construction worksite, based on planning of LTA, the mitigated scenario construction worksite footprint of A1-W2 would be relocated near to watercourses of D/S9, D/S15 and drain D/S16 in Sites I and II. Hence, the impact on hydrology and water quality of drain D/S15 and stream D/S16 were reassessed accordingly. Since the mitigated scenario construction worksite footprint of A1-W2 would be located near to the upstream of drain D/S9, minor land use change may occur on drain D/S9. It would bring Medium intensity and Medium consequence to hydrology and water quality impact of drain D/S9 due to Priority 1 sensitivity level. By considering the minimum controls as described in Table 8-11 are implemented accordingly, drain D/S9 was assessed to has Minor impact with Rare impact likelihood according to Table 6-8.

For D/S15, the impact significance was reassessed to be remained as Negligible if the minimum controls as described in Table 8-11would be applied accordingly. With additional proposed mitigation measures, the impact significance on stream D/S16 will be reduced to Moderate with Medium intensity and Occasional likelihood of occurrence although additional mitigation measures have been proposed. Although the impact on stream D/S16 within Site I has been slightly increased to Moderate, compared with the previous major impact on natural stream within Eng Neo Avenue Forest due to base scenario construction worksite, the overall impact on watercourses within this region has been reduced as the natural stream in Eng Neo Avenue Forest has relatively higher ecological value than the naturalised concrete drain in Site I.

Table 8-15 Summary of Residual Impacts and its Mitigation Measures

Activity	Receptor Sensitivity	Biodiversity Study Area	Impacts	Impact Significance (without Mitigation Measures)	Mitigation Measures	Significance of Residual Impact (with Mitigation Measures)
During construction phase: • Land clearing, earthworks and excavation activities; • Storage and disposal of solid, liquid and toxic wastes; and • Use and storage of chemical substances, and refuelling activities During operational phase: Stormwater runoff generation	D/S10 (Priority 1) D/S11 (Priority 1) D/S14 (Priority 1)	Eng Neo Avenue Forest	• During both construction and operational phases: • Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as Eng Neo Avenue Forest will be occupied by the construction worksite during construction phase and facility building during operational phase • Reduction of baseflow due to land use change • Habitat disruption of flora and fauna along the stream	Hydrology: Moderate for D/S10 and D/S11, Major for D/S14 Water Quality: Moderate for D/S10 and D/S11, Major for D/S14	• Shift worksite A1-W2 out from Eng Neo Avenue Forest during construction phase • Remove facility building A1-W2 from Eng Neo Avenue Forest during operational phase • Flow diversion of affected drain area of D/S16 before temporary access road construction. The flow diversion will seek for PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from worksites to the diverted drain requires to meet NEA Trade Effluent Discharge Limits if applicable.	Negligible
During construction phase: • Land clearing, earthworks and excavation activities; • Storage and disposal of solid, liquid and toxic wastes; and • Use and storage of chemical substances, and refuelling activities	D/S9 (Priority 1) D/S15 (Priority 1) D/S16 (Priority 1)	Sites I and II	During construction phase: • Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as Sites I and II will be occupied by the construction worksite during construction phase • Reduction of baseflow due to land use change	Hydrology: Negligible for D/S9, D/S15 and D/S16 Water Quality: Negligible for D/S9, D/S15 and D/S16 During construction phase, after applied mitigated A1-W2 worksite: Hydrology: Minor for D/S9, Negligible for D/S15, Major for D/S16 Water Quality: Minor for D/S9, Negligible for D/S15, Major for D/S16	Flow diversion of affected drain area of D/S16 before temporary access road construction. The flow diversion will seek for PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from worksites to the diverted drain requires to meet NEA Trade Effluent Discharge Limits if applicable.	Minor Negligible Moderate
Note: Windsor was not included here as the impact on it is Minor and no mitigation measures are required						

