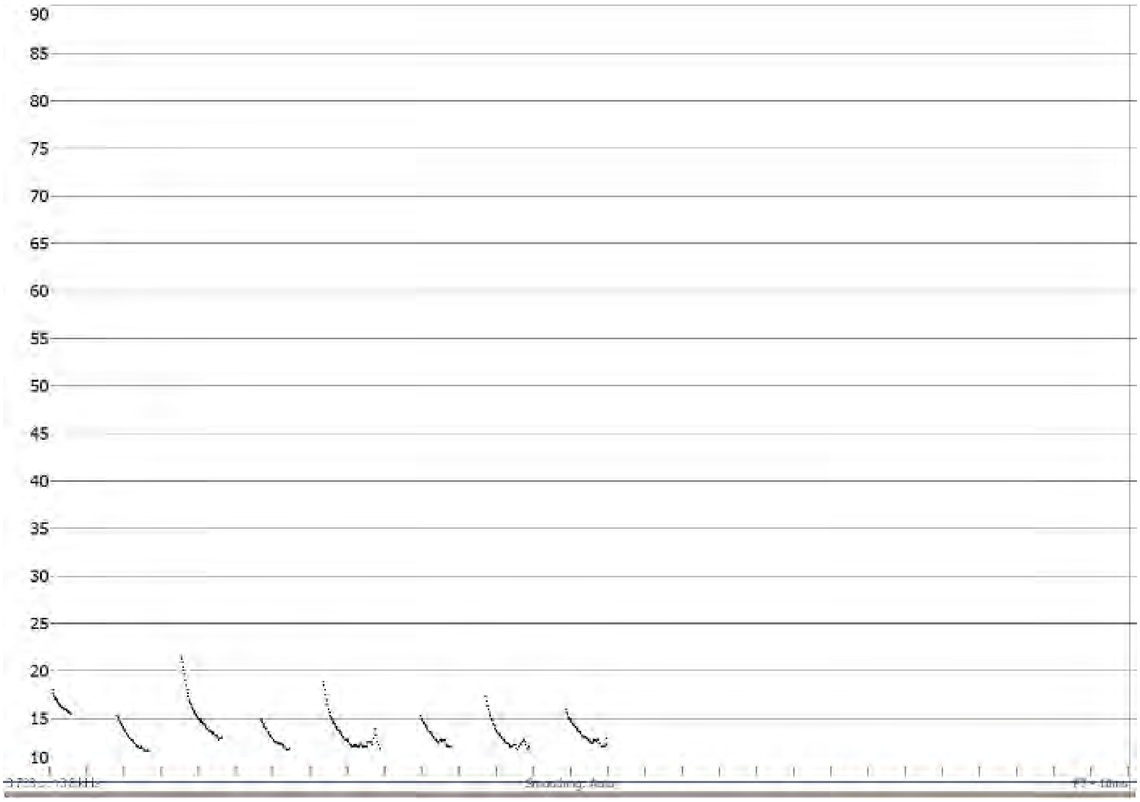
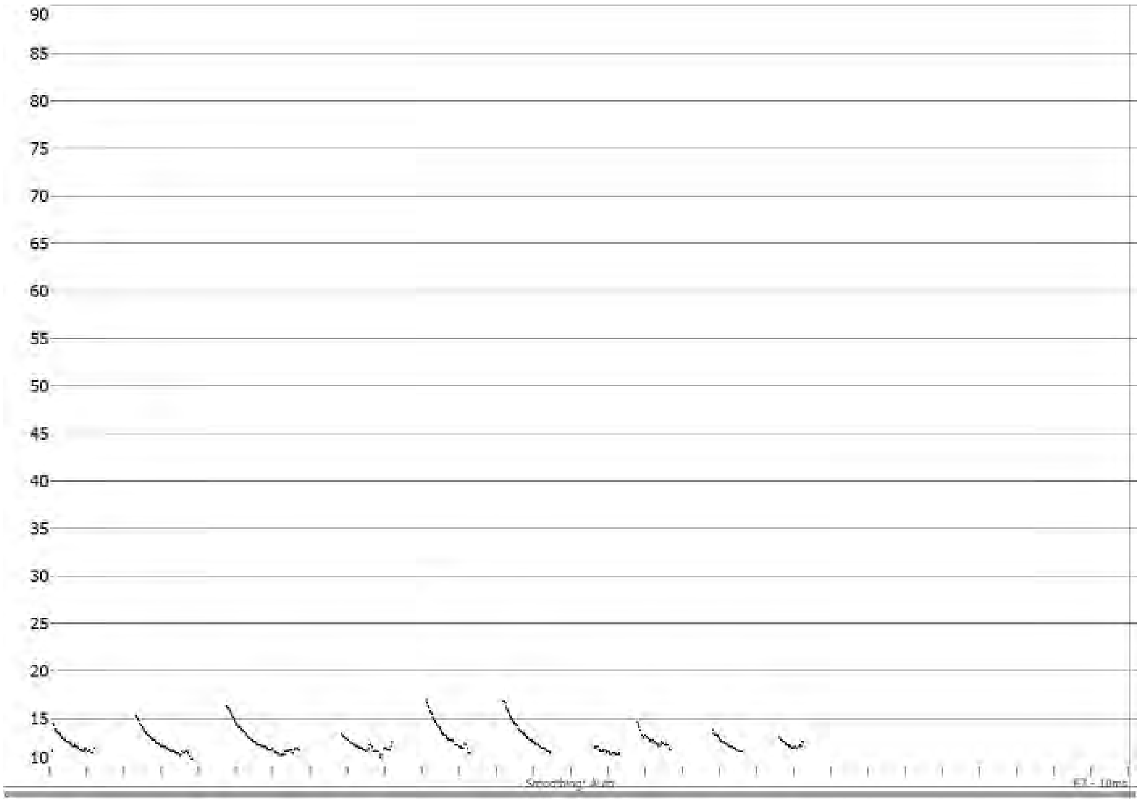
Annexure F – Microbat call graphs

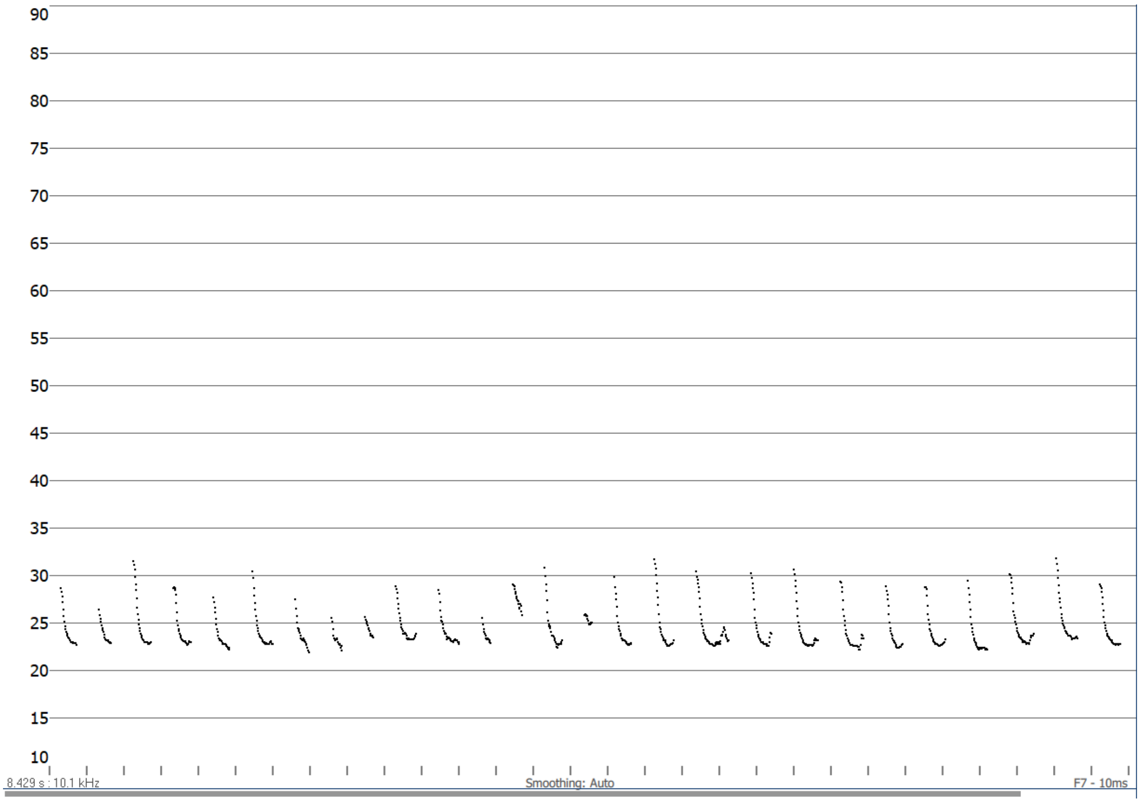
Example time versus frequency graphs from calls recorded during the survey are shown in the following graphs. Calls are displayed in compressed mode unless otherwise stated.



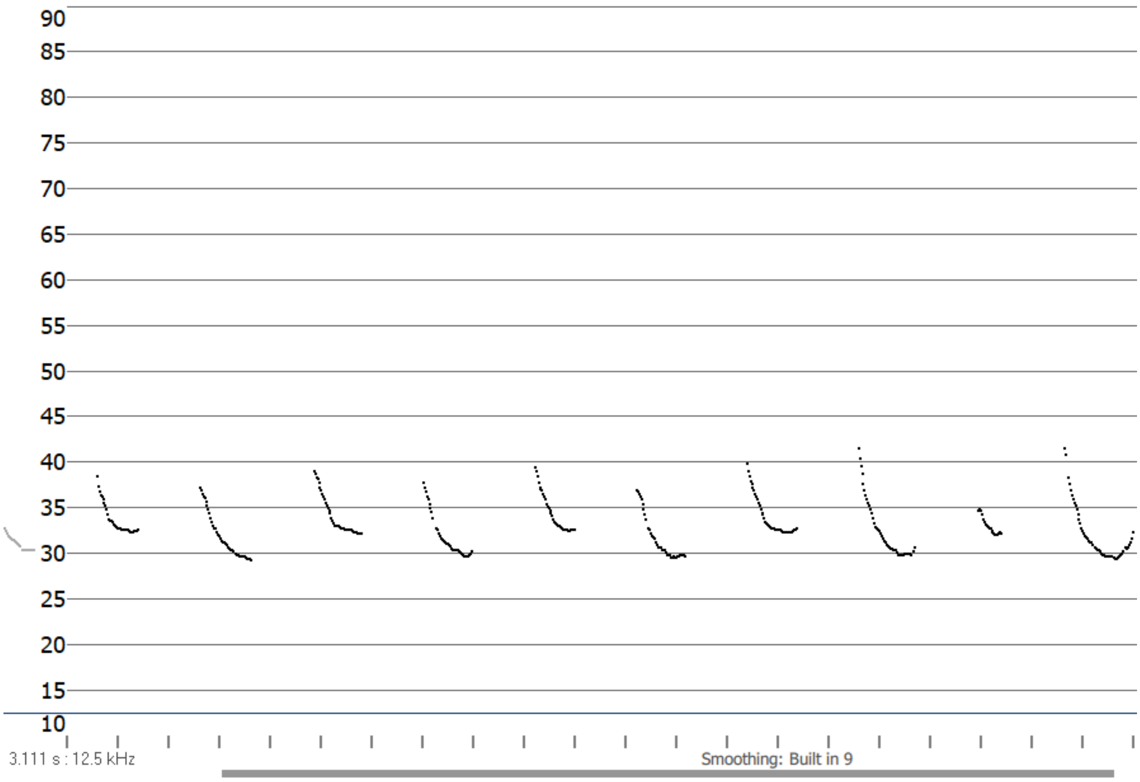
Graph A.E-1: Time versus frequency call graph for White-striped Free-tailed Bat (1 of 2)



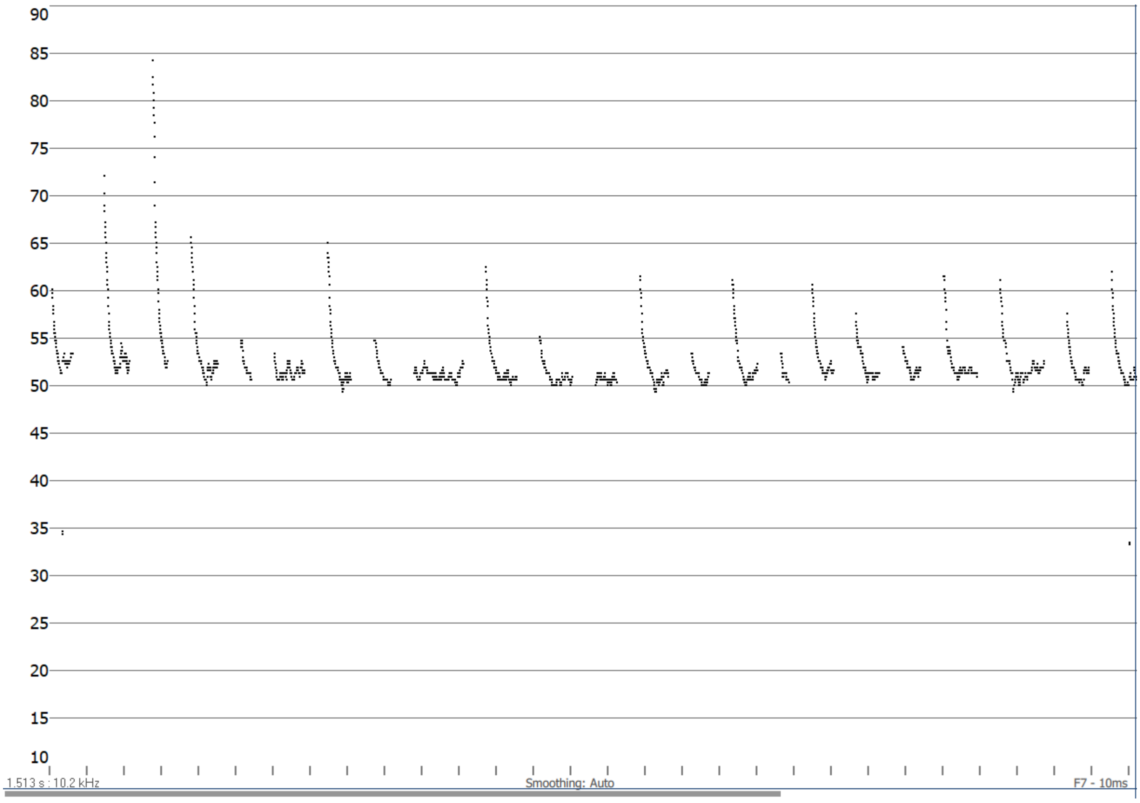
Graph A.E-2: Time versus frequency call graph for White-striped Free-tailed Bat (2 of 2)



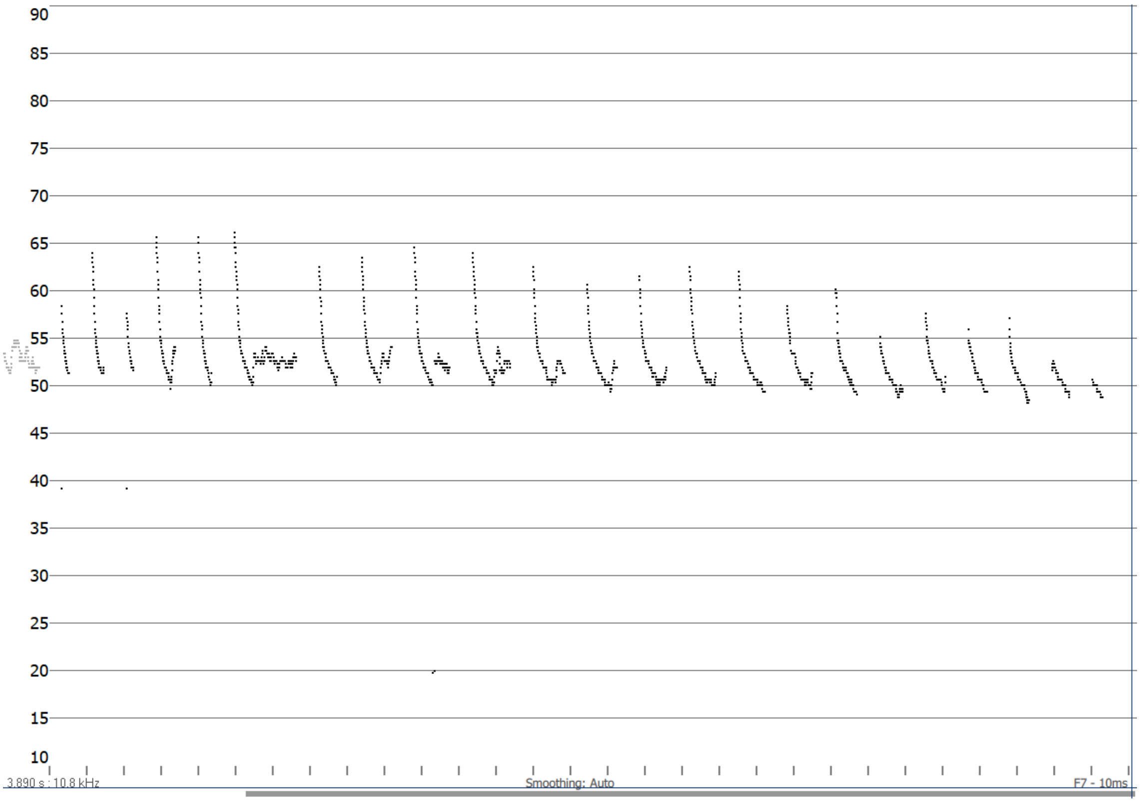
Graph A.E-3: Time versus frequency call graph for Large-eared Pied Bat



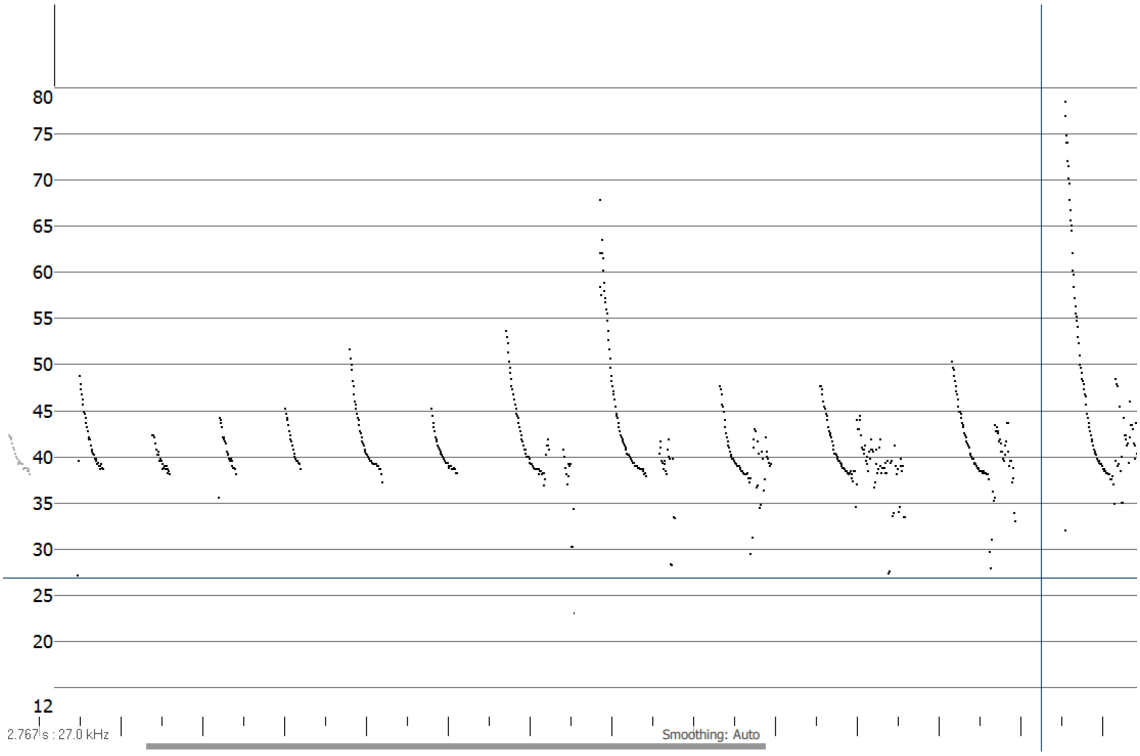
Graph A.E-4: Time versus frequency call graph for Gould's Wattled Bat



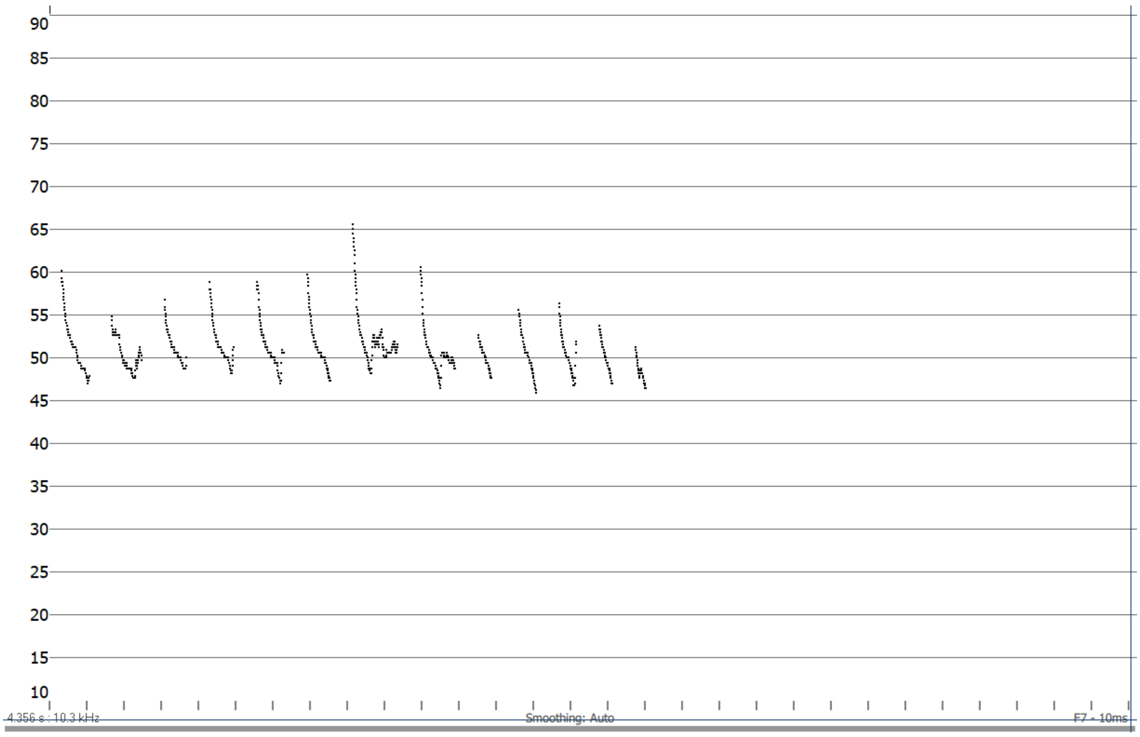
Graph A.E-5: Time versus frequency call graph for Chocolate Wattled Bat (1 of 2)



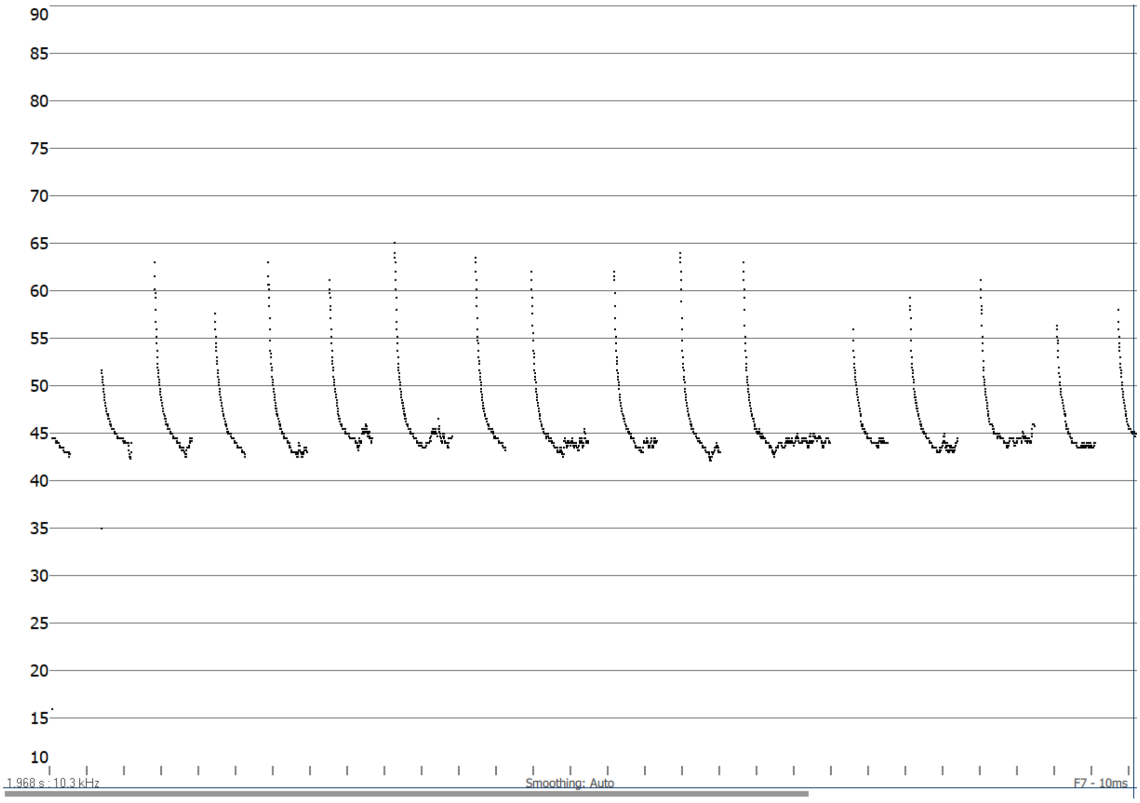
Graph A.E-6: Time versus frequency call graph for Chocolate Wattled Bat (2 of 2)



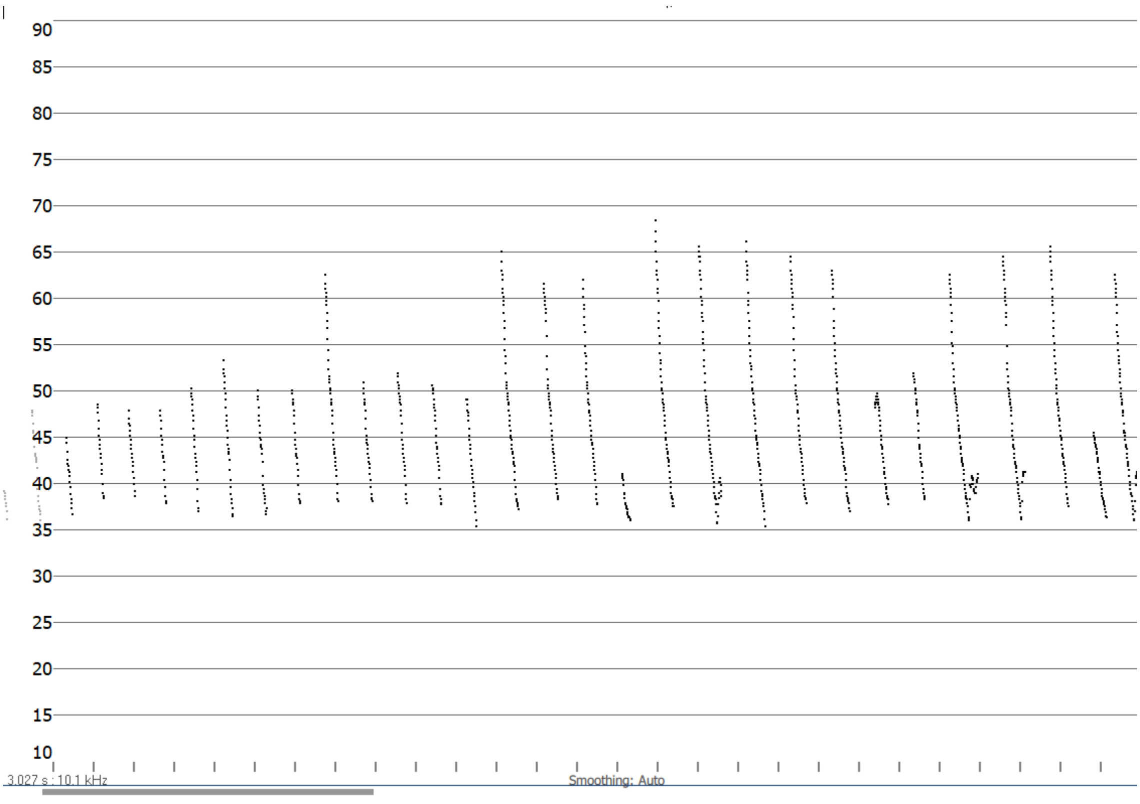
Graph A.E-7: Time versus frequency call graph for Eastern False Pipistrelle



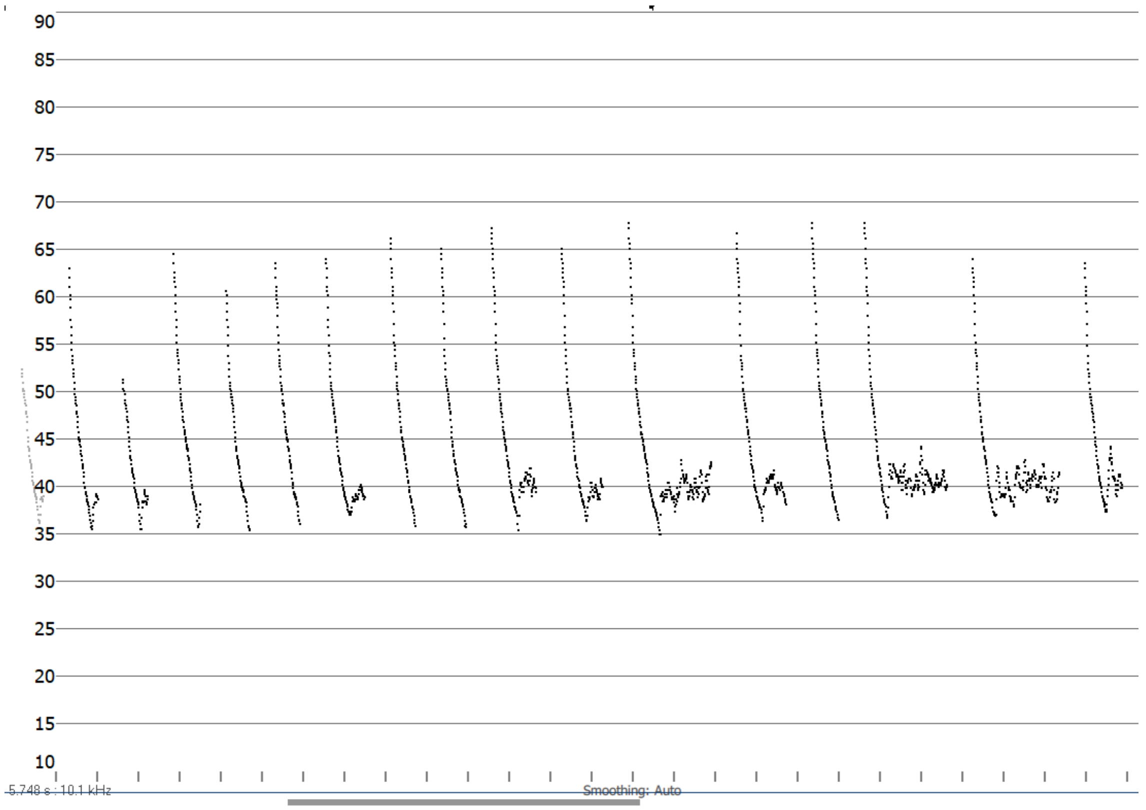
Graph A.E-8: Time versus frequency call graph for Large Bent-winged Bat (1 of 2)



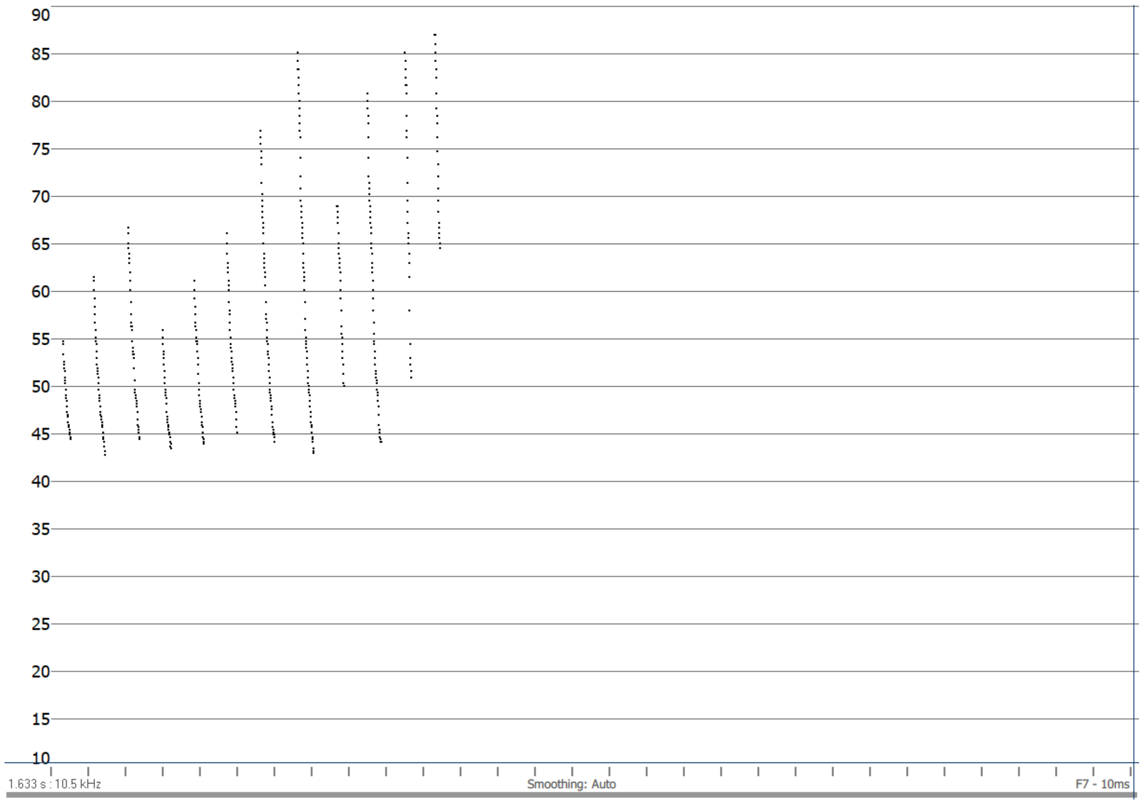
Graph A.E-9: Time versus frequency call graph for Large Bent-winged Bat (2 of 2)



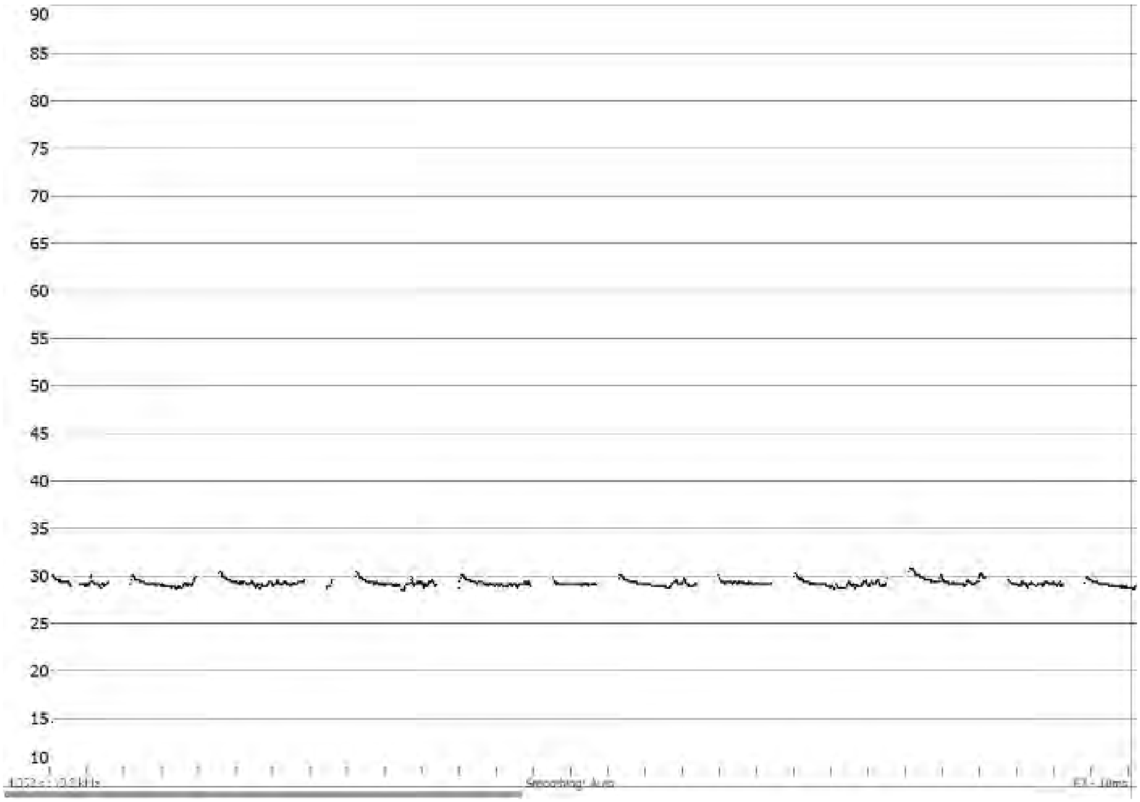
Graph A.E-10: Time versus frequency call graph for species group related to Southern Myotis (1 of 2)



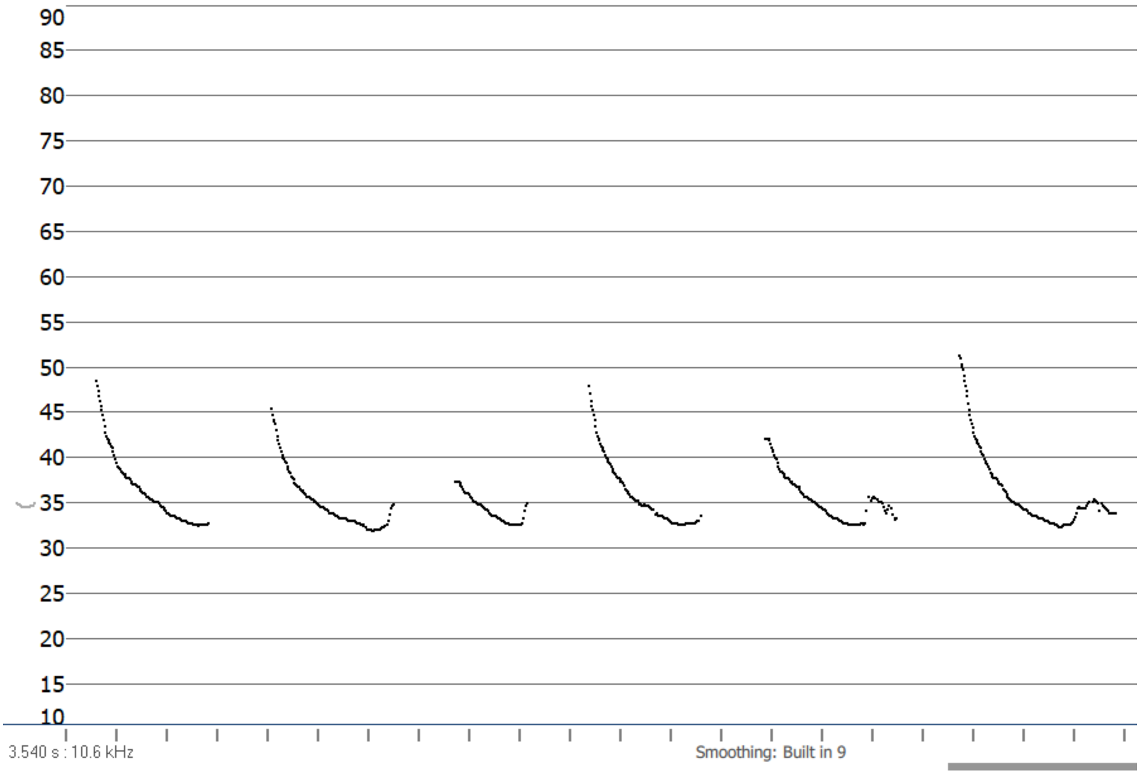
Graph A.E-11: Time versus frequency call graph for species group related to Southern Myotis (2 of 2)



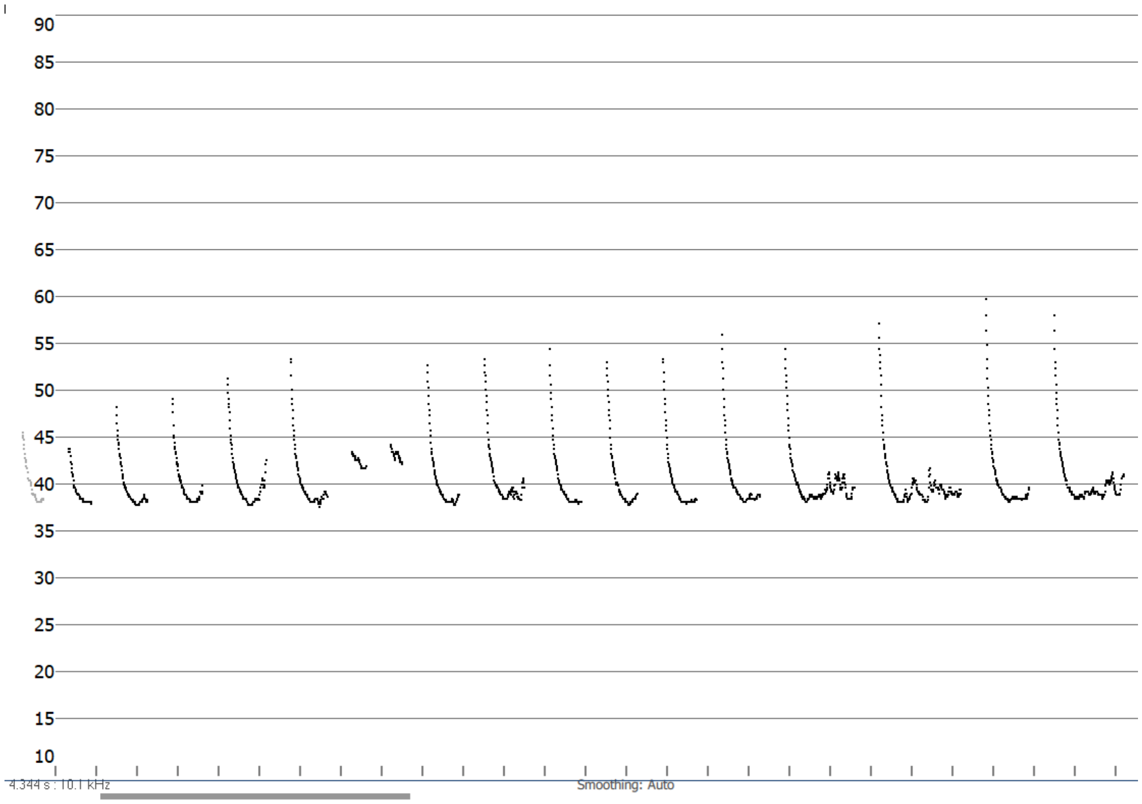
Graph A.E-12: Time versus frequency call graph for *Nyctophilus* species group



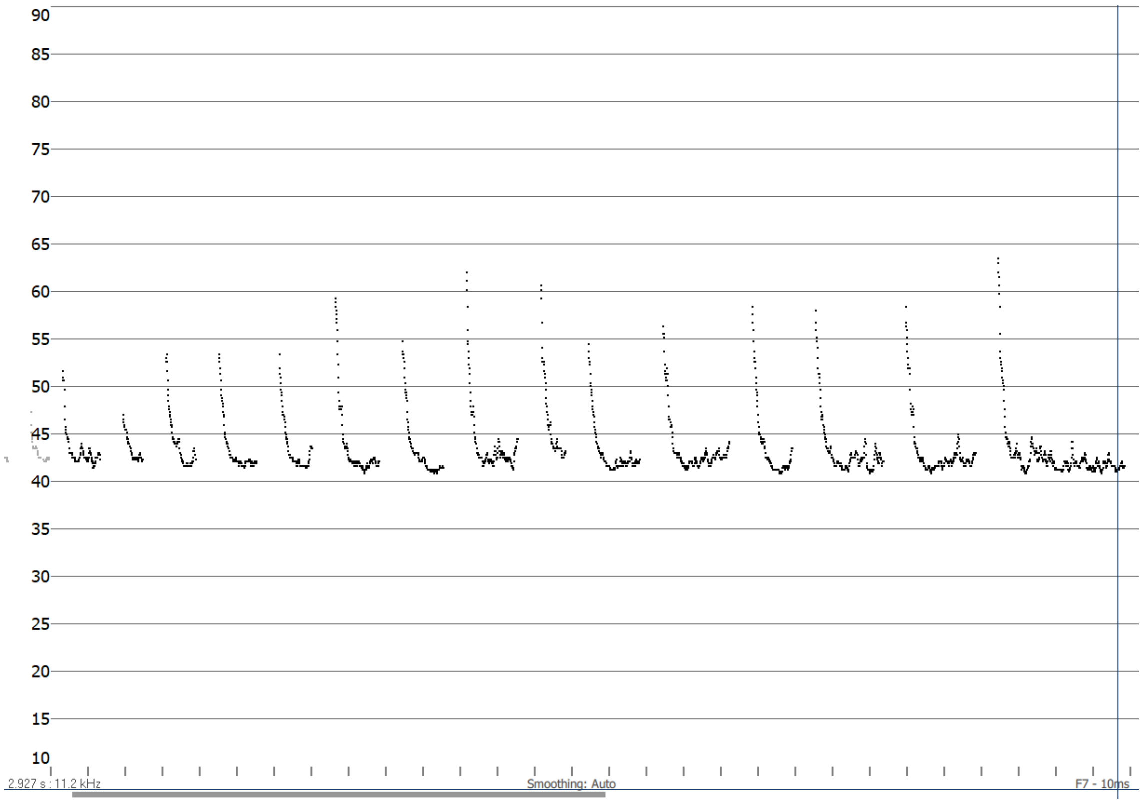
Graph A.E-13: Time versus frequency call graph for Ride’s Free-tailed Bat



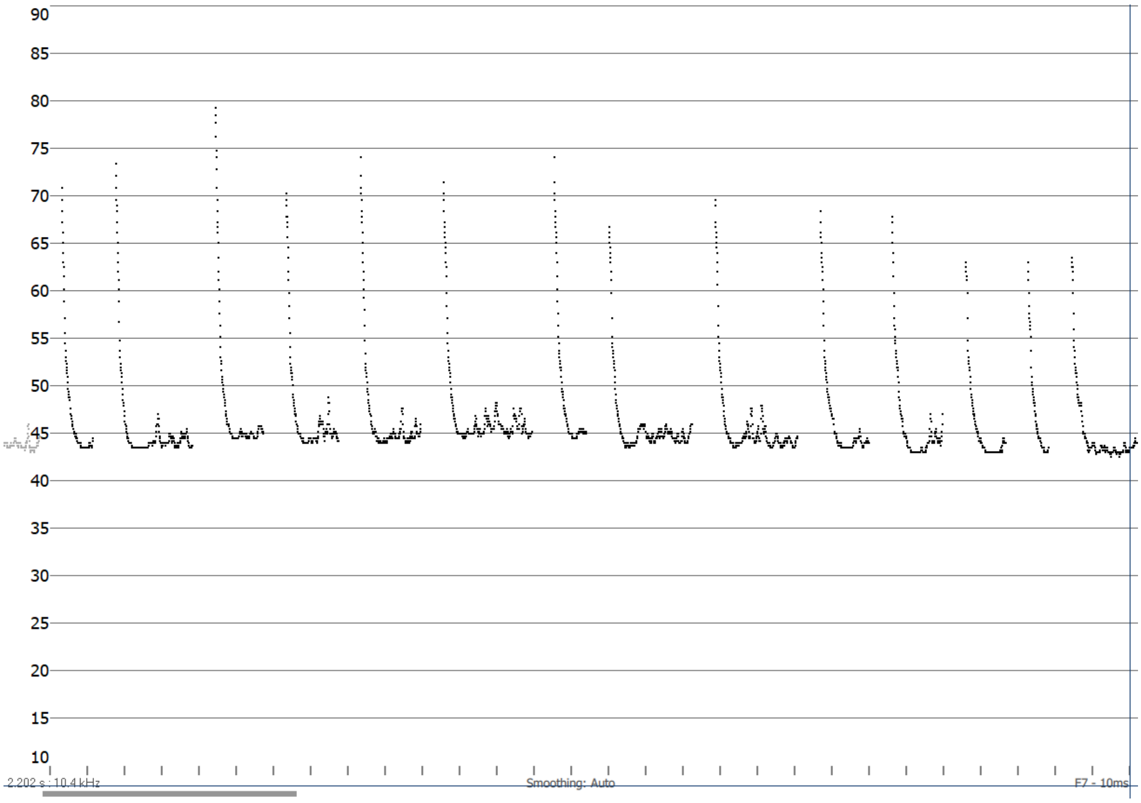
Graph A.E-14: Time versus frequency call graph for Greater Broad-nosed Bat



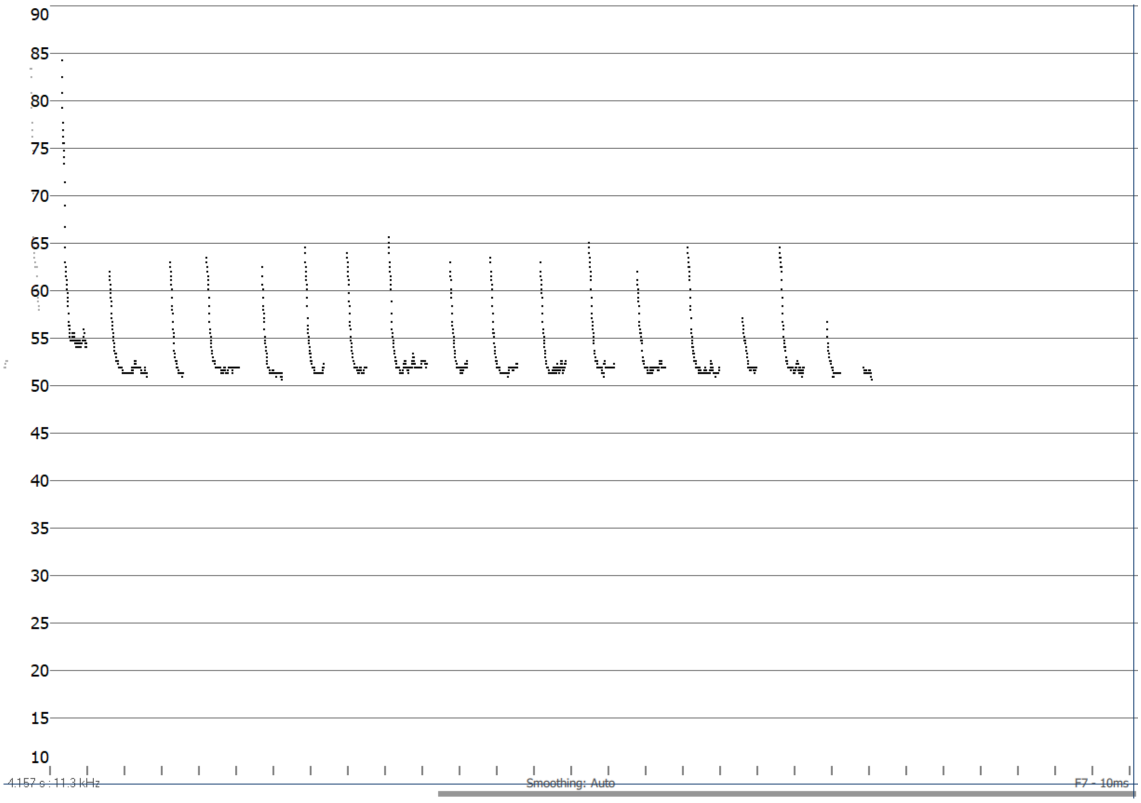
Graph A.E-15: Time versus frequency call graph for South-eastern Broad-nosed Bat



Graph A.E-16: Time versus frequency call graph for Large Forest Bat



Graph A.E-17: Time versus frequency call graph for Southern Forest Bat



Graph A.E-18: Time versus frequency call graph for Eastern Cave Bat and Little Forest Bat species group

Great Western Highway
Blackheath to Little Hartley

Appendix H
Biodiversity (part 2)

Annexure G – Species expert reports

Expert report for Flockton Wattle *Acacia flocktoniae*

ECOLOGICAL
SURVEYS & PLANNING

Expert Report For

Acacia flocktoniae

(Flockton Wattle)

Biodiversity Development Assessment Report for the Great Western Highway upgrade (Blackheath to Little Hartley)

Prepared for Biosis on behalf of Transport for NSW July 2022

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Table of Contents

Executive Summary

This Expert Report finds that there is one population of this species in habitat that is comparable with some of the assessment area that would be affected by the proposed roadworks project. That population is currently believed to be very small but has not been subject to thorough survey. It occurs well outside the assessment area on private tenure in the Kanimbla Valley on the footslopes of Mount Victoria. The species has not been subject to targeted surveys for new populations across potential habitat within or beyond its currently accepted distribution. This means that the absence of records for it in potential habitat should not be considered evidence that the species does not occur there.

There are numerous database records that wrongly plot in and near Mount Victoria village, nearby parts of the Blue Mountains Plateau, and west of the escarpment in and near the assessment area east of Little Hartley. They have been assessed by me and in part by AMBS (2019) and deemed likely to be or definite spatial errors that relate to the Kanimbla site, or in one case, to the much larger Blackheath Glen Reserve site in the top of the Megalong Valley. There are no credible records of the species from the assessment area nor in habitat comparable to portion of the assessment area on the Blue Mountains Plateau. The only part of the assessment area that I consider to be potential habitat for the species is below the escarpment in the section east of Little Hartley. Much of that part of the assessment area is heavily cleared pastoral land. Very little vegetation clearance or detrimental modification is proposed in that area.

The species was not detected during surveys by Biosis staff. I consider those surveys adequate to detect any previously undocumented occurrences of the species in that area irrespective of whether the plants were flowering at that time. Thus, I determine that the species is not present in and not likely to occur within the assessment area, and that species polygons and the calculation of credit requirements is not necessary in this case.

Acacia flocktoniae west of Byrnes Gap, via Yerranderie

1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Acacia flocktoniae*, the inability of Biosis' ecologists to survey the species at the BAM-prescribed time of year is the primary reason for preparing an Expert Report. The BAM requires survey for this species in July to September. Biosis was not able to commence fieldwork until November 2021. The project schedule prevented delaying assessments until July-September of 2022. The proponent opted to use an Expert Report.

The purpose of this Report is to provide an assessment of the status and conservation requirements of *Acacia flocktoniae* within the proposed work corridors for the upgrade to the Great Western Highway between Blackheath and Little Hartley to determine whether:

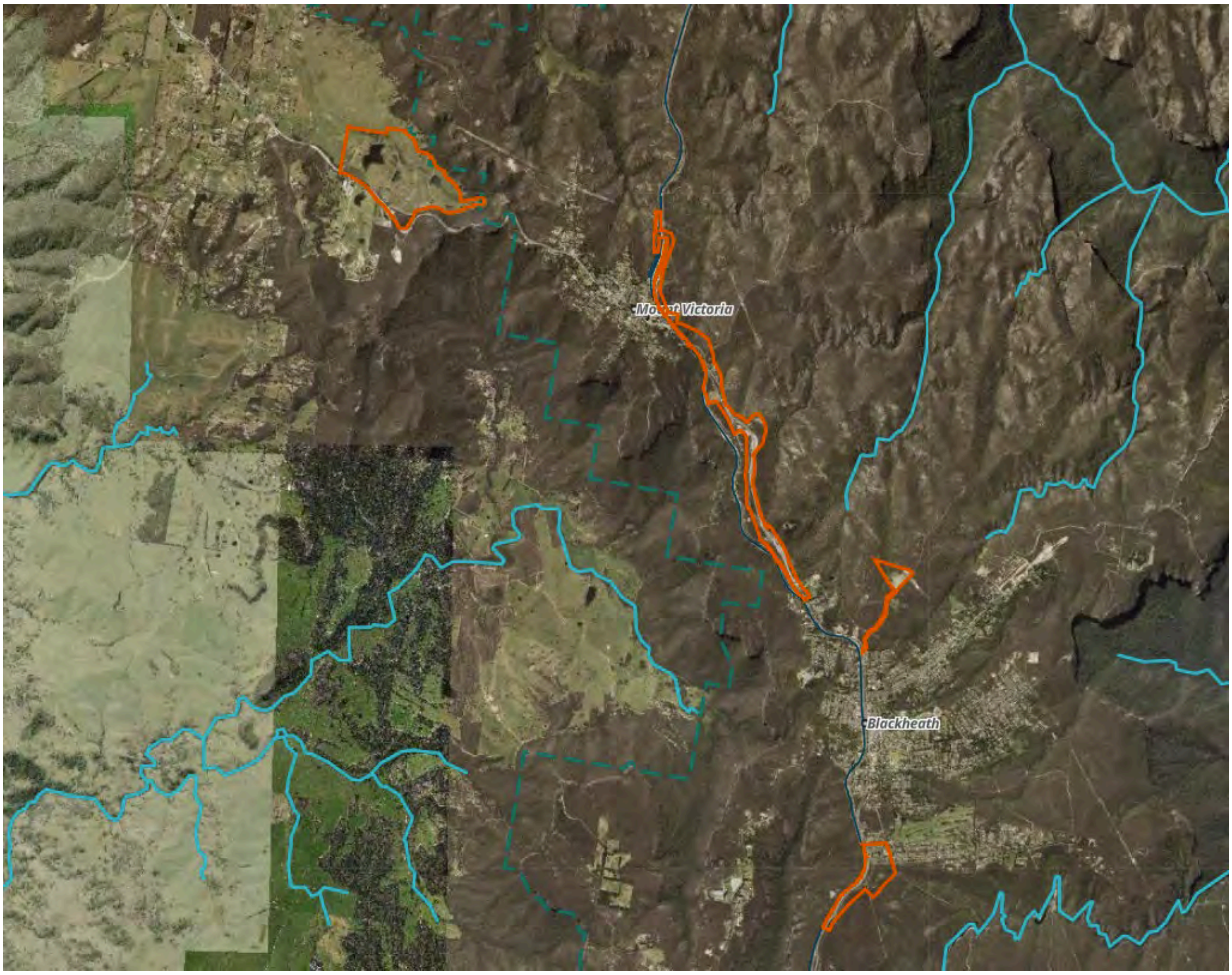
a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within corridors as part of the biocertification process.

1.2 Project context

Transport for NSW (TfNSW) is assessing the ecological impacts of the proposed upgrade to the Great Western Highway between Blackheath and Little Hartley. This includes calculating biodiversity credit (offset) requirements for the proposed clearing of threatened species and their habitat. This Expert Report will assist in determining the extent and quantum of impacts of the proposed works on *Acacia flocktoniae*.

The proposed upgrades involve construction of twin tunnels (10.4 kms), tunnel portals and ventilation systems, changes to the road to connect it with the new tunnels, and formalisation of the Berghofers Pass car park.

1.3 Study area



Map 1. Assessment areas (orange outline) that are subject to this Expert Report

Description of assessment areas

The assessment areas that are the subject of this Expert Report are parcels of land adjoining or adjacent to the Great Western Highway from the southern fringe of the town of Blackheath to the village of Mount Victoria, then below the Blue Mountains Escarpment into the valley east of the village of Little Hartley (Map 1).

The subject land is within the Wollemi and Burragorang Subregions of the Sydney Basin Bioregion (after SEWPaC, 2021). Terrain is predominantly flat to gently undulating along the Blue Mountains Plateau section, then drops dramatically to the west at the escarpment known as Hassans Walls. The Plateau surface is dominated by Triassic Narrabeen Group sediments, predominantly Banks Wall Sandstone that overlies Permian sediments that outcrop roughly midway down the escarpment face and in deeper valleys within the Plateau. Permian sedimentary strata dominate within the Little Hartley section of the assessment area (as Berry Siltstone), with the much older Bathurst Suite (granite and monzogranite) only evident in the far west of the assessment area. Further information on the region's lithology is provided by Martyn (2018).

Most of the remnant vegetation on the Plateau comprises heathy sclerophyll forest ranging to scrub, heath, and small areas of montane swamp. These habitats are generally common in the nearby Blue Mountains National Park. In stark contrast, within the Little Hartley area, the native vegetation has been extensively cleared and is very poorly conserved in the region due to the terrain being far more arable than that of the Plateau. Within the corridor adjoining the current Highway, weeds are locally common and sometimes severe in the more disturbed roadside and associated drainage situations.

1.4 Justification for the use of an Expert Report

An Expert Report for *Acacia flocktoniae* is required as part of the threatened biota assessment for the proposed upgrade to the Great Western Highway (Blackheath to Little Hartley) because:

1) Survey effort for this species could not occur during the flowering period specified in OEH (2016) and the Threatened Biodiversity Database Collection (TBDC) as necessary for compliant surveys.

An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region. I have primarily been self-employed, with a mix of government, private, NGO and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for the then OEH (Native Vegetation Information Science). I am recognised as a 'threatened species expert' by DPE EES for numerous flora and TEC. I was approved by the Department of Planning & Environment (DPE) as a Species Expert (limited to this project) for *Acacia flocktoniae* under s.6.5 of the BAM in July 2022.

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Acacia flocktoniae*

BAM requirement	Details
Name of expert	Dr Steven Douglas
Expert's qualifications	BSc (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. MEnvPlan, GSE, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006.
History of experience in ecological research and survey method for the relevant entity	Review of database records of the species to determine the best location for records that are spatially unsound. Recommended survey to detect a 'lost' population. Have surveyed part of the Byrne's Gap (Yerranderie) population to establish a monitoring plot and PCT typing sample. I built a very basic habitat model that provides the first context in which the presence of the species can be predicted. This will be used by DPE to undertake surveys for undocumented populations in potential habitat.
Resumé detailing projects pertaining to the survey of the relevant entity	See above.
Employer's name and period of employment (if relevant)	Self-employed ecological consultant from 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map; review of mapping/definitional issues relating to TECs).
Relevant peer-reviewed publications	None. My reports to DPE are for internal use by that agency.
Evidence that the person is a well-known authority on the relevant entity	I am a member of the expert panel that advises DPE about the management of this species. I am an accredited expert for several other threatened *Acacia* species and have prepared approved Expert Reports for *Acacia bynoeana* and *A. pubescens* and have drafted an Expert Report for *A. meiantha*.

2. Species information

2.1 Description

Flora of Australia online (Kodela 2018) describes the species as “Sparingly branched, weak shrub 2–4 m high. Branchlets somewhat pendulous, angled at extremities, red-brown, glabrous. Phyllodes rather crowded, on raised stem-projections, ascending to erect, linear to narrowly oblanceolate, 5–9 cm long, 2–5 mm wide, normally gradually narrowed to an acute or acuminate apex, thin, glabrous, with fine midrib, obscurely penninerved; gland not prominent, 0–6 mm above pulvinus. Inflorescences racemose, with raceme axes 2–6 cm long, slender, glabrous; peduncles 3–5 mm long, to 8 mm long in fruit, glabrous; heads globular, densely 20–30-flowered, creamy white or bright yellow. Flowers 5-merous; sepals united almost to apex. Pods broadly linear, to 13 cm long, 6–7 mm wide, firmly chartaceous to thinly coriaceous, glabrous. Seeds longitudinal, oblong, 4.5–5.5 mm long, slightly shiny, black; funicle encircling seed in a double fold, red-black; aril clavate.”

DPE (2019) describes it as an erect or somewhat pendulous shrub 2 - 4 m tall, with somewhat winged branchlets. The wattle ‘leaves’ (phyllodes) are straight, between 5 - 10 cm long and 2 - 5 mm wide. Sprays of 5 - 10 golden-yellow globular flower-heads appear between June and August.

PlantNet (Kodela 2012) describes the species as “Erect or spreading shrub 1.5–3 m high; branchlets angled or flattened at extremities, glabrous. Phyllodes linear to very narrowly elliptic-oblanceolate, ± straight, usually 4–10 cm long, 2–5 mm wide, glabrous, midvein ± prominent, obscurely penniveined, apex subacute with a mucro; 1 inconspicuous gland 0–6 mm above pulvinus; pulvinus < 2 mm long. Inflorescences 4–10 in an axillary raceme; axis 1–6 cm long; peduncles 2–4 mm long, glabrous; heads globose, 20–30-flowered, 3.5–5 mm diam., cream-coloured to bright yellow. Pods straight to slightly curved, ± flat, barely to slightly and often irregularly more deeply constricted between seeds, 4–11 cm long, 5–7 mm wide, firmly papery to thinly leathery, glabrous; seeds longitudinal; funicle filiform, ± encircling seed.

In the above descriptions, some real differences are evident, but other apparent differences are a result of different terms being used for the same thing. It should also be noted that the known populations of the species are spatially disjunct and there may be some genetic and morphological differentiation between them. AMBS (2015: 3) note that the phyllodes of the Blackheath Glen Reserve population are broader than those of the Byrnes Gap population.

2.2 Ecology

Acacia flocktoniae was considered data-deficient by the Saving Our Species program as very little was known about it. A recent review in which I participated, recommended that it be reclassified as site-managed, and that a conservation project be developed. Preliminary work on that project has produced some new and refined information about the species’ distribution and ecology.

DPE (2019) provides very little information on the species’ ecology, only stating that it “Grows in dry sclerophyll forest on sandstone”. This information is partial and tending towards incorrect. The source of that description appears to PlantNet (Kodela 2012) which is repeated in Flora of Australia (Kodela 2018).

My detailed review of database records found that the species is most strongly associated with mapped Berry Siltstone. However, some populations may occur on soils that have a Siltstone base but where colluvium and detritus from up-slope escarpments of Narrabeen Sandstone makes a significant contribution. The Moorara Boss population may occur on sandy soils derived from granite and may also have soils derived from residual and largely eroded sandstone that overlay the granite.

The largest documented population is referred to as occurring at Byrnes Gap near the former silver mining town of Yerranderie. This population has not been thoroughly surveyed but has been substantially documented by AMBS (2019) and occurs in predominantly dry sclerophyll forest on a ridge and upper to mid-slopes. However, AMBS (2015, 2019) note that the species generally prefers sheltered aspects.

The much smaller population in Blackheath Glen Reserve at the top of the Megalong Valley occurs in a very sheltered valley in wet sclerophyll forest, with sheltered dry sclerophyll forest on the margins.

The small Moorara Boss population is known from an exposed ridge and hilltop in dry sclerophyll forest.

The apparently small Kanimbla Valley population (below, not at Mount Victoria) is in sheltered dry to wet sclerophyll forest reportedly similar (in part) to that in the upper Megalong Valley (AMBS 2019).

The species is said to usually flower from June-September but has also been recorded flowering in March, April, October, and December. I observed some flowering of post-fire recruits or resprouts at Byrnes Gap in May. Flowering may be opportunistic and driven by factors such as post-fire regeneration and soil moisture.

The TBDC states "Flowering is sporadic throughout late winter and early spring. Flowering peak Jul - Aug and fruiting mainly in Sep - Oct. The fruit are especially helpful for locating [the species] in the field due to their clustered and pendulous habit."

The species is believed to largely clonal through root suckering. It does set seed, but viability is expected to be low (AMBS 2015, 2019). This situation is known to occur in other *Acacias* with disjunct populations that are no longer able to exchange genetic material, and where low genetic diversity is known or inferred. However, at this time, genetic assessment has not been undertaken to determine how clonal *A. flocktoniae* is at the species and population levels, nor the level of seed production at all populations, or seed viability. My partial observations within the large Byrne's Gap population did not support clonality as the plants that I observed appeared much more likely to be seedlings that established after fire. I did not see any evidence of clonality but only viewed small and peripheral parts of the population.

2.3 Distribution and abundance

Until very recently, the distribution of the species has been inferred from unrefined database records, many of which are marked as spatially vague and when reviewed, were found to be spatially inaccurate.

PlantNet (Kodela 2012) wrongly gives the species' distribution as "the Blue Mtns from Mt Wilson south to the Picton district". This has been repeated in various online and other sources. There are no known spatially sound database records from near Mount Wilson in the higher Blue Mountains, and I was not able to discern the basis for referring to that locality. The reference to Picton is derived from an earlier arbitrary location assigned to the historic 'Nepean River' record that is now believed to have occurred much further downstream.

Flora of Australia (Kodela 2018, last updated in 2020) gives a more accurate distribution of the species as "Occurs in the Blue Mountains at Mount Victoria and Megalong Valley, at Byrnes' Gap near Yerranderie and also the Nepean River".

Records suggested that the species had been collected from below the escarpment east of Little Hartley, from the locality of Mount Victoria and environs such as Blackheath, and from a rural area west of the escarpment and northwest of Mount Victoria (west of Coxs River Road). After review by AMBS (2019) and then by Douglas (2022), those records were considered to relate to a single collection site below Mount Victoria in the Kanimbla Valley, roughly southwest of the locality of Mount Victoria. That population is currently known from only 5 stems but has not been subject to thorough survey, and significant areas of potential habitat were identified (AMBS 2019).

Several records plot in various seemingly random locations in different habitats and cleared land within the Megalong Valley. I believe that they relate to a single population close to Megalong Valley Road in what is now Blackheath Glen Reserve managed by Blue Mountains City Council. That population has been censused in recent years and is less than 300 apparent plants (AMBS 2015, 2019). There is similar potential habitat around the margins of the Megalong Valley, but no records from those areas.

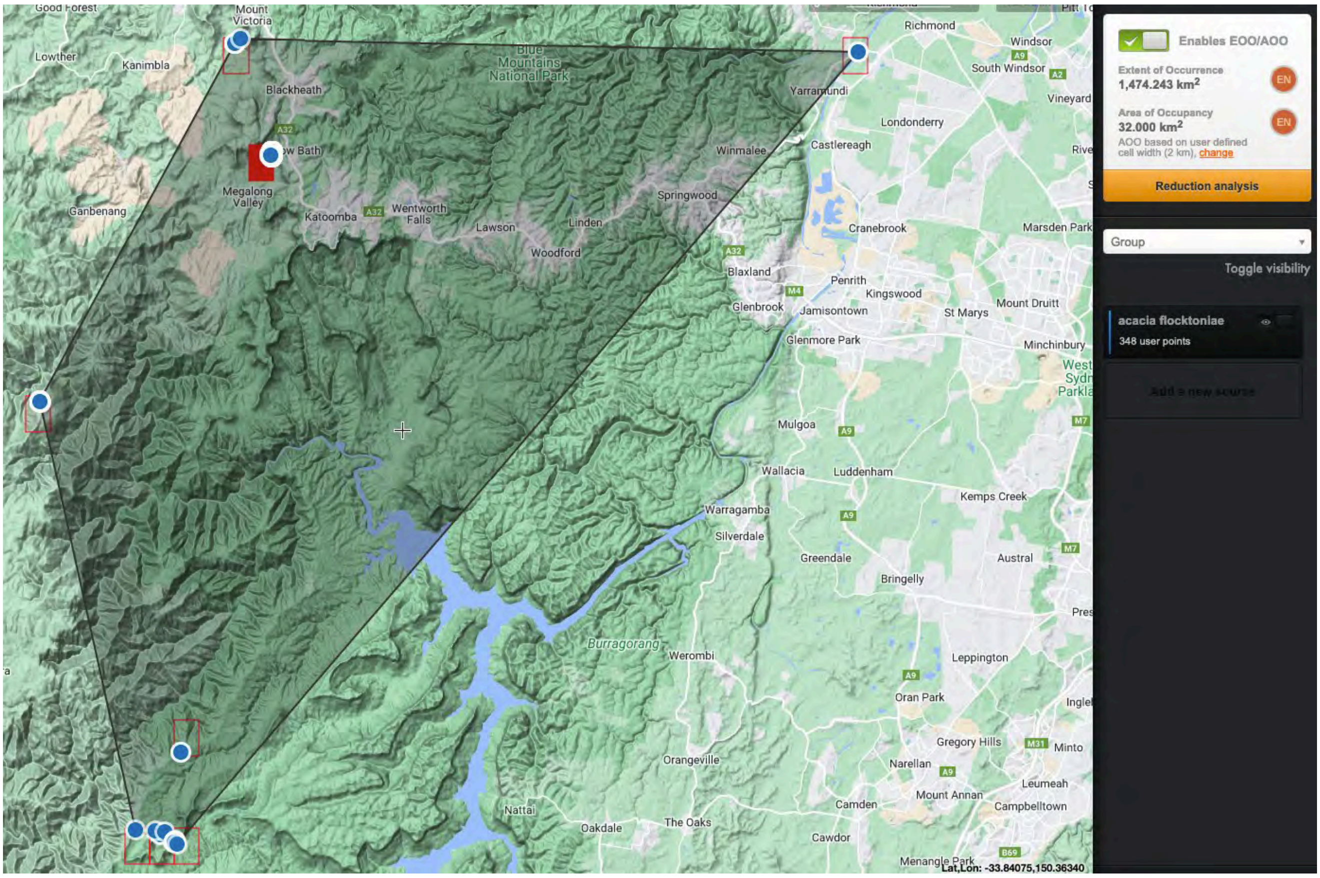
A small and isolated population is known from Moorara Boss AKA Moorara Mountain in Kanangra Boyd National Park. Before the 2019-20 wildfire burnt this area, this population was counted at 12 stems but again, survey was not comprehensive (AMBS 2019). Post-fire, the population has increased to at least 15 apparent plants (UTS 2022).

The largest known population of this species is on the ridge and upper to mid slopes from Byrnes Gap and along Scotts Main Range northwest of Yerranderie. Prior to the 2019-20 wildfire, this population was estimated to contain up to 6500 stems. It is unknown how many individuals (genets) are present (AMBS 2019).

An old collection record of the species that refers to the Nepean River has no co-ordinates or other substantial location details. At some stage, it appears to have been mistakenly linked to the property name of Urimbirra, which relates to the Kanimbla Valley population below Mount Victoria. This appears to later have been interpreted as Wirrimbirra, which is the name of a designated wildlife sanctuary on the western edge of the Woronora Plateau near the locality of Bargo. The record has variously been plotted in or near Wirrimbirra, and on the Nepean River in the Macarthur District. However, several rounds of review culminated in the species' SOS panel agreeing that the record is best placed near the confluence of the Grose and Nepean River in habitat that was destroyed by gravel and sand mining, and perhaps for agriculture, as well as by severe floods. This population is believed to have been an outlier arising from seed washed downstream from the Byrnes Gap population before the construction of Warragamba Dam. The population has long been considered extinct.

There are a very small number of database records of the species from the Warrumbungle National Park in the northwestern slopes botanical division. These are reportedly misidentifications of a superficially similar species, *A. forsythii* (Andrew Denham, pers. comm. 2022), and the error has been brought to the attention of the relevant herbaria and to BioNet Atlas, but errors persist in some sources.

The species has not been subject to genetic analysis that would determine relationships within and between the known populations, as well as providing information on the extent of any clonality.



Map 1 Amended BioNet Atlas records (July 2022) displayed using the GeoCAT web tool.

The records use to generate the above map include NSW Herbarium records within BioNet at that time. Records from other Herbaria were reviewed and were all deemed to be replicates of NSW Herbarium collections or at least related to sites subject to NSW Herbarium collections.

2.3.1 Reservation status

At the time of writing, the species was known to occur in Kanangra Boyd National Park, Blue Mountains National Park (both within the Greater Blue Mountains World Heritage Area), and in the Council-managed Blackheath Glen Reserve. The available information indicates that the species cannot be considered adequately conserved. Only one reserved population (Byrnes Gap) is moderately large. All others are apparently much smaller, and some may be too small to be viable in the medium to long term.

2.4 Habitat

The species is known from dry and wet sclerophyll forest at mid-altitudes (~600-800 m) of the south-western Blue Mountains. Most of the dry sclerophyll forest sites have sheltered aspects (AMBS 2015, 2019).

2.4.1 Geology and soil

Within the limits of mapped lithology per Colquhoun *et al*. (2022), spatially sound records of the species are strongly associated with Permian Berry Siltstone and not associated with mapped Narrabeen Sandstone. However, lithology is mapped at 1:100 000 scale and cannot be relied upon in this context. Site inspections indicate that some of the Byrne's Gap population may be on Narrabeen Sandstone or at least the transition from it to Berry Siltstone. This and some other sites likely have soils derived from weathered Narrabeen Sandstone and a parent substrate of Berry Siltstone.

The lithology of the Moorara Boss site maps as granite, but site reports indicate the substrate may be weathered sandstone, presumably Narrabeen Group, overlying the granite. Some of the spatially dubious records from the central and southern Megalong Valley plot on granite and monzogranite but in habitats that would likely have been very different to where the species is known to occur. A very spatially dubious records that plots west of Coxs River Road in the Kanimbla Valley plots on gabbro, which is a very different substrate to any of the validated locations of the species. That record very likely relates to the site below Mount Victoria.

2.4.2. Associated vegetation communities and NSW and Commonwealth TECs

The TBDC records 12 Plant Community Types (PCTs) as being associated with BioNet Atlas records of this species at an unspecified time. Whilst useful at a coarse scale, the process of associating records of the species with PCTs is undermined by problems such as potential inclusion of planted or naturalised occurrences not flagged as such; spatially inaccurate records (which is a large factor in this case); and the coarse spatial resolution and variable quality of most vegetation (PCT) maps. In this case, it is very apparent that the process of associating mapped PCTs with unrefined database records of the species has resulted in some very unsound PCT associations. The TBDC list of associated PCTs is shown below. Translations are given to or from the old PCTs (blue text) that are used in the BDAR with which this Expert Report is associated.

PCT	PCT Name	Assessment of relevance to the species
3474 / 871	Burragorang Escarpment Grey Gum Sheltered Forest	Credible
3601 / 862	Burragorang Footslopes Scribbly Gum Forest	Invalid
3479 / 858	Burragorang Gorges Grey Gum-Stringybark Dry Forest	Potentially credible
3484 / 832	Burragorang Gorges Red Gum-Ironbark Sheltered Forest	Invalid
3650 / 1151, 1155	Goulburn-Lithgow Ranges Silvertop Ash Forest	Invalid
3653 / 966, 967	Kanangra Peaks Silvertop Ash Forest	Unlikely but may relate to Moorara Boss or the spatially dubious ‘Kiaramba Range’ 1947 record.
3611 / 1086	Nattai Plateau Bloodwood-Peppermint Forest	Unlikely
3266 / 1254	Nattai-Morton Sandstone Peppermint Gully Forest	Potentially credible
3619 / 1790	Sydney Hinterland Enriched Sandstone Bloodwood Forest	Invalid
3692 / 1630, 1631	Upper Blue Mountains Moist Forest	Credible
3495 / 941	Western Blue Mountains Monkey Gum Gully Forest	Credible
1330 / 3373, 3376)	Yellow Box - Blakely's Red Gum grassy woodland on the tablelands, South Eastern Highlands Bioregion	Invalid and a result of spatially unsound records from in and near Megalong Valley.

None of the known occurrences of the species are within Threatened Ecological Communities listed under NSW or Commonwealth laws. The association with PCT 1330 is a result of spatially unsound records.

Distribution of PCTs associated with Acacia flocktoniae in the assessment areas

A basic habitat model was drafted for DPE as part of the Saving Our Species project. This relies on mapped lithology and elevation and can be extended to include aspect and a shelter index. The model is not yet developed enough to be used here other than in a very simple way.

Based on the earlier review of database records, it was determined that the species is strongly but not exclusively associated with Berry Siltstone, sometimes below Narrabeen Sandstone escarpments, with a preference for sheltered aspects. On this basis, it is not expected to occur or to have ever occurred in most of the assessment area. The exception is below the escarpment in the western portion of the assessment area east of Little Hartley. SVTM PCT 3495 occurs in that area and is potential habitat for the species. PCT maps in the BDAR use the old classification, and according to the BioNet PCT Lineage report, the equivalent PCT in that scheme is given as 941, which does not occur in the assessment area. However, PCT 1615 is arguably related to 3495 and is mapped in the assessment area.

2.4.3 Habitat condition

The species can sucker and apparently germinate from soil stored seed in sites disturbed by fire and by earthworks such as road maintenance and roadside vegetation suppression (see for e.g., AMBS 2015, 2019). It is not known how tolerant it is of disturbance in general or in particular forms. However, because it suckers readily and is likely to have a long-lived soil seedbank (where viable seed is produced), it is likely to be tolerant of moderate to light disturbance. I would not expect it to persist in areas subject to pastoralism as it is likely to be palatable to livestock.

3. Description of the study area

3.1 Landscape context and land use history

The subject land is predominantly flat to gently undulating along the Blue Mountains Plateau section, then drops dramatically to the west at the escarpment. Much of the plateau is non-arable and the dominant land use is Nature conservation with a relatively small portion under housing and ancillary uses such as transport and tourism.

Below the plateau, land is generally much more arable and is heavily cleared, with pastoralism the dominant land use. Terrain is steep at the escarpment, grading to rolling further to the west. The section of the assessment area that is below the plateau is mostly devoid of native woody cover and has been cleared for livestock grazing and for construction of associated dams.

3.2 Geology and remnant vegetation

The assessment area is dominated by Narrabeen Group sandstone on the Blue Mountains Plateau and the top of the escarpment. Most of this area is naturally vegetated or partially vegetated. The natural vegetation is primarily dry sclerophyll forest ranging to scrub, heath, and montane swamps. Wet sclerophyll forest occurs in topographically sheltered sites such as along watercourses.

Below the escarpment, the lithology is Permian Berry Siltstone, which is much more arable than much of the Plateau, so is extensively cleared for pastoralism. The native vegetation would have been dry to wet sclerophyll forest with a more shrubby to grassy understorey relative to the much more heathy understorey on the plateau.

3.2.1 Plant Community Types with the assessment areas

Table 4. PCTs mapped as present with the assessment areas

PCT	PCT Name	Distribution & notes
708	Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains	Not suitable habitat for the subject species. Not a TEC where it occurs in the assessment area. 1.8 ha proposed for clearing, mostly in High condition, balance in Moderate.
766	Carex sedgeland of the slopes and tablelands	Not suitable habitat for the subject species. Treated as a TEC component in at least some situations. Common in moist pasture. 0.4 ha in Low condition proposed for clearing.
1078	Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion.	Not suitable habitat for the subject species. No proposed clearing. Treated as a TEC component in at least some situations.
1248	Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains	Not known or likely habitat for the subject species. Roughly 6 ha proposed for clearing (mostly High condition).
1256	Tableland swamp meadow on impeded drainage sites of the western Sydney Basin Bioregion and South Eastern Highlands Bioregion	Not suitable habitat for the subject species. No proposed clearing. Treated as a TEC component in at least some situations.
1615	Monkey Gum - *Eucalyptus blaxlandii* shrubby open forest on basalt of the Sydney Basin.	Not known or likely habitat for the subject species because the species has no association with basalt. However, this old PCT appears to be related to the new PCT 3495 based on interpretation of descriptive text. The latter is a much better classification for the subject vegetation in the assessment area below the escarpment. Biosis is obliged to use the old PCTs in the BDAR, and 1615 is apparently the best fit despite not occurring on basalt. Very small areas of Low and Moderate condition are proposed for clearing. Part of a TEC (Blue Mountains Basalt Forest and Upland Basalt Eucalypt Forest under BC and EPBC Acts) when all other specifications are met, which they are not in the assessment area.
1740	Tall Spike Rush freshwater wetland	Not suitable habitat for the subject species. No proposed clearing.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principal source of threatened flora records in NSW is the DPE BioNet Atlas database, which includes most records held by the NSW Herbarium (specimen-based), as well as unvouchered sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used significantly in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet Atlas are original – most are simply replicates based on multiple specimens held in various herbaria.

BioNet Atlas data should only be treated as indicative. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate. Furthermore, not all observations are provided to BioNet Atlas.

The species was not detected by Biosis during fieldwork in the assessment area in 2021 and 2022.

4.1.1 Existing records in the assessment area

No database records of the species are known from within or near to the assessment area as of mid-2022. The nearest known occurrence is in the Kanimbla Valley on the SW footslopes of Mount Victoria. This is well removed from the assessment area. Records that plot at and near Mount Victoria are considered by me to be spatial errors based on many collectors providing very limited location notes and no co-ordinates. There is no credible evidence that the species occurs on the plateau in that area, nor at such relatively high altitude.