8.10 Cumulative Impacts from Other Major Concurrent Developments

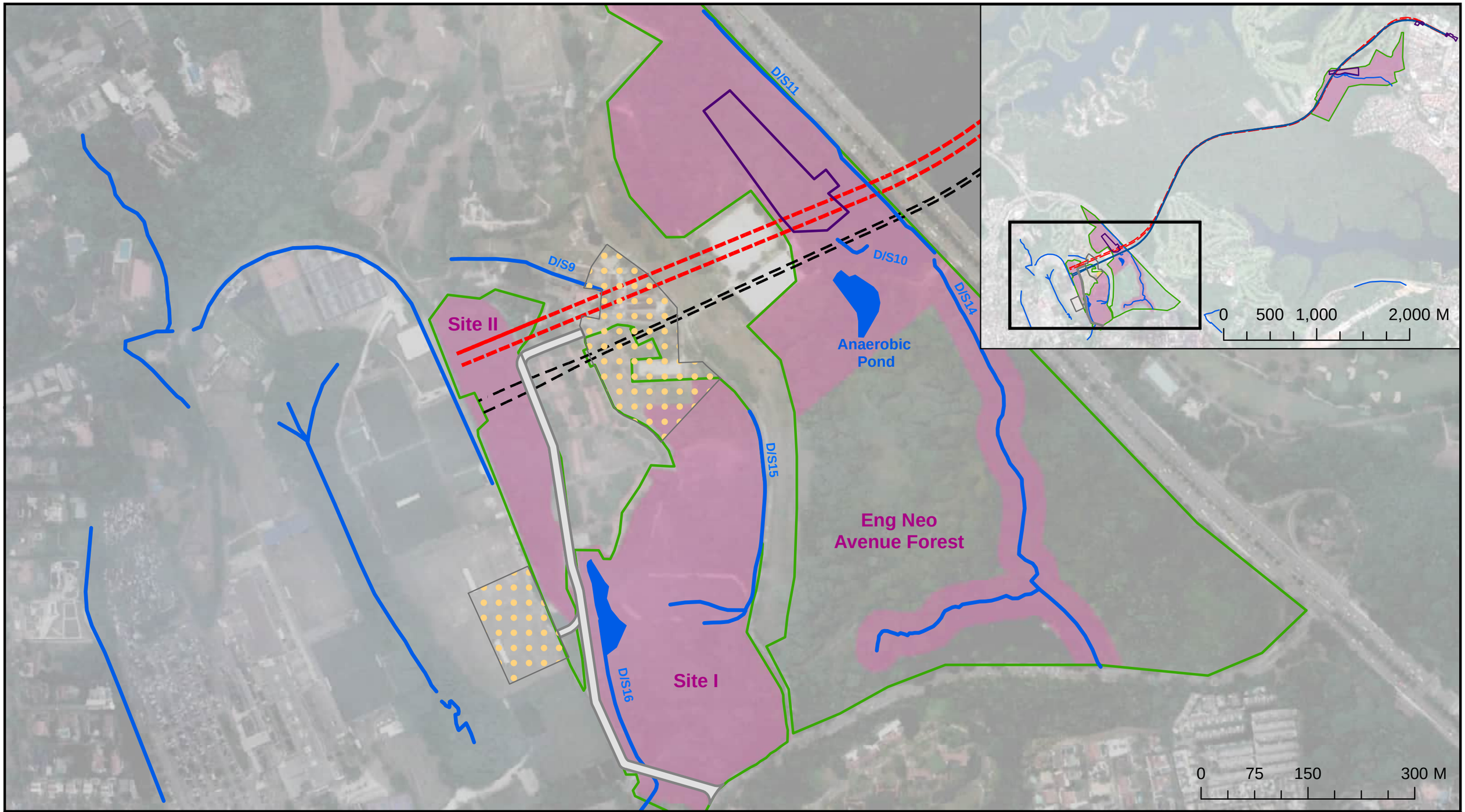
This section focuses on assessing cumulative impacts of the construction and operational activities from identified concurrent developments on the watercourses. It should be noted that since the detailed construction and operational activities were not available at the time of writing this report, only qualitative cumulative impact assessment was carried out.