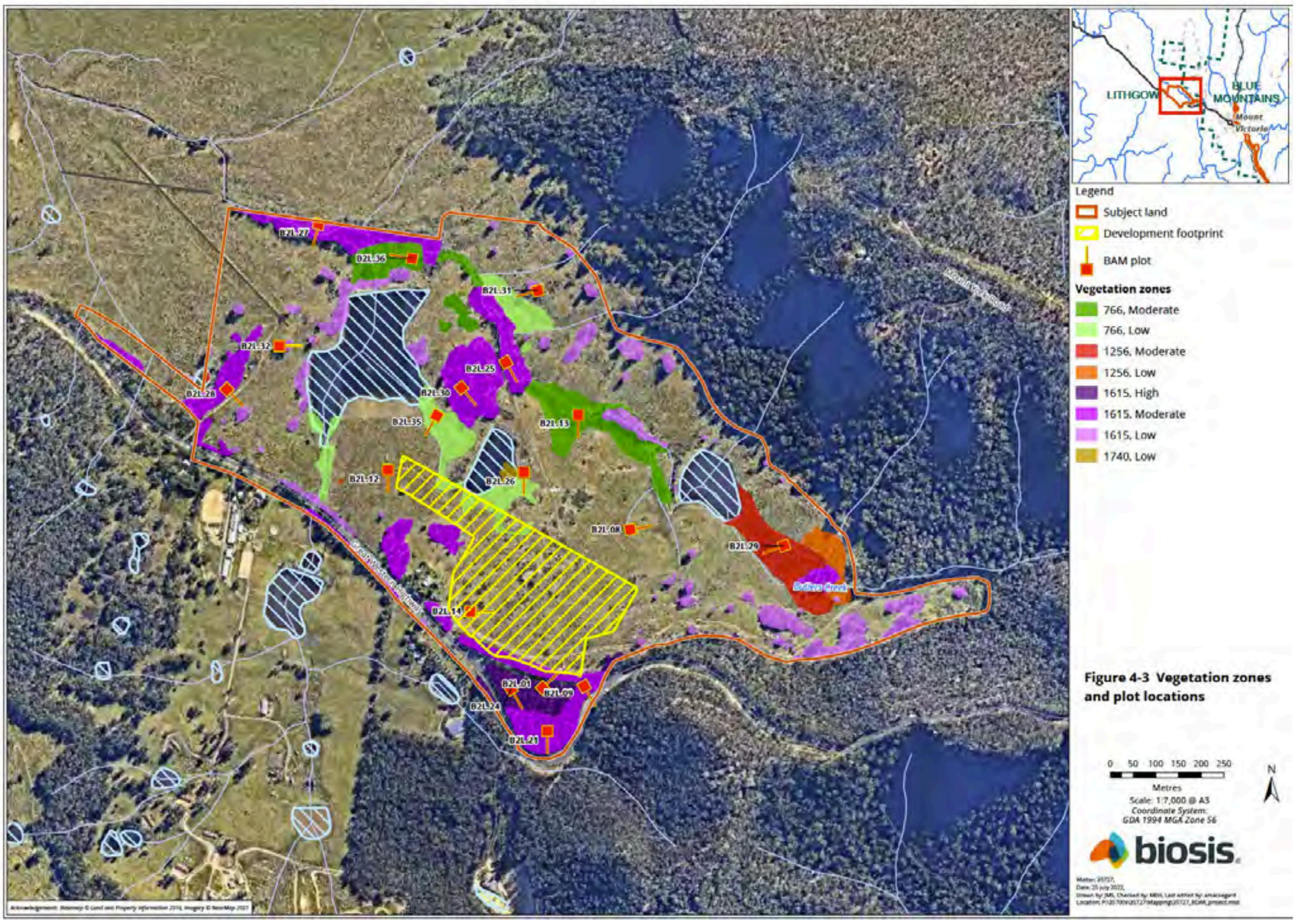
4.2 Summary of survey work undertaken for the BDAR

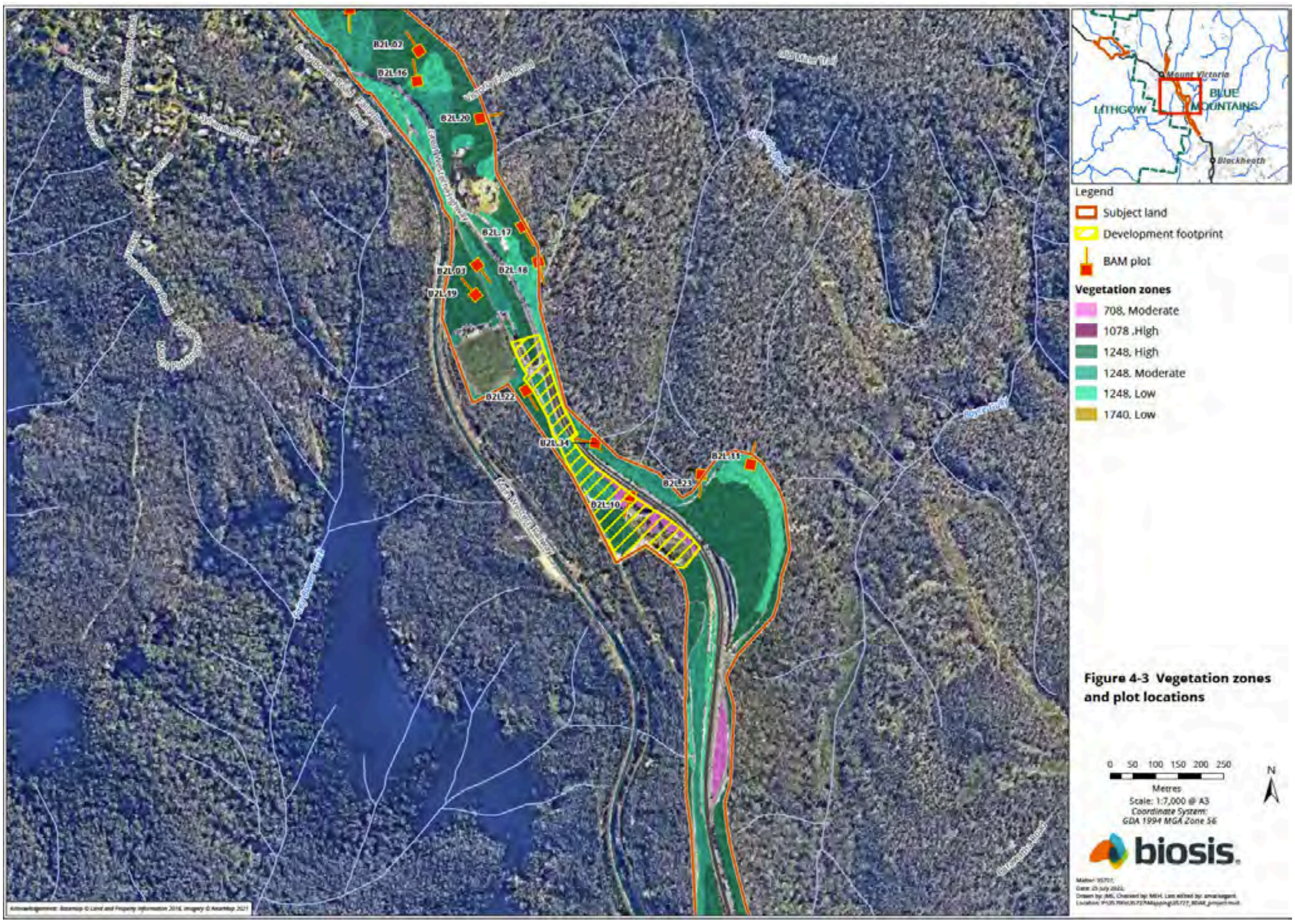
4.2.1 Vegetation mapping

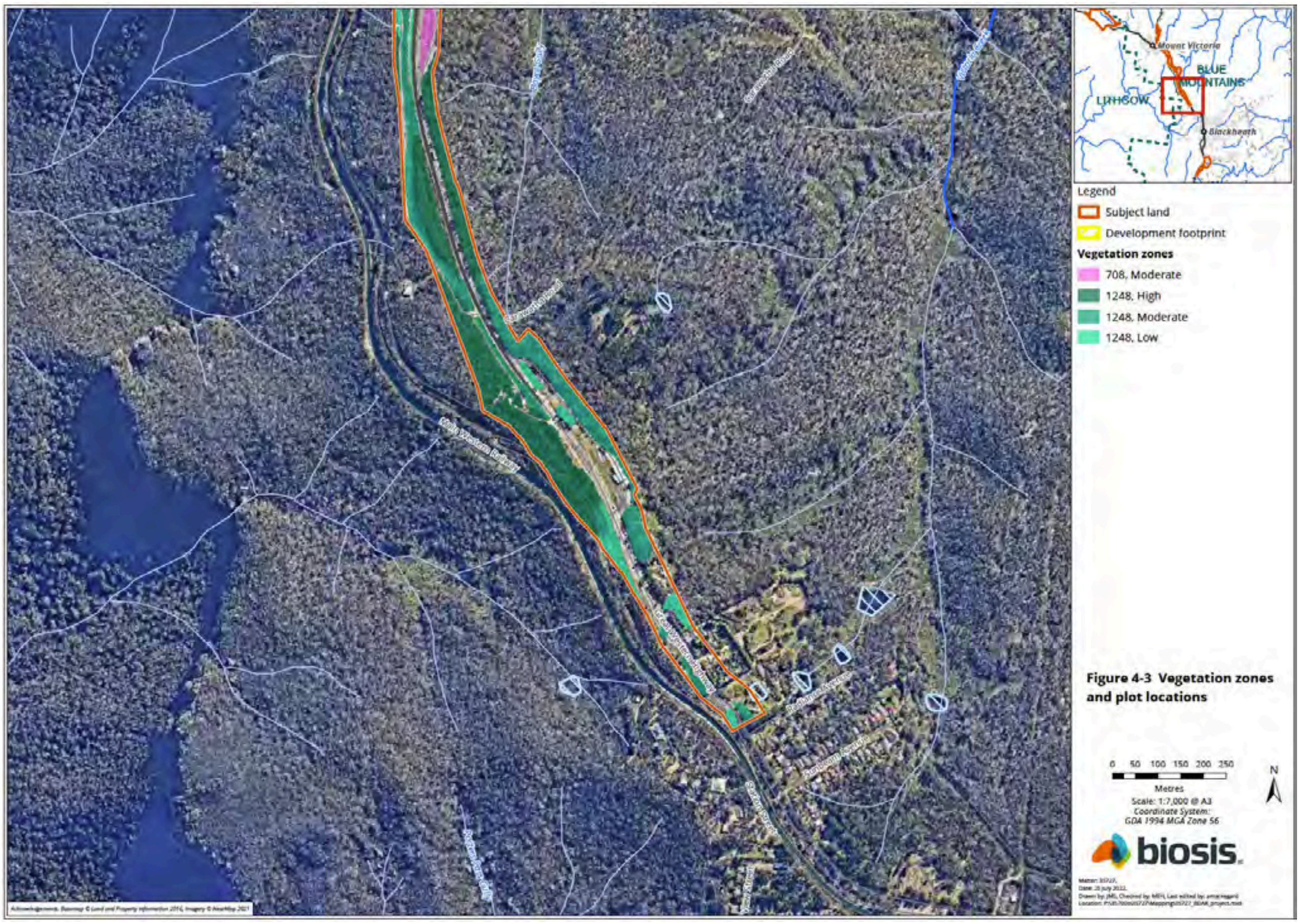
Biosis has mapped PCTs in the area proposed for clearing as shown below. At this time, the pre-SVTM PCTs are still required to be used within the Biodiversity Offset Scheme.

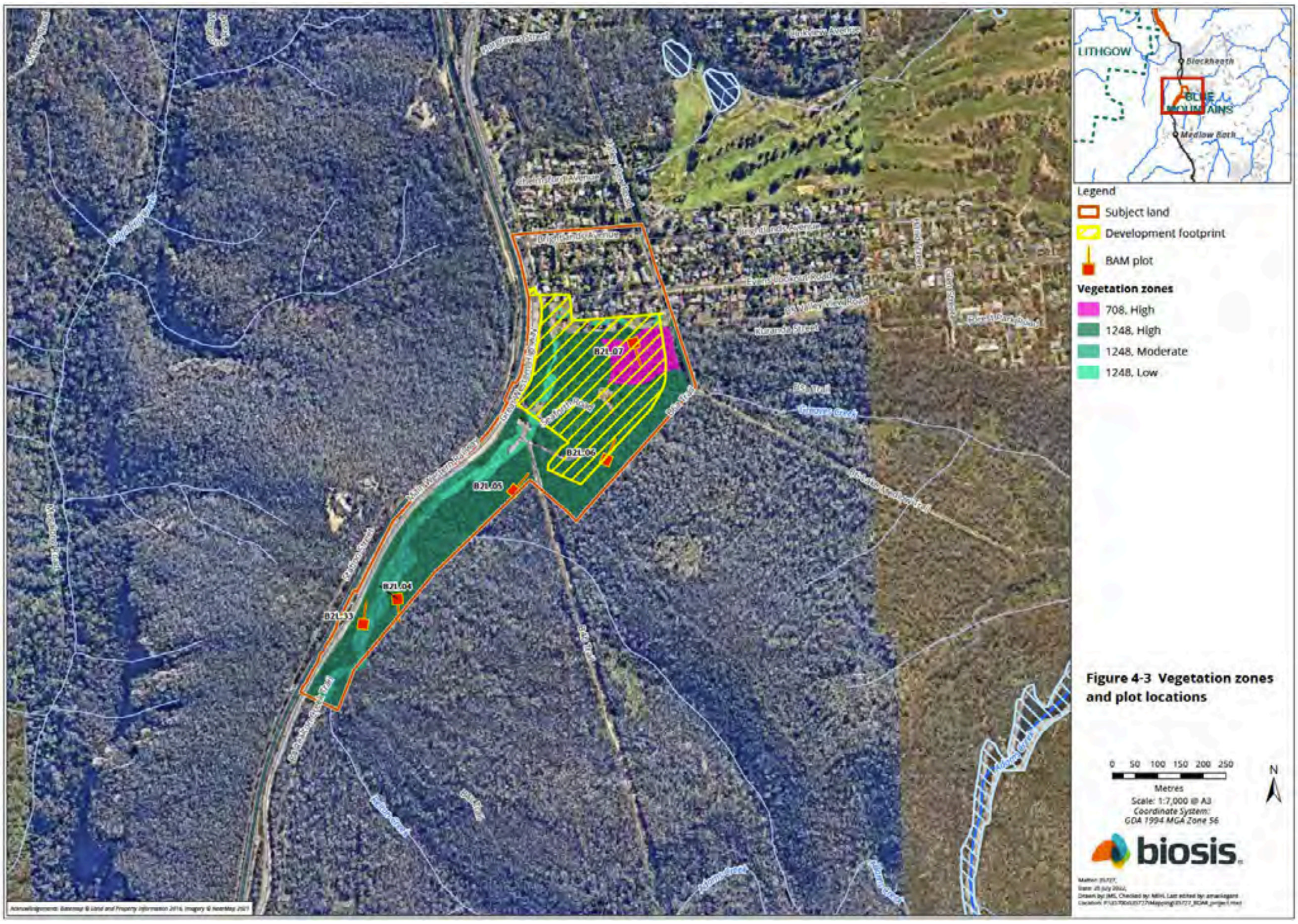
Plant Community Type	**Condition class**	**Area (ha)**
UNE (Urban Native/Exotic)	<Null>	11.01784
708	High	1.294575
708	Moderate	0.496758
766	Low	0.432809
1248	High	6.142838
1248	Low	0.33048
1248	Moderate	0.860616
1615	Low	0.013094
1615	Moderate	0.179315

The following PCT maps also show PCTs in the assessment area. The clearing area or Development Footprint is shown in yellow hatching. Blue hatching designates water bodies (mostly farm dams). BAM plot locations are shown as red squares, with the tail of the square being the orientation of the associated transect (30m extension beyond the 20 x 20 m plot). Condition classes are shown in the map keys. Maps are from north to south: Kanimbla Valley section, then moving south along the highway to the southern fringe of Blackheath.


LITHGOW
BLUE MOUNTAINS
Mount Victoria
Legend
Subject land
Development footprint
BAM plot
Vegetation zones
766, Moderate
766, Low
1256, Moderate
1256, Low
1615, High
1615, Moderate
1615, Low
1740, Low
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56
biosis


Mount Victoria
BLUE MOUNTAINS
LITHGOW
Blackheath
Legend
Subject land
Development footprint
BAM plot
Vegetation zones
708, Moderate
1078, High
1248, High
1248, Moderate
1248, Low
1740, Low
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56
biosis

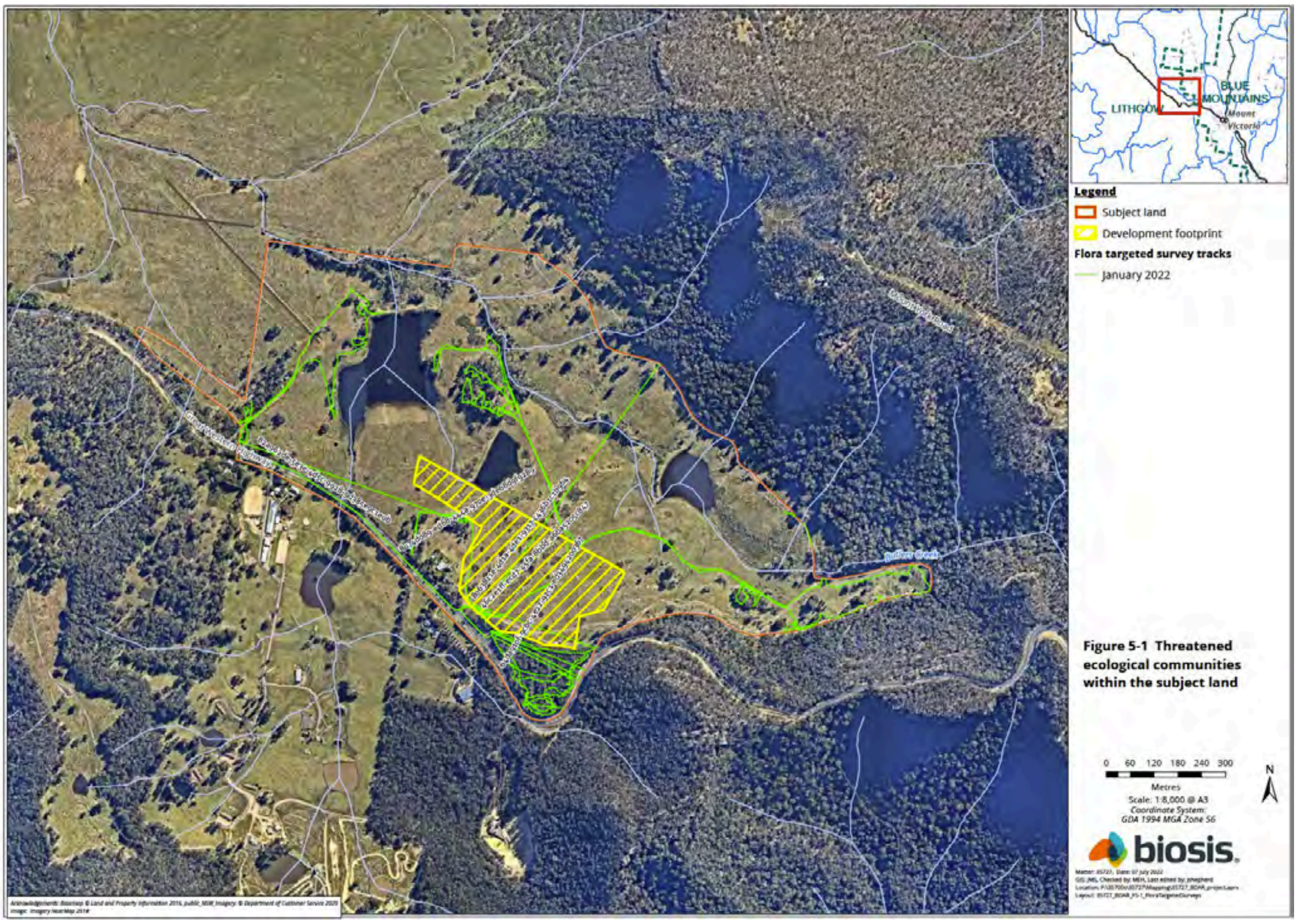

Mount Victoria
BLUE MOUNTAINS
LITHGOW
Blackheath
Legend
Subject land
Development footprint
Vegetation zones
708, Moderate
1248, High
1248, Moderate
1248, Low
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System:
GDA 1994 MGA Zone 56
biosis.


LITHGOW
Blackheath
BLUE MOUNTAINS
Medlow Bath
Legend
Subject land
Development footprint
BAM plot
Vegetation zones
708, High
1248, High
1248, Moderate
1248, Low
BZL 07
BZL 06
BZL 05
BZL 04
BZL 11
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System:
GDA 1994 MGA Zone 56
biosis.

4.2.2 Field survey effort

Biosis has undertaken substantial ecological field survey within the assessment area as shown in the maps below. Maps are from north to south: Kanimbla Valley section, then moving south along the highway to the southern fringe of Blackheath. This included targeted transects for threatened species (parallel traverses of 5-10m width by two experienced botanists), BAM vegetation plots (for PCT typing and condition assessment), and fauna surveys. Its botanists were asked to look for *A. flocktoniae* but were not able to survey it during the BAM-prescribed flowering period. Biosis' vegetation surveys occurred primarily from November 2021 to January 2022, with some survey plots recorded up to May 2022.

Whilst I do not believe the species would have ever occurred in most of the assessment area (the plateau sections), I also believe that Biosis' survey effort is reasonable as a means of ruling out any extremely unlikely and potentially unnatural occurrences in area below the escarpment. Whilst it is preferable that any surveys for this species occur when it is flowering, simply because this increases the prospects of detection and of correct identification, I do not consider flowering to be essential for detection of the species. Notably, AMBS (2015, 2019) felt that flowering was not essential for detection of the species because it has a relatively distinctive habit and form.



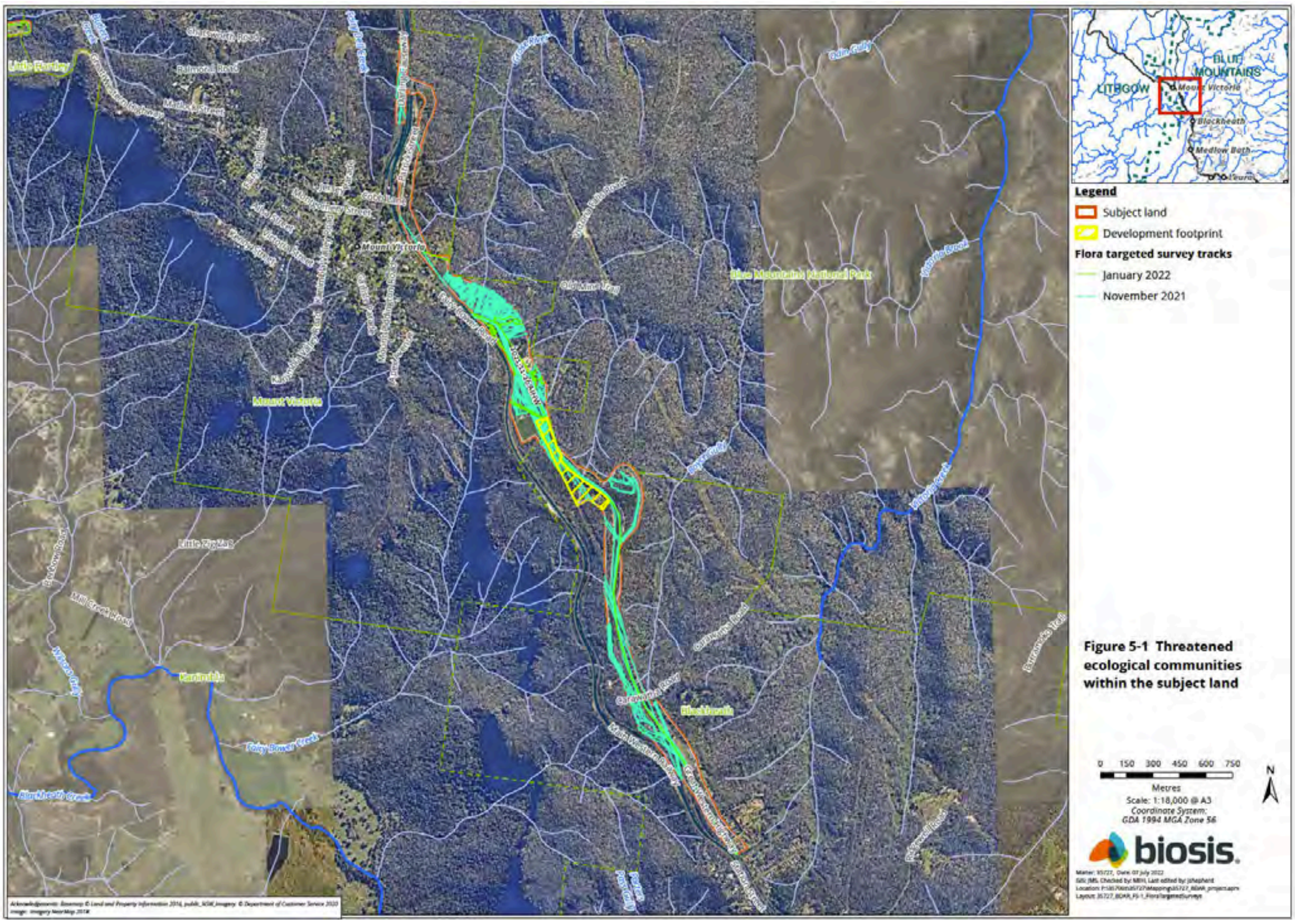


Figure 5-1 Threatened ecological communities within the subject land

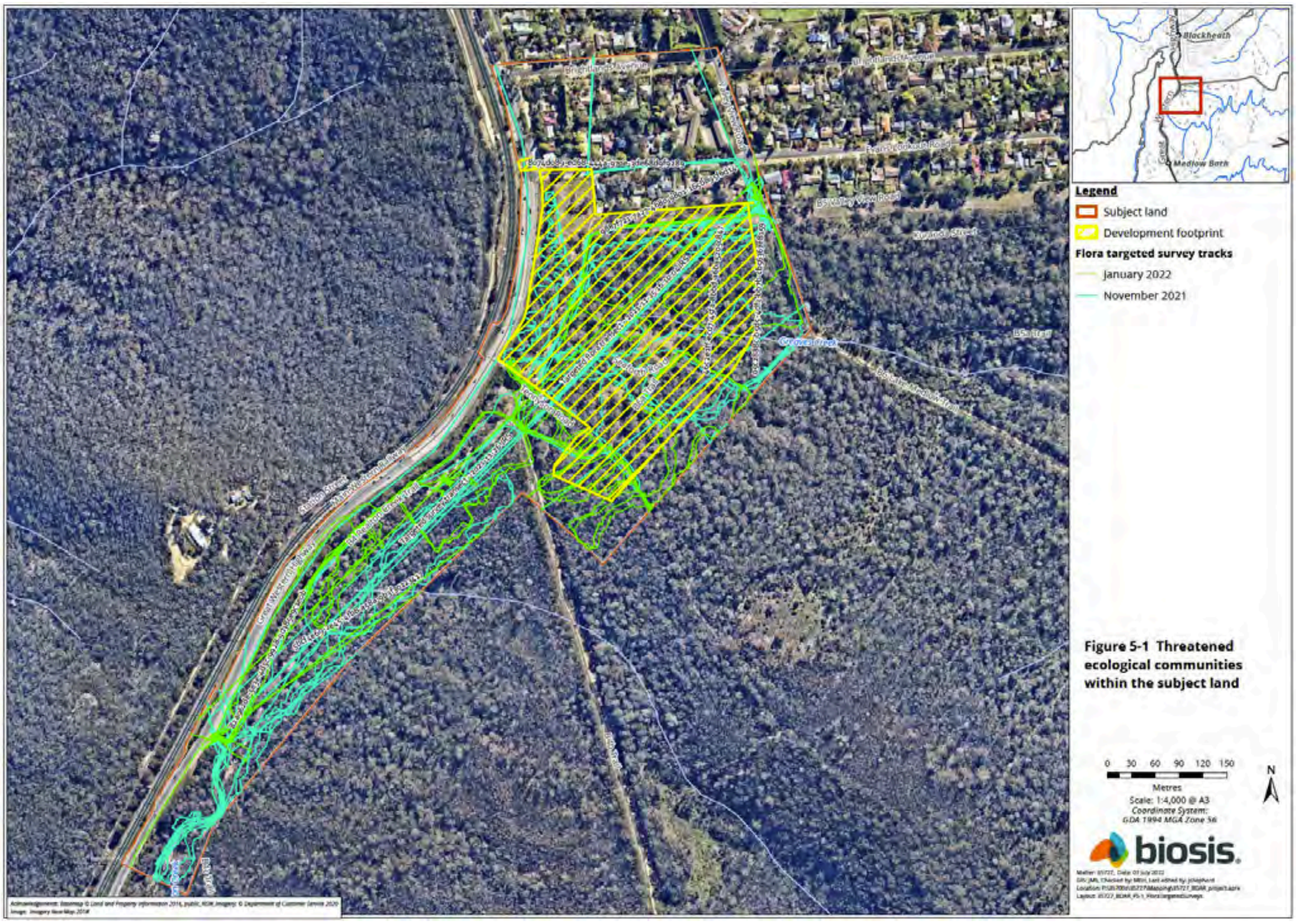


Figure 5-1 Threatened ecological communities within the subject land

Targeted survey for threatened species

Because I do not believe the species would occur naturally in most of the assessment area, with the only potential habitat being below the escarpment where vegetation clearing has been extensive and pastoralism is the main land use; and because I consider Biosis' fieldwork adequate to detect any occurrences of this species, I did not seek to access the assessment area to undertake my own fieldwork.

Biosis botanists included the species in their targeted surveys but did not detect it during that work or in BAM survey plots. Survey effort in the only area of potential habitat is at least adequate. In addition, there is very little potential habitat for the species in the area below the escarpment that has been subject to assessment, and only 0.18 ha of the associated PCT (in low and moderate condition) is proposed for clearing. Those patches are small enough and accessible enough to be thoroughly surveyed, making the non-detection of the species during those surveys a reliable finding.

4.2.3 Survey constraints –timing / site conditions

As noted earlier, this Report was required primarily because surveys could not be undertaken during the BAM-prescribed survey (flowering) period for this species. This constraint could reduce the prospect of detecting the species as it is more apparent when flowering. However, I do not believe that this represents a significant constraint in this case because the areas of potential habitat were accessible and readily traversed, and the species can be detected when not in flowering, unless access is obstructed by dense shrub cover as can occur post-fire. That is not the case here. I again note that AMBS (2015, 2019) independently argued in its reports to UNSW and the then OEH that it believes flowering is not essential for adequate survey of this species because it has a sufficiently distinctive habit and form.

4.3 Surveys completed specifically for this Report

I did not undertake fieldwork within the assessment area.

4.4 Assessment of species' presence

There are no records of the species occurring in or near the assessment area. The nearest spatially refined database records (including herbarium specimens) are from the SW footslope of Mount Victoria and from Blackheath Glen Reserve based on my review for DPE in 2022. The available evidence is that the subject species is associated with only one of the PCTs mapped in the assessment area, and that association is questionable and may be an artefact of PCT classification and association issues. Patches of the potentially associated PCT are relatively small and are well surveyed based on track logs and BAM plot locations. Some patches of this PCT are in low to moderate condition and may not be able to support the species because it is very likely palatable to livestock, and grazing is the dominant land use in that area. I conclude that the species is not present in the assessment area.

4.5 Assessment of suitable habitat for *Acacia flocktoniae*

4.5.1 Relative significance of potential habitat

Most of the assessment area does not comprise credible habitat for the subject species. The only potential habitat is below the escarpment, and this area is mostly cleared of native vegetation and is subject to livestock grazing that is likely to have destroyed any remnants of the species. Some patches are not grazed but these are outside the area of proposed clearing.

4.5.2 Species habitat polygons

I have not prepared species habitat polygons for the subject species in the assessment area as I do not consider the species to be present there.

4.5.3 Estimated number of individuals that could be destroyed

There are no known occurrences of the species that could be destroyed by works in the assessment area, and I do not predict any potential occurrences in that area.

5. Summary and conclusion

I have reviewed database records of *A. flocktoniae* and developed an adequate understanding of its habitat preferences – far beyond the information available from most public sources, though supported by the work of AMBS (2015, 2019). I conclude that the species has not been known from and is unlikely to occur in the assessment area on the Blue Mountains Plateau, and that if it did occur below the escarpment in the western portion of the assessment area, it is no longer present there, most likely due to grazing pressure. No biodiversity credits are required to be calculated for it in the assessment area.

6. Information used in the assessment

6.1 Digital resources not cited in References

- BioNet Atlas (internal access provided under license for use in this Expert Report)
- Atlas of Living Australia on-line
- NSW Herbarium specimen database
- DPE Threatened Biodiversity Database Collection
- DPE BioNet Vegetation Classification Database
- PCT maps for the assessment area provided by Biosis
- Field data from Biosis

6.2 References

AMBS, 2015. *Data-Deficient Species Research Grants Program, Priority Research Action Outcomes Report: Acacia flocktoniae - Filling the gaps ecological investigation of 17 Data Deficient plant species in NSW.* Prepared by Australian Museum Business Services (AMBS) Ecology and Heritage for University of New South Wales.

AMBS, 2019. *SOS Data Deficient Species: Targeted Survey Results and Management Recommendations for Acacia flocktoniae Maiden*. Prepared by Australian Museum Business Services (AMBS) Ecology and Heritage for University of New South Wales under the Saving Our Species program.

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University of Technology Sydney (UTS) 2022. *Results of field survey and vegetation plot survey at the Moorara Mountain population of Acacia flocktoniae*. Unpublished dataset provided to NSW DPE.

7. Acknowledgements

Earlier research funded by NSW DPE and the Saving Our Species program provided important information used in this Expert Report.

8. Statement of professional independence

Whilst I was ultimately engaged and funded by Transport for NSW to prepare this Expert Report through its consultant, Biosis, and draft reports and maps were reviewed by Biosis staff, I was not coerced by either party to amend my work in any manner that I did not otherwise agree with. I had appropriate professional independence in the preparation of this document.

I also declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses within or near the study area, nor do I have other active clients with real estate or associated commercial interests in the study area at the time of writing.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria, and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for many private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management, and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation. I am recognised as a 'threatened species expert' by DPE for many threatened plant species, Endangered Populations of plants, and threatened ecological communities within south-eastern NSW. I recently completed a review for DPE of all plant species and one Endangered Population of a plant species that were on the original edition of the SAII list under the BAM. I was the largest contributor of fieldwork and reports for the recent post-fire Priority Plants research project administered by DPE.

I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields.

I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management.

I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Visiting Fellow

Hawkesbury Institute for the Environment, Western Sydney University, 2019-May 2022

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).
- Member of the Ecological Society of Australia.
- Member of the Australian Network for Plant Conservation.

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated or contributed to nominations for three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honeybee. In late 2021, DPE contracted me to review 347 SAII listed threatened flora species and one population. I delegated some of the work to two subcontractors. That project furthered my knowledge of species that I was already familiar with and included working on many species with which I had no prior experience.

Species / population	Work conducted
Acacia baueri subsp. *aspera*	Requested to assist DAWE with the first ever CAM review of this species. Discovered a mislabelled record that when corrected, generated a new southern limit for the entity, with fieldwork funded by an ET grant to Wingecarribee Shire Council. CAM review recommended to Cwth TSSC that the entity be listed as Critically Endangered. This will likely be mirrored under the NSW BC Act. SAII nomination.
A. bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan.
A. flocktoniae	Member of DPE expert panel required to complete an assessment of the species and to design an SOS project. Appointed to conduct post-fire fieldwork at the Yerranderie population in 2022. SAII nomination. Approved by DPE to prepare an Expert Report for this species (July 2022).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset. Contributed to DAWE CAM review (2021-22)
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan.
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS. SAII review.
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH. Fieldwork and rediscovered of spatially vague record for DPE Priority Plants post-fire project (2021/2).

Species / population	Work conducted
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA, post-wildlife assessment for NPWS/SOS (2020, 2022). SAII nomination based on <3 'locations'.
Callistemon linearifolius	Fieldwork, research, successful nomination as a threatened species, advice to RMS and NPWS, PAS2 review for OEH, recognised as Species Expert in July 2020. Requested by DPE to advise on actions to progress its understanding of the species (March, 2022). SAII review.
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going). SAII review.
Callistemon purpurascens	Co-described and published new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going). Assist DPE with project design to manage risk of dam collapse as a threat to the downstream population. SAII review.
Calotis glandulosa	Fieldwork (new and extended populations, Kosciusko NP), CAM review. Discovered 'invalid' but legitimate population within BioNet Atlas data that represents the only known occurrence in NSW Southern Highlands.
Calotis pubescens	Fieldwork (new population, Kosciusko NP), CAM review
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records. SAII review.
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs. Consulted by DPI Forestry in relation to the conservation of the post-fire Wingello SF population in the context of proposed salvage logging.
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review. SAII review.
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council, OEH, LLS, documentation of previously unknown Wingello population. CAM review.
E. aquatica	Fieldwork, advice to Council and Forestry Corporation. SAII review and detection of significant error in BioNet Atlas data.
E. benthamii	Advice to DPE, CAM review and nomination for upgrade of threat status. SAII nomination based on 3 'locations'.
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel. SAII review. Co-author of a forthcoming paper formally describing and naming this species as *Eucalyptus cryptica* (in prep. July 2022).

Species / population	Work conducted
E. kartzoffiana	Fieldwork, research, expert witness. SAII review.
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH. Review of database records, and GIS analysis of PCT associations to inform a 1750 and current PCT habitat model. SAII nomination.
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review. SAII review.
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination, and advice to NSWSC and to DPE
Gyrostemon thesioides	Successful nomination
Helichrysum calvertianum	Fieldwork, research, nomination, and advice to NSWSC and to DPE
Hibbertia fumana	Research, minor fieldwork, expert witness
H. incana (syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal), post-fire fieldwork for ET grant to Wingecarribee Shire Council and support of DAWE CAM review (recommended as Endangered)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Recognised by OEH as a species expert under BC Act (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan. SAII review.
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset. Post-fire survey of a known habitat for Wingecarribee Shire Council (2021). SAII review.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset. Post-fire survey of a known habitat for Wingecarribee Shire Council (2021).

Species / population	Work conducted
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable, and advice to NSWSC and to DPE
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Recognised by OEH as a Species Expert under BC Act (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan. Monitoring of wild and translocated populations (Londonderry, Agnes Banks) for DPE/SOS (2020).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct. Facilitated RBG/NSW Herbarium post-fire survey at Wingello (2021). SAII review. Assist DPE with CAM review.
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review, recognised as Species Expert in July 2020.
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review, post-wildfire fieldwork for NPWS/SOS (2020) and for ET grant (2021). SAII review. AIS nomination of eastern populations.
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH. Post-fire fieldwork under ET grant to Wingecarribee Shire Council.

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel member, consulted by DPE
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel, consulted by DPE
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DAWE re EPBC Act listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DAWE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DAWE Recovery Plan update, fieldwork and advice to DAWE; advice to OEH
Elderslie Banksia Scrub Forest	Major review for DAWE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DAWE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping (OEH), advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping (WSC/OEH), advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping (WSC/OEH), and advice about revised listing, advice to DAWE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent in WSC LGA), advice to DAWE re new listing
Robertson Basalt Tall Open-forest	Modelling and mapping (WSC/OEH), advice to NSW TSSC and to DAWE
Robertson Rainforest	Modelling and mapping (WSC/OEH) and advice to DAWE
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters dissertation. Published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping. First to map/model the community in WSC LGA at new southern and high-altitude limits
Southern Highlands Shale (Forest &) Woodland	Major contributor to EPBC Act listing (drafting of Listing and Conservation Advice), advice to OEH about revision of NSW listing, modelling and mapping. Contracted by WSC to prepare nomination for upgrade to CE. Assistant in mapping the TEC for BV Map.

Ecological community	Nature of engagement
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils, DAWE and to OEH/NSW TSSC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping (WSC/OEH), advice to OEH and DAWE
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to EPBC Act listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advice
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy*, 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Atkinson, J., Kirkpatrick, J. & Douglas, S.M. 2021. *World Heritage values and the Warragamba Dam*. Report to the Colong Foundation for Wilderness.

Douglas, S.M. 2020. *Environmental Impact Assessment in the Greater Blue Mountains World Heritage Area: a context for assessment and decision-making in relation to proposed flood mitigation works*. Prepared for the Colong Foundation for Wilderness. Submission the NSW Upper House Inquiry into the proposed raising of Warragamba Dam.

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

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Douglas, S.M. 2014. “When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum”. *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. “Black Gum: a threatened tree of upland New South Wales and Victoria.” *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. “Species profile and monitoring of Dampiera fusca”. *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. “Endangered plant discovered” (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. “Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong”. News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. “Phoenix flora: a post-fire discovery in the ACT”. *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. “Phoenix flora” (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. “Mysteries of the Megalong Valley: another rare plant for the Blue Mountains.” *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. “Land of the living dead – tree decline in urban areas”. *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. “Bushland weeds – more on native weeds”. *Environment NSW*, December

Douglas, S.M. 2000. “Regional Parks”. *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. “Community biodiversity surveys”. *National Parks Journal*, 40(3)

Douglas, S.M. 1996. “Mapping our urban bushland”. *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. “Healing the Hawkesbury: start with bushland protection”. *National Parks Journal*. 38(4)

Public media coverage

2021, February 10. “Offsets for Sydney toll road were promised but never delivered.” The Guardian. https://www.theguardian.com/environment/2021/feb/10/its-an-ecological-wasteland-offsets-for-sydney-tollway-were-promised-but-never-delivered

2021, May 7. “Mission to save Sydney’s rarest eucalyptus species from extinction.” Sydney Morning Herald. https://www.smh.com.au/environment/conservation/mission-to-save-sydney-s-rarest-eucalyptus-species-from-extinction-20210505-p57p4h.html

2020, September 18. “NSW government ordered to revisit world heritage assessments for Warragamba Dam expansion”. The Guardian. https://www.theguardian.com/environment/2020/sep/18/nsw-government-ordered-to-revisit-world-heritage-assessments-for-warragamba-dam-expansion

2020, September 14. “Barilaro failed to respond to koala protection concessions from Stokes.” Sydney Morning Herald. https://www.smh.com.au/environment/conservation/barilaro-failed-to-respond-to-koala-protection-concessions-from-stokes-20200913-p55v5n.html

2004, November 6. “Bright flowering spot after fire” - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran

- Supervisor for undergraduate dissertation, “Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve” (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation “Riparian Vegetation of upper Cattai Creek” (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**
- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**
- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report for *Acacia meiantha*

ECOLOGICAL
SURVEYS & PLANNING

Expert Report For

Acacia meiantha

(Barradam-bang Wattle)

Biodiversity Development Assessment Report for the Great Western Highway upgrade (Blackheath to Little Hartley)

Prepared for Biosis on behalf of Transport for NSW July 2022

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Table of Contents

Executive Summary

This Expert Report finds that there is one population of this species in habitat that is comparable with some of the assessment area that would be affected by the proposed roadworks project. That population may be a naturalisation arising from one or more seeds accidentally deposited at a site distant from the others; may be a paleo-climatic relic population; and occurs in habitat that is very different to those that are very likely to be natural occurrences. Irrespective of its origins, the habitat of the Clarence population is sufficiently different from parts of the assessment area that it is unlikely to occur in that area, especially below the escarpment to the west. I conclude that this species would not be likely to naturally occur in the assessment area and that survey effort by Biosis was sufficient to detect it. I conclude that no further assessment such as the calculation of species polygons or biodiversity credits is required for it.

1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Acacia meiantha*, the inability of Biosis’ ecologists to survey the species at the BAM-prescribed time of year is the primary reason for preparing an Expert Report. The BAM requires survey for this species in July to September. Biosis was not able to commence fieldwork until November 2021. The project schedule prevented delaying assessments until July-September of 2022. The proponent opted to use an Expert Report.

The purpose of this Report is to provide an assessment of the status and conservation requirements of *Acacia meiantha* within the proposed work corridors for the upgrade to the Great Western Highway between Blackheath and Little Hartley to determine whether:

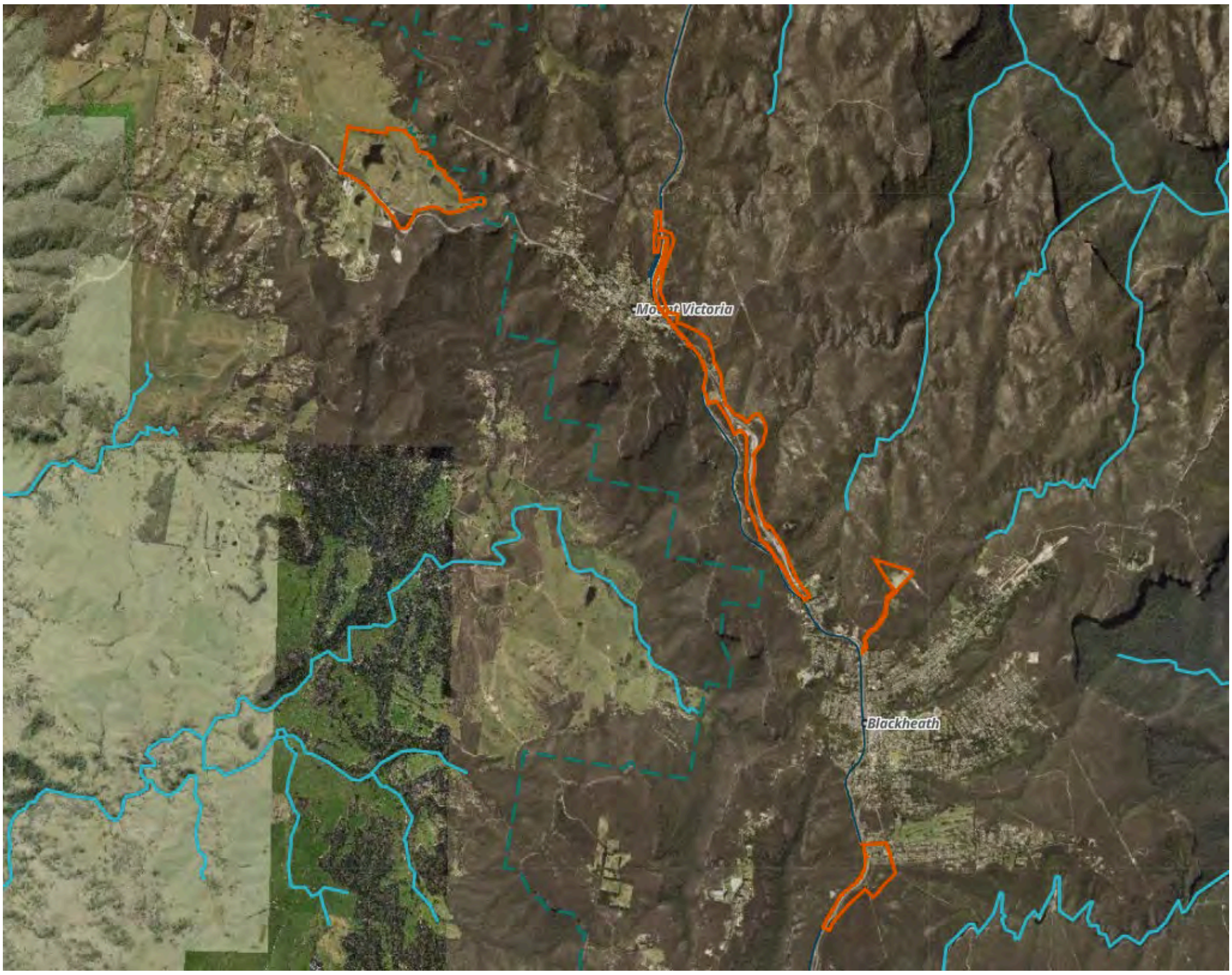
a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within corridors as part of the biocertification process.

1.2 Project context

Transport for NSW (TfNSW) is assessing the ecological impacts of the proposed upgrade to the Great Western Highway between Blackheath and Little Hartley. This includes calculating biodiversity credit (offset) requirements for the proposed clearing of threatened species and their habitat. This Expert Report will assist in determining the extent and quantum of impacts of the proposed works on *Acacia meiantha*.

The proposed upgrades involve construction of twin tunnels (10.4 kms), tunnel portals and ventilation systems, changes to the road to connect it with the new tunnels, and formalisation of the Berghofers Pass car park.

1.3 Study area



Map 1. Assessment areas (orange outline) that are subject to this Expert Report

Description of assessment areas

The assessment areas that are the subject of this Expert Report are parcels of land adjoining or adjacent to the Great Western Highway from the southern fringe of the town of Blackheath to the village of Mount Victoria, then below the Blue Mountains Escarpment into the valley east of the village of Little Hartley (Map 1).

The subject land is within the Wollemi and Burragorang Subregions of the Sydney Basin Bioregion (after SEWPaC, 2021). Terrain is predominantly flat to gently undulating along the Blue Mountains Plateau section, then drops dramatically to the west at the escarpment known as Hassans Walls. The Plateau surface is dominated by Triassic Narrabeen Group sediments, predominantly Banks Wall Sandstone that overlies Permian sediments that outcrop roughly midway down the escarpment face and in deeper valleys within the Plateau. Permian sedimentary strata dominate within the Little Hartley section of the assessment area (as Berry Siltstone), with the much older Bathurst Suite (granite and monzogranite) only evident in the far west of the assessment area. Further information on the region's lithology is provided by Martyn (2018).

Most of the remnant vegetation on the Plateau comprises heathy sclerophyll forest ranging to scrub, heath, and small areas of montane swamp. These habitats are generally common in the nearby Blue Mountains National Park. In stark contrast, within the Little Hartley area, the native vegetation has been extensively cleared and is very poorly conserved in the region due to the terrain being far more arable than that of the Plateau. Within the corridor adjoining the current Highway, weeds are locally common and sometimes severe in the more disturbed roadside and associated drainage situations.

1.4 Justification for the use of an Expert Report

An Expert Report for *Acacia meiantha* is required as part of the threatened biota assessment for the proposed upgrade to the Great Western Highway (Blackheath to Little Hartley) because:

1) Survey effort for this species could not occur during the flowering period specified in OEH (2016) as necessary for compliant surveys.

An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region. I have primarily been self-employed, with a mix of government, private, NGO and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for the then OEH (Native Vegetation Information Science). I am recognised as a ‘threatened species expert’ by DPE EES for numerous flora and TEC. I was approved by the Department of Planning & Environment (DPE) as a Species Expert (limited to this project) for *Acacia meiantha* under s.6.5 of the BAM in July 2022.

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Acacia meiantha*

BAM requirement	Details
Name of expert	Dr Steven Douglas
Expert’s qualifications	BSc (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. MEnvPlan, GSE, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006.
History of experience in ecological research and survey method for the relevant entity	Visited all known occurrences in mid-2022 to familiarise myself with the species and the habitats and circumstances of these occurrences. Communicated with the species’ AO about my observations.
Resumé detailing projects pertaining to the survey of the relevant entity	No species-specific work other than a review of database records, followed by field inspection of known occurrences, supported by discussions with the species’ AO.
Employer’s name and period of employment (if relevant)	Self-employed ecological consultant from 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map; review of mapping/definitional issues relating to TECs).
Relevant peer-reviewed publications	None
Evidence that the person is a well-known authority on the relevant entity	I do not claim to be a well-known authority on this species. However, I am an accredited expert for several other threatened Acacia species and have prepared large and approved Expert Reports for *Acacia bynoeana* and *A. pubescens*, with continuing work on *A. flocktoniae* for DPE.

2. Species information

2.1 Description

“This species is an erect or sometimes straggling shrub to 1.5 m high (sometimes to 2.5 m) with a root suckering habit. It has smooth greenish/brown bark and with straight to slightly curved phyllodes (leaf like structure) 2-5 cm long; 0.4-1.2 mm wide. Mid vein indistinct. Inflorescences 2-19, heads globulose, 4-8 flowered, 3-5mm diameter, yellow to dark yellow. Pods straight or slightly curved, 2-8cm long 4-7mm wide. Plants are able to reproduce clonally through underground suckering, adult plants may comprise of dense clusters of stems arising from the roots of a single parent plant” (DPE, June 2022). *Acacia meiantha* is allied to *A. linifolia* and *A. boormanii* but can be distinguished by its non-weeping upper branchlets and phyllodes lacking a visible midvein (Tindale *et al.* 1992).

Flora of Australia online (Kodela 2018) describes the species as “Erect, erect-spreading or straggling shrub to 2 (–2.5) m high, often multi-stemmed, often with root suckering. Bark smooth. Branchlets angled apically, clothed with short stiff hairs to 0.2 mm long, with prevalent lenticels; phyllode bases persistent. Bipinnate leaves sometimes present. Phyllodes crowded, erect or retrorse, linear, straight to slightly curved, subterete to ± flattened, (1–) 2–5 (–6.5) cm long, 0.4–1.2 mm wide, with curved mucro (0.2–0.5 mm long), glabrous or almost so; midrib obscure; gland not prominent, 0.5–7 mm above the slightly hairy pulvinus. Inflorescences racemose; raceme axes (0.3–) 1.5–3 (–7) cm long, puberulous to glabrous; peduncles 2–4.5 mm long, puberulous to glabrous; heads globular, 4–6 (–8)-flowered, yellow to dark yellow. Flowers 5-merous; calyx membranous, dissected to ¼–⅖ of its length, with broadly deltate lobes and tube slightly hairy. Legumes narrowly oblong, scarcely constricted between seeds, flat, to 8.5 cm long, 4–7 mm wide, firmly chartaceous, light brown, smooth. Seeds longitudinal, black; areole narrowly elliptic-oblong. *Acacia meiantha* is distinguished by a combination of features, including low to medium shrub habit, very narrow, subterete to ± flattened phyllodes, minute hairs on branchlets, and usually 4–6-flowered, yellow to bright yellow heads.”

Acacia meiantha in Mullions Range SF. (from Medd, 2020)

2.2 Ecology

Acacia meiantha is a relatively recently described species (1992) with affinities to *A. boormanii*, with the first herbarium collection of it being initially labelled as *Acacia* aff. *boormanii*. *A. boormanii's* natural distribution is in the far southern ranges of NSW, but it has been widely cultivated and has naturalised in the ACT and to a lesser degree in the NSW Southern Highlands. *A. meiantha* is not widely cultivated and has not been proven to have naturalised, but I believe that this is the origin of the atypical population at Clarence.

A. meiantha has a clonal suckering habit (Medd, 2020: n185), though this is an inference based on field observations, not on genetic analysis. Several other *Acacia* species are known to sucker and produce sometimes very large numbers of clones. The Vulnerable *Acacia pubescens* has been subject to some genetic analysis, with the disjunct population at the locality of Mountain Lagoon occurring over at least 1 ha comprising thousands of stems but being shown to be a single genet (Moore *et al*. 1999).

A. meiantha appears to have received little scientific or conservation attention until after it was listed as Endangered in 2015. Its ecology is not fully documented, and conservation efforts have so far focused on mapping the accessible individuals within the known populations and reducing some of the threats where feasible. Genetic research has not been undertaken to determine how many individuals are present in these populations that appear to comprise numerous suckering stems and clusters (ramets) from far fewer genetic individuals (genets); what the genetic relationship between the populations is; how long they may have been separated (they are sufficiently separate from each other that unless there are undocumented populations present between them, they would be expected to show some genetic differentiation because there can be no natural exchange between them); the genetic relationship between the very small and largely infertile population to the east relative to the western populations; and the genetic diversity (or lack of it) in the eastern population.

The species flowers reliably but seed-set is not currently documented at one of the Central West sites, is known to be relatively good at the other, larger population in that region; and is known to be very poor at the eastern site (NSW Scientific Committee 2015). Post 2019-20 site assessment at the Clarence population by Doug Benson found that the population had regenerated from suckers along shallow roots, with several clonal clusters found over ~50 x 10m, with no evidence of seedlings (Medd pers. comm. July 2022).

"There have been no observations of natural seed germination or recruitment, and knowledge of seed set and seed longevity is lacking. Although flowering profusely, the Clarence subpopulation rarely sets seed (H. Drewe pers. comm. 2020). Has this subpopulation lost the ability to sexually reproduce, or are other environmental factors intervening? In contrast, both the other two subpopulations are fertile, although seed set, seed yield and quality appear to be dependent on seasonal conditions and parasitism (D. Benson and R. Johnstone pers. comm. 2016). Considering that flowering commences in mid-winter (July) and extends through to mid-spring (Oct.) (Kodela 2018; 2020), temporal factors may also be at play with respect to insect pollination; wattles are reputedly opportunistic pollinators, but mechanisms are unknown for this species. Likewise, given the clumping habit and often considerable distances between clusters and colonies, spatial factors are also likely to be involved in determining fertility" (Medd, 2020: 189).

The species does not appear in the outdated but legally current Rural Fire Service Threatened Species Hazard Reduction List (RFS 2013) that prescribes conditions under which fire and/or mechanical management may or may not be used. That list is in the process of being expanded and updated (L Hook DPE, pers. comm. July 2022). The DPE Threatened Biodiversity Data Collection (TBDC) does not show any fire prescription for the species.

The Mullions Range population occurs over a relatively large area of different tenures and land uses. Most records and most plants are within State Forest, some of which is now managed for the species' conservation (Medd. 2020) and others occur amongst long-established pine plantations. The habitat is temperate dry sclerophyll forest with a shrubby to grassy understorey. This population has been subject to substantial survey and there are numerous modern, spatially accurate records within it.

"At Mullions Range it occurs mainly in open eucalypt forest or woodland in association with *Eucalyptus rossii*, *E. mannifera*, *E. dives* and *E. macrorhyncha* as well as *Acacia buxifolia*, *A. dealbata* and *A. gunnii*. Here *A. meiantha* can be found on gravelly clay or brown loamy soil and is generally confined to areas above 860 m a.s.l. where it occurs in clumps due to its suckering habit (Pratten 1986, Tindale *et al*. 1992). It is not found on rocky outcrops (Tindale *et al*. 1992)" (NSW Scientific Committee, 2015). Priday (2017) says that the species does occur in rocky outcrops. The closest PCT association for most occurrences in this population is given as 1093 (pre-SVTM classification) from Medd (2020: 185).

Threats at the Mullions Range site include weed invasion (including form plantation pines), recreational vehicle misuse, further land clearing, pine harvesting and management (can include relatively indiscriminate herbicide use to suppress plants that compete with newly planted pine seedlings) and very likely a suboptimal fire regime. DPE advised that fire has been used for conservation purposes in part of this population, with further use planned when conditions permit (J. Peterie pers. comm. May 2022).

The Carcalgong population is much more spatially confined based on current data, though this is highly likely to be biased by limited access to private tenure adjoining the roadsides in which the species has been relatively well documented. Most records are from the road verges, and the plant can sometimes be seen extending well beyond the verge into private rural land that is mostly naturally vegetated and appears to have little or no livestock grazing (Priday 2017, Douglas pers. obs. 2022). Terrain is relatively steep, and soils are of relatively low fertility, at least along the higher terrain. Land use is mostly 'lifestyle' blocks, not commercial farming. The habitat is like that at Mullions Range, being temperate dry sclerophyll forest with a grassy to shrubby understorey. Whilst the canopy and understorey is different to the main habitat at Mullions Range, Medd (2020: 185) ascribes it to the same pre-SVTM PCT of 1093.

"The Aarons Pass [Carcalgong] population occurs in relatively undisturbed old growth low forest and is the dominant understorey species within the main stand; it shares some similarities with respect to geology and species associations with the Mullions Range population (R. Medd & C. Bower *in litt*. 2013)" (NSW Scientific Committee, 2015). More recent information from Medd (2020) shows that whilst the vegetation type is similar between those populations, the lithology at Carcalgong is very different to that at Mullions Range, being relatively low nutrient sandstone compared to much higher nutrient volcanics.

Threats to the Carcalgong population include road maintenance, road widening for a proposed wind farm (NSW Scientific Committee, 2015), and potentially land clearing for bushfire hazard reduction and for grazing. Priday (2017) noted that roadwork along Aaron's Pass Road has "limited impacts" on the species, but that the associated disturbance may facilitate weed establishment.

During an inspection of this population, it was found that herbicide had been sprayed into a section of roadside vegetation adjoining private land, killing several *A. meiantha*. This was reported to DPE. There was no apparent reason for the herbicide use but it may have been an attempt at weed control. It is possible that a contractor or land owner mistook *A. meiantha* for the declared weed 'broom', though only a very small part of the population was affected.

There is some possibility that the Carcalgong population is a naturalisation from seed accidentally broad to the site (roadsides) from the Mullions Range population via soil on vehicles. Whilst it is much larger in extent and number of suckers and likely number of individuals than the very small site at Clarence, the lithology is very different to that of the far larger (extent and numbers) population at Mullions Range, and this latter site is much closer to Carcalgong than to Clarence. It is conceivable that vehicles involved in roadmaking and road maintenance, or powerline installation, accidentally transported seed in soil stuck to vehicles when moving from Mullions Range to Carcalgong. For this to be feasible, given the extent of the Carcalgong population (and that this is very likely an underestimate of individuals and actual extent given survey constraints) such an introduction may need to have occurred many decades ago. This possibility is entirely speculative but is because *Acacia* seed is very hardy and resilient, can persist in a viable state for many decades or more, that a method of accidental transport is conceivable, and that the largest numbers of plants at Carcalgong are known from the road verges. This latter fact could be purely an artefact of the survey limitations, or it could be a product of seed germinating beside the roads, then a population establishing and progressively moving downslope into less disturbed areas where grazing pressure do not prevent germination and establishment. Only genetic analysis can determine if this potential scenario explains this population.

The Clarence population is in a significantly modified environment, primarily under a high voltage powerline where vegetation is suppressed by trittering. It is very small in extent ($75m^2$), in a different climate, bioregion, and on a different substrate in a different vegetation type than the occurrences further west. It flowers but rarely produces seed (of unknown viability), potentially indicating low genetic diversity as could readily occur in an accidentally established population derived from very little seed. This population may be a naturalisation or a paleo-climatic relic.

"The Clarence population occurs in open eucalypt forest in association with *E. dives* and *E. sieberi* and in an adjacent area of mostly shrubs where the tree overstorey was cleared for power lines; it is found on sandy soil over sandstone at *ca*. 1000 m a.s.l. (Tindale *et al*. 1992)" (NSW Scientific Committee, 2015). More accurately, the Clarence population occurs primarily in derived heathland resulting from vegetation slashing under an aerial powerline. Medd (2020: 185) ascribes the original vegetation community that best matches the habitat of this population as PCT 967. It shares very few species with the sites in the Central West and has completely different canopy species.

Threats to this occurrence include weeds and damage from recreational and other vehicles, and that it is apparently lacking genetic diversity and rarely produces seed (the viability of which is not mentioned in the Final Determination but seems likely to be low or even non-existent). It is conceivable that this population was established from a single or very few seed and that it has expanded mainly or entirely by suckering – something that may have been promoted by disturbances such as the suppression of vegetation under the powerlines.

2.3 Distribution and abundance

In its Final Determination to list the species as Endangered, the NSW Scientific Committee states, "*Acacia meiantha* is endemic to New South Wales. Three disjunct populations occur within the Central Tablelands within 100 km of each other. The Clarence population covers approx. 1 ha between Lithgow and Bell on Crown and Railway Corridor land. This population is on the east of the Great Dividing Range (GDR) in a headwater catchment of the Coxs River (Medd & Bower *in litt*. 2013). The Mullions Range population is west of the GDR, *ca*. 20 km northwest of Orange. A survey of this population has found that it consists of many widely distributed and disjunct stands covering *ca*. 5 ha with no stands known to occur on conservation land (R. Medd & C. Bower *in litt*. 2013). The Aarons Pass population was discovered in October 2011 approx. 18 km northwest of Ilford and is also to the west of the GDR in the Macquarie River catchment. This population is primarily confined to approx. 2.5 km of road easements (R. Medd & C. Bower *in litt*. 2013)."

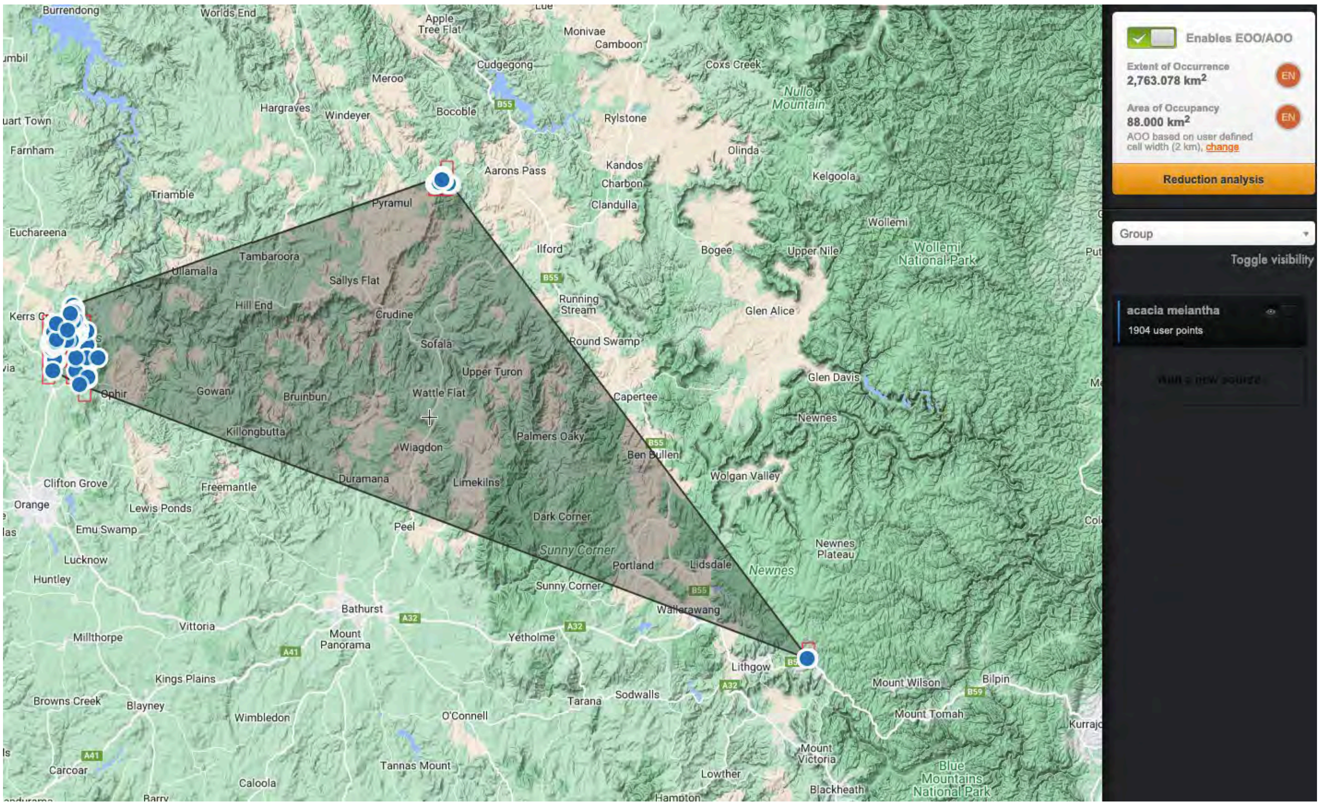
In the updated online species' profile, DPE (June 2022) refer to the 'Aaron's Pass' population as occurring in the locality of Carcalgong. This is a more accurate description and is also used by Medd (2020).

Some database records refer to the Clarence population as occurring at the adjoining locality of Dargan and at the nearby regional centre of Lithgow, as well as the locality of Newnes Junction. Those records relate to one small occurrence but have varying levels of spatial accuracy, and when mapped, give the false impression that the species is more widespread in that area than is the case. A thorough review of those records found that many are spatially inaccurate (some very significantly). Fieldwork by others such as Coote (2016), Eco Logical Australia (2011), Priday (2017), RMS (2018) and a review by Medd (2020) determined that the plant is only known from a far smaller area – a patch that is largely underneath high voltage powerlines above Bells Line of Road and not far from the railway cutting and road. Discussions with the species' AO indicate that this assessment is correct and that DPE only knows of the species at that site where it is subject to some level of conservation management (weed control), though most of the plants remain suppressed by vegetation trimming under the powerlines. Earlier claims that the population occurs over 1 ha are based on the spread of a subset of database records with varying spatial accuracy.

"Of the three populations, the majority (96%) are known to occur in Mullions Range State Forest occurring both within remnant native forest and in plantation forests. Where it occurs at both Carcalgong and Mullions Range State Forest, plants are among the tallest and most common shrub forming dense aggregates" (DPE, June 2022). Population estimates provided in the Final Determination in 2015 are now out-dated and are complicated by the tendency of the species to sucker. Medd (2020) notes that as the species has a clonal, suckering habit, traditional methods used to census individuals are inappropriate. Stems and clusters were used instead, but Medd believed this was "subjectively adapted within and across the various surveys". Stem or cluster counts are given as 390 (Clarence), 1566 (Carcalgong), and 39800 (Mullions Range) (Medd, 2020: 185).

DPE has recently advised that a fourth population has been tentatively identified ~15 km from the rural locality of Hargraves, which is closest to the Carcalgong occurrence and in apparently similar habitat (J. Peterie pers. comm. May 2022). At the time of writing, DPE had not confirmed the new occurrence and was waiting for flowering and fruiting to make a definitive identification. I do not have co-ordinates for this putative new population, so have not included it in a map of the species' known distribution.

During unrelated fieldwork with NPWS Ranger Dave Monahan in northwestern Sydney, the species was tentatively recorded as a small roadside population adjoining and potentially just within the boundary of Yellomundee Regional Park at Hawkesbury Heights. A specimen was taken, and my understanding is that it was identified by the NSW Herbarium as *A. meiantha*. However, subsequent photos from this site suggest that the plant is *A. fimbriata* – a superficially similar species that is widely cultivated and frequently naturalises. At this time, I have not been able to determine why *A. meiantha* was suggested or identified at the earlier time. The record remains in BioNet Atlas as *A. meiantha* but with text noting that it is a naturalisation. It seems much more likely that it is *A. fimbriata*.



Map 1 Amended BioNet Atlas records (July 2022) displayed using the GeoCAT web tool.

Note that the dataset used to generate the above map has only been partially treated to remove known spatial or other errors such as many near the Clarence site, some that plot south of their stated collection location in Mullions Range, and some that are records that appear to relate to incorrect collection locations of what are described as cultivated specimens. Notably, the GeoCAT tool provides an AOO of 88 km^2 versus the figure of 68km^2 provided in the Final Determination from 2015. This reflects the addition of numerous records to the dataset since 2015, with those at the Mullions Range site apparently responsible for most of the increase in AOO. The tool also provides a smaller EOO of 2763km^2 versus 2900km^2 from the Final Determination. This difference is very likely a result of my having removed spatially unsound records from my dataset, whereas it appears that the 2015 calculation used all records that were available at that time. Medd (2020) supported the Committee's calculated EOO but calculated an "actual *in situ* AOO of 19.6km^2 based on the sum of subpopulation polygons.

The Clarence location is clearly very disjunct from the two further to the west and is also in a different Bioregion with different climate, lithology, and Plant Community Type (cf. Medd, 2020). It occupies only 75m2 (Medd 2020 citing data from Priday 2017). The recent tentative natural occurrence from near Hargraves is closest to the Carcalgong site and would extend the species' distribution to the north. It seems highly likely that the species also occurs at other yet to be found locations because it has not been subject to targeted survey across potential habitat and because most of the potential habitat is not within public lands, making access potentially more difficult or even prohibitive. Whilst some species are genuinely rare and have quite disjunct, seemingly remnant occurrences (some *Pomaderris* are acute examples of this), I have not seen or read anything in the context of *A. meiantha* that suggests its distribution is as uncommon and disjunct as current records suggest. It has very likely experienced significant loss of individuals and populations, and significant fragmentation of potential habitat due to land clearing and pastoralism, but I believe that more occurrences will be found if sufficient access is made available to private land in suitable habitat.

The species' known authentic habitat is not so rare or specialised as would suggest that it is as ultraendemic as its current distribution suggests. It is also able to reproduce from seed and regenerate from root suckers and has persisted in some less than favourable situations where it has not been managed for conservation for many decades. It does not appear to be suffering from population decline due to genetic problems, and it can apparently naturalise to some degree.

The species was listed as threatened in 2015 and has been subject to some targeted survey but only within or adjoining known locations, rather than in potential habitat removed from known occurrences. In my experience, it seems very likely that at least several yet unknown populations will be found.

A particularly acute example of a species being considered very rare and range-restricted when listed as threatened, and subsequently being found to be more common and much more widespread is *Callistemon linearifolius*. It was listed as threatened in 1998 when it was believed endemic to metropolitan Sydney and the nearby southern Central Coast region. It has since been found much further to the north (Grafton), further south (Kangaroo Valley), and further west (Yerranderie) as well as at considerably higher altitude (Balmoral, Southern Highlands). Species tend to receive more attention in general once they are listed as threatened, though the level of attention from ecologists can depend very much on where the species occurs (or could occur) and the level of general survey effort in that area. *C. linearifolius* has not been subject to targeted survey funded by DPE, even within metropolitan Sydney. Most discoveries (some supported by specimens) well outside its previously accepted range, and sometimes in substantial populations, occurred because of surveys for various development assessments in coastal and hinterland regions where various pressures for land clearing are relatively high. The situation is somewhat different for *A. meiantha* in that it is currently known from only two confirmed legitimate occurrences and one apparent naturalisation in very different habitat, and development assessment in and near the more western populations is likely to be relatively low. It is much less likely that *A. meiantha* will be discovered at new locations through non-targeted surveys as part of various impact assessments. Consequently, targeted survey in potential habitat for conservation purposes is likely to be more important in documenting new occurrences.

An alternative scenario is that A. meiantha is an old species that has been experiencing long-term natural decline in AOO and EOO and genetic diversity due to natural climate change and geological factors. This could mean that it is restricted to relic populations that are fragmented.

2.3.1 Reservation status

At the time of writing, there were no known occurrences of *A. meiantha* from formal conservation estate e.g., NPWS-reserves.

Some of the Mullions Range population north of Orange is within land managed by Forestry Corporation, and a portion of this is within an area managed for conservation but not formally set aside as a Flora Reserve. Medd (2020: 190) states that the Mullions Range Flora Preserve does contain the species but that this classification "has no legal status from a conservation standpoint and no formal management plan for the Preserve exists".

The Clarence population is within Dargans Creek Crown Land Reserve, but it is "in a precarious and disturbed environment". Crown lands, even Crown Reserves are rarely subject to conservation management unless there is intervention from the local government Council and/or from NSW Department of Planning & Environment. Crown Reserves have minimal legal standing and usually no internal resources for their management.

2.4 Habitat

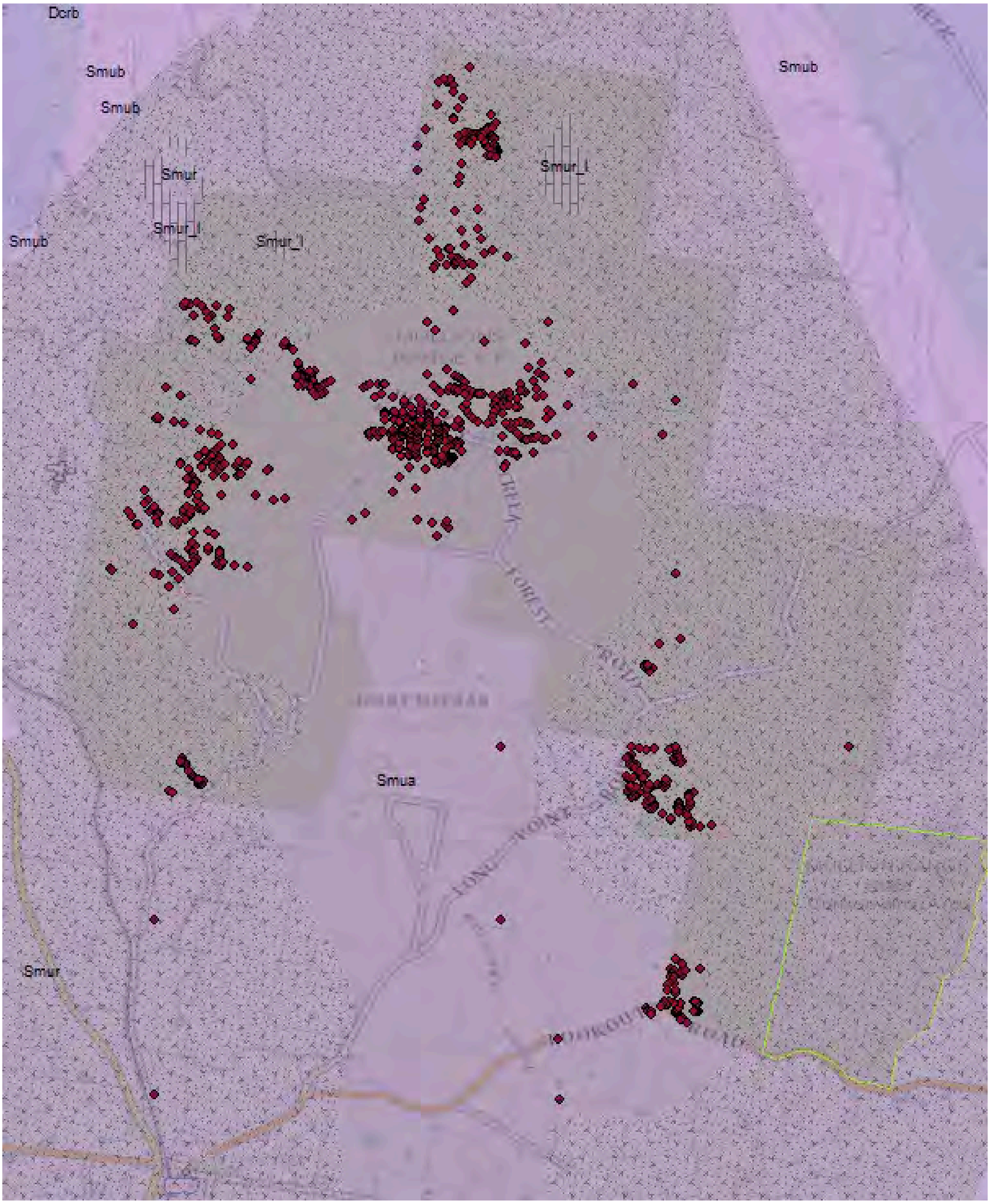
The species has two broad habitats based on currently known locations: Tablelands dry sclerophyll forest west of the Blue Mountains; and an outlying eastern habitat that is largely in a derived heathland (originally heathy low open forest) on Narrabeen Group sandstone. As noted elsewhere in this report, I do not consider the eastern outlying occurrence to be natural as this habitat is very different to those further west; the population at this site is small in area and appears to be very small in the number of genetic individuals; and the site is significantly disturbed by a mix of infrastructure including a high voltage powerline easement, the adjoining Bells Line of Road and adjoining railway plus associated access roads for these features and for the nearby Dargan Dam. Medd (2020) provides more information on the habitats at each of the known occurrences.

2.4.1 Geology and soil

The Mullions Range population maps on two lithogies: a) the Anson Formation of the Mumbul Group which is described as "Carbonaceous pyritic siltstone, felsic volcanics, volcanic sandstone, limestone" and on b) the Mullions Range Volcanics comprising "Rhyolite, tuffaceous mudstone, rhyolite breccia, volcanic conglomerate, dacite, limestone" (Colquhoun *et al*., 2022). Medd (2020) says that the Mullion Creek population is limited to the the Mullion Range Volcanics and is predominantly on the Mookerawa Soil Landscape of red podzolic sandy loan, and not present on the Mullion Creek (alluvial) or Burrendong Soil Landscapes.

The Carcalgong population maps on Permian strata of polymictic fine to coarse-grained conglomerate of the Shoalhaven Group as a very outlying occurrence of Sydney Basin lithology. It overlies the much older Turondale Formation of the Crudine Group and is described as "Thick-bedded, crystal-lithic, rhyolitic to rhyodacitic volcaniclastic sandstone interbedded with lesser thin-bedded, pelagic and volcaniclastic sandstone, siltstone and phyllitic shale. Minor rhyolitic tuff and conglomerate" (Colquhoun *et al*., 2022). Three outlying roadside records to the east of the main group of records may occur on the Cookman Formation of the Crudine Group which is described as "Cream to dark grey, interbedded fine- to medium-grained quartz rich sandstone, siltstone, laminated shale and minor dark to black cherty tuff" (Colquhoun *et al*., 2022).

The Clarence population maps on Triassic Narrabeen Group Banks Wall Sandstone (Colquhoun *et al*., 2022), which is a quartz rich chert sandstone producing sandy clayey soil. The spatially accurate records of this population all plot on the Wollangambe Soil Landscape which is a diverse group of related soils ranging from shallow siliceous sands to moderately deep earthy sands, yellow earths, and red earths to moderately deep yellow podzolics and gleyed podzolics (King, 1993).



Map 2. The Mullions Range records plotted over a base map and the seamless geology layer (Rock Units – colours – LAO and Rock Units – patterns – LAO). The patterned area shows the Mullions Range Volcanics. The unpatterned area shows the Anson Formation.

2.4.2. Associated vegetation communities and NSW and Commonwealth TECs

The TBDC records 16 Plant Community Types (PCTs) as being associated with BioNet Atlas records of this species at an unspecified time. Whilst useful at a coarse scale, the process of associating records of the species with PCTs is undermined by problems such as potential inclusion of planted or naturalised occurrences; spatially inaccurate records; and the coarse spatial resolution and variable quality of most PCT maps. Further complicating output from the TBDC is that at the time of use (20th July 2022), the new PCT (SVTM) classification and the earlier classification were used but the system does not explain their relationships. This information had to be sourced separately. The 16 associated PCTs includes two disparate classifications, with 5 legacy PCTs and 11 new SVTM PCTs. Some of these are duplicated.

The BioNet list of associated PCTs is shown below. Three-digit PCTs and some four-digit PCTs are legacy units and are coloured blue. Those shaded yellow are classified as 'in progress'. Four-digit PCTs are those used in the SVTM but not used in the BDAR with which this Expert Report is associated. Where the association between old and new PCTs is not simple, I have inferred the relevant association from the PCT Lineage Export.

PCT	PCT Name	Assessment of relevance
322	Inland Scribbly Gum - Red Stringybark - Black Cypress Pine hillslope shrub-tussock grass open forest on mainly sandstone ranges in the NSW central western slopes	Seemingly unlikely. *Callitris* wasn't present at sites that I visited but may be present at locations that I did not see in Mullions Range. Not in assessment area.
324	Inland Scribbly Gum grassy open forest on hills in the Mudgee Region, NSW central western slopes	Does not align well with sites that I visited. Not in assessment area.
345	Red Box - Tumbledown Gum - Red Stringybark - Long-leaved Box dry woodland, upper NSW South Western Slopes Bioregion	Association seems unsound given this PCT is described from the SW Slopes, when the species is only known from the Central Tablelands. Not in the assessment area.
351	Brittle Gum - Broad-leaved Peppermint - Red Stringybark open forest in the north-western part (Yass to Orange) of the South Eastern Highlands Bioregion	Credible but not in assessment area.
727	Broad-leaved Peppermint - Brittle Gum - Red Stringybark dry open forest on the South Eastern Highlands Bioregion	Credible but not in assessment area.
649 / 3734	Central Tableland Dry Slopes Stringybark-Box Forest	Credible but not in assessment area.
649 / 3370	Central Tableland Red Stringybark Grassy Forest	Credible but not in assessment area.
345 / 3534	Central West Stony Hills Stringybark-Box Forest	Credible but not in assessment area.
657 / 3945	Newnes Plateau Shrub Swamp	An unsound association caused by spatial errors in records at the Clarence site.
1248 /3688	Newnes Plateau Silvertop Ash Woodland	Credible at Clarence but not present in assessment area. Appears to be analogous to PCT 967 in the old scheme.
1093 / 3747	Red Stringybark - Brittle Gum - Inland Scribbly Gum dry open forest of the tablelands, South Eastern Highlands Bioregion	Credible but not present in assessment area. Duplicated, at least in part, as new PCT 3747 below.
1093 / 3747	Southern Tableland Western Hills Scribbly Gum Forest	Seems highly unlikely as the species does not occur in or near the Southern Tablelands. Not in the assessment area.
NA / 3691	Upper Blue Mountains Fringing Swamp Woodland	An unsound association caused by spatial errors in records at the Clarence site.
816 / 3863	Upper Blue Mountains Mallee Heath	An unsound association caused by spatial errors in records at the Clarence site.
1248, 1249 / 3694	Upper Blue Mountains Ridgetop Woodland.	Credible at Clarence. 3694 incorporates two former and similar PCTs. 1248 but not present in assessment area.
765 / 3954	Western Central Tableland Upland Swamp	This PCT is known from Mullions Range and is likely associated with the species based on spatially unsound records and/or coarse PCT mapping. It is highly unlikely habitat for the species. Not present in assessment area.

Medd (2020) places the Clarence population in Newnes Plateau Woodland of Benson & Keith (1990) which is closest to PCT 967 (pre-SVTM). The two western populations are sensibly associated with the old PCT 1093 as the closest match to the vegetation community, even though there are distinct differences between the communities within those populations.

None of the known occurrences of the species, including Clarence, are within Threatened Ecological Communities listed under NSW or Commonwealth laws. PCTs listed above that are associated with TECs such as Newnes Plateau Shrub Swamps and Temperate Highland Peat Swamps on Sandstone / Montane Peatlands & Swamps are incorrect associations due to spatial errors in records of the species, and relatively coarse mapping.

Distribution of PCTs associated with Acacia meiantha in the assessment areas

An empirically sound habitat model such as a Species Distribution Model used under the EPBC Act cannot be developed for this species because there are too few populations and because the species has not been subject to adequate targeted survey in potential habitat across its known and likely distribution.

In the context of this Report, the most important element of PCTs that are credibly associated with this species is that only one common and widespread PCT (1248) is present in the assessment area. The association of the subject species with this PCT is relatively weak and relates only to the Clarence population. That population is better associated with PCT 967, but BioNet generates an association with 1248 – potentially and very likely because of spatially unsound records. Additionally, PCT 1248 is very widespread, common and well conserved, suggesting that if the subject species was genuinely associated with it, there should be more than one occurrence of the species in this PCT. I do not consider the BioNet association between the species and PCT 1248 to be sound. Most occurrences of the species are in a different bioregion, on different lithologies, and in different PCTs to those present in the assessment area. Of the SVTM PCTs sensibly associated with the species at the Clarence population (3688 and 3694), only 3694 could occur in the assessment area, and is mapped by Biosis as present in the form of PCT 1248. PCT 3688 is specific to the Newnes Plateau, which is well to the north of the assessment area. Of the pre-SVTM PCTs, only 967 is relevant to the Clarence population, and this PCT is not mapped by Biosis in or adjoining the assessment area.

2.4.3 Habitat condition

Degraded and significantly modified areas of the sensibly associated PCTs can still be habitat for this species due to its likely ability to tolerate significant degradation. It can persist in ‘cleared’ site as a soil-stored seedbank, and because of its ability to sucker. It has persisted amongst pine plantations and despite significant threats in Mullions Range State Forest. Such modified sites may have reduced or no indigenous canopy and/or midstorey, and/or reduced understorey and significant weed invasion. The most modified sites may not even be mapped as native vegetation, yet the species could persist or naturally regenerate under those conditions.

3. Description of the study area

3.1 Landscape context and land use history

The subject land is predominantly flat to gently undulating along the Blue Mountains Plateau section, then drops dramatically to the west at the escarpment. Much of the plateau is non-arable and the dominant land use is Nature conservation with a relatively small portion under housing and ancillary uses such as transport and tourism.

Below the plateau, land is generally much more arable and is heavily cleared, with pastoralism the dominant land use. Terrain is steep at the escarpment, grading to rolling further to the west. The section of the assessment area that is below the plateau is mostly devoid of native woody cover and has been cleared for livestock grazing and for construction of associated dams.

3.2 Geology and remnant vegetation

The assessment area is dominated by Narrabeen Group sandstone on the Blue Mountains Plateau and the top of the escarpment. Most of this area is naturally vegetated or partially vegetated. The natural vegetation is primarily dry sclerophyll forest ranging to scrub, heath, and montane swamps. Wet sclerophyll forest occurs in topographically sheltered sites such as along watercourses.

Below the escarpment, the lithology is Permian Berry Siltstone, which is much more arable than much of the Plateau, so is extensively cleared for pastoralism. The native vegetation would have been dry to wet sclerophyll forest with a more shrubby to grassy understorey relative to the much more heathy understorey on the plateau.

3.2.1 Plant Community Types with the assessment areas

Table 4. PCTs mapped as present with the assessment areas (including areas proximate to but not in the proposed zone of clearing or other degradation)

PCT	PCT Name	Distribution & notes
708	Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains	Not known or likely habitat for the subject species. Not a TEC where it occurs in the assessment area. 1.8 ha proposed for clearing, mostly in High condition, balance in Moderate.
766	*Carex* sedgeland of the slopes and tablelands	Not suitable habitat for the subject species. Treated as a TEC component in at least some situations. Common in moist pasture. 0.4 ha in Low condition proposed for clearing.
1078	Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion.	Not suitable habitat for the subject species. No proposed clearing. Treated as a TEC component in at least some situations.
1248	Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains	Potential habitat for the subject species based on the association with the Clarence population. This PCT also has similarities to PCT 967 in which the species occurs at Clarence. Roughly 6 ha proposed for clearing (mostly High condition). Very common, widespread and well conserved.
1256	Tableland swamp meadow on impeded drainage sites of the western Sydney Basin Bioregion and South Eastern Highlands Bioregion	Not suitable habitat for the subject species. No proposed clearing. Treated as a TEC component in at least some situations.
1615	Monkey Gum - *Eucalyptus blaxlandii* shrubby open forest on basalt of the Sydney Basin.	Not known or likely habitat for the subject species. Very small areas of Low and Moderate condition proposed for clearing. Part of a TEC (Blue Mountains Basalt Forest and Upland Basalt Eucalypt Forest under BC and EPBC Acts) when all other specifications are met. Very small are of Low and Moderate condition proposed for clearing. Those sites are not within any TEC.
1740	Tall Spike Rush freshwater wetland	Not suitable habitat for the subject species. No proposed clearing.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principal source of threatened flora records in NSW is the DPE BioNet Atlas database, which includes most records held by the NSW Herbarium (specimen-based), as well as unvouchered sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used significantly in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet Atlas are original – most are simply replicates based on multiple specimens held in various herbaria.

BioNet Atlas data should only be treated as indicative. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate. Furthermore, not all observations are provided to BioNet Atlas.

The three known occurrences of *A. meiantha* have been surveyed by Priday (2017), and some have been subject to later checked by DPE staff or contractors. Medd (2020: 184) states that the species has been surveyed in part in "environmental assessment surveys…for infrastructure developments at Clarence and Carcalgong, and plantation forestry operations at Mullion Creek". These include Coote (2016) at Clarence, Eco Logical Australia (2011) at Dargans Creek Crown Land Reserve, and Roads & Maritime Services (2018) at Clarence. The Carcalgong population was found by Medd in 2011 and surveyed by Priday (2017) and then a partial survey of that site by Eco Logical Australia (2019) in relation to roadworks. At the Mullions Range/Creek site, the earliest collections were in 1936 and 1959. "Priday (2017) surveyed most of the 2,300 ha of remnant native forest during flowering in September 2017, with about 30 km of foot transects, and an additional 50 km of forest fire trails by vehicle recording occurrences within 50-70 m of the transects. Priority was given to surveying remnant parts lacking historical records. Plant associations and assemblages recorded along transects, combined with existing data for the State Forest and nearby Mullion Range State Conservation Area, enabled the derivation of an 'expert' classification of vegetation assemblages for the area to identify habitat preferences" (Medd 2020). Porteners (2000) undertook a vegetation survey that included Mullion Range State Conservation Area but did not find the species in that reserve, and there are no other records of it in that area.

"Surveys of silviculture areas of Mullions Range SF in the latter half of 2016 aimed to establish the extent of *Acacia meiantha* within the accredited timber plantation zone. Certain plantation areas were excluded from survey, based on preliminary inspections, in order to focus on areas most likely to support the species, and to this end the plantation zone was classified into two broad 'priority' areas for survey (Anon. 2016). Priority 'one' compartments involved areas of mature standing forests scheduled for harvest, and priority 'two' compartments encompassed compartments recently harvested and/or re-established as second rotation plantings, excluding areas that had been subjected to blanket herbicide applications in preparation for replanting. To accommodate harvesting schedules, surveys of priority one areas could be undertaken at any time of the year along parallel transects at 80 m intervals. In priority two areas surveying was restricted to the flowering period of July to October along parallel transects 50 m apart. Data capture included geo-referencing and the number of Acacia meiantha plants observed for each sighting, along with elevation, landform, geology, slope, aspect and soil type for independent transects (Anon. 2016)" (Medd 2020).

Numerous modern sighting records exist in BioNet Atlas because of those relatively recent surveys. However, surveys on private land associated with the two western populations are very limited, and it is known the species occurs beyond where it is currently mapped at Carcalgong. There are also a range of older herbarium collections, especially from the Clarence population which is where the species was first collected in 1975. Many herbarium records are spatially inaccurate, partly because GPS was not available at those times, but also because there was a long-standing tendency of collectors to either not supply co-ordinates or detailed location data, or to supply only very rough estimates of the collection location.

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods, and findings relating to the species across the study area. DPE does not hold a registry of surveys in which a species was surveyed by second or third parties, whether detected or not. In general, DPE staff would only be aware of their managed species being detected if this was in surveys that they commissioned or as part of an ecological assessment that they are required to review, or if they check BioNet Atlas for new records.

The species was not detected by Biosis during fieldwork in the assessment area in 2021 and 2022.

4.1.1 Existing records in the assessment area

No database records of the species are known from within or near to the assessment area as of mid-2022. Only one record occurs in the wider vicinity (Clarence). It occurs in a modified condition state of PCT 967, which is not present in the assessment area or environs. BioNet also associated at least one of the database records of the species with PCT 1248, which is present in the assessment area, but I consider that association potentially unsound and likely to be a result of a spatially unsound record (of which there are many at the Clarence site) and/or coarse or inaccurate PCT mapping.

4.2 Summary of survey work undertaken for the BDAR

4.2.1 Vegetation mapping

Biosis has mapped PCTs in the area proposed for clearing as shown below. At this time, the pre-SVTM PCTs are still required to be used within the Biodiversity Offset Scheme.

Plant Community Type	**Condition class**	**Area (ha)**
UNE (Urban Native/Exotic)	<Null>	11.01784
708	High	1.294575
708	Moderate	0.496758
766	Low	0.432809
1248	High	6.142838
1248	Low	0.33048
1248	Moderate	0.860616
1615	Low	0.013094
1615	Moderate	0.179315

The following PCT maps also show PCTs in the assessment area. The clearing area or Development Footprint is shown in yellow hatching. Blue hatching designates water bodies (mostly farm dams). BAM plot locations are shown as red squares, with the tail of the square being the orientation of the associated transect (30m extension beyond the 20 x 20 m plot). Condition classes are shown in the map keys. Maps are from north to south: Kanimbla Valley section, then moving south along the highway to the southern fringe of Blackheath.

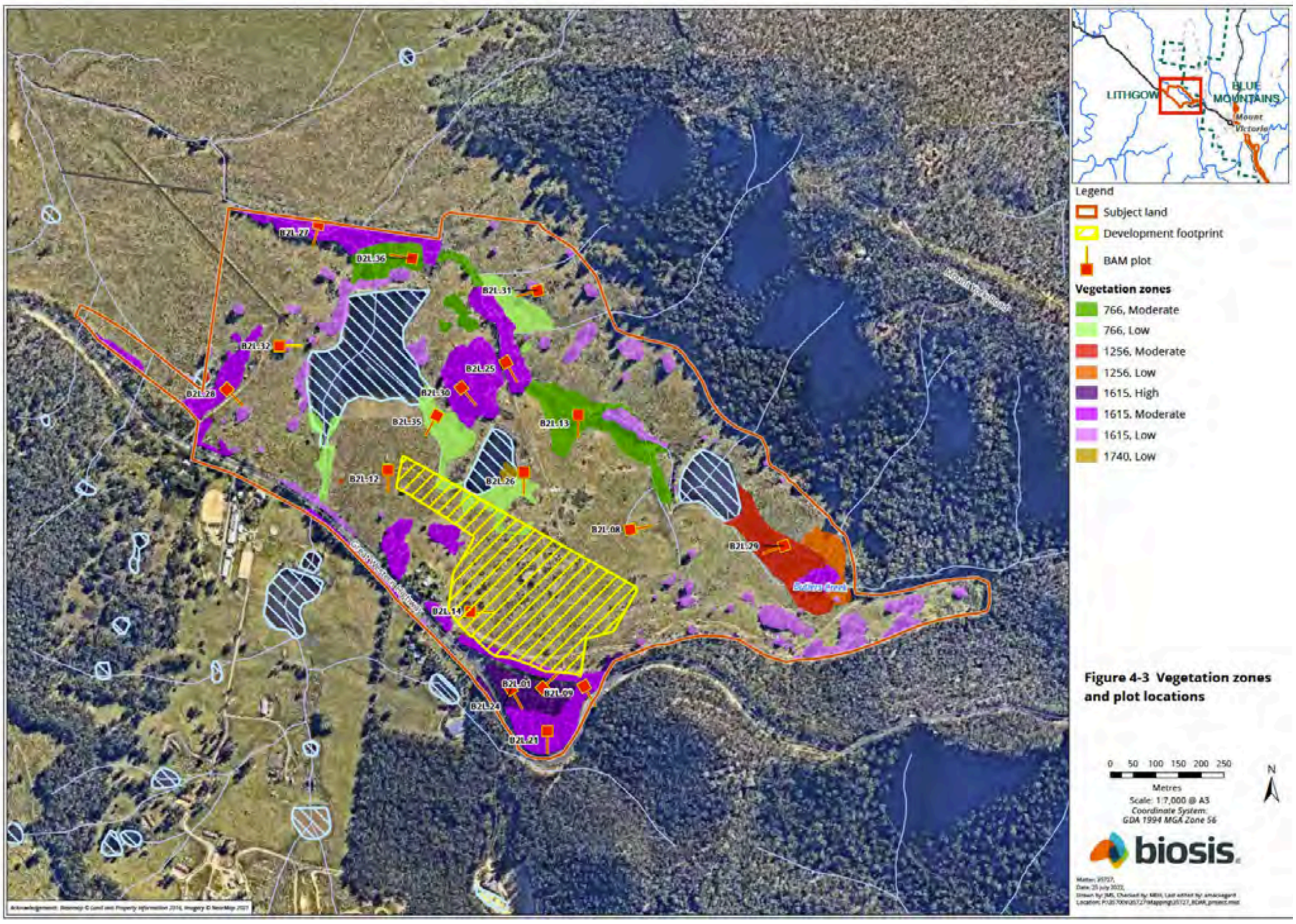


Figure 4-3 Vegetation zones and plot locations

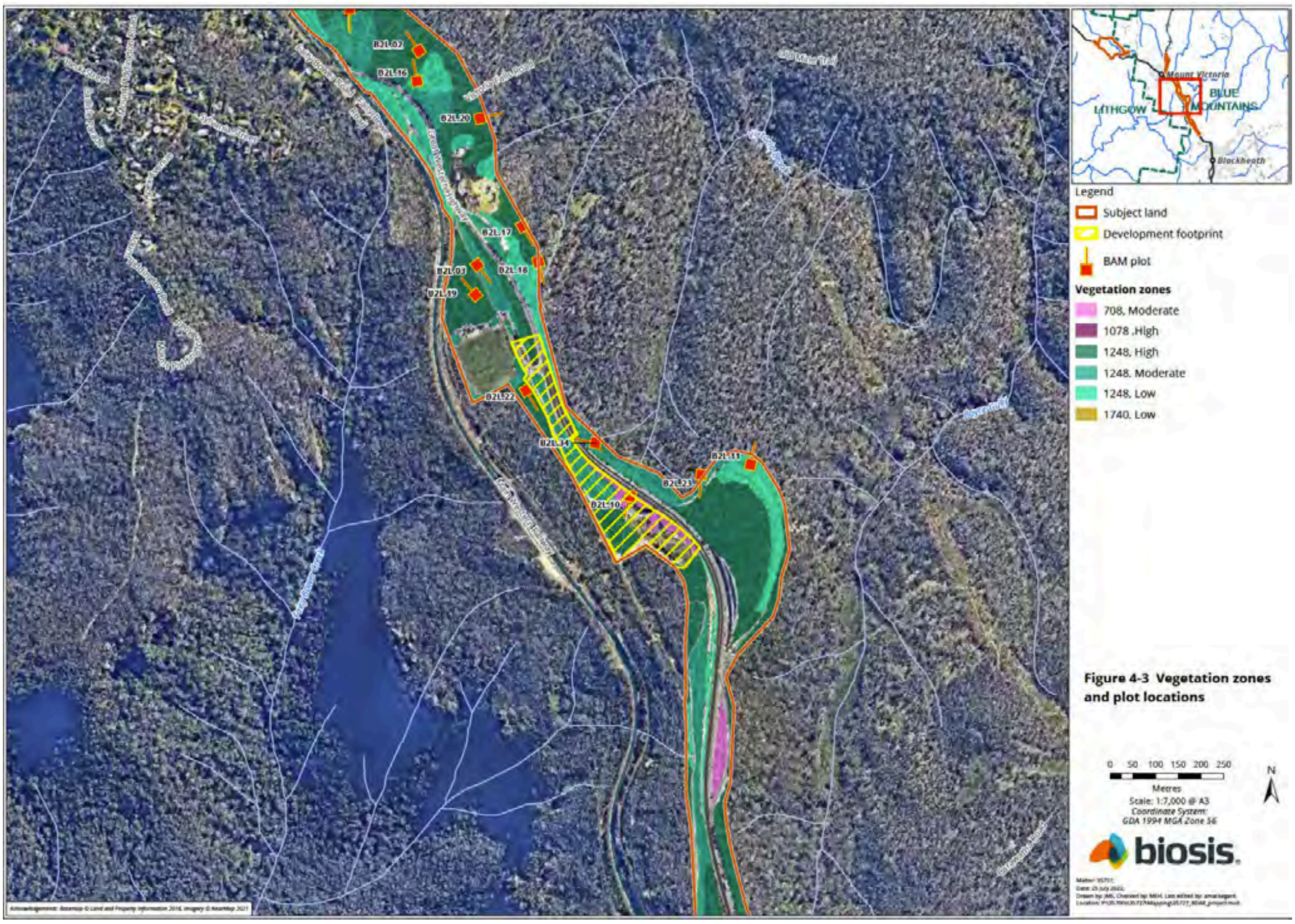
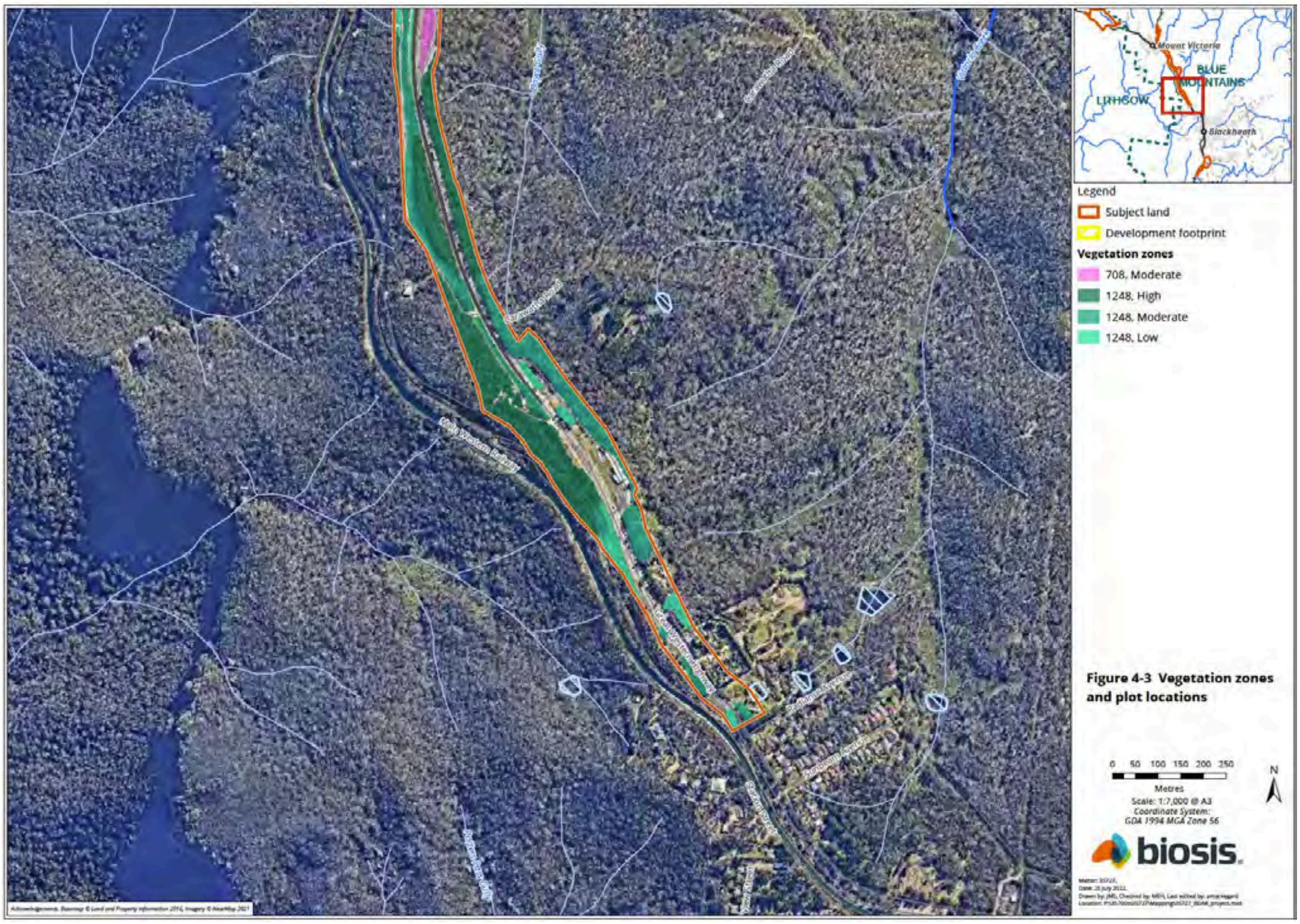
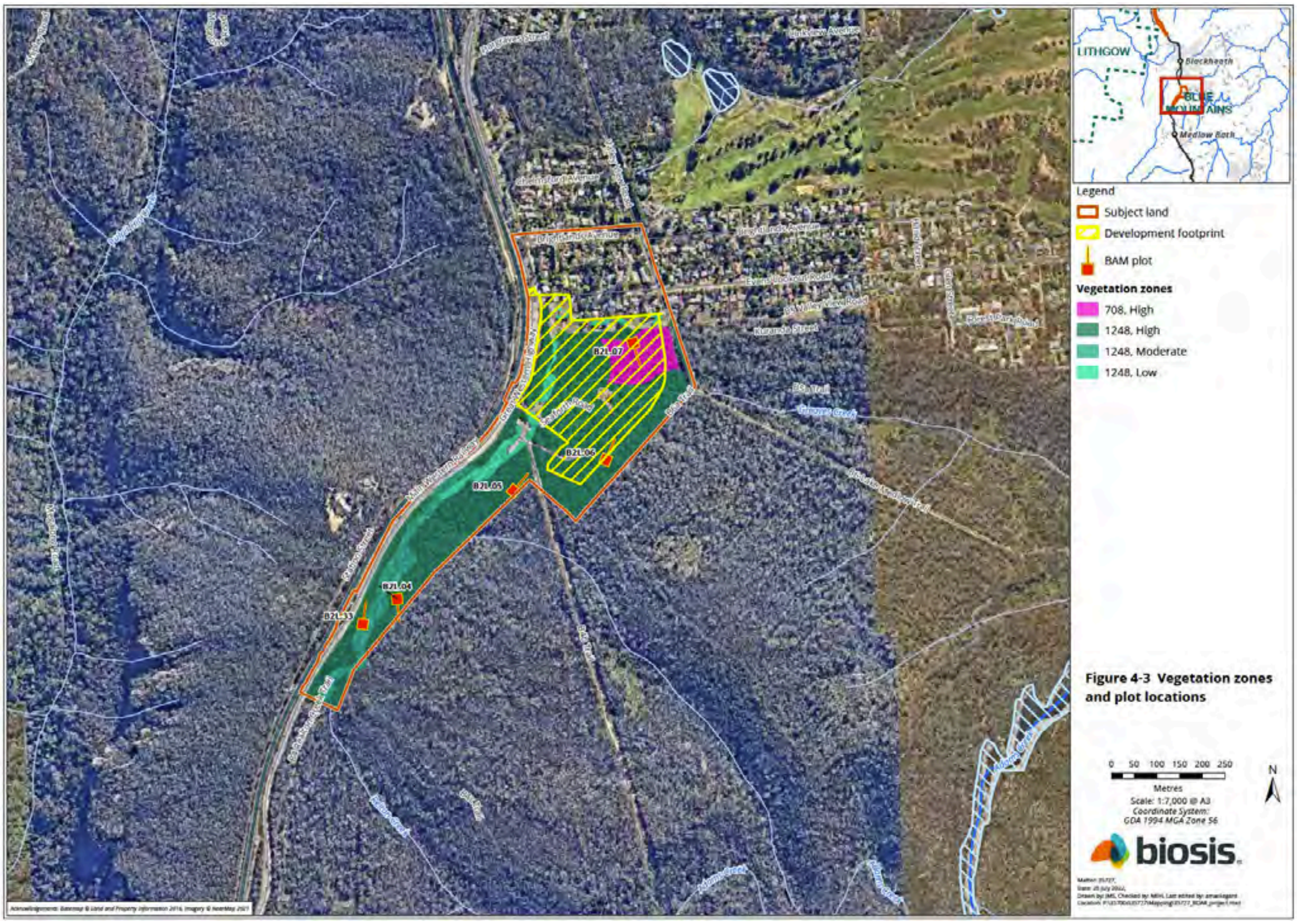


Figure 4-3 Vegetation zones and plot locations



Mount Victoria
BLUE MOUNTAINS
LITHGOW
Blackheath
Legend
Subject land
Development footprint
Vegetation zones
708, Moderate
1248, High
1248, Moderate
1248, Low
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System:
GDA 1994 MGA Zone 56
N
biosis.



LITHGOW
Blackheath
BLUE MOUNTAINS
Medlow Bath
Legend
Subject land
Development footprint
BAM plot
Vegetation zones
708, High
1248, High
1248, Moderate
1248, Low
BZL 07
BZL 06
BZL 05
BZL 04
Figure 4-3 Vegetation zones and plot locations
0 50 100 150 200 250
Metres
Scale: 1:7,000 @ A3
Coordinate System:
GDA 1994 MGA Zone 56
N
biosis.

4.2.2 Field survey effort

Biosis has undertaken substantial ecological field survey within the assessment area as shown in the maps below. Maps are from north to south: Kanimbla Valley section, then moving south along the highway to the southern fringe of Blackheath. This included targeted transects for threatened species (parallel traverses of 5-10m width by two experienced botanists), BAM vegetation plots (for PCT typing and condition assessment), and fauna surveys. Its botanists were asked to look for *A. meiantha* but were not able to survey it during the BAM-prescribed flowering period. Notably, the TBDC says that the species can be surveyed at any time of year, but then notes that it flowers prolifically from July to October (during which time it is more readily detected). Biosis' vegetation surveys occurred primarily from November 2021 to January 2022, with some survey plots recorded up to May 2022.

Whilst I do not believe the species would have occurred in the assessment area, at least in modern times, I also believe that Biosis' survey effort is reasonable as a means of ruling out any extremely unlikely and potentially unnatural occurrences in that area. Whilst it is preferable that any surveys for this species occur when it is flowering, simply because this increases the prospects of detection and of correct identification, I do not consider flowering to be essential for detection of the species.

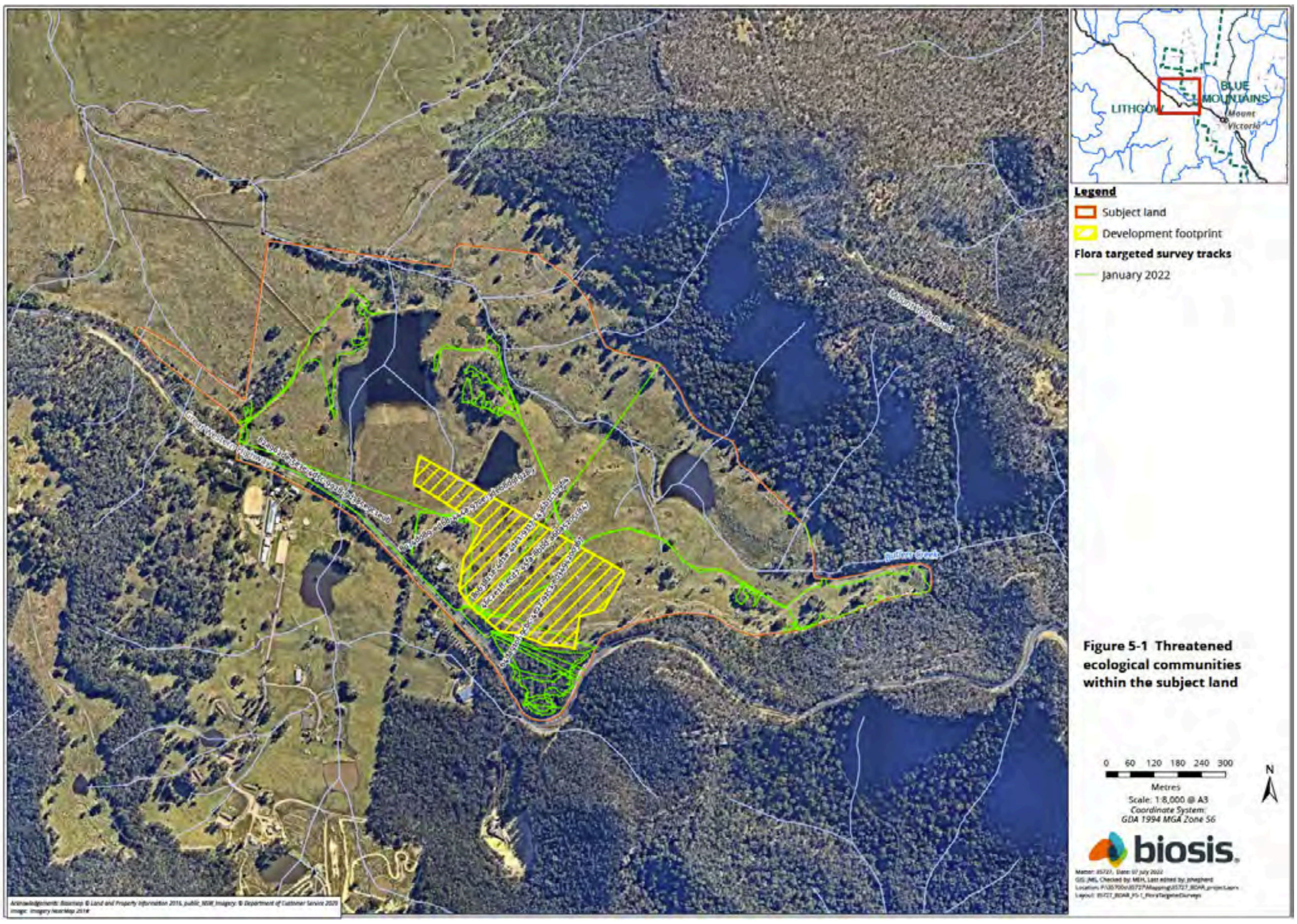
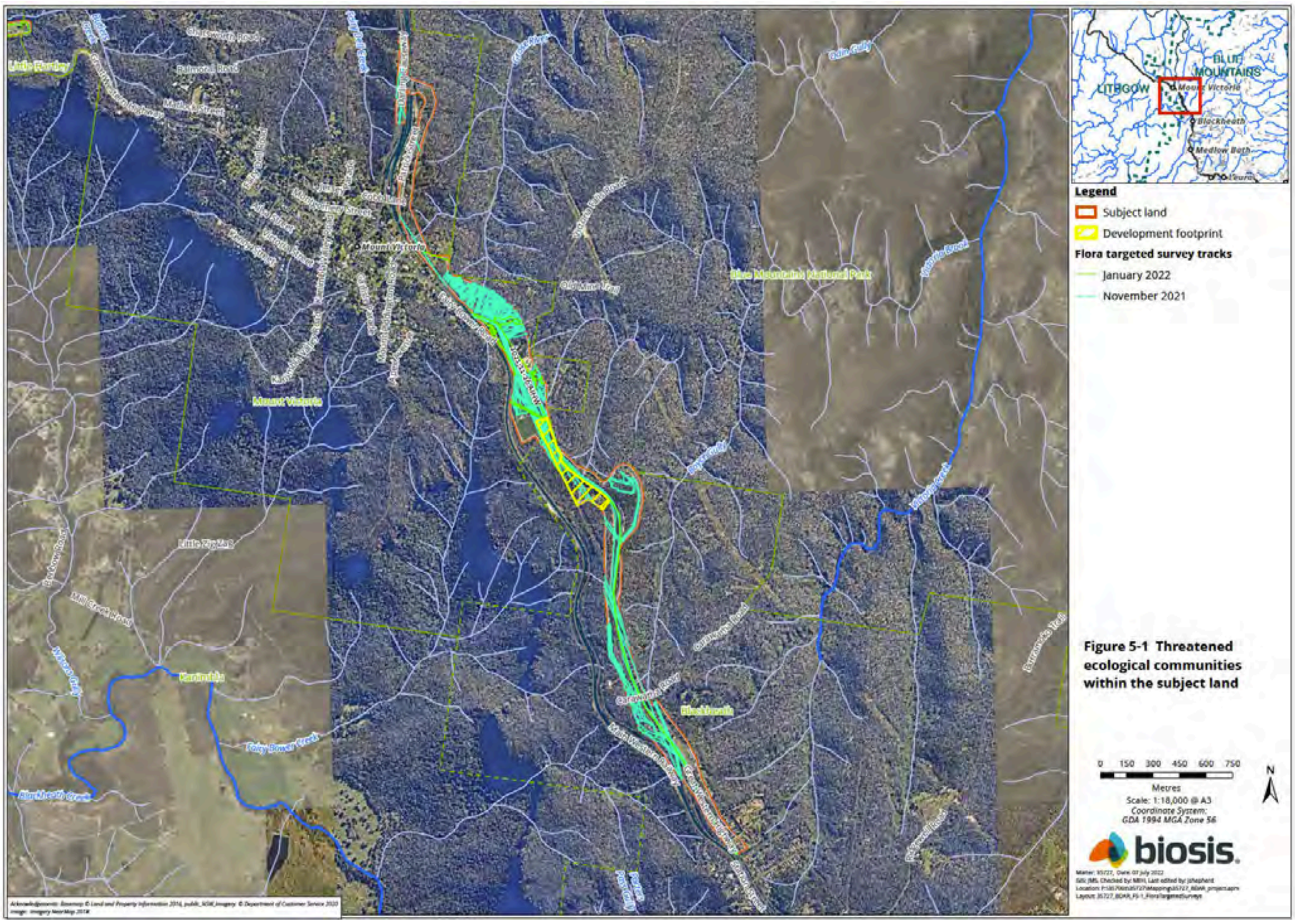
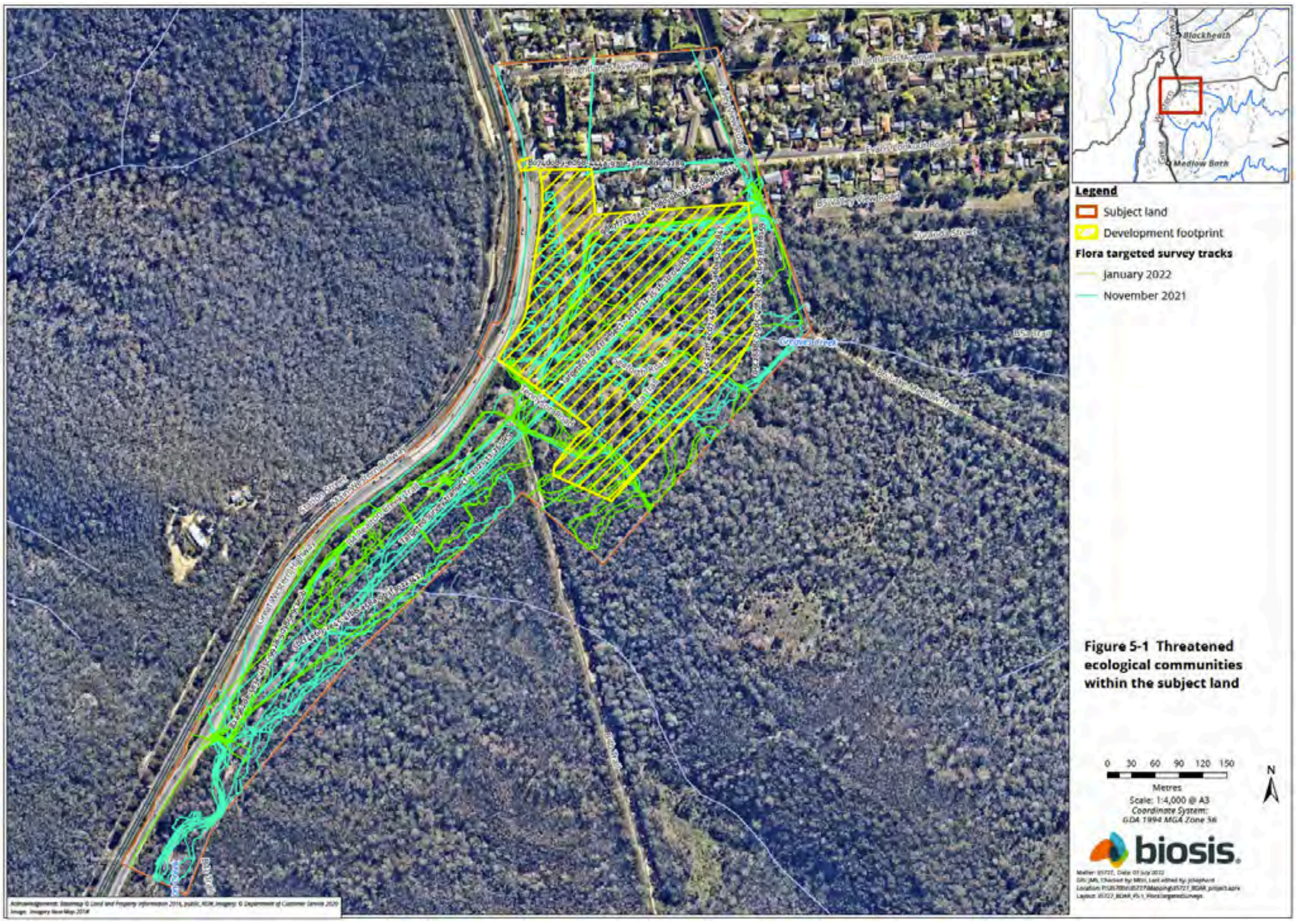


Figure 5-1 Threatened ecological communities within the subject land



Legend
Subject land
Development footprint
Flora targeted survey tracks
January 2022
November 2021
Figure 5-1 Threatened ecological communities within the subject land
Metres
Scale: 1:18,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56
biosis.



Legend
Subject land
Development footprint
Flora targeted survey tracks
January 2022
November 2021
Figure 5-1 Threatened ecological communities within the subject land
Metres
Scale: 1:4,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56
biosis.

Targeted survey for threatened species

Because I do not believe the species would occur naturally in the assessment area, and because I consider Biosis' fieldwork adequate to detect any occurrences of this species, I did not seek to access the assessment area to undertake my own fieldwork. Instead, I concentrated on visiting the few known occurrences of the species.

Biosis botanists included the species in their targeted surveys but did not detect it during that work or in BAM survey plots.

4.2.3 Survey constraints –timing / site conditions

As noted earlier, this Report was required primarily because surveys could not be undertaken during the BAM-prescribed survey (flowering) period for this species. This constraint could reduce the prospect of detecting the species as it is more apparent when flowering. However, I do not believe the species is or was present in the assessment area, and that it was only required to be considered in the BDAR based on the existence of records from the Clarence population, and through some connection between PCTs associated (rightly and wrongly) with that population and with the assessment area.

4.3 Surveys completed specifically for this Report

I did not undertake fieldwork within the assessment area, but instead visited and assessed known occurrences of the species to better understand its habitat requirements.

4.4 Assessment of species' presence

There are no records of the species occurring in or close to the assessment area. The nearest database records (including herbarium specimens) are from Clarence to the north. If the population were natural, there is one PCT (967) that is credibly associated with it and that could also occur in the assessment area, but is not mapped within it. However, the species has never been recorded in or near the assessment area, including after targeted surveys for it and other threatened flora species, along with collection of vegetation survey plots. Whilst dense shrub cover could obscure the species from those surveys, I do not consider the habitat to be suitable for a natural occurrence of this species, especially given the available evidence that it is far more strongly associated with different PCTs, a different climate, a different bioregion, and different lithologies well to the west of the assessment area.

4.5 Assessment of suitable habitat for *Acacia meiantha*

4.5.1 Relative significance of potential habitat

The assessment area does not comprise known or significantly credible habitat for the subject species.

4.5.2 Species habitat polygons

I have not prepared species habitat polygons for the subject species in the assessment area as I do not consider that area to be suitable potential habitat for it.

4.5.3 Estimated number of individuals that could be destroyed

There are no known occurrences of the species that could be destroyed by works in the assessment area, and I do not predict any potential occurrences in that area.

5. Summary and conclusion

I have reviewed database records of *A. meiantha*, visited all currently confirmed occurrences of this species, and read the available literature about this species. I have reviewed maps of PCT type and condition, and maps of survey effort provided by Biosis. I conclude that the species has not been known from and is very unlikely to occur in the assessment area, and that no biodiversity credits are required to be calculated for it in that area.

6. Information used in the assessment

6.1 Digital resources not cited in References

- BioNet Atlas (internal access provided under license for use in this Expert Report)
- Atlas of Living Australia on-line
- NSW Herbarium specimen database
- DPE Threatened Biodiversity Database Collection
- DPE BioNet Vegetation Classification Database
- PCT maps for the assessment area provided by Biosis
- Field data from Biosis

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7. Acknowledgements

I acknowledge the contributions to this Expert Report from the DPE Accountable Officer for *Acacia meiantha*, Jessica Petrie, who remotely assisted with my fieldwork and assessments of known occurrences of this species.

8. Statement of professional independence

Whilst I was ultimately engaged and funded by Transport for NSW to prepare this Expert Report through its consultant, Biosis, and draft reports and maps were reviewed by Biosis staff, I was not coerced by either party to amend my work in any manner that I did not otherwise agree with. I had appropriate professional independence in the preparation of this document.

I also declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses within or near the study area, nor do I have other active clients with real estate or associated commercial interests in the study area at the time of writing.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria, and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for many private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management, and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation. I am recognised as a 'threatened species expert' by DPE for many threatened plant species, Endangered Populations of plants, and threatened ecological communities within south-eastern NSW. I recently completed a review for DPE of all plant species and one Endangered Population of a plant species that were on the original edition of the SAII list under the BAM. I was the largest contributor of fieldwork and reports for the recent post-fire Priority Plants research project administered by DPE.

I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields.

I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management.

I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Visiting Fellow

Hawkesbury Institute for the Environment, Western Sydney University, 2019-May 2022

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).
- Member of the Ecological Society of Australia.
- Member of the Australian Network for Plant Conservation.

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated or contributed to nominations for three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honeybee. In late 2021, DPE contracted me to review 347 SAII listed threatened flora species and one population. I delegated some of the work to two subcontractors. That project furthered my knowledge of species that I was already familiar with and included working on many species with which I had no prior experience.

Species / population	Work conducted
Acacia baueri subsp. *aspera*	Requested to assist DAWE with the first ever CAM review of this species. Discovered a mislabelled record that when corrected, generated a new southern limit for the entity, with fieldwork funded by an ET grant to Wingecarribee Shire Council. CAM review recommended to Cwth TSSC that the entity be listed as Critically Endangered. This will likely be mirrored under the NSW BC Act. SAII nomination.
A. bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan.
A. flocktoniae	Member of DPE expert panel required to complete an assessment of the species and to design an SOS project. Appointed to conduct post-fire fieldwork at the Yerranderie population in 2022. SAII nomination. Approved by DPE to prepare an Expert Report for this species (July 2022).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset. Contributed to DAWE CAM review (2021-22)
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan.
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS. SAII review.
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH. Fieldwork and rediscovered of spatially vague record for DPE Priority Plants post-fire project (2021/2).

Species / population	Work conducted
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA, post-wildlife assessment for NPWS/SOS (2020, 2022). SAII nomination based on <3 'locations'.
Callistemon linearifolius	Fieldwork, research, successful nomination as a threatened species, advice to RMS and NPWS, PAS2 review for OEH, recognised as Species Expert in July 2020. Requested by DPE to advise on actions to progress its understanding of the species (March, 2022). SAII review.
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going). SAII review.
Callistemon purpurascens	Co-described and published new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going). Assist DPE with project design to manage risk of dam collapse as a threat to the downstream population. SAII review.
Calotis glandulosa	Fieldwork (new and extended populations, Kosciusko NP), CAM review. Discovered 'invalid' but legitimate population within BioNet Atlas data that represents the only known occurrence in NSW Southern Highlands.
Calotis pubescens	Fieldwork (new population, Kosciusko NP), CAM review
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records. SAII review.
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs. Consulted by DPI Forestry in relation to the conservation of the post-fire Wingello SF population in the context of proposed salvage logging.
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review. SAII review.
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council, OEH, LLS, documentation of previously unknown Wingello population. CAM review.
E. aquatica	Fieldwork, advice to Council and Forestry Corporation. SAII review and detection of significant error in BioNet Atlas data.
E. benthamii	Advice to DPE, CAM review and nomination for upgrade of threat status. SAII nomination based on 3 'locations'.
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel. SAII review. Co-author of a forthcoming paper formally describing and naming this species as *Eucalyptus cryptica* (in prep. July 2022).

Species / population	Work conducted
E. kartzoffiana	Fieldwork, research, expert witness. SAII review.
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH. Review of database records, and GIS analysis of PCT associations to inform a 1750 and current PCT habitat model. SAII nomination.
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review. SAII review.
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination, and advice to NSWSC and to DPE
Gyrostemon thesioides	Successful nomination
Helichrysum calvertianum	Fieldwork, research, nomination, and advice to NSWSC and to DPE
Hibbertia fumana	Research, minor fieldwork, expert witness
H. incana (syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal), post-fire fieldwork for ET grant to Wingecarribee Shire Council and support of DAWE CAM review (recommended as Endangered)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Recognised by OEH as a species expert under BC Act (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan. SAII review.
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset. Post-fire survey of a known habitat for Wingecarribee Shire Council (2021). SAII review.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset. Post-fire survey of a known habitat for Wingecarribee Shire Council (2021).

Species / population	Work conducted
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable, and advice to NSWSC and to DPE
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Recognised by OEH as a Species Expert under BC Act (Nov 2018) and prepared an approved Expert Report for the species as part of the Cumberland Plain Conservation Plan. Monitoring of wild and translocated populations (Londonderry, Agnes Banks) for DPE/SOS (2020).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct. Facilitated RBG/NSW Herbarium post-fire survey at Wingello (2021). SAII review. Assist DPE with CAM review.
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review, recognised as Species Expert in July 2020.
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review, post-wildfire fieldwork for NPWS/SOS (2020) and for ET grant (2021). SAII review. AIS nomination of eastern populations.
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH. Post-fire fieldwork under ET grant to Wingecarribee Shire Council.

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel member, consulted by DPE
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel, consulted by DPE
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DAWE re EPBC Act listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DAWE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DAWE Recovery Plan update, fieldwork and advice to DAWE; advice to OEH
Elderslie Banksia Scrub Forest	Major review for DAWE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DAWE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping (OEH), advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping (WSC/OEH), advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping (WSC/OEH), and advice about revised listing, advice to DAWE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent in WSC LGA), advice to DAWE re new listing
Robertson Basalt Tall Open-forest	Modelling and mapping (WSC/OEH), advice to NSW TSSC and to DAWE
Robertson Rainforest	Modelling and mapping (WSC/OEH) and advice to DAWE
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters dissertation. Published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping. First to map/model the community in WSC LGA at new southern and high-altitude limits
Southern Highlands Shale (Forest &) Woodland	Major contributor to EPBC Act listing (drafting of Listing and Conservation Advice), advice to OEH about revision of NSW listing, modelling and mapping. Contracted by WSC to prepare nomination for upgrade to CE. Assistant in mapping the TEC for BV Map.

Ecological community	Nature of engagement
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils, DAWE and to OEH/NSW TSSC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping (WSC/OEH), advice to OEH and DAWE
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to EPBC Act listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advice
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy,* 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Atkinson, J., Kirkpatrick, J. & Douglas, S.M. 2021. *World Heritage values and the Warragamba Dam*. Report to the Colong Foundation for Wilderness.

Douglas, S.M. 2020. *Environmental Impact Assessment in the Greater Blue Mountains World Heritage Area: a context for assessment and decision-making in relation to proposed flood mitigation works*. Prepared for the Colong Foundation for Wilderness. Submission the NSW Upper House Inquiry into the proposed raising of Warragamba Dam.

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

Edited but not refereed publications

Douglas, S.M. 2014. "When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum". *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. "Black Gum: a threatened tree of upland New South Wales and Victoria." *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. "Species profile and monitoring of Dampiera fusca". *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. "Endangered plant discovered" (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. "Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong". News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. "Phoenix flora: a post-fire discovery in the ACT". *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. "Phoenix flora" (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. "Mysteries of the Megalong Valley: another rare plant for the Blue Mountains." *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. "Land of the living dead – tree decline in urban areas". *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. "Bushland weeds – more on native weeds". *Environment NSW*, December

Douglas, S.M. 2000. "Regional Parks". *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. "Community biodiversity surveys". *National Parks Journal*, 40(3)

Douglas, S.M. 1996. "Mapping our urban bushland". *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. "Healing the Hawkesbury: start with bushland protection". *National Parks Journal*. 38(4)

Public media coverage

2021, February 10. "Offsets for Sydney toll road were promised but never delivered." The Guardian. https://www.theguardian.com/environment/2021/feb/10/its-an-ecological-wasteland-offsets-for-sydney-tollway-were-promised-but-never-delivered

2021, May 7. "Mission to save Sydney's rarest eucalyptus species from extinction." Sydney Morning Herald. https://www.smh.com.au/environment/conservation/mission-to-save-sydney-s-rarest-eucalyptus-species-from-extinction-20210505-p57p4h.html

2020, September 18. "NSW government ordered to revisit world heritage assessments for Warragamba Dam expansion". The Guardian. https://www.theguardian.com/environment/2020/sep/18/nsw-government-ordered-to-revisit-world-heritage-assessments-for-warragamba-dam-expansion

2020, September 14. "Barilaro failed to respond to koala protection concessions from Stokes." Sydney Morning Herald. https://www.smh.com.au/environment/conservation/barilaro-failed-to-respond-to-koala-protection-concessions-from-stokes-20200913-p55v5n.html

2004, November 6. "Bright flowering spot after fire" - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran

- Supervisor for undergraduate dissertation, "Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve" (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation "Riparian Vegetation of upper Cattai Creek" (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**
- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**
- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report for Littlejohn's Tree Frog *Litoria littlejohni*

Blackheath to Little Hartley – Littlejohn's Frog Expert Report

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1. Introduction

1.1 Background

The Blackheath to Little Hartley Upgrade Project is in the Blue Mountains, just west of Katoomba (Figure 1), and forms part of the broader upgrade of the Great Western Highway between Katoomba and Lithgow to a four-lane carriageway. This project footprint is comprised of three separate areas of surface works that fall north to south along the proposed alignment (see Figure 1).

The final project design is comprised of new twin tunnels around 10.4 km long between Blackheath and Little Hartley in the Blue Mountains, with these tunnels being connected to the upgraded Great Western Highway at both ends. Each tunnel would accommodate two lanes of traffic and would range in depth from just below the surface near the tunnel portals, to up to around 200 m underground at Mount Victoria.

The tunnels would be connected to the surface road network through:

- Mainline carriageways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road
- Mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Surface road upgrade work would be required to facilitate the connection between the tunnels and surface road network south of Blackheath and at Little Hartley. At Little Hartley, surface work would include formalisation of the informal Berghofers Pass car park.

The existing Great Western Highway alignment would be retained for local traffic with targeted improvement works to be delivered separately to this Project.

1.2 Project infrastructure

Following are the main components of infrastructure and associated construction activities planned for the surface works being completed as part of the development.

Surface connections

Tunnel ramps and portal structures would be built to provide connections to and from the surface road network including:

- The Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road.
- The Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.

Surface road upgrades

Surface road upgrade works would be required to facilitate the connection between the tunnels and surface road network on the existing Great Western Highway east of Blackheath and near Little Hartley.

Heavy vehicle safety station

Relocation of the existing Mt Boyce heavy vehicle safety station.

Active transport infrastructure

Shared cycle and pedestrian pathways would be provided. Pedestrian and cyclist traffic would be excluded from the tunnels as well as along on-ramps and off-ramps.

Operational ancillary facilities

Ancillary facilities to be provided by the Project include:

- A tunnel operations facility adjacent to the Blackheath portal.
- In-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities.
- Two options for tunnel ventilation including:
    - a ventilation outlet at each portal (ventilation outlet option)
    - portal emissions (portal emissions option).
- Noise management controls.
- Fauna management controls such as fauna fences/crossings/passages, if required.
- Groundwater and drainage management including water quality basins and a water treatment plant at Little Hartley.
- Fire and life safety systems, lighting, signage, emergency evacuation and ventilation infrastructure and Closed Circuit Television (CCTV).

Finally, the project would include some additional alterations to the landscape including:

- Utilities connections and modifications.
- Landscaping.
- Urban design and placemaking initiatives.

1.3 Purpose of the expert report

This expert report is being written to assess the impacts of the proposed surface works to Littlejohn's Tree Frog (hereafter LJTF), which has the scientific name *Litoria littlejohni* and is also known by another common name of the Heath Frog. This species is predicted to have suitable habitat within the locality of the proposed surface works and so may be impacted by those works. Surveys have not been able to be completed for this species due to land access restrictions and, therefore, the presence and any needs for offsets have not been able to be established as part of the BDAR. This expert report has been included as a component of the BDAR to adequately assess this species.

The study area for this report is being taken as the development footprint of the surface works (the area being directly impacted by the works) plus a 300 m buffer zone around the footprint. This study area is based on the Biodiversity Assessment Method (BAM) NSW Survey Guide for Threatened Frogs (DPIE 2020) that note that LJTF is likely to use any suitable vegetation located within 300 m of any water body it uses for breeding and offsets for the species constitute any vegetation lost in that 300 m buffer zone. This then includes for consideration any breeding habitat for the species located within the development footprints any of the three sperate surface works areas. It also includes and any vegetation located within 300 m of breeding habitat that falls within one of the surface works development footprints, even if the breeding site is located > 300 m from a footprint as the species would still suffer the loss of non-breeding habitat.

Section 5.3 Box 3of the Biodiversity Assessment Method (DPE 2020) sets out the following essential requirements for the preparation of an expert report:

- Identify the relevant species or population.
- Justify the use of an expert report.
- Indicate and justify the likelihood of presence of the species or population.
- Estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made.
- Demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report.
- Identify the expert and provide evidence of their expert credentials.

The report needs to determine whether:

- The target species is unlikely to be present, in which case no further assessment is required, or
- The target species is likely to be present in which case the expert report must provide estimates of habitat area within the impact assessment area.

1.4 Impact assessment area

The location of the proposed Upgrade is provided in Figures 1 and 2, which records that there are three separated surface works areas and that forms the study area. The location and extent of the study area is provided in more detail in Figures 3-5, that show in more detail the individual surface works development footprints along with the 300 m buffer zone. Information for the study area encompassed by this infrastructure and a further buffer zone of 10 km around the infrastructure was obtained from a range of data layers including:

- Native vegetation: provided by Biosis
- Waterbodies: NSW LPI
- LJTF Records: NSW BioNet.

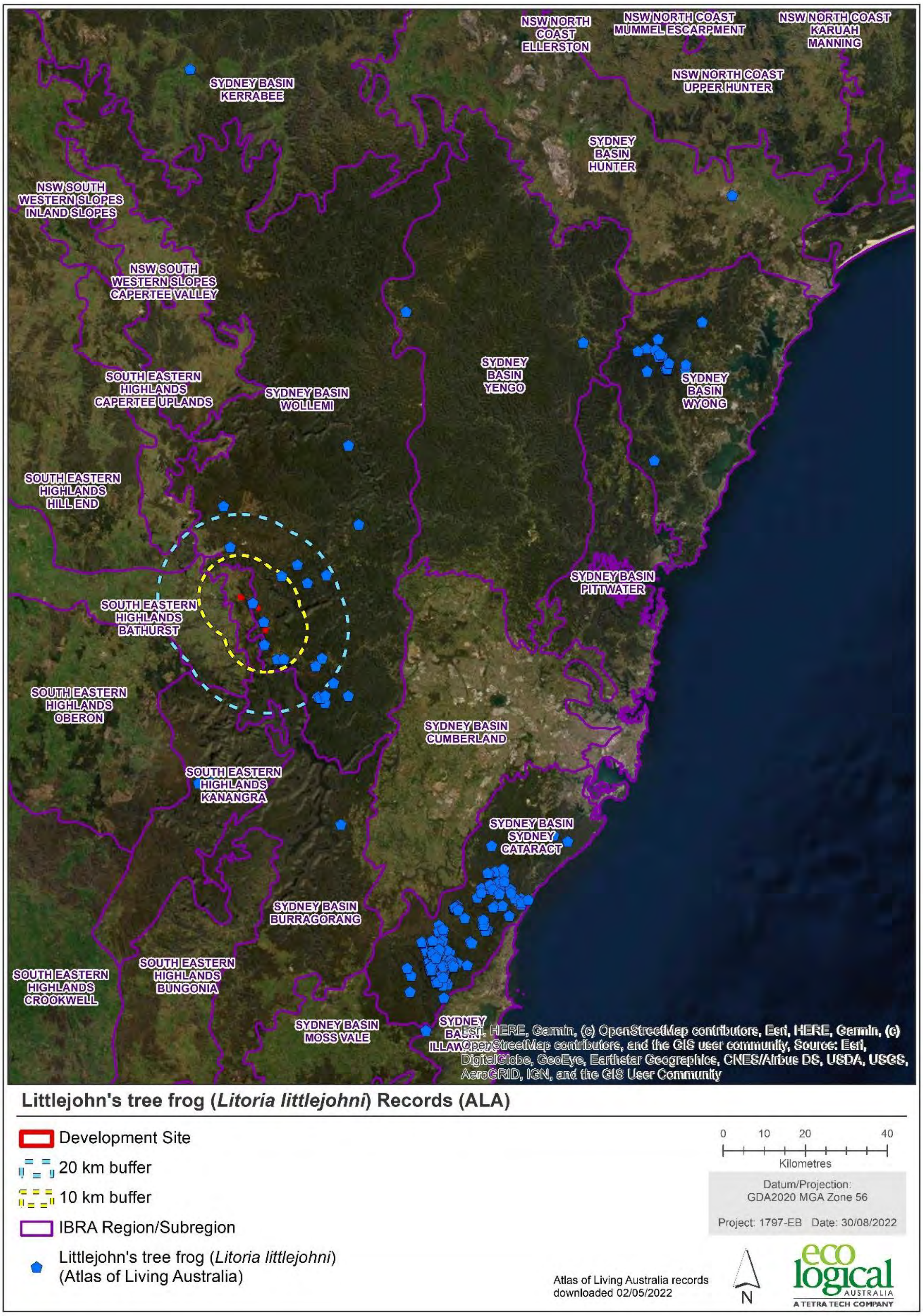

Figure 1. Location of the study area within NSW and NSW records of Littlejohn's Tree Frog

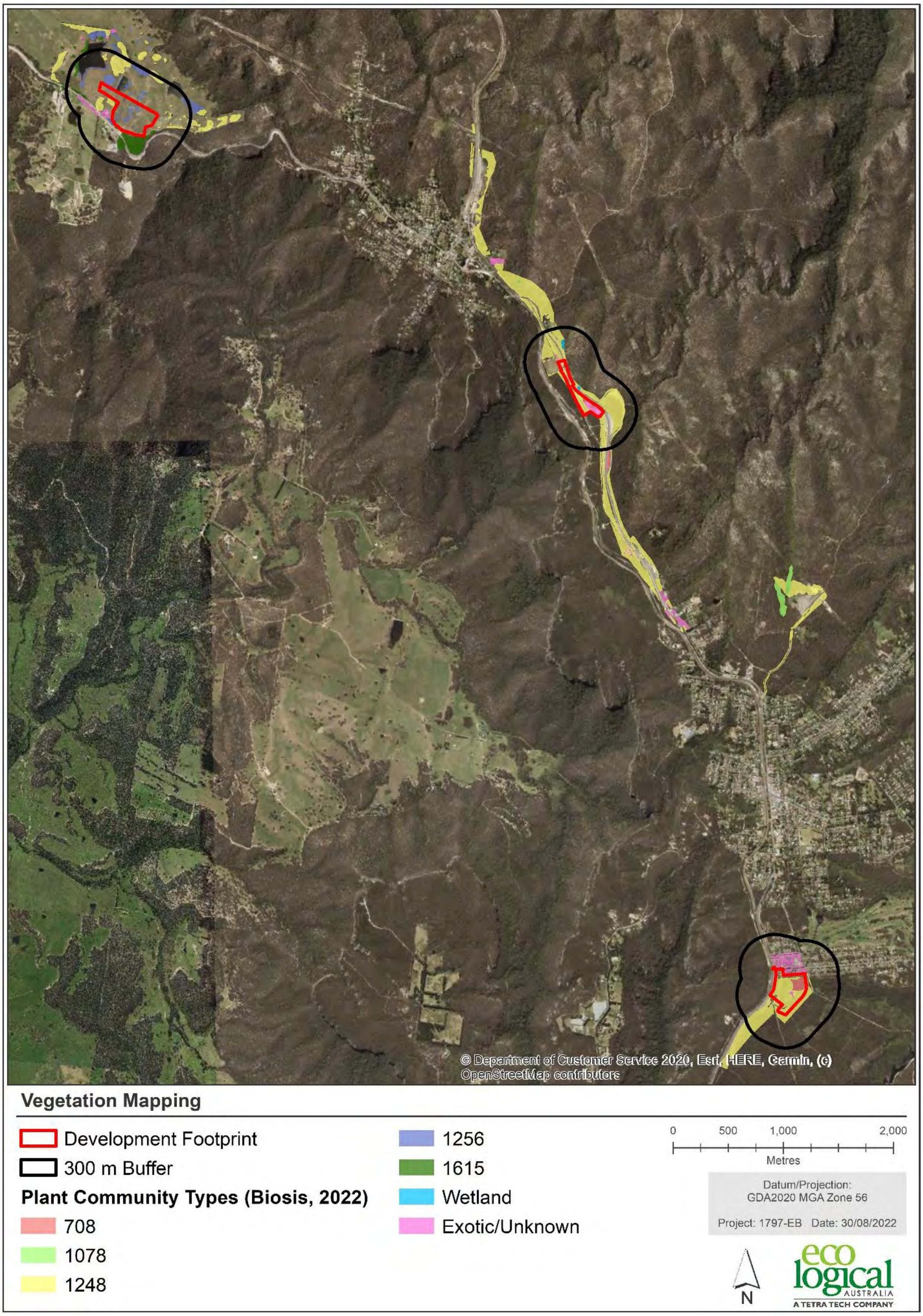

Figure 2. Overview of study area with mapped vegetation. Note the presence of three separate areas of surface works

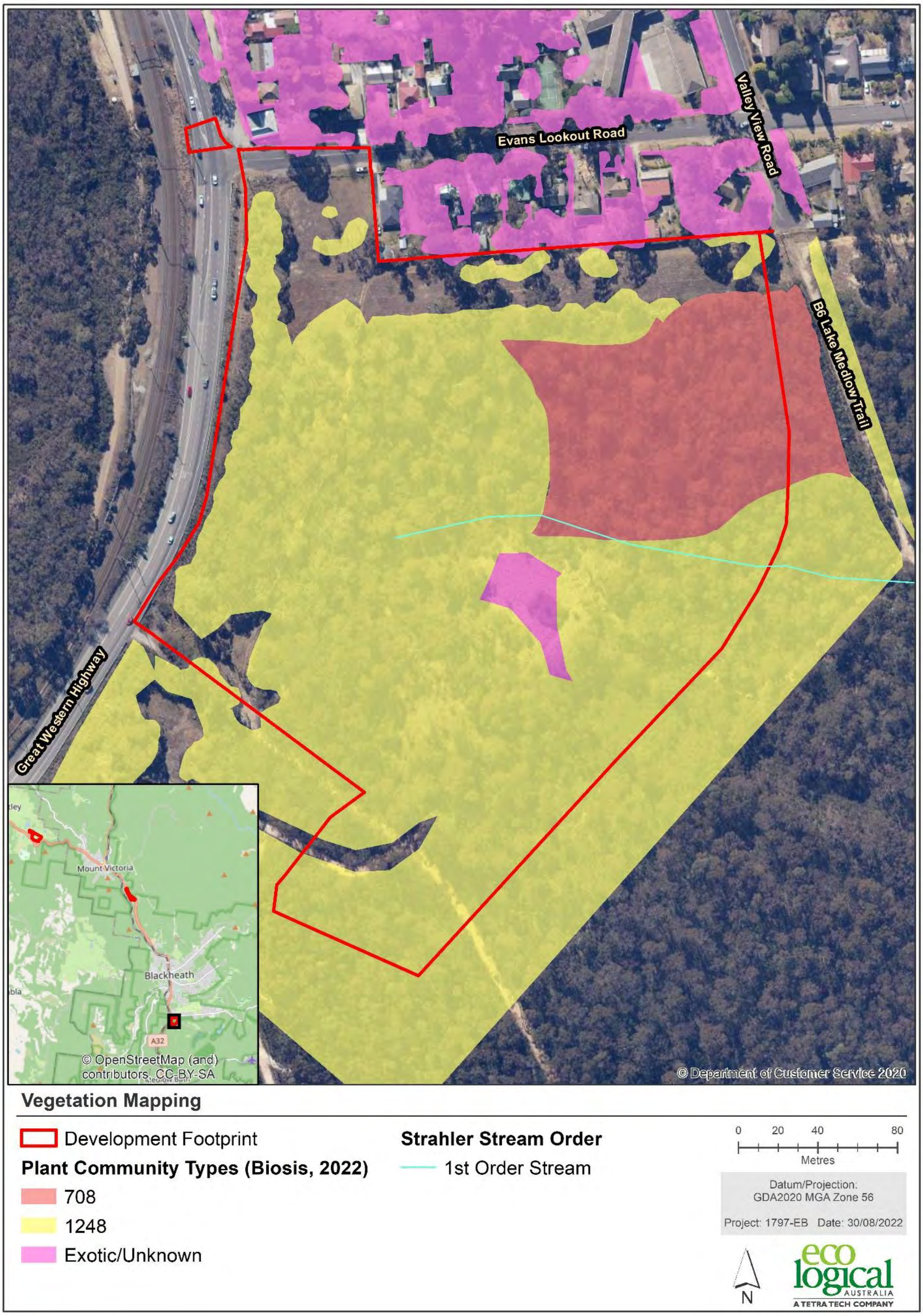

Figure 3. Southern Blackheath section of surface works and vegetation mapping

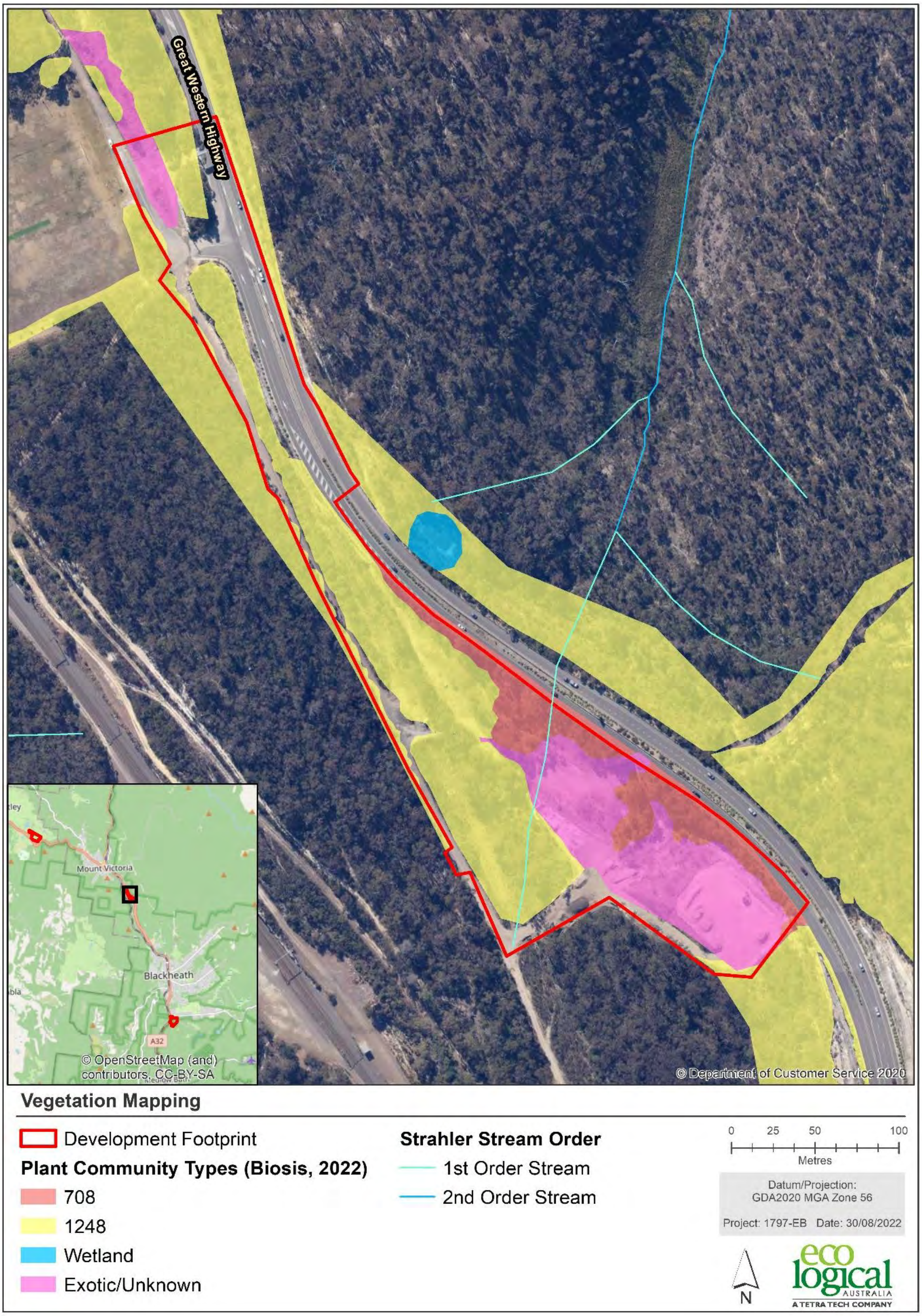

Figure 4. Central Mt Victoria section of the surface works and vegetation mapping

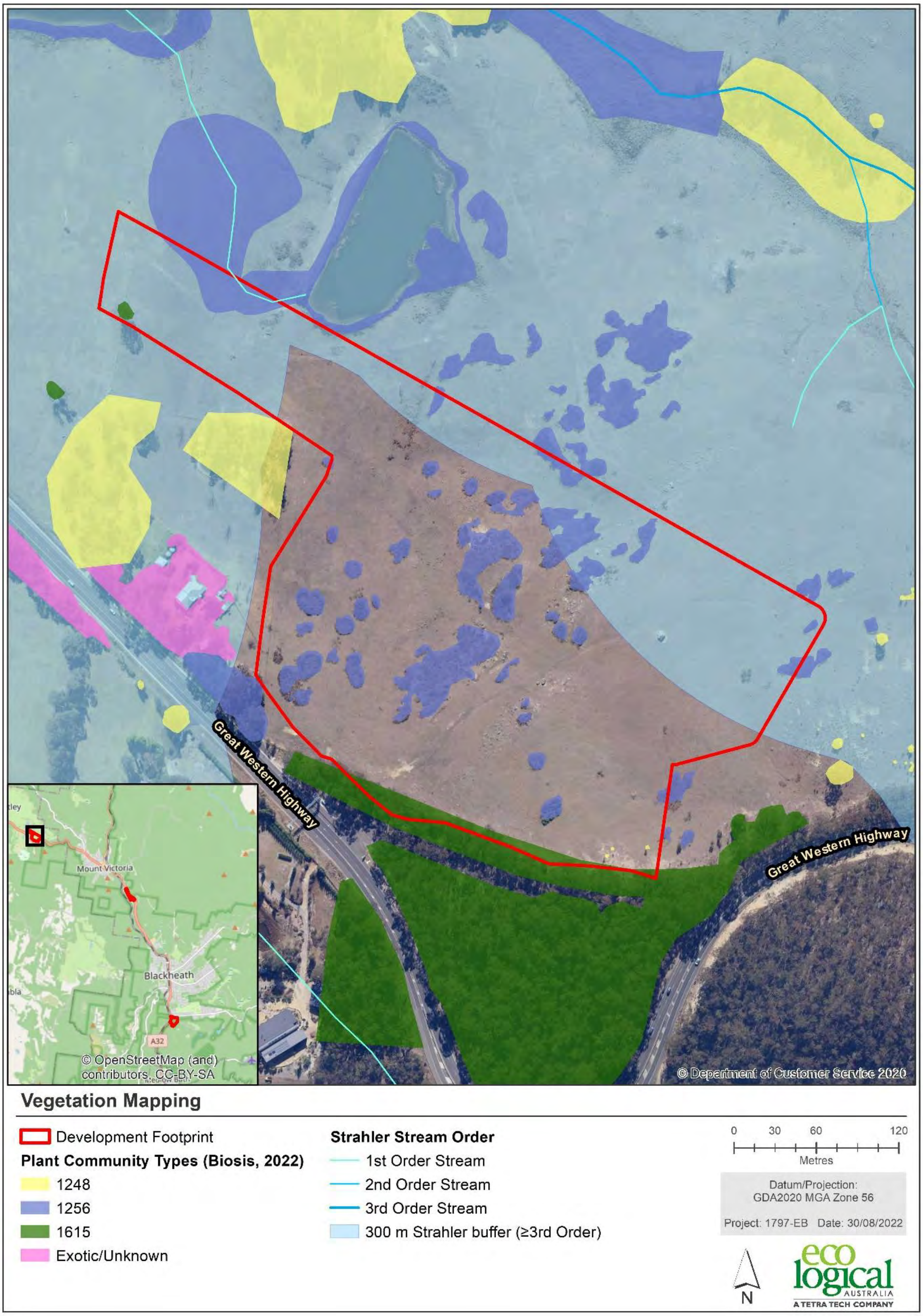

Figure 5. Northern Hartley section of surface works and vegetation mapping

Reasons for use of an expert report

Section 5.3 Box 3 of the Biodiversity Assessment Method (DPE 2020) places two specific requirements for where an expert report can be used instead of surveys:

- An expert report can only be used instead of a survey for species to which species credits apply.
- An expert report may be obtained instead of undertaking a species survey at a development site, clearing site, land to be biodiversity certified or a biodiversity stewardship site.

The LJTF meets the first criteria, being a species credit species under the *Biodiversity Conservation Act 2016* (BC Act).

The LJTF is known to inhabit the types of landscapes present within the impact assessment area of the proposed Blackheath to Hartley tunnel works and historic records exist across broadly, albeit very limited, across the study area (Figure 1). Field survey is unable to be undertaken to adequately assess the presence of the LJTF within the impact assessment area, with extensive areas of potential habitat occurring on lands with limited access.

On that basis, an expert report was determined to be required for this species.

CREDENTIALS OF EXPERT

Dr Lemckert is an Ecologist who has been undertaking studies into the ecology and management of frogs since 1986 and has been a principal ecological consultant since 2011. His skills include survey design/ implementation/ targeted species surveys, data handling, analysis and interpretation and the production of high level reports including papers published in international peer-reviewed journals and technical reports and recovery plans for the Commonwealth and NSW Governments. He has also been an expert witness for the assessment of the impacts of alleged illegal clearing for the Commonwealth, NSW and Local Governments (Hornsby Council) and provided expert advice to NSW DPI for legal considerations over the potential for forestry operations to impact on rock outcrop dependent species. At the broadest level Dr Lemckert represented Forests NSW (now Forestry Corporation NSW) as a reptile and amphibian expert in the Comprehensive Regional Assessments and Regional Forest Agreement Process carried out between 2000 and 2002 and as an expert in fauna management for negotiations over a new Threatened Species License for harvesting operations in 2014. He provided an expert review of the developed assessment process for impacts on Matters of National Environmental Significance for two proposed Coal Seam Gas Developments in Queensland and has completed two rounds of expert review of the status of Australia's amphibians for the IUCN.

Dr Lemckert is an acknowledged expert on eastern Australian frogs having completed his MSc and PhD on the ecology and management of frogs in this region and has published over 70 papers (or book chapters) in Australian and International peer-reviewed journals. He has been used by both the NSW and Commonwealth Governments as an expert witness in court cases assessing the impacts of land clearing on threatened frogs. He is a member of the Amphibian Specialist Group of the IUCN, secretary of the NSW Declining Frog Working Group of NSW and past president of the Australian Society of Herpetologists. He co-supervised two PhD students, a Master of Applied Science Student and three Bachelor of Science (Honours) students who completed theses addressing issues of frog biology and conservation. He is listed as an accredited expert by the NSW Department of Planning, Industry and Environment (DPIE) to provide expert reports under the Biodiversity Assessment Method (BAM). Dr Lemckert has written the survey guidelines for NSW threatened frog species to be used in assessments under the Biodiversity Assessment Method (BAM) (for the NSW

Department of Planning and Environment). He has previously produced an expert report for the LJTF for the Warragamba Dam raising project that also was required to assess an area of land with limited access.

Dr Lemckert has a long history of working on LJTF, having undertaken a number of ecological projects assessing the habitat requirements of the species as well as the monitoring of populations and their breeding habits. He has published papers detailing the ecology of this frog, modelling its habitat requirements and distributions, the predicted impacts of climate change and he has been part of multiple assessments of the conservation status of the species. These conservation assessments have been used both by the Australian Government and the IUCN (for its Redlist) to set the conservation status of this species. Dr Lemckert recently was a co-author on a paper that re-described the species and split it into two separate taxa: Littlejohn's Tree Frog (*Litoria littlejohni*), occurring around the Sydney Basin down to Robertson on the NSW South Coast and Watsons Tree Frog (*Litoria watsoni*) that is located from south of Robertson and down into Victoria. He has also contributed to two recently accepted papers assessing the impacts of fire on this and other species of frogs, both stemming from the need to understand the longer term impacts that the major bushfires of 2019/2020 are likely to have on this group of vertebrates.

Recent Dr Lemckert has been assisting the University of Newcastle by providing advice on the locations of breeding populations of this species in the Watagan Mountains and providing details on the historical construction of ponds that assisted the species to establish new breeding populations. This knowledge is being used to create additional breeding for both LJTF and Watson's Tree Frog in areas of forest affected by the 2019/2020 bushfires. These fires had a major impact on the habitats used by this species and the construction of additional higher quality breeding habitat is being used as a means of better securing the species into the future by enhancing population sizes and recruitment.

Additional experience and use of his expertise include:

- Engagement by RPS to conduct targeted expert surveys in the Newnes Plateau as part of assessments of impacts of mining at the Centennial Colliery (2021).
- Completion of surveys and an expert report (under the Framework for Biodiversity Assessment) for the Warragamba Dam Raising project for SMEC (2019).
- Engagement by the NSW Office of Environment and Heritage to be part of the expert panel determining the categorisation of this species under the SOS program and in determining the populations requiring specific management actions (2016/17 & 2020/21).
- Providing expert opinion on the status of this species during assessments undertaken for the IUCN in 2001 and 2016.
- Contracted by OEH to collect genetic samples from Littlejohn's Frogs to assist in determining the potential for two species to be present within the current recognised taxa. The data collected has indicated that two species may be present, but this needs further confirmation (2014).
- Provided expert opinion on the habitat requirements, sub-population status and reservation requirements for Littlejohn's Frog during the NSW Government's Comprehensive Regional Assessment program completed in 2000-2001.

Specific to the Blackheath to Hartley development, Dr Lemckert has:

- Conducted targeted expert surveys in the Newnes Plateau as part of assessments of impacts of mining at the Centennial Colliery (2021).

- Undertook surveys and habitat assessments around the perimeter of the Warragamba Dam to complete an expert assessment and report for the presence of the species, which included areas immediately adjacent to the current study area (2018-2019).
- Provided advice to Sarsha Gorrisen from the University of Sydney during her PhD studies to assess the potential use of upland swamps by this species in the Blue Mountains area around Katoomba (2014).

Dr Lemckert publications and reports that deal specifically with LJTF are:

a. Mahony, M.J., Hines, H.B., **Lemckert, F.**, Newell, D., Roberts, J.D., Rowley, J.J.L., Scheele, B.C., & West, M. (In Press). The impacts of the 2019-20 wildfires on Australian frogs. In Australia's 2019-20 megafires: biodiversity impacts and lessons for the future. S. Legge (Ed.).

b. Mahony, M., Gould, J., Beranek, C., Callen, A., Clulow, J., Clulow, S., Klop-Toker, K., Mahony, S., Wallace, S., Stock, S., Garnham, J., **Lemckert, F.**, Thumm, K., Moses, B. & Pickett, E. (2022). A trait-based analysis for predicting impact of wildfires on frogs. Australian Zoologist.

c. Geyle, H.M, Hoskin, C.J., Bower, D.S., Catullo, R., Clulow, S., Driessen, M., Daniels, K., Garnett, S., Gilbert, D., Heard, G.W., Hero, J-M., Hines, H.B., Hoffmann, E.P., Hollis, G. Hunter, D.A. **Lemckert, F.L.**, Mahony, M., Marantelli, G., McDonald, K.R., Mitchell, N.J., Newell, D., Roberts, J.D., Scheele, B.C., Scroggie, M., Vanderduys, E., Wassens, S., West, M., Woinarski, J.S.C. & Gillespie, G.R. (2021). Red hot frogs: identifying the Australian frogs most at risk of extinction. Pacific Conservation Biology. https://doi.org/10.1071/PC21019.

d. Gillespie, G.R., Roberts, J.D., Hunter, D., Hoskin, C.J., Alford, R.A., Heard, G.W., Hines, H. **Lemckert, F.**, Newell, D. & Scheele, B.C. 2020. Status and Priority Conservation Actions for Australian Frog Species. Biological Conservation 247, 108543. https://doi.org/10.1016/j.biocon.2020.108543.

e. Mahony, M., Moses, B., Mahony, S.V., **Lemckert, F.L.** & S Donnellan. 2020. A new species of frog in the Litoria ewingii species group (Anura: Pelodryadidae) from south-eastern Australia. Zootaxa 4858:201-230.

f. **Lemckert, F.L.**, & Mahony, M.J. 2018. The status of Decline and Conservation of Frogs in Temperate Coastal South-eastern Australia. **Pp 59-72** In: *Amphibian Biology Volume 11 - Conservation and Decline of Amphibians: Eastern Hemisphere (Australia, New Zealand and Pacific Islands)*. H. Heatwole and J. Rowley (Eds.). CSIRO Publishing, Melbourne.

g. Lemckert, F.L. & Penman, T. 2012. Climate Change and Australia's frogs: how much do we need to worry? Pp 92-98 In: Wildlife and Climate Change: towards robust conservation strategies for Australian fauna. D. Lunney & P. Hutchings (Eds.). Royal Zoological Society of NSW, Mosman, NSW, Australia.

h. Lemckert, F. 2010. Habitat relationships and presence of the threatened heath frog *Litoria littlejohni* (Anura: Hylidae) in central New South Wales, Australia. Endangered Species Research 11:271-278.

i. Lemckert, F.L. & Mahony, M.J. 2008. Core calling periods of the frogs of temperate New South Wales, Australia. Herpetological Conservation and Biology 3:71-76.

j. Penman, T. D. and Lemckert, F. L. 2010. Predicted impact of climate change on threatened amphibians. Unpublished report to the Department of the Environment, Climate Change and Water, Hurstville.

k. Hero, J-M, Richards, S, Alford, R., Allison, A., Bishop, P., Gunther, R., Iskandar, D., Kraus, F., Lemckert, F., Menzies, J., Roberts, D. & Tyler, M. 2008. Amphibians of the Australasian Realm. Pp 65-73 In: Threatened Amphibians of the World. S.N. Stuart, M. Hoffman, J.S., Chanson, N.A. Cox, R.J. Berridge, P.J. Ramani & B.E. Young (Eds.). Lynx Edicions, Barcelona.

l. Gillespie, G., Lemckert, F. & Robertson, P. 2004. *Litoria littlejohni*. The IUCN Red List of Threatened Species. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T41036A10391959.en. Downloaded on 17 May 2018.
m. Lemckert F. 2004. The biology and conservation status of the heath frog (*Litoria littlejohni*). Herpetofauna 34:99-104.

Dr Lemckert's full CV is provided as Appendix A of this report.

2. Species information

2.1 Species description

The LJTF is an endemic Australian tree frog that is a member of the family Hylidae and forms one member of the Whistling Tree Frog species group. It is a large species by Australia, ranging in an adult size for males of 57-69 mm and females 65-108 mm snout to vent length (Tyler and Knight 2009; Clulow and Swan 2018) and is the largest of the Whistling Tree Frogs. It colouration is slightly variable, with individuals having a grey or brown back, with an indistinct longitudinal stripe along the middle. There are sometimes brown mottling or flecks on the back and the species will likely change the shade of dorsal covering between day and night. There is a dark brown tympanic stripe that runs the tip of the snout to the armpit. The belly is a relatively uniform white in colouration. One of its distinctive features are the bright colourations on the sides of individuals, with the armpits, groin, backs of the thighs and parts of the lower legs being coloured a bright red or orange. The fingers are slightly webbed and toes are nearly fully webbed. The tips of the fingers and toes have distinctive large discs (suckers) that allow it to climb agilely. One last distinctive feature is the smell of curry that it exudes with skin secretions when the frog is handled or feels threatened.

Very recently Litoria littlejohni was broken into two separate species (Mahony et al. 2020), with the populations present in the Blue Mountains being part of the species continuing to be known as Littlejohn's Tree Frog, but with frogs located to the south of the Sydney Basin now being referred to as Watsons Tree Frog (*Litoria watsoni*). The two species are physically very similar in looks and appear to share similar ecologies.