8.10.1 Construction Phase

At Eng Neo Avenue Forest, the concurrent Project of CR14 at Turf Club Road will has overlapping construction period of 96 months with the A1-W2 worksite construction. Since the construction worksite of CR14 is located at a distance from Eng Neo Avenue Forest, the CR14 is unlikely to increase the impact on the surroundings hydrology and water quality of Eng Neo Avenue Forest given the best management practices and minimum controls provided by its developer accordingly during its construction phase. Since the mitigated scenario of A1-W2 worksite which located in Sites I and II nears to the concurrent project, so the concurrent project is likely to increase the impact extent of hydrology and water quality in Sites I and II.

In Windsor (refer to Figure 8-18), the concurrent Project, PUB water pipeline construction at BKSR including pipelaying and permanent and reinstatement works at Shaft 4 will has overlapping period of 15 months with the A1-W1 worksite construction based on Section 3.4.1. It should be noted that the PUB construction worksite was proposed to be located within A1-W1 worksite. Since PUB's Project will not discharge stormwater/wastewater to the roadside drains surrounding the A1-W1 worksite, and the treated effluent will be discharged to a suitable surface water drain (e.g. at Venus Drive or Thomson Road), the PUB water pipeline construction works is unlikely to increase the hydrology and water quality impact extent in Windsor significantly given best management practices and minimum controls provided by its developer are in place during its construction phase.

The concurrent Project of CR13 excavation and shaft construction works will be located exactly at CR13 retrieval shaft worksite during development of Cross Island Line. The construction works for the concurrent Project are expected to overlap with the retrieval shaft works of CR13 retrieval shaft worksite of this Project for about 21 months (refer to Section 3.4.1). Given the existing land use is already urban development area and watercourses in the vicinity are only roadside drains, the CR13 excavation and shaft construction work are unlikely to increase the impact extent on surrounding hydrology and water quality given best management practices and minimum controls provided by its developer are in place during its construction phase.



Legend

- Watercourses
- A1-W2 Worksite (Base Scenario)
- A1-W2 Worksite (Mitigated Scenario)
- A1-W2 Temporary Access Road
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Biodiversity Study Area
- Area of High Conservation Value

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

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Figure Title :
CONCURRENT DEVELOPMENTS WITH WATERCOURSES AT ENG NEO AVENUE FOREST DURING CONSTRUCTION PHASE