Plate 1: Amplexing Littlejohn's Tree Frogs and a typical male in a calling position

2.2 Life cycle

Littlejohn's Tree Frog is recorded to have two distinct breeding patterns. The majority of records of calling and breeding come from areas of still water (dams, swamps or temporary pools with longer hydroperiods) located in forests (Lemckert 2004), which includes sites in both the very north of its range in the Watagan Mountains (Lemckert 2004) and records in the south of its range (Mahony et al. 2020). However, records from coastal southern NSW between approximately Nowra and Darkes Forest appear to mainly be associated with permanently flowing rocky creeks where larger pools with relatively slow water flows are used for breeding (Daly & Craven 2007; F. Lemckert, Pers. Obs.).

The calling seasons are apparent similarly disparate depending on the calling environment. The pond breeding frogs in the Watagan Mountains, have been recorded calling throughout the year, with activity being triggered by heavier rain events (Lemckert 2004). There appears to be a more elevated chance of calling occurring from late summer to early spring (Lemckert and Mahony 2008). The rocky stream breeding frogs at Nowra however were found by Daly & Craven (2007) to typically call in late winter and spring and little calling activity outside of this time. The differences in breeding habit were thought potentially to be a result of the species including two distinct taxa. However, there has been a recent split of the taxa into two species (Mahony et al. 2020), the analysis shows that both of the nominated species undertake both breeding habits. Hence, it is likely that preferred breeding habitats in any given area are more a function of the types of habitats available rather than an actual preference for one type of habitat over another.

Males call from low vegetation or on the ground close to the breeding pools. Clutches of up to 60 eggs are attached as jelly clumps to submerged twigs, stems or branches, often near the banks of still pools in clear, slowly flowing streams (Anstis 2013). Hatching occurs seven to eight days after laying and the larval life span of a group of captive tadpoles was an average of 124 days (Anstis 2013). Littlejohn's Tree Frog Tadpoles are black or very dark grey with dark grey bellies. Tadpoles grow to 65 mm in length (Anstis 2013). The eggs and tadpoles are mostly found in areas of water that receive extended exposure to sunlight and the tadpoles are notable for their very dark colouration that may assist in thermoregulation.

2.3 Distribution and abundance

2.3.1 Broad distribution

Littlejohn's Tree Frog, after the recent taxonomic split, has a distribution that covers the broad area of the Sydney Basin Bioregion and covers the coast and adjacent ranges from Watagan State Forest (90 kilometres north of Sydney) to the area west of Shellharbour south of Wollongong (Mahony et al. 2020). White and Ehmann (1997) indicate that the species lives over an altitude range of 100 m to 950 m above sea level which includes dams and streams in coastal forests to upland swamps in woodlands and heathlands near the top of the Great Dividing Range. Mahony et al. (2020) provides an estimated extent of occurrence for Littlejohn's Tree Frog of 16,317 km^2 and an area of occupancy of 390 km^2.

2.3.2 Abundance

The LJTF has never been recorded to be abundant in any of its locations (typically less than 10 calling males at a breeding site; Lemckert 2004) and there are relatively few records of the species across its currently recognised range (Figure 1), and the number of record sites appears to be declining (see Figure 6). However, it is only a recently recognised species, being first proposed as a species in 1980 (White et al. 1980) and only fully recognised in 1994 (White et al. 1994). Hence records obtained before 1980 and most before 1994 would not necessarily have been identified or now be identifiable as this species and its historic abundance is not well understood.

Survey results since the 2000s shows the species remains commonly recorded in coastal areas in the Watagan Mountains to the north of Sydney and on the Illawarra Escarpment to the south of Sydney (Figure 6), although the species can be patchy even in these locations (Pers. Obs.). However, records for the Blue Mountains are now very rare and Mahony et al. (2020) was able to find only three recorded populations of the species in the Greater Blue Mountain National Park and World Heritage Area in the past decade (Figure 6).

LJTF has relatively low fecundity for a frog of its size, producing clutches of only 60 eggs compared to a clutch size of 1777 for the similarly sized Peron's Tree Frog (*Litoria peronii;* Anstis 2013). Similarly, the duration of the tadpole development period is relatively long at a minimum of 4 months compared to a mean of 3.5 months for Peron's Tree Frog. All of this indicates that the species is less able to rapidly rebound from a drop in numbers when these occur.

A further concern for the abundance of this species has been the impact of the 2019/2020 bushfires, which were estimated to have impacted 34% of the range of LJTF (Mahony et al. In Press). The species is also rated as being moderately highly sensitive to bushfires (Mahony et al. 2022) and so it is expected to have suffered significant declines in abundance due to the bushfires and so make the species more vulnerable to extinction.

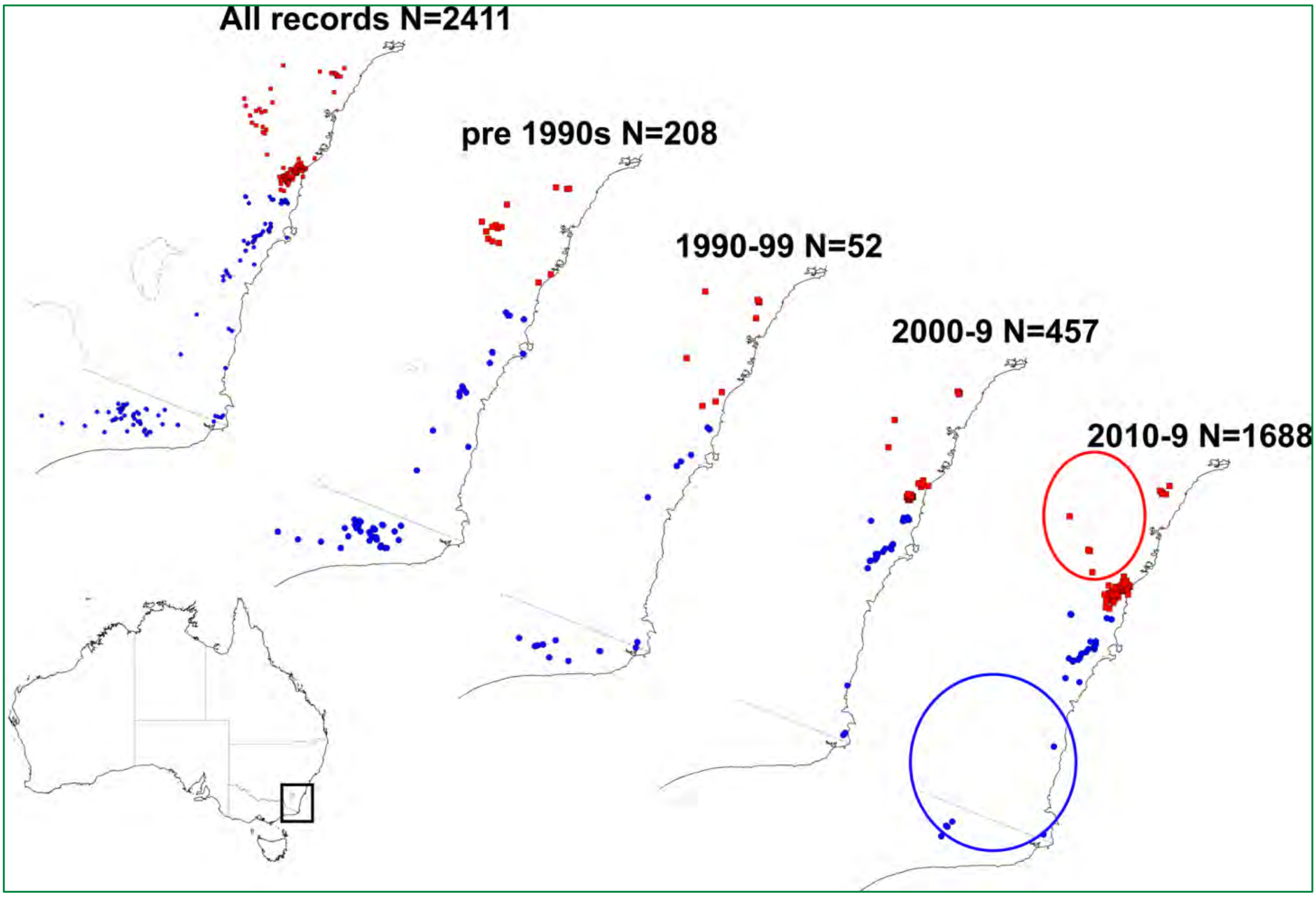

Figure 6. Records for Littlejohn's Tree Frogs (in red) over different decades (Taken from Mahony et al. 2020)

Plate 2: Examples of breeding habitats observed in proximity to the impact assessment area. Left is a 3rd order stream and right an isolated pool created in a scraped area

Plate 3: Left - Typical sandstone ridgetop native vegetation present throughout the study area. Right – typical cleared grazing land habitat present in the study area

2.4 Habitat requirements

2.4.1 Breeding Habitat

Breeding habitat for this species is broad and variable. It has been recorded to use rocky streams and semi-permanent dams (Barker et al. 1995), still water in dams, ditches, isolated pools and flooded hollows (Hero et al. 1991), dams, creeks and lagoons (Griffiths 1997), semi-permanent or permanent dams, ponds and creeks (Anstis 2013) and temporary pools when sufficient run-off water was available (White et al. 1994). Lemckert (2004) confirmed this array of breeding habitats in a review of the records for this species and noted the prevalence of the use of ponds in the Watagan Mountains (northern part of the range) and the use of rocky creeks on the southern side of the Sydney Basin. This difference in breeding habitat preference appears to most likely be simply a result of the availability of permanent water sources. In the Watagan Mountains there are no rocky creeks present and the creeks are generally highly ephemeral in nature. The only more permanent water present are dams created historically for stock watering and fire control. In the south of the Sydney Basin the lands do not have such dams (not being areas used for forestry), but there are rocky based creeks widespread through that area that have permanent or near permanent pools that offer the available permanent water sources. Therefore, the likelihood is that Littlejohn's Tree Frog breeds in whatever more permanent still or slow moving water that is available.

Both types of breeding habitat contain few or no fish and sites around the Sydney Basin are all associated with Triassic Sandstones. Records from the Blue Mountains have been obtained both from ponded areas and from rocky streams and so both types of aquatic habitat must be viewed as potential breeding habitat within the study area.

2.4.2 Non-breeding habitat

LJTF is known to inhabit wet and dry sclerophyll forests and coastal woodlands and heath and is not known to be located in areas that are cleared, highly disturbed or contain non-native vegetation (Lemckert 2004). Lemckert (2010) undertook a GIS based assessment of the species and found that the species is more likely to occur in grass-free, moist and sunny areas that are relatively flat (Lemckert 2010), but these variables were too broad to accurately predict where Littlejohn's Tree Frog would occur and the species was absent from many apparently suitable sites (Lemckert 2010).

Within these areas of native vegetation, the species has been recorded sheltering under leaf litter and low vegetation (Lemckert 2010) or under rocks on ridges 100-200 m from their breeding sites. They have well-developed suckers on their toes which suggests that the species is also a capable climber (Cogger 2013; Hero et al. 1991), although there are few records of them occurring higher in trees. A radio-tracking study recorded three adults all staying within 50 m of the breeding sites up to a month after breeding (F. Lemckert Unpubl. Data.). Notably, these individuals were all found only on the ground whenever they were located and took shelter either in deep leaf litter or within thick tussocks of grass.

2.4.3 Foraging

The diet of LFTF has not been investigated in any detail, but adult LJTF presumably consume a variety of invertebrates. Furthermore, being a larger frog, they probably will also eat any small vertebrates they can capture and subdue.

Similarly, the tadpoles show a very standard set of mouth parts (Anstis 2013) and are again likely to eat a broad range of food items during that stage.

Hence there is no expectation of any dietary specialisation and so little likelihood that the species has a specific foraging habitat or method that might provide a limitation on where the species can exist.

2.4.4 Vegetation associations

The OEH profile records the LJTF to be associated with a broad range of vegetation formations and classes within the Sydney Basin Interim Biogeographic Region in which the study area is located (https://www.environment.nsw.gov.au/threatenedSpeciesApp/profileData.aspx?id=10488&cmaName=Sydney+Basin). These are:

Dry sclerophyll forests (shrub/grass sub-formation)

- Central Gorge Dry Sclerophyll Forests
- Hunter-Macleay Dry Sclerophyll Forests.

Dry sclerophyll forests (shrubby sub-formation)

- South Coast Wet Sclerophyll Forests
- South East Dry Sclerophyll Forests
- Southern Tableland Dry Sclerophyll Forests
- Sydney Coastal Dry Sclerophyll Forests
- Sydney Hinterland Dry Sclerophyll Forests
- Sydney Montane Dry Sclerophyll Forests
- Western Slopes Dry Sclerophyll Forests.

Dry sclerophyll forests (shrubby sub-formation)

- South East Dry Sclerophyll Forests
- Sydney Coastal Dry Sclerophyll Forests
- Sydney Hinterland Dry Sclerophyll Forests
- Sydney Montane Dry Sclerophyll Forests
- Western Slopes Dry Sclerophyll Forests.

Forested wetlands

- Eastern Riverine Forests
- Coastal Floodplain Wetlands.

Freshwater wetlands

- Coastal Heath Swamps
- Montane Bogs and Fens.

Grassy woodlands

- Coastal Valley Grassy Woodlands
- Tableland Clay Grassy Woodlands.

Heathlands

- South Coast Heaths
- Sydney Coastal Heaths
- Sydney Montane Heaths.

Miscellaneous ecosystems

- Water bodies, rivers, lakes, streams (not wetlands).

Rainforests

- Northern Warm Temperate Rainforests
- Southern Warm Temperate Rainforests
- Subtropical Rainforests.

Wet sclerophyll forests (grassy sub-formation)

- Northern Hinterland Wet Sclerophyll Forests
- Southern Lowland Wet Sclerophyll Forests
- Southern Tableland West Sclerophyll Forests.

Wet sclerophyll forests (shrubby sub-formation)

- North Coast Wet Sclerophyll Forests
- Southern Escarpment Wet Sclerophyll Forests.

The wide range of predicted vegetation formations and vegetation types indicates that Littlejohn's Frog has relatively little identifiable habitat specificity when it comes to the vegetation it prefers. LJTF lives in both wet and dry forest types with both grassy and shrubby elements and also can be found in woodlands and rainforest. The presence of suitable breeding habitat with adjacent native vegetation is considered to be the best determinant of the likelihood of Littlejohn's Frog being present in an area.

2.4.5 Threats

Littlejohn's Tree Frog is currently listed as vulnerable under BC Act and under the EPBC Act, but is listed as of Least Concern under the IUCN Redlist.

The Department of Environment and Planning profile for this species lists the following threats to Littlejohn's Tree Frog:

- Loss of streamside vegetation through clearing or frequent burning.
- Changes to natural water flows and water quality.
- Predation of eggs and tadpoles by introduced fish.
- Infection by amphibian chytrid fungus.
- Disturbance to habitat and hydrology due to longwall mining.
- Climate change.
- Disturbance to forest and woodland breeding and non-breeding habitat by trail bike activity and other recreation.
- Poor knowledge of the current distribution and abundance of the species, particularly in the blue mountains, south coast and hinterland areas.
- Forest disturbance associated with forestry operations.
- Lack of understanding of taxonomy, particularly the status of southern populations.
- Intense wildfire resulting in destruction of habitat.

(see https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10488).

The IUCN Redlist profile (Gillespie et al. 2004) lists only one major threat: "Logging might be a threat to the species' habitat. It has been found to persist in some logged areas but whether or not it can persist long-term is not known".

The Species Profile and Threats Database (SPRAT) profile for this species (DoE 2022) raises the following as consideration of threats:

- White and Ehmann (1997) report Littlejohn's Tree Frog as dependent on relatively undisturbed forested areas and the species is sensitive to habitat changes.
- Lemckert (2004) noted sites in the Watagan Mountains being disturbed by logging and with limited land clearing adjacent to them, but the frog is absent from cleared lands and so land clearing is a threat.
- Daly & Craven (2007) state that the introduction of Mosquitofish (*Gambusia holbrooki*) and Yabby (*Cherax destructor*) into streams could reduce recruitment success.
- Chytridiomycosis is an unknown threat to this species.

The lack of records from coastal southern NSW and Victoria provide a reasonably strong suggestion that this disease may have impacted Littlejohn's Tree Frog.

In regard to the study area, the majority of these threats would already be in place and not significantly added to by the proposed development. The following are considered to be of relevance as the proposed development may significantly add to already existing threats:

- Loss of streamside vegetation through clearing or frequent burning.
- Changes to natural water flows and water quality.
- Predation of eggs and tadpoles by introduced fish.
- Infection by amphibian chytrid fungus.
- Intense wildfire resulting in destruction of habitat.

2.4.6 Variables determining LJTF presence

This information provides the following important points when trying to assess the potential presence of the LJTF in any area:

- The presence of permanent water bodies including slow moving or still sections of rocky based creeks or permanent ponds.
- The presence of that breeding habitat within or immediately adjacent to areas of relatively intact native vegetation.
- The LJTF is more likely to be present at a location when there are other LJTF occupied ponds in close proximity.
- The LJTF is unlikely to be present within areas containing a large number of introduced fish.

3. Description of the study area

The study area for the Blackheath to Hartley Upgrade is illustrated in Figures 1 and 2 and represents three separated areas of surface work. The study area consists of the footprint of three surface area footprints and a surrounding 300 m buffer that represents the range that Littlejohn's Tree Frog is considered likely to move away from any breeding habitat (DPE 2020). The study area is located about 110 kilometres west of Sydney along the Great Western Highway and is to be centred around the towns of Blackheath and Little Hartley (Figure 1). The study area is located in the Blue Mountains local government areas (LGA).

3.1 Landscape features

The following landscape features are relevant to the project, as defined by the BAM.

3.1.1 Bioregions

The study area is located within the Sydney Basin Bioregion.

The Sydney Basin bioregion occupies approximately 3.6 million hectares (approximately 4.5 percent of NSW) and extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee. The Sydney Basin Bioregion is one of the most species diverse in Australia, which is the result of the variety of rock types, topography and climates in the bioregion. It consists of a geological basin filled with near horizontal sandstones and shales of Permian to Triassic age that overlie older basement rocks of the Lachlan Fold Belt. The sedimentary rocks have been subject to uplift with gentle folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has created a landscape of deep, cliffed gorges and remnant plateaus across which an east-west rainfall gradient and differences in soil control the vegetation of eucalypt forests, woodlands and heaths. The Sydney Basin Bioregion includes coastal landscapes of cliffs, beaches and estuaries.

The study area is located on the Frontal Slope of the Blue Mountains, which is formed along the Lapstone monocline.

3.1.2 Subregions

The study area is located within the Wollemi subregion of the Sydney Basin IBRA region (Figure 1). Details on these subregions are provided in Table 1 below.

Table 1. Description of the subregions covering the study area.

Subregion	Geology	Characteristic landforms	Typical Soils	Vegetation
Sydney Basin Bioregion				
Wollemi	Hawkesbury Sandstone and equivalent quartz sandstones of Narrabeen Group, sub-horizontal bedding, strong vertical joint patterns. A few volcanic necks.	Highest part of the Blue Mountains. Sandstone plateau with benched rock outcrops. Creek directions controlled by jointing deep gorge of the Capertee and Wolgan Rivers.	Thin sands or deep yellow earths on plateau, thin texture contrast soils on shale benches. Organic sands in swamps and joint crevices, bouldery slope debris below cliffs, sandy alluvium in pockets along the streams. Red brown structured loams on basalts.	Red bloodwood, yellow bloodwood, rough-barked apple, smooth-barked apple, hard-leaved scribbly gum, and grey gum with diverse shrubs and heaths on plateau. Smooth-barked apple, Sydney peppermint, blue-leaved stringybark, and turpentine and gully rainforests in gullies and canyon heads. Ribbon gum and Blaxland's stringybark on basalt. River oak along main streams.

3.1.3 NSW (Mitchell) Landscape

Based on the SEED database (see Geocortex Viewer for HTML5 (nsw.gov.au)), the study area is contained within one Mitchell Landscapes associated with the Sydney Basin Bioregion: Blue Mountains Plateau. The following description is taken directly from DECC (2002).

Blue Mountains Plateau

Elevated, dissected plateau of Triassic quartz sandstones. Largely undeformed with prominent sub-horizontal bedding defining a plateau that rises to the west with maximum elevation 1100 m and local relief in cliffed gorges up to 500 m. Very strong joint control on stream patterns and cliff lines. Thin shale beds form stepped topography and deeply weathered sandstones form pagoda towers and turrets on gorge margins. Exposed high slopes with Dwarf Casuarina (*Allocasuarina nana*) heath, Blue Mountains Ash (*Eucalyptus oreades*) and Silvertop Ash (*Eucalyptus sieberi*) woodlands, and perched swamps. Elsewhere heaths, woodlands and forests with very high plant diversity on sandy soils.

3.1.4 Soil

The dominant geology in the study area the Hawkesbury Sandstone.

The impact area and impact assessment area occur on the following soil landscapes of the *Soil Landscapes of the Katoomba 1:100,000 Sheet map* (King 1994):

Wollangambe - Shallow (<70 cm), well-drained Siliceous Sands/Lithosols (Uc1.21, Uc1.24, Um1.33), well-drained Earthy Sands (Uc5.21, Uc5.22) and Yellow Earths (Gn2.21) on crests; moderately deep (<100 cm), well-drained Earthy Sands (Uc5.21, Uc5.22), Yellow Earths (Gn2.21) and Red Earths (Gn2.11) on sideslopes; moderately deep (<120 cm), moderately well-drained Yellow Podzolic Soils (Dy4.21, Dy4.11, Dy5.11) and Gleyed Podzolic Soils (Dg3.1, Dg4.11) developed over shale lenses; shallow (<50 cm), well-drained Siliceous Sands/Lithosols (Uc1.21, Uc1.24) on small rock ledges and low broken scarps.

Warragamba - shallow to deep (50 – 150 cm), rapidly drained Lithosols (Uc6.1, Um6.34, Um1.44) and Earthy Sands (Uc5.22, Um5.42) on crests and ridges; moderately well-drained Brown Earths (Gn3.2) and Yellow Earths (Gn2.2, Gn2.81) on upper slopes; moderately well-drained Yellow Podzolic Soils (Dy4.41, Dy4.11) on lower slopes.

Medlow Bath - moderately deep (<100 cm), well-drained Earthy Sands (Uc5.21, Uc5.22, Um5) and Yellow Earths (Gn2.21) on crests. Moderately deep (<100 cm), well-drained Yellow Earths (Gn2.21, Gn2.24, Gn2.31) and Earthy Sands (Uc5.22) and imperfectly drained Grey Earths (Gn2.81) on sideslopes. Shallow (<60 cm), well-drained Lithosols/Siliceous Sands (Uc1.24, Um1.41) are associated with rock outcrop.

Hassan's Walls - shallow (<30 cm), discontinuous, rapidly drained Lithosols/Siliceous Sands (Uc1.21, Uc1.24, Uc5.11) on small rocky ledges on cliffs; moderately deep, stony, rapidly drained Lithosols/Sands on upper slopes and recently deposited talus; moderately deep (>80 cm), imperfectly to moderately well- drained Yellow Podzolic Soils (Dy2.11, Dy4.11, Dy4.21, Dy5.11) and Brown Podzolic Soils (Db4.11) on lower slopes; shallow (>70 cm), well-drained Sands/Lithosols (Uc1.2) along narrow steep, deeply incised drainage lines; and moderately deep (70 – 150 cm), well-drained Sands/Lithosols (Uc1.2, Uc5.11) along narrow drainage flats.

Cullen Bullen - shallow to moderately deep (<100 cm), moderately well-drained Yellow Podzolic Soils (Dy2.41, Dy2.51) and Yellow Earths (Gn2.21, Gn3.71) on crests; moderately deep (<100 cm), moderately well-drained Yellow Podzolic Soils (Dy5.21), Soloths (Dy3.31, Dy3.41) and Yellow Leached Earths (Gn2.34) on upper slopes and midslopes. Moderately deep to deep (50 – 150 cm), moderately well-drained yellow Solodic Soils and Yellow Podzolic Soils (Dy2.32, Dy2.41, Dy2.42, Dy4.42, Dy5.42) on lower slopes near drainage lines. Shallow (>80 cm), well-drained Yellow Earths (Gn2.21) and Lithosols (Uc1.24) associated with low scarps.

Lithgow - moderately deep (<120 cm), moderately well-drained Red Podzolic Soils (Dr3.41), Yellow Podzolic Soils (Dy2.11, Dy3.11, Dy3.51), Yellow Leached Earths (Gn2.34) and Yellow Earths (Gn2.11) on upper slopes and well-drained areas. Moderately deep to deep (<170 cm), imperfectly drained Solods/yellow Solodic Soils (Dy2.41, Dy3.41, Dy5.41) on lower slopes and in areas of poor drainage.

3.1.5 Native vegetation

Biosis (2022) identified the following plant communities that will be impacted by the proposed development:

- 708: *Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion; 1.79 ha (1.29 ha High Condition Class and 0.50 ha Moderate Condition Class)*
- 766: *Carex sedgeland of the slopes and tablelands*; 0.43 ha *(Low Condition Class)*
- 1248: *Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion; 7.33 ha (6.14 ha High Condition Class, 0.86 Moderate Condition Class and 0.33 Low Condition Class)*
- 1615: *Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin; 0.19 ha (0.18 ha Moderate Condition Class and 0.01 ha Low Condition Class)*
- *Exotic/Unknown: Cleared lands and pastures*.

The BAM lists only two of these as PCTs that LJTF is associated with: PCT 708, PCT 1248.

The location of the PCTs relative to the impact assessment area are provided in Figures 3, 4 and 5.

3.1.6 Rivers and streams

There are very few significant waterways flowing within the study area (Figure 7). This is because the majority of the study area sits on top of ridgelines and the immediately adjacent slopes and so there is little potential for larger streams to develop and there are only short drainage paths in the study area. The Blackheath (Figure 3) and Mt Victoria (Figure 4) sections of the study area contain no more than first order streams within their boundaries and have no permanent water within those streams. Second order streams investigated within the 300 m buffer were still relatively small and ephemeral and did not show any indications of pools of an adequate size and depth to be suitable breeding habitat for JTF.

Larger order streams form in the Hartley section in the southern part of the study area (Figure 5) where Butlers Creek is a 3rd order stream within the western end of the footprint and continues through the 300 m buffer to the west. Notably however, Butlers Creek as a 3rd order stream flows entirely through cleared grazing lands. In the eastern half of the Hartley section and where there is native forest the creek is only a 2nd order stream that is ephemeral flowing and without any permanent pools or rocky base (Plate 2). This type of stream is not identified as breeding habitat for LJTF.

The study area does not contain any water bodies listed on the Directory of Important Wetlands in Australia or that are classified as a Ramsar wetland (see (https://www.awe.gov.au/water/wetlands/australian-wetlands-database/directory-important-wetlands).

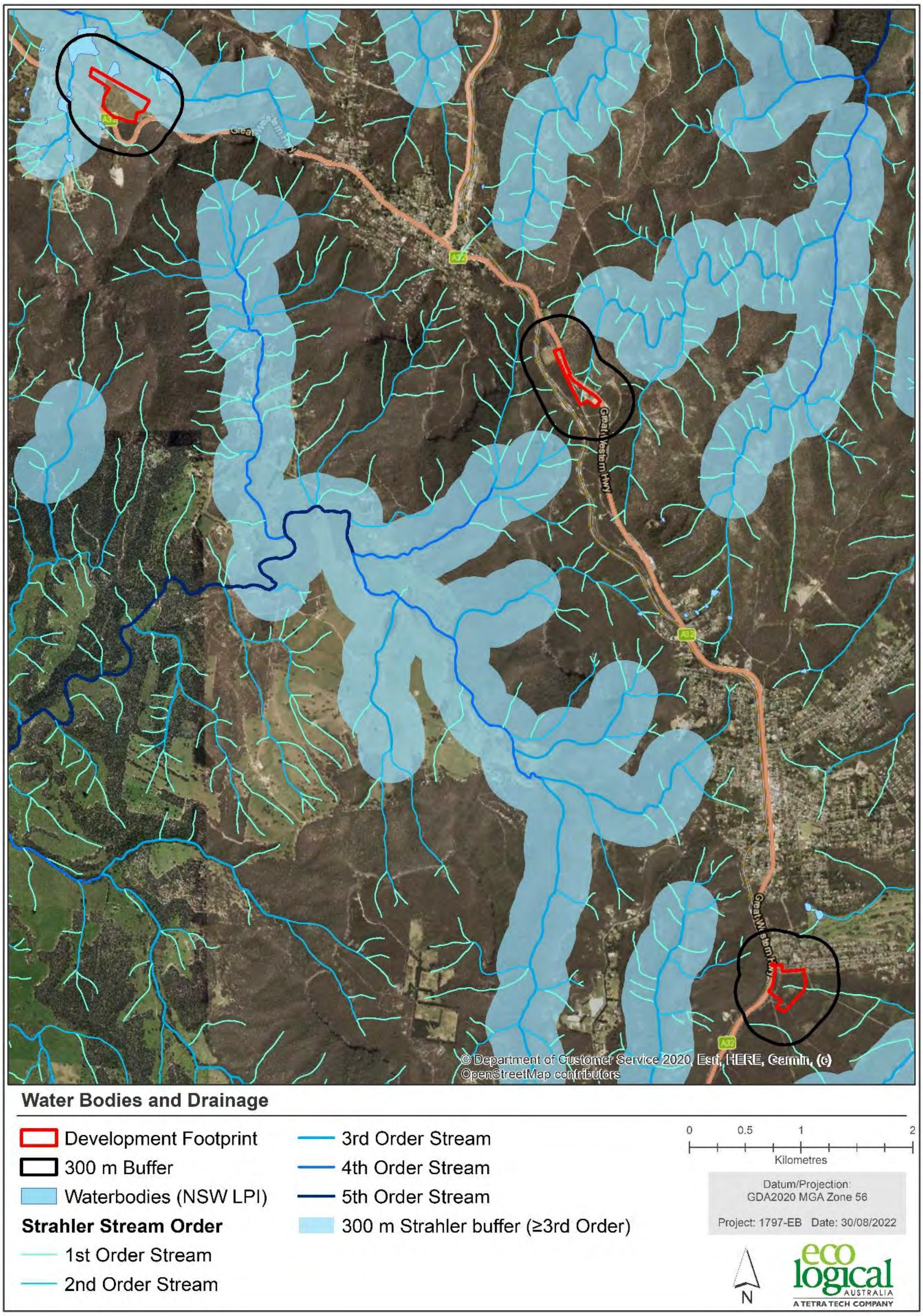

Figure 7. Location of mapped water bodies associated with the study area

3.1.7 Connectivity features

The study area is embedded within areas of National Park. The current footprint of the Great Western Highway dissects this landscape and provides a broad fragmentation of lands to the north and south. Otherwise, native vegetation is relatively continuous either side of the Highway from Blackheath to Mt Victoria and only being interrupted by the urban areas of the towns themselves. The Hartley Valley is substantially cleared for agricultural purposes and the majority of the Hartley section of the proposed development falls on cleared lands. However, there are broad corridors of intact native vegetation all around the Hartley Valley and broadly speaking there is good connectivity across the landscape regardless of the proposed development activities for this project.

3.1.8 Areas of geological significance

There were no recorded karst formations within the study area or within the 300 m buffer area surrounding the study area. The Greater Blue Mountains Area contains cliffs and other rock formations that have deep overhangs and caves and exposed rock outcrops.

3.1.9 Climate

Key climate statistics for the weather stations located for the study area is provided in Table 2. This demonstrates that the study area receives moderate rainfall and has a relatively cool climate compared to much of coastal NSW. This reflects the higher altitude of the study area.

Table 2: Climatic statistics for Mt Boyce and Mt Victoria (taken from the Bureau of Meteorology)

Rainfall station	Mean total rainfall (mm)	Mean January maximum (°C)	Mean January	Mean July	Mean July
Mt Boyce	1005.9	24.3	13.5	9.6	2.6
Mt Victoria	1062.5	23.0	12.0	8.8	1.7

3.2 Land use history

At the time of European settlement, the study area would have consisted of extensive areas of eucalypt forests that produced the eucalypt droplets that lead to the blue haze for which the mountains were named. There would also have been varying areas of sandstone rock outcropping. The area had a long history of aboriginal occupation and the areas around Blackheath were thought to be a summer corroboree meeting place for several Indigenous peoples of the Dharug, Gundungurra and Wiradjuri nations.

Following European settlement of Australia, the site was originally named Hounslow. Governor Lachlan Macquarie renamed the settlement as "Black-Heath", in reference to the colour and texture of the native shrubbery present.

The first road across the Blue Mountains was created in 1814 and Governor Macquarie journeyed across the Blue Mountains in 1815 naming both Springwood and Blackheath. In 1816 – 1817 a military post was built at Springwood to keep communications with Bathurst, which was followed by further posts located at Bull's Camp, Woodford, Weatherboard (Wentworth Falls), Blackheath and Mount Victoria. In 1832 a new and better road was built connecting Mount Victoria to Hartley allowing for safer travel of horse-drawn vehicles.

Buildings were first erected at Blackheath in 1831 and in the 1850's gold was discovered at Bathurst district, resulting in a movement of many people through the area to reach the goldfields. The Blue Mountains railway was completed in the late 1860s to assist in transporting people and materials. Blackheath developed into a town after the Main Western railway line was built with the current station location completed in 1883. A large dam built to supply water for railway steam engines became the public baths.

Although there are the above listed land uses for the area, the majority of the locality (area within 10 km of the study area) remains as conservation lands located in the Blue Mountains National Park. This includes some part of the Greater Blue Mountains World Heritage Area (GBMWHA) to the east of the development footprint. The remaining natural areas are comprised of temperate eucalypt forest with sandstone cliffs.

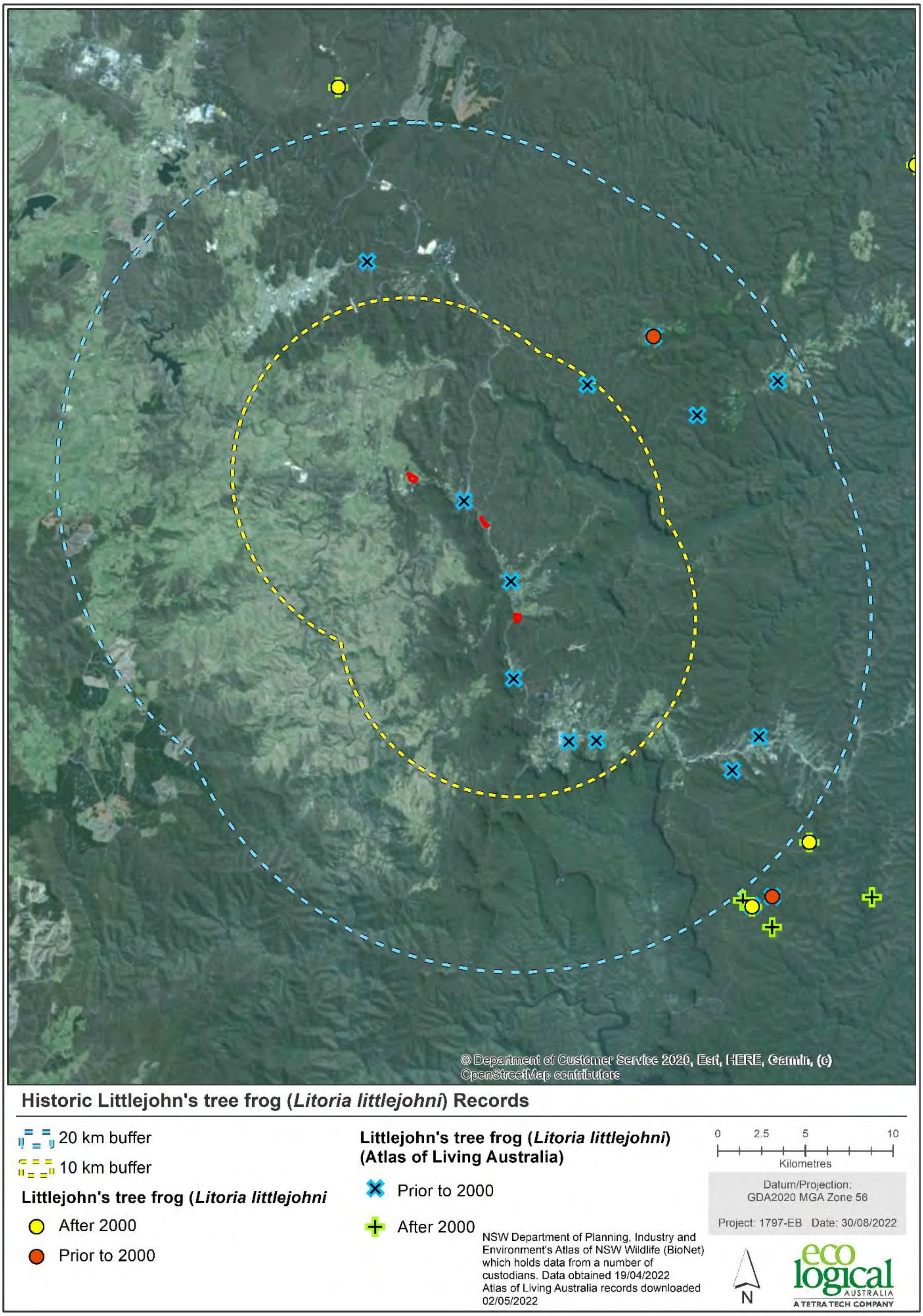

Figure 8. Location of historic records for Littlejohn's Frog in association with the study area

4. Impact assessment area as Littlejohn's Tree Frog habitat

4.1 Littlejohn's Tree Frogs within 20 km of the study area

There are no records of the LJTF within the surface area development footprint and none within the study area or within 10 km (Figure 8). There is a single pre-2000 record of the LJTF within 20 km of the study area that is located to the east. There are four more records to the south of the study area and one to the northeast that fall just outside of the 20 km radius.

The minimal set of available records for the study area is very likely to indicate a true historic rarity of the species, although it is noted again the only recent (1995) recognition of this species that may have results in mis-identifying records of LTJF as another type of whistling tree frog. There remains large areas of relatively undisturbed habitat in the Blue Mountains National Park immediately adjacent to the study site and so there is no lack of apparently suitable habitat for the LJTF. The main impediment to the presence of the species appears to be the lack of suitable breeding habitat observed, with permanent water bodies located within at least relatively intact native vegetation being almost entirely absent (see below).

4.2 Available habitat

An assessment of the habitat present within the three different sections of the study area is provided below. This is based mainly on consideration of the factors provided in Section 2.4.6 and in consideration of the site survey carried out on the 5th and 6th of April (see Figure 9). This site visit provided the opportunity to complete a visual inspection of the length of the development footprint However, some general points can be made for all three sections of the study area.

- The three surface area development footprints run along ridge tops with the edges including the upper slopes of the fall off into the valleys.
- The clearing of the woodlands to create farms and grazing land or for the development of the Great Western Highway and the towns located along the study area will not have favoured this frog as it is known to not inhabit human modified landscapes (Lemckert 2004).
- A viewing of the various creeks present within the study area indicated that only 3rd or higher order streams may potentially hold water enough water to form pools that LJTF may breed in and no streams were seen to have rocky bases that would facilitate the maintenance of longer hydroperiods.
- An important point to note too is that the Plague Minnow (*Gambusia holbrooki*) was found to be present through nearly all of the permanent ponds that occurred in areas that could be flooded or were created on riparian pathways. This included the large number of ponds created on grazing lands to provide water for stock. These ponds would not be suitable for the species given it has not been recorded using ponds or streams outside of areas of native vegetation.

4.2.1 Southern Blackheath section

As indicated in Figure 3, the footprint for this surface area runs along the ridge top and upper slopes to the south of Blackheath from the edge of the township. There is some clearing of the native vegetation for urban development at the northern end of the footprint, otherwise the native vegetation outside of the current road alignment is relatively contiguous and in a sufficiently natural state that it would be suitable foraging and sheltering habitat for this species. This habitat meets the definition of what Lemckert (2010) found as the features that the species is associated with: grass-free, moist and sunny areas that are relatively flat.

The vegetation has been mapped as PCT 708 and PCT 1248, both of which are listed under the BAM as PCTs used by LJTF.

Several gully lines were inspected through the study are for this section and all were found to be very small and showed no indications of carrying water for more than very short periods of time. This was based on the absence of anything more than very shallow water bodies despite their being significant rainfalls through the region over the preceding month (446 mm for Mt Boyce in March). This is supported by the hydrology mapping that shows that all streams within the footprint are first order streams and no greater than a 2nd order stream within the 300 m buffer that comprises the study area. The closest 3rd order streams that may provide large enough pools with a hydro-period suitable for use by the LJTF are all beyond 300 m distance from the edge of the footprint. No ponds or pools were observed located within areas of native vegetation.

4.2.2 Central Mt Victoria section

This section of surface area footprint runs southward along the Great Western Highway from the edge of the Mt Victoria township (Figure 4). This is an approximately 0.6 km length of footprint that falls mainly on the western sides of the Great Western Highway and again follows along ridge tops that mostly run through relatively intact native bushland. There is some clearing of the native vegetation for urban development at the northern and southern ends of the footprint, otherwise the native vegetation outside of the current road alignment remains relatively contiguous and in a sufficiently natural state that it would be suitable foraging and sheltering habitat for LJTF. The vegetation has been mapped as PCT 708 and PCT 1248, again both of which are listed as PCTs used by LJTF.

No permanent streams are present within the study area, with the closest 3rd order streams all being located more than 300 m distance from the edge of the footprint (Figure 6).

One isolated water body was located that was determined to provide suitable pond breeding habitat for LJTF and that was embedded within sufficient native vegetation so that it had the potential to be used. This was a water body approximately 20 m in diameter (Plate 4) and provides a good example of habitat that was being looked for in the site inspection. This pond was located within the initial potential work area, but is now located over 2 km south of the Mt Victoria section (Figure 10). Therefore, it is not of further consideration.

Plate 4: Potential breeding habitat for the LJTF that was located just north of Blackheath, near the Mt Boyce Heavy Vehicle Safety Station. Note the cover of native vegetation along the banks

4.2.3 Northern Hartley Section

The Hartley surface works development footprint runs through an area south of Butlers Creek (Figure 5). As previously noted, Butlers Creek forms a 3rd and then 4th order stream in this section of the development, and this has permanent pools and water flows within those lower order streams. There are also several large human created permanent pondages within the pasture lands adjacent to the footprint, some of which are very large at >100 m in diameter. However, none of these permanent water bodies are located within areas of natural vegetation and so are not to be suitable breeding habitat for the LJTF. They also all appear to contain the Plague Minnow, further reducing their potential for use as breeding habitat. Greater than 95% of this part of the study area is cleared land and so unsuitable as habitat. The only area retaining native vegetation is the southern end of the footprint and comprises native vegetation on a mid-slope. Biosis lists the plant communities present in the study area as 1248 and 1615. PCT1248 first is listed as habitat used by LTJF, but 1615 is not.

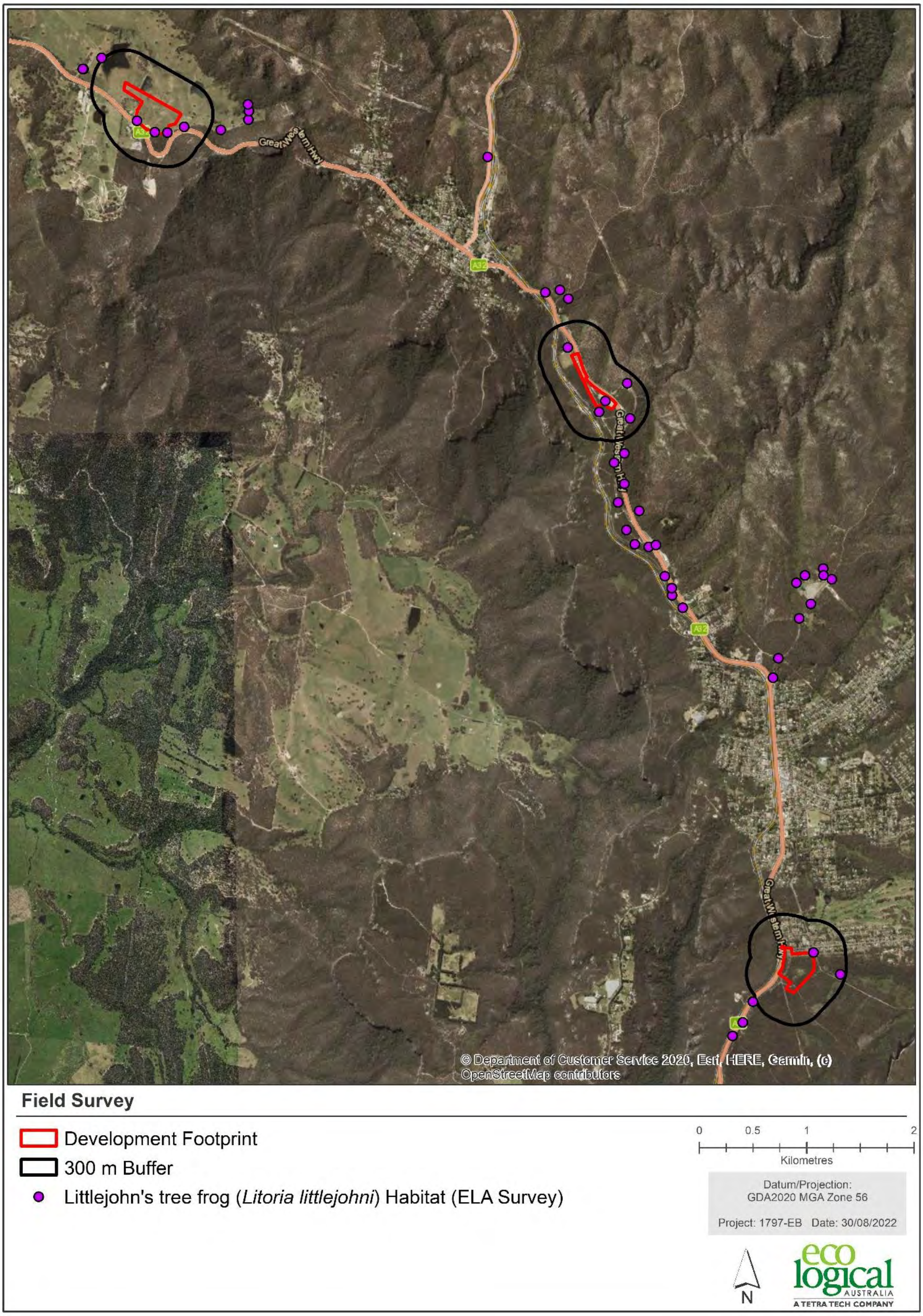

Figure 9: Location of habitat assessment points conducted for the expert report

5. Species presence in the impact assessment area

5.1 Main features determining presence

The main consideration in determining the presence of the LJTF is whether there are suitable water bodies for breeding that are located embedded within areas of relatively intact native vegetation of the type used by this species. Studies have demonstrated the species does not exist in locations where native vegetation is absent, indicating a dependence on elements of native vegetation for their ongoing survival. Water bodies need to have a long enough hydroperiod to allow for the tadpoles to be able to reach metamorphosis, and this is longer than for other species of a similar size. They also should be free of the Plague Minnow and likely other introduced fish that will prey on the eggs and tadpoles.

5.2 Suitability of habitat within the impact assessment area

The surface area development footprints and broader study areas for all three separated development locations contain at least some suitably intact native vegetation identified as being used by LJTF, with the majority of the southern and central surface areas providing relatively continuous foraging and sheltering habitat through most of their lengths. The northern section contains such habitat only within the southern section of the surface area development footprint, although more occurs on the surrounding slopes that are included in the 300 m buffer. Hence there are significant areas of suitable foraging and shelter habitat present and these are continuous with areas of the adjacent Blue Mountains National Park.

However, no suitable breeding habitat was detected within the study area. Streams present were not large and permanent enough and the ponds all occurred within cleared pastures.

The Plague Minnow is known to be widespread within the stream systems of the area and was observed in all water bodies able to be accessed in the site visit. All streams and any pools occurring on floodplains areas, and any associated swamplands, are severely reduced in value as breeding habitat where the Plague Minnow is present, as they eat the eggs and tadpoles of frogs when they can easily access them (Gillespie and Hero 1999). However, the full extent of the effect of the Plague Minnow is uncertain as there have been no direct studies to determine the impact of this fish on LJTF. It is possible that LJTF can co-habit sites where there is suitable emergent vegetation and/or where fish free ephemeral sites can develop. The ponds and streams known to be preferred by the LJTF do not contain dense vegetation.

5.3 Littlejohn's Tree Frog presence within the impact assessment area

Based on the considerations provided in Section 5.1, there are no locations within the study area that would be used by LJTF. None of the ponds or streams observed provided a suitable environment where I would expect LJTF to be present. The streams that occurred within areas of intact native vegetation and that occurred within the footprint or within 300 m of the footprint were not of sufficient size to provide a regular enough water flow and pools with long enough hydroperiods to expect the frog to use the streams and so the surrounding areas. All of the other ponds located were isolated in lands that were essentially cleared of native vegetation and so the species cannot be expected to use those ponds or any vegetation found on or within 300 m of either of the three surface area development footprints.

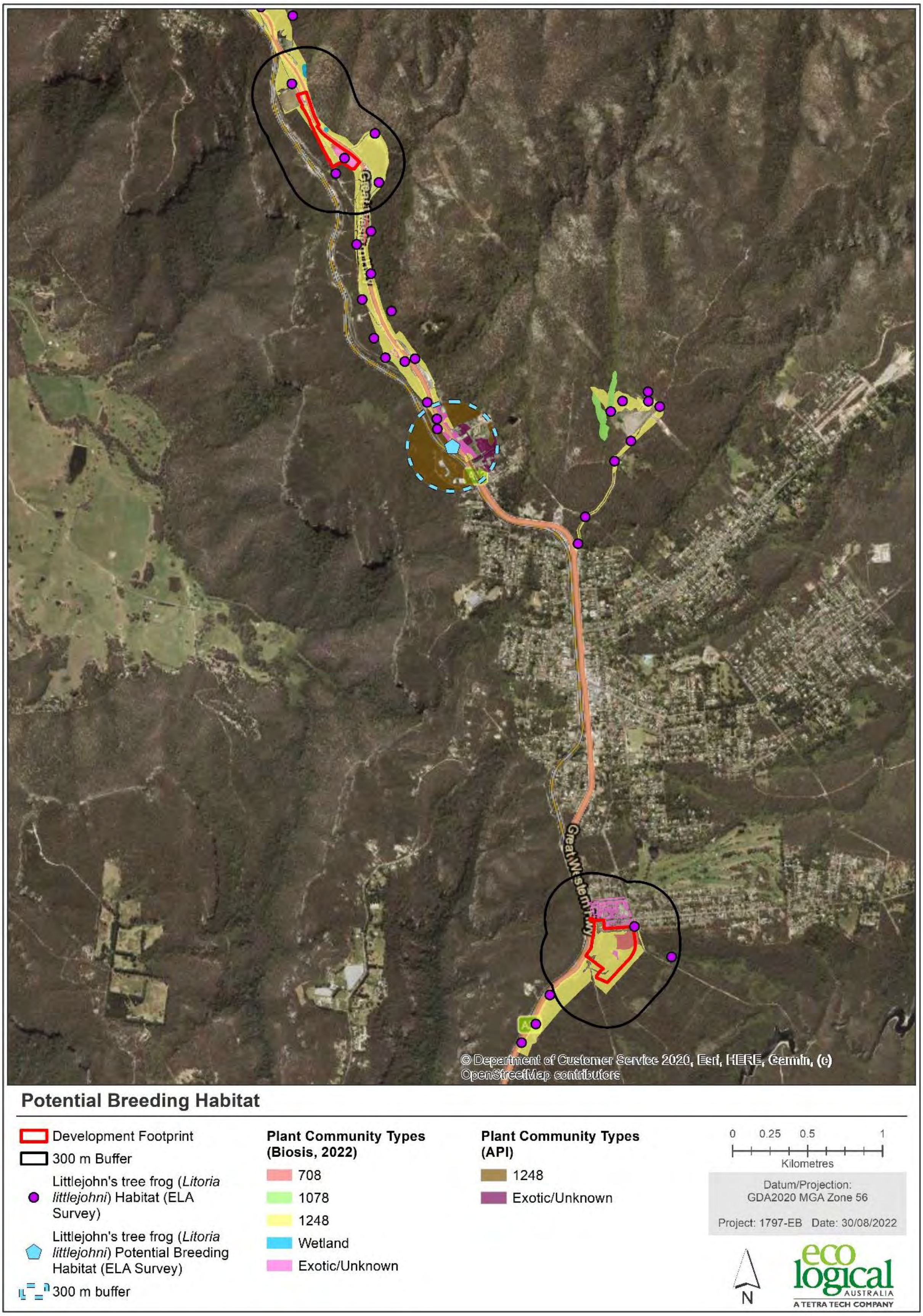

Figure 10. Location of identified LJTF potential breeding habitat compared to surface area development footprints

5.4 Offset for Littlejohn's Tree Frog

As the species is not considered to be present on or within 300 m of either of the three surface area development footprints, there is no impact the LJTF and there is no requirement for an offset.

6. Conclusion

The proposed Blackheath to Little Hartley Upgrade Project of the Great Western Highway will result in disturbance and loss of native vegetation in three separate locations.

This will involve the removal of an estimated 11.02 ha of native vegetation of which 9.12 ha are PCTs that LJTF is listed as being associated with. The loss of any of this vegetation will require an offset if the vegetation falls within 300 m of an identifiable potential breeding habitat for LJTF. However, there are no suitable streams or water bodies that fall within the either of the three surface area development footprints or within 300 m of those footprints (the study area).

Hence there is no requirement for an offset for the LJTF as a result of the loss of breeding or non-breeding habitat as a result of the proposed works.

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8. Appendix A Dr Frank Lemckert CV

Frank Lemckert **PRINCIPAL SCIENTIFIC ECOLOGIST**

Frank has been a professional scientist since 1992, specialising in understanding and managing the ecology and management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland), establishing long-term research and monitoring programs into the management of fauna and developing strategies to mitigate the impacts of human disturbances. He has worked extensively with the NSW state and federal Governments on varying issues of fauna and flora management including the preparation of a draft NSW/National recovery plan for the Giant Burrowing Frog (*Heleioporus australiacus*) and recent expert review roles on fauna management plans and monitoring strategies for the NSW Natural Resources Commission. Frank is an accredited expert under the NSW Biodiversity Assessment Method (BAM) for a range of threatened frogs and wrote the BAM survey guidelines for NSW's threatened frogs. Frank has prepared reports on endemism and representation in reserves of flora and fauna for the Commonwealth, represented the NSW Forestry Commission in license negotiations for the Comprehensive Regional Assessment process (2000), been a member of a state regulators advisory group for the management of Cane Toads across Australia and the Taren Point Cane Toad Advisory Group, and provided expert ecological advice on illegal land clearing for the NSW and Commonwealth Governments. He has authored over 90 peer-reviewed publications. Frank is a research associate with the Australian Museum and University of Newcastle and convenor of the NSW Declining Frog Working Group. He is a recognised expert in frog ecology and management, but has completed management related projects and works on a range of terrestrial vertebrate fauna.

Frank's primary role as a consultant has been to use his expertise and experience in technical writing and threatened species legislation to develop and maintain quality assurance in project reporting including:

- Species Impact Statements.
- >100 flora and fauna reports and assessments of significance using the EP&A Act and EPBC Act.
- Biodiversity Assessment Reports for Warragamba Dam Raising, Nowra Bridge, Golden Highway and Eurobodalla Dam.
- Manager for the Oxley Highway to Kempsey and Frederickton to Eungai ecological monitoring program.
- Lead fauna survey design for the HumeLink transmission line project for Snowy Hydro 2.0.
- Complete targeted survey and monitoring works for threatened frog species including Giant Barred Frogs, Wallum Froglets, Green-thighed Frog and Green and Golden Bell Frogs.
- Construction and Environmental Management Plans, Monitoring Plans and Vegetation Management Plans for roads at Port Macquarie, Berry to Bomaderry and South Nowra.
- Nest Box, microbat and Green and Golden Bell Frog management plans for the Berry to Bomaderry and Oxley Highway to Kempsey Highway Upgrades.
- Review of monitoring strategies for the Woolgoolga to Ballina and Warrell Creek to Nambucca Heads programs for the Pacific Highway Upgrade.
- Review of two proposed Coal Seam Gas Impact Assessment methods for Matters of National Environmental Significance (contracted by the Commonwealth Government).
- Provision of species credit species expert reports for the Warragamba Dam raising project and Western Sydney Growth Centres Biocertification.

- Roadside mapping, survey and management strategies for the Wallum Froglet and Mahony's Toadlet.
- Develop frog and reptile survey guidelines and impact offset guidelines for the Biodiversity Assessment Method.

QUALIFICATIONS

- Bachelor of Science, University of Sydney, 1984 (Terrestrial Ecology and Marine Management)
- Master of Science, University of Sydney, 1991 (Population biology of the Common Froglet)
- PhD, University of Newcastle, 2009 (Management of forest frogs in timber production forests of NSW).

PROJECT EXPERIENCE

ECOLOGICAL IMPACT ASSESSMENT

- MONITORING OF BAT POPULATIONS AND ASSESSMENT OF POTENTIAL IMPACTS OF THE PROPOSED JEREMIAH WINDFARM AT ADJUNGBILLY, NSW (2019-PRESENT).
- MANAGEMENT OF IMPACTS ON GREEN AND GOLDEN BELL FROGS FOR THE KIWEF PROJECT AT KOORAGANG ISLAND, NSW FOR DARACON (2019-PRESENT).
- IMPACT ASSESSMENTS FOR HOUSING DEVELOPMENTS ON KOALAS IN THE CAMPBELLTOWN AREA (PRIVATE DEVELOPMENT AND CAMPBELLTOWN COUNCIL (2019)
- EXPERT REPORT ON THE GREEN AND GOLDEN BELL FROG FOR TWO WESTERN SYDNEY GROWTH AREAS BIOCERTIFICATION PROJECT (2018-PRESENT)
- WARRAGAMBA DAM RAISING PROJECT TARGET SURVEYS, IMPACT ASSESSMENTS, EXPERT REPORTING (SIX SPECIES) AND Q/A FOR WATER NSW (2018-19)
- GRANITE HILLS WINDFARM BIRD AND BAT STRIKE MODELLING AND ECOLOGICAL IMPACT ASSESSMENT, NIMMITABEL, AKUO ENERGY (2018) AND ELYSIAN WINDFARM, NIMMITABEL, AKUO ENERGY (2018)
- VEGETATION REMOVAL AND THREATENED FROG MANAGEMENT STRATEGIES, NEW INTERCITY FLEET MANAGEMENT FACILITY, JOHN HOLLAND GROUP (2018-PRESENT)
- NOWRA BRIDGE EIS ECOLOGICAL ASSESSMENTS, NSW RMS (2018)
- HEATHCOTE ROAD UPGRADE IMPACT ASSESSMENT AND REVIEW OF MITIGATION MEASURES, NSW RMS (2018-2019)
- EUROBODALLA DAM BIODIVERSITY ASSESSMENT REPORT, EUROBODALLA SHIRE COUNCIL (2017-18).

GOVERNMENT REVIEWS/REPORTS

- BIODIVERSITY ASSESSMENT METHOD FROG SURVEY GUIDELINES FOR SPECIES CREDIT SPECIES (2020)
- EXPERT WORKSHOP TO DEVELOP A NSW-WIDE NIL-TENURE FAUNA MONITORING PROGRAM, NSW NATURAL RESOURCES COMMISSION (2020)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- EXPERT REVIEW OF BIODIVERSITY IMPACT ASSESSMENT REPORT FOR THE HORNSBY QUARRY REHABILITATION PROJECT (2019)
- HORNSBY COUNCIL EXPERT WITNESS FOR DEVELOPMENT IMPACTS AT DURAL, HORNSBY SHIRE COUNCIL (2016)

- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT EVANS HEAD, NSW STATE GOVERNMENT (2016)
- EXPERT ADVICE ON IMPACTS OF ILLEGAL LAND CLEARING AT SOMERSBY, COMMONWEALTH GOVERNMENT (2015)
- REVIEW OF MONITORING STRATEGIES FOR THE WOOLGOOLGA TO BALLINA AND WARRELL CREEK TO NAMBUCCA HEADS PROGRAMS FOR THE PACIFIC HIGHWAY UPGRADE, NSW RMS (2014)
- REVIEW OF IMPACT ASSESSMENT PATHWAYS FOR TWO LPNG PROJECTS, COMMONWEALTH GOVERNMENT (2013)
- REVIEW OF THREATENED SPECIES MODELLING IN FORESTRY AREAS, VIC FORESTS (2012)
- FLORA AND FAUNA REPRESENTATION IN THE AUSTRALIAN RESERVE SYSTEM, COMMONWEALTH GOVERNMENT (2010)
- FLORA AND FAUNA ENDEMISM PATTERNS ACROSS AUSTRALIA, COMMONWEALTH GOVERNMENT (2009)
- REVIEW IMPACTS TO THREATENED REPTILES AND AMPHIBIANS IN THE SOUTHERN BRIGALOW BELT, FOR WPS (2008)
- EXPERT REPRESENTING FORESTS NSW IN THE COMPREHENSIVE REGINAL ASSESSMENT PROGRAM FOR THE REGIONAL FOREST AGREEMENT PROGRAM (1999-2001)
- EXPERT REVIEW OF FAUNA AND FLORA IMPACTS FOR 13 NSW FORESTRY COMMISSION EIS REPORTS (1992-94).

EPBC REFERRALS

- AUSTEN QUARRY (*EUCALYPTUS PULVERULENTA*), HARTLEY, HY-TEC INDUSTRIES (2014-15)
- MARYS MOUNT KOALA (*PHASCOLARCTOS CINEREUS*) REFERRAL, GUNNEDAH QUARRY PRODUCTS (2015)
- GREEN AND GOLDEN BELL FROG (*LITORIA AUREA*) REFERRALS FOR THE PRINCES HIGHWAY UPGRADE AT SOUTH NOWRA, NSW RMS (2011-2012).

MONITORING PROGRAMS

- NIL-TENURE FERAL MANAGEMENT AND MONITORING STRATEGY FOR THE NARRABRI COAL SEAM GAS PROJECT, SANTOS (2019).
- THREATENED FAUNA MONITORING HUME HIGHWAY, KAPOOKA, NSW RMS (2018)
- GREEN AND GOLDEN BELL FROG BASELINE MONITORING PROGRAM AT MEROO LAKES, NSW OEH (2016-17)
- OXLEY HIGHWAY TO KEMPSEY THREATENED BIODIVERSITY MONITORING, NSW RMS (2013-2017)
- FCNSW STATE-WIDE ECOLOGICAL MONITORING PROGRAM, FORESTRY CORPORATION OF NSW (2009-10)

PLANS OF MANAGEMENT / STRATEGIES

- GREEN AND GOLDEN BELL FROG PRE-CLEARING WORKS KOORAGANG ISLAND (DARACON 2016 & CURRENT)
- REVIEW OF SPECIES MANAGEMENT PLANS FOR THE YELLOW-BELLIED GLIDER, GIANT BURROWING FROG, EASTERN BRISTLEBIRD AND SOUTHERN BROWN BANDICOOT PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- PROVISION OF INFORMATION AS THE BASIS FOR THE DEVELOPMENT OF SIX THREATENED FLORA SPECIES MANAGEMENT PLANS TO BE PREPARED UNDER THE NSW THREATENED SPECIES LICENSE FOR FORESTRY OPERATIONS, NSW NATURAL RESOURCES COMMISSION (2019)
- NESTBOX, MICROBAT AND GREEN AND GOLDEN BELL FROG MANAGEMENT PLANS, BERRY TO BOMADERRY UPGRADE OF THE PRINCES HIGHWAY, NSW RMS (2017)
- GREEN AND GOLDEN BELL FROG SURVEYS AND MONITORING, PRINCES HIGHWAY UPGRADES AT SOUTH NOWRA AND BERRY TO BOMADERRY, NSW RMS (2012-2017)
- THREATENED FROG MODELLED HABITAT REQUIREMENTS, HORNSBY SHIRE COUNCIL (2016)
- MICROBAT MANAGEMENT PLAN FOR CLARENCETOWN BRIDGE, NSW RMS (2016)

- EASTERN BENTWING-BAT MANAGEMENT PLAN, GERRINGONG, NSW RMS (2014)
- GREEN AND GOLDEN BELL FROG MANAGEMENT STRATEGY, PRINCES HIGHWAY UPGRADE, NSW RMS (2012-2014)
- EXPERT REVIEW OF THREATENED FROG MANAGEMENT PLAN - WOOLGOOLGA TO BALLINA UPGRADE, NSW RMS (2014)
- THREATENED MICROBAT MANAGEMENT PLAN FOR WARRINGAH MALL, NORTHERN BEACHES COUNCIL (2014)
- COMMONWEALTH/NSW GIANT BURROWING FROG RECOVERY PLAN, DEWHA/DECC (2012)
- NSW DPI REPRESENTATIVE FOR THE NATIONAL ADVISORY GROUP ON CANE TOAD MANAGEMENT (2009-2011)
- TAREN POINT CANE TOAD MANAGEMENT ADVISORY GROUP (2007-2008).

TRAINING

- LEAD INSTRUCTOR > 50 WILDLIFE TRAINING SCHOOLS RUN IN NSW, ACT AND VICTORIA PROVIDING PRESENTATIONS ON THE SURVEY, IDENTIFICATION AND MANAGEMENT OF ALL FLORA AND FAUNA. THIS INCLUDED DETAILED INSTRUCTION ON THE MANAGEMENT OF THREATENED WADING AND AQUATIC BIRDS AND OTHER AQUATIC SPECIES PRESENTED TO QUEENSLAND, VICTORIAN, NSW AND COMMONWEALTH GOVERNMENT STAFF (1993-2017)
- PRIVATE FORESTRY SURVEY REQUIREMENTS, VICTORIAN TIMBER (2016).

PUBLICATIONS

Book Chapters

Hecnar S. J., & Lemckert, F.L. 2012. Habitat Protection: Refuges and Reserves. Pp 3636-3675 In Biology of the Amphibia Volume 10 - Conservation and Decline of Amphibians: Ecology, Effects of Humans, and Management. H. Heatwole (Ed.). Surrey-Beattey and Sons, Sydney.

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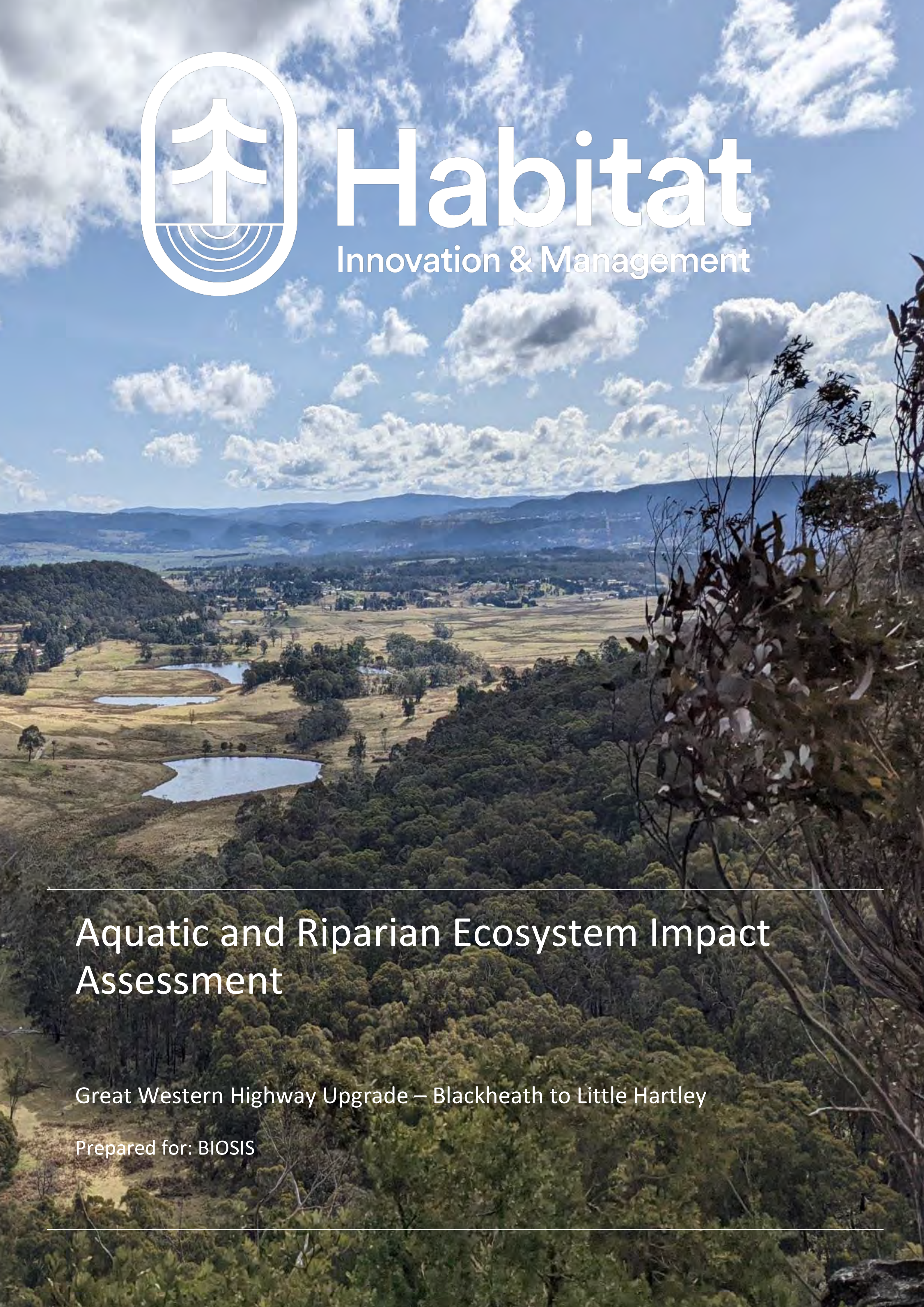
Annexure H – Aquatic ecology report



Habitat
Innovation & Management

Aquatic and Riparian Ecosystem Impact Assessment

Great Western Highway Upgrade – Blackheath to Little Hartley

Prepared for: BIOSIS

Document Tracking

PROJECT NUMBER	2020-40 HAB
PROJECT NAME	Aquatic and Riparian Ecosystem Impact Assessment
PROJECT ADDRESS	Great Western Highway Upgrade – Blackheath to Little Hartley
PREPARED FOR	BIOSIS
AUTHOR/S	Carl Tippler, Ben Green, James Taylor
DATE PREPARED	[Comments]
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Glossary and Abbreviations

ACRONYM	DESCRIPTION
AWRC	Advanced Water Recycling Centre
BC Act	NSW Biodiversity Conservation Act 2016
CEMP	Construction Environmental Management Plan
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
FM Act	NSW Fisheries Management Act 1994
GBMWHA	Greater Blue Mountains World Heritage Area
IA	Impact Assessment
KFH	Key Fish Habitat
GDE	Groundwater Dependent Ecosystem
LGA	Local Government Area
MNES	Matters of National Environmental Significance
NorBE	Negative or Beneficial Effect
SEARs	Secretary's Environmental Assessment Requirements
PCT	Plant Community Type
VMP	Vegetation Management Plan
VRZ	Vegetated Riparian Zone
WMA	NSW Water Management Act 2000

Executive Summary

Transport for NSW is seeking approval under Division 5.2, Part 5 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) to upgrade the Great Western Highway between Blackheath and Little Hartley (the project).

The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for portals to the east and west of the proposed tunnel portals. The project would be located within the Blue Mountains and Lithgow Local Government Areas (LGA).The majority of the project would be located below ground generally along or adjacent to the west of the existing Great Western Highway between around Blackheath and Little Hartley.

The primary objective of this study is to provide a scientifically robust assessment of aquatic and riparian ecosystems, with focus on the legislative requirements outlined by the Environment Protection and Biodiversity Conservation Act 1999, NSW Biodiversity Conservation Act 2016, NSW Fisheries Management Act 1994 and the NSW Water Management Act 2000.

This report assesses potential impacts to aquatic and riparian ecosystems resulting from direct, indirect and cumulative impacts associated with the construction and operational phases of the project.

Measures to prevent and/or minimise any potential environmental impacts recommended.

The key findings of this assessment include:

- potential impacts to water quality of receiving creeks and swamps during the construction phase of the project which are associated with aboveground bulk earthworks and construction. Overland flow and stormwater discharge from the construction sites have potential to increase turbidity and suspended sediments in the water column, the effects of which are well known and include reduced light penetration of the water column which in turn reduces photosynthesis and associated primary production and can lead to a shift in the trophic status of the creeks. To mitigate the potential risks of surface water runoff from construction sites, comprehensive environmental mitigation measures would need to be implemented at each construction site. These mitigation measures should focus on avoiding or minimising the release of sediment-laden water from the sites, and management of potential leaks and spills. A program to monitor surface water quality around construction sites would be established prior to the commencement of construction, and would continue during construction activities, to provide a real-time early indicator of potential impacts from construction site runoff and an opportunity for adaptive management measures to be implemented to reduce pollutant loads leaving construction sites
- potential impacts to receiving creeks and swamps during the construction phase of the project would be related to increased run-off from construction areas which have potential to scour and erode creek bed and banks causing channelisation. Earthworks and changes to the site resulting in concentrated flows, that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters. If left unmitigated erosion impacts have potential to cause damage to the headwater wetland/swamp ecosystems. However, the risk of these impacts occurring can be avoided if best practice construction methods are used and effective erosion and sediment controls are put in place. The controls should focus on reducing the volume/ energy of construction site discharges (to more closely reflect existing environmental conditions) and to align discharge water quality, particularly turbidity/ suspended solids to be generally consistent with or better than existing environmental water quality (as relevant to the receiving watercourse).
- the predicted changes in baseflow indicate that the majority of creeks present in the study area will experience a less than one percent change in average minimum baseflow during construction and operation of the project.

The exception to this is Greaves Creek (near the Blackheath construction site) which is predicted through groundwater modelling to experience:

- a reduction in baseflow during a dry year of 15.5% (50^{th} percentile) and 17.0% (95^{th} percentile) following construction of the project
- a reduction in baseflow during an average year of 0.5% (50^{th} percentile) and 1.0% (95^{th} percentile) following construction of the project
- a reduction in baseflow during a wet year of 0.2% (50^{th} percentile) and 0.4% (95^{th} percentile) following construction of the project.

- to better understand and respond to potential impacts on groundwater dependent ecosystems (GDEs) along Greaves Creek, it is recommended that further investigations be carried out, including:
  - surface and groundwater monitoring to extend and augment the existing dataset relevant to Greaves Creek and associated GDEs
  - ecological monitoring to better characterise the extent, composition and health of the Greaves Creek aquatic and riparian ecosystems, including GDEs
  - updated groundwater modelling based on the final design of the project, and taking into account additional surface water and groundwater data
  - further consideration of potential impacts on Greaves Creek and GDEs through groundwater drawdown and loss of baseflow based on updated groundwater modelling.
- subject to the outcomes of more detailed assessment based on updated groundwater modelling, where a material impact on Greaves Creek and GDEs continues to be identified, further consideration of appropriate mitigation and management measures should be pursued. If required, additional design-related mitigation measures could be considered, particularly relating to options to reduce the ongoing groundwater drawdown associated with the Blackheath portal. Other measures to supplement/ offset predicted reductions in watercourse baseflows could also be considered.
- the project would not have a significant impact on the Macquarie Perch (*Macquaria australasica*), which is listed as endangered under both the NSW *Fisheries Management Act 1994* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
- mitigation of operational risks to aquatic and riparian ecosystems can be avoided if best practice surface water management methods are used and effective erosion and sediment controls are put in place. The controls should focus on reducing the volume/ energy of operational site discharges (to more closely reflect existing environmental conditions) and to align discharge water quality, particularly turbidity/ suspended solids to be generally consistent with or better than existing environmental water quality (as relevant to the receiving watercourse).
- concrete used in the construction of operational infrastructure may cause impacts to the aquatic and swamp/riparian ecosystems. These effects are most likely to occur in the upper reaches of the receiving waterways and impacts will likely decrease with distance downstream as the self-amelioration action of these creeks, which is evidenced by the water quality and macroinvertebrate results shown in this study. The potential for concrete related change should be considered in establishing water quality criteria for site discharges to minimise the potential for material impacts to downstream aquatic and swamp/riparian ecosystems.

1 Introduction

1.1 Project context and overview

The Great Western Highway is the key east-west road freight and transport route between Sydney and Central West New South Wales (NSW). Together, the Australian Government and the NSW Government are investing more than $4.5 billion towards upgrading the Great Western Highway between Katoomba and Lithgow (the Upgrade Program). Once upgraded, over 95 kilometres of the Great Western Highway will be two lanes in each direction between Emu Plains and Wallerawang.

The Upgrade Program comprises the following components:

- Great Western Highway Upgrade – Medlow Bath (Medlow Bath Upgrade): upgrade and duplication of the existing surface road corridor with intersection improvements and a new pedestrian bridge (approved)
- Great Western Highway East – Katoomba to Blackheath (Katoomba to Blackheath Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway east of Blackheath (approved)
- Great Western Highway Upgrade Program – Little Hartley to Lithgow (West Section) (Little Hartley to Lithgow Upgrade): upgrade, duplication and widening of the existing surface road corridor, with connections to the existing Great Western Highway at Little Hartley (approved)
- Great Western Highway Blackheath to Little Hartley: construction and operation of a twin tunnel bypass of Blackheath and Mount Victoria and surface road works for tie-ins to the east and west of the tunnel (the project).

The components of the Upgrade Program are shown in Figure 1.

Transport for NSW (Transport) is seeking approval under Division 5.2, Part 5 of the Environmental Planning and Assessment Act 1979 (NSW) (EP&A Act) to upgrade the Great Western Highway between Blackheath and Little Hartley (the project).

The project would comprise the construction and operation of new twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, and associated surface road upgrade work for tie-ins to the east and west of the proposed tunnel portals.

The project would be located around 90 kilometres northwest of the Sydney CBD and located within the Blue Mountains and Lithgow Local Government Areas (LGA).

The majority of the project would be located below ground generally along or adjacent to the west of the existing Great Western Highway between around Blackheath and Little Hartley.

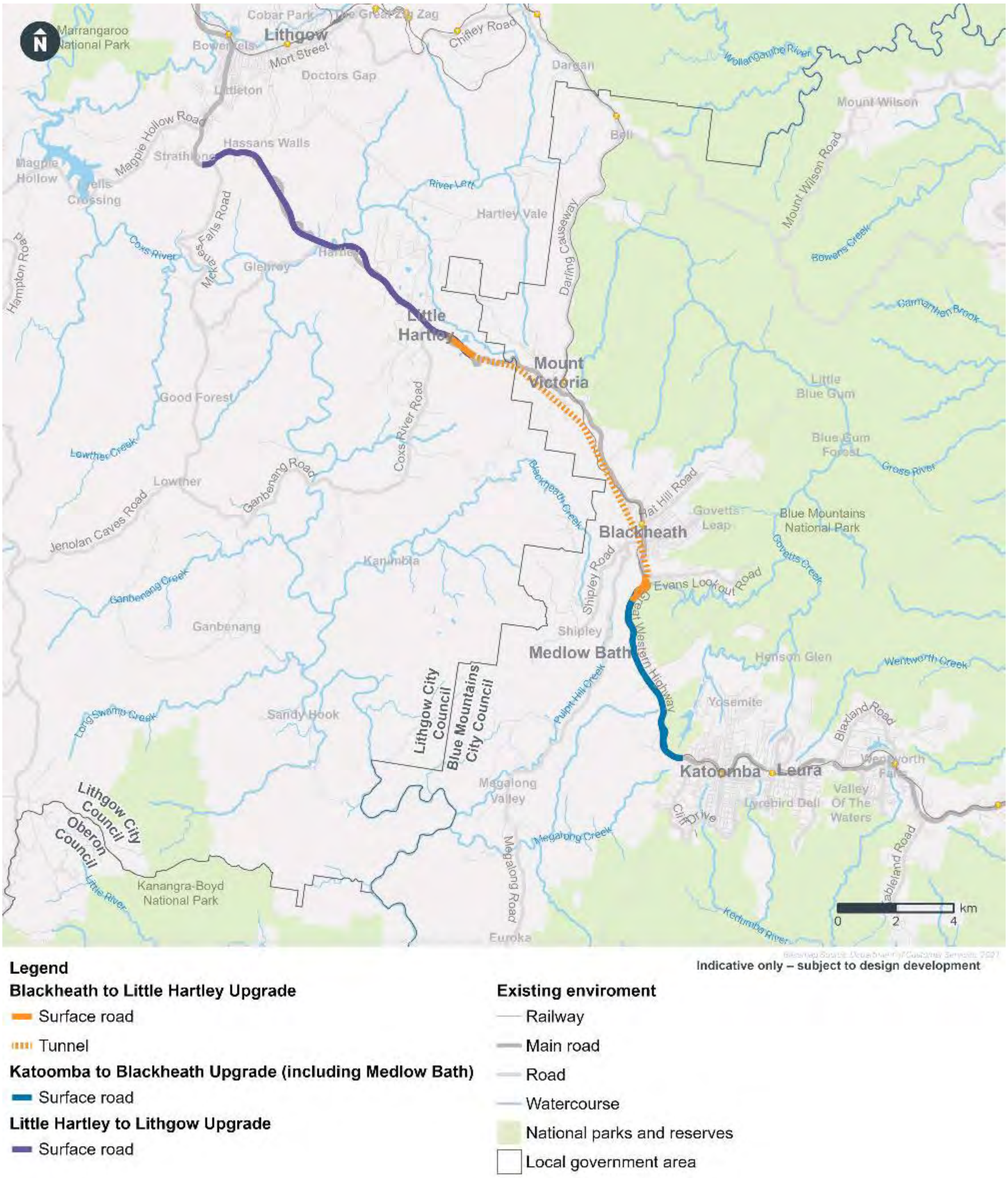

Figure 1 The Great Western Highway Upgrade Program (AECOM 2022a).

1.2 The project

1.2.1 Key components of the project

Key components of the project are summarised in Table 1 and shown in Figure 2. These components are described in more detail in Chapter 4 (Project description) of the environmental impact statement (EIS).

The indicative operational configuration of the surface road network at Blackheath and Little Hartley is shown in Figure 3 and Figure 4.

Subject to approval, the project is anticipated to be open to traffic in 2030.

Table 1 Key components of the project

Key project components	Summary
Tunnels	Twin tunnels around 11 kilometres in length between Blackheath and Little Hartley, connecting to the upgraded Great Western Highway at both ends. Each tunnel would include two lanes of traffic and road shoulders and would range in depth from just below the surface near the tunnel portals, to up to around 200 metres underground at Mount Victoria.
Surface work	Surface road upgrade work would be required to connect the tunnels and surface road networks south of Blackheath and at Little Hartley. The twin tunnels would connect to the surface road network via: • mainline carriage ways and on- and off-ramps at the Blackheath portal, located adjacent to the existing Great Western Highway and south of Evans Lookout Road • mainline carriageways at the Little Hartley portal, located adjacent to the existing Great Western Highway at the base of the western escarpment below Victoria Pass and southwest of Butlers Creek.
Operational infrastructure	Operational infrastructure that would be provided by the project includes: • a tunnel operations facility adjacent to the Blackheath portal • in-tunnel ventilation systems including jet fans and ventilation ducts connecting to the ventilation facilities • one of two potential options for tunnel ventilation currently being investigated, being: - ventilation design to support emissions via ventilation outlets; or - ventilation design to support emissions via portals • water quality infrastructure including sediment and water quality basins, an onsite detention tank at Blackheath and a water treatment plant at Little Hartley • fire and life safety systems, emergency evacuation and ventilation infrastructure and closed circuit television • lighting and signage including variable message signs and associated infrastructure such as overhead gantries.
Utilities	Key utilities required for the project would include: • a new electricity substation at Little Hartley to facilitate construction and operational power supply • a new pipeline between Little Hartley and Lithgow to facilitate construction and operational water supply

Key project components	Summary
	• other utility connections and modifications, including electricity substations in the tunnel.
Other project elements	The project would also include: • integrated urban design initiatives • landscape planting.

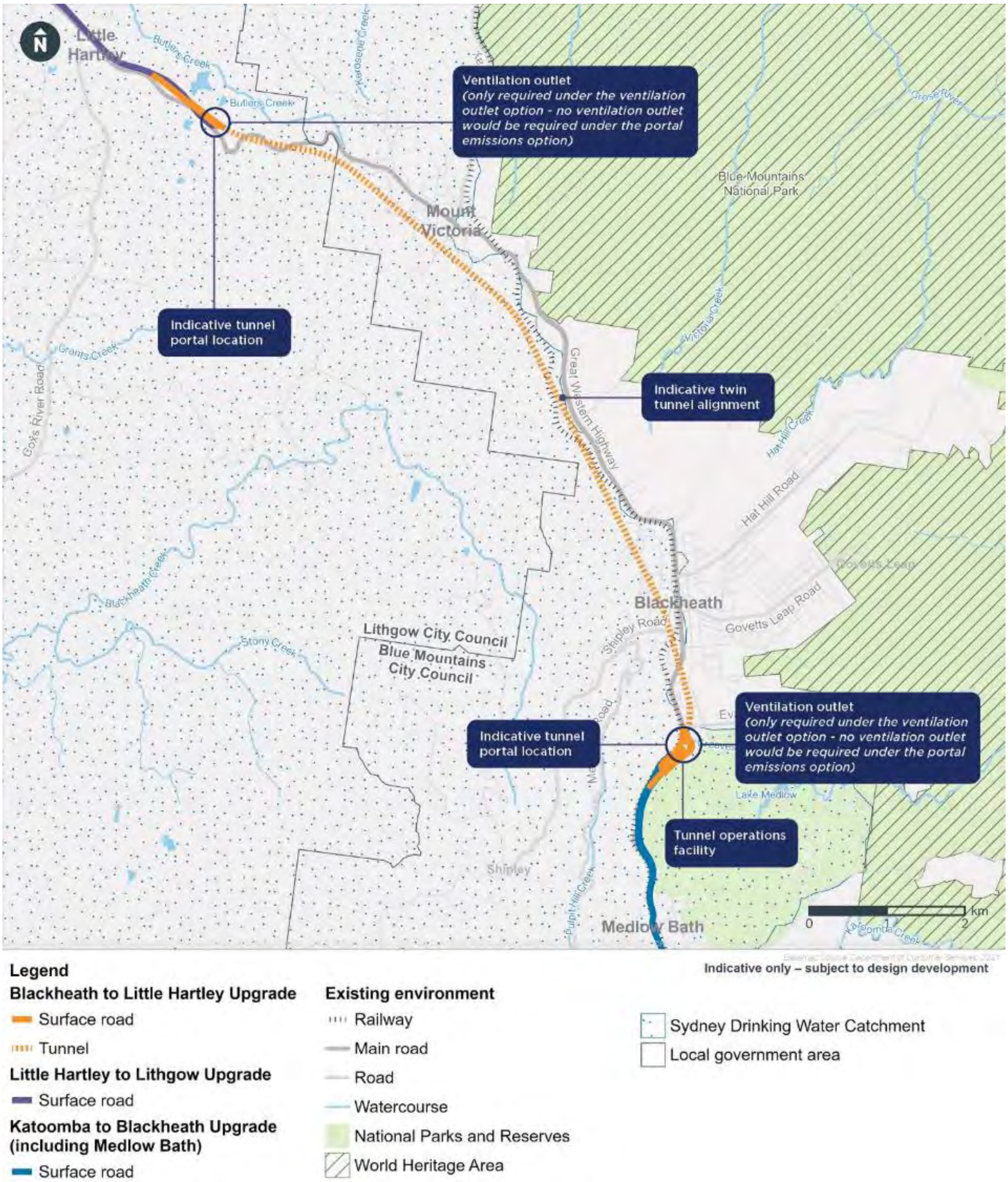

Figure 2 Overview of the project (AECOM 2022a).

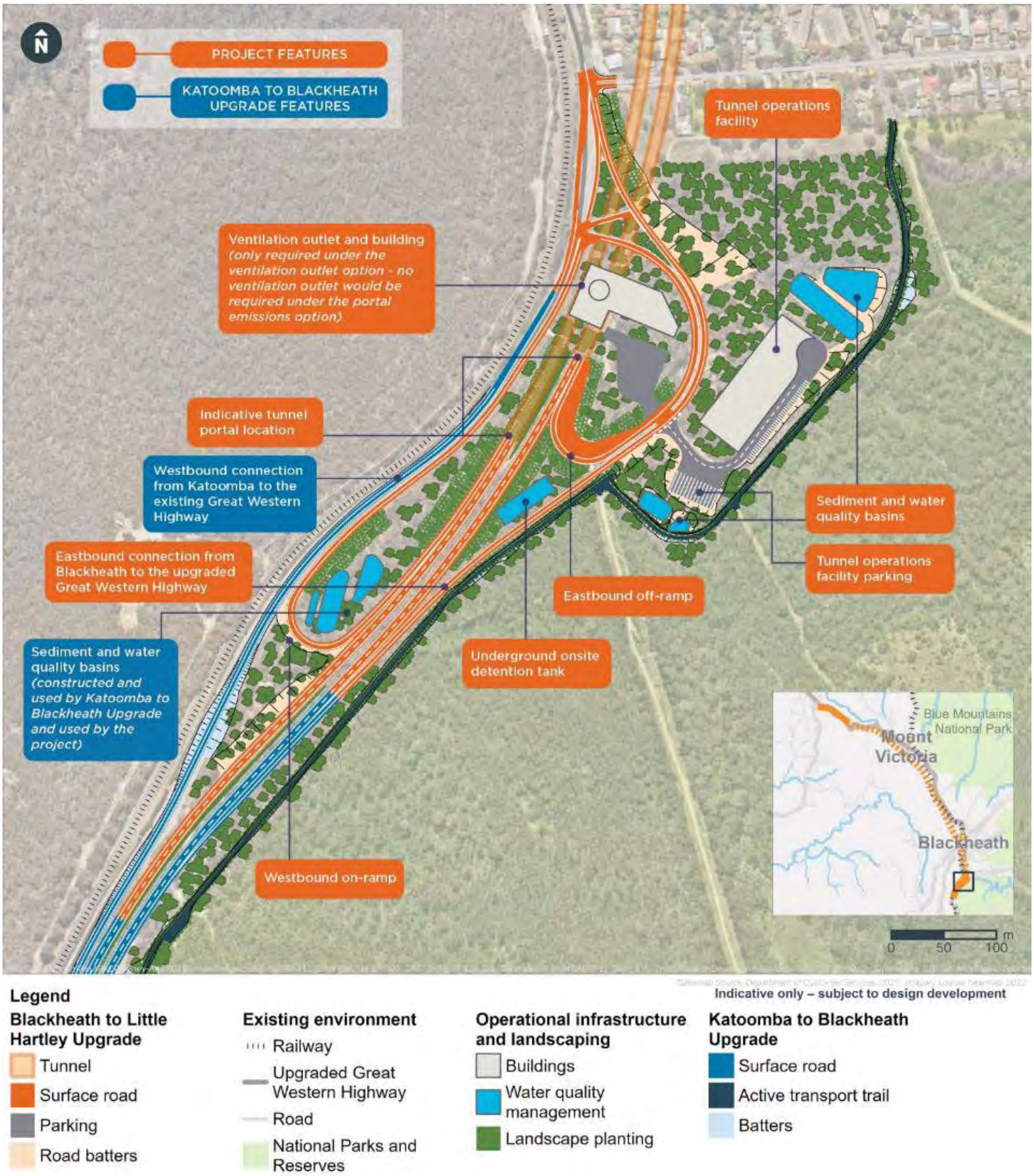

Figure 3 Indicative operational configuration at Blackheath (AECOM 2022a).

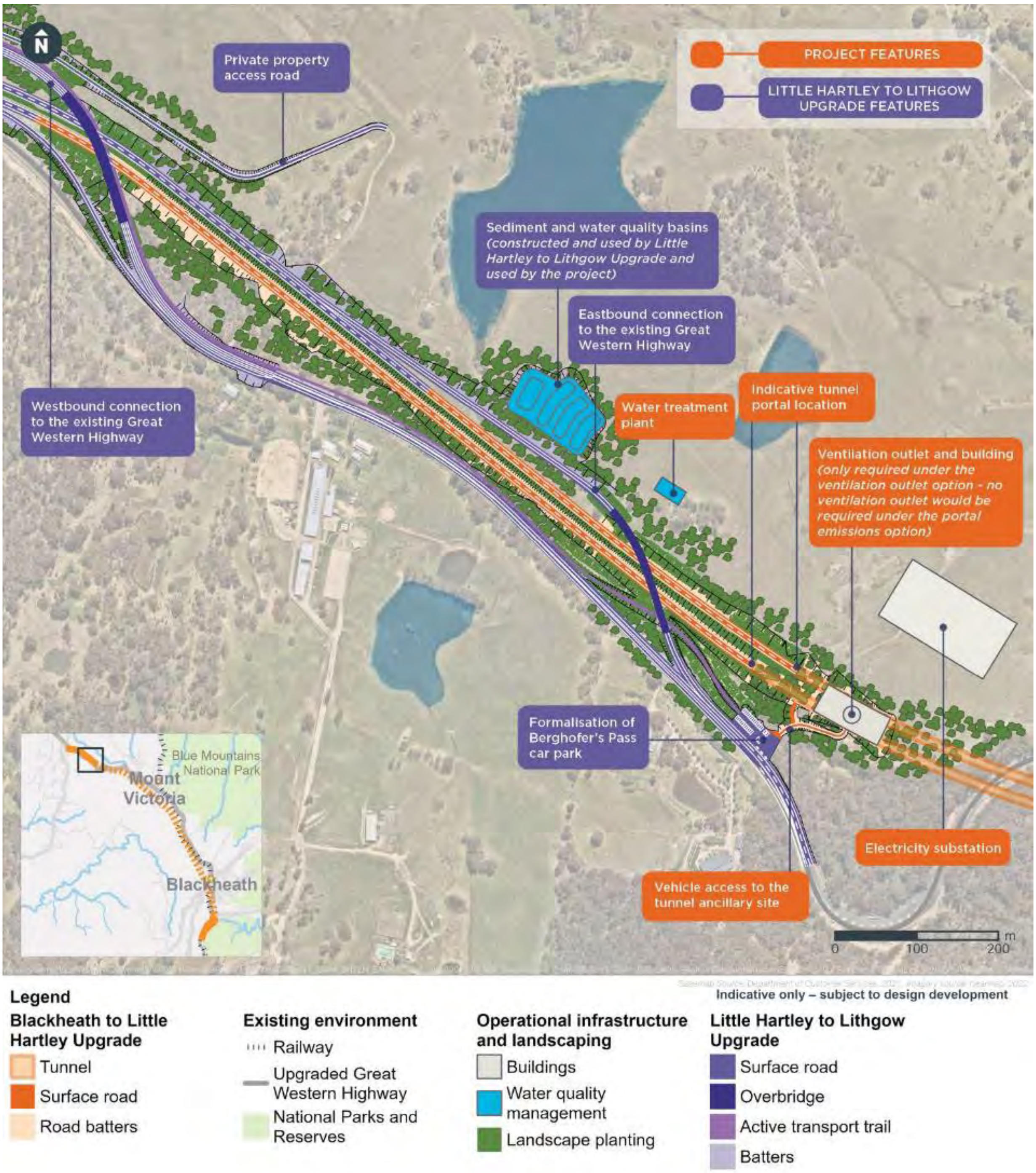

Figure 4 Indicative operational configuration at Little Hartley (AECOM 2022a).

1.2.2 Project construction

Construction of the project would include:

- site establishment and enabling works
- tunnel portal construction
- tunnelling and associated works
- surface road upgrade works
- operational infrastructure construction and fit-out, including construction of operational environmental controls
- finishing works, testing, and commissioning.

These activities are described in more detail in Chapter 5 (Construction) of the EIS.

The indicative construction footprint for the project is shown in Figure 5 to Figure 7, including construction site layout and access arrangements.

Construction of the project is expected to take around eight years. Subject to planning approval, construction is planned to commence in 2024 and be completed by late 2031; however, the project would be open to traffic by 2030.

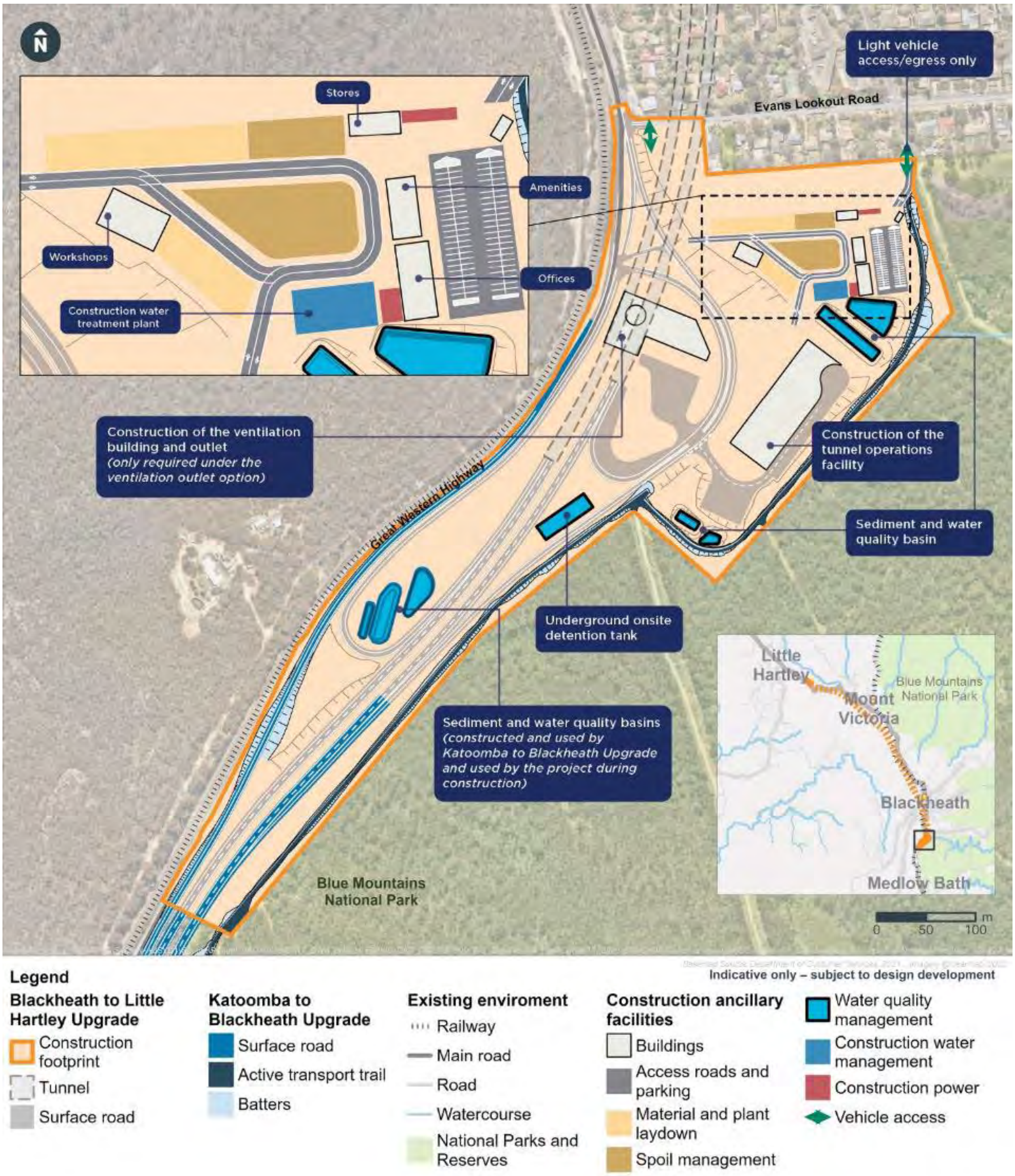

Figure 5 Indicative construction footprint at Blackheath (AECOM 2022a).

Figure 6 Indicative construction footprint at Soldiers Pinch (AECOM 2022a).

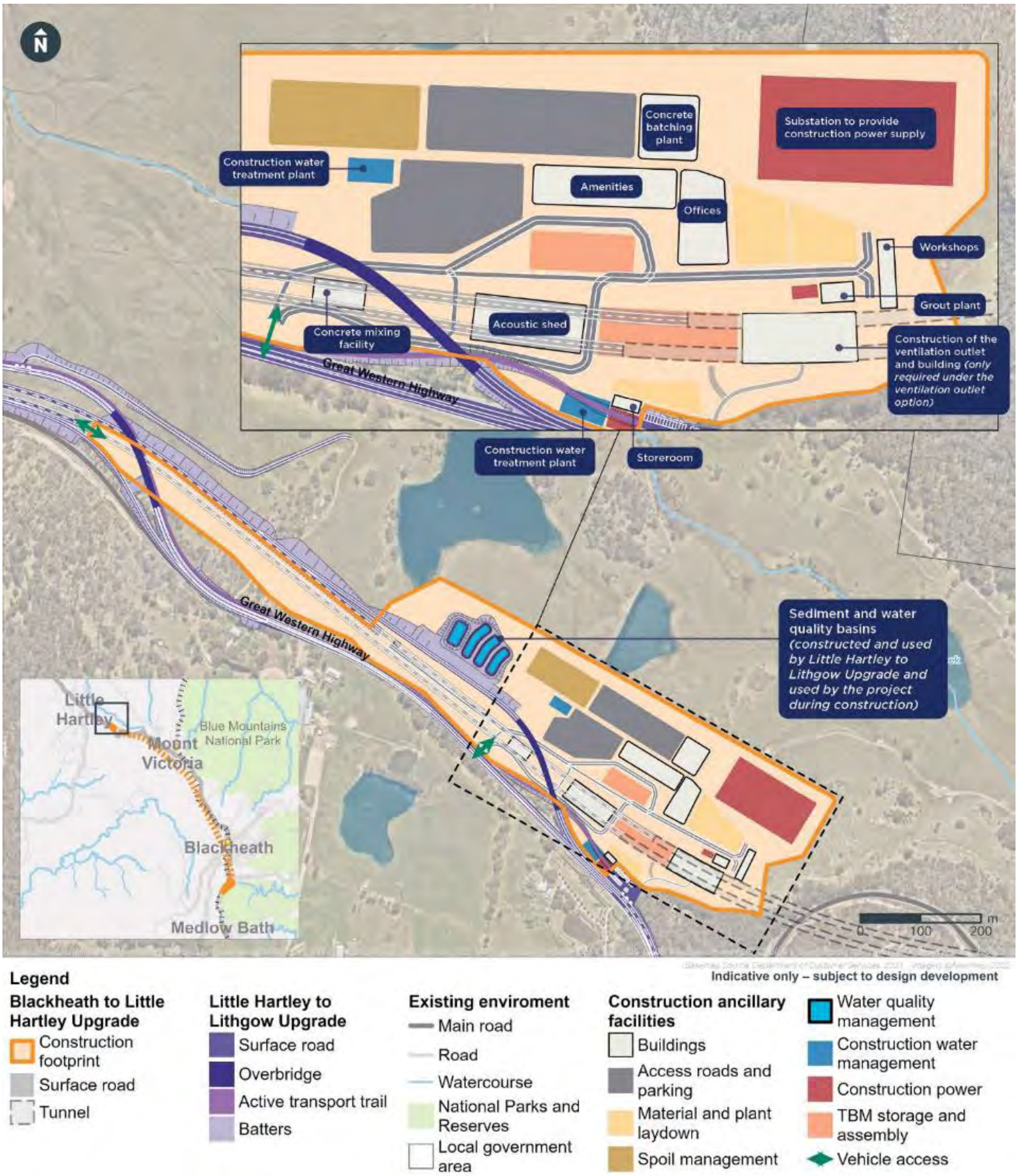

Figure 7 Indicative construction footprint at Little Hartley (AECOM 2022a).

1.2.3 Baseline environment

The Katoomba to Blackheath and Little Hartley to Lithgow Upgrades adjoining the project to the east and west respectively would be under construction when construction of the project commences (refer to Figure 8). To minimise environmental impacts, parts of the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade construction footprints would be used to support construction of the project.

As a result, the following activities will be undertaken at the construction sites as part of the Katoomba to Blackheath and Little Hartley to Lithgow Upgrades:

- vegetation would be cleared
- topsoil would be levelled and compacted
- site access tracks would be established
- water quality controls such as water quality and sediment basins would be installed.

The environmental impacts associated with these works have been assessed as part of the Katoomba to Blackheath Upgrade and the Little Hartley to Lithgow Upgrade.

The construction footprint for these projects are shown in Figure 9 and Figure 10 and form the baseline environment considered at Blackheath and Little Hartley for this EIS.

No work is proposed at Soldiers Pinch as part of the Katoomba to Blackheath Upgrade or the Little Hartley to Lithgow Upgrade and therefore the existing environment forms the baseline environment for this EIS.

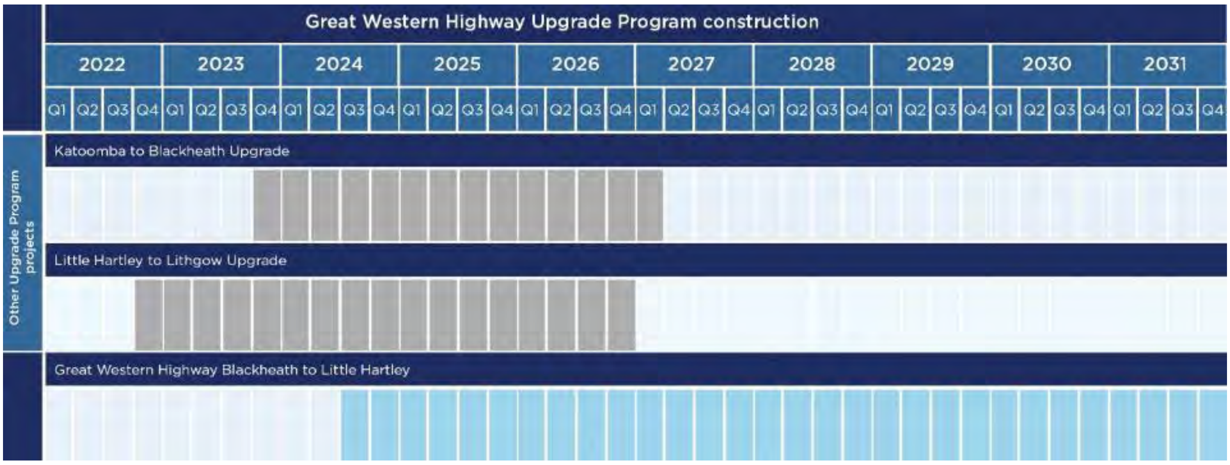

Figure 8 Great Western Highway Upgrade Program construction (AECOM 2022a).

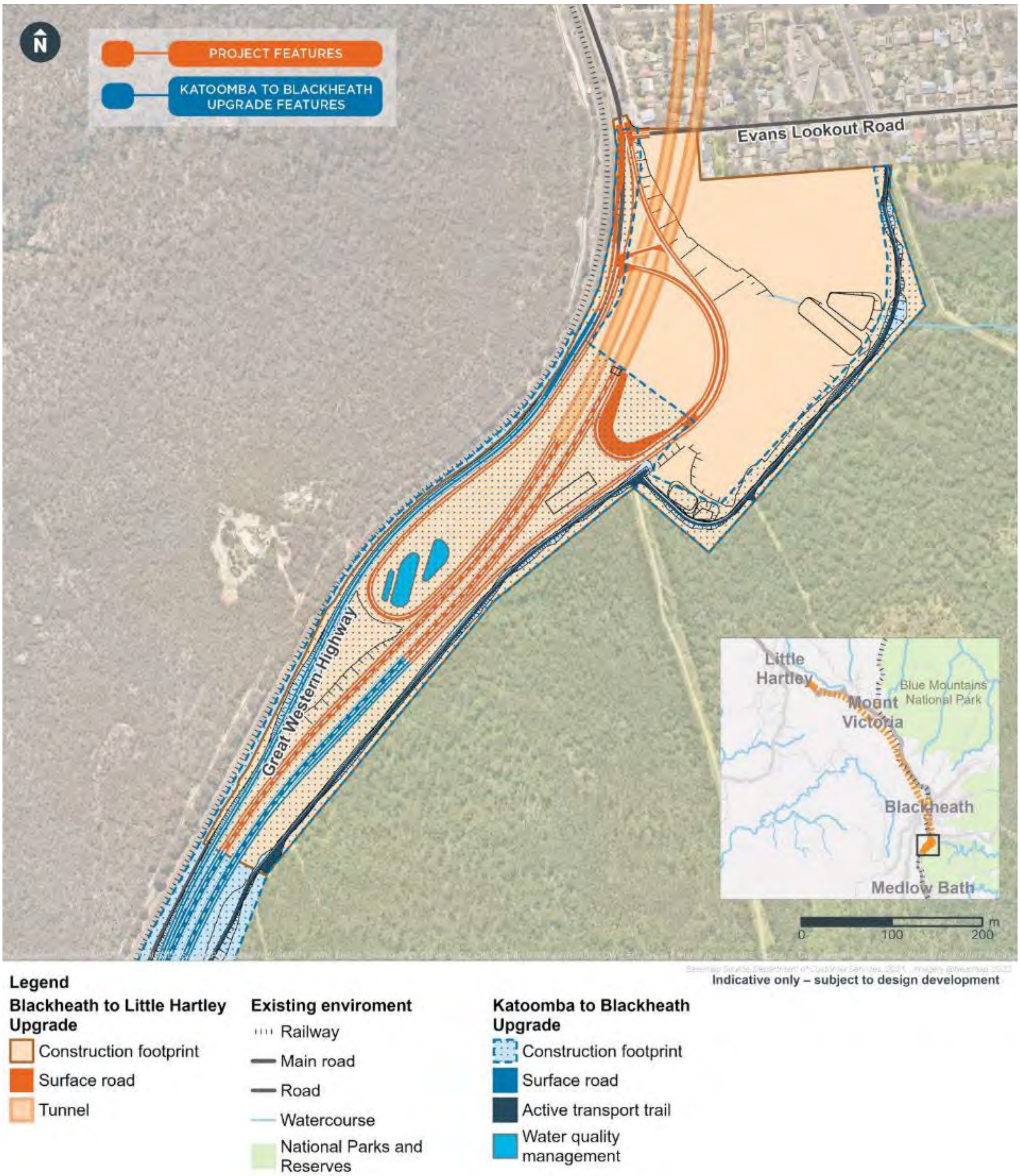

Figure 9 Baseline environment at Blackheath (AECOM 2022a).

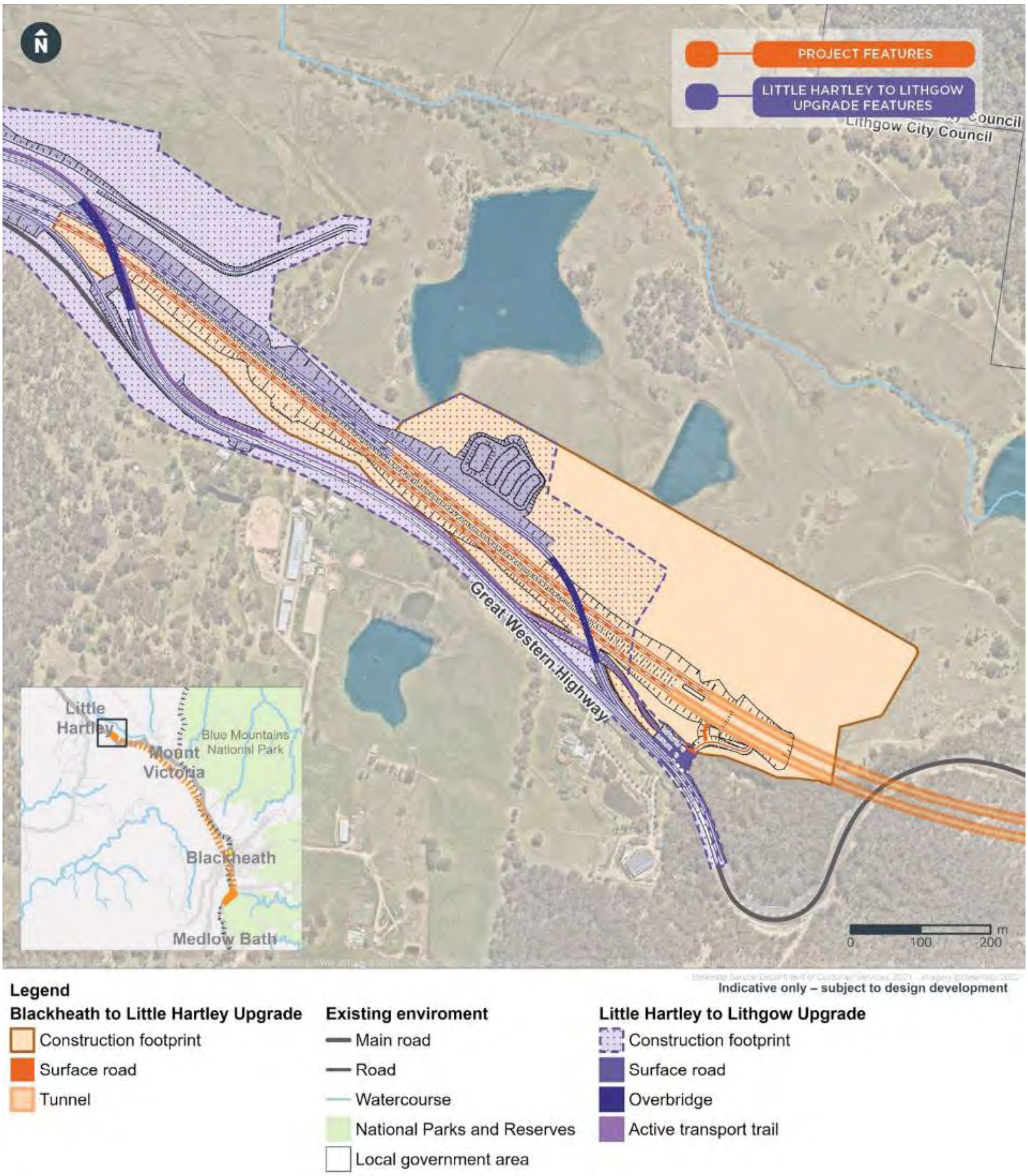

Figure 10 Baseline environment at Little Hartley (AECOM 2022a).

1.3 Purpose of this report

This report has been developed to support the Environmental Impact Statement (EIS) and associated Biodiversity Development Assessment Report (BDAR) being developed for the project (BIOSIS 2022) and covers impacts on biodiversity values not covered by the Biodiversity Assessment Method (BAM). This includes a threatened aquatic species assessment (Part 7A NSW *Fisheries Management Act* 1994) to address whether there are likely to be any significant impacts on listed threatened aquatic species, populations or ecological communities listed under the NSW *Fisheries Management Act* 1994 (FM Act) and *Environment Protection and Biodiversity Conservation* Act 1999 (EPBC).

This assessment focuses on the aquatic and riparian ecosystems, including waterways and swamps, that may be affected by the project during construction and operation. It specifically considers whether the project would have a significant impact on listed threatened species, populations or ecological communities listed under the NSW *Fisheries Management Act* 1994. The focal point of the assessment is the major named waterways identified by the groundwater and surface water impact assessments provided in Appendix I (Technical report – Groundwater) and Appendix J (Technical report – Surface water and flooding) of the EIS, respectively. The current ecological condition of these waterways and wetlands has been assessed and reported, including instream, riparian, wetland and groundwater dependent habitats.

Although this study assesses the potential impacts to swamp ecosystems, it is intended to inform the BDAR which, under the NSW Biodiversity Conservation Act 2016, assesses impacts and associated offsetting requirements as per the NSW Biodiversity Offsets Scheme.

1.3.1 Assessment requirements

The Secretary's Environmental Assessment Requirements (SEARs) issued by the NSW Department of Planning and Environment (DPE), relating to aquatic ecology and where these requirements are addressed in this technical report are outlined in Table 2.

Table 2 Secretary's Environmental Assessment Requirements (SEARS) – aquatic ecology.

Desired performance outcome	**Requirement**	**Section where addressed in the report**
2. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. The offsets and/or biodiversity conservation actions are assured and are equivalent to any residual impacts of project construction and operation.	7. Impacts on biodiversity values not covered by the BAM must be assessed. This includes a threatened aquatic species assessment (Part 7A Fisheries Management Act 1994) to address whether there are likely to be any significant impact on listed threatened species, populations or ecological communities listed under the Fisheries Management Act 1994 (FM Act). 8. Identify whether the project, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the BC Act, FM Act and the *Environmental Protection and the Biodiversity Conservation Act* 1999 (EPBC Act).	Section 4.1.4, Threatened aquatic species and habitats Section 4.1.4, Key threatening processes

11. Protected and sensitive lands The project is designed, constructed and operated to avoid or minimise impacts on protected and sensitive lands. The project is designed, constructed and operated to avoid or minimise future exposure to coastal hazards and processes.	1. Impacts of the project on environmentally sensitive land and processes (and the impact of processes on the project) including, but not limited to: (a) protected areas (including land and water) managed and/or reserved under the National Parks and Wildlife Act 1974; (b) Key Fish Habitat as mapped and defined in accordance with the Fisheries Management Act 1994 (FM Act); (c) waterfront land as defined in the Water Management Act 2000; (d) land or waters identified as Critical Habitat under the FM Act or EPBC Act or areas of outstanding biodiversity value under the BC Act; and (e) biodiversity stewardship sites, private conservation lands and other lands identified as offsets.	Refer to the BDAR and main EIS document Section 3.1.1, Key fish habitat mapping and threatened species distribution; Section 4.1.4, Threatened aquatic species and habitats Refer to main EIS document Section 4.1.4, Threatened aquatic species and habitats Refer to the BDAR

2 Assessment method

2.1 Relevant legislation, policies and guidelines

Table 3 summarises the relevant legislation, policy and guidelines related to the assessment of potential impacts to aquatic and riparian ecosystems associated with the construction and operational phases of the project.

Table 3 Commonwealth and State Legislation, Policy and Guidelines relevant to this study.

Legislation, Policy and Guidelines	Description	Project Relevance
Commonwealth legislation and guidelines		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Under the EPBC Act, proposed ‘actions’ that have the potential to significantly impact on matters of national environmental significance (MNES) or the environment or Commonwealth land, or 'actions' that are being carried out by a Commonwealth agency, must be referred to the Commonwealth Minister for the Environment. If the Minister determines that a referred project is a ‘controlled action’, the approval of the Minister will be required for the project in accordance with the EPBC Act, in addition to any State approvals.	The project would affect land within the Grose River and Coxs River catchments, both of which are considered habitat for Macquarie Perch (*Macquaria australasica*) which is listed as endangered species under the EPBC Act. Note that other ecological matters of national environmental significance are identified in the BDAR for the project.
Matters of National Environmental Significance Significant impact guidelines 1.1	The purpose of these guidelines is to provide overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under the EPBC Act.	
State legislation and guidelines		
Fisheries Management Act 1994 (FM Act)	The FM Act aims 'to conserve, develop and share the fishery resources of the State for the benefit of present and future generations and, in particular to: • Conserve fish stocks and key fish habitats • Conserve threatened species, populations and ecological communities of fish and marine vegetation • Promote ecologically sustainable development, including the conservation of biological diversity • Promote viable commercial fishing and aquaculture industries • Promote quality recreational fishing opportunities, and appropriately share fisheries resources between the users of those resources and provide social and economic benefits for the wider community of New South Wales. To meet these objectives, Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines provisions to conserve threatened species of fish and marine vegetation and their habitat.	The project would affect land within the Grose River and Coxs River catchments, both of which are considered habitat for Macquarie Perch (*Macquaria australasica*) which is listed as endangered species under the FM Act. As per the FM Act, a Test of Significance for the Macquarie Perch was carried out to determine whether the project would have a significant impact on

Legislation, Policy and Guidelines	Description	Project Relevance
		this species or its habitat.
Biodiversity Conservation Act 2016 (BC Act)	The BC Act aims to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development.	A Biodiversity Development Assessment Report (BDAR) is being developed for the project under the BC Act. This report provides supporting information in relation to aquatic ecology and matters under the FM Act.
Policy and Guidelines for Fish Habitat Conservation and Management (update 2013) (DPIE Fisheries 2013)	This document outlines policies and guidelines aimed at maintaining and enhancing fish habitat for the benefit of native fish species, including threatened species, in marine, estuarine and freshwater environments. The document aims to help developers, their consultants and government and non-government organisations to ensure compliance with legislation, policies and guidelines as they relate to fish habitat conservation and management. It can be used to inform land use and natural resource management planning, development planning and assessment processes.	The Policy and Guidelines for Fish Habitat Conservation was used when conducting field verification of waterways mapped as Key Fish Habitat.
NSW Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation 2002)	Groundwater Dependent Ecosystems (GDEs) refer to both terrestrial and aquatic ecosystems that require access to groundwater to meet all or some of their water requirements for their ecological processes and ecosystem services. The GDE Policy adopts principles outlined in the NSW State Groundwater Policy Framework Document and provides a framework the management of GDEs in NSW.	The NSW Groundwater Dependent Ecosystems Policy (2002) was used when assessing areas of mapped GDE and determining potential impacts, particularly relating to Temperate Highland Peat Swamps on Sandstone
Other Guidelines and Recovery Plans		
National Recovery Plan for the Macquarie Perch (*Macquaria australasica*) (Commonwealth of Australia 2018)	The overarching objective of this recovery plan is to ensure the recovery and ongoing viability of Macquarie perch populations throughout the species' range (including historically translocated populations). The recovery plan sets out six recovery strategies that build toward this overarching objective: • Conserve existing Macquarie perch populations (including historically translocated populations in Cataract Reservoir and the Mongarlowe and Yarra rivers). • Protect and restore Macquarie perch habitat. • Understand and address threats to Macquarie perch populations and habitats. • Establish additional Macquarie perch populations within the species' natural range. • Improve understanding of the biology and ecology of the Macquarie perch and its distribution and abundance. • Increase participation by community groups in Macquarie perch conservation.	The National Recovery Plan for the Macquarie Perch (2018) was used to assess the likelihood of preferred habitat of the Macquarie perch occurring within the study area. The plan was also used to assess the threat to the Macquarie perch from the project.

Legislation, Policy and Guidelines	Description	Project Relevance
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2018 and 2000)	The ANZECC Water Quality Guidelines provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters and list a range of environmental values assigned to that waterbody. The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection, which have been considered when describing the existing water quality and key indicators of concern.	The Australian and New Zealand Guidelines for Fresh and Marine Water Quality was used to assess the current condition of waterways. The guidelines were then used to assess the quality of the stormwater proposed to be discharged and to determine the ecological impact.
Guidelines for controlled activities on waterfront land - Riparian corridors (NSW Office of Water 2012)	The overarching objective of the controlled activities provisions of the WM Act is to establish and preserve the integrity of riparian corridors. Ideally, the environmental functions of riparian corridors should be maintained or rehabilitated by applying the following principles: • Identify whether or not there is a watercourse present and determine its order in accordance with the Strahler System • Seek to maintain or rehabilitate a riparian corridor (RC) or vegetated riparian zone (VRZ) with fully structured native vegetation • Seek to minimise disturbance and harm to the recommended RC/VRZ • Minimise the number of creek crossings and provide perimeter road separating development from the RC/VRZ and locate services and infrastructure outside of the RC/VRZ. • Within the RC/VRZ provide multiple service easements and/or utilise road crossings where possible and treat stormwater run-off before discharging into the RC/VRZ. • Upstream movement - access to new habitats or established spawning areas. • Downstream movement - post-spawning movement, avoid predators. • Lateral movement - access food, breeding cycle and juvenile recruitment to habitat areas.	The principles expressed in the Guidelines for controlled activities on waterfront land - Riparian corridors (NSW Office of Water 2012) were used to inform mitigation measures.
Risk assessment Guidelines for Groundwater Dependent Ecosystems (Office of Water, 2012)	This document aims to minimise impacts on GDEs and: • Defines GDE types. • Supports the requirements of the Water Management Act 2000. • Determines the risk of an activity to the ecological value of an aquifer and associated GDEs. • Provides management strategies for aquifers and identified GDEs using the Risk Matrix Approach.	Risk assessment Guidelines for Groundwater Dependent Ecosystems (Office of Water, 2012) were used to define areas of GDE, determine risks and to aid in the recommendation of mitigation strategies.

2.2 Study area

The study area for this assessment incorporates the project construction footprints located at Blackheath, Mount Victoria and Little Hartley and an area of around two kilometres based on preliminary predictions of potential groundwater drawdown extents associated with project construction and operation (Figure 11).

Due to the steep terrain and inaccessibility of many of the waterways in the study it was necessary in some cases to collect samples from these creeks in areas outside of the study area.

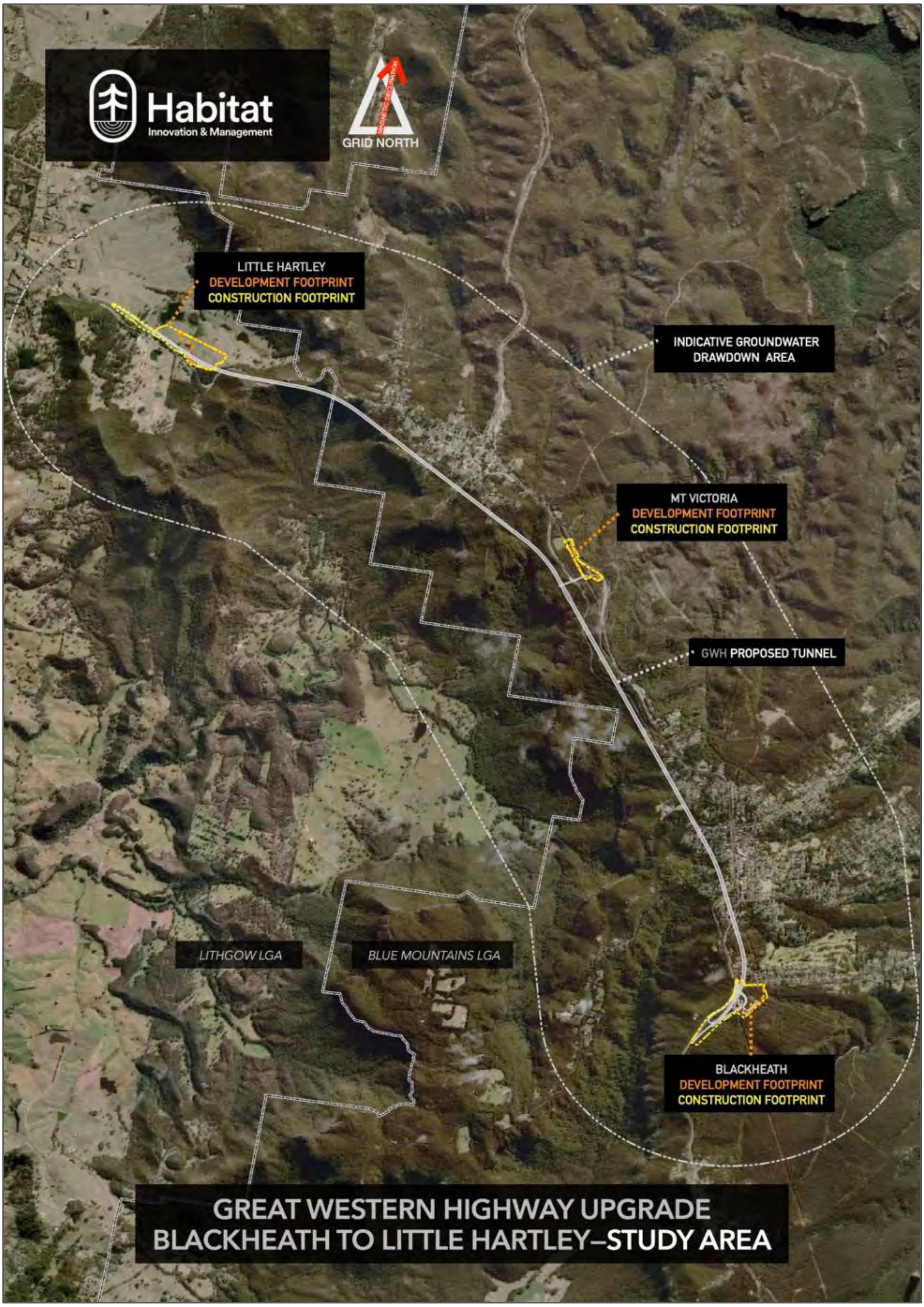

Figure 11 Riparian and aquatic ecosystem impact assessment study area.

2.3 Methodology

The methodology applied to the preparation of this aquatic and riparian ecosystems impact assessment included:

- A desktop review of peer reviewed literature and the following resources was undertaken to determine current condition of the aquatic and riparian ecosystems within study area
- A field assessment to validate the presence of aquatic and riparian ecosystem constraints identified by the desktop review and to provide condition assessments of aquatic and riparian habitats
- Field validation of potentially impacted waterways with the primary objective being to determine if subject waterways fit the criteria of a "river" as defined by the NSW *Water Management Act 2000*, and subsequent allocation of a Strahler order to the waterways
- Field verification of mapped Key Fish Habitat (KFH) in Butlers Creek following the framework outlined in Policy and Guidelines for Fish Habitat Conservation and Management (DPIE Fisheries, 2013), which enabled determination of KFH type and class based on the presence of habitat attributes and threatened species
- Assessment of the relative condition of riparian vegetation and waterway channels across the study area using the Rapid Riparian Appraisal (RRA) method
- Ground truthing the extent of GDE's within Butlers Creek
- Measurement of physicochemical water quality parameters in-situ at 22 sites to understand the current water quality conditions of waterways across the study area
- Macroinvertebrate and benthic diatom surveys at the same location as water quality samples
- eDNA sampling of platypuses
- assessment of potential direct and indirect impacts on aquatic ecology, riparian areas and GDEs within the study area during construction and operation of the project, including consideration of assessments carried out by other relevant technical specialists.

This aquatic and riparian ecosystems impact assessment aimed to assess the current or background ecological conditions, including groundwater dependent ecosystems and major named waterways and their swamp and wetland ecosystems. A range of ecological indicators have been used to determine current ecological conditions, including:

- water quality
- aquatic macroinvertebrates
- benthic diatoms
- riparian vegetation and creek channel condition
- platypus eDNA.

Potential impacts on aquatic and riparian ecosystems due to construction and operation of the project have considered:

- construction impacts - impacts to aquatic and riparian ecosystems within Blackheath, Soldiers Pinch and Little Hartley construction footprints, sediment and erosion impacts from construction areas to receiving waterways and surface water pollution, and the potential impacts to aquatic and groundwater dependent ecosystems caused by groundwater drawdown associated with the construction of the project tunnels
- operational impacts - impacts associated with the long-term operation of the project including the effects of stormwater velocity on receiving swamps and waterways, sediment and erosion ,and water quality and geochemical alteration.

2.3.1 Desktop Review

A desktop review of peer reviewed literature and the following resources was carried out to determine current the condition of the aquatic and riparian ecosystems within study area, and to understand constraints and pressures associated with the project. A combination of spatial data, database search, monitoring data and technical specialist reports prepared for the project EIS were reviewed, including:

- NSW Statewide Topographic Mapping – to determine Strahler stream ordering - (SIX maps, 2022)
- NSW Key Fish Habitat Mapping (NSW Department of Primary Industries – Fisheries Spatial Data Portal, 2022a)
- Freshwater threatened species distribution (NSW Department of Primary Industries – Fisheries, Spatial Data Portal 2022b)
- NSW State Vegetation Type Map (SVTM) (NSW Department of Planning and Environment 2022)
- Matters of National Environmental Significance (MNES) – Protected Matters Search Tool (Australian Government 2013) (accessed and search completed on 6 October 2022)
- Species Profile and Threats Database (SPRAT) (Australian Government 2022) (accessed 6 October 2022)
- Groundwater Dependent Ecosystem Atlas of Australia (BOM, 2022)
- Great Western Highway Blackheath to Little Hartley – Appendix J (Technical Report – Surface water and flooding) (AECOM 2022a)
- Great Western Highway Blackheath to Little Hartley – Appendix I (Technical Report – Groundwater) (AECOM 2022b)
- Biodiversity Development Assessment Report (BDAR) Great Western Highway Upgrade – Blackheath to Little Hartley (select map sets) (BIOSIS 2022).

2.3.2 Field assessment

A field assessment was carried out to validate the presence of aquatic and riparian ecosystem constraints identified by the desktop review and to provide condition assessments of aquatic and riparian habitats. The fieldwork component of the project was conducted in August and September 2022. The weather conditions during the fieldwork are included in Table 4 and ranged from periods of snowfall and rainfall to overcast and sunny conditions.

Climate data was sourced from the Mount Boyce AWS station located within the study area in Blackheath. Fieldwork was generally conducted on days where the weather was favourable, in efforts to standardise the assessment method and to maintain worker safety.

The daily weather observations (Bureau of Meteorology 2022) recorded at Mount Boyce AWS indicate that the weather conditions in August 2022 were consistent with the long-term average. In August 2022, Mount Boyce AWS recorded 56.8 mm of precipitation, compared to the long-term average of 56.5 mm of precipitation. The average minimum and maximum temperatures recorded were 3.7°C and 11.3°C respectively. These conditions were close to the long-term averages for minimum and maximum temperatures of 3.0°C and 11.3°C respectively.

Conversely, in September, weather conditions differed from the long-term averages substantially. In September 2022, Mount Boyce AWS recorded 142.0 mm of rainfall, compared to the long-term average of 56.7 mm.

The average minimum and maximum temperatures for September were 5.2°C and 13.1°C respectively. These conditions were cooler compared to the long-term averages of 5.4°C and 14.8°C respectively.

A summary of the sample sites and aquatic and riparian ecosystem metrics sampled/assessed at each site are included in Table 6.

Table 4 Summary of weather conditions during field assessment.

Field assessment	Dates	Weather conditions
Riparian Vegetation and Creek Channel Assessment	25/08/2022 – 19/09/2022	fine to overcast
Water Quality Sampling	30/08/2022, 09/09/2022, 14/09/2022	fine to overcast
Diatom Sampling	30/08/2022, 13/10/2022	fine to overcast
Macroinvertebrate Sampling	30/08/2022,	fine to overcast conditions
Top of Bank Mapping	24/08/2022, 25/08/2022, 26/08/2022, 29/08/2022, 30/08/2022	snow, overcast to fine
Platypus eDNA Sampling	16/09/2022	fine

Strahler stream order and waterway validation

Field validation of potentially impacted waterways was carried out with the primary objective being to determine if subject waterways fit the criteria of a "river" as defined by the *NSW Water* Management Act 2000 which is:

a) any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and

b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and

c) anything declared by the regulations to be a river.

In relation to point (c) of the definition of 'river' in the Dictionary to the Act, the following are declared to be a river as per the Water Management (General) Regulation 2018 (WM Regulation):

a) any watercourse, whether perennial or intermittent, comprising an artificial channel that has changed the course of the watercourse

b) any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows.

Once validated as a "river", mapped Strahler ordering was assigned.

To complement the validation of waterways, top of bank mapping was carried out in the reach of Butlers Creek that occurs within the study area. This was carried out to ensure that vegetated riparian zones (VRZ) as required by the NSW Water Management Act 2000 could be accurately assigned.

In addition, the extent of the swamp ecosystem adjacent to Butlers Creek was mapped to validate and delineate the extent of Temperate Highland Peat Swamps on Sandstone community (THPSS) which is listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* and is also listed as endangered under the NSW *Biodiversity Conservation Act 2016* as Blue Mountains Swamps. The mapped extent THPSS completed as part of this assessment has been provided as an input into the BDAR for the project.

Reliability when defining top of bank and swamp extent was optimised through observation calibration between the field ecologist and botanist at the beginning of each survey day.

Key Fish Habitat

Field verification of mapped Key Fish Habitat (KFH) in Butlers Creek was carried out following the framework outlined in Policy and Guidelines for Fish Habitat Conservation and Management (DPIE Fisheries, 2013), which enabled determination of KFH type and class based on the presence of habitat attributes and threatened species. A total of three assessments across Butlers Creek were completed. Assessment criteria for KFH Type and Class (DPIE Fisheries, 2013) are shown in Table 5.

Table 5 Key Fish Habitat Type and associated sensitivity classification (top) and Key Fish Habitat Class (bottom).

TYPE 1 - Highly sensitive key fish habitat:

- *Posidonia australis* (strapweed)
- *Zostera, Heterozostera, Halophila and Ruppia* species of seagrass beds >$5m^2$ in area
- Coastal saltmarsh >$5m^2$ in area
- Coral communities
- Coastal lakes and lagoons that have a natural opening and closing regime (i.e. are not permanently open or artificially opened or are subject to one off unauthorised openings)
- Marine park, an aquatic reserve or intertidal protected area
- SEPP 14 coastal wetlands, wetlands recognised under international agreements (e.g. Ramsar, JAMBA, CAMBA, ROKAMBA wetlands), wetlands listed in the Directory of Important Wetlands of Australia[2]
- Freshwater habitats that contain in-stream gravel beds, rocks greater than 500 mm in two dimensions, snags greater than 300 mm in diameter or 3 metres in length, or native aquatic plants
- Any known or expected protected or threatened species habitat or area of declared 'critical habitat' under the FM Act
- Mound springs

TYPE 2 – Moderately sensitive key fish habitat:

- *Zostera, Heterozostera, Halophila* and *Ruppia* species of seagrass beds <$5m^2$ in area
- Mangroves
- Coastal saltmarsh <$5m^2$ in area
- Marine macroalgae such as *Ecklonia* and *Sargassum* species
- Estuarine and marine rocky reefs
- Coastal lakes and lagoons that are permanently open or subject to artificial opening via agreed management arrangements (e.g. managed in line with an entrance management plan)
- Aquatic habitat within 100 m of a marine park, an aquatic reserve or intertidal protected area
- Stable intertidal sand/mud flats, coastal and estuarine sandy beaches with large populations of in-fauna
- Freshwater habitats and brackish wetlands, lakes and lagoons other than those defined in TYPE 1
- Weir pools and dams up to full supply level where the weir or dam is across a natural waterway

TYPE 3 – Minimally sensitive key fish habitat may include:

- Unstable or unvegetated sand or mud substrate, coastal and estuarine sandy beaches with minimal or no in-fauna
- Coastal and freshwater habitats not included in TYPES 1 or 2
- Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation

Notes: For the purposes of these policy and guidelines the following are **not considered key fish habitat**[5]:

- First and second order streams on gaining streams (based on the Strahler method of stream ordering)
- Farm dams on first and second order streams or unmapped gullies
- Agricultural and urban drains
- Urban or other artificial ponds (e.g. evaporation basins, aquaculture ponds)
- Sections of stream that have been concrete-lined or piped (not including a waterway crossing)
- Canal estates

CLASS 1 Major key fish habitat	Marine or estuarine waterway or permanently flowing or flooded freshwater waterway (e.g. river or major creek), habitat of a threatened or protected fish species or 'critical habitat'.
CLASS 2 Moderate key fish habitat	Non-permanently flowing (intermittent) stream, creek or waterway (generally named) with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Freshwater aquatic vegetation is present. TYPE 1 and 2 habitats present.
CLASS 3 Minimal key fish habitat	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or other CLASS 1-3 fish habitats.
CLASS 4 Unlikely key fish habitat	Waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (e.g. dry gullies or shallow floodplain depressions with no aquatic flora present).

Threatened fish species and Matters of National Environmental Significance

The desktop review of NSW Fisheries Data Portal and MNES Protected Matters Search Tool identified Macquarie Perch (*Macquaria australasica*) occurring within or near the study area. The Macquarie Perch is a threatened species listed under the NSW *Fisheries Management Act 1994* (FM Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Macquarie Perch is unlikely to be present in receiving waterways within the study area, however the species is known to inhabit the Cox's River and Grose River. The study area is contained within both of these river catchments and therefore a precautionary consideration of the presence of Macquarie Perch has been adopted as waterways in the study area flow either into the Cox's River or Grose River, which are considered to be Macquarie Perch habitat.

As a result, no field survey for this species was carried out. Instead this study includes a Test of Significance for this species as per the NSW *Fisheries Management Act 1994* and a Commonwealth Test of Significant Impact as per the *Environment Protection and Biodiversity Conservation Act 1999*.

Riparian vegetation and waterway channel condition

To assess the relative condition of riparian vegetation and waterway channels across the study area, the Rapid Riparian Appraisal (RRA) method developed by Findlay *et al.* (2011) and later refined and localised by Dean and Tippler (2016) was applied. A total of 25 RRA assessments were completed across the study area (Figure 12 to Figure 14).

This method provides a snapshot of the current condition of aquatic and riparian areas and was developed in the Sydney region specifically for visual examination of urban and urbanising waterways. The RRA method combines qualitative and quantitative assessment of urban stream condition and riparian habitat (on both the left and right bank), incorporating land use, riparian vegetation and weed density, channel features, key fish habitat, and depositional and erosional features. This method produces a rich data set, which can be used to strategically target actions for waterway management.

The RRA method used covers seven main categories, which include site features, riparian vegetation, habitat features, channel features, key fish habitat, deposition and erosion, and liveability and community values. These categories are then broken down into indices and sub-indices, each receiving a score. Scoring for each feature is based on a scale that ranges from +10 (reflecting excellent condition or a positive impact) to -10 (reflecting degraded condition or a negative impact), with zero indicating a neutral effect (Findlay *et al*. 2011).

These values are then used to calculate an overall site condition score out of 100, which is grouped into one of seven categories that reflect a gradient of disturbance and riparian condition; 'Excellent' (ranging from 90-100), 'Very Good' (80-<90), 'Good' (70-<80), 'Fair' (60-<70), 'Poor' (50-<60), 'Very Poor' (40-<50), and 'Degraded' (<40) (based on Findlay et al. (2011) and Dean and Tippler (2016)).

'Poor' to 'Degraded' condition is typical of creeks with highly urbanised catchments that have undergone severe channel alteration, are possibly concrete lined, with very restricted or absent vegetated buffer width or riparian vegetation structure. Conversely, 'Excellent' condition indicates a minimally disturbed catchment with intact channel geomorphology, an expansive and complex riparian vegetation community with minimal weeds and unaffected by human induced impacts such as stormwater and sewage.

Groundwater Dependent Ecosystems

Identification of GDEs in the study area was determined by reviewing the high probability GDEs mapped by DPE (Spatial Layer of HEVAE Vegetation Groundwater Dependent Ecosystems Value in NSW). A precautionary approach was applied whereby these mapped GDEs have been assumed to be valid (present) for the purposes of this assessment. GDEs along Butlers Creek were confirmed through field survey as these areas are of particular importance given their proximity to the Little Hartley construction footprint and potential for impacts through changes in surface water quality and drainage.

Water quality

To understand the current water quality conditions of waterways across the study area physicochemical water quality parameters were measured in-situ at 22 sites (Figure 12 to Figure 14). Measurements were taken using a calibrated TPS WP-82Y meter with a YSI dissolved oxygen probe for dissolved oxygen, TPS WP-88 turbidity meter with a TPS turbidity sensor for turbidity and a TPS WP-81 conductivity, pH and temperature meter with TPS conductivity and temperature probe and a TPS submersible k407 pH sensor for conductivity, pH and temperature.

In addition, surface water grab samples were taken at each site for analysis of Total Suspended Solids (TSS), Alkalinity as $CaCO_3$, Sulfate as SO_4, major anions and cations, metals, Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Nitrate and Nitrite as N (NOx), Total Phosphorus (TP), Reactive Phosphorus (FRP), Chloride and Ammonia - N (NH_3-N).

Grab samples were collected in decontaminated, acid preserved sample containers. After collection, samples were stored in a chilled esky and delivered to a commercial laboratory for analysis (ALS Smithfield, NSW). All grab samples were analysed using standard methods (APHA 1998) by a National Associations of Testing Authorities (NATA) accredited laboratory.

Aquatic macroinvertebrates

Aquatic macroinvertebrates are a commonly used indicator of the quality of aquatic habitats and have known sensitivities to water quality alteration, hydrological change and habitat loss. Macroinvertebrate surveys were carried out at the same locations as water quality samples (Figure 12 to Figure 14).

To collect samples, a total of 10 metres of representative habitat was selected and sampled from a 100 metre section of waterway at each site. Macroinvertebrates were sampled following the Australian National River Health Program protocols (DEST *et al*. 1994; Chessman 1995). This involved collection using a dip net with 250 µm mesh and square 30 × 30 cm net frame. Edge, riffle and knickpoint habitats were sampled when possible, and benthic rocks and detritus was disturbed instream to dislodge any potential macroinvertebrate and catch them in the dip net.

Samples were live picked in the field by two aquatic ecologists for 30 minutes. Macroinvertebrate specimens were then preserved in ethanol and later identified using recommended Australian taxonomic keys listed in Hawking and Smith (1997). The majority of taxa were identified to Family level, with the exceptions of Acarina (water mites) and Oligochaetes (segmented worms).

Five macroinvertebrate indices for each sample were calculated:

- percentage of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) (%EPT) (Cairns and Pratt 1993) – a biotic index based on the percentage of those pollution sensitive taxa present at a site
- family taxonomic richness (Rosenberg and Resh 1993).
- Shannon Weiner biodiversity index (Krebs 1989) – a biodiversity measure that reflects taxon richness and evenness of the abundances of taxa
- Unweighted family level SIGNAL 2-2 scores (Chessman 2003) – a biotic index based on the relative abundances of pollution tolerant/intolerant invertebrate taxa. Results are interpreted by displaying SIGNAL 2 score and family richness on a bi-plot following the method outlined by Chessman (2003)
- in addition, mean values from reference site data was calculated for EPT%, family richness, Shannon Index and SIGNAL 2 score.

Benthic diatoms

Benthic diatoms are a reliable and sensitive indicator of anthropogenic nutrient enrichment in freshwater environments and unlike aquatic macroinvertebrates are far less influenced by hydraulic or habitat factors.

Benthic diatoms were sampled at 22 sites from rock substrata or submerged woody debris as per the method described Chessman *et al*. (2016) using a single use wooden spatula to scrape biofilm from benthic substrate.

Samples were preserved in 70% ethanol and sent to Australia's industry specialist Jason Sonneman of Ecological for identification.

Diatom relative abundance and Trophic Diatom Index (TDI) (Kelly 1998) was calculated using OMNIDIA v6 software package. TDI is a commonly used biological index which applies a scale between 0-100. A TDI value of 60 and over is typically representative of a eutrophic state.

Platypus eDNA testing

Although outside the scope of aquatic ecosystem impact assessment, platypuses are protected under the BC Act 2016, and therefore eDNA sampling for the species was undertaken as a due diligence measure as this species is a highly valued species to the Blue Mountains community. Further, there is a known population of Platypus that inhabits the River Lett, about six kilometres west of the project (Transport for NSW 2022).

To test for platypuses, eDNA kits were supplied by EnviroDNA, a commercial testing laboratory. Following directions provided by eDNA, a 60 ml syringe was used to draw-up 50 ml of water from sample creek. A filter was then screwed onto the syringe and the contents was pushed through the filter and then removed.

This method was repeated until water could no longer be pushed through the filter. To help preserve the sample, the remaining water from the filter was expelled by drawing air into the syringe and pushing it through the filter. Once the excess water was expelled, the cap was removed from a preservative syringe and attached to the filter, the preservative was added, and the preservative syringe was left attached to the filter.

Each filter and preservative syringe were stored in an individual plastic bag provided by EnviroDNA, the bags were labelled, and were stored out of sunlight were posted to the EnviroDNA lab within 12 hours for analysis.

Platypus eDNA testing was conducted at three sites (Figure 15) which were all further downstream of the study areas. These included a site further downstream of the Butlers Creek study sites, a site further downstream of the Pulpit Hill sites and a site within Blackheath which is downstream of Fairy Bower Creek. At each site, two replicates were sampled at 50 metres apart.

Sites were selected based on the presence of suitable habitat required by platypuses which included deep, large pools and riffle zones, vegetated riparian zones and overhanging vegetation.

Table 6 Sample sites and aquatic and riparian ecosystem metrics sampled/assessed at each site.

Site	Water Quality	Aquatic Macroinvertebrates	Benthic Diatoms	Riparian Vegetation and Waterway Channel Condition	Platypus eDNA Testing
Upper Fairy Bower Creek	✓	✓	✓	✓	–
Mid Fairy Bower Creek	✓	✓	✓	✓	–
Lower Fairy Bower Creek	✓	✓	✓	✓	–
Upper Pulpit Hill Creek	✓	✓	✓	✓	–
Mid Pulpit Hill Creek	✓	✓	✓	✓	–
Lower Pulpit Hill Creek	✓	✓	✓	✓	–
Upper Relton Creek	✓	✓	✓	✓	–
Mid Relton Creek	✓	✓	✓	✓	–
Lower Relton Creek	✓	✓	✓	✓	–
Upper Adams Creek	✓	✓	✓	✓	–
Mid Adams Creek	✓	✓	✓	✓	–
Lower Adams Creek	✓	✓	✓	✓	–
Upper Greaves Creek	✓	–	✓	✓	–
Mid Greaves Creek	✓	✓	✓	✓	–
Lower Greaves Creek	✓	✓	✓	✓	–
Upper Young Creek	✓	✓	✓	✓	–
Mid Young Creek	✓	✓	✓	✓	–
Lower Young Creek	✓	✓	✓	✓	–
Upper Butlers Creek	✓	✓	✓	✓	–
Mid Butlers Creek	✓	✓	✓	✓	–
Lower Middle Butlers Creek	✓	✓	✓	✓	–
Butlers Creek unnamed tributary 1	✓	✓	✓	✓	–
Lower Butlers Creek eDNA	–	–	–	✓	✓
Pulpit Hill Creek eDNA	–	–	–	✓	✓
Blackheath Creek eDNA	–	–	–	✓	✓

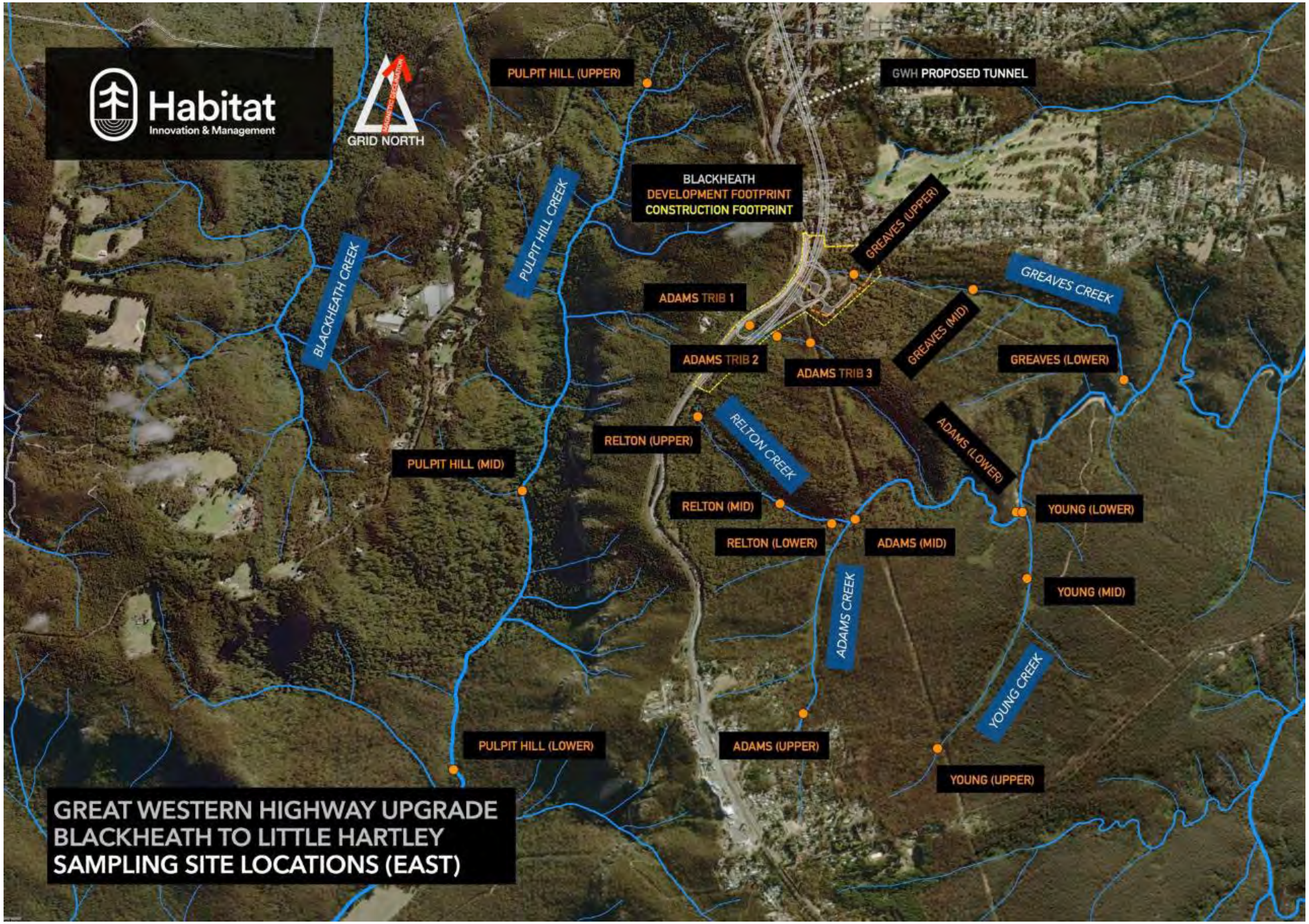

Figure 12 Location of sample sites in the eastern section of the study area (Blackheath area).

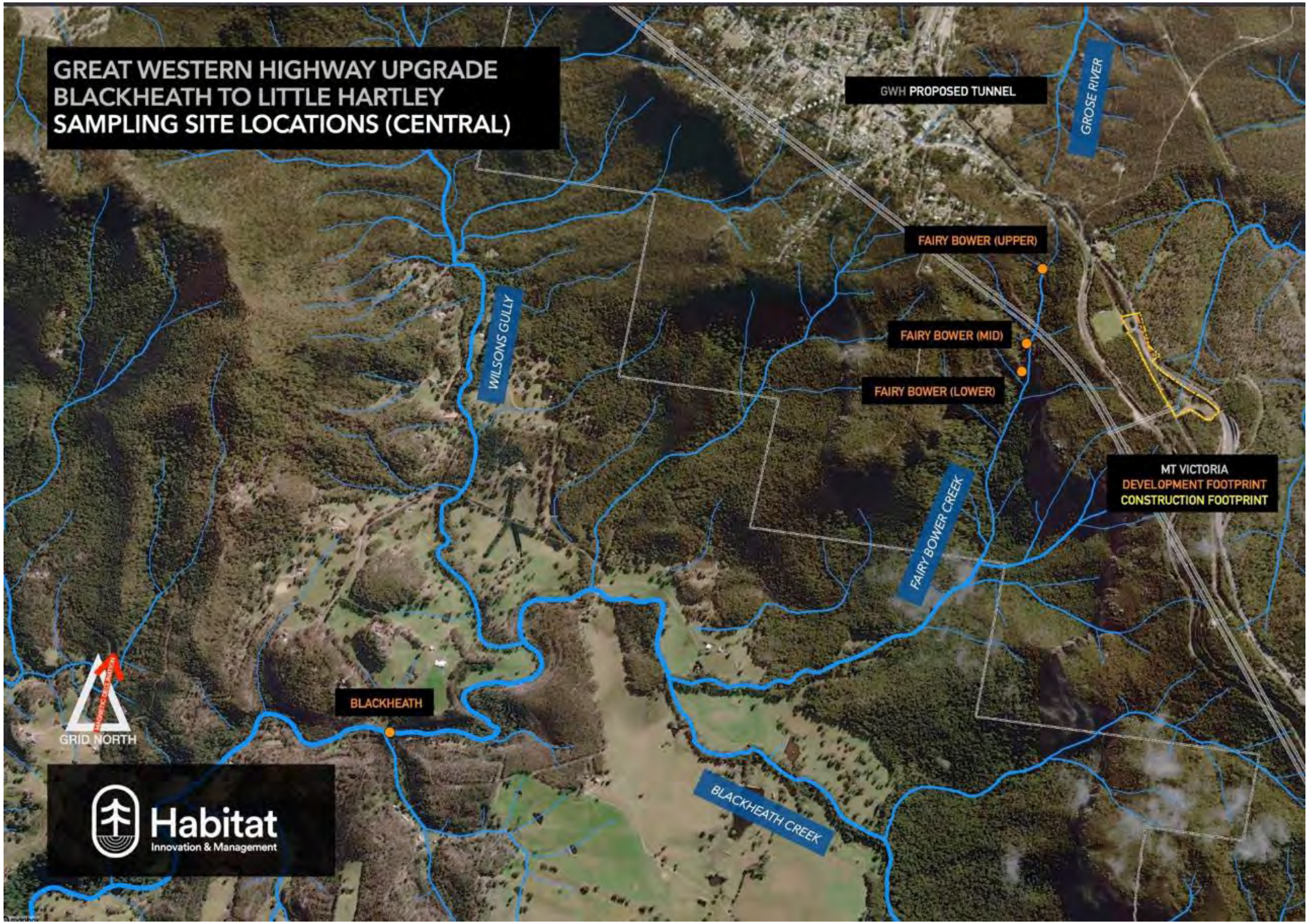

Figure 13 Location of sample sites in the central section of the study area (Mount Victoria area).

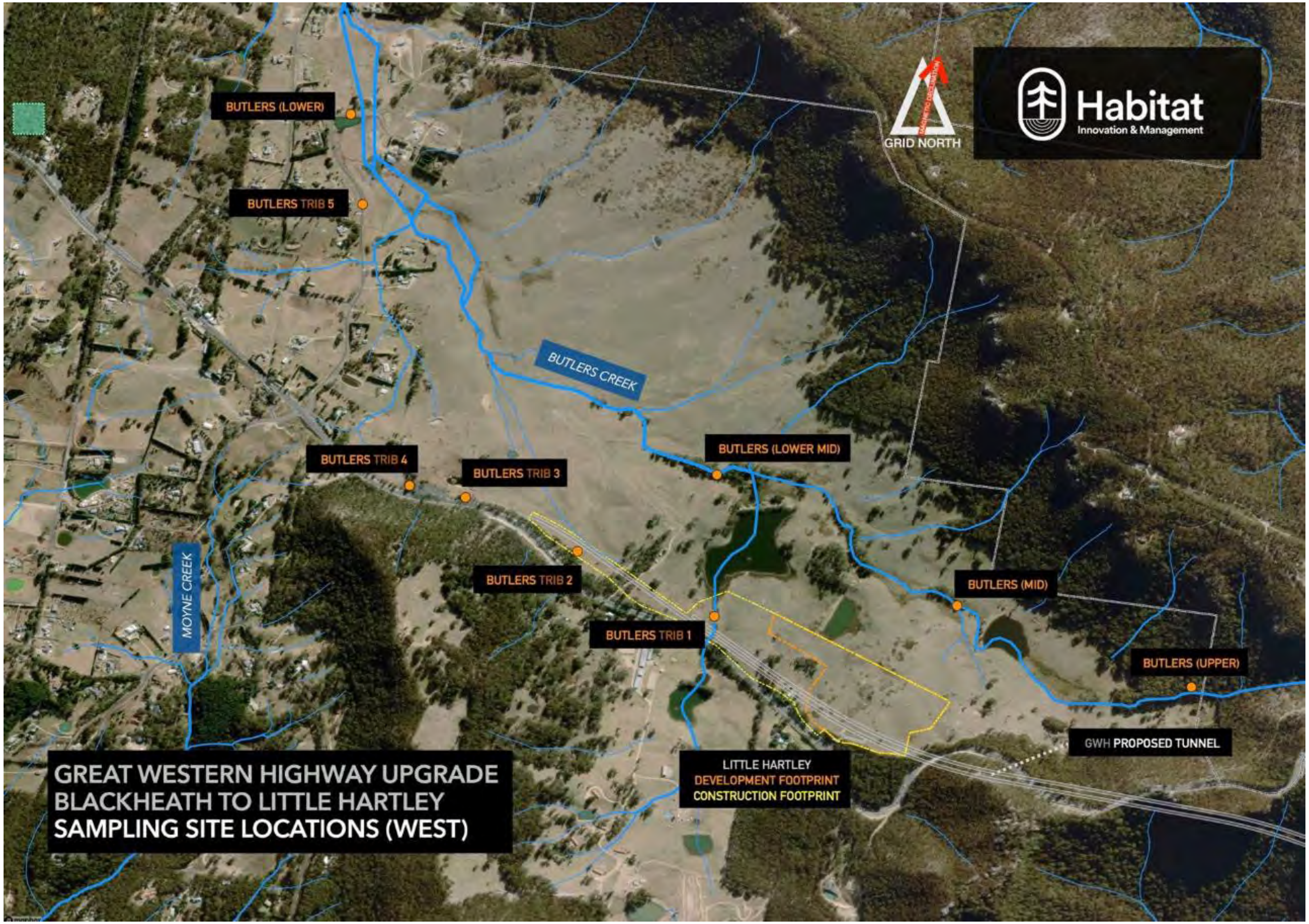

Figure 14 Location of sample sites in the western section of the study area (Little Hartley area).

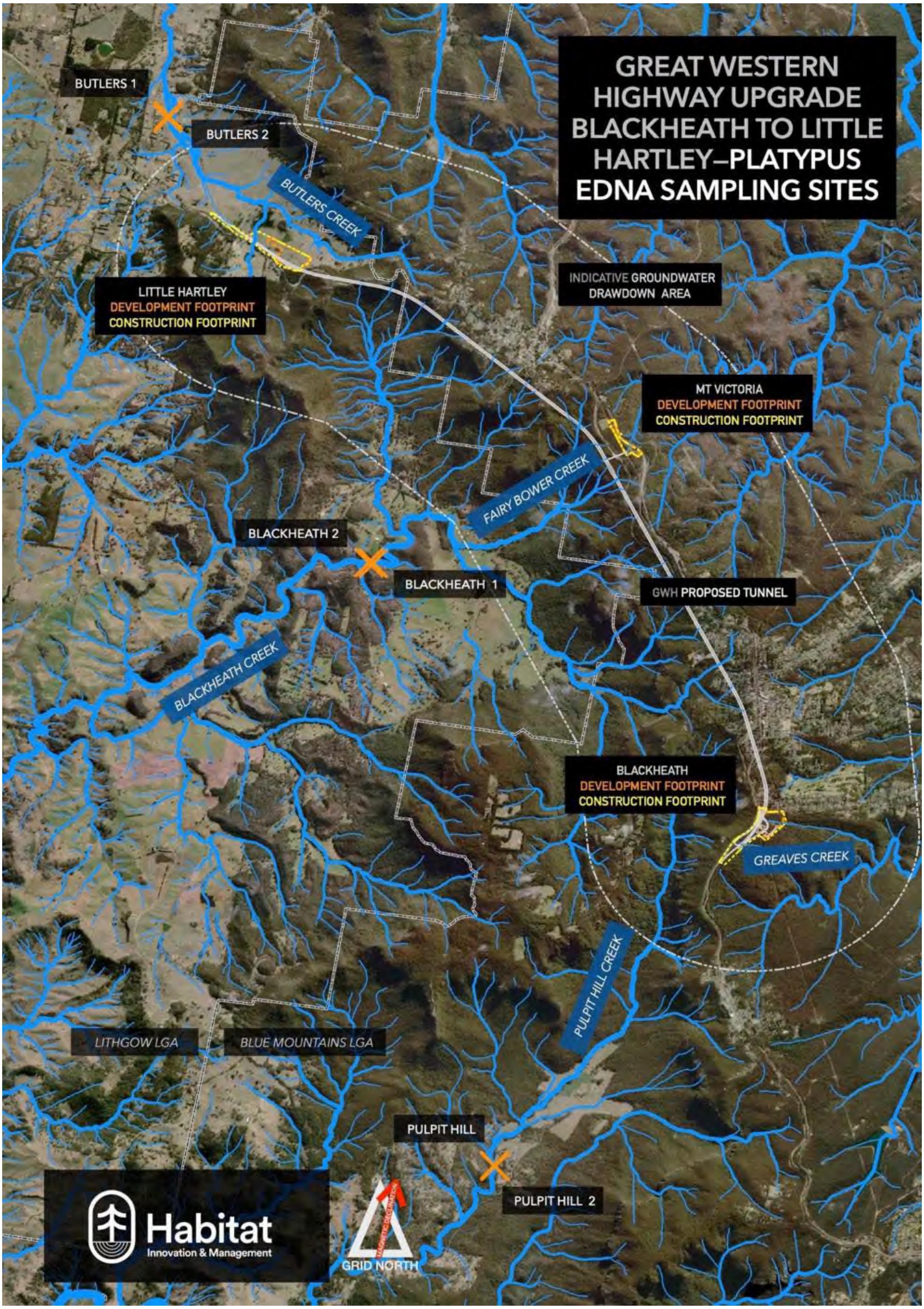

Figure 15 Location of eDNA Platypus sampling

2.3.3 Impact assessment

Assessment of potential impacts on aquatic and riparian ecosystems due to construction and operation of the project have considered:

- construction impacts - impacts to aquatic and riparian ecosystems within Blackheath, Soldiers Pinch and Little Hartley construction footprints, sediment and erosion impacts from construction areas to receiving waterways and surface water pollution, and the potential impacts to aquatic and groundwater dependent ecosystems caused by groundwater drawdown associated with the construction of the project tunnels
- operational impacts - impacts associated with the long-term operation of the project including the effects of stormwater velocity on receiving swamps and waterways, sediment and erosion, and water quality and geochemical alteration.

Assessment of potential impacts have been determined by review of data and reporting developed by other technical specialists working as part of the broader EIS team. Data and reporting presented by the specialist reports were compared to current ecological conditions determined by field survey and spatial review and relevant project waterway objectives. Specialist studies reviewed to assess potential impacts include:

- Great Western Highway Blackheath to Little Hartley – Appendix J (Technical report – Surface water and flooding
- Great Western Highway Blackheath to Little Hartley – Appendix I (Technical report – Groundwater)
- Biodiversity Development Assessment Report (BDAR) (select map sets) (BIOSIS 2022).

To determine potential impacts to threatened species the following documents were also reviewed:

- Matters of National Environmental Significance - Significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth of Australia, 2013)
- Species Profile and Threats Database (SPRAT) (Australian Government 2022)
- Threatened Species Assessment Guidelines: The assessment of significance. (NSW Department of Primary Industries, 2008
- National Recovery Plan for Macquarie Perch (*Macquaria australasica*). (Commonwealth of Australia, 2018)
- Draft Guidelines for Threatened biodiversity survey and assessment. Guidelines for developments and activities (2004 working draft) (NSW Government, 2004).

Frameworks for assessment detailed in these documents were followed to determine the significance of impacts and listed KTPs.

The project footprint, receiving waters and predicted groundwater drawdown zone are uniquely positioned adjacent to significant natural assets which include a World Heritage Area, NSW National Parks and Wildlife Service (NPWS) Estate and Sydney drinking water catchment. Due to the legislative protections awarded to much of the surrounding areas it is assumed, for the purpose of this assessment that the ecological condition will remain relatively stable into the future, notwithstanding stochastic events such as bushfire or climate associated change.

Therefore, for the purpose of this assessment, baseline ecological conditions act as a suitable and representative measure of future background conditions. The study assesses modelled future impacts including potential groundwater drawdown and stormwater runoff associated with the project.

2.3.4 Waterway objectives

Table 7 provides a summary of the waterway objectives for the Hawksbury/Nepean Catchment, within which all waterways assessed by this study are located. The objectives are specific to this project and were developed in accordance with the Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use

Planning Decisions (OEH, 2017). The numerical criteria are sourced from existing guidelines and objectives. Predicted impacts from the project will be assessed against the waterway objectives.

The framework defines waterway objectives as consisting of:

- community's environmental values and uses of the water
- indicator(s) and corresponding numerical criteria to assess whether the waterway will support a particular environmental value or use.

The values and uses adopted for the Hawkesbury/Nepean Catchment are:

- aquatic ecology
- recreation and aesthetics
- primary industries
- drinking water (Nepean River only).

Management goals and numerical criteria for each of these values and uses have been informed by the following guidelines:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000 and ANZG, 2018)
- Guidelines for managing risks in recreational water (NHMRC 2008)
- Australian Drinking Water Guidelines 2011, Version 3.5 Updated August 2018 (NHMRC 2008 and NRMMC 2011).

Table 7 outlines the water quality objectives relevant to the project, and water quality modelling and compliance to are detailed in Great Western Highway Blackheath to Little Hartley as provided in Appendix J (Technical report – Surface water and flooding).

Table 7 Waterway objectives for Hawkesbury/Nepean River catchment.

Values and uses and associated management goals	**Indicator**		**Numerical criteria/metric**
			WQO/ANZECC
1. Aquatic Ecosystems *Management goal: Protect, maintain and restore the ecological condition of aquatic systems and their riparian zones overtime.*	Total nitrogen (TN)		0.35 mg/L[1]
	Total phosphorus (TP)		0.025 mg/L[1]
	NOx		0.040 mg/L[1]
	Ammonium (NH_4^+)		0.020 mg/L[1]
	Filterable reactive phosphorus (FRP)		0.020 mg/L[1]
	Chlorophyll-*a* (Chl *a*)		0.003 mg/L[1]
	Dissolved oxygen (DO)		85 - 110 % Saturation[1]
	pH		6.5 - 8.0[1]
	Conductivity		125-2200 µS/cm[1]
	Toxicants/metals		Default to ANZECC
	Turbidity		6-50NTU[1]
2. Recreation and Aesthetics *Management Goal: Maintain or improve water quality for recreational activities such as swimming, boating and fishing.*	Recreational water quality: Primary Contact	Enterococci	95th percentile for intestinal enterococci/100 mL ≤ 40[3]
		Cyanobacteria	No overall increase in (cyanobacteria) risk under any scenario, as determined by the length of period with index values consistently above 0.8.