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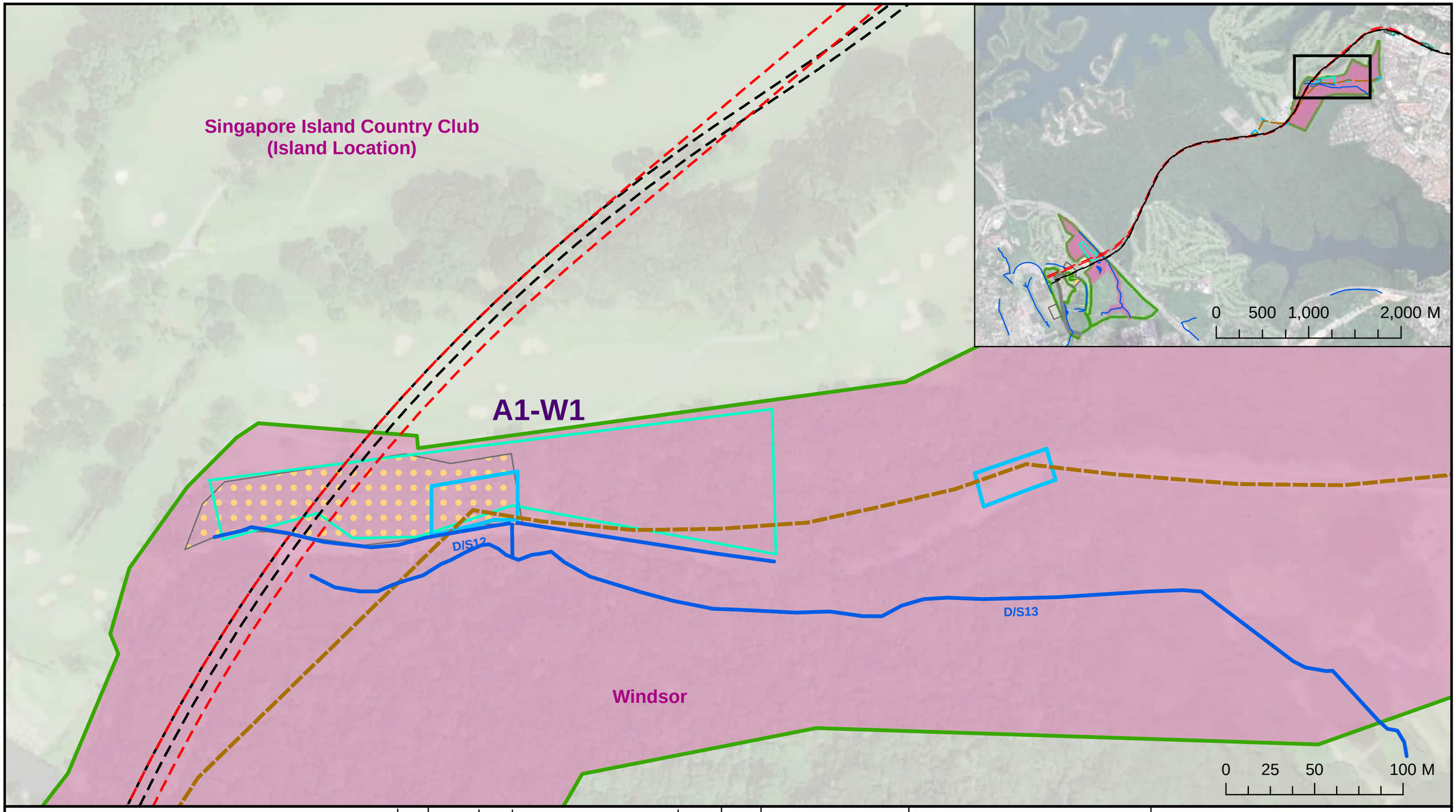

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- A1-W1 Worksite (Base Scenario)
- A1-W1 Worksite (Mitigated Scenario)
- PUB Water Pipeline Project at BKSR (Pipeline)
- PUB Water Pipeline Project at BKSR (Shafts)
- Study Area (Biodiversity)
- Area of High Conservation Value

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**CONCURRENT DEVELOPMENT
WITH WATERCOURSES
AT WINDSOR
DURING CONSTRUCTION PHASE**