	Recreational water quality: Secondary Contact	Enterococci	95th percentile for intestinal enterococci/100 mL > 40 and ≤ 200[3]
		Cyanobacteria	No overall increase in (cyanobacteria) risk under any scenario, as determined by the length of period with index values consistently above 0.8.
Management Goal: Maintain or improve the aesthetic qualities of the waterways	Visual clarity and colour		Surface waters should be free from substances that produce undesirable colour, odour or foaming.[1]
	Surface films and debris		Surface waters should be free from floating debris, oil, grease and other objectionable matter[1]
	Nuisance organisms		Surface waters should be free from undesirable aquatic life, such as algal blooms, or dense growths of attached plants or insects[1].
3. Primary industries (irrigation and livestock drinking) *Management Goal: Protect the quality of water used for a broad range of irrigation activities and livestock drinking*	As per Water Quality metrics		
	Human Pathogens		Thermotolerant Coliforms <10 cfu/100 mL[1] *E. Coli* used as representative indicator
	Cyanobacteria		No overall increase in (cyanobacteria) risk under any scenario, as determined by the length of period with index values consistently above 0.8.
4. Protection of Raw Drinking Water Supplies *Management Goal: Maintain or improve the quality of raw drinking water extracted downstream*	As per Water Quality metrics		
	Microorganisms		*E. Coli* < 1cfu/100mL Enterococci <1cfu/100mL Viruses, protozoa and helminths[4] – Absent Cyanobacteria risk index. Criteria: No overall increase in risk under any scenario.
	Toxicants		Refer to ANZECC

Table notes:

- Indicators and metrics adopted from ANZECC (default trigger values) are for slightly disturbed lowland river ecosystems in south-east Australia
- Guidelines for managing risks in recreational water (NHMRC 2008)
- Australian Drinking Water Guidelines 6 v3.5 (NHMRC 2011)

3 Existing environment

This section details results of the desktop review and field assessment components, which describe the current condition of the aquatic and riparian ecosystems across the study area.

3.1 Existing environment

3.1.1 Desktop assessment

Strahler stream order

A review of NSW state-wide topographic mapping to determine Strahler stream ordering of creeks (Figure 16) within the study area (SIX maps 2022) showed that:

Around Little Hartley:

- Butlers Creek is a 3rd order stream, progressing to a 4th order stream below the junction of an unnamed tributary that flows from the south

Around Soldiers Pinch:

- the headwaters of Fairy Bower Creek are located within the study area and consist of multiple 1st order streams. At the location below which the project tunnels would pass, Fairy Bower Creek is classed as a 2nd order stream. Downstream of this point, Fairy Bower Creek flows into Blackheath Creek. Prior to the confluence with Blackheath Creek, Fairy Bower Creek becomes a 4th order stream. Blackheath Creek continues to flow south-west becoming a 5th order stream prior to the confluence with the Cox's River

Around Blackheath:

- the headwaters of Pulpit Hill Creek are located within the study area and consist of multiple 1st order streams. While the project tunnels would not pass under Pulpit Hill Creek, it remains underneath the catchment of Pulpit Hill Creek. At the point where Pulpit Hill Creek flows out of the upper confines of Megalong Valley, it is a 4th order stream. Pulpit Hill Creek remains a 4th order stream before it flows into the Cox's River
- the headwaters of Young Creek lie inside the study area but are outside of the Blackheath construction footprint. Young Creek flows from a 1st order stream to a 2nd order stream before it joins Adams Creek
- the headwaters of Relton Creek are within the project construction footprint. Relton Creek flows from a 1st order stream to a 2nd order stream before it joins Adams Creek
- the headwaters of Adams Creek reside inside the study area but are outside of the project construction footprint. Adams Creek flows from a 1st order stream to a 2nd order stream prior to the junction of Relton Creek. At the point where Relton Creek flows into Adams Creek, Adams Creek becomes a 3rd order stream. Adams Creek remains a 3rd order stream before it flows into Greaves Creek
- the headwaters of Greaves Creek are within the project construction footprint. Greaves Creek flows from a 1st order stream to a 2nd order stream before the junction with Adams Creek. At the downstream most point, Greaves Creek becomes a 4th order stream before it flows into Govetts Creek.

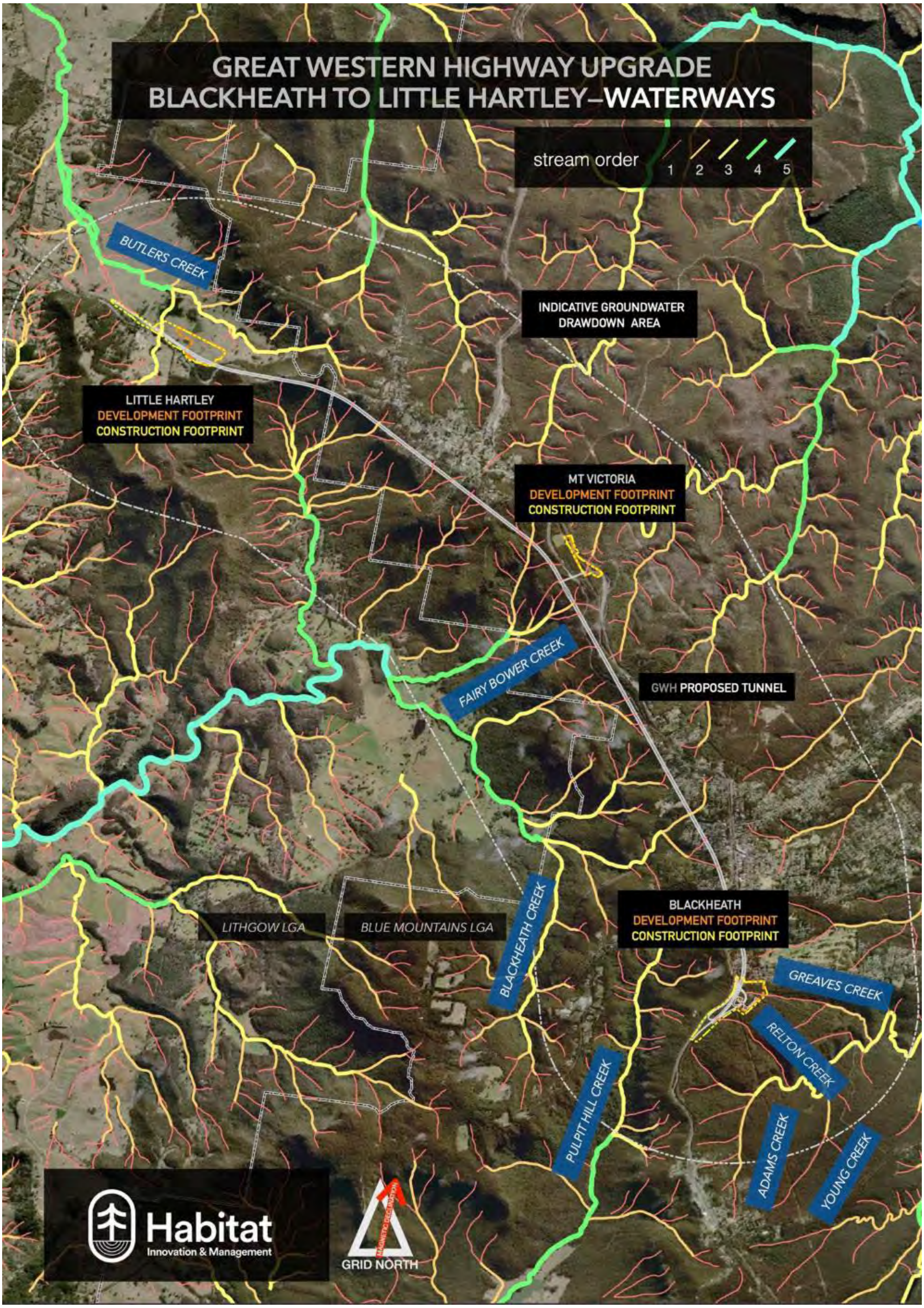

Figure 16 Strahler stream ordering of all creeks across the study area.

Key Fish Habitat mapping and threatened species distribution

Review of NSW Key Fish Habitat Mapping (NSW Department of Primary Industries 2015) shows that sections of mapped KFH are present within the study area. All waterways that are classified as 3rd order and above are mapped as KFH, which includes reaches of Butlers Creek, Fairy Bower Creek, Pulpit Hill Creek, Adams Creek and Greaves Creek (Figure 17 to Figure 19). Only one waterway, un-named tributary of Butlers Creek, would be within the project construction footprint (at Little Hartley) (Figure 19)

Review of indicative threatened fish distribution mapping via NSW Fisheries Spatial Data Portal shows that no waterways within the study area are considered likely habitat for threatened fish. However, creeks within the study area fall within the Grose River or the Cox's River catchments, both of which are considered habitat for Macquarie Perch (*Macquaria australasica*) which is listed as endangered under the FM Act 1994 and EPBC Act 1999 (Figure 20).

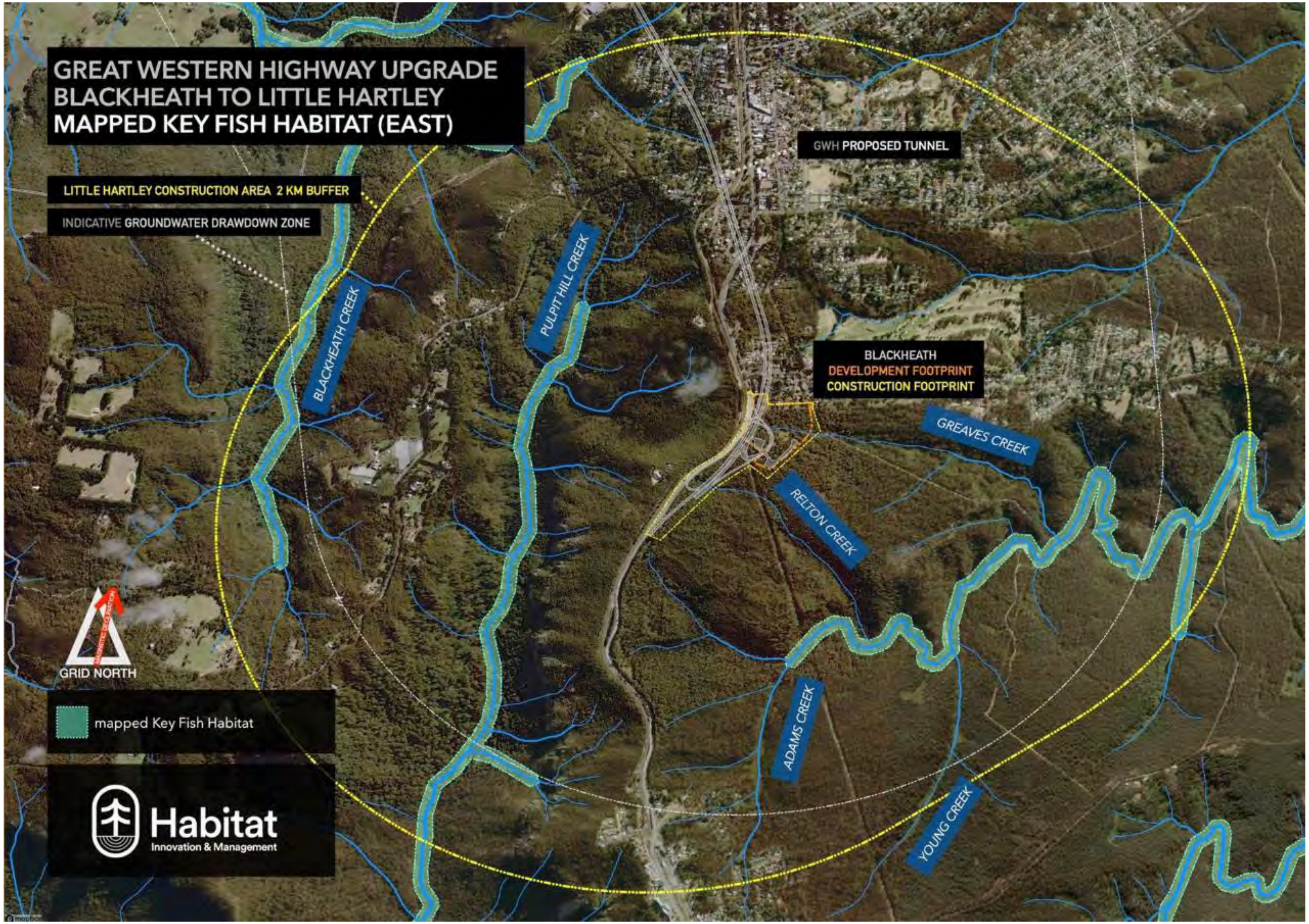

Figure 17 Mapped Key Fish Habitat for the eastern section of the study area (NSW DPI Fisheries 2015).

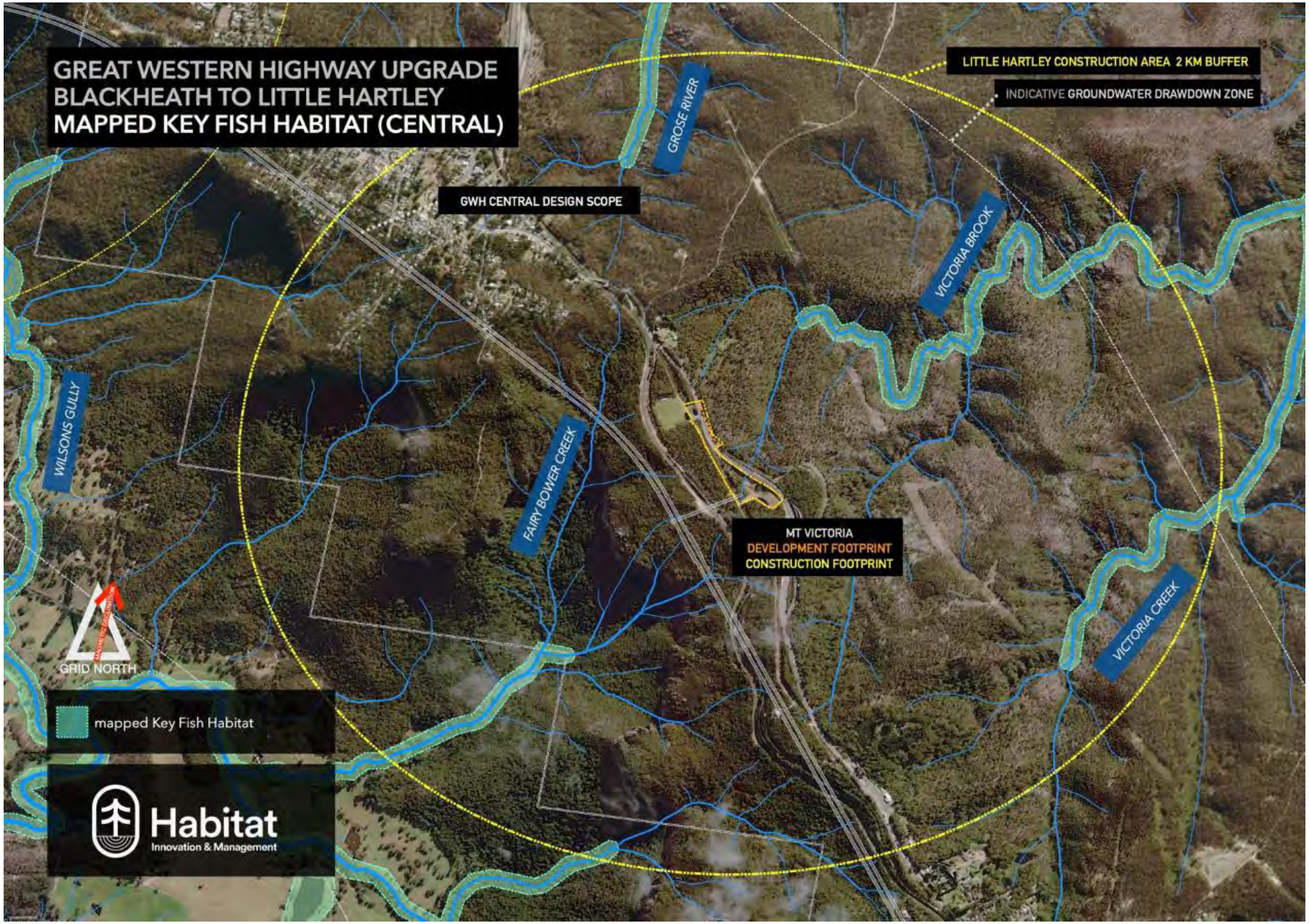

Figure 18 Mapped Key Fish Habitat for the central section of the study area.(NSW DPI Fisheries 2015).

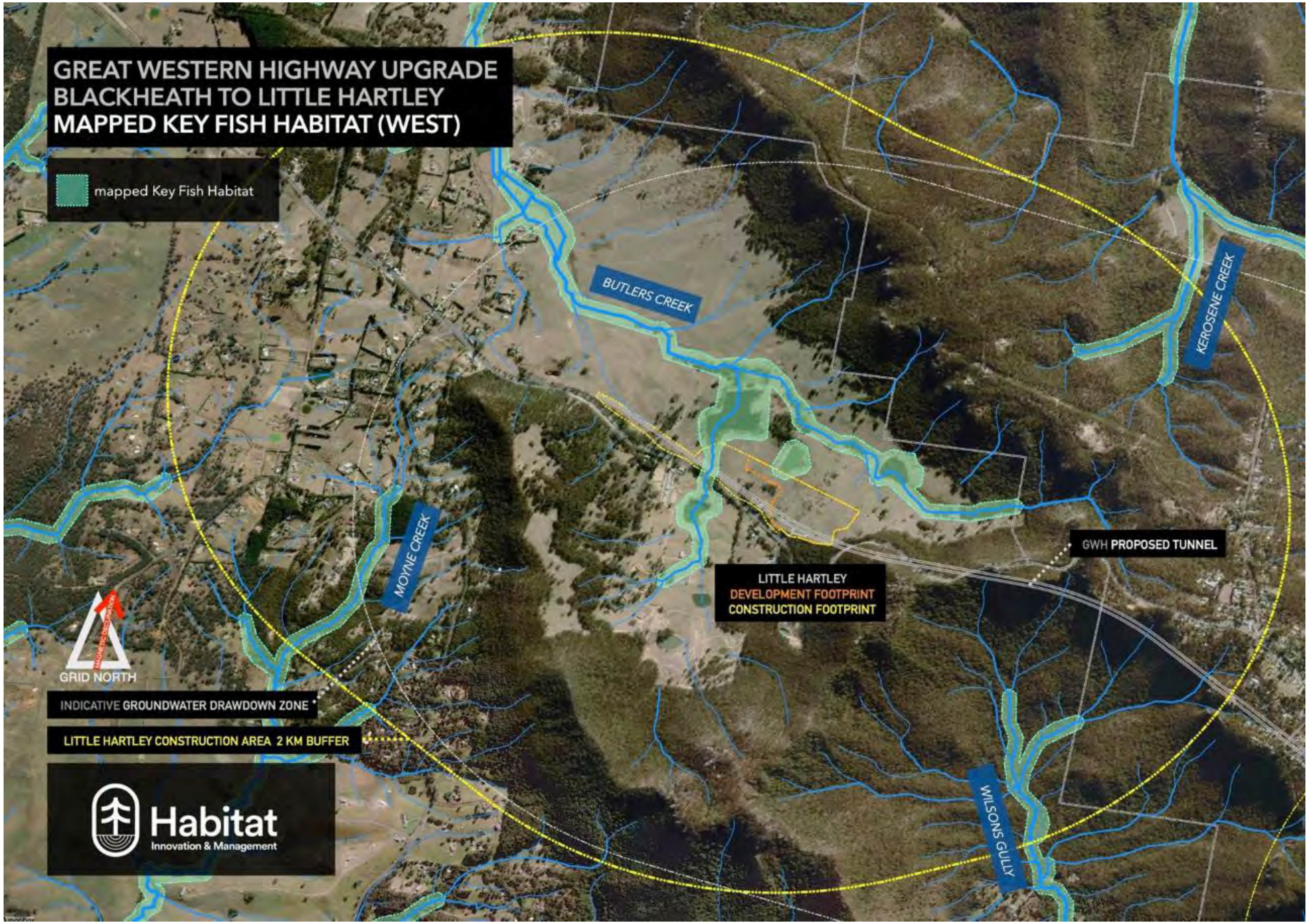

Figure 19 Mapped Key Fish Habitat for the western section of the study area. (NSW DPI Fisheries 2015).

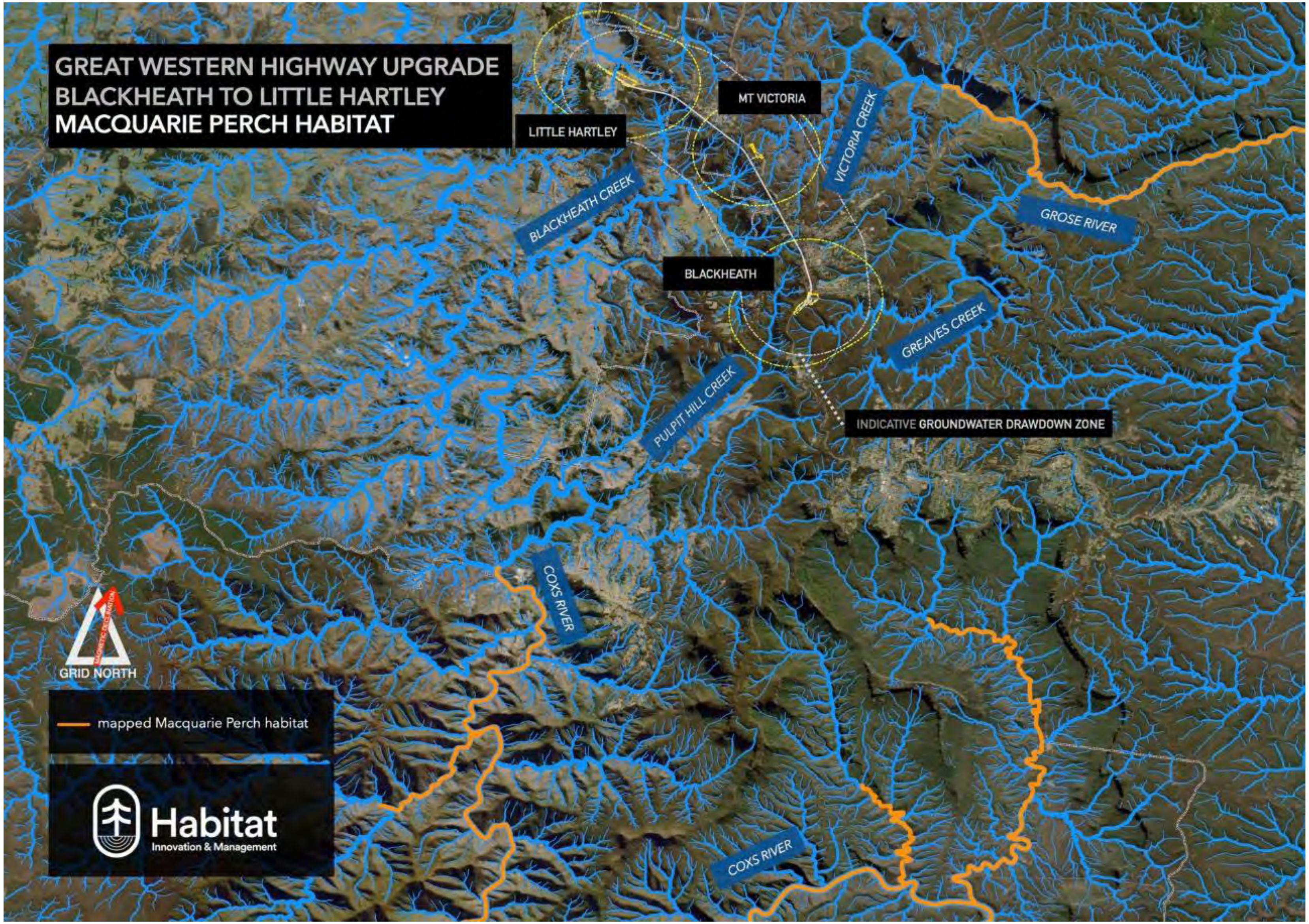

Figure 20 Indicative distribution of Macquarie Perch across the greater region in relation to the study area (NSW DPIE Fisheries 2015).

Groundwater Dependent Ecosystems

Review of the Atlas of Groundwater Dependent Ecosystems (BOM, 2022) showed that patches of both terrestrial and aquatic GDEs are present within the study area.

Areas of aquatic GDE correspond with mapped areas of THPSS. THPSS are classified as GDEs which are defined as communities of plants and animals whose extent and life processes are dependent on groundwater, such as through wetlands or springs. Cox’s River is also considered an aquatic GDE, but it is well outside of the study area.

Terrestrial GDEs are present within the study area, in the Butlers Creek region. These areas of terrestrial GDE correspond with mapped patches of native vegetation which include Plant Community Types (PCTs) 1248 – Sydney Peppermint – Silver Topped Ash and PCT 1256 – Tableland Swamp Meadow on Impeded Drainage. Review of mapping within the BDAR (BIOSIS 2022) shows these areas of mapped PCT 1248 and PCT1256 are:

- also considered to be THPSS which is a listed Threatened Ecological Community (TEC) under the EPBC
- contain Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps Bioregions also a considered a TEC under the NSW BC Act.

High Ecological Value Aquatic Ecosystems

High Ecological Value Aquatic Ecosystems (HEVAE) relate to ecological values that are protected or managed under Commonwealth or State legislation and include NSW Water Management Act 2000, NSW Fisheries Management Act 1994 and NSW Biodiversity Conservation Act 2016. HEVAEs have been mapped as present in isolated patches within the study area. The highest concentration of mapped HEVAEs is in and adjacent to Butlers Creek. The areas mapped as HEVAE correspond to patches of native vegetation on the banks of Butlers Creek. The only other areas of mapped HEVAEs that are relevant to the project are located on the two dams on the Adams Creek / Greaves Creek system (Figure 21 to Figure 23).

Matters of National Environmental Significance

The only aquatic or riparian matter of national environmental significance relevant to the project is the Macquarie Perch (*Macquaria australasica*), which is listed as endangered species under the EPBC Act. As discussed above, there are no waterways within the study area considered likely habitat for the Macquarie Perch. However, creeks within the study area fall within the Grose River or the Cox’s River catchments, both of which are considered habitat for the species.

Note that other ecological matters of national environmental significance are identified in the BDAR for the project.

Figure 21 High Ecological Value Water Dependent Ecosystems for the eastern portion of the study area.

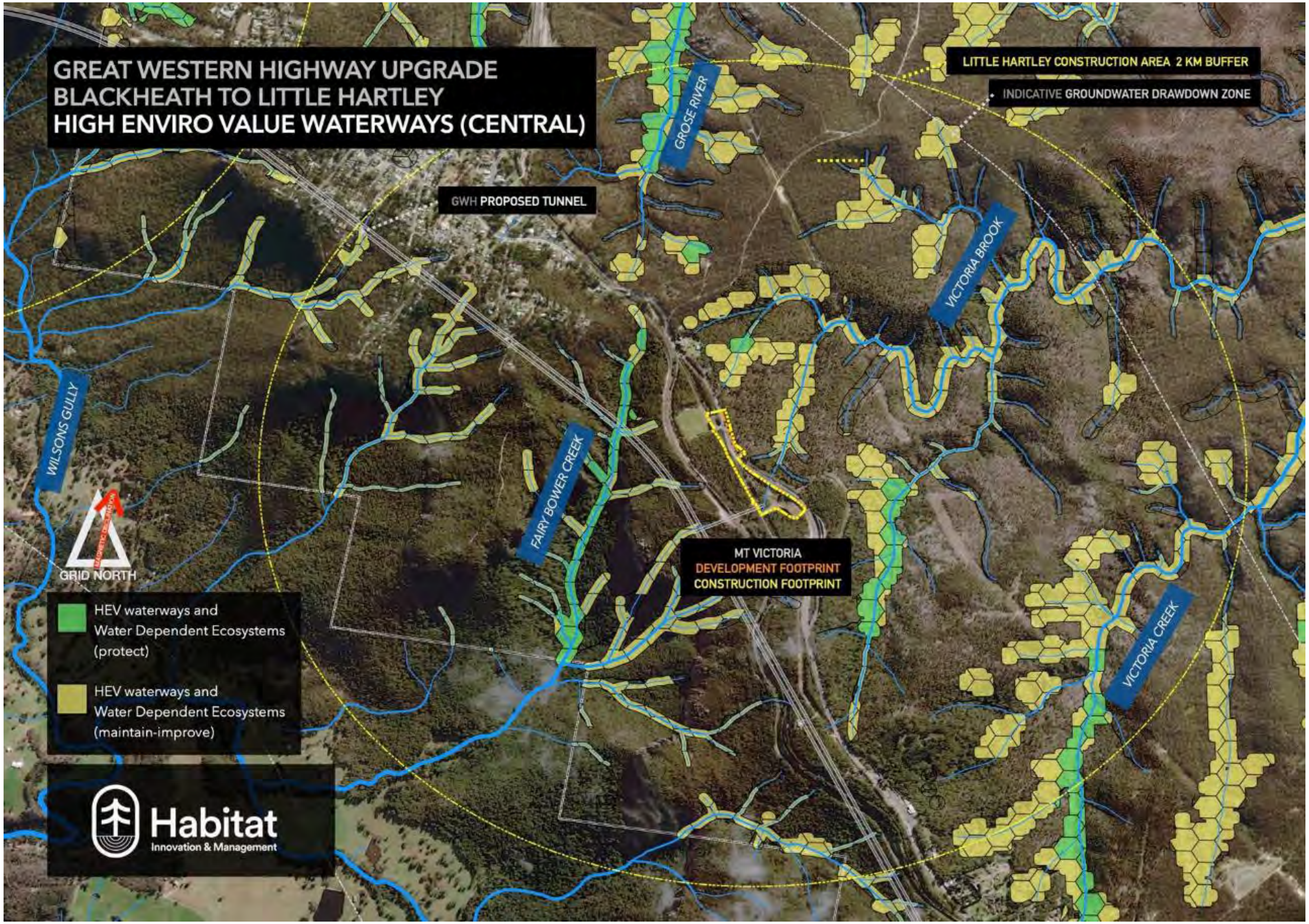

Figure 22 High Ecological Value Water Dependent Ecosystems for the central portion of the study area.

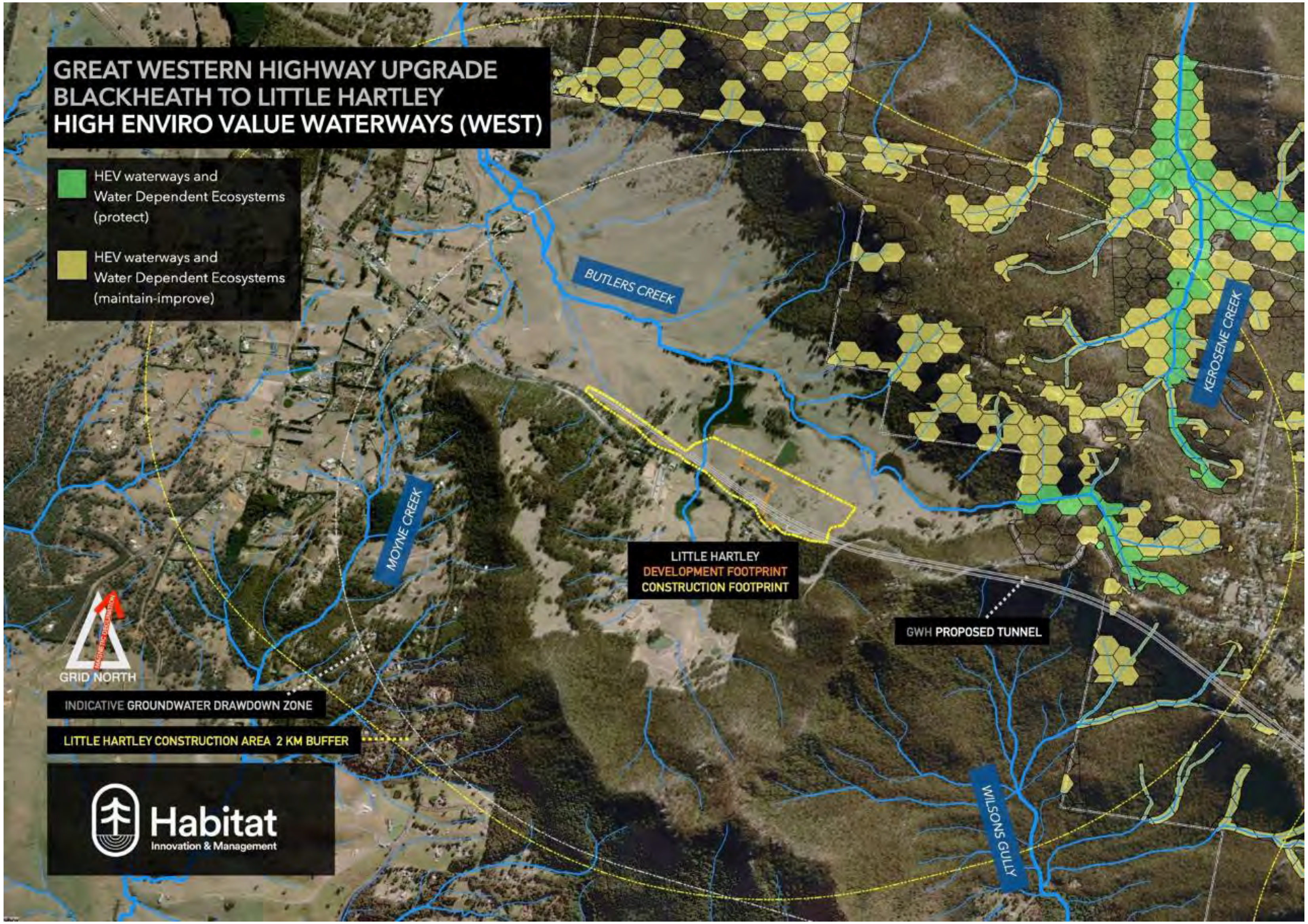

Figure 23 High Ecological Value Water Dependent Ecosystems for the western portion of the study area.

3.1.2 Field assessment

Waterway validation

Field assessment validated that all creeks assessed as part of this study fit the definition of a “river” as defined by the NSW *Water Management Act 2000* as all creeks had defined bed and banks and/or had permanent or intermittent flow with a defined flow path.

Riparian vegetation and creek channel condition and key fish habitat

Results of the assessment of riparian vegetation and creek channel condition using the Rapid Riparian Appraisal (Findlay *et al*. 2011) are shown in Figure 24 to Figure 26 and summarised in Table 8. The results indicate the condition of the creeks surveyed in this study ranged from ‘poor’ to ‘excellent’. The primary factor influencing the RRA scores is surrounding land use.

Around Little Hartley:

In Butlers Creek, and the tributaries of Butlers Creek, the vegetation type varies from natural bushland to pasture / grassland. The upper two sites of Butlers Creek are primarily naturally vegetated, with a riparian buffer that extends over 40 metres. Due to the naturally vegetated catchment and lack of disturbance in the headwaters of Butlers Creek, anthropogenic impacts are low. This is reflected in the low litter, weed and erosion scores in the upper reaches of Butlers Creek. The combination of a naturally vegetated catchment and low disturbance results in the two upper most sites of Butlers Creek graded as being in ‘excellent’ ecological condition.

Further downstream, the land use changes on Butlers Creek from natural bushland to pasture. Pasture grassland is not as effective as natural bushland at buffering rainfall events nor at stabilising stream geomorphology. This reduces buffering capacity and reduces geomorphic stability, causing increased erosion and loss of instream habitat. However, as the headwaters of Butlers Creek are naturally vegetated, the full environmental effect is not immediately evident upon the change to pasture grassland. This is apparent when examining the furthest downstream site on Butlers Creek, which was graded as ‘poor’.

The condition of the tributaries flowing into Butlers Creek are predominantly graded as ‘fair’. At the upper reach of Butlers Creek, KFH has been assessed as Type 1, Class 2 (highly sensitive, moderate key fish habitat) due to the semi-permanent nature of the waterway along with habitat features that include: overhanging vegetation, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, and instream rocks.

Around Soldiers Pinch:

Blackheath Creek, a tributary of the Cox’s River, to the south of Butlers Creek is outside of the project construction footprint with the RRA condition assessed below the junction of Fairy Bower Creek. This assessment corresponds with the Blackheath Creek eDNA sampling point. The majority of the catchment of upstream Blackheath Creek is naturally vegetated, with limited agricultural activities. This lack of disturbance is reflected in the ‘excellent’ nature of the assessed reach of Blackheath Creek. At the site of the KFH assessment, Blackheath Creek is categorised by the presence of overhanging vegetation, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, instream rocks and gravel beds, the presence of native aquatic plants and likely permanent flow.

Fairy Bower Creek, a tributary of Blackheath Creek is graded as ‘excellent’ at all three sites. This was determined due to the intact nature of the riparian zone, abundant habitat, natural features and lack of weeds. The sandstone bedrock and bank has insulated Fairy Bower Creek to adverse erosion, which prevents stream simplification. As volume of water increases, permanent pools and flowing water become a feature. Although there was no mapped KFH at the locations of the Fairy Bower Creek sites, habitat features were present at all sites. These included presence of overhanging vegetation and natural bed detritus at upper Fairy Bower Creek and overhanging vegetation presence, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, instream rocks, the presence of native aquatic plants and permanent flow at middle and lower Fairy Bower Creek.

Around Blackheath:

Pulpit Hill Creek, a tributary of the Coxs River, to the east of Fairy Bower Creek is graded as ‘excellent’ at all three sites. This was determined due to the intact nature of the riparian zone, abundant habitat, natural features and lack of weeds. As the gradient of Pulpit Hill Creek reduces and the volume of water increases, cobbled riffle zones become a feature. This is reflected in the mapped and assessed KFH where, although it contains habitat features such as overhanging vegetation and natural bed detritus, the upstream reach is not mapped as KFH due to its smaller steam size, while the middle and lower sites are assessed as a Type 1, Class 1 (highly sensitive, major key fish habitat). This high classification was awarded due to the presence of overhanging vegetation, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, instream rocks, the presence of native aquatic plants and the permanency of water at middle and lower Pulpit Hill Creek.

Greaves Creek recorded RRA condition scores of ‘excellent’ at all three sites. This was determined due to the intact nature of the riparian zone, abundant habitat and natural features and lack of weeds. As the volume of water increases, permanent pools and flowing water become a feature. All three Greaves Creek sites are not mapped as KFH. Upper Greaves Creek has an ephemeral nature with no permanent refuge and a lack of native aquatic vegetation. Although not mapped as KFH, the middle and lower sites both have a presence of overhanging vegetation, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, instream rocks, and the presence of native aquatic plants, as well as permanent stream hydrology.

Adams Creek, at the eastern end of the study area and a tributary of Greaves Creek, recorded an RRA grade of ‘very good’ at the upstream site and grades of ‘excellent’ at the middle and lower sections. The upper section of Adams Creek, while predominantly naturally vegetated receives stormwater input from residential Medlow Bath. This is reflected in the lower RRA score, compared to the downstream sections.

By the middle and lower sections of Adams Creek, this stormwater impact is not apparent, and the stream returns to ‘excellent’ condition. Upper Adams Creek is not mapped as KFH. This is due to the ephemeral nature of the creek with sporadic refuge and the lack of native aquatic vegetation. The middle Adams Creek site was awarded a Type 2, Class 2 (moderately sensitive, moderate key fish habitat) due to it containing overhanging vegetation, natural bed detritus and snags greater than 300 millimetres in diameter or three metres in length. Lower Adams Creek was assessed as Type 1, Class 1 (highly sensitive, major key fish habitat) due to the increased size and volume of the stream as well as the presence of overhanging vegetation, natural bed detritus, snags greater than 300 millimetres in diameter or three metres in length, instream rocks, the presence of native aquatic plants and the permanency of water hydrology.

Relton Creek, a tributary of Adams Creek recorded RRA condition scores of ‘excellent’ at all three sites. This is due to the intact nature of the riparian zone, abundant habitat, natural features and lack of weeds. As volume of water increases, permanent pools and flowing water become a feature. All three Relton Creek sites are not mapped as KFH, although habitat features such as overhanging vegetation, natural bed detritus, snags over three metres in length and the presence of native macrophytes are evident at the middle and lower sites.

Young Creek recorded RRA condition scores of ‘excellent’ at all three sites. This is due to the intact nature of the riparian zone, lack of erosion, abundant habitat and natural features and lack of weeds. As the volume of water increases, permanent pools and flowing water become a feature. All three Young Creek sites are not mapped as KFH. Upper Young Creek showed an ephemeral nature with no permanent refuge and a lack of native aquatic vegetation, while middle and lower Young Creek sites both contained habitat features such as presence of overhanging vegetation, natural bed detritus, snags over three metres in length, native macrophytes, in-stream habitat rocks and a permanent water hydrology.

Detailed assessment for each site is provided in Attachment C.

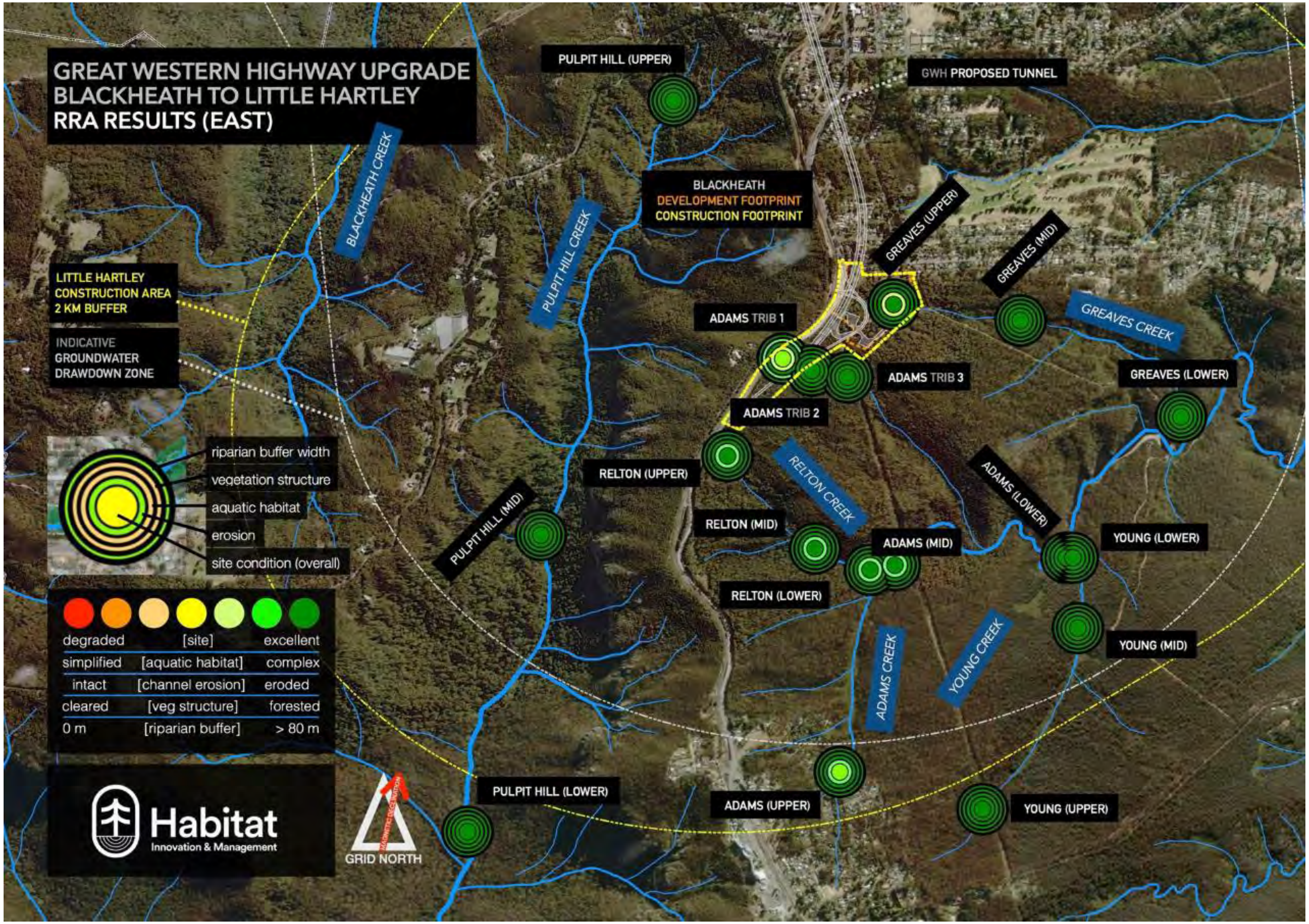

Figure 24 Results of riparian vegetation and creek channel assessment for the eastern section of the study area.

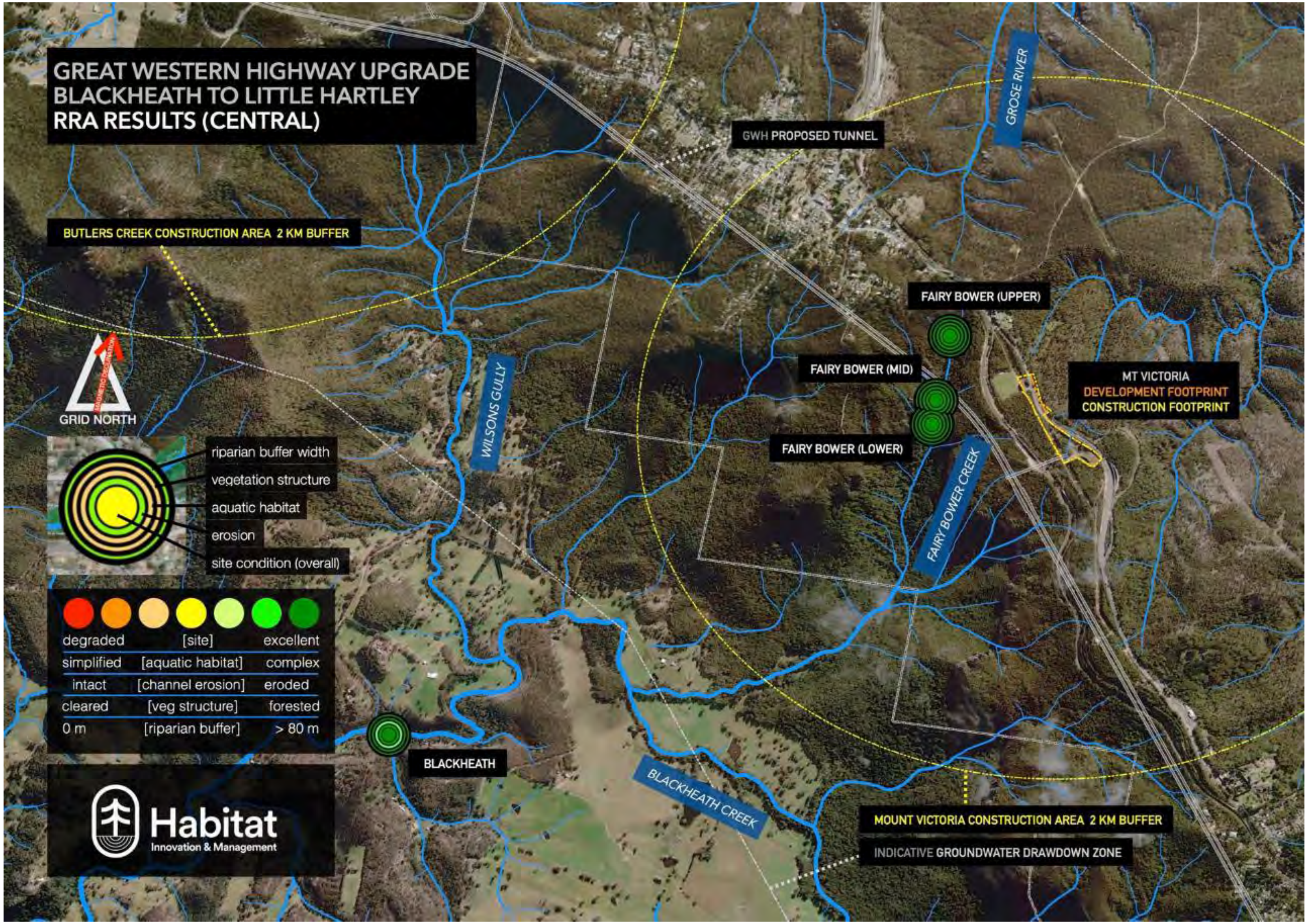

Figure 25 Results of riparian vegetation and creek channel assessment for the central section of the study area.

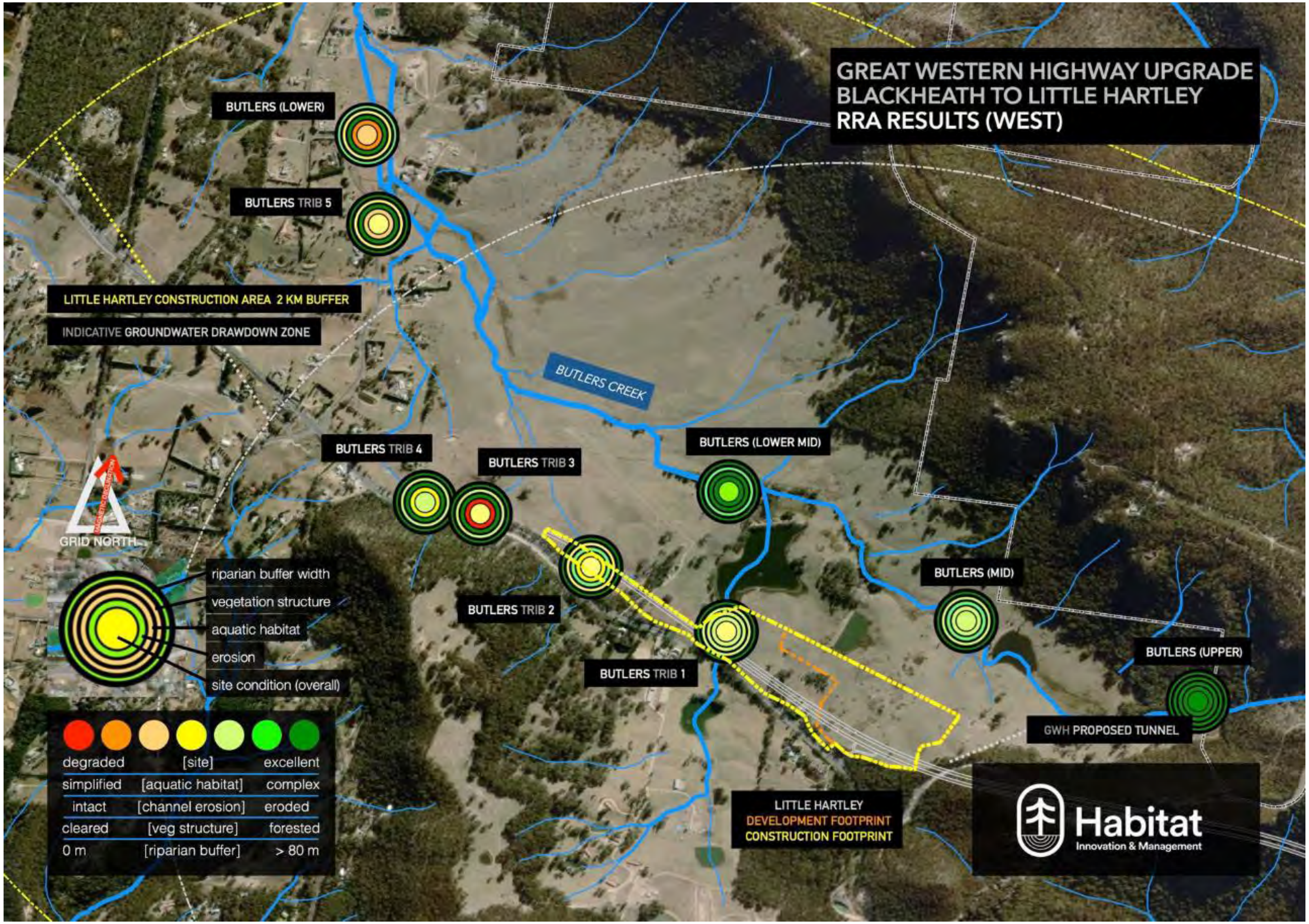

Figure 26 Results of riparian vegetation and creek channel assessment for the western section of the study area.

Table 8 Riparian vegetation and creek channel assessment indices, assessed condition and percentage score for assessed creeks across the study area.

Site	Dominant land use	Riparian buffer	Deposition and erosion	Weeds	Litter	KFH Class	KFH type	Condition	Total Score (%)
Upper Adams Creek	Bushland	Over 40m	Absent	Sparse	Absent	-	-	Very Good	88
Middle Adams Creek	Bushland	Over 40m	Absent	Absent	Absent	2	2	Excellent	94
Lower Adams Creek	Bushland	Over 40m	Absent	Absent	Absent	1	1	Excellent	96
Adams Creek unnamed tributary 1	Bushland	Over 40m	Absent	Sparse	Absent	-	-	Very Good	81
Adams Creek unnamed tributary 2	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	97
Adams Creek unnamed tributary 3	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	96
Blackheath Creek	Bushland	Over 40m	Absent	Sparse	Absent	1	1	Excellent	93
Upper Butlers Creek	Bushland	Over 40m	Minor	Sparse	Absent	2	1	Excellent	91
Middle Butlers Creek	Pasture	Over 40m	Minor	Light	Low	2	2	Good	73
Lower Middle Butlers Creek	Pasture	Over 40m	Minor	Light	Low	2	1	Very Good	81
Lower Butlers Creek	Pasture	20m - 40m	Absent	Sparse	Low	3	2	Poor	53
Butlers Creek tributary 1	Pasture	Over 40m	Minor	Sparse	Low	2	2	Fair	69
Butlers Creek tributary 2	Pasture	Over 40m	Absent	Sparse	Low	4	3	Good	70
Butlers Creek tributary 3	Pasture	20m - 40m	Absent	Sparse	Low	-	-	Fair	64
Butlers Creek tributary 4	Pasture	Over 40m	Absent	Sparse	Low	-	-	Fair	60
Butlers Creek tributary 5	Pasture	Over 40m	Minor	Light	Low	-	-	Fair	66

Site	Dominant Landuse	Riparian Buffer	Deposition and Erosion	Weeds	Litter	KFH Class	KFH Type	Condition	Total Score (%)
Upper Fairy Bower Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	97
Middle Fairy Bower Creek	Bushland	Over 40m	Minor	Absent	Absent	-	-	Excellent	96
Lower Fairy Bower Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	97
Upper Greaves Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	91
Middle Greaves Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	96
Lower Greaves Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	96
Upper Pulpit Hill Creek	Bushland	Over 40m	Minor	Absent	Absent	-	-	Excellent	96
Middle Pulpit Hill Creek	Bushland	Over 40m	Absent	Absent	Absent	1	1	Excellent	97
Lower Pulpit Hill Creek	Bushland	Over 40m	Absent	Absent	Absent	1	1	Excellent	97
Upper Relton Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	92
Middle Relton Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	95
Lower Relton Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	93
Upper Young Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	98
Middle Young Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	97
Lower Young Creek	Bushland	Over 40m	Absent	Absent	Absent	-	-	Excellent	97

Table note: '-' indicates not considered KFH.

Groundwater Dependent Ecosystems and swamps

Field validation of GDEs and swamps was carried out at the Butlers Creek swamp only as this area is highly susceptible to change that may be caused by the construction and operation of parts of the project at Little Hartley, and particularly the construction phase concrete batching plant and the operational water treatment plant.

Field validation was carried out to distinguish between swamp and wetland communities, and to map the extent of the Temperate Highland Peat Swamps on Sandstone community which is listed as a TEC under the EPBC Act. Results of the field validation have been considered as part of the BDAR for the project.

Several swamp communities listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) make up THPSS. These are:

- Blue Mountains Swamps in the Sydney Basin Bioregion (Vulnerable, BC Act)
- Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion (Endangered, BC Act)
- Montane peatlands and swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions (Endangered, BC Act).

Field assessment concluded that the extent of THPSS in the Butlers Creek study area is confined to a patch in the upper reach of Butlers Creek. The remaining swampy ground in and around Butlers Creek and the associated farm dams is considered to contain species more akin to wetlands rather than the THPSS community (Figure 28).

The patch of THPSS within the Butlers Creek study area are dominated by diagnostic species which included Leptospermum *juniperinum, Leptospermum grandifolium, Juncus sp., Schoenoplectus Validus* and *Geranium neglectum.* In contrast the remaining areas are dominated by species more typical of wetland communities which include *Carex appressa, Juncus* sp.*, and Microlaena stipoides* (Figure 27).

Figure 27 Comparative photos of the THPSS (top) and wetland (bottom) in Butlers Creek.

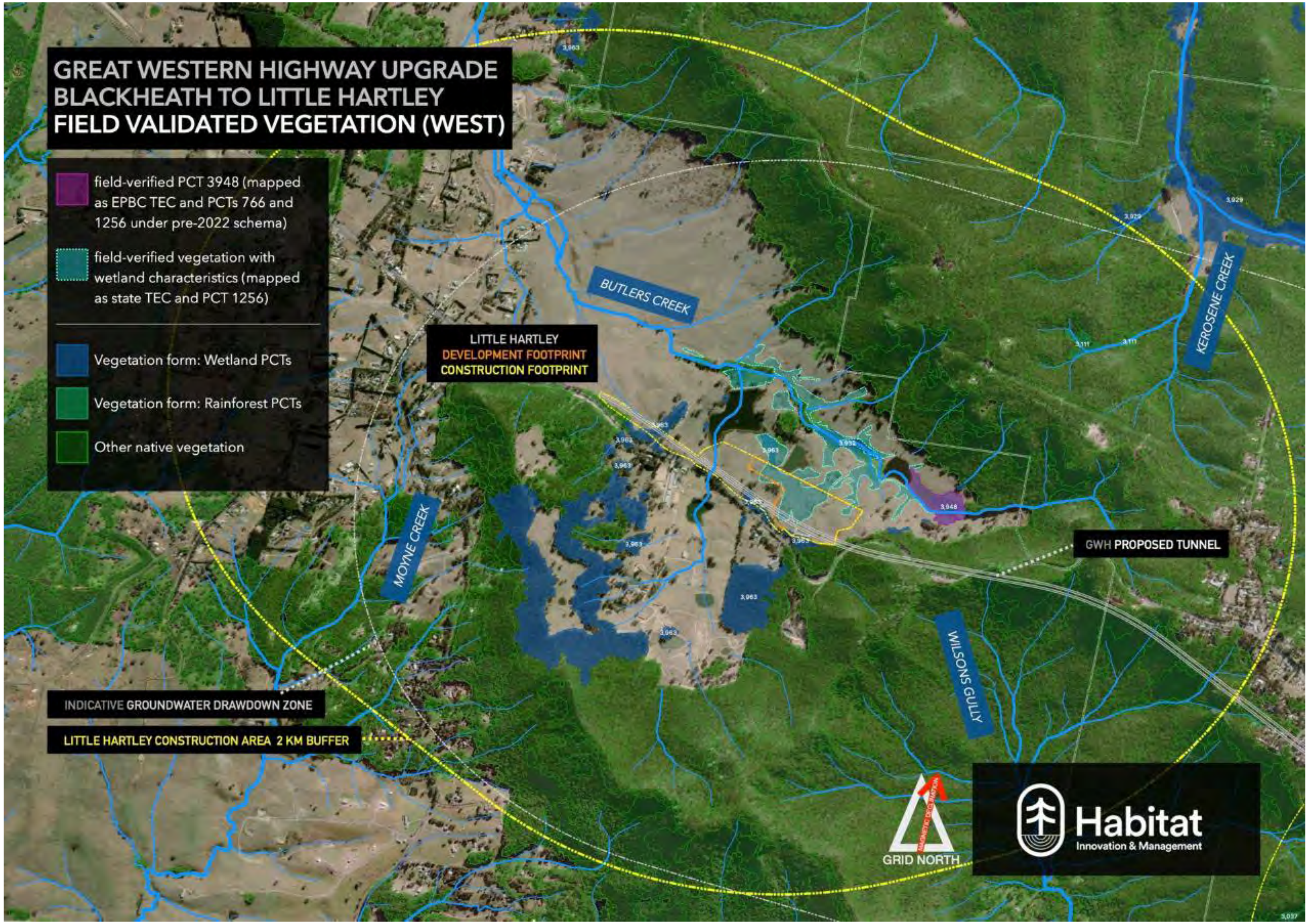

Figure 28 Field validated extent of THPSS (PCT 3948) and wetlands (mapped as PCT 1256) in the Butlers Creek area.

Water quality

In-situ water quality

Results of water quality sampling show that dissolved oxygen is often below the water quality objectives (WQO), i.e., default ANZECC Water Quality Guidelines (ANZECC 2018). Fifteen of the 22 sites had dissolved oxygen below the ANZECC Guideline (Table 9).

The considerably low dissolved oxygen readings at the upper Relton Creek and upper Greaves Creek sites are likely due to these sites being at the headwaters of the creeks where very little flow occurs, which results in small, oxygen poor pools of water being present.

Electrical conductivity is within the WQO at most sites with 16 of the 22 sites being within the ANZECC guideline range, and the six sites that are not within this range were below the lower limit. However, the ANZECC guideline does not accurately reflect the true geochemical nature of Blue Mountains streams which are typically dilute and can often have conductivity below 100 µS/cm (e.g. Belmer et 2018).

Results of pH testing shows that 20 of the 22 streams sampled have pH below the lower limit of the ANZECC guidelines, with only two sites having pH that is within the ANZECC guideline. The lowest pH was recorded at the middle Greaves Creek site which has a pH of 4.74. However, as with EC, the ANZECC guidelines do not reflect the naturally acidic nature of Blue Mountains streams and results such as this are typical of Blue Mountains creeks with minimally disturbed catchments (e.g. Belmer *et al*. 2018).

Turbidity at the sites monitored is generally low, with 18 of the 22 sites being within the ANZECC guideline ranges. The four sites that are not within the guideline range are below the lower limit, which is indicative of excellent water quality and reflects the nature of dilute sandstone derived waters.

Flow velocity of the sites sampled is typically between <0.1 and 0.3 m/s at the slow-flowing sites, and 1.2 m/s in the fast-flowing sites. This difference is due to the size and shape of the channel, the volume of water within the channels, and the different stream gradients of where the sites were located. The faster flowing sites are typically the middle and lower sites which is attributed to the larger channels that allow a higher volume of water to pass through them.

A likely disturbance of the upper reaches of the streams studied is apparent in the Total Suspended Solids results. The upper or middle sites of most streams show an increase in TSS compared to most lower sites which show undetectable readings. The exception to this is the reaches of Butlers Creek which show an increasing trend from below the detection limit in upstream sites (Upper Butlers Creek and Middle Butlers Creek), to 17000 µg/L in the downstream site (Lower Middle Butlers Creek) and 97000 µg/L in the un-named tributary. These results reflect the land use change between the upper and lower reaches of the creek which transitions from minimally disturbed upper reach to an agricultural land use around lower reaches.

Table 9 In-situ water quality results for creeks subject to this study.

Site	Sample Date	Dissolved Oxygen (% sat)	Conductivity (mS/cm)	pH	Turbidity (NTU)	Temperature (°C)	Flow (m/s)	Suspended Solids (TSS) (mg/L)
Upper Fairy Bower Creek	9/09/2022	***75.4***	48.7	***5.80***	3.02	9.8	0.1	<5
Middle Fairy Bower Creek	9/09/2022	***84.5***	57.3	***5.89***	2.66	9	0.2	9
Lower Fairy Bower Creek	9/09/2022	93.7	39.9	***6.24***	5.34	8.8	0.8	<5
Upper Pulpit Hill Creek	9/09/2022	94	***25.3***	***5.29***	4.79	9.4	<0.1	***70***
Middle Pulpit Hill Creek	9/09/2022	94.4	31.9	***5.85***	***1.28***	9.6	0.8	<5
Lower Pulpit Hill Creek	9/09/2022	91.4	60.8	***5.63***	3.13	9.9	0.7	<5
Upper Relton Creek	9/09/2022	***17.4***	40.5	***5.35***	5.4	9.1	<0.1	<5
Middle Relton Creek	9/09/2022	***72.2***	31.7	***5.66***	***1.60***	9.1	<0.1	12
Lower Relton Creek	9/09/2022	***70.2***	32.9	***4.91***	7.51	9.6	<0.1	<5
Upper Adams Creek	9/09/2022	***60.5***	105.4	***5.71***	3.29	11.3	<0.1	<5
Middle Adams Creek	9/09/2022	***89.4***	40.5	***6.29***	4.03	9.7	0.8	<5
Lower Adams Creek	14/09/2022	96.5	***26.4***	***5.15***	4.10	9.2	0.6	<5
Upper Greaves Creek	9/09/2022	***25.9***	32.1	***5.19***	***1.82***	9.5	<0.1	<5
Middle Greaves Creek	9/09/2022	***67.1***	***25.1***	***4.74***	3.86	10.3	<0.1	***538***
Lower Greaves Creek	9/09/2022	94.2	***26.6***	***5.09***	2.53	10.6	0.9	<5
Upper Young Creek	9/09/2022	***77.1***	172	***5.30***	4.85	10.1	<0.1	***129***
Middle Young Creek	14/09/2022	***87.9***	***24.31***	***5.32***	2.81	8.4	0.2	<5
Lower Young Creek	14/09/2022	98.2	***23.51***	***5.04***	2.30	9.4	1.2	<5
Upper Butlers Creek	30/08/2022	96	44.8	***5.57***	***1.49***	8.6	<0.1	<5
Middle Butlers Creek	30/08/2022	***62.6***	168.9	***6.15***	2.84	9.1	<0.1	<5
Lower Middle Butlers Creek	30/08/2022	***87.8***	135	6.87	3.28	9.1	0.3	17
Butlers Creek unnamed tributary 1	30/08/2022	***24.9***	253	6.78	10.21	12.2	1.1	***97***
WQO/ANZECC GUIDELINE	-	90-110	30-350	6.5-8	2-25	n/a	-n/a	50

Table notes:

- Values in bold and italics shows value outside WQO/ANZECC guideline.
- '<' symbol denotes below limit of equipment detection.

Surface water geochemistry

Analysis of geochemistry results show all creeks within the study have relatively dilute geochemistry which is evidenced by low concentrations of bicarbonate and other major cation and anion species (Table 10).

An exception to this is results for upper Adams Creek, middle Butlers Creek, lower middle Butlers Creek and Butlers Creek unnamed tributary 1, which all have elevated bicarbonate and all other major cations and anion species.

This result is typically indicative of urban and agricultural runoff, and which tends to increase ionic concentrations and particularly bicarbonates through the dissolution of concrete in the urban drainage infrastructure. Lesser disturbed streams on sandstone, typical of Blue Mountains creeks, are more dilute and acidic and are dominated by sodium and chloride ions (Tippler et al. 2012, Belmer et al. 2018). These results are also reflected by the electrical conductivity disparity evident between these sites and those of upper Adams Creek and Butlers Creek (Table 9).

Metals

Analysis of metals sampled from surface waters at study sites shows arsenic concentrations were undetectable at 20 of the 22 sites sampled and 2 µg/L and 3 µg/L at middle Greaves Creek and Butlers Creek unnamed tributary 1 respectively. Although no speciation of arsenic was carried out, these results are well below the ANZECC guideline (Table 11).

Cadmium was undetectable at all sites with the exception of Butlers Creek unnamed tributary 1 where 0.2 µg/L was recorded. This is equivalent to the ANZECC guideline.

Four of 22 sites sampled had elevated chromium which included upper Pulpit Hill Creek (2 µg/L), middle Greaves Creek (9 µg/L), lower middle Butlers Creek (1 µg/L) and Butlers Creek unnamed tributary 1 (4 µg/L). Speciation was not carried out and therefore it cannot be determined if these results exceed the ANZECC guideline which is applicable to hexavalent chromium (CrVI).

Results for copper sampling showed that two sites recorded concentrations in excess of the ANZECC guideline of 1.4 µg/L, being middle Greaves Creek (22µg/L) and Butlers Creek unnamed tributary 1 (7µg/L). These sites were also found to have elevated lead concentrations and nickel was elevated at Butlers Creek unnamed tributary 1.

Five of 22 sites were found to have zinc concentrations above the ANZECC guideline (8µg/L), including upper Fairy Bower Creek (8µg/L), upper Greaves Creek (19µg/L), middle Greaves Creek (18µg/L), upper Butlers Creek (15µg/L) and Butlers Creek unnamed tributary 1 (60µg/L). Zinc is a common indicator of urban runoff as it can originate from galvanised roofing, guttering and fencing in urban areas.

All sites showed undetectable concentrations of mercury.

Of particular interest are the results of the middle Greaves Creek which exceeded the ANZECC guidelines for half of metals that were tested, and Butlers Creek unnamed tributary 1 which exceeded the ANZECC guidelines for six of the eight metals tested. These results reflect the moderately disturbed state of these waterways.

Table 10 Surface water geochemical analysis for creeks subject this assessment.

Site	Sample Date	Bicarbonate Alkalinity as $CaCO_3$ (mg/L)	Total Alkalinity as $CaCO_3$ (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)
Upper Fairy Bower Creek	9/09/2022	3	3	10	<1	<1	8	1	4
Middle Fairy Bower Creek	9/09/2022	<1	<1	9	<1	<1	7	<1	3
Lower Fairy Bower Creek	9/09/2022	<1	<1	9	<1	<1	7	<1	5
Upper Pulpit Hill Creek	9/09/2022	<1	<1	4	<1	<1	4	<1	2
Middle Pulpit Hill Creek	9/09/2022	2	2	6	<1	<1	4	<1	2
Lower Pulpit Hill Creek	9/09/2022	11	11	8	3	2	6	1	8
Upper Relton Creek	9/09/2022	1	1	4	2	1	4	<1	8
Middle Relton Creek	9/09/2022	<1	<1	5	<1	<1	4	<1	2
Lower Relton Creek	9/09/2022	<1	<1	4	<1	<1	4	<1	2
Upper Adams Creek	9/09/2022	16	16	4	7	<1	3	1	4
Middle Adams Creek	9/09/2022	4	4	6	1	<1	4	<1	2
Lower Adams Creek	14/09/2022	2	2	6	<1	<1	4	<1	1
Upper Greaves Creek	9/09/2022	3	3	2	1	<1	3	<1	4
Middle Greaves Creek	9/09/2022	<1	<1	5	<1	<1	3	<1	<1
Lower Greaves Creek	9/09/2022	<1	<1	4	<1	<1	3	<1	<1
Upper Young Creek	9/09/2022	<1	<1	7	<1	<1	4	<1	<1
Middle Young Creek	14/09/2022	3	3	6	<1	<1	4	<1	<1
Lower Young Creek	14/09/2022	<1	<1	6	<1	<1	3	<1	<1
Upper Butlers Creek	30/08/2022	6	6	10	<1	1	3	1	3
Middle Butlers Creek	30/08/2022	48	48	23	11	8	11	2	10
Lower Middle Butlers Creek	30/08/2022	20	20	18	8	5	12	3	26
Butlers Creek unnamed tributary 1	30/08/2022	43	43	23	16	11	18	8	56

Table notes: '< 1mg/L' denotes below laboratory limit of detection.

Table 11 Total metal concentrations for creeks subject to this assessment.

Site	Sample Date	Arsenic (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Nickel (µg/L)	Zinc (µg/L)	Mercury (µg/L)
Upper Fairy Bower Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	***8***	<0.1
Middle Fairy Bower Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	7	<0.1
Lower Fairy Bower Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	6	<0.1
Upper Pulpit Hill Creek	9/09/2022	<1	<0.1	***2***	1	<1	<1	<5	<0.1
Middle Pulpit Hill Creek	9/09/2022	<1	<0.1	<1	<1	<1	1	<5	<0.1
Lower Pulpit Hill Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Upper Relton Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Middle Relton Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Lower Relton Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Upper Adams Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	7	<0.1
Middle Adams Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Lower Adams Creek	14/09/2022	<1	<0.1	<1	<1	<1	1	<5	<0.1
Upper Greaves Creek	9/09/2022	<1	<0.1	<1	1	<1	1	***19***	<0.1
Middle Greaves Creek	9/09/2022	2	<0.1	***9***	***22***	***11***	2	***18***	<0.1
Lower Greaves Creek	9/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Upper Young Creek	9/09/2022	<1	<0.1	<1	<1	1	<1	<5	<0.1
Middle Young Creek	14/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Lower Young Creek	14/09/2022	<1	<0.1	<1	<1	<1	<1	<5	<0.1
Upper Butlers Creek	30/08/2022	<1	<0.1	<1	<1	<1	4	***15***	<0.1
Middle Butlers Creek	30/08/2022	<1	<0.1	<1	<1	<1	2	<5	<0.1
Lower Middle Butlers Creek	30/08/2022	<1	<0.1	***1***	<1	<1	3	<5	<0.1
Butlers Creek unnamed tributary 1	30/08/2022	3	***0.2***	***4***	***7***	***21***	***11***	***60***	<0.1
WQO/ANZECC GUIDELINE	-	As III - 24 AsV -13	0.2	CrVI - 1.0	1.4	3.4	11	8	(Inorganic): 0.06

Table notes:

- Values in bold and italics shows value outside WQO/ANZECC guideline.
- ‘<’ symbol denotes below limit of equipment detection.

Nutrients

Eight of 22 sites sampled were found to have Ammonia- N concentrations in excess of the ANZECC guideline of 13 µg/L, including lower Fairy Bower Creek (40 µg/L), lower Relton Creek (70 µg/L), upper Adams Creek (40 µg/L), upper Greaves Creek (30 µg/L), upper Butlers Creek (20 µg/L), middle Butlers Creek (70µg/L), lower middle Butlers Creek (60µg/L) and Butlers Creek unnamed tributary 1 (60µg/L) (Table 12).

Results for Total Nitrogen (TN) show that 10 of 22 sites had concentrations that exceeded the ANZECC guideline of 250 µg/L. The majority of the sites that exceed the ANZECC guidelines were in a range between 300 and 800 µg/L with the exception of middle Greaves Creek (7800 µg/L) and Butlers Creek unnamed tributary 1 (3700 µg/L) which were significantly higher than the other sites.

Although these TN concentrations are elevated, they must be read in conjunction with results of Total Kjeldahl Nitrogen (TKN) and Ammonia – N, from which the concentration of Organic Nitrogen can be derived by applying the following equation:

Organic Nitrogen = Total Kjehdahl Nitrogen – Ammonia-N

Application of this equation to TN results shows that the elevated concentrations reported are, for the most part, dominated by Organic Nitrogen, which is typically derived from organic acids generated from the breakdown of humic materials in the upper catchment swamps.

Results for Total Phosphorous show that eight of 22 sites were equal to or were in excess of the ANZECC guideline trigger value of 20 µg/L. The sites that had exceeded the guidelines were in a range between 20 and 40 µg/L, with the exception of middle Greaves Creek (480 µg/L) and Butlers Creek unnamed tributary 1 (490 µg/L) which, similar to the TN results, were significantly higher than the other sites (Table 12).

Table 12 Nutrient concentrations for creeks subject to this assessment

Site	Sample Date	Ammonia- N (µg/L)	NOx - N (µg/L)	Total Kjeldahl Nitrogen (µg/L)	Total Nitrogen (µg/L)	Total Phosphorus (µg/L)	Reactive Phosphorus (µg/L)
Upper Fairy Bower Creek	9/09/2022	<10	***40***	200	200	***20***	<10
Middle Fairy Bower Creek	9/09/2022	<10	10	200	200	<10	<10
Lower Fairy Bower Creek	9/09/2022	40	10	300	***300***	<10	<10
Upper Pulpit Hill Creek	9/09/2022	<10	<10	200	200	***20***	<10
Middle Pulpit Hill Creek	9/09/2022	<10	***40***	<100	<100	<10	<10
Lower Pulpit Hill Creek	9/09/2022	<10	***100***	100	200	<10	<10
Upper Relton Creek	9/09/2022	<10	***30***	100	100	<10	<10
Middle Relton Creek	9/09/2022	<10	<10	<100	<100	<10	<10
Lower Relton Creek	9/09/2022	70	***20***	<100	<100	<10	<10
Upper Adams Creek	9/09/2022	40	***20***	300	***300***	<10	<10
Middle Adams Creek	9/09/2022	<10	***130***	200	***300***	<10	<10
Lower Adams Creek	14/09/2022	<10	***20***	<100	<100	<10	<10
Upper Greaves Creek	9/09/2022	30	<10	400	***400***	***40***	<10
Middle Greaves Creek	9/09/2022	<10	<10	7800	***7800***	***480***	<10

Lower Greaves Creek	9/09/2022	<10	***30***	200	200	<10	<10
Upper Young Creek	9/09/2022	10	***150***	600	***800***	10	<10
Middle Young Creek	14/09/2022	<10	10	100	100	<10	<10
Lower Young Creek	14/09/2022	<10	10	100	100	<10	<10
Upper Butlers Creek	30/08/2022	20	***210***	100	***300***	***30***	<10
Middle Butlers Creek	30/08/2022	70	***30***	500	***500***	***20***	<10
Lower Butlers Creek	30/08/2022	60	***140***	400	***500***	***30***	<10
Butlers Creek unnamed tributary 1	30/08/2022	60	***30***	3700	***3700***	***490***	<10
WQO/ANZECC GUIDELINE	-	2570 @ pH 6	15	n/a	250	20	15

Table notes:

- Values in bold and italics shows value outside WQO/ANZECC guideline.
- ‘<’ symbol denotes below limit of equipment detection.

Aquatic Macroinvertebrates

Results of aquatic macroinvertebrate sampling across creeks with potential to be affected by the project showed a general trend of high macroinvertebrate abundance which was reflected by high family richness, % EPT (ie sensitive Ephemeroptera, Plecoptera and Tricoptera taxa) , Shannon Diversity (an index reflecting richness and abundance and SIGNAL SF scores (an index indicative of creek condition based on the presence/absence of macroinvertebrate taxa) (Table 13). These results indicate that the majority of waterways surveyed exhibit low-level disturbance, reflective of stable hydrology, dilute levels of potential pollutants and a varied range of aquatic habitats.

There were some exceptions to this, notably upper Relton Creek, upper Adams Creek and the middle and lower sections of Butlers Creek. The majority of macroinvertebrate indices, particularly SIGNAL SF scores indicate mild levels of disturbance in the upper catchments of Relton and Adams Creeks and in the middle and lower sections of Butlers Creek.

The results of survey are similar to those reported by Wright *et al.* (2017) who reported that the reference stream (i.e. low disturbance) abundance ranged between 8-166 with a mean of 50.7, and family richness ranged between 3-14 with a mean of 8.7.

Additionally, the Blue Mountains City Council Waterways Health Snapshot 2022 (BMCC 2022) has rated the health of streams in the Blue Mountains based on macroinvertebrate samples which bear resemblance to results of this study. Notably BMCC (2022) results from Pulpit Hill Creek and Adams Creek indicate an “excellent” health rating, which is mirrored by the results of this study, particularly by the high percentage of EPT taxa recorded at the middle and lower reaches as they move away from the urbanised areas.

Longitudinal survey of Fairy Bower Creek showed no specific trend in macroinvertebrate indices was evident which reflects the relatively stable hydrological, water quality and habitat along this creek.

Similarly, no longitudinal trend was evident in Pulpit Hill Creek and Young Creek, again a result which reflects the stability of water quality, hydrology and habitat in the creek.

Results from Relton Creek show an increasing trend in all indices with distance downstream as the creek moves away from the headwater urban zone. A similar trend is evident at Adams Creek where indices increase with distance from the urbanised headwater catchment.

Due to the lack of sampling habitat, macroinvertebrate samples were unable to be collected from upper Greaves Creek. Conditions in the middle and lower sections of the creek are predicted to experience low levels of urban based disturbance which is evidenced in the comparison of indices to low disturbance creeks such as Fairy Bower and Pulpit Hill Creeks.

Results from Butlers Creek indicate a trend of a decreasing abundance, richness, EPT %, Shannon index and SIGNAL SF scores from the upper site to the lower site which reflects the evident decrease in water quality, habitat and hydrology as land use changes from bushland to pasture. Results from the Butlers Creek unnamed tributary 1 site show similar results to the middle and lower sites which reflects the agricultural land use.

Table 13 Aquatic macroinvertebrate indices calculated for creeks subject in this study.

Site	Date Sampled	Shannon Index	Abundance	Family Richness	% EPT	SIGNAL-SG
Upper Fairy Bower Creek	06/09/2022	2.8	81	10	58	6.1
Middle Fairy Bower Creek	05/09/2022	2.9	109	11	68	6.0
Lower Fairy Bower Creek	16/09/2022	1.9	59	9	75	5.9
Upper Pulpit Hill Creek	05/09/2022	2.9	74	9	65	5.9
Middle Pulpit Hill Creek	05/09/2022	3.1	97	11	74	5.8
Lower Pulpit Hill Creek	05/09/2022	3.3	119	11	63	5.4
Upper Relton Creek	05/09/2022	1.8	58	12	16	3.8
Middle Relton Creek	05/09/2022	3.2	96	7	62	6.4
Lower Relton Creek	05/09/2022	2.5	144	13	75	5.7
Upper Adams Creek	05/09/2022	1.2	79	9	10	4.2
Middle Adams Creek	05/09/2022	1.9	62	7	74	5.6
Lower Adams Creek	05/09/2022	3.0	145	11	78	6.0
Upper Greaves Creek	Not sampled due to lack of suitable habitat					
Middle Greaves Creek	05/09/2022	2.3	34	8	71	6.2
Lower Greaves Creek	16/09/2022	2.6	127	10	63	5.5
Upper Young Creek	06/09/2022	2.2	115	11	78	5.9
Middle Young Creek	06/09/2022	1.6	142	9	80	6.3
Lower Young Creek	06/09/2022	1.9	158	9	85	6.4
Upper Butlers Creek	30/08/2022	3.4	151	14	60	5.4
Middle Butlers Creek	30/08/2022	3.3	140	18	30	4.4
Lower Butlers Creek	30/08/2022	1.7	88	10	6	3.1
Butlers Creek unnamed tributary 1	30/08/2022	2.4	109	12	28	4.1

Benthic diatoms

Results of benthic diatom analysis show that the majority of sites sampled had a TDI of < 35, a result indicative of oligotrophic conditions which are caused by the combination of low concentrations of bioavailable nutrients and well oxygenated waters. This result indicates the ecological status of these creeks is relatively good (Table 14), a condition also reflected by the macroinvertebrate sampling results.

Table 14 Interpretation of TDI with regards trophic status and ecological status of waterways (from Szczepocka,*et al*. 2018).

TDI	Trophic Status	Ecological Status
0-35	Oligotrophic	Very Good
35-50	Oligo/mesotrophic	Good
50-60	Mesotrophic	Moderate
60-75	Eutrophic	Poor
75-100	Hypertrophic	Bad

In contrast, nutrient impacts are evident in the results for Lower Butlers Creek and Butlers Creek Tributary where TDI scores were 53.62 and 78.55 respectively (Table 15). These results indicate the trophic condition of Lower Butlers Creek is mesotrophic (i.e. contains a moderate level of dissolved available nutrients) and Butlers Creek tributary is Eutrophic, bordering hypertrophic (i.e. being rich in nutrients and low in available oxygen).

These result reflect the elevated nutrient concentrations found in these waterways and it is evident that water quality in the tributary of Butlers Creek is highly influential on the downstream environment of Lower Butlers Creek (Table 12). The TDI for these two sites indicates moderate to poor ecological condition which is also reflected by the low SIGNAL SF scores and per cent EPT taxa recorded at these sites (Table 13).

Table 15 Trophic Diatom Index for sample sites

Creek Name	Reach	Date	TDI
Adams Creek	Lower	13/10/2022	5.82
Adams Creek	Middle	13/10/2022	14.62
Adams Creek	Upper	13/10/2022	32.26
Butlers Creek	Lower	30/08/2022	53.62
Butlers Creek	Middle	30/08/2022	33.32
Butlers Creek	Tributary	30/08/2022	78.55
Butlers Creek	Upper	30/08/2022	0.3
Fairy Bower Creek	Lower	13/10/2022	8.04
Fairy Bower Creek	Middle	13/10/2022	5.58
Fairy Bower Creek	Upper	13/10/2022	12.23
Greaves Creek	Lower	13/10/2022	5.71
Greaves Creek	Middle	Not sampled due to lack of benthic material	
Greaves Creek	Upper	13/10/2022	1.64
Pulpit Hill Creek	Lower	13/10/2022	24.43
Pulpit Hill Creek	Middle	13/10/2022	29.64
Pulpit Hill Creek	Upper	13/10/2022	1.46
Relton Creek	Lower	13/10/2022	0.4
Relton Creek	Middle	13/10/2022	0.3
Relton Creek	Upper	13/10/2022	5.08

Young Creek	Lower	13/10/2022	0.34
Young Creek	Middle	13/10/2022	13.18
Young Creek	Upper	13/10/2022	0.66

Platypus

Results of eDNA sampling show no platypuses were detected in Butlers Creek, Pulpit Hill Creek or Blackheath Creek. Results of eDNA sampling are provided in Attachment C.

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4 Impact assessment

The section presents the assessment of potential impacts of the project on aquatic and riparian ecology during construction and operation, and has been prepared to support the EIS and BDAR for the project.

This assessment has applied the following terminology d to describe the severity of environmental impact:

- improved or improvement - considered as changes in ambient conditions that support the protection or enhancement of applicable environmental values and objectives. In the context of this assessment, this may relate to maintenance/achievement of the following:
- lower ambient concentrations of water quality parameters and/or increased levels of dissolved oxygen
- increased availability of aquatic or riparian habitats and/or aquatic connectivity.
- insignificant/minor impacts - classified as being recognisable as short term, or temporary, or of limited magnitude in nature and only predicted at a local scale
- significant impact - defined as an impact which is important, notable, or of consequence, having regard to its context or intensity as per the EPBC Act 1999 and FM Act 1994
- likely or conversely unlikely - used to define the probability of an event occurring. Likely has been defined in the EPBC Act (1999) as "*To be 'likely', it is not necessary for a significant impact to have a greater than 50% chance of happening; it is sufficient if a significant impact on the environment is a real or not remote chance or possibility.*
- negligible – used to define a very small impact that is unlikely to lead to a change in conditions.