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date MAR 2022

Figure No. : 8 - 18 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

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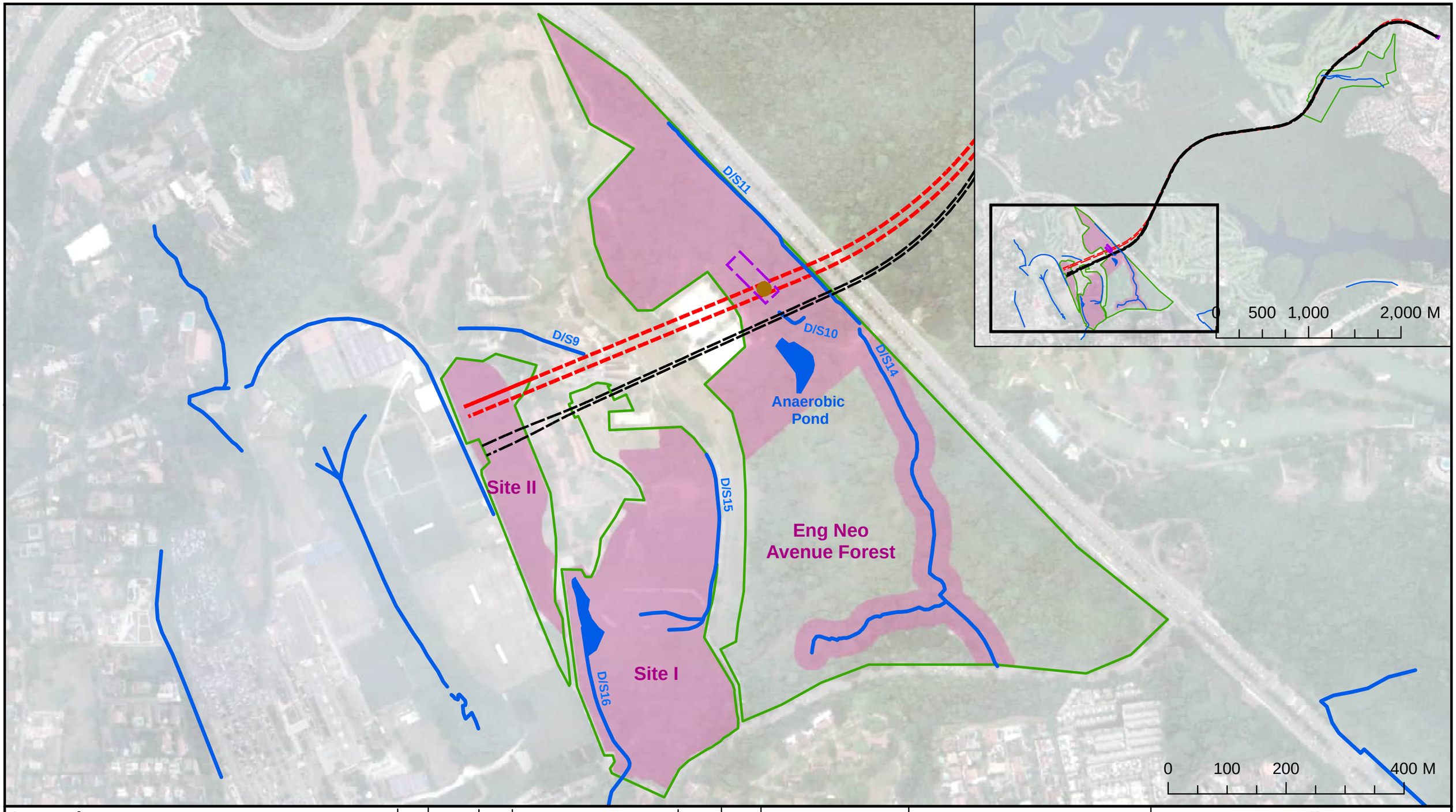
8.10.2 Operational Phase

The CR14 will be located outside of Eng Neo Avenue Forest during operational phase as shown in Figure 8-19. Since the CR14 is located at a distance from Eng Neo Avenue Forest, the CR14 is unlikely to increase the impact on the surroundings hydrology and water quality of Eng Neo Avenue Forest, Sites I and II. This is evaluated based on the assumption that best management practices and operation controls are followed strictly by its developer during the Project's operational phase.

In Windsor (refer to Figure 8-20), the concurrent project, PUB water pipeline's footprint at BKSR will only have manholes as the project footprint, which normally only occupy small area at the roadside. Furthermore, it was envisaged that maintenance works will be restricted at the manhole area, and any contamination (e.g. chemical spills, leaking, etc.) will be minimised, since the given best management practices and minimum controls are expected to be in place. Hence, the PUB water pipeline project might not increase the hydrology and water quality impact extent in Windsor significantly given proper management and operation of pipeline system provided by PUB during operational phase.

The concurrent project of CR13 excavation will only have the station building above ground during operational phase. As long as the best management practices are closely followed by its developer, the construction footprint of CR13 is likely to increase the extent of impact slightly on hydrology and water quality of surrounding roadside drains.



Legend

- Watercourses
- A1-W2 Underground Structures (Base Scenario)
- A1-W2 Above-ground Structures (Base Scenario)
- Proposed CRL Alignment (Mitigated)
- Proposed CRL Alignment (Base)
- Biodiversity Study Area
- Area of High Conservation Value

Note:
Site I and II: Forested area adjacent to Fairways Quarters

N

Rev.	Date	By	Description	Chk'd	App'd
-	JUN 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY (WINDSOR AND ENG NEO AVENUE FOREST)

Figure Title :
CONCURRENT DEVELOPMENTS WITH WATERCOURSES AT ENG NEO AVENUE FOREST DURING OPERATIONAL PHASE

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date JUN 2022

Figure No. : 8 - 19 | Rev. - | Sheet 1 of 1

CAD File Name : NA | A3

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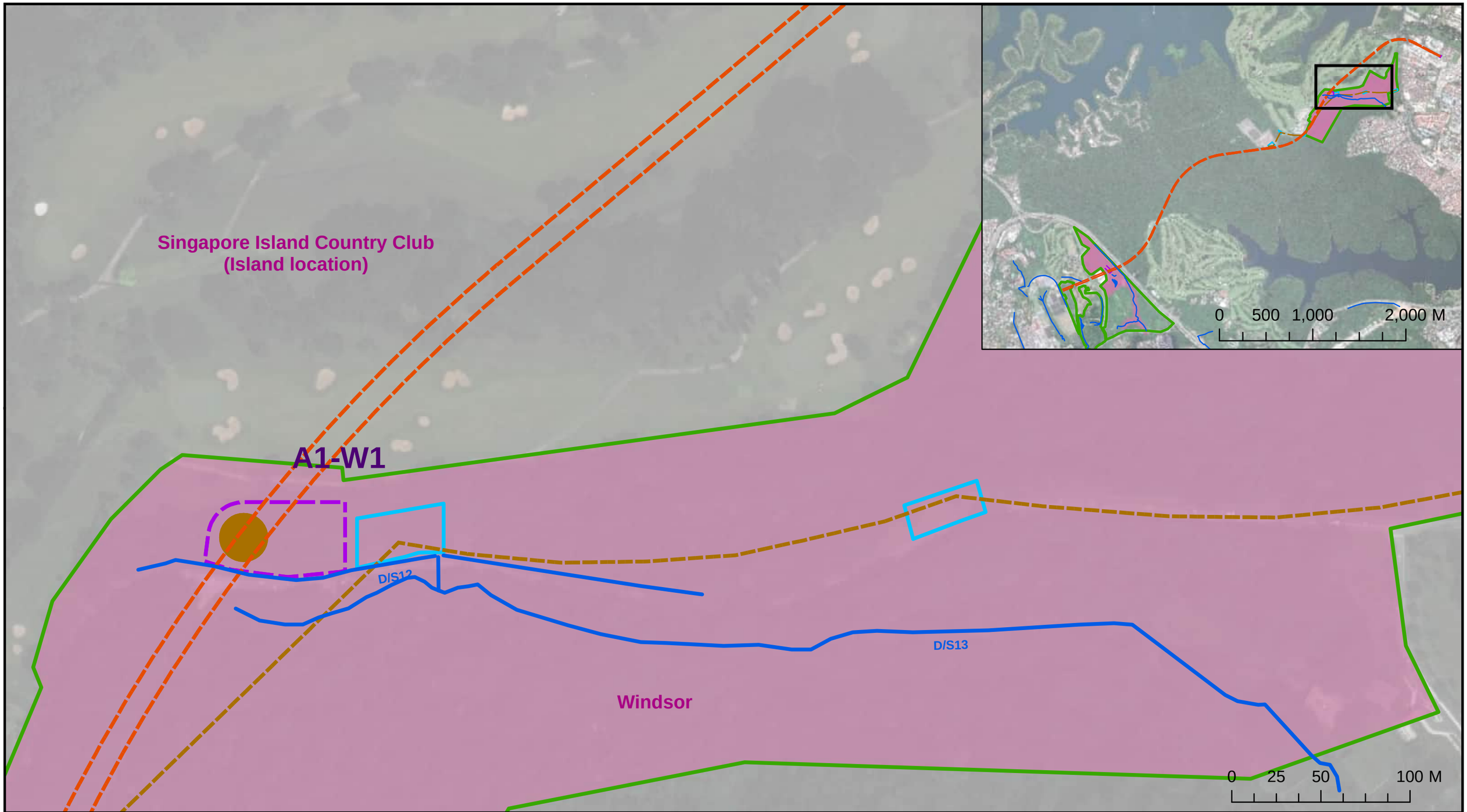