4.1 Construction phase impacts

The construction phase of the project has the potential to impact the aquatic, inclusive of key fish habitat, and riparian and swamp ecosystems of waterways in the study area, principally through:

- changes to the volume and/ or quality of surface water, through surface water runoff or other releases from construction sites
- changes in water resources through groundwater drawdown and potential impacts on surface watercourse baseflows
- potential impacts to threatened species, including the Macquarie Perch (*Macquaria australasica*) and its habitat.

4.1.1 Changes in surface water quality

During construction, the project has the potential to affect surface water resources and the aquatic and riparian ecology that rely on them through changes to surface water volumes and surface water quality. Appendix J (Technical report - surface water and flooding) of the EIS provides detail with regards to construction activities and the associated potential impacts which may include:

- increased surface water runoff (e.g. due to removal of vegetation) and associated impacts to surface water quality due to the increased mobilisation of sediments (soil erosion) and contaminant laden stormwater
- accidental spills and leaks of substances (e.g. fuel and oils) and associated impacts to surface water quality

- concreting activities impacting receiving waterways in the result of accidental runoff of concrete washout water and spills of excess or waste concrete
- disturbance and oxidisation of acid sulfate rock (ASR) around Little Hartley during construction excavation and earthworks leading to acidification of runoff
- activities related to discharges potentially resulting in increased erosion and scouring due to increased discharged volumes and impacts to ambient water quality due to poorly treated discharges which may contain sediments and other mobilised pollutants.

Creeks relevant to the assessment of potential construction phase surface water impacts include:

- around the Little Hartley construction footprint: Butlers Creek
- around the Soldiers Pinch construction footprint: Fairy Bower
- around the Blackheath construction footprint: Relton Creek, Adams Creek, Greaves Creek and Young Creek.

The risks posed to these waterways through water quality pollution would be high if left unmitigated. If unmitigated, overland flow and stormwater discharge from the construction sites have potential to increase turbidity and suspended sediments in the water column. The effects of increased turbidity are well known and include reduced light penetration of the water column which in turn reduces photosynthesis and associated primary production and can lead to a shift in the trophic status of the creeks. This would then affect the macroinvertebrate taxa, which as results of this study show, the creeks in question maintain a high percentage of disturbance sensitive taxa as indicated by the high percentage of EPT taxa (Table 13).

It is evident by the results of macroinvertebrate sampling that the upper reaches of Relton and Adams Creeks exhibit signs of disturbance, most likely from urban pressures in the upper catchments, which is evident in the relatively low % EPT index and SIGNAL SF scores. The stark difference in these results is not as evident in review of water quality from these creeks (Table 10 - Table 12) which may point to urban hydrology (i.e. flashiness of flows, impacting creek ecosystems in the upper reaches that receive stormwater with the creek and associated ecosystems self-ameliorating with distance downstream). Although this may be the case, influx of fine sediments and pollutant laden run-off has the potential to exacerbate this headwater degradation and push the effects further downstream, reducing the ability of the creek to ameliorate itself.

Continued discharge of sediment and pollutant laden stormwater entering these creeks would contribute to what is known as the Urban Stream Syndrome (Walsh *et al*. 2005) which includes loss of benthic habitats, loss of aquatic biodiversity, invasion by exotic pest species, both aquatic and riparian and a change in the trophic status of the creeks.

Alteration of water quality, particularly increase in suspended solids, has potential to clog the gills of native fish and ultimately lead to the death and local extinctions of those species with low tolerance to turbid waters. This is particularly the case with lower Greaves Creek and Butlers Creek which are considered Key Fish Habitat under the NSW FM Act and therefore caution should be shown when managing water quality impacts associated with construction phase. The water supply pipeline is the only project scope that would cross waterways. As outlined in Chapter 5 (Construction) of the EIS, a less intrusive methodology (for example underboring or attachment to bridges) would be adopted. Therefore the project is not expected to have any impact on riparian corridors or Key Fish Habitat.

To mitigate the potential risks of surface water runoff from construction sites, comprehensive environmental mitigation measures would need to be implemented at each construction site. These mitigation measures should focus on avoiding or minimising the release of sediment-laden water from the sites, and management of potential leaks and spills. Ideally a program to monitor surface water quality around construction sites would be established prior to the commencement of construction, and would continue during construction activities, to provide a real-time early indicator of potential impacts from construction site runoff and an opportunity for adaptive management measures to be implemented to reduce pollutant loads leaving construction sites.

4.1.2 Changes in surface water flows (erosion and sedimentation)

There is the potential for impacts to receiving creeks and swamps during the construction phase of the project associated with increased run-off from construction sites. Increased runoff has the potential to scour and erode creek bed and banks and cause channelisation to the sand dominated bed of swamp ecosystems.

Appendix J (Technical report - surface water and flooding) of the EIS provides detail with regards to construction activities and the associated potential impacts which may include:

- earthworks and changes to the site resulting in concentrated flows, that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters
- increase in baseflow rate to receiving waterways due to continuous discharge from construction water treatment plants, causing a potential for increased erosion and scouring of waterways due to increased discharged volumes.

The majority of waterways in the study area have headwaters where flow and water quality is regulated by wetland/swampy ecosystems. These systems are typically flat or shallow basins infilled with sand dominated sediments that are thickly vegetated and contain high levels of humic material. Typically, there is no defined channel and flow is generally sub-surface and very low energy.

As a result, these systems are highly vulnerable to increased flow velocity which has potential to cause erosion and channelisation through the wetland/swamp system which can eventually lead to a drop in water level causing drying out of the system and an eventual change in both the aquatic and wetland ecological communities from one that is dependent on groundwater and permanent or near permanent waterlogging to one that is tolerant to dry spells and periodic term waterlogging.

Sandy substrates such as those in these headwater wetlands/swamps mobilise at around 0.22 m/sec flow (Hjulstrom 1935) and are most readily mobilised of sediment. Therefore, the risk presented to the swampy/wetland headwaters of these receiving creeks would be high if left unmitigated and there is a high likelihood that channelisation of these environments will occur, which will alter the aquatic and fringing ecosystems.

In addition, erosion of these sandy environments will lead to increased deposition downstream of sand particles which has the potential to smother and infill benthic substrates and reduce habitat for aquatic species, particularly species of native fish and invertebrates that seek refuge in deeper pools.

Erosion of fine sediments from construction sites and of wetland/swamp substrates can lead to the liberation of nutrients, particularly phosphorus, which are bound to sediment particles. Once exposed and exposed to oxygen, phosphorus may become liberated and, under ideal conditions, result in nutrient enrichment of the downstream environments. This can cause excessive algae/macrophyte growth and once all nutrients are consumed oxygen levels deplete as a response to decaying algae/macrophytes and the risk of turning the creek eutrophic increases.

If left unmitigated erosion impacts have potential to cause damage to the headwater wetland/swamp ecosystems. However, the risk of these impacts occurring can be avoided if best practice construction methods are used and effective erosion and sediment controls are put in place. The controls should focus on reducing the volume/ energy of construction site discharges (to more closely reflect existing environmental conditions) and to align discharge water quality, particularly turbidity/ suspended solids to be generally consistent with or better than existing environmental water quality (as relevant to the receiving watercourse).

4.1.3 Groundwater Dependent Ecosystems

There is the potential for impacts to GDEs, including THPSS, during the construction phase of the project. These impacts may be associated with above ground bulk earthworks and water loss through drawdown during the construction of the project tunnels.

Temperate Highland Peat Swamps on Sandstone are listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act* 1999 and is also listed as endangered under the New South Wales *Biodiversity Conservation Act* 2016.

The majority of waterways in the study have headwaters where flow and water quality is regulated by THPSS. These systems are typically flat or shallow basins infilled with sand dominated sediments that are thickly vegetated and contain high levels of humic material. Typically, there is no defined channel and flow is generally sub-surface and very low energy. As a result, these systems are highly vulnerable to increased flow velocity, derived from stormwater runoff which has potential to cause erosion and channelisation through THPSS. This causes drop in water level causing drying out of the system and an eventual change in both the aquatic and wetland ecological communities from one that is dependent on groundwater and permanent or near permanent waterlogging, to one that is tolerant to dry spells and periodic waterlogging.

Sandy substrates such as those in these headwater wetlands/swamps mobilise at around 0.22 m/sec flow (Hjulstrom 1935) and are most readily mobilised of sediment. Therefore, the risk presented to the THPSS headwaters of these receiving creeks would be high if left unmitigated and there is a high likelihood that channelisation of these environments will occur which will alter the aquatic and fringing ecosystems.

Potential surface water quality and surface water flow impacts, and appropriate mitigation measures, would be the same as discussed more broadly in Section 4.1.1 and Section 4.1.2.

During the construction phase, areas of GDEs, including THPSS are exposed to the risk of dewatering due to the process of drawdown (AECOM 2022b). Potential impacts to GDEs may result from:

- groundwater drawdown directly affecting a groundwater resource relied on by a GDE
- groundwater drawdown leading to a loss of baseflow in a surface watercourse relied on by a GDE, or other aquatic or riparian ecosystem.

Maximum groundwater level drawdown during the construction phase is predicted to occur and have been modelled for the water table and Banks Wall Sandstone, Mount York Claystone, and the Burra-Moko Head Sandstone hydrostratigraphic units. Appendix I (Technical report – Groundwater) of the EIS predicts groundwater drawdown in the range of 0.6 – 20 metres (with maximum drawdown close to project tunnel portals and the mid-tunnel adit at Soldiers Pinch, and decreasing with distance from these sites), dependent on the hydrostratigraphic unit. The groundwater modelling predicts a maximum groundwater drawdown at GDEs, and particularly THPSS, occurring at the mapped THPSS on Butlers Creek (near the Little Hartley construction site) of:

- 0.7 metres (95th percentile) during project tunnel construction
- 0.05 metres (50th percentile) during project tunnel construction.

Groundwater levels have been modelled to recover to natural or near natural conditions following completion of construction. Appendix I (Technical report – Groundwater) of the EIS has assessed this drawdown impact as being a low risk to GDEs.

Groundwater drawdown has also been modelled to affect baseflows in surface watercourses near the project. This drawdown translates to a reduction in groundwater baseflow for most creeks assessed by this study of less than 0.5% in both minimum baseflows (i.e. during dry periods) and average baseflows. For the majority of creeks assessed by this study, this represents an insignificant reduction and therefore the risk of impact to the aquatic and riparian ecosystems is considered minimal. The exception to this is Greaves Creek (near the Blackheath construction site) which is predicted through groundwater modelling to experience:

- a reduction in baseflow during a dry year of 15.5% (50th percentile) and 17.0% (95th percentile) following construction of the project

- a reduction in baseflow during an average year of 0.5% (50^{th} percentile) and 1.0% (95^{th} percentile) following construction of the project
- a reduction in baseflow during a wet year of 0.2% (50^{th} percentile) and 0.4% (95^{th} percentile) following construction of the project.

Areas of GDEs, particularly THPSS, have been mapped along Greaves Creek (Figure 29).

The groundwater modelling results presented in Appendix I (Technical report – Groundwater) of the EIS are conservative, and actual impacts in practice may be lower than predicted.

During average and wet years, the predicted loss of baseflow from Greaves Creek and the potential associated impacts to GDEs and THPSS would be not be significant. During a dry year, material impacts to GDEs and THPSS along Greaves Creek may occur. There is some uncertainty about the potential for impacts to GDEs from a reduction in baseflow from Greaves Creek, and the magnitude and extent of resulting changes to the GDEs, based on currently limited information about these ecosystems and their responses to changes in surface and groundwater resources. The frequency of occurrence of dry years in the future, while accepted as likely to increase under the influence of climate change, is also uncertain.

To better understand and respond to potential impacts on GDEs along Greaves Creek, it is recommended that further investigations be carried out, including:

- surface and groundwater monitoring to extend and augment the existing dataset relevant to Greaves Creek and associated GDEs
- ecological monitoring to better characterise the extent, composition and health of the Greaves Creek aquatic and riparian ecosystems, including GDEs
- updated groundwater modelling based on the final design of the project, and taking into account additional surface water and groundwater data
- further consideration of potential impacts on Greaves Creek and GDEs through groundwater drawdown and loss of baseflow based on updated groundwater modelling.

Subject to the outcomes of more detailed assessment based on updated groundwater modelling, where a material impact on Greaves Creek and GDEs continues to be identified, further consideration of appropriate mitigation and management measures should be pursued. If required, additional design-related mitigation measures could be considered, particularly relating to options to reduce the ongoing groundwater drawdown associated with the Blackheath portal. Other measures to supplement/ offset predicted reductions in watercourse baseflows could also be considered.

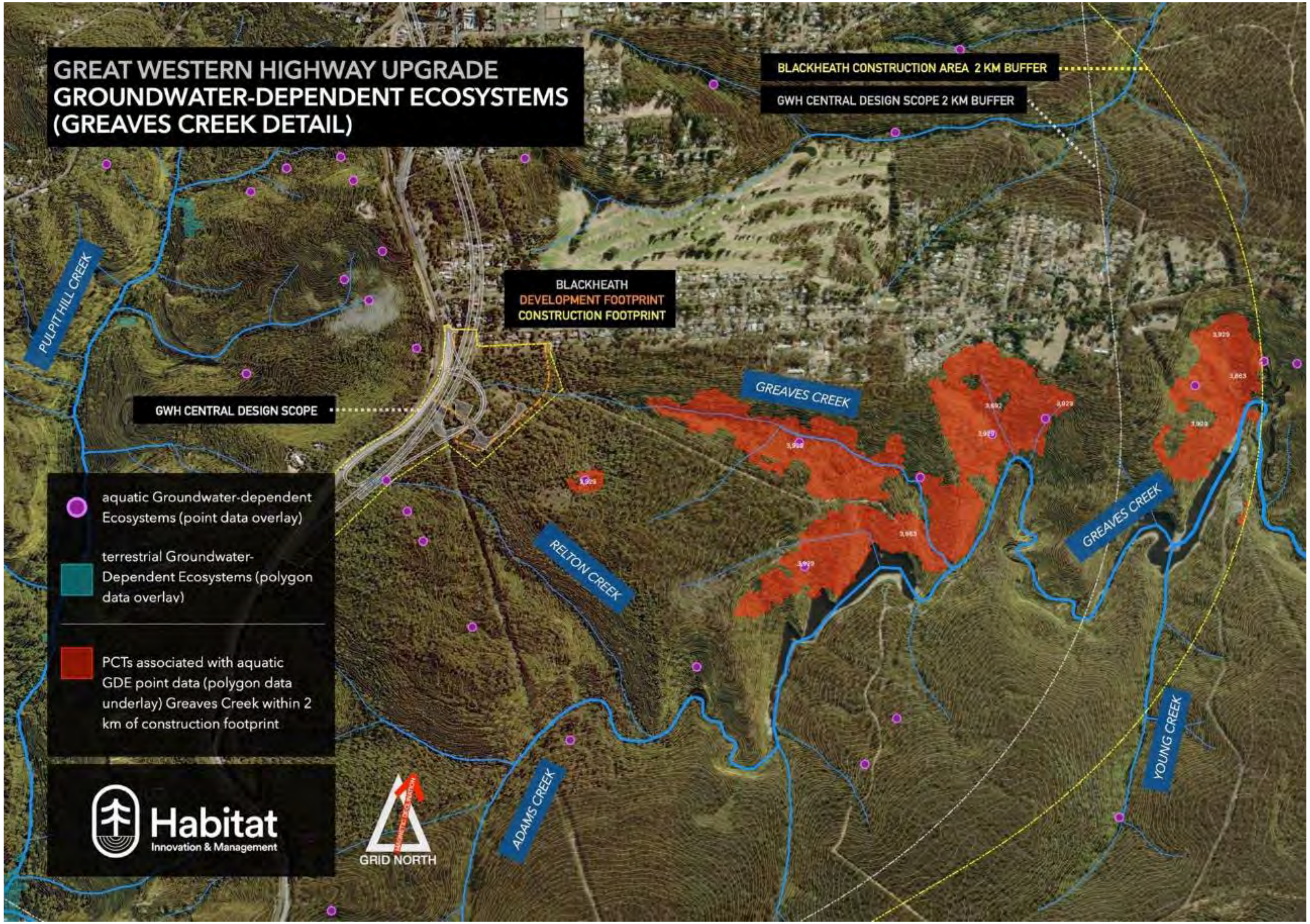

Figure 29 Groundwater dependent ecosystems and swamp ecosystems around Greaves Creek.

4.1.4 Threatened aquatic species and habitats

Due to the known distribution of Macquarie Perch in the Grose River and Coxs River, assessment of the potential impacts to this species and its habitat has been carried out. Potential project-related impacts may arise during construction and operation of the project and principally relate changes in water quality and flows.

The species is listed as threatened under both the FM Act 1994 and EPBC Act 1999. A Test of Significance has been carried out as per the FM Act 1994 and a Significant Impact Assessment has been carried out as per the EPBC Act 1999.

Critical Requirements of Macquarie Perch (*Macquaria australasica*)

The Grose River and Cox's River are mapped as habitat for the Macquarie Perch and although these rivers do not fall within the study area, all the identified receiving waters are within these river catchments and therefore a precautionary approach to this species has been taken.

The critical requirements of the Macquarie Perch are summarised in Table 16.

Table 16 Critical requirements of the Macquarie Perch

Factor	Critical requirements
Conservation significance	• listed as Endangered under the NSW Fisheries Management Act 1994 (Commonwealth of Australia, 2018) • listed as Endangered under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999, with associated recovery plan completed in 2018 (Commonwealth of Australia, 2018) • listed as Endangered on the International Union for the Conservation of Nature (IUCN) Red List.
Refuge habitat	• adults found in cool, clear water in both rivers and lakes (and reservoirs), especially upper reaches of rivers and tributaries (i.e. 400 m to 700 m above sea level), where natural flow and temperature regimes persist, and riparian vegetation is intact (Lintermans et a.. 2019) • preferred microhabitat is slow-flowing, deep and rocky pools with lots of cover including aquatic macrophytes, large boulders, debris, and overhanging banks (Lintermans *et al*. 2019) • juveniles often at the head and tails of pools (depth 0.2 m – 1.0 m) in associated with boulders, cobbles, or large wood (Broadhurst *et al*. 2012) • small schools of larvae at middle to upper water column (< 1 m depth), along steep rock faces, in deep sections of pools (> 1.5 m depth) and in low or no-flow areas (Broadhurst *et al*. 2012) • newly hatched larvae shelter amongst pebbles (Broadhurst *et al*. 2012).
Spawning habitat	• those fish living in lakes migrate to tributaries to spawn (fish living in streams may not need to migrate) (Tonkin *et al*. 2018) • spawning occurs in spring or summer (i.e. October to December, when water temperature reaches between 14°C and 18°C) (NSW DPI 2016) • spawning occurs in shallow upland streams and rivers (Cadwallader and Rogan, 1977)

Factor	Critical requirements
	• ability to swim against flow varies with the body size of fish and temperature: mean sprint swimming speed is >80 cm s^{-1} for adults at 22°C, but <20 cm s^{-1} for juveniles at 10°C (Starrs *et al*. 2011) • riffles: spawning occurs at the lower end of pools and eggs settle amongst downstream cobbles and gravel on the bed of riffles, or spawning directly to riffles (NSW DPI, 2016).
Food	• generalist predators (Cadwallader and Rogan, 1977) • benthic feeding, with only a small amount of food captured at the water surface (Cadwallader and Rogan, 1977) • primary food items include nymph/adult stages of flies and mosquito (Diptera, particularly Chironomidae), caddisflies (Trichoptera), mayflies (Ephemeroptera); secondary food includes stoneflies (Plecoptera), dragonflies and damselflies (Odonata), bugs (Hemiptera), beetles (Coleoptera), Crustacea (from microcrustaceans to Decapoda), gastropod snails (Mollusca) and small fish (NSW DPI, 2016) • dietary diversity and size of prey increase with age (e.g. dietary shift from microcrustaceans to dipterans to decapods) (Cadwallader and Rogan, 1977).
Threats	• urban expansion and water pollution has the potential to affect all aspects of the life history of the Macquarie Perch. Of particular concern are endocrine disrupting chemicals such as pesticides, sewage effluent and plasticisers (NSW DPI, 2016) • in-stream habitat modification or destruction, e.g. removal of rocks or large wood (Lintermans et al. 2019) • clearing of riparian vegetation (Lintermans et al. 2019) • suspended sediment reducing water quality, damaging gills, hindering primary productivity, submergent macrophytes, food and habitat availability for fish (Cadwallader, 1981) • siltation/sedimentation, including that after bushfires and hazard reduction burns (blankets suitable spawning substrate and alters composition of benthic prey) (Lintermans et al. 2019) • habitat fragmentation – lost connectivity between populations and habitats required through life cycle (Lintermans et al. 2019). Fast-flowing water through culvert pipes may be just as impassable as a vertical weir • river damming and regulation (flood spawning habitat and inhibit migration, plus reduced water temperatures below impoundments) (Lintermans et al. 2019) • altered flow regimes: most studies related to reductions in flow, reduced frequency and magnitude of natural flooding and associated reduced habitat quality, loss of spawning cues and reduced opportunities for dispersal and migration (Tonkin et al. 2018) • introduced trout and other exotic fish (predation and competition, plus the diseases such as Epizootic Haematopoietic Necrosis Virus (EHNV), largely spread by Redfin Perch and Rainbow Trout) (Cadwallader, 1981) • illegal fishing (Cadwallader, 1981) • episodic disturbance from drought (Lintermans et al. 2019).

Factor	Critical requirements
General suggested management actions	• determine local population sizes, habitats, and ecological requirements (Commonwealth of Australia, 2018) • develop local recovery plan to conserve existing populations (Commonwealth of Australia, 2018) • improved education, including signage to increase awareness of protected status and improve participation by community groups in Macquarie Perch conservation (Commonwealth of Australia, 2018) • prevent hydrological alteration (Commonwealth of Australia, 2018) • restore native riparian vegetation (Commonwealth of Australia, 2018) • protect and restore Macquarie Perch habitat, e.g. resnagging (Commonwealth of Australia, 2018) • eradicate pest fish (Commonwealth of Australia, 2018).
Possible impacts of altered hydrology	• large flows could reduce access to preferred refuge habitat, which have considerably lower flow velocities than the mainstream, and flush larvae and juveniles downstream (Starrs *et al*. 2011) • changes in flow prompt adult migration during the spawning season (Tonkin *et al*. 2018), so altered flow regimes could influence movement, distribution and spawning (spawning season from October to December; Koster and Crook, 2017) • large flow events negatively affect recruitment during the egg and larval period of the lifecycle, possibly owing to scour of eggs or displacement of larvae, siltation of eggs, loss of critical nursery habitat and/or high turbidity and velocity hindering foraging (Tonkin *et al*. 2018) • large flushing flows could reduce the quality and availability of preferred habitat, such as slow-flowing deep pools and/or large wood (Koster and Crook, 2017) • large flushing flows could reduce the quality and availability of preferred food • sedimentation and other water quality degradation, owing to higher peak flows transporting pollutants, lack of smaller flushing flows and low baseflows facilitating accumulation of pollutants in pools (Koster and Crook, 2017).

Key threatening processes (KTPs)

Key threatening processes (KTPs) listed under the FM Act 1994 include:

- degradation of native riparian vegetation along New South Wales water courses
- hook and line fishing in areas important for the survival of threatened fish species
- human-caused climate change
- installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams
- introduction of fish to waters within a river catchment outside their natural range
- introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales

- removal of large woody debris from New South Wales rivers and streams
- the current shark meshing program in New South Wales waters.

Of these, the project has the potential to contribute to:

- degradation of native riparian vegetation along New South Wales water courses
- installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.

The project's potential contributions to these KTPs are assessed in the following tests of significance under State and Commonwealth legislation.

Test of Significance (Fisheries Management Act 1994)

This section presents a Test of Significance for the Macquarie Perch (*Macquaria australasica*) under the FM Act. Based on the assessment provided below, it is concluded that Macquarie Perch is unlikely to be significantly impacted by the project.

a) in the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Correspondence with DPI Fisheries has confirmed populations of Macquarie Perch are present in the Coxs River and the Grose River. It is unlikely that Macquarie Perch persist in the reaches of Butlers Creek within the study area. This is due to the regulated nature of Butlers Creek, with multiple farm dams and weirs that prevent migration. Butlers Creek within the study area has few areas of cobbled riffle zone, which are necessary for the spawning requirements of the Macquarie Perch. Butlers Creek presents few areas for refuge, with the exception of farm dams, which are not considered to be Macquarie Perch habitat.

This same restriction applies to the upper Greaves Creek catchment, which includes a series of dams on Adams Creek and Greaves Creek. However, there were sections of creek which had habitat features that are required by Macquarie Perch.

Groundwater drawdown has the potential to decrease instream flow, specifically in the Greaves Creek region, which can lead to detrimental impacts to aquatic ecosystems. Maximum groundwater level drawdown during the construction period, predicted to occur at the end of construction (2030), have been modelled for the water table.

Groundwater drawdown has been modelled to affect baseflows in surface watercourses near the project. This drawdown translates to a reduction in groundwater baseflow for most creeks assessed by this study of less than 0.5% in both minimum baseflows (i.e. during dry periods) and average baseflows. For the majority of creeks assessed by this study, this represents an insignificant reduction and therefore the risk of impact to the aquatic and riparian ecosystems is considered minimal. The exception to this is Greaves Creek (near the Blackheath construction site) which is predicted through groundwater modelling to experience:

- a reduction in baseflow during a dry year of 15.5% (50th percentile) and 17.0% (95th percentile) following construction of the project
- a reduction in baseflow during an average year of 0.5% (50th percentile) and 1.0% (95th percentile) following construction of the project
- a reduction in baseflow during a wet year of 0.2% (50th percentile) and 0.4% (95th percentile) following construction of the project.

As Greaves Creek eventually flows into known Macquarie Perch habitat, a loss of baseflow in Greaves Creek would translate to a loss of water volumes delivered to habitat areas. However, given the size of Grose River catchment (into which Greaves Creek flows), the maximum reduction in baseflow from Greaves Creek is unlikely to result in a material change in water volumes delivered to the Macquarie Perch habitat.

As a result of this assessment, water quality is not predicted to change significantly downstream of the waterways examined in this study (AECOM 2022b, MUSIC modelling). Therefore, water quality impacts are not expected to affect the population of Macquarie Perch.

Pulpit Hill Creek and Blackheath Creek, to the south of the study area represent the most likely refuge for Macquarie Perch. Both of these creeks are permanently flowing largely free from barriers to fish passage, have good water quality and necessary habitat features required by Macquarie Perch. The headwaters of these creeks are outside the project construction footprint. Therefore, it is highly unlikely that the project would have any impact on the Macquarie Perch (if present) or its habitat in Pulpit Hill Creek or Blackheath Creek.

(b) in the case of an endangered population, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable.

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable.

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the proposed development or activity, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed development or activity, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the threatened species, population or ecological community in the locality,

No areas of likely Macquarie Perch habitat would be removed or modified as a result of the project. Further, MUSIC modelling predicts that there would be limited changes to the volume and quality of water discharged to receiving waterways. Therefore, potential populations would not become isolated and not threaten the survival of the species.

(e) whether the proposed development or activity is likely to have an adverse effect on any critical habitat (either directly or indirectly).

No critical habitat for Macquarie Perch (*Macquaria australasica*) is present in the study area. As the waterways present in the study area flow into known Macquarie Perch habitat, it is important to consider the downstream impact of the discharge of stormwater. MUSIC modelling predicts that there will be limited changes to the volume and quality of water discharged to receiving waterways. Therefore, populations in the Coxs River and the Grose River would remain unaffected.

(f) whether the proposed development or activity is consistent with a Priorities Action Statement

The Priorities Action Statement - Actions for Macquarie Perch, outlines a range of recovery actions for Macquarie Perch. These relate to:

- collating existing information
- community education
- compliance activities
- natural resource management planning
- habitat rehabilitation
- pest eradication
- research
- stocking and translocation
- survey and mapping.

The project is consistent with the Priorities Action Statement. The actions listed above are the responsibility of other parts of government and the project would not impact on them being achieved.

(g) whether the proposed development constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

It is considered that the potential impacts listed above are consistent with the Key Threatening Processes of:

- degradation of native riparian vegetation along New South Wales water courses
- installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams.

The Coxs River system is a controlled system with major weirs and dams throughout the catchment and therefore the key threatening process of alteration of the natural flow regimes of rivers and streams is already imposed on the river ecosystem. Modelling suggests that water volumes entering the Coxs River system would be unlikely to be impacted as a result of the project.

Test of Significant Impact (Environment Protection and Biodiversity Conservation Act 1999)

This section presents a Test of Significance Impact for the Macquarie Perch (*Macquaria australasica*) under the EPBC Act. Based on the assessment provided below, it is concluded that Macquarie Perch is unlikely to be significantly impacted by the project.

a) Lead to a long-term decrease in the size of a population

Review of habitat distribution mapping for Macquarie Perch shows the Coxs River and the Grose River are considered habitat for the species.

It is unlikely that Macquarie Perch persist in the reaches of Butlers Creek within the study area. This is due to the regulated nature of Butlers Creek, with multiple farm dams and weirs that prevent migration. Butlers Creek within the study area has few areas of cobbled riffle zone, which are necessary for the spawning requirements of the Macquarie Perch. Butlers Creek presents few areas for refuge, with the exception of farm dams, which are not considered to be Macquarie Perch habitat.

This same restriction applies to the upper Greaves Creek catchment, which includes a series of dams on Adams Creek and Greaves Creek. Above the dams, within the study area there are sections of creek which had habitat features that are required by Macquarie Perch. However, due to the ephemeral nature of the creeks it is unlikely that Macquarie Perch would inhabit the creeks above the dam.

Groundwater drawdown has the potential to decrease instream flow in the region of Greaves Creek, which can lead to detrimental impacts to aquatic ecosystems. Maximum groundwater level drawdown during the construction period, predicted to occur at the end of construction (2030), have been modelled for the water table.

Groundwater drawdown has been modelled to affect baseflows in surface watercourses near the project. This drawdown translates to a reduction in groundwater baseflow for most creeks assessed by this study of less than 0.5% in both minimum baseflows (i.e. during dry periods) and average baseflows. For the majority of creeks assessed by this study, this represents an insignificant reduction and therefore the risk of impact to the aquatic and riparian ecosystems is considered minimal. The exception to this is Greaves Creek (near the Blackheath construction site) which is predicted through groundwater modelling to experience:

- a reduction in baseflow during a dry year of 15.5% (50th percentile) and 17.0% (95th percentile) following construction of the project
- a reduction in baseflow during an average year of 0.5% (50th percentile) and 1.0% (95th percentile) following construction of the project
- a reduction in baseflow during a wet year of 0.2% (50th percentile) and 0.4% (95th percentile) following construction of the project.

As Greaves Creek eventually flows into known Macquarie Perch habitat, a loss of baseflow in Greaves Creek would translate to a loss of water volumes delivered to habitat areas. However, given the size of Grose River catchment (into which Greaves Creek flows), the maximum reduction in baseflow from Greaves Creek is unlikely to result in a material change in water volumes delivered to the Macquarie Perch habitat.

As a result of this assessment, water quality is not predicted to change significantly downstream of the waterways examined in this study. Therefore, water quality impacts are not expected to affect the population of Macquarie Perch.

Pulpit Hill Creek and Blackheath Creek, to the south of the study area represent the most likely refuge for Macquarie Perch. Both of these creeks are permanently, flowing largely free from barriers to fish passage, have good water quality and necessary habitat features required by Macquarie Perch. Fortunately, the headwaters of these creeks are outside of the surface construction footprint. Therefore, it is highly unlikely that the proposed development will have any impact on the Macquarie Perch (if present).

b) Reduce the area of occupancy of the species

No. As discussed above, there is insignificant impact to water quality, migration and other habitat needs of the species. Accordingly, this will not influence the area of occupancy of the Macquarie Perch.

c) Fragment an existing important population into two or more populations

No. There would be no removal or modification of habitat within identified Macquarie Perch habitat. Further, there would be no construction of barriers that would impact migration, causing fragmentation. Hydrological MUSIC modelling predicts that there would be limited changes to the volume and quality of water discharged to receiving waterways. Thus, the water quality of the streams in the study area is unlikely to change. Therefore, it would be highly unlikely that water quality in Grose River and Coxs River would change. Thus, the inflow of waters from creeks in the study area into the Grose River and Coxs River would not cause separation and isolation of populations of the Macquarie Perch.

d) Adversely affect habitat critical to the survival of a species

No. There would be no removal or modification of habitat within identified Macquarie Perch habitat. Hydrological MUSIC modelling predicts that there would be limited changes to the volume and quality of water discharged to receiving waterways. Thus, the water quality of the streams in the study area would be unlikely to change. Therefore, it would be highly unlikely that water quality in Grose River and Coxs River would change. Thus, the inflow of waters from creeks in the study area into the Grose River and Coxs River would not adversely affect habitat critical to the survival of the Macquarie Perch.

e) Disrupt the breeding cycle of a population

The Macquarie Perch requires cobbled riffle zones in cool, unpolluted waters to reproduce. These areas are abundant in both the Grose River and Coxs River. Hydrological MUSIC modelling predicts that there would be limited changes to the volume and quality of water discharged to receiving waterways. Thus, the water quality of the streams in the study area would be unlikely to change. Therefore, it would be highly unlikely that water quality in Grose River and Coxs River would change. Thus, the inflow of waters from creeks in the study area into the Grose River and Coxs River would not cause disrupt the zones required by the Macquarie Perch for breeding.

f) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No. No habitat would be modified, destroyed, removed or in a way that adversely affects the Macquarie Perch. Hydrological MUSIC modelling predicts that there would be limited changes to quality of water discharged to receiving waterways. Thus, the water quality of the streams in the study area would be unlikely to change. Therefore, it would be highly unlikely that water quality in Grose River and Coxs River would change. Thus, the inflow of waters from creeks in the study area into the Grose River and Coxs River would not cause separation and isolation of populations of the Macquarie Perch.

g) Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

No. The project would be unlikely to adversely alter the water quality, habitat or hydraulic characteristics of waterways that flow into the Grose River or Coxs River in a way that would allow the establishment or increase of any invasive species populations.

h) Introduce disease that may cause the species to decline, or

No. The project would be unlikely to adversely alter the water quality, habitat or hydraulic characteristics of waterways that flow into the Grose River or Coxs River that would allow the introduction or increase in a disease that may cause the species to decline.

i) Interfere with the recovery of the species

No. The National Recovery Plan for Macquarie Perch (Commonwealth of Australia, 2018) has been established to 'ensure the recovery and ongoing viability of Macquarie perch populations throughout the species' range'. It identifies a range of actions to:

- protect populations from competition, predation, recreational fishing and disease
- restore populations by translocations
- enhance habitat and provide appropriate flow regimes downstream of water storages
- research spawning, life cycle competition, predation, disease, parasites and best practice habitat restoration
- improve captive breeding techniques and undertake a conservation stocking program
- implement long term monitoring programs
- raise community awareness about the conservation status of Macquarie Perch and educate private landholders and land managers responsible for land adjacent to relevant waterways.

As with the NSW Priorities Action Statement, many of these actions are the responsibility of others to implement, and the project would not interfere with any of these actions.

4.2 Operational phase impacts

The operational phase of the project has the potential to impact the aquatic, inclusive of key fish habitat, and riparian and swamp ecosystems of waterways in the study area, principally through:

- changes to the volume and/ or quality of surface water, through surface water runoff or other releases from construction sites
- changes in water resources through groundwater drawdown and potential impacts on surface watercourse baseflows
- potential impacts to threatened species, including the Macquarie Perch (*Macquaria australasica*) and its habitat.

4.2.1 Changes in surface water quality

Modelled outputs of surface water quality were conducted by AECOM (2022a) to determine if NorBE is achieved for the discharge of stormwater during the operational phase of the project. To achieve NorBE, nutrient loads for the operational phase case should aim to achieve the target of 10% less than the pre-development (existing) case for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN).

For gross pollutants (GP), the modelled existing scenario load only needs to be equal to or less than the existing load.

NorBE is deemed to be met if the target post-development pollutant concentrations are equal to or less than the pre-development case concentrations between the 50th and 98th frequency percentiles.

The reduction of stormwater pollutant concentration (AECOM 2022) was modelled to achieve NorBE in the catchments around the Blackheath and Little Hartley operational footprints (noting that there will be no operational infrastructure at Soldiers Pinch). At Blackheath, there is predicted to be a 92% improvement in total suspended solids, a 30% improvement in total phosphorus, a 13% improvement in total nitrogen and a 100% improvement in gross pollutant load. At Little Hartley, there is predicted to be a 91% improvement in total suspended solids, a 42% improvement in total phosphorus, a 24% improvement in total nitrogen and a 100% improvement in gross pollutant load. Based on modelling, NorBE will be met and therefore no water quality impacts to receiving aquatic systems is expected.

However, it is important to consider the limitations of modelling. One such limitation is the consideration of total nitrogen and total phosphorus, rather than separating the pollutants into their bioavailable and stable forms. Forms of nitrogen in freshwater systems include inorganic nitrogen i.e. nitrate (NO_3), nitrite (NO_2), ammonia (NH_3) and ammonium (NH^{+4}). These inorganic forms of nitrogen are the most bioavailable, meaning they are most easily used and taken up by aquatic organisms, particularly aquatic plants, benthic diatoms and algae. It is evident in results of water quality monitoring presented in this study that the majority of nutrients in receiving waterways is in the organic form (Table 12). As such, any increase in the amount of inorganic nitrogen entering the streams is likely to cause adverse environmental impacts, which in the most extreme case can lead to a system becoming eutrophic.

Reactive phosphorus, the inorganic, bioavailable form of phosphorus needs to be regulated in the same manner as inorganic nitrogen. Increased concentrations of inorganic nitrogen and phosphorus are characteristic of stormwater. Thus, caution should be used when assessing modelled improvement percentages. To reduce concentrations of inorganic, more readily bioavailable nutrients advanced stormwater treatment will likely need to be implemented to achieve NorBE.

It is evident by the results of macroinvertebrate sampling that the upper reaches of Relton and Adams Creeks exhibit signs of disturbance, most likely from urban pressures in the upper catchments, which is evident in the relatively low % EPT index and SIGNAL SF scores. The stark difference in these results is not as evident in review of water quality from these creeks (Table 10 to Table 12) which may point to urban hydrology (i.e. flashiness of flows, impacting creek ecosystems in the upper reaches that receive stormwater with the creek and associated ecosystems self-ameliorating with distance downstream). However caution must be applied when considering the potential nutrient impacts to aquatic systems which include changing the trophic status of the water column, depletion of available oxygen, enrichment of swamp and riparian soils which becomes a vector of weed invasion, increased primary production and a dominance in algal grazing fauna leading to a simplification of instream fauna.

In addition to nutrient change there is a risk of ionic pollution to surface waters as a result of dissolution of salts from concrete surfaces associated with the concrete infrastructure of the project and the water treatment plant. In the past decade the impacts of concrete caused geochemical change on freshwater ecosystem have become evident, so much so the term “freshwater salinization syndrome” (Kaushal *et al*. 2021) was coined to describe the multiple impacts to associated with ionic pollution to freshwater systems. A body of evidence specifically focused on ionic, or geochemical pollution” of sandstone bedrock creek systems of the Sydney region has been built around the concept of freshwater salinisation (e.g. Davies *et al*. 2010, Belmer *et al*. 2012, Belmer *et al*. 2016, Wright 2018)

It is expected that stormwater runoff and water treatment plant discharge will have elevated ionic components, notably calcium (Ca) and bicarbonate (HCO_3). If released to the receiving waters assessed by this study, which are chemically dilute and dominated by sodium (Na) and chloride (Cl) and are typically acidic (Table 9 and Table 10), a material change in stream and swamp geochemistry may occur. The impacts will include a shift from dilute Na and Cl dominated waters that are acidic to an alkaline system dominated by Ca and HCO_3. This change is likely to trigger the onset of riparian and swamp weed invasion (Grella *et al*. 2014) and facilitate the dominance of invasive New Zealand Mud Snail (*Potamopyrgus antipodarum*) of the benthic macroinvertebrate community (Shield *et al*. 2014).

Concrete related change may cause impacts to the aquatic and swamp/riparian ecosystems. These effects are most likely to occur in the upper reaches of the receiving waterways and impacts will likely decrease with distance downstream as the self-amelioration action of these creeks, which is evidenced by the water quality and macroinvertebrate results shown in this study. The potential for concrete related change should be considered in establishing water quality criteria for site discharges to minimise the potential for material impacts to downstream aquatic and swamp/riparian ecosystems.

4.2.2 Changes in surface water flows (erosion and sedimentation)

There is the potential for impact to receiving creeks and THPSS during the operational phase of the project which are associated with increased run-off from impervious surfaces which have potential to scour and erode creek bed and banks and cause channelisation to the sand dominated bed of swamp ecosystems.

The majority of waterways in this study have headwaters where flow and water quality are regulated by wetland/swampy ecosystems. These systems are typically flat or shallow basins infilled with sand dominated sediments that are thickly vegetated and contain high levels of humic material. Typically, there is no defined channel and flow is generally sub-surface and very low energy.

As a result, these systems are highly vulnerable to increased flow velocity which has potential to cause erosion and channelisation through the wetland/swamp system which can eventually lead to a drop in water level causing drying out of the system and an eventual change in both the aquatic and wetland ecological communities from one that is dependent on groundwater and permanent or near permanent waterlogging to one that is tolerant to dry spells and period/short term waterlogging.

Sandy substrates such as those in these headwater wetlands/swamps mobilise at around 0.22 m/sec flow (Hjulstrom 1935) and are most readily mobilised of sediment. Therefore, the risk presented to the swampy/wetland headwaters of these receiving creeks would be high if left unmitigated and there is a high likelihood that channelisation of these environments will occur which will alter the aquatic and fringing ecosystems.

In addition, erosion of these sandy environments will lead to increased deposition downstream of sand particles which has the potential to smother and infill benthic substrates and reduce habitat for aquatic species, particularly species of native fish and invertebrates that seek refuge in deeper pools.

Erosion of fine sediments from wetland/swamp substrates can lead to the liberation of nutrients, particularly phosphorus, which are bound to sediment particles but once exposed and oxidised release in to the water column and in the ideal conditions result in nutrient enrichment of the downstream environments which can cause excessive algae/macrophyte growth and once all nutrients are consumed oxygen levels depleted as a response to decaying algae/macrophytes and the risk of turning the creek eutrophic increases.

As discussed in Section 4.1.2 in relation to construction impacts, if left unmitigated erosion impacts have potential to cause damage to the headwater wetland/swamp ecosystems. However, the risk of these impacts occurring can be avoided if best practice surface water management methods are used and effective erosion and sediment controls are put in place. The controls should focus on reducing the volume/ energy of operational site discharges (to more closely reflect existing environmental conditions) and to align discharge water quality, particularly turbidity/ suspended solids to be generally consistent with or better than existing environmental water quality (as relevant to the receiving watercourse).

4.2.3 Groundwater Dependent Ecosystems

Potential impacts to groundwater dependent ecosystems during operation relate to:

- changes to the volume and/ or quality of surface water, through surface water runoff or other releases from construction sites (refer to Section 4.2.1 and 4.2.2)
- changes in water resources through groundwater drawdown and potential impacts on surface watercourse baseflows (refer to Section 4.1.3, which considers groundwater drawdown and loss of surface watercourse base flow during construction, and recovery of groundwater and surface water systems following construction).

4.2.4 Threatened aquatic species and habitats

Assessment of potential impacts on the Macquarie Perch (*Macquaria australasica*) during construction and operation of the project has been assessed collectively in Section 4.1.4.

5 Cumulative impacts

Cumulative impacts have the potential to occur when benefits or impacts from a project overlap or interact with those of other projects, potentially resulting in a larger overall effect (positive or negative) on the environment or local communities. Cumulative impacts may occur when multiple projects are constructed or operated concurrently or consecutively. Once the project is operational, other projects which interrelate may enhance the project and create positive cumulative benefits.

Potential cumulative aquatic and riparian ecosystem cumulative impacts may arise through changes to surface water and groundwater. Appendix I (Technical report – Groundwater) and Appendix J (Technical report – Surface water and flooding) identify the potential for the project to have cumulative surface water and/ or groundwater impacts with other adjacent Great Western Highway Upgrade projects:

- Katoomba to Blackheath Upgrade (including Medlow Bath Upgrade)
- Little Hartley to Lithgow Upgrade.

Given the regional setting of the project primarily within the Blue Mountains Local Government Area (LGA) and a small portion within the Lithgow LGA, there are few major projects within the locality.

Potential surface water and related impacts on aquatic and riparian ecosystems would be similar in nature across the project comprising the Great Western Highway Upgrade Program. These potential impacts relate to changes in surface water quality and surface water flows during construction and operation. Subject to each project comprising the Great Western Highway Upgrade Program applying adequate surface water management measures during construction and operation, the cumulative impact of all upgrade projects would not be significant. Particularly, adequate surface water management measures would include:

- mitigation and management of surface water runoff from construction sites, including management/ treatment to minimise release of turbid water (i.e. erosion and sedimentation) from construction sites, and where construction water discharges are required, ensuring that those discharges are designed and carried out to avoid stream scour, and where possible reflecting low energy flow conditions commensurate with the natural receiving system(s)
- mitigation and management of surface water runoff from operational sites in a similar manner as for construction sites, including discharge of water treated to a standard and release in a manner comparable with the quality and flow characteristics of the receiving environment
- effective spill and leak mitigation and management
- appropriate monitoring of surface water, groundwater and ecology and application of adaptive management measures where changes to ecology are identified as a result of changes to surface and/ or groundwater as a result of the project(s).

Neither the Katoomba to Blackheath Upgrade (including Medlow Bath Upgrade) nor the Little Hartley to Lithgow Upgrade would have a material impact on groundwater (including groundwater flows, quality, potential drawdown and loss of surface watercourse baseflow). Cumulatively, potential groundwater and related aquatic and riparian ecosystem impacts associated with the overall Great Western Highway Upgrade Program would be principally related to the project.

6 Management of impacts

6.1 Performance outcomes

Performance outcomes have been developed that are consistent with the SEARs for the project. The performance outcomes for the project are summarised below in Table 17 and identify measurable, performance-based standards for environmental management.

Table 17 Performance outcomes for the project – aquatic ecology

SEARs desired performance outcomes	**Project performance outcome**	**Timing**
The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity.	Design the project to minimise adverse impacts on native terrestrial and aquatic flora and fauna.	Construction and operation

6.2 Management and mitigation of impacts

There are no specific mitigation measures recommended for aquatic and riparian ecology. Because potential impacts on aquatic and riparian ecosystems may arise through the surface water and groundwater impacts of the project during construction and operation, environmental mitigation measures from those technical assessments are appropriate and are reproduced in Table 18.

Table 18 Relevant groundwater, surface water and biodiversity mitigation measures

ID	Mitigation measure	Timing
GW1	The numerical groundwater model for the project will be updated as part of ongoing design development, will consider the construction schedule and methodology, and will take into account relevant additional geotechnical and groundwater monitoring data. Anticipated groundwater impacts will be confirmed and if required inform the development of detailed groundwater mitigation and management measures. The updated numerical groundwater numerical model will be calibrated against groundwater monitoring data collected during the construction phase. If observed groundwater level responses identified through monitoring markedly differ from predictions made by the updated numerical groundwater model, including extent of drawdown and timing, the model will be further refined and calibrated against the observed groundwater conditions.	Design
GW2	Where the updated groundwater model predicts groundwater impacts or related baseflow reductions in surface water resources that markedly differ from predictions presented in the EIS, further environmental mitigation measures and/or design responses will be identified and applied where feasible and reasonable. Design responses could include the review of tanked or drained infrastructure elements, pre-grouting of cross-passages and/or the treatment and discharge of treated groundwater into the affected creeks to address baseflow reductions.	Design

GW3	As part of detailed design, the existing groundwater monitoring network will be reviewed and maintained in consultation with relevant government agencies, and monitoring data will be made available to those agencies upon request, to: • continue to gather representative groundwater monitoring data to inform ongoing project design development, and the updated numerical groundwater model for the project • characterise the hydrogeological environment along and around Greaves Creek and associated groundwater dependent ecosystems in more detail • monitor groundwater prior to, during, and after construction of the project • complement the surface water monitoring network for the project (refer to environmental mitigation measure SW2). A suitably qualified person, such as a hydrogeologist and/or an environmental scientist will undertake periodic reviews of the groundwater monitoring data, and advise on potential groundwater impacts and appropriate mitigation and management measures prior to, during and after construction of the project for up to two years.	Design
SW1	A Construction Soil and Water Management Plan (CSWMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with relevant government agencies and local councils. The CSWMP will be prepared and implemented to detail measures to minimise erosion and sedimentation, manage surface water and flooding, and protect local water quality during construction, including the potential impacts of high risk construction activities to the Sydney Drinking Water Catchment and the Blue Mountains Special Area. The CSWMP will include: • erosion and sediment control measures prepared by or in consultation with a soil conservationist to be applied to each construction site, consistent with the guidance in *Managing Urban Stormwater – Soils and Construction (4th Edition)* (Landcom, 2004). Specific control measures may include: - diversion of runoff from undisturbed areas of the catchment around project disturbance areas - diversion of existing drainage lines disturbed by construction, or establishment of an alternative drainage line - construction and commissioning of sediment and water quality basins before major earthworks. Where projects overlap, the sizing of basins would account for the concurrent construction catchments and common discharge locations shared between the east, central and west projects, and sizing would be modified as required to accommodate the construction catchments. - use of sediment management devices such as fencing, sandbags, coir logs and graded or lined earth or sandbag diversion bunds and banks - measures to divert or capture and filter water prior to discharge, such as drainage diversion channels to flush and sediment sumps or traps - scour protection and energy dissipaters at locations of high erosion risk	Construction

	- location and storage of construction materials, fuels, and chemicals, including controls where possible to minimise the risk of leaks, spills and other unintended releases - storage of materials clear of frequently flooded low-lying areas - stabilisation of the surface of batters and drains, including temporary works and diversions - regular inspections and responsive adaptive management to improve erosion and sedimentation control practices as required to achieve the outcomes of the Blue Book. This will include inspections at regular intervals and after large rainfall events. • planning and management of stockpile areas in accordance with *Stockpile Site Management Guideline* (RTA, 2011) • progressive and timely stabilisation and rehabilitation of disturbed areas, taking into account the ultimate requirements of the Place Design and Landscape Plan (PDLP) for the project (refer to environmental mitigation measure LV1) • a spill management procedure to minimise the risk of release of construction materials, fuels, and chemicals from construction sites. The procedure will include: - management of chemicals, fuels and potentially polluting materials - any specialised containment, security and bunding requirements (refer to environmental mitigation measure HR02) - maintenance of plant and equipment - emergency management, including notification, response, and clean-up procedures • measures to manage construction activities in areas prone to flooding or inundation, particularly around Rosedale Creek, including: - daily monitoring of weather conditions, including rainfall forecasts, to provide advance warning of potential flooding or inundation - cessation of relevant works and site security and stabilisation requirements in the event of a severe weather warning - site clean-up and recovery measures in the event of flooding or inundation • measures to manage acid sulfate rock, consistent with the Acid Sulfate Rock Management Plan (ASRMP) for the project (refer to environmental mitigation measure SC3).	
SW2	A surface water monitoring network will be maintained for the project to: • continue to gather baseline surface water monitoring data to inform ongoing design development, and the updated numerical groundwater model for the project • characterise the hydrological environment along and around Greaves Creek and associated groundwater dependent ecosystems	Design, construction and operation

	• monitor surface water, including surface water quality, prior to, during and for two years after completion of construction of the project • complement the groundwater monitoring network for the project (refer to environmental mitigation measure GW2). The surface monitoring network will be developed in consultation with the relevant government agencies, and monitoring data will be made available to those agencies upon request. A qualified hydrologist or environmental scientist or equivalently experienced professional will be engaged to periodically review surface water monitoring data, and to advise on potential surface water impacts and appropriate mitigation and management measures prior to, during and after construction of the project.	
B10	Based on the updated numerical groundwater model for the project (refer to environmental mitigation measure GW1), and groundwater and surface water monitoring data (refer to environmental mitigation measures GW2 and SW2), further consideration of the potential impacts of the project on groundwater dependent ecosystems along Greaves Creek as a consequence of groundwater drawdown and/ or reduction in watercourse baseflow will be carried out during further design development. Subject to the outcomes, options to avoid and/ or minimise anticipated impacts will be identified, and implemented if reasonable and feasible.	Design

7 Conclusion

The proposed upgrade of the Great Western Highway from Blackheath to Little Hartley has potential to affect aquatic and riparian ecosystems including State and Commonwealth listed Temperate Highland Peat Swamps on Sandstone (THPSS) endangered ecological community.

Associated with the project are water quality and groundwater related impacts which include alteration of surface water quality, erosion and sedimentation and short-term groundwater drawdown during the construction phase and surface water quality, erosion, and reduction in groundwater base flows. With appropriate mitigation measures the risk of impacts associated with surface water quality and quantity and groundwater quantity to the aquatic and riparian ecosystems would be lessened, however there will be requirement to apply best practice when it comes to addressing potential impacts associated with inorganic nutrients and ionic pollution.

No impact to the Macquarie Perch or its habitat is expected.

Results of this assessment conclude that predicted impacts to waterways within the study area are negligible with exception of Greaves Creek. There is potential for a material reduction in baseflow to Greaves Creek due to groundwater drawdown from the project during dry years, with associated impacts to THPSS along the watercourse. It is recommended that further investigations be carried out, including update groundwater modelling taking into account ongoing surface water, groundwater and ecological monitoring. Where updated groundwater modelling confirms the likelihood of material impacts on Greaves Creek baseflows, then further consideration should be given to design-related mitigation measures with a focus on reducing groundwater drawdown around the Blackheath portals.

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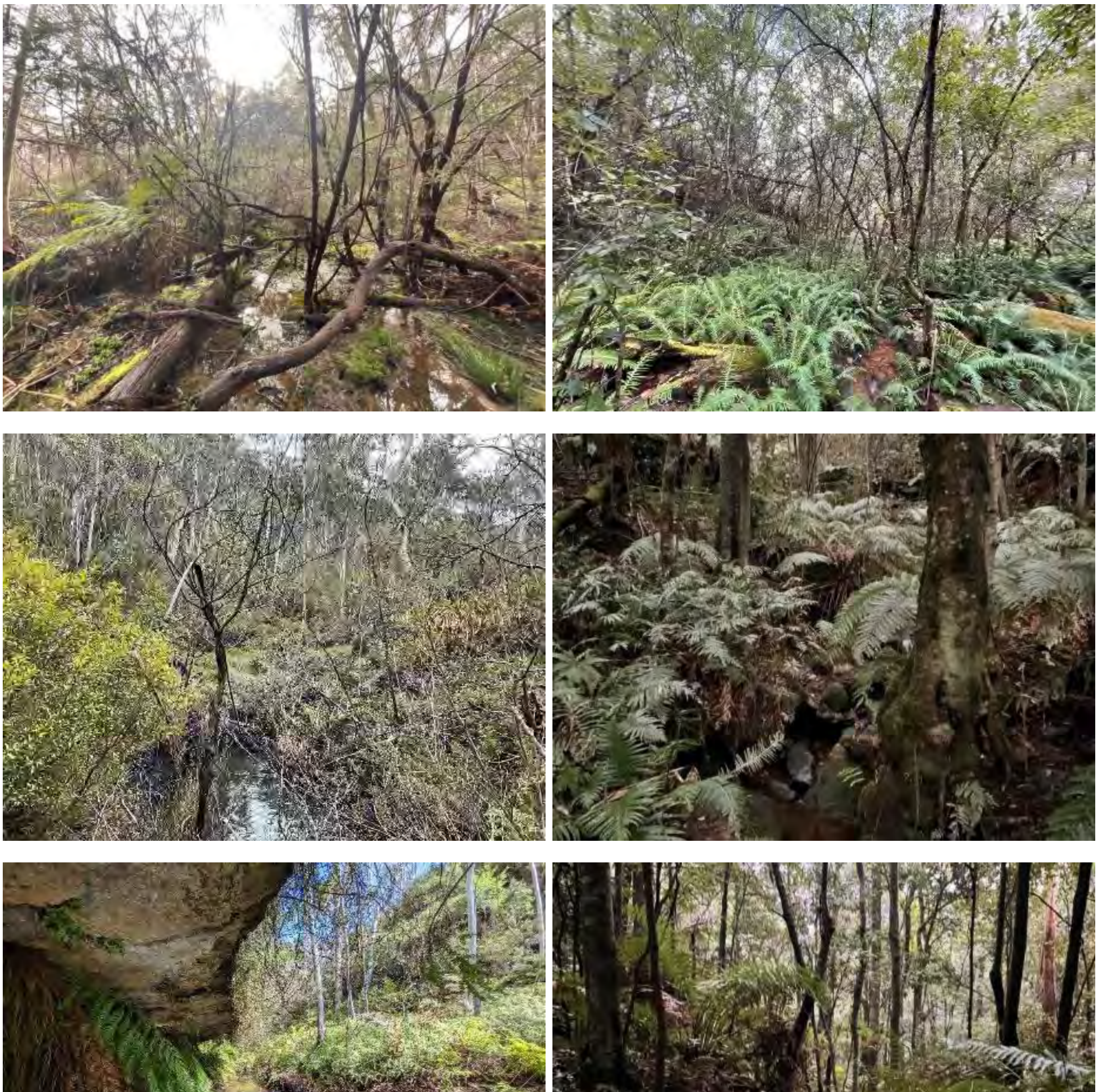
Attachment A: Assessment site photos



Top left: Upper Adams Creek, Middle left: Middle Adams Creek, Bottom left: Lower Adams Creek, Top right: Upper Fairy Bower Creek, Middle right: Middle Fairy Bower Creek, Bottom right: Lower Fairy Bower Creek.

Top left: Upper Greaves Creek, Middle left: Middle Greaves Creek, Bottom left: Lower Greaves Creek, Top right: Upper Pulpit Hill Creek, Middle right: Middle Pulpit Hill Creek, Bottom right: Lower Pulpit Hill Creek.

Top left: Upper Relton Creek, Middle left: Middle Relton Creek, Bottom left: Lower Relton Creek, Top right: Upper Young Creek, Middle right: Middle Young Creek, Bottom right: Lower Young Creek.

Platypus eDNA Sites. Top left: Middle Blackheath Creek Upstream, Middle left: Lower Butlers Creek Upstream, Bottom left: eDNA Site Pulpit Hill Creek Upstream, Top right: Middle Blackheath Creek Downstream, Middle right: Lower Butlers Creek Downstream, Bottom right: eDNA Site Pulpit Hill Creek Downstream.

Attachment B: Aquatic macroinvertebrate taxa

Table 1: Taxonomic Classification (Family) abundance for Butlers Creek, Relton Creek and Greaves Creek.

Taxonomic Classification (Family)	Upper Butlers Creek	Middle Butlers Creek	Lower Butlers Creek	Butlers Creek Trib	Upper Relton Creek	Middle Relton Creek	Lower Relton Creek	Middle Greaves Creek	Lower Greaves Creek
Acarina	-	-	-	-	-	-	3	-	-
Aeshnidae	3	-	2	-	-	3	-	-	-
Atyidae	-	-	12	3	-	-	-	-	-
Calocidae	3	-	-	-	-	-	-	2	-
Ceratopogonidae	3	-	-	-	-	-	-	-	-
Chironomidae	14	22	45	38	22	8	8	4	16
Corixidae	5	8	4	9	-	-	-	-	-
Corydalidae	-	1	-	-	-	3	-	-	-
Dugesiidae	-	-	-	4	-	-	-	-	20
Dytiscidae	10	6	-	3	-	-	-	-	-
Elmidae	15	17	-	-	-	15	7	-	-
Gerridae	-	-	-	-	-	-	-	-	-
Glossiphoniidae	2	5	-	-	-	-	-	-	-
Gyrinidae	-	-	-	-	-	-	6	-	-
Isotomidae	-	-	-	-	8	-	-	-	-
Lymnaeidae	-	4	-	-	-	-	-	-	-
Nematoda	-	4	3	-	-	4	4	-	-
Notonectidae	5	-	6	-	-	-	-	-	-
Physidae	-	4	7	-	-	-	-	-	-
parastacidae	-	-	-	-	-	-	-	-	3
Psephenidae	-	2	-	-	-	-	-	-	-
Pleidae	-	5	-	-	-	-	-	-	-
Richardsonianidae	-	-	-	2	-	2	-	-	-
Simuliidae	-	9	-	18	4	2	4	-	8
Sphaeriidae	-	8	-	-	-	-	-	-	-
Tabanidae	-	-	4	2	5	-	-	-	-

Veliidae	-	3	-	-	-	-	4	4	-
Unknown	-	-	-	-	-	-	-	-	-
Hydrophilidae	-	-	-	-	10	-	-	-	-
Baetidae	-	-	-	-	-	4	6	3	8
Caenidae	-	-	-	13	-	-	-	-	-
Leptoceridae	13	7	-	8	3	9	12	2	5
Leptophlebiidae	41	8	1	-	-	27	63	6	45
Ecnomidae	-	-	-	-	-	-	-	-	-
Philopotamidae	10	-	-	4	6	10	2	12	4
Hydroptilidae	4	6	-	-	-	3	3	-	-
Hydropsychidae	-	-	-	-	-	-	-	1	6
Gripopterygidae	23	21	4	5	-	6	22	-	12

Table 2: Taxonomic Classification (Family) abundance for Fairy Bower Creek, Young Creek, Adams Creek and Pulpit Hill Creek.

Taxonomic Classification (Family)	Upper Fairy Bower	Middle Fairy Bower	Lower Fairy Bower	Upper Young Creek	Middle Young Creek	Lower Young Creek	Upper Adams Creek	Middle Adams Creek	Lower Adams Creek	Upper Pulpit Hill Creek	Middle Pulpit Hill Creek	Lower Pulpit Hill Creek
Acarina	-	2	-	-	-	-	-	-	-	-	-	-
Aeshnidae	4	4	3	2	2	2	-	-	4	7	4	-
Ceratopogonidae	1	-	2	1	-	-	-	4	-	-	-	-
Chironomidae	11	11	8	15	12	14	56	12	13	9	2	5
Corixidae	-	-	-	-	-	-	5	-	-	-	-	3
Dytiscidae	-	-	-	-	-	-	3	-	2	-	3	7
Elmidae	9	8	-	-	6	7	2	-	9	-	-	8
Gyrinidae	3	-	-	-	-	-	-	-	4	-	9	10
Isotomidae	-	-	-	-	-	-	2	-	-	-	-	-
Nematoda	-	-	-	2	-	-	3	-	-	-	-	-
Psephenidae	-	-	-	-	-	-	-	-	-	-	4	5
Philorheithridae	-	-	2	-	-	-	-	-	-	-	-	-
Scirtidae	-	-	-	2	-	-	-	-	-	-	-	-
Simuliidae	-	6	-	3	8	-	-	-	-	5	-	-
Veliidae	6	4	-	-	-	-	-	-	-	5	3	6
Baetidae	-	-	-	6	-	9	-	-	11	3	-	-
Caenidae	-	-	-	-	-	-	-	8	-	-	-	-
Leptoceridae	3	3	4	32	29	31	2	16	8	-	7	16
Leptophlebiidae	13	37	22	28	22	18	-	6	22	8	16	22
Philopotamidae	9	12	7	19	10	14	3	-	8	13	10	-
Hydroptilidae	-	-	2	-	-	-	-	-	-	-	-	-
Hydropsychidae	-	9	9	-	41	42	-	5	29	7	19	19
Gripopterygidae	22	13	-	5	12	21	3	11	35	17	20	18

Attachment C: Benthic diatom taxa

Site	Adams Creek	Adams Creek	Adams Creek	Butlers Creek	Butlers Creek	Butlers Creek	Butlers Creek	Fairy Bower Creek	Fairy Bower Creek	Fairy Bower Creek	Greaves Creek	Greaves Creek	Pulpit Hill Creek	Pulpit Hill Creek	Pulpit Hill Creek	Relton Creek	Relton Creek	Relton Creek	Young Creek	Young Creek	Young Creek
	Lower	**Middle**	**Upstream**	**Lower**	**Middle**	**Trib**	**Upstream**	**Lower**	**Middle**	**Upstream**	**Lower**	**Upstream**	**Lower**	**Middle**	**Upstream**	**Lower**	**Middle**	**Upstream**	**Lower**	**Middle**	**Upstream**
Date	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022	13/10/2022
Species count	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97	97
Population	375	325	354	321	335	350	315	339	314	324	325	344	345	324	317	324	322	313	314	347	325
Diversity	3.05	3.26	3.59	2.87	2.37	3.68	0.91	3.2	3.29	3.28	1.14	1.74	3.09	1.58	2.29	2.3	1.95	1.84	2.03	1.16	2.43
Eveness	0.72	0.72	0.72	0.63	0.53	0.77	0.27	0.78	0.79	0.75	0.28	0.44	0.69	0.41	0.72	0.64	0.59	0.58	0.61	0.35	0.68
Genera count	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
TDI	5.82	14.62	32.26	53.62	33.32	78.55	0.3	8.04	5.58	12.23	5.71	1.64	24.43	29.64	1.46	0.4	0.3	5.08	0.34	13.18	0.66
Species																					
Achnanthes abundans	1	105	4	2	0	0	0	64	14	5	0	0	82	244	0	0	0	0	0	0	0
Achnanthes cf. lapidosa	0	2	1	0	0	0	0	3	11	0	0	0	0	0	0	0	0	0	0	0	0
Achnanthes nodosa	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0
Achnanthes oblongella	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Achnanthes sp. 3	0	0	0	0	0	0	0	0	0	0	0	2	15	2	0	0	0	0	0	0	0
Achnanthidium cf. minutissimum var jackii	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Achnanthidium minutissimum	3	2	125	87	204	2	0	2	2	0	0	6	120	0	0	0	0	0	0	0	0
Achnanthidium minutissimum sp. 2	0	2	0	6	4	0	0	0	7	0	0	0	0	0	8	0	0	0	0	0	0
Actinella sp. 1	127	63	1	0	0	0	0	55	81	42	276	0	8	6	113	71	16	0	167	266	2
Bacillaria paxillifer	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachysira brebissonii	18	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0
Brachysira styriaca	27	7	0	0	0	0	0	0	0	0	0	0	11	3	0	0	0	0	0	0	0
Brachysira vitrea	5	7	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Caloneis bacillum	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Caloneis hyalina	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cavinula cocconeiformis	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cymbella aequalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Diadesmis contenta	0	0	28	0	0	0	0	4	16	2	0	0	0	0	4	1	0	0	0	0	0

Encyonema gracile	11	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Encyonema minutum	0	1	5	2	2	10	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Eolimna minima	0	0	10	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eunotia bilunaris	2	12	0	0	1	0	0	0	0	0	4	2	0	0	0	2	6	3	0	1	2
Eunotia bilunaris var. mucophila	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eunotia cf. musicola var. perminuta	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eunotia cf. subarcuatoides	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	3
Eunotia exigua	7	32	6	0	4	0	274	17	27	87	0	73	30	17	31	77	186	203	16	0	32
Eunotia implicata	1	15	15	0	23	0	2	24	2	4	1	0	4	4	0	0	36	0	0	0	0
Eunotia incisa	4	7	0	0	0	0	0	22	37	22	4	0	10	4	0	14	0	0	0	0	10
Eunotia intermedia	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0
Eunotia muscicola	0	0	0	0	2	0	14	0	0	0	3	218	0	0	0	2	0	0	0	0	24
Eunotia naeglii	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	4	0	8	3	137
Eunotia paludosa	3	1	8	0	0	0	6	60	47	61	0	0	0	23	104	24	59	14	62	3	85
Eunotia sp. 001	0	0	4	0	0	0	0	0	2	2	0	2	0	4	0	0	0	0	0	0	8
Fallacia pygmaea	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Fragilaria capucina var. capucina	0	3	43	20	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fragilaria cf. campyla	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Fragilaria gracilis	0	1	26	78	12	6	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Fragilaria vaucheriae	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frustulia magaliesmontana	45	4	0	0	0	0	8	42	4	11	10	0	19	8	36	0	0	0	43	57	0
Frustulia rhomboides var. elongatissima	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Frustulia saxonica	53	25	1	0	2	0	0	1	0	0	5	6	0	0	14	5	6	16	11	11	0
Frustulia sp. 1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Frustulia vulgaris	1	0	2	1	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphonema angustatum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Gomphonema cf. sacrophagus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphonema clavatum	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphonema gracile	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Gomphonema parvulum var parvulum	0	0	14	74	27	103	0	0	0	23	0	2	5	1	0	0	0	0	0	2	0
Gomphonema psuedoaugur	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphonema pumilum	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hantzschia amphioxys	0	0	2	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
Hippodonta capitata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luticola mutica	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Mayamaea atomus var. permitis	0	0	4	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meridion circulare	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula bryophila	8	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0	6	2	0	0
Navicula cf. molestiformis	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	2	13	0	0	0
Navicula cf. muticoides	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Navicula cryptocephala	0	0	2	2	1	49	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Navicula gregaria	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula heimansioides	52	14	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0
Navicula incertata	0	0	16	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Navicula rhyncocephala	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula soehrensis	0	0	2	0	0	0	0	33	44	10	0	0	0	4	0	123	0	0	0	0	0
Navicula sp. 002	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula sp. 010	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula sp. 011	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Navicula sp. 021	0	0	0	0	0	0	0	2	6	9	1	1	0	2	6	0	1	34	0	0	7
Navicula veneta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nitzschia agnita	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Nitzschia cf. fonticola	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia cf. perminuta	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia clausii	0	0	1	4	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	0	0
Nitzschia dissipata	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia filiformis var. conferta	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia frustulum	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Nitzschia gracilis	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia inconspicua	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia linearis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia palea	0	0	6	4	0	12	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Nitzschia paleacea	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia pseudofonticola	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia pusilla	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia sp. 005	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitzschia terrestris	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinnularia borealis	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0
Pinnularia cf. sinistra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Pinnularia divergentissima	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Pinnularia gibba	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinnularia microstauron	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pinnularia subcapitata	0	0	5	0	0	0	4	0	3	30	2	24	0	0	1	1	6	23	2	0	13
Pinnularia viridiformis	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Sellaphora pupula	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sellaphora seminulum	0	0	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staurosirella pinnata	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surirella angusta	0	0	0	1	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra acus	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra nana	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Synedra ulna	0	0	0	5	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tabellaria flocculosa	2	13	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	0

Attachment D: Riparian assessment

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek Main

type Regular | date 19 Sep 2022 | time 4:24:56 pm | assessor Ben Green

weather sunny | reach type permanent | flow medium

96 %

29 | 20 | 46 | 6 | 11 | 1

excellent

Adams (Lower Adams Creek)

stream order 3

notes

The site is in excellent condition, with a raw score of 87 (96%) overall. The bed type is natural bedrock. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

downstream

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	low 1-3
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	yes; Class 1; Type 1
KFH riparian buffer zone	100 metres
Aquatic Habitat Total	11
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	60
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek Main

type Regular | date 9 Sep 2022 | time 10:47 am | assessor James Taylor

weather overcast | reach type permanent | flow medium

94 % excellent — 29 | 20 | 46 | 6 | 6 | 1

Adams (Middle Adams Creek)

notes

The site is in excellent condition, with a raw score of 82 (94%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 3

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 9-9-2022 7.48.06
-33.663220
150.287322
9/09/2022 10:02:24 AM

downstream

Photo 9-9-2022 7.48.24
-33.663217
150.287308
9/09/2022 10:02:29 AM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	simple
pool riffle sequence	present
meanders	confined yes
large woody debris	moderate 4-10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	natural < 500 mm
native macrophyte	absent
mapped Key Fish Habitat	yes; Class 2; Type 2
KFH riparian buffer zone	50 metres
Aquatic Habitat Total	6
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	60
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek Main

type Regular | date 7 Sep 2022 | time 8:44:38 am | assessor James Taylor

weather sunny | reach type permanent | flow low

88 %	very good
Site Features	18
Riparian Vegetation	20
Vegetation Structure	40
Weeds	0
Aquatic Habitat	8
Deposition / Erosion	0

Adams (Upper Adams Creek)

notes

The site is in excellent condition, with a raw score of 66 (88%) overall. The bed type is natural bed sand - Nvs. The bank type is natural vegetation - Nveg.

stream order: 2

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Cyprus .

upstream

Photo 7-9-2022 8.46.34
-33.672303
150.284897
7/09/2022 8:46:09 AM

downstream

Photo 7-9-2022 8.47.24
-33.672347
150.284928
7/09/2022 8:46:14 AM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	present
odour	normal/none
turbidity	medium
Land Use Subtotal	18
Site Features Total	18
channel shape	simple
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	natural < 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	8
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	40

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek unnamed trib

type Regular date 5 Sep 2022 time 1:21:16 pm assessor James Taylor

weather sunny reach type ephemeral flow none

81 %	very good
15.1	
20	
34	
0	
0	
0	

Adams-unnamed trib-1

notes

The site is in good condition, with a raw score of 49.1 (81%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 2

landuse

Within the 50 metre assessment radius, left bank land use is 85% bushland, 15% road, approximately. Right bank land use is 85% bushland, 15% road, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 85% forest/woodland, 15% absent/concrete/earth, approximately. Right bank vegetation structure is 85% forest/woodland, 15% absent/concrete/earth, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Paspalum.

upstream

Photo 5-9-2022 1.23.19
-33.654147
150.282395
5/09/2022 1:17:41 PM

downstream

Photo 5-9-2022 1.23.44
-33.654247
150.282592
5/09/2022 1:19:34 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	present
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	15.1
Site Features Total	15.1
channel shape	simple
pool riffle sequence	absent
meanders	unconfined no
large woody debris	moderate 4-10
woody debris size	> 3 metres length
overhanging vegetation	low <30%
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	0
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	14
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	34

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek unnamed trib

type Regular | date 5 Sep 2022 | time 1:36:08 pm | assessor Ben Green

weather overcast | reach type ephemeral | flow low

97 % excellent — 28 | 20 | 46 | 6 | 15 | 0

Adams-unnamed trib-2

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order: 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022 1.36.45
-33.654667
150.283675
5/09/2022 1:35:46 PM

downstream

Photo 5-9-2022 1.36.58
-33.654667
150.283675
5/09/2022 1:35:45 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	28
Site Features Total	28
channel shape	complex
pool riffle sequence	present
meanders	unconfined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	absent
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	15
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Adams Creek unnamed trib

type Regular date 5 Sep 2022 time 1:54:27 pm assessor Ben Green

weather overcast reach type ephemeral flow low

96 %

26.7
20
44
6
15
0

excellent

Adams-unnamed trib-3

stream order 1

notes

The site is in excellent condition, with a raw score of 85.7 (96%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 95% bushland, 5% road, approximately. Right bank land use is 95% bushland, 5% road, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 95% forest/woodland, 5% absent/concrete/earth, approximately. Right bank vegetation structure is 95% forest/ woodland, 5% absent/concrete/earth, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022 1.54.56
-33.654963
150.285233
5/09/2022 1:51:19 PM

downstream

Photo 5-9-2022 1.55.20
-33.654970
150.285233
5/09/2022 1:51:20 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	26.7
Site Features Total	26.7
channel shape	complex
pool riffle sequence	present
meanders	unconfined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	absent
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	15
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	18
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	44

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Blackheath Creek Main

type Regular | date 30 Aug 2022 | time 12:44:27 pm | assessor Ben Green

weather sunny | reach type ephemeral | flow none

93 % — 27 | 20 | 40 | 0 | 13 | -2 — excellent

Blackheath (Middle Blackheath Creek)

notes

The site is in excellent condition, with a raw score of 78 (93%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 5+

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Blackberry.

upstream

Photo 30-8-2022
-33.618153
150.233125
30/08/2022 1:00:11 PM

downstream

Photo 30-8-2022
-33.618222
150.233138
30/08/2022 1:00:08 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	medium
Land Use Subtotal	27
Site Features Total	27
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	yes; Class 1; Type 1
KFH riparian buffer zone	100 metres
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	minor <10% bank
bank slumps	minor <10% bank
knick point	absent
bank erosion	absent
Erosion Total	-2
riparian corridor WMAct	80
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	40

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek Main

type Regular | date 30 Aug 2022 | time 12:20 pm | assessor Ben Green

weather sunny | reach type ephemeral | flow low

53 % poor

-7.8
12
9.6
0
-23
0

Butlers (Lower Butlers Creek)

notes

The site is in poor condition, with a raw score of -21.2 (53%) overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg.

stream order 4

landuse

Within the 50 metre assessment radius, left bank land use is 80% pasture, 20% road, approximately. Right bank land use is 80% pasture, 20% residential, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 80% pasture grassland, 20% absent/concrete/earth, approximately. Right bank vegetation structure is 80% pasture grassland, 20% absent/concrete/earth, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 30-8-2022
-33.560347
150.208253
30/08/2022 12:17:39 PM

downstream

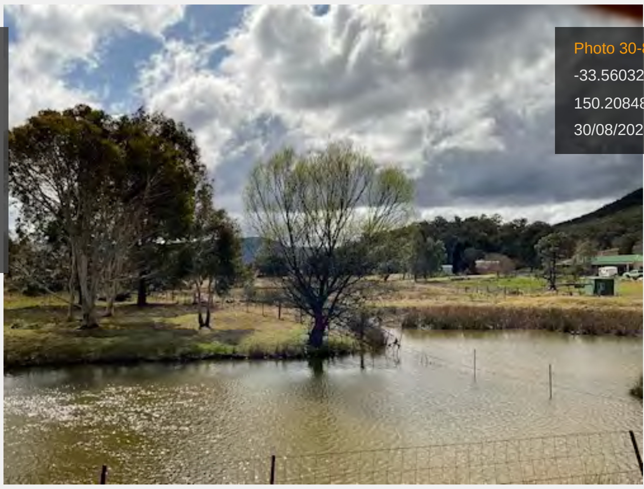


Photo 30-8-2022
-33.560325
150.208480
30/08/2022 12:17:52 PM

extraction	water
excavation	absent
litter	low 1-5
sewer	absent
stormwater	present
odour	normal/none
turbidity	medium
Land Use Subtotal	-7.8
Site Features Total	-7.8
channel shape	dam/divert/pipe
pool riffle sequence	absent
meanders	unconfined yes
large woody debris	absent
woody debris size	absent
overhanging vegetation	absent
natural bed detritus	present
natural gravel bed	not visible
natural rock in-stream	absent
native macrophyte	present
mapped Key Fish Habitat	yes; Class 3; Type 2
KFH riparian buffer zone	50 metres
Aquatic Habitat Total	-23
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	80
riparian buffer width left	20-40m
riparian buffer width right	20-40m
Riparian Vegetation Subtotal	12
Vegetation Structure Subtotal	-2.4
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	9.6

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek Main

type Regular date 26 Aug 2022 time 11:09:03 am assessor Ben Green

weather overcast reach type permanent flow low

81 %	very good
Site Features	11.7
Riparian Vegetation	20
Vegetation	25.3
Weeds	-3
Aquatic Habitat	12
Deposition / Erosion	0

Butlers (Lower Middle Butlers Creek)

stream order 4

notes

The site is in good condition, with a raw score of 49 (81%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 30% bushland, 70% pasture, approximately. Right bank land use is 40% bushland, 60% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 30% forest/woodland, 70% pasture grassland, approximately. Right bank vegetation structure is 40% forest/woodland, 60% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Blackberry.

upstream

Photo 26-8-2022
-33.571603
150.219667
26/08/2022 10:33:32 AM

downstream

Photo 26-8-2022
-33.571597
150.219667
26/08/2022 10:33:29 AM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	11.7
Site Features Total	11.7
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural < 500 mm
native macrophyte	present
mapped Key Fish Habitat	yes; Class 2; Type 1
KFH riparian buffer zone	100 metres
Aquatic Habitat Total	12
benches	present unconstricted
islands	present
channel bars	minor restriction
Deposition Total	1
bedrock/clay exposure	absent
undercutting	absent
bank slumps	minor <10% bank
knick point	absent
bank erosion	absent
Erosion Total	-1
riparian corridor WMAct	80
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	8.3
weed density left bank	light up to 40%
weed density right bank	sparse less than 5%
Weeds Subtotal	-3
Vegetation Total	25.3

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek Main

type Regular | date 25 Aug 2022 | time 12:42:49 pm | assessor James Taylor

weather overcast | reach type permanent | flow low

73 %

8.05 | 20 | 20.15 | -6 | 4 | -3

good

Butlers (Middle Butlers Creek)

stream order 3

notes

The site is in good condition, with a raw score of 29.2 (73%) overall. The bed type is natural bed mud - Nvm. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 35% bushland, 65% pasture, approximately. Right bank land use is 20% bushland, 80% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 10% forest/woodland, 25% waterway/wetland/swamp, 65% pasture grassland, approximately. Right bank vegetation structure is 5% forest/woodland, 15% waterway/wetland/swamp, 80% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Blackberry.

upstream

Photo 25-8-2022
-33.575687
150.227158
25/08/2022 12:43:52 PM

downstream

Photo 25-8-2022
-33.575687
150.227158
25/08/2022 12:43:56 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	medium
Land Use Subtotal	8.05
Site Features Total	8.05
channel shape	simple
pool riffle sequence	absent
meanders	confined yes
large woody debris	moderate 4-10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	not visible
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	yes; Class 2; Type 2
KFH riparian buffer zone	50 metres
Aquatic Habitat Total	4
benches	minor restriction
islands	absent
channel bars	absent
Deposition Total	-1
bedrock/clay exposure	absent
undercutting	minor <10% bank
bank slumps	minor <10% bank
knick point	absent
bank erosion	absent
Erosion Total	-2
riparian corridor WMAct	60
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	6.15
weed density left bank	light up to 40%
weed density right bank	light up to 40%
Weeds Subtotal	-6
Vegetation Total	20.15

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek Main

type Regular | date 25 Aug 2022 | time 11:05:56 am | assessor James Taylor

weather overcast | reach type permanent | flow low

91 %

22.15 | 20 | 36.85 | 0 | 14 | 2

excellent

Butlers (Upper Butlers Creek)

notes

The site is in excellent condition, with a raw score of 75 (91%) overall. The bed type is natural bed gravel - Nvg. The bank type is natural vegetation - Nveg.

stream order 3

landuse

Within the 50 metre assessment radius, left bank land use is 65% bushland, 35% pasture, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 65% forest/woodland, 35% pasture grassland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 25-8-2022
-33.578228
150.234467
25/08/2022 11:04:04 AM

downstream

Photo 25-8-2022
-33.578195
150.234375
25/08/2022 11:04:12 AM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	22.15
Site Features Total	22.15
channel shape	complex
pool riffle sequence	absent
meanders	unconfined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	absent
mapped Key Fish Habitat	yes; Class 1; Type 2
KFH riparian buffer zone	50 metres
Aquatic Habitat Total	14
benches	present unconstricted
islands	absent
channel bars	no restriction
Deposition Total	2
bedrock/clay exposure	absent
undercutting	minor <10% bank
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	60
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	16.85
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	36.85

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek unnamed trib

type Regular | date 25 Aug 2022 | time 2:42:36 pm | assessor James Taylor
weather overcast | reach type permanent | flow low

69 %

2.65
20
23.05
0
-3
-4

fair

Butlers-unnamed trib-1

stream order 3

notes

The site is in fair condition, with a raw score of 18.7 (69%) overall. The bed type is natural bed clay - Nvc. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 10% bushland, 90% pasture, approximately. Right bank land use is 5% bushland, 95% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 10% waterway/wetland/swamp, 90% pasture grassland, approximately. Right bank vegetation structure is 5% waterway/wetland/swamp, 95% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 25-8-2022
-33.576020
150.219588
25/08/2022 2:40:48 PM

downstream

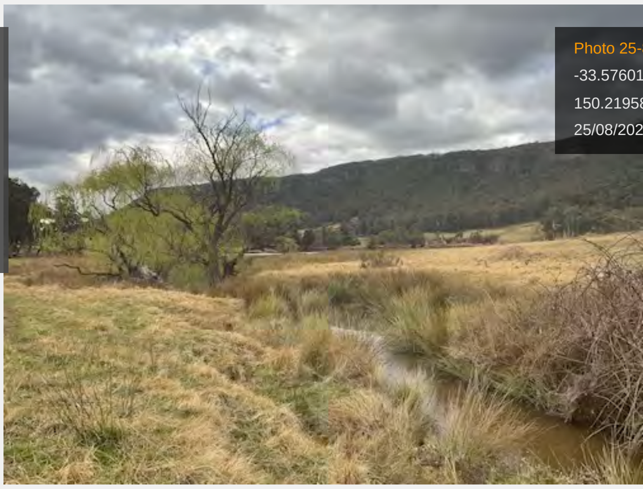


Photo 25-8-2022
-33.576012
150.219588
25/08/2022 2:40:52 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	high
Land Use Subtotal	2.65
Site Features Total	2.65
channel shape	straighened/deepened
pool riffle sequence	absent
meanders	confined yes
large woody debris	low 1-3
woody debris size	< 300 mm dia or 3 m
overhanging vegetation	low <30%
natural bed detritus	not visible
natural gravel bed	not visible
natural rock in-stream	not visible
native macrophyte	absent
mapped Key Fish Habitat	yes; Class 2; Type 2
KFH riparian buffer zone	50 metres
Aquatic Habitat Total	-3
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	minor <10% bank
bank slumps	absent
knick point	unsupported
bank erosion	absent
Erosion Total	-4
riparian corridor WMAct	60
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	3.05
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	23.05