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- A1-W1 Underground Structure (Base Scenario)
- A1-W1 Above-ground Structure (Base Scenario)
- PUB Water Pipeline Project at BKSR (Pipeline)
- PUB Water Pipeline Project at BKSR (Shafts)
- Biodiversity Study Area
- Area of High Conservation Value

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAR 2022	JAC	EIS (Windsor and Eng Neo Avenue Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
**CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(WINDSOR AND
ENG NEO AVENUE FOREST)**

Figure Title :
**CONCURRENT DEVELOPMENTS
WITH WATERCOURSES
AT WINDSOR DURING
OPERATIONAL PHASE**

Designed	Checked	Approved
JAC	NHT	JAG
	Drawn JAC	Date MAR 2022

Figure No. :	Rev.	Sheet
8 - 20	-	1 of 1

CAD File Name : NA — A3

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8.11 Summary of Key Findings

The hydrological baseline survey was aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on available topographic data, secondary baseline data from concurrent study carried out by AECOM in the vicinity , site survey as well as PUB water catchment map, water catchment areas within the vicinity of the Biodiversity Study Area mainly contribute to the identified nine (9) major watercourses. Water from the identified drains/streams will eventually flow into Marina Reservoir, which stores water to be treated for drinking water purposes. Four (4) watercourses are located in Eng Neo Avenue Forest, which includes a man-made ephemeral earth drain, an ephemeral concrete drain, an Anaerobic Pond and a natural stream. In Sites I and II, there are two (2) drains and one (1) stream: a perennial naturalised stream and ephemeral concrete drains. In Windsor, there are one (1) ephemeral concrete drain and one (1) natural stream. The natural stream in Windsor Nature Park (i.e. D/S13) and stream D/S14 in Eng Neo Avenue Forest are located within the areas of high ecological conservation values, supporting surrounding ecological systems. Hence, it is very important to understand how the potential environmental impacts arising from the Project activities can impact those drains/streams.

To study water quality within the identified drains/streams, two (2) dry and/or one (1) wet weather samples were taken from each of the thirteen (13) water quality stations at the watercourses from Eng Neo Avenue Forest, Sites I and II, and Windsor. Water samples were tested for both physical and chemical parameters relevant for 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), Nitrates (NO_3-N), Ammoniacal Nitrogen (NH_4-N), Total Organic Carbon (TOC), *Enterococcus* and Lead (Pb). Analysis of the water quality results have shown that the water quality of the watercourses is relatively consistent with its ecological significance.

The ephemeral man-made earth drain and concrete drain in Eng Neo Avenue Forest were found to have relatively good water quality. The Anaerobic Pond in Eng Neo Avenue Forest was found to have relatively poor water quality, which corresponds with the absence of aquatic life with high ecological value present within the watercourse. However, the Pond still has some ecological value as it can support the surrounding bird species. The water quality of natural stream in the Eng Neo Avenue Forest was found to have suitable conditions for aquatic life, which is consistent with its identified high ecological value (Section 7.4.1.1). At Sites I and II, the water quality in the ephemeral concrete drain was found to have high TSS, as the runoff likely contained solids that were flushed from surrounding soil, vegetation and urban areas. Elevated BOD_5 level found in an ephemeral concrete drain to the north of Sites I and II (i.e. D/S9) might be due to receiving stormwater runoff from the surrounding horse barn in Bukit Timah Saddle Club which could consist of high organic substances during wet weather. The perennial naturalised stream was found to have relatively good water quality during dry weather. However, the naturalised stream to be slightly impacted by storm events, as the water quality deteriorates during wet weather conditions. Despite the variation in water quality, this watercourse was found to support aquatic life and has a high ecological value (Section 7.4.2.1). For Windsor Nature Park, the perennial natural stream was found to have good water quality in term of physical and chemical parameters and the stream considered to be of high ecological value also based on biodiversity findings (Section 7.4.3.1).

Based on the assessment of the hydrology and surface water quality related impacts on the various sensitive receptors, the assessment findings have been summarised in Table 8-13 and Table 8-14. The proposed construction footprint was assessed to cause significant Moderate impact on drains D/S10 and D/S11 and Major impact on stream D/S14 while the operational footprint was assessed to cause Moderate impact on the watercourses (i.e. D/S10, D/S11 and D/S14) in term of hydrology and/or water quality components, even with implemented minimum controls. Hence, mitigation measures were proposed such as shifting of A1-W2 construction and operational footprint outside of Eng Neo Avenue Forest which reduced the impact significance on watercourses in Eng Neo Avenue Forest. However, the mitigated scenario construction footprint of A1-W2 would cause significant hydrology and surface water quality impact on the watercourse (i.e. stream D/S16) in Sites I and II. Therefore, the impact significance was assessed to be Negligible to Major in summary during both construction and operational phases.

For the rest of the watercourses, they were assessed to cause only Negligible to Minor impacts during both construction and operational phases. Thus, apart from the minimum controls identified and those incorporated in the construction and operational plans for the Minor impacts, no additional management or mitigation measures are required. It is noted that the LTA had further minimised the area of the A1-W1 worksite (from the base scenario to mitigated scenario) to significantly reduce adverse impact on the surrounding biodiversity. This smaller worksite has also helped to further reduce the impacts to the hydrology and water quality of the surrounding watercourses.

Therefore, given that the minimum controls and mitigation measures for the LTA construction and operational activities will be implemented, as well as the additional mitigation measures such as the flow diversion of affected area of D/S16 before temporary access road construction during construction phase, the significance of residual impacts from the potential hydrology and water quality impacts on the sensitive water receptors was assessed to be **Negligible to Moderate** as in Table 8-16. Although the impact on the D/S16 within Site I has been slightly increased to Moderate, compared with the previous major impact on natural stream within Eng Neo Avenue Forest due to base scenario of worksite, the overall impact on watercourses within this region has been reduced as the natural stream in Eng Neo Avenue Forest has relatively higher ecological value than the naturalised concrete drain in Site I.

Assessing the cumulative impacts from concurrent developments identified in the vicinity of the Project, it was concluded that only the concurrent project of CR14 at Turf Road is likely to increase the impact extent on hydrology and water quality of watercourses at Sites I and II during construction phase. PUB water pipeline works in Windsor and CR13 excavation with shaft construction works are unlikely to increase the impact extent on hydrology and water quality of identified watercourses at Eng Neo Avenue, Sites I and II, and Winsor given best management practices and minimum controls provided by its developer are in place during both construction and operational phases.

Table 8-16 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			
Eng Neo Avenue Forest	Earth Drain D/S10	Moderate	Negligible
	Concrete Drain D/S11	Moderate	Negligible
	Steam D/S14	Major	Negligible
Site I and Site II	Concrete Drain D/S9	Negligible	Minor
	Concrete Drain D/S15	Negligible	Negligible
	Naturalised Stream D/S16	Negligible	**Moderate**[2]
Windsor	Natural Stream D/S13	Minor	Minor
-	Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	Minor	Minor
Operational Phase			
Eng Neo Avenue Forest	Earth Drain D/S10	Moderate	Negligible
	Concrete Drain D/S11	Moderate	Negligible
	Steam D/S14	Moderate	Negligible
Site I and Site II	Concrete Drain D/S9	Negligible	Negligible
	Concrete Drain D/S15	Negligible	Negligible
	Naturalised Stream D/S16	Negligible	Negligible
Windsor	Natural Stream D/S13	Minor	Minor
-	Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	N.A.[1]	N.A. [1]

Note:
1. N.A. – Not applicable as the worksites at CR13 and Peirce Secondary School will have only permanent underground structures without housing any facilities during operational phase.

	Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
2.	Water Quality: Moderate at Site I, as the proposed road will cross existing major drain in Site I, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the immediate presence of drain segment adjacent to the construction site.		