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek unnamed trib

type Regular | date 30 Aug 2022 | time 2:42:04 pm | assessor Ben Green

weather sunny | reach type ephemeral | flow none

66 %

fair

3
20
16
-6
-5
-3

Butlers-unnamed trib-2

stream order 1

notes

The site is in fair condition, with a raw score of 11 (66%) overall. The bed type is grass - G. The bank type is grass - G.

landuse

Within the 50 metre assessment radius, left bank land use is 100% pasture, approximately. Right bank land use is 100% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% pasture grassland, approximately. Right bank vegetation structure is 100% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 30-8-2022
-33.573988
150.215317
30/08/2022 1:55:46 PM

downstream

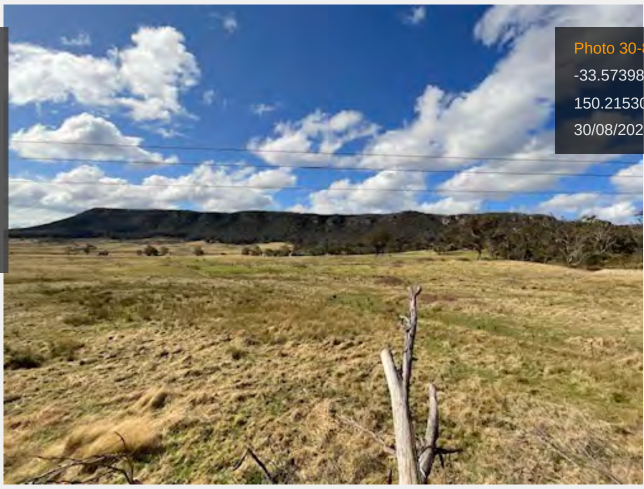


Photo 30-8-2022
-33.573987
150.215303
30/08/2022 1:55:49 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	3
Site Features Total	3
channel shape	grass-lined
pool riffle sequence	absent
meanders	unconfined yes
large woody debris	absent
woody debris size	absent
overhanging vegetation	absent
natural bed detritus	absent
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	-5
benches	minor restriction
islands	absent
channel bars	absent
Deposition Total	-1
bedrock/clay exposure	absent
undercutting	minor <10% bank
bank slumps	minor <10% bank
knick point	absent
bank erosion	absent
Erosion Total	-2
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	2
weed density left bank	light up to 40%
weed density right bank	light up to 40%
Weeds Subtotal	-6
Vegetation Total	16

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek unnamed trib

type Regular date 30 Aug 2022 time 1:39:44 pm assessor James Taylor
weather sunny reach type ephemeral flow low

60 %

3.45	
20	
22.25	fair
0	
-29	
0	

Butlers-unnamed trib-3

notes

The site is in poor condition, with a raw score of -3.3 (60%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% pasture, approximately. Right bank land use is 15% bushland, 75% pasture, 10% road, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% pasture grassland, approximately. Right bank vegetation structure is 15% forest/woodland, 10% absent/ concrete/earth, 75% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 30-8-2022
-33.572303
150.211822
30/08/2022 1:36:20 PM

downstream

Photo 30-8-2022
-33.572003
150.211822
30/08/2022 1:37:08 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	medium
Land Use Subtotal	3.45
Site Features Total	3.45
channel shape	dam/divert/pipe
pool riffle sequence	absent
meanders	unconfined no
large woody debris	absent
woody debris size	absent
overhanging vegetation	absent
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	-29
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	2.25
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	22.25

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek unnamed trib

type Regular date 30 Aug 2022 time 11:56:28 am assessor James Taylor
weather sunny reach type ephemeral flow none

70 %	5.45	good
	20	
	22.85	
	0	
	-7	
	0	

Butlers-unnamed trib-4

stream order 1

notes

The site is in fair condition, with a raw score of 21.3 (70%) overall. The bed type is grass - G. The bank type is grass - G.

landuse

Within the 50 metre assessment radius, left bank land use is 10% bushland, 80% pasture, 10% road, approximately. Right bank land use is 15% bushland, 80% pasture, 5% residential, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 80% pasture grassland, 10% forest/woodland, 10% absent/concrete/earth, approximately. Right bank vegetation structure is 80% pasture grassland, 5% urban yards, 15% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Blackberry, Ivy, Purple top.

upstream

Photo 30-8-2022
-33.571938
150.210083
30/08/2022 11:46:56 AM

downstream

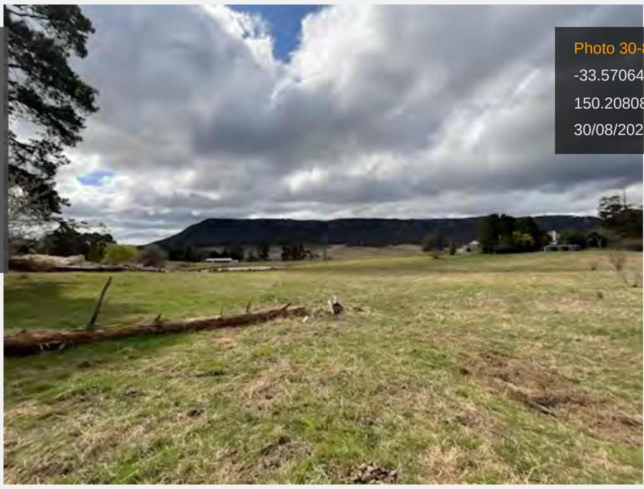


Photo 30-8-2022
-33.570642
150.208083
30/08/2022 11:50:54 AM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	5.45
Site Features Total	5.45
channel shape	grass-lined
pool riffle sequence	absent
meanders	unconfined no
large woody debris	absent
woody debris size	absent
overhanging vegetation	low <30%
natural bed detritus	absent
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	-7
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	2.85
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	22.85

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Butlers Creek unnamed trib

type Regular | date 30 Aug 2022 | time 12:31:27 pm | assessor James Taylor

weather sunny | reach type ephemeral | flow none

64 %	fair
	2.6
	16
	15.8
	0
	-11
	0

Butlers-unnamed trib-5

stream order 3

notes

The site is in fair condition, with a raw score of 7.4 (64%) overall. The bed type is grass - G. The bank type is grass - G.

landuse

Within the 50 metre assessment radius, left bank land use is 80% pasture, 20% road, approximately. Right bank land use is 100% pasture, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 80% pasture grassland, 20% absent/concrete/earth, approximately. Right bank vegetation structure is 100% pasture grassland, approximately. This is reflected in the vegetation structure subtotal.

weeds

Weed species observed at the site include Blackberry, Purple top.

upstream

Photo 30-8-2022
-33.563155
150.208620
30/08/2022 12:16:19 PM

downstream

Photo 30-8-2022
-33.563153
150.208620
30/08/2022 12:16:23 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	2.6
Site Features Total	2.6
channel shape	grass-lined
pool riffle sequence	absent
meanders	unconfined no
large woody debris	absent
woody debris size	absent
overhanging vegetation	absent
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	-11
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	60
riparian buffer width left	20-40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	16
Vegetation Structure Subtotal	-.2
weed density left bank	sparse less than 5%
weed density right bank	sparse less than 5%
Weeds Subtotal	0
Vegetation Total	15.8

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Fairy Bower Creek Main

type Regular | date 9 Sep 2022 | time 6:14 am | assessor James Taylor
weather light rain | reach type permanent | flow medium

97 % excellent — 29 | 20 | 46 | 6 | 13 | 1

Fairy (Lower Fairy Bower Creek)

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 2

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

downstream

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Fairy Bower Creek Main

type Regular | date 6 Sep 2022 | time 2:55:11 pm | assessor Ben Green
weather sunny | reach type permanent | flow medium

96 % excellent

29
20
46
6
13
-1

Fairy (Middle Fairy Bower Creek)

notes

The site is in excellent condition, with a raw score of 87 (96%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 2

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 6-9-2022 2.55.54
-33.600983
150.261230
6/09/2022 8:45:16 AM

downstream

Photo 6-9-2022 2.56.20
-33.642820
150.277603
5/09/2022 4:25:14 PM

extraction	absent	
excavation	absent	
litter	absent	
sewer	absent	
stormwater	absent	
odour	normal/none	
turbidity	low	
Land Use Subtotal		29
Site Features Total		29
channel shape	complex	
pool riffle sequence	present	
meanders	confined yes	
large woody debris	high >10	
woody debris size	> 3 metres length	
overhanging vegetation	high >60%	
natural bed detritus	present	
natural gravel bed	present	
natural rock in-stream	natural > 500 mm	
native macrophyte	present	
mapped Key Fish Habitat	no	
KFH riparian buffer zone		
Aquatic Habitat Total		13
benches	minor restriction	
islands	absent	
channel bars	absent	
Deposition Total		-1
bedrock/clay exposure	natural	
undercutting	minor <10% bank	
bank slumps	absent	
knick point	rock-supported	
bank erosion	absent	
Erosion Total		0
riparian corridor WMAct	40	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation Subtotal		20
Vegetation Structure Subtotal		20
weed density left bank	absent	
weed density right bank	absent	
Weeds Subtotal		6
Vegetation Total		46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Fairy Bower Creek Main

type Regular date 6 Sep 2022 time 2:52:03 pm assessor Ben Green
weather overcast reach type permanent flow low

97 %

29 | 20 | 46 | 6 | 13 | 1

excellent

Fairy (Upper Fairy Bower Creek)

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bedrock. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 6-9-2022 2.53.30
-33.597683
150.261933
6/09/2022 9:30:25 AM

downstream

Photo 6-9-2022 2.54.04
-33.597725
150.261917
6/09/2022 9:30:14 AM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 3 metres length
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Greaves Creek Main

type Regular | date 9 Sep 2022 | time 1:48 pm | assessor James Taylor

weather sunny | reach type permanent | flow medium

95 %

26 | 20 | 45.5 | 6 | 11 | 1

excellent

Greaves (Lower Greaves Creek)

stream order 2

notes

The site is in excellent condition, with a raw score of 83.5 (95%) overall. The bed type is natural bedrock. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 95% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 9-9-2022 7.53.30
-33.656697
150.299880
9/09/2022 12:50:42 PM

downstream

Photo 9-9-2022 7.53.46
-33.656703
150.299867
9/09/2022 12:50:48 PM

extraction	absent
excavation	absent
litter	low 1-5
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	26
Site Features Total	26
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	moderate 4-10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	11
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	19.5
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	45.5

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Greaves Creek Main

type Regular | date 6 Sep 2022 | time 2:49:21 pm | assessor Ben Green

weather overcast | reach type ephemeral | flow low

96 %	excellent
29	
20	
43	
6	
15	
0	

Greaves (Middle Greaves Creek)

notes

The site is in excellent condition, with a raw score of 87 (96%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 50% waterway/wetland/swamp, 50% forest/woodland, approximately. Right bank vegetation structure is 100% waterway/wetland/swamp, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 6-9-2022 2.50.24
-33.652467
150.292830
6/09/2022 2:00:23 PM

downstream

Photo 6-9-2022 2.51.06
6/09/2022 1:59:45 PM

extraction	absent	
excavation	absent	
litter	absent	
sewer	absent	
stormwater	absent	
odour	normal/none	
turbidity	low	
Land Use Subtotal		29
Site Features Total		29
channel shape	complex	
pool riffle sequence	present	
meanders	unconfined yes	
large woody debris	moderate 4-10	
woody debris size	< 300 mm dia or 3 m	
overhanging vegetation	high >60%	
natural bed detritus	present	
natural gravel bed	present	
natural rock in-stream	natural < 500 mm	
native macrophyte	present	
mapped Key Fish Habitat	no	
KFH riparian buffer zone		
Aquatic Habitat Total		15
benches	absent	
islands	absent	
channel bars	absent	
Deposition Total		0
bedrock/clay exposure	absent	
undercutting	absent	
bank slumps	absent	
knick point	absent	
bank erosion	absent	
Erosion Total		0
riparian corridor WMAct	20	
riparian buffer width left	over 40m	
riparian buffer width right	over 40m	
Riparian Vegetation Subtotal		20
Vegetation Structure Subtotal		17
weed density left bank	absent	
weed density right bank	absent	
Weeds Subtotal		6
Vegetation Total		43

RAPID RIPARIAN SITE ASSESSMENT
Biosis
Greaves Creek Main

type Regular | date 5 Sep 2022 | time 2:08:22 pm | assessor James Taylor
weather sunny | reach type ephemeral | flow none

91 %

28 | 20 | 46 | 6 | 1 | 0

excellent

Greaves (Upper Greaves Creek)

notes

The site is in excellent condition, with a raw score of 75 (91%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

downstream

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	28
Site Features Total	28
channel shape	simple
pool riffle sequence	absent
meanders	unconfined no
large woody debris	moderate 4-10
woody debris size	< 300 mm dia or 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	absent
natural rock in-stream	absent
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	1
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Pulpit Hill Creek Main

type Regular date 7 Sep 2022 time 11:43:36 am assessor Ben Green
weather sunny reach type permanent flow medium

97 % excellent

29
20
46
6
13
1

Pulpit (Lower Pulpit Hill Creek)

stream order 4

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 7-9-2022
-33.674933
150.268555
7/09/2022 11:10:59 AM

downstream

Photo 7-9-2022
-33.674930
150.268555
7/09/2022 11:10:56 AM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	yes / Class 1 / Type 1
KFH riparian buffer zone	100 metres
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	80
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT
Biosis
Pulpit Hill Creek Main

type Regular | date 5 Sep 2022 | time 4:03:54 pm | assessor James Taylor
weather sunny | reach type permanent | flow medium

96 %

28 | 20 | 46 | 6 | 12 | 1

excellent

Pulpit (Middle Pulpit Hill)

stream order 4

notes
The site is in excellent condition, with a raw score of 87 (96%) overall. The bed type is natural bed gravel - Nvg. The bank type is natural vegetation - Nveg.

landuse
Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation
Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022 4.05.12
-33.661892
150.271775
5/09/2022 4:04:45 PM

downstream

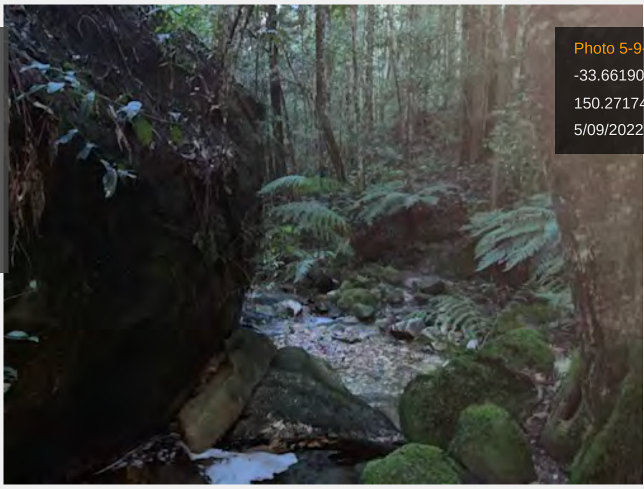


Photo 5-9-2022 4.05.32
-33.661908
150.271745
5/09/2022 4:04:52 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	28
Site Features Total	28
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	moderate 4-10
woody debris size	> 3 metres length
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	absent
mapped Key Fish Habitat	yes; Class 1; Type 1
KFH riparian buffer zone	100 metres
Aquatic Habitat Total	12
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	80
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Pulpit Hill Creek Main

type Regular date 5 Sep 2022 time 4:26:56 pm assessor Ben Green
weather sunny reach type permanent flow medium

96 %

28
20
46
6
12
0

excellent

Pulpit (Upper Pulpit Hill Creek)

notes

The site is in excellent condition, with a raw score of 86 (96%) overall. The bed type is natural bed gravel - Nvg. The bank type is natural vegetation - Nveg.

stream order

2

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022 4.27.20
-33.642812
150.277603
5/09/2022 4:25:07 PM

downstream

Photo 5-9-2022 4.27.34
-33.642820
150.277603
5/09/2022 4:25:14 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	no flow
Land Use Subtotal	28
Site Features Total	28
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	moderate 4-10
woody debris size	< 300 mm dia or 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	12
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	minor <10% bank
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Relton Creek Main

type Regular | date 7 Sep 2022 | time 3:27:04 pm | assessor James Taylor
weather sunny | reach type permanent | flow low

93 % — excellent

29
20
46
6
5
0

Relton (Lower Relton Creek)

stream order 2

notes

The site is in excellent condition, with a raw score of 80 (93%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 9-9-2022 4.28.07
-33.663425
150.286225
7/09/2022 2:00:35 PM

downstream

Photo 9-9-2022 4.28.45
-33.663400
150.286225
7/09/2022 2:00:38 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	simple
pool riffle sequence	absent
meanders	confined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural < 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	5
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Relton Creek Main

type Regular | date 5 Sep 2022 | time 12:42:32 pm | assessor James Taylor
weather sunny | reach type permanent | flow medium

95 % excellent

29 | 20 | 46 | 6 | 8 | 0

Relton (Middle Relton Creek)

stream order 2

notes

The site is in excellent condition, with a raw score of 83 (95%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022
-33.662492
150.283813
5/09/2022 12:44:18 PM

downstream

Photo 5-9-2022
-33.662497
150.283813
5/09/2022 12:44:23 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	simple
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 3 metres length
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural < 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	8
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	root-supported
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Relton Creek Main

type Regular | date 5 Sep 2022 | time 12:13:55 pm | assessor Ben Green

weather overcast | reach type ephemeral | flow low

92 % excellent

23 | 20 | 46 | 6 | 8 | 0

Relton (Upper Relton Creek)

notes

The site is in excellent condition, with a raw score of 77 (92%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 5-9-2022
-33.658417
150.279970
5/09/2022 12:15:28 PM

downstream

Photo 5-9-2022
-33.658447
150.279953
5/09/2022 12:15:30 PM

extraction	absent
excavation	absent
litter	absent
sewer	present
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	23
Site Features Total	23
channel shape	simple
pool riffle sequence	absent
meanders	unconfined yes
large woody debris	high >10
woody debris size	> 3 metres length
overhanging vegetation	mod <30>60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural < 500 mm
native macrophyte	absent
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	8
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Young Creek Main

type Regular | date 19 Sep 2022 | time 4:19:47 pm | assessor Ben Green

weather sunny | reach type permanent | flow medium

97 %

29 | 20 | 46 | 6 | 13 | 1

excellent

Young (Lower Young Creek)

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bedrock. The bank type is natural vegetation - Nveg.

stream order

2

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 19-9-2022
-33.662892
150.295137
14/09/2022 12:37:46 PM

downstream

Photo 19-9-2022
-33.662895
150.295137
14/09/2022 12:37:49 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 3 metres length
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Young Creek Main

type Regular | date 19 Sep 2022 | time 4:11:20 pm | assessor Ben Green

weather sunny | reach type permanent | flow medium

97 %

29 | 20 | 46 | 6 | 13 | 1

excellent

Young (Middle Young Creek)

stream order 2

notes

The site is in excellent condition, with a raw score of 89 (97%) overall. The bed type is natural bed (invert) - Nv. The bank type is natural bedrock.

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 19-9-2022
-33.665988
150.295350
14/09/2022 12:03:17 PM

downstream

Photo 19-9-2022
-33.665987
150.295350
14/09/2022 12:03:12 PM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	confined yes
large woody debris	high >10
woody debris size	> 3 metres length
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural > 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	13
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	natural
undercutting	absent
bank slumps	absent
knick point	rock-supported
bank erosion	absent
Erosion Total	1
riparian corridor WMAct	40
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

RAPID RIPARIAN SITE ASSESSMENT

Biosis

Young Creek Main

type Regular date 7 Sep 2022 time 9:55:26 am assessor Ben Green

weather sunny reach type ephemeral flow low

98 %

29 20 46 6 16 0

excellent

Young (Upper Young Creek)

notes

The site is in excellent condition, with a raw score of 91 (98%) overall. The bed type is natural wetland - Wet. The bank type is natural vegetation - Nveg.

stream order 1

landuse

Within the 50 metre assessment radius, left bank land use is 100% bushland, approximately. Right bank land use is 100% bushland, approximately. This is included in the site features score.

vegetation

Within the 50 metre assessment radius, left bank vegetation structure is 100% forest/woodland, approximately. Right bank vegetation structure is 100% forest/woodland, approximately. This is reflected in the vegetation structure subtotal.

weeds

upstream

Photo 7-9-2022 9.56.48
-33.673937
150.291170
7/09/2022 9:54:28 AM

downstream

Photo 7-9-2022 9.57.34
-33.673937
150.291170
7/09/2022 9:54:25 AM

extraction	absent
excavation	absent
litter	absent
sewer	absent
stormwater	absent
odour	normal/none
turbidity	low
Land Use Subtotal	29
Site Features Total	29
channel shape	complex
pool riffle sequence	present
meanders	unconfined yes
large woody debris	high >10
woody debris size	> 300 mm dia and 3 m
overhanging vegetation	high >60%
natural bed detritus	present
natural gravel bed	present
natural rock in-stream	natural < 500 mm
native macrophyte	present
mapped Key Fish Habitat	no
KFH riparian buffer zone	
Aquatic Habitat Total	16
benches	absent
islands	absent
channel bars	absent
Deposition Total	0
bedrock/clay exposure	absent
undercutting	absent
bank slumps	absent
knick point	absent
bank erosion	absent
Erosion Total	0
riparian corridor WMAct	20
riparian buffer width left	over 40m
riparian buffer width right	over 40m
Riparian Vegetation Subtotal	20
Vegetation Structure Subtotal	20
weed density left bank	absent
weed density right bank	absent
Weeds Subtotal	6
Vegetation Total	46

Annexure I – Calculation of biodiversity credits to offset an indirect impact

The following steps have been applied in the calculation of biodiversity credit offsets for indirect impacts. These offsets are specifically for degradation of native vegetation that may occur within retained patches of native vegetation adjacent to the project's development footprint as a result of edge effects.

Step 1: Assess the existing condition of vegetation within an indirect impact assessment buffer of 50 metres from the boundary of the subject land:

- Establish an indirect impact investigation area by applying a 50-metre buffer to the boundary of the subject land
- Classify the native vegetation within the 50-metre buffer into the following categories, based on vegetation mapping undertaken for the assessment or regional vegetation mapping where required.

Category	Description	Next step
Isolated patches	Small fragments of vegetation (<0.25 hectares patch size after project clearing) within the buffer that will remain following the completion of the project. These vegetation fragments are considered no longer likely to be viable in the long term.	Assess and offset as if directly impacted (i.e. future VI score reduced to zero)
Existing edge	An existing vegetation edge either adjoins, only slightly overlaps (i.e. 1-2 metres of overlap) or is set back from the subject land. These areas are already subject to existing edge effects, which are unlikely to increase due to the project.	No further assessment or offsetting required
New edge in fragmented and/or disturbed vegetation	Vegetation in any condition that is less than 50 metres wide and/or is currently fragmented and disturbed with modified structure and high exotic cover. Therefore, the creation of new edges is unlikely to result in substantial alteration to remaining areas of this vegetation.	No further assessment or offsetting required
New edge in un-fragmented and undisturbed vegetation	Vegetation patch that meets the vegetation integrity score offset thresholds detailed in Subsection 9.2.1 of the BAM that will be fragmented by the construction footprint to form one or more new edges within previously un-fragmented vegetation that extends over 50 metres from the edge of the subject land.	Further assessment required – proceed to step 2

Step 2: Biosis then assumed a 20 per cent reduction in the vegetation integrity score for the impacted zones. Following this we adjusted the condition scores for the zone in the 'Future vegetation integrity score' section of the BAM-C until a 20 per cent reduction was achieved. When adjusting condition scores to obtain the future vegetation integrity, we considered attributes which were likely modified by the edge effects (species richness, understorey species, abundance, cover etc.).

Step 3: Biosis estimated the credit requirement by calculating credit value for each vegetation zone based on Step 22. Isolated patches are to be offset assuming total loss of vegetation integrity for these patches.

Annexure J – Significant impact criteria assessments

Temperate Highland Peat Swamps on Sandstone

Temperate Highland Peat Swamps on Sandstone (THPSS) is listed as an EEC under the EPBC Act. This community comprises temporary or permanent swamps occurring on sandstone in the temperate highlands region of NSW occurring between 650 and 1200 meters above sea level (DEWHA 2005, DCCEEW 2022b). The wetter parts of the swamps are occupied by sphagnum bogs and fens, while sedge and shrub heath-like associations occur in the drier parts. The level of waterlogging and amount of sedimentation are influenced by the location of the swamps, i.e., hanging swamps (occurring on steep valley sides) have low levels of sedimentation and accumulate organic material slowly whereas valley swamps and those along watercourses have greater levels of sedimentation, and accumulate organic material more quickly. In drier areas, such as the Blue Mountains, the thicker vegetation found around the peat swamps provides 'islands' of good habitat for a diverse range of fauna (DEH 2005, TSSC 2005).

There is no Recovery Plan for this ecological community.

Occurrence within the study area

The community, also defined as PCT 1256, *Tableland swamp meadow on impeded drainage sites of the western Sydney Basin Bioregion and South Eastern Highlands Bioregion,* was recorded within the valley swamps along the Butlers Creek watercourse within the study area. The EEC is found approximately 250 metres to the north-east of the Little Hartley development footprint along the nearby riparian area of Butlers Creek (Figure 4-2). The local occurrence of Temperate Highland Peat Swamps on Sandstone, referred to herein as the EEC, includes 2.86 hectares of the mapped EEC, verified by Biosis (2022) and previously mapped by the Commonwealth of Australia and Macquarie University (2016) as part of the Temperate Highland Peat Swamps on Sandstone spatial distribution maps – VIS_IDs 4480 to 4485.

The project will not directly impact the EEC despite its location within the study area, approximately 250 meters to the north-east. This assessment looks to the possibility of indirect impacts due to the proximity of the development footprint to the EEC, and the two being at being on the same elevation, of 850 meters.

Occurrence outside the study area

The EEC also occurs outside of the study area for this BDAR along the Greaves Creek catchment as mapped by Temperate Highland Peat Swamps on Sandstone spatial distribution maps – VIS_IDs 4480 to 4485 (CoA and Macquarie University 2016) and the Native Vegetation mapping in the Blue Mountains 1999-2002 VIS ID 2239 (DPE 2010b). The swamps in this catchment fall outside the study area for this BDAR however are associated with prescribed impacts as a result of the changes to groundwater drawdown and surface water rate and volume changes due to the project. Based on groundwater and surface water modelling, peat swamps are at risk from reduced baseflows (especially during dry times) and changes to surface water flows, which could result in drying out or damage to the swamps (refer to section 7.4.4).An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-1.

Table App I-0-1: SIC assessment of Temperate Highland Peat Swamps of Sandstone

Significant impact criteria (critically endangered / endangered community)
Reduce the extent of an ecological community.
Temperate Highland Peat Swamps on Sandstone is limited to the Blue Mountains, Lithgow, Southern Highlands and Bombala regions in NSW. It predominantly occurs in areas at elevation ranges from 650-1200m above sea level (DEWHA 2005, DCCEEW 2022b).

Significant impact criteria (critically endangered / endangered community)
The extent of the community occurs within the valley swamps, along a watercourse (Butlers Creek), immediately above a farm dam, with the EEC exhibiting a high level of sedimentation, and organic material. There are no direct impacts to the 2.86 hectare patch of the EEC, however the EEC is approximately 250 metres from the development footprint (within the study area) in part on the same level of elevation (850 metres). The extent of the community occurs along Greaves Creek, downstream of the Blackheath development footprint outside the study area, mapped by CoA and Macquarie University (2016) and the DPE (2010b). It is unlikely that the proposed construction works will cause any significant reductions to the extent of the EEC at Butlers Creek, however all efforts must be made to ensure that any surface water discharge from the tunnel and temporary concrete batching plant is directed away from the EEC to elevations below 840 metres. Regarding the extent of the EEC on Greaves Creek and the proposed changes to groundwater drawdown and surface water flows (section 7.4.4), there are a range of proposed measures (in addition to the bioretention systems and flow spreaders) to be incorporated either as part of the detailed design or post approval, so to avoid impacts to the extent of the EEC. Further investigation into the impacts of baseflow reductions on watercourses and swamps will be undertaken during design development. Future investigations would include field hydrogeological investigations to provide more accurate, site-specific parameters that can be used in predictive groundwater modelling. Modelling would then be revised for this catchment to enable more accurate predictions of the likely impact of the Blackheath portal on baseflow reductions. If revised modelling determines that a reduction in baseflow to the valley floor infill swamps of Greaves Creek is likely and that there is a risk of detrimental impacts to these ecosystems as a result, then further mitigation measures would be investigated. Performance outcomes for the mitigation measures would be developed and agreed upon by subject matter experts, and mitigation actions including design responses such as lining the Blackheath tunnel portal would be assessed for their effectiveness in addressing the risk. In the instance that residual risk is predicted monitoring would continue during construction for the hydrogeology, geomorphology and vegetation community likely to be impacted. Observations would be assessed against set triggers, trigger thresholds, and responses for observed impacts. Monitoring methods would be developed with reference to supporting justification including the recommendations of Commonwealth of Australia (2014) where appropriate. Swamp extent and PCT mapping would be carried out for the BC Act and EPBC Act listed peat swamps (GDEs) on Greaves Creek and Butlers Creek prior to construction commencement, followed by seasonal swamp extent mapping and species composition assessment to assess change in swamp dynamics for a 24 month period. Should these measures be appropriately designed, and ongoing monitoring undertaken to assess for any change, the local extent of the EEC at these two locations should not be significantly impacted.
Fragment or increase fragmentation of an ecological community.
The proposed works will not result in any direct impacts to Temperate Highland Peat Swamps on Sandstone. Therefore, the project will not cause fragmentation, nor will it increase fragmentation of the ecological community. There will however be prescribed impacts to the EEC along Greaves Creek, downstream of surface water discharge that will need to be appropriately managed (refer to prior response above) to avoid the fragmentation of this EEC.
Adversely affect habitat critical to the survival of an ecological community.
No habitat critical to the survival of Temperate Highland Peat Swamps on Sandstone has been listed under the EPBC Act, nor is it provided for on the SPRAT profile or EEC's Conservation or Listing Advices.
Modify or destroy abiotic factors necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns.

Significant impact criteria (critically endangered / endangered community)
The project is not anticipated to cause the modification or destruction of EEC habitat, or the abiotic factors necessary for the EEC's survival due to the following; • The flow and water quality of upstream Butlers Creek to the EEC is not expected to change and it is not anticipated that any surface water impacts from the tunnel discharge or from the temporary construction batching plant will reach the EEC. • The groundwater report anticipates minimal groundwater drawdown in the Butlers Creek catchment associated with this community, as detailed in Appendix I (Technical report - Groundwater) of the EIS. • Bioretention systems for the two locations (Butlers Creek and Greaves Creek) would be sized to treat runoff in order to achieve NorBE pollutant reduction targets for total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS) and gross pollutants (GP). Bioretention systems will be unlined to allow infiltration of treated stormwater directly into the surrounding soils and will also include usage of engineered filter media and will be planted with native flora species that are representative of the surrounding PCTs. These native plants will help build a peat like environment in the bioretention systems, which will assist in reducing the pH to a more acidic pH, better suited to the receiving waterways/peat swamps (Greaves Creek). • Flood retarding basins will be provided to ensure peak flow rates do not increase for events from the one event/year to the one per cent Annual Exceedance Probability event (around one in 100 year annual recurrence internal). • Flow spreaders will be utilised to create float, low energy sheet flow conditions to further encourage filtration, upstream of the EEC on Greaves Creek. • Energy dissipation such as flow spreaders on stormwater outlets to reduce the potential for scour and erosion to the EEC. Furthermore, it is not anticipated that there will be any changes to other Conservation Advice listed threats (DEH 2005, TSSC 2005) such as; land clearing, fertiliser runoff, weed ingress or coal mining. Therefore there should not be any modification or destruction of abiotic factors necessary for the EEC survival at both locations, pending detailed design incorporates the above listed measures.
Cause a substantial change in the species composition of an occurrence of an ecological community, including a decline or loss of functionally important species, for example through regular burning or flora and fauna harvesting.
The local occurrence of Temperate Highland Peat Swamps on Sandstone is 2.86 hectares, situated 250 meters away from the development footprint. As there are no direct impacts forecast to the EEC and given indirect impacts will be managed by strict water quality discharge parameters, flow controls and standard construction safeguards, it is not anticipated that there will be any substantial change in the species composition of an occurrence of the EEC. Regarding the local occurrence of the EEC on Greaves Creek and the proposed changes to groundwater drawdown and surface water flows (section 7.4.4), there are a range of proposed measures (in addition to the bioretention systems and flow spreaders) to be incorporated either as part of the detailed design or post approval, so to avoid impacts to the local occurrence of the EEC listed above in response to question, r*educe the extent of an ecological community*. Should these measures be carefully planned and designed for and assessed during the construction and operational phase of the project, there should not be an impact to the local occurrence of the EEC on Greaves Creek of Butlers Creek.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including but not limited to: **- Assisting invasive species establishment** **- Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community.**

Significant impact criteria (critically endangered / endangered community)
The proposed works will include development of bioretention systems and flow spreaders at the discharge surface water treatment point above Greaves Creek which will be managed by licenced discharge water quality parameters and volume, which will stipulate that all discharge is to meet a high standard of quality (i.e. *Neutral or Beneficial Effect* (NorBE) *on Water Quality Assessment Guideline* [Water NSW, 2021], *Using MUSIC in Sydney's Drinking Water Catchment* [Sydney Catchment Authority, 2012] and various stormwater management guidelines, refer to Appendix J of the EIS for the Surface Water Report), In addition, management will occur through the Construction Environment Management Plan (or similar) which will set out detailed management measures to prevent the spread or establishment of weeds and the activation of erosion points and/or sedimentation. Therefore, given the strict controls around the water quality discharge parameters and flow controls as well as the standard construction safeguards there should not be a substantial reduction in the quality or integrity of an occurrence of the EEC.
Interfere with the recovery of an ecological community.
The project is not likely to cause any interference with the recovery of the EEC, due to the strict controls that are to be applied to the water quality discharge parameters and flow controls as well as construction safeguards. In addition, at Butlers Creek, given the distance between the development footprint and the EEC is 250 meters there should be a sufficient buffer so to avoid any indirect impacts that could interfere with the recovery of the EEC. Lastly as the flows upstream of the EEC at Butlers Creek are expected to be maintained and it is not anticipated that there will be any changes to the Conservation Advice listed threats (DEH 2005, TSSC 2005) such as; receiving water quality or flow volume, land clearing, fertiliser runoff, weed ingress or coal mining the recovery of this community should not be impacted. The Greaves Creek catchment will be managed by strict surface water management through a bioretention system and will include the use of flow spreaders to assist with the downstream impacts to the EEC. Therefore, the project design will focus on minimising impact to receiving water quality, rates and volume as well as land clearing, fertiliser runoff, weed ingress. Given these management and design initiatives, the recovery of this community should not be impacted.
Conclusion
Based on the assessment provided above, it is concluded that Temperate Highland Peat Swamps on Sandstone is unlikely to be significantly impacted by the project. This conclusion was made on the basis that: • the project will not have any direct impacts to the EEC at Butlers Creek • prescribed impacts will be managed carefully through the implementation of design features such as an unlined bioretention system and associated flow spreaders to minimise impacts to the EEC downstream on Greaves Creek • impacts will be monitored on Butlers Creek and Greaves Creek by further hydrological monitoring and modelling as well as biodiversity monitoring of the swamp extent and assessment of seasonal PCT extent and floristics to monitor for change through a set of triggers, trigger thresholds, and responses for observed impacts • the project will not contribute to any fragmentation of the community • no impacts are anticipated that would cause the potential modification of abiotic factors necessary for the survival of the EEC • it is not anticipated that there will be any change to the species composition of the EEC, however there are a range of mitigation measures (design and ongoing monitoring) proposed, especially for Greaves Creek to ensure this is the case • there are no foreseen barriers to the recovery of the EEC as a result of the project • minimal groundwater drawn down is anticipated in the vicinity of this EEC at Butlers Creek. Groundwater drawdown in the Greaves Creek catchment is to be further assessed post approval to

Significant impact criteria (critically endangered / endangered community)
adequately model impacts, as well as biodiversity swamp extent mapping so to determine if additional mitigation measures need to be developed prior to construction • water quality discharge parameters and flow controls as well as construction safeguards should prevent the works causing any reduction to the quality or integrity of the EEC. This Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Koala *Phascolarctos cinereus*

Koala populations in QLD, NSW and ACT are listed as Endangered under the EPBC Act. Koalas occupy a range of eucalypt-dominated forest and woodland types throughout their range but favour habitats that support key forage species in more mesic microhabitats. Altitude (<800 metres ASL) and temperature restrict the koalas distribution, as does leaf moisture at the western and northern ends of their range (DAWE 2022).

Key threats to Koala include climate change, habitat fragmentation, habitat loss due to changes in fire regimes, predation by dogs, vehicle strikes and disease (DAWE 2022).

Koala populations throughout Australia are currently under increased pressure due to the 2019-2020 summer bushfires that occurred across the southern and eastern states of Australia. Twelve percent of the likely and known distribution of the combined Koala populations across Australia has been identified as occurring within fire affected areas, and the Koala has been identified as one of the species requiring urgent management intervention. Given this context, any remaining areas of high-quality Koala habitat are now critical to the conservation of the species.

Occurrence in the development footprint

In the surrounding locality, Koala populations are known to occur within 362 metres of the study area, concentrated in the area around the north-west and south-east of the study area. No evidence of Koala occupation (scats or tree scratches) was recorded during targeted surveys,, however the site does constitute potential Koala habitat due to the availability of known feed trees within the study area. Furthermore, given the high level of connectivity of the study area, it is likely that Koala population may utilise the study area on occasion. The project will directly impact approximately 9.31 hectares of potential Koala habitat.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-2.

Table App I-0-2: SIC assessment of Koala *Phascolarctos cinereus*

Significant impact criteria (critically endangered / endangered species)
Lead to a long-term decrease in the size of a population.
Koalas within the locality are highly likely to be part of the Blue Mountains Koala population, identified within the NSW Koala Strategy (DPE 2022f), which is also known to be one of the most genetically diverse populations (NSW Legislative Council 2020). Vehicle strikes is one of the most frequently reported causes of injury and death for koalas in NSW (DPIE 2020e) and represents one of the biggest threats to the species as result of the project. During the construction phase of the works, mortality rates for Koalas are likely to increase from current levels if left unmitigated, due to an increase in traffic. However, post construction impacts associated with vehicle strike should fall to lower levels than those observed pre-construction along the current Great Western Highway as a greater volume of vehicles will be underground in the tunnel reducing vehicle strike. Mitigation measure adopted during construction will help ensure that that the threat of vehicle strike is

Significant impact criteria (critically endangered / endangered species)
appropriately managed. These measures include construction driver awareness training, signage, project speed limits and fauna exclusion fencing around construction facilities will help reduce this impact. The project will result in the removal of 9.31 hectares of potential foraging habitat (1.79 hectares of PCT 708, 7.33 hectares of PCT 1248 and 0.19 hectares of PCT 1615). While we are removing 9.31 hectares of native vegetation, the vegetation to be removed is considered to be low-quality potential koala habitat due to the edge impacts associated with the current Great Western Highway as well as nearby residential development land use. Targeted surveys did not detect any sign of Koalas within the study area. Given the edge effected nature of that vegetation and the availability of higher quality habitat within the broader locality, which includes large intact sections of the Blue Mountains National Park, it is unlikely that the vegetation to be removed would provide more than occasional foraging habitat for individuals of this population. Given the scale of the impact in the context of available habitat in the region (>200,000 hectares of remnant vegetation), it is unlikely that the proposed development will lead to a long-term decrease in the size of the Blue Mountains Koala population. To further minimise the risk of impact to this population, a pre-clearance assessment will be undertaken prior to the removal of native vegetation.
Reduce the area of occupancy of the species.
The native vegetation to be removed from the development footprint contains four known key feed trees for Koala including; Sydney Peppermint *Eucalyptus piperita*, Silvertop Ash *Eucalyptus sieberi*, Monkey Gum *Eucalyptus cypellocarpa* and Hard-leaved Scribbly Gum *Eucalyptus sclerophylla.* While this vegetation may provide some minimal foraging habitat for the local Blue Mountains population of Koalas, the 9.31 hectares of potential habitat to be removed would not be considered significant in the scope of available habitat in the broader locality (>200,000 hectares). The Koala has a wide area of occupancy across most of the east coast, from Queensland to Victoria and across the Great Dividing Range. As such, impacts associated with the proposed work will not impact populations at the edge of this species range. It is likely that the current Great Western Highway represents a barrier to the movement of this species, as well as representing a significant threat due to the risk of vehicle strikes. The proposed works includes the construction of a tunnel which will ultimately reduce the volume of vehicle traffic in the section of the Great Western Highway between Blackheath, and Little Hartley. As such, the project would not further limit the movement of this species or reduce for the area of occupancy of the local populations and may even result in fewer vehicle strikes within the immediate locality which may aid in species movement across the highway. Given the overall context of the region and the extent of the vegetation connected to the study area, the 9.31 hectares of low-quality potential koala habitat expected to be removed is unlikely to have an impact on the area of occupancy for the Koala.
Fragment an existing population into two or more populations.
In the scope of the greater context of the surrounding land, the 9.31 hectares of potential Koala habitat to be removed represents a relatively small portion of habitat. The study area primarily occurs along the linear corridor of the Great Western Highway, of which the highway may represent a barrier to movement for this species as well as a significant threat due to the risk of vehicle strike. Individuals within the locality would form part of the broader Blue Mountains population which extends throughout the Blue Mountains region. As such, impacts associated with the three development footprints along the road corridor are unlikely to result in any further fragmentation of this populations and the project may even

Significant impact criteria (critically endangered / endangered species)
reduce road related mortalities on the Great Western Highway between Blackheath and Little Hartley once the tunnel is operational and vehicle traffic is moved underground.
Adversely affect habitat critical to the survival of a species.
Habitat critical to the survival of the Koala is defined in the *National Recovery Plan for the Koala Phascolarctos cinereus (combined populations of Queensland, New South Wales and the Australian Capital Territory*) (DAWE 2022). Using the criteria outlined in section 25 of the National Recovery Plan, the main reason that the study area may be utilised by Koala would be during periods of stress such as a major fire event. The 9.31 hectares of vegetation to be removed from the study area is impacted by edge effects due to its proximity to the Great Western Highway and other urban development. Although the vegetation contains four known Koala feed trees (Sydney Peppermint, Silvertop Ash, Monkey Gum and Hard-leaved Scribbly Gum), the vegetation to be removed occurs along an already impacted linear corridor and targeted surveys did not detect Koala presence. As such, it is unlikely that there will be any adverse impacts to Koala habitat especially given the much larger adjoining critical habitat area. This adjoining area encompass' well over 200,000 hectares of vegetation throughout the throughout the Blue Mountains National Park and surrounds. The removal of 0.005% of the low-quality habitat is therefore unlikely to have an adverse effect on habitat critical to the survival of the species.
Disrupt the breeding cycle of a population.
No Koalas were detected during targeted survey undertaken for the project. While the project may result in the removal of vegetation occasionally occupied by the species,, including individuals that may breeding, the project is unlikely to result in disruption to the breeding cycle of the Blue Mountains Koala population, given the breadth of higher quality adjoining habitat. It is also unlikely that temporary disturbance from noise or lighting associated with the construction will substantially interfere with the species' ability to reproduce successfully. Koalas will continue to breed in the expansive adjoining vegetation in areas unaffected by vegetation loss. The project may also result in an increase in the number of individuals of reproductive age due to the decreased risk of vehicle strike once the tunnel becomes operational and traffic along the existing Great Western Highway between Blackheath and Little Hartley decreases. As a result, the breeding cycle of the Blue Mountains population will not be disrupted.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Koalas may occasionally utilise vegetation within the study area. The project will impact 9.31 hectares of low condition potential habitat that contains four known Koala feed tree species; however this is a small amount when compared to the broader adjoining landscape. The project is not likely to isolate the local population as the Great Western Highway already acts as a barrier, in addition the development will not significantly impact on Koala corridors and further will reduce the likelihood of vehicle strike due to the nature of the tunnel reducing vehicles While the project will result in the removal of 9.31 hectares of vegetation (1.79 hectares of PCT 708, 7.33hectares of PCT 1248 and 0.19 hectares of PCT 1615), this level of loss is not likely to largely modify, destroy, remove or isolate habitat such that there would be a decline of the species.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.

Significant impact criteria (critically endangered / endangered species)
There are a number of feral animals that are known or likely to be well established in the study area. Some of these are known to negatively impact Koalas including dogs and foxes. The proposed action is unlikely to exacerbate the current level of invasive species threat that is already operating within the study area.
Introduce disease that may cause the species to decline.
The project is unlikely to result in the new introduction of a disease (e.g. Chlamydia) that could impact the reproductive ability of Koala populations in or near the study area. Given the widespread nature of chlamydia within NSW populations, it is highly likely that individuals within the local population have already been infected or at risk of infection from other individuals within the locality. While the Blue Mountains Koalas are known to have a strong gene pool which may assist with a lower likelihood of Chlamydia infections, the only disease-free local population is that at Kanangra (NSW Legislative Council 2020). There is also the threat of *Phytophthora cinnamomi* in the region, a plant disease that could impact the condition of Koala habitat (Eucalypts). The project will require high standards of machinery wash-down which will aim to prevent the spread of pathogens such as *Phytophthora cinnamomi* (RTA 2011a). The project is therefore unlikely to result in the new introduction of disease that could lead to further species decline, due to the mitigation measures that will be employed during construction.
Interfere with the recovery of the species.
Actions considered likely to substantially interfere with the recovery of Koala are defined in *EPBC Act Referral Conservation Advice for Phascolarctos cinereus (Koala) combined populations of Queensland, New South Wales and the Australian Capital Territory* (DCCEEW 2022c) as follows: • *Increasing Koala fatalities in habitat critical to the survival of the koala due to dog attacks to a level that is likely to result in multiple, ongoing mortalities.* • *Increasing Koala fatalities in habitat critical to the survival of the Koala due to vehicle-strikes to a level that is likely to result in multiple, ongoing mortalities.* • *Facilitating the introduction or spread of disease or pathogens for example Chlamydia or Phytophthora cinnamomi to habitat critical to the survival of the Koala that are likely to reduce the carrying capacity of the habitat.* • *Creating a barrier to movement to, between or within habitat critical to the survival of the Koala that is likely to result in a long-term reduction in genetic fitness or access to habitat critical to the survival of the Koala.* • *Changing hydrology which degrades habitat critical to the survival of the Koala to the extent that the carrying capacity of the habitat is reduced in the long-term.* The project is unlikely result in increased dog attacks, which are primarily an issue where new urban development encroaches upon Koala habitat. While the project will result in an increase in traffic during the construction phase, this will be temporary and mitigation measures including construction driver awareness training, signage, project speed limits and fauna exclusion fencing around construction facilities will ensure that this will not result in sustained increases in Koala based road mortalities. The project is unlikely to result in the new introduction of a disease (e.g. Chlamydia) that could reduce the reproductive output of Koala populations in or near the project area. Similarly, the project is unlikely to exacerbate the current level of invasive species threat operating within the project area. High standards of machinery wash-down will prevent the spread of pathogens such as *Phytophthora cinnamomi*. The project will not constitute an increased barrier to the movement of Koalas between habitat patches and therefore will not further restrict the species' ability to disperse or carry out normal demographic processes. The project is not expected to result in substantial changes to hydrology that would result in degradation of

Significant impact criteria (critically endangered / endangered species)
any critical habitat to the extent that the carrying capacity of that habitat is reduced. The project is therefore unlikely to substantially interfere with the recovery of the Koala.
Conclusion Clearing in the project footprint is restricted to of 9.31 hectares of low-quality potential koala habitat , located on the edge of a large continuous patch greater than 200,000 hectares. The nature and location of this clearing will not significantly reduce the availability of habitat, which is already fragmented by the Great Western Highway and subject to edge effects associated with this roadway.. In consideration of the above significant impact criteria, the proposed activity is not likely to significantly impact Koalas within the study area or wider locality, as: • targeted surveys did not detect signs of Koalas within the development footprint • the proposed works will result in the clearing of 9.31 hectares of low-quality potential habitat, containing four feed trees important for this species • the removal of this vegetation is not likely to further adversely affect Koala populations to the extent that it would cause a significant impact • less than 0.005% of available habitat within the locality will be impacted. When considering the surrounding higher quality habitat this removal is not considered to adversely affect habitat critical to the survival of the species. • the project is unlikely to further fragment or isolate the population given the current fragmented state of the study area • the proposed works are unlikely to result in the introduction of disease that could significantly impact the reproduction or survival of Koalas. Vehicle wash down will take place in accordance with RTA (2011a) which will also limit the potential spread of *Phytophthora cinnamomi* • temporary exclusion fencing is to be installed around the construction footprints to minimise road mortalities • pre-clearance surveys will be undertaken prior to the removal of native vegetation to ensure no individuals are present. As such, it is considered unlikely that the proposed action will significantly impact the Koala. However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Greater Glider *Petauroides volans*

Greater Glider is listed as an endangered species under the EPBC Act. The Greater Glider is the largest gliding possum in eastern Australia, with a head and body length of 35-46 cm. This arboreal nocturnal marsupial is predominantly solitary and largely restricted to eucalypt forests and woodlands of eastern Australia. This species is also known to occur in moist forest at higher elevations. The Greater Glider utilises multiple dens across its home range and shelters in large hollows of >10 centimetres (DCCEEW 2022d).

The Greater Glider is threatened by a number of processes including loss and fragmentation habitat through land-clearing, road mortality through habitat and movement areas as well as predation from cats, dogs and foxes. The Greater Glider is slow to respond to disturbance and therefore is at a higher susceptibility of population decline.

Occurrence in the development footprint

The habitat present (7.33 hectares of PCT 1248) within the study area provides critical foraging and nesting habitat for the Greater Glider. Greater Gliders were recorded during spotlighting surveys at both the eastern (Blackheath) and western (Little Hartley) extents of the subject land. There are also 52 known records of the species within 10 kilometres of the study area (DPE 2022g). There are no large hollows (>15 centimetres), however there are seven medium hollows (greater than 10 centimetres) present in PCT 1248 within the study area and in the Soldiers Pinch and Blackheath areas, therefore there is a high likelihood that they are used by Greater Glider for sheltering or nesting.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-3.

Table App I-0-3: SIC assessment of Greater glider *Petauroides volans*

Significant impact criteria (critically endangered / endangered species)
Lead to a long-term decrease in the size of a population.
The study area and development footprint occur along a long linear alignment (approximately 11 kilometres from start to finish). Given the distance between the Greater Gliders observed at Blackheath and Little Hartley, it is assumed Greater Glider in these two locations form two distinct populations. This conservative approach has been undertaken as it assumes worse case impacts to two populations. Based on an approximate 19 hectare home range of the species and the presence of several large towns and infrastructure as well as elevation changes, it has been assumed that these populations are distinct. While population density for this species remains largely unclear, it is estimated that population density within the available habitat (7.33 hectares of PCT 1248) of the development footprint would have a carrying capacity of between 0.073 and 36.65 individuals (DCCEEW 2022d). However, it is noted in the conservation advice that populations within the Blue Mountains have suffered a 60 % decline in population density after years of drought and after the 2019 bushfire season which burnt 84 % of the known sites of occupancy for this species within the Blue Mountains National Park. As such impacts to Greater Gliders would result in an overall population decline of up to 0.04 % (for a density of 5 individuals per hectare, over 7.33 hectares) based on an estimated population size of 100,000 individuals across Australia (DCCEEW 2022d). Direct mortality of individuals will be avoided by implementing preclearance surveys and a two-stage hollow-bearing tree clearance process for the seven medium hollows that need to be removed for the project, as part of the proposed vegetation removal. The presence of hollows (dens) greater than 10 centimetres within an individual's home range (19 hectares) would be considered vital to the survival of a local population; with Greater Gliders in Queensland observed to use 4-20 such hollows within their home range (DCCEEW 2022d). While it is highly likely that the connected surrounding vegetation would contain several large hollows, the removal of the seven hollows as part of the project would result in an impact to the Greater Glider individuals in the locality, however this is unlikely to be significant impact given the likelihood of a high amount of large hollows with respect to the surrounding vegetation as well as those likely to occur within the local population's area of occurrence.
Reduce the area of occupancy of the species.
The Greater Glider has a broad distribution, occurring along the east coast of Australia from around Proserpine in Queensland to Wombat State Forest in central Victoria and across the Great Dividing Range. The works will require the removal of 7.33 hectares of habitat, containing seven suitable sized hollows, which occurs adjacent to a large area of native vegetation providing suitable habitat and hollow resources for the Greater Glider. Connectivity throughout the study area is very high as the study area occurs within large tracks of remnant vegetation, including vegetation within the Blue Mountains National Park which is over 200,000 hectares in size. Although Greater Glider are known to be utilising the development footprint, it is unlikely that the removal of this vegetation will reduce the area of occupancy for this species, as connectivity will not be severed to surrounding vegetation nor will the works result in a level of fragmentation which would restrict the area of occupancy for this species. Any individuals disrupted by the impacts associated with the project will seek

Significant impact criteria (critically endangered / endangered species)
refuge in adjoining vegetation and continue to inhabit the Blue Mountains area. Therefore, due to the relatively small area of Greater Glider habitat proposed for removal for the project as well as the very large amount of commensurate habitat available in areas directly adjacent to the project, it is unlikely that the project will reduce the area of occupancy of this species.
Fragment an existing population into two or more populations.
Given the length of the alignment it is assumed that at least two populations of Greater Glider occur throughout the alignment. The works would require the removal of 7.33 hectares of habitat for the Greater Glider, the majority of which is already fragmented by the current Great Western Highway roadway and local residential areas. While parts of the current infrastructure are within the glide range of the Greater Glider, given this species is vulnerable to fragmentation and reluctant to cross roadways; even with glider poles, it is likely that the Great Western Highway already represents a barrier to movement for this species. As such the removal of vegetation along the edge of already fragmented areas is unlikely to exacerbate current fragmentation. Connectivity throughout the remainder of the development footprint area is very high, with virtually all works occurring adjacent to large tracks of remnant vegetation. As vegetation removal is expected to occur along already impacted edges and as connectivity will remain intact to remnant vegetation, the works are not expected to further fragment an existing population of the species into two or more populations.
Adversely affect habitat critical to the survival of a species.
Habitat critical to the survival of the Greater Glider is defined in the DCCEEW (2022d) *Conservation Advice for Petauroides volans (greater glider (southern and central)).* Vegetation to be removed from the study area may be considered habitat critical to the survival of the species for the follow reasons: • it is part of an adjoining large contiguous areas of eucalypt forest • it comprises a cool microclimate forest/woodland area. Vegetation to be removed from the study area is already heavily impacted by edge effects associated by the proximity to the Great Western Highway. This habitat also occurs on the edge of a large continuous patch of eucalypt forest, with the removal of a relatively small (7.33 hectares) band of native vegetation along a linear alignment being unlikely to adversely affect the broader Greater Glider habitat available in adjoining areas. Despite the removal of seven hollows (to be undertaken in a supervised manner) within the 7.33 hectare patch of PCT 1248, it is assumed that the small number of potentially displaced Greater Glider individuals will utilise other hollow resources in directly adjoining and surrounding areas. Therefore there should be no adverse effect on habitat critical to the survival of the Greater Glider.
Disrupt the breeding cycle of a population.
Impacts likely to disrupt the breeding cycle of Greater Glider include direct mortality, disturbance to nesting sites, loss of nesting and sheltering habitat, and the loss and fragmentation of foraging habitat, particularly within extensive areas of continuous forest and areas of high productivity. The project will remove up to 7.33 hectares of native vegetation represented by PCT 1248, including seven hollows greater than 10 centimetres. The habitat to be removed is within a large patch (>200,000 hectares) of good quality bushland in the Blue Mountain's National Park. It is likely that if the species uses the study area for foraging, sheltering and nesting then the local population would use the entire patch of connected bushland. Hollows within the development footprint provide important nesting resources for the Greater Glider. While Greater Gliders are known to utilise multiple hollows throughout their home range, given the extent of available vegetation within the broader locality containing similar habitat features the removal of seven medium sized hollows within the development footprint (Soldiers Pinch and Blackheath areas) will not reduce the availability of hollows such that the breeding cycle of an existing population would be interrupted...

Significant impact criteria (critically endangered / endangered species)
It is highly likely that surrounding native vegetation will provide a large range suitable hollows for this species. Offsetting of the lost hollows with artificial nest boxes is not recommended, as Greater Gliders have not been observed to utilise the boxes with sufficient frequency for breeding. Given the availability of additional nesting resources in the broader landscape in higher quality vegetation, further from the urban impacts, it is assumed that the works will not disrupt the breeding cycle of an existing population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
The project will remove up to 7.33 hectares of native vegetation represented by PCT 1248. The habitat to be removed is within a large patch (>200,000 hectares) of good quality bushland within the Blue Mountain's National Park. It is reasonably assumed that if the species uses the study area for foraging, sheltering and nesting than the local population would also use the entire patch of connected adjoining bushland. Direct mortality of individuals during the removal of native vegetation will be mitigated by implementing preclearance surveys and a two-stage hollow-bearing tree clearance process for all seven hollows. Therefore, despite hollow removal, the proposed action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
There are a number of feral animals that are known or likely to be well established in the project area. Some of these are known to negatively impact the Greater Glider including cats, dogs and foxes. The proposed action is unlikely to further exacerbate the current level of invasive fauna species threat operating within the project area.
Introduce disease that may cause the species to decline.
The project is not likely to result in the introduction of a disease that is harmful to the Greater Glider. A range of controls will also be employed (RTA 2011a) to mitigate generally against disease.
Interfere with the recovery of the species.
Actions considered likely to interfere with the recovery of Greater Glider are defined in DCCEEW Conservation Advice for Petauroides volans (greater glider (southern and central)) (2022d) and include the following: • habitat loss, disturbance and modification (including fire) • remove vegetation with provides a refuge for climate change • introduction of invasive species. The removal of 7.33 hectares of potential habitat is unlikely to interfere with the recovery objective, given the context of surrounding remnant vegetation in the Blue Mountains National Park which provides excellent connectivity throughout the landscape. The construction and operational works are not expected to lead to further fragmentation of a population as impacts are expected to occur along a linear alignment associated with the already impacted edge of the Great Western Highway. Vegetation to be removed is largely exposed along the edge of either the Great Western Highway or in areas of urban development and as such provides little refuge during extreme heat events or in drought. Although the highway would provide some refuge in fire events, as vegetation along the road is more easily defended. The project will not result in increased attacks by invasive species, which are primarily an issue where new urban development encroaches upon Greater Glider habitat. The project is therefore unlikely to interfere with the recovery of the Greater Glider.

Significant impact criteria (critically endangered / endangered species)
Conclusion Based on the factors above, it is concluded that the proposed works are not likely to lead to a significant impact on the Greater Glider, due to the following: • he relatively small area of habitat proposed for removal for the project as well as the very large amount of commensurate habitat available in areas directly adjacent to the project. Therefore it is unlikely that the project will reduce the area of occupancy of this species • as vegetation removal is expected to occur along already impacted edges and as connectivity will remain intact to remnant vegetation, the works are not expected to further fragment an existing population into two or more populations • given the availability of additional nesting resources in the broader landscape in higher quality vegetation, further from the urban impacts, it is assumed that the works will not disrupt the breeding cycle of an existing population • mitigation measures include preclearance surveys and a two stage hollow bearing tree removal clearance process • despite removal of seven hollow-bearing trees, given the Greater Gliders ability to use multiple hollows for breeding, the proposed action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • the works will not result in the introduction of new invasive pest of diseases and should not further exacerbate current threats provided by cats, dogs or foxes • the project is not likely to result in the introduction of a disease that is harmful to the Greater Glider • the project is therefore unlikely to interfere with the recovery of the Greater Glider. As such, it is considered unlikely that the proposed action will significantly impact the Greater Glider. However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Large-eared Pied Bat *Chalinolobus dwyeri*

The Large-eared Pied Bat is a small to medium-sized bat with long, prominent ears and glossy black fur. The distribution of the species is poorly known however, records occur from Rockhampton in Queensland through to Ulladulla in southern NSW. It is generally rare with a very patchy distribution in NSW. The species is known to form small colonies (DERM 2011) and it has been suggested that Large-eared Pied Bat does not occur continuously within its range, likely due to the lack of available roosts that may have resulted in colonies or populations becoming isolated from each other.

The species is found mainly in areas with extensive cliffs and caves. Sandstone cliffs and fertile wooded valley habitat, particularly box gum woodlands or river/rainforest corridors which are used for foraging, within close proximity of each other is thought to be critical habitat for the species (TSSC 2012). The species roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin *Petrochelidon ariel*, frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves and overhangs. They remain loyal to the same cave over many years. The species is also found in well-timbered areas containing gullies (DERM 2011).

Occurrence in the development footprint

Large-eared Pied Bat is readily identifiable from acoustic recordings due to the frequency it typically calls at and the unique pattern of call alternation it produces. Large-eared Pied Bat was detected within the subject area via ultrasonic call analysis conducted as part of targeted surveys. Previous records of Large-eared Pied Bat exist in the surrounding locality (7 records within 10 kilometres of the study area), with the most recent collected in 2021. The closest record was approximately 0.07 kilometres from the study area.

No rocky areas occur within the study area however, the subject land occurs within 2 kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, which represent potential roosting and breeding habitat for cave-dependant microbat species such as the Large-eared Pied Bat. The study area therefore represents potential foraging habitat for Large-eared Pied Bat.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-4.

Table App I-0-4: SIC assessment of Large-eared Pied Bat *Chalinolobus dwyeri*

Significant impact criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of a species.
Information about the size, distribution and interactions of Large-eared Pied Bat populations is largely unknown. The species was only formerly described in 1966 and targeted surveys utilising appropriate techniques to record this species have only taken place since the 1990s. The *National Recovery Plan for the Large-eared Pied Bat* states that it has not yet been determined whether any specific populations of the Large-eared Pied Bat are at a higher level of threat than others, and that a better understanding of distribution, population size, roost preferences and threats is required before such populations can be identified (DERM 2011). The fact that the preferred habitat for the species, comprised of suitable foraging and roosting habitat in close proximity to each other, occurs so rarely in the landscape suggests the species may have always been uncommon (DERM 2011). No populations have been defined as ‘important populations’ for the Large-eared Pied Bat. The primary threat facing the species is disturbance and damage to primary nursery sites (maternity caves). Unlike other cave-roosting bat species, Large-eared Pied bats form multiple, small maternity colonies in suitable cave environments, rather than congregating in single large nursery caves. The species requires cave environments of a specific structure (arch caves with dome roofs and indentations for holding) in order to breed successfully, making these habitats critical to the survival of the species. These physical characteristics are very uncommon and their scarcity presumably poses a limiting factor on the distribution of the species (DERM 2011, Pennay 2008). Extensive surveying has been undertaken to determine maternity roost sites for the Large-eared Pied Bat however, only four sites have been recorded across the species’ range, two of which are no longer in use (DERM 2011, DCCEEW 2022e, TSSC 2012). The cryptic and often inaccessible nature of the species’ preferred roosting habitat makes it difficult to determine the number and location of roost sites in order to more accurately assess the size of the population. No maternity roost sites occur within the study area or immediate surrounds. Impacts to breeding habitat are most likely to result in population declines for this species. No breeding habitat has been identified within the study area and works associated with the project are not expected to impact on any breeding habitat for the Large-eared Pied Bat. The project would result in the removal of 9.13 hectares of potential foraging habitat (PCTs 708 and 1248) for this species. However, given the availability of high-quality foraging habitat within the broader locality, including within the Blue Mountains National Park, this is not expected to significantly reduce foraging resources available within the broader locality, including the Blue Mountain National Park. As such it is unlikely that the proposed works would significantly lead to a long-term decrease in the local population.
Reduce the area of occupancy of the species.

Significant impact criteria (vulnerable species)
The area of occupancy for Large-eared Pied Bat is approximately 9,120 km^2. This is calculated form the extent of occurrence and the detection rate of echolocation calls of 1.6 % at 3,154 sites across the broader range of Large-eared Pied Bat (DCCEEW 2022e). The project would remove 9.13 hectares of potential foraging habitat which would represent a reduction of less than 0.001% of the area of occupancy for the species.
Fragment an existing important population into two or more populations.
As above, no populations have been defined as 'important populations' for the Large-eared Pied Bat. Microbats are highly mobile, and capable of moving through fragmented landscapes. It has been suggested that Large-eared Pied Bat does not occur continuously within its range and that colonies or populations already occur in isolation from each other (DERM 2011). Individual colonies have been shown to forage in close proximity (<3km) from roosts, and it is unclear over what distance individuals are capable of dispersing. The project would not result in any impacts to roosting habitat and the removal of 9.13 hectares of potential foraging habitat is unlikely to impact on the connectivity of available habitat for this species such that the local population would become fragmented.
Adversely affect habitat critical to the survival of the species.
No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat. The *National Recovery Plan for the Large-eared Pied Bat* defines habitat critical to its survival as maternity roosts and sandstone cliffs in close proximity to fertile wooded valley habitat (DERM 2011). There are no identified sandstone cliffs within the study area, although such habitats do occur within 2 kilometres of the study area. Preferred foraging habitat is thought to be within 700 metres of roost sites (Williams & Thomson 2018). The 9.13 hectares of potential foraging habitat is therefore unlikely to represent habitat critical to the survival of the species. Removal of this vegetation is therefore unlikely to adversely affect any habitat critical to the survival of the Large-eared Pied Bat.
Disrupt the breeding cycle of an important population.
As above, no populations have been defined as 'important populations' for the Large-eared Pied Bat. There is little information available on the breeding biology of the Large-eared Pied Bat. Nursery colonies are thought to be established in September, with females giving birth in early December and juveniles becoming independent in February / March. The number of known breeding sites is limited, and the structure of maternity roosts is highly specific. Up to 100 individuals may be present in a roost at any one time, representing a substantial portion of a local population (DERM 2011). Destruction of roost sites is therefore likely to be the primary mechanism for disruption of the breeding cycle for this species. The study area does not contain suitable roosting habitat for the species as there are no sandstone caves, cliffs or overhangs. No maternity colonies are therefore likely to be present in the study area. The project would not result in any impacts to roosting habitat and is therefore considered unlikely to disrupt the breeding cycle of the Large-eared Pied Bat.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Significant impact criteria (vulnerable species)
The proposed works will likely result in the loss of 9.13 hectares of potential foraging habitat within the study area. Large-eared Pied Bats were recorded via ultrasonic detection within the study area as part of the current assessment. It is not possible however to determine from acoustic data whether these recordings represented foraging bats or bats commuting through the area to preferred foraging habitats. Large-eared Pied Bat is thought to forage along forest edges containing diverse vegetation types and nearby water bodies, within 700 meters of roost sites (Williams & Thomson 2018). The proposed works are occurring within previously disturbed habitat as a result of existing land uses. Habitat within the study area is considered unlikely to represent preferred foraging habitat due to the absence of known nearby roosting sites and its disturbed nature. The extensive tracts of undisturbed native vegetation associated with the Blue Mountains National Park is considered more suitable habitat for the Large-eared Pied Bat. Removal of 9.13 hectares of vegetation is unlikely to decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
All habitat within the study area is likely to be subject to low levels of invasive species as a result of surrounding land uses (residential and farming). The proposed action will not 'open up' habitat that was previously inaccessible to invasive species and as such is unlikely to exacerbate the current level of invasive species threat operating within the study area to the point that they become harmful to the Large-eared Pied Bat.
Introduce disease that may cause the species to decline.
The IUCN Species Survival Commission released a statement on 19 June 2020 stating that there is a credible risk of human-to-bat transmission of SARS-Cov-2, a virus currently circulating the globe and causing a pandemic of the illness Covid-19 (IUCN SSC 2020). However, introduction of this disease to Large-eared Pied Bats within the study area as a result of the proposed works is unlikely for the following reasons: • There will be no contact or sharing of closed areas between humans and bats is expected as a result of the proposed works. • When preclearance inspections are undertaken by a suitably qualified ecologist within potential roosting habitat for the Large-eared Pied Bat, the recommendations provided by the IUCN will be followed, including the wearing of a face mask by the ecologist, and avoidance of handling of any microbats. The transmission of SARS-Cov-2 is considered unlikely as a result of the proposed works. An emerging threat to Australian bats, particularly cave-roosting species, is the fungal disease white-nose syndrome. To date there have been no cases of white-nose syndrome recorded in Australia however, a recent risk assessment considers it 'likely' that the pathogen causing the disease (*Pseudogymnoascus destructans*) will come into contact with Australian bats in the coming decade (Holz et al. 2019). Cave-roosting bats are particularly at risk, leaving them more susceptible to developing white-nose syndrome in the event it enters Australia (Turbill & Welbergen 2020). Should the disease become established in Australia, it is probable that Large-eared Pied Bat populations would incur some impacts although more research is required to determine the extent and severity (Turbill & Welbergen 2020). It is therefore unlikely that the project would contribute to any increased risk in the introduction of white-nose syndrome.
Interfere substantially with the recovery of a species.
The following recovery objectives have been specified within the National recovery plan for the Large-eared Pied Bat:

Significant impact criteria (vulnerable species)
• *Identify priority roost and maternity sites for protection.* • *Implement conservation and management strategies for priority sites.* • *Educate the community and industry to understand and participate in the conservation of the Large-eared Pied Bat.* • *Research the Large-eared Pied Bat to augment biological and ecological data to enable conservation management.* • *Determine the meta-population dynamics throughout the distribution of the Large-eared Pied Bat.* No roosting habitat occurs within the study area. Removal of 9.13hectares of potential foraging habitat for the Large-eared Pied Bat within the study area is unlikely to interfere substantially with the recovery of the species.
Conclusion Based on the assessment provided above, it is concluded the Large-eared Pied Bat is unlikely to be significantly impacted by the project. This conclusion was made on the basis that: • the project will not lead to a long-term decrease in the size of the population of Large-eared Pied Bat • the project will not reduce the area of occupancy of the species or further fragment an existing population or habitat • the project will not adversely affect habitat critical to the survival of the species (i.e. breeding or roosting habitat) or disrupt the breeding cycle of a population • given the surrounding suitable habitat, the project will not modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • the project will not result in invasive species or disease becoming established and should not further exacerbate current invasive species threats • there are no foreseen barriers to the recovery of the species as a result of the project. As such, it is considered unlikely that the proposed action will significantly impact the Large-eared Pied Bat. However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Spotted-tailed Quoll *Dasyurus maculatus*

The Spotted-tailed Quoll is about the size of a domestic cat, with rich-rust to dark-brown fur above, with irregular white spots on the back and tail, and a pale belly. The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found in eastern NSW, eastern Victoria, south-east and north-eastern Queensland, and Tasmania. Only in Tasmania is it still considered relatively common. It has been recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline (DAWE 2020).

The species uses a combination of large hollow, fallen logs, other animal burrows, small caves and rock outcrops as den sites. Females occupy home ranges of 200-500 hectares, while males occupy very large home ranges from 500 to over 4000 hectares. Are known to traverse their home ranges along densely vegetated creek lines (DAWE 2020).

Occurrence in the development footprint

Previous records of Spotted-tailed Quolls exist within the study area and the surrounding locality (171 records within 10 kilometres of the study area, with the most recent collected in 2021).

Native vegetation conforming to PCTs 708, 1248 and 1615 (9.31 hectares) was present within the development footprint and represents potential foraging habitat for this species. As this species is an ecosystem credit species, no targeted surveys were undertaken, and presence was assumed based on associated PCTs.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-5.

Table App I-0-5: SIC assessment of Spotted-tailed Quoll *Dasyurus maculatus*

Significant impact criteria (critically endangered / endangered species)
Lead to a long-term decrease in the size of a population.
Given the linear nature of the study area and the distance between subject sites (approximately 11 km) it is likely that the study area occurs across several distinct populations. It is likely that the continuous vegetation within the broader locality may provide a link to other populations allowing for the maintenance of genetic diversity within local populations. The project will result in the removal of 9.31 hectares of potential habitat (1.79hectares of PCT 708, 7.33hectares of PCT 1248 and 0.19hectares of PCT 1615) for the species. This habitat is currently subject to edge impacts associated with the current Great Western Highway as well as nearby residential development land use. This vegetation is directly connected to large patches of remnant native vegetation, including sections of the Blue Mountains National Park. Given the scale of the impact in the context of available habitat in the region (>200,000 hectares of remnant vegetation), it is unlikely that the proposed development will lead to a long-term decrease in the size of the local population. To further minimise the risk of impact to this population, a pre-clearance assessment will be undertaken prior to the removal of native vegetation. Therefore, it is unlikely that the proposed works would lead to the long-term decline of an existing population.
Reduce the area of occupancy of the species.
The Spotted-tailed Quoll is widely but patchily distributed in eastern Australia, occurring from north-eastern Queensland to Tasmania and across the Great Dividing Range. As the study area occurs within the middle of this species range and includes impacts to a small area of edge-effected habitat, the proposed works are not expected to reduce the area of occupancy for this species. While a small number of individuals may be affected as a result of the proposed works, the Spotted-tailed Quoll is known to be solitary, occurring at low density and are known to have a very large home ranges (females: 200-500hectares and males: 500 – 4000 ha) (DELWP 2016). As such given the minor nature of vegetation clearance (9.13 hectares) the project is unlikely to impact on a more than four to five individuals and is therefore unlikely reduce the area of occupancy for the species.
Fragment an existing population into two or more populations.
In the scope of the greater context of the surrounding land, the 9.31 hectares of potential habitat to be removed represents a relatively small portion of habitat available to a local population of Spotted-tailed Quoll. The study area primarily occurs along the linear corridor of the Great Western Highway, of which the highway may represent a barrier to movement for this species as well as a significant threat due to the risk of vehicle strike. Given their location along the existing Great Western Highway, on the edges of vegetation patches, impacts associated with the clearance of native vegetation within the three development footprints are unlikely to result in any further fragmentation of any existing populations. The project may even reduce road related mortalities on the Great Western Highway between Blackheath and Little Hartley once the tunnel is operational and vehicle traffic is moved underground.

Significant impact criteria (critically endangered / endangered species)
Adversely affect habitat critical to the survival of a species.
No habitat critical to the survival of the Spotted-tailed Quoll has currently been formally defined. Given the threatened status of the Spotted-tailed Quoll, all habitats within its current distribution that are known to be occupied are considered important. These areas include; patches of forest with adequate denning resources and areas of relatively high density of mammalian prey (DELWP 2016). The Spotted-tailed Quoll has been recorded 171times within 10 kilometres of the study area (DPE 2022g). As the species is an ecosystem credit species, no targeted surveys were required to be undertaken for the project and the presence of the species within the study area has been assumed. The extent of the vegetation within the study area, the availability of dens sites and the high number of records, indicate that while the habitat within the development footprint is small, it and the adjoining vast expanse of connected remnant native vegetation, may be considered important habitat for the species. The removal of 9.31 hectares of potential habitat (1.79hectares of PCT 708, 7.33hectares of PCT 1248 and 0.19 hectares of PCT 1615) across the three development footprints is unlikely to adversely affect the quality of this habitat overall, nor will it limit its availability within the broader landscape. Therefore, while some small portion of habitat will be impacted, overall it is unlikely to significant reduce or adversely affect habitat critical to the survival of the Spotted-tailed Quoll.
Disrupt the breeding cycle of a population.
While the project may result in the removal of vegetation occupied by the species, including individuals that may breeding, given the large home ranges occupied by the species the project is only likely to result in impacts to four or five individuals. Furthermore, given the edge-effected nature of this habitat, occurring along the edge of the Great Western Highway, it is highly likely that more intact native vegetation already occurs within the home ranges of impacted individuals. The project is therefore unlikely to result in disruption to the breeding cycle of any local populations. The project may also result in an increase in the number of individuals of reproductive age due to the decreased risk of vehicle strike once the tunnel becomes operational and traffic along the existing Great Western Highway between Blackheath and Little Hartley decreases.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Vegetation within the development footprint is largely subject to edge effects associated with the Great Western Highway, recreational land (Browntown Oval), urban development and farmland. The removal of 9.31 hectares of potential habitat across the three development footprints, is not expected to further isolate or fragment any local population of Spotted-tailed Quoll, as impacts are not expected to increase beyond the level of fragmentation already occurring within the projects' vicinity. While some potential den locations may be removed as a result of the proposed works, given the extent of vegetation within the broader locality it is unlikely that the proposed works would significantly reduce the availability of these habitat resources. In order to further minimise impacts to the Spotted-tailed Quoll during the removal of hollow-bearing trees, a preclearance survey and a two stage hollow-bearing tree clearance process will be implemented prior to the commencement of works. The project is therefore considered unlikely to result in the modification, destruction, removal, isolation or decrease in the availability or quality of habitat within the locality, such that species would decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.

Significant impact criteria (critically endangered / endangered species)
There are a large number of feral animals and plants that are known or likely to be well established in the project area. Some of these are known to negatively impact the Spotted-tailed Quoll including; cats, dogs and foxes. However, it is unlikely that the project would result in the establishment of new species. The proposed action is unlikely to exacerbate the current level of invasive species threat operating within the study area.
Introduce disease that may cause the species to decline.
The works are not expected to result in the introduction or spread of any diseases.
Interfere with the recovery of the species.
The following recovery objectives have been specified within the National recovery plan for the Spotted-tailed Quoll (DELWP 2016): • *Reduce the rate of habitat loss and fragmentation on private land.* • *Determine and manage the threat posed by introduced predators (foxes, cats, wild dogs).* • *Reduce the frequency of Spotted-tailed Quoll road mortality.* The removal of 9.31hectares of potential habitat is unlikely to interfere with these recovery objectives, given the context of surrounding remnant vegetation in the Blue Mountains National Park and the extensive home ranges of the species. The works are not expected to further fragment a population as impacts are expected to occur along a linear alignment off the already impacted edge of the Great Western Highway. The works are unlikely to increase the rate of predation of Spotted-tailed Quolls as the works are not expected to introduce new predators to the study area. Like other large carnivorous marsupials, Spotted-tailed Quolls are susceptible to road mortality because they scavenge the carcasses of other road-killed fauna (DELWP 2016). The risk of road mortality for the Spotted-tailed Quolls is expected to increase during the temporary construction phase of the highway upgrade if left unmitigated, as traffic increases to support the works. Mitigation measures including construction driver awareness training, signage, project speed limits and fauna exclusion fencing around construction facilities will help reduce this risk. This risk will also fall significantly upon completion and operation of the tunnels which will divert traffic away from the surface between Blackheath and Little Hartley. As such, it is unlikely that the works would significantly interfere with the recovery objectives of the National recovery Plan.
Conclusion Based on the factors above, it is concluded that the proposed works are unlikely to lead to a significant impact on the Spotted-tailed Quoll, as: • given the minor nature of low condition vegetation clearance (9.31 hectares), the project will not significantly reduce the availability of foraging resources in the broader locality as the study area occurs adjacent to large areas of remnant vegetation including the Blue Mountains National Park • it is unlikely to significantly reduce or adversely affect habitat critical to the survival of the Spotted-tailed Quoll • no disruption to the breeding cycle of the existing population is expected to occur. • the works will not result in the introduction of new invasive pest of diseases and should not further exacerbate current invasive species threats • the works are not expected to result in the introduction or spread of any diseases • it is unlikely that the works would significantly interfere with the recovery objectives of the National recovery Plan. As such, it is considered unlikely that the proposed action will significantly impact the Spotted-tailed Quoll.

Significant impact criteria (critically endangered / endangered species)
However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Purple Copper Butterfly *Paralucia spinifera*

A small butterfly with a wingspan of approximately 20 millimetres. The upper sides of the butterfly's wings are copper-coloured and display a purple, blue, and green iridescence when sunning. Until very recently purple copper butterfly was only known to occur on the Central Tablelands of NSW however in August 2021 the species was discovered flying within Namadgi National Park, ACT. This species has highly specific habitat requirements and only occurs where *Bursaria spinosa* subsp. *lasiophylla* and an attendant is present (NPWS 2001).

The species requires open woodland or open forest with a sparse understorey that is dominated by the shrub, Native Blackthorn *Bursaria spinosa* subsp. *Lasiophylla* occurring at altitudes of above 900 metres. Its lifecycle relies on a mutualistic relationship with the ant, *Anonychomyrma itinerans*, and on the presence of *B. spinosa* subsp. *lasiophylla* which the larvae of the species feed exclusively on. Larvae of the Butterfly are tended by the ants and protected from predators. The butterflies can emerge late August (later at higher altitude sites) through to early November, peak activity varies between sites and may also vary between seasons.

Occurrence in the development footprint

Potential habitat for this species is represented within the subject land where Native Blackthorn is present. The occurrence of Native Blackthorn was mapped within the entire study area. As such a species polygon with a 50 metre buffer was established around such mapped areas and species presence has been assumed to be present within this area. Six known records have been recorded within the broader locality, with the nearest record nearly 8 kilometres away. As surveys could not be undertaken during the required timeframe presence has been assumed within the species polygon area.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-6.

Table App I-0-6: SIC assessment of Purple Copper Butterfly *Paralucia spinifera*

Significant impact criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of a species.
No important populations have been described for the Purple Copper Butterfly, however giving its restricted range, all populations would likely be considered important. Vegetation to be removed from the study area will include the removal of one small population of *Bursaria spinosa* within associated PCT 1248. As the Purple Copper Butterfly has been assumed present within this area, a total of 0.35 hectares of habitat for Purple Copper Butterfly is expected to be removed. Overall habitat would be considered to be in poor condition, due to the presence of the Great western Highway to the west, and fire trails to the south and the east. Given the proximity of the habitat to these roadways it is likely that this area represents poor quality habitat for the species, as dust from the roadway likely limits habitat use (NPWS 2001). Given the small size of low-quality habitat to be removed it is unlikely that the works would lead to a long-term decrease in the size of an important population of Purple Copper Butterfly.

Significant impact criteria (vulnerable species)
Reduce the area of occupancy of the species.
The proposed works will require the removal of one small and relatively poor condition 0.35 hectares patch of habitat for the Purple Copper Butterfly. The dispersal ability of the Bathurst Copper Butterfly is limited due to its size and the proximity of potential habitat (NPWS 2001). Given that the small patch of habitat is located directly adject to the Great Western Highway it is unlikely that the habitat to be removed provides a key movement pathway to adjoining habitat. In addition, habitat to be removed in Blackheath would be considered to occur outside of the expected distribution of this species (Capertee, Black Springs, Hartley and Bathurst) (Threatened Species Scientific Committee 2016b). As such, given the extent of remnant vegetation throughout the Blue Mountains; including throughout the Blue Mountains National Park, it would be reasonable to assume that if an unidentified population of Purple Copper Butterfly were using this small patch of low-quality habitat that they would also be present in the broader landscape. As such, the works re unlikely to reduce the area of occupancy for this species.
Fragment an existing important population into two or more populations.
As habitat to be removed is likely heavily affected by dust pollution from nearby roadways, is isolated from other potential habitat and occurs outside of the known area of occupancy. It is highly unlikely that the removal of 0.35 hectares of habitat would resulting in the fragmentation of two or more important populations.
Adversely affect habitat critical to the survival of the species.
Critical habitat has not been declared for this species. However, given the known Symbiotic relationship between the Purple Copper Butterfly, its host plant Native Blackthorn and a species of attending ant *Anonychomyrma itinerans.* All habitat containing a combination of PCTs associated with the Purple Copper Butterfly and patches of *Bursaria spinosa,* would be considered to constitute habitat crucial to the survival of the species. While habitat identified within the study area does contain habitat which aligns with this definition, as the habitat occurs outside of the species known distribution, is very small in size and is likely affected by dust pollution from the road, it is not considered ideal habitat (NPWS 2001). The habitat available would be considered to be in poor condition and is therefore not critical to the survival of the species.
Disrupt the breeding cycle of an important population.
Population dynamic of the Purple Copper Butterfly is largely unknown population as it is unclear if the population is stable and fluctuating within normal ranges due or weather this species is in a state of decline (NPWS 2001). Breeding success is heavily reliant on the availability of new foliage on its host plant Native Blackthorn)(Threatened Species Scientific Committee 2016b). While breeding population have been known to utilise sites with less than 10 individuals of Native Blackthorn) (Threatened Species Scientific Committee 2016b), given that the habitat to be removed occurs outside of the species known distribution, occurs in a very small patch of Native Blackthorn (0.35 hectares) and is likely affected by dust pollution it is unlikely that the removal of this habitat would disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
The works are expected to remove 0.35 hectares of habitat for the Purple Copper Butterfly. As habitat to be removed, occurs outside the known disruption for this species, has a high level of connectivity to surrounding

Significant impact criteria (vulnerable species)
remanent vegetation, is of very small size and is likely impacted by dust pollution off the Great Western Highway. The works are unlikely to result in impact to this species such that it would be at risk of decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
The proposed works are unlikely to result in an increase of any invasive species likely to threaten the Purple Copper Butterfly Construction activities will be managed through standard practices to prevent increase in invasive species and spread of any invasive species in accordance with RTA (2011a)
Introduce disease that may cause the species to decline.
The project is unlikely to introduce a disease that is harmful to these species.
Interfere substantially with the recovery of a species.
The following recovery objectives have been specified within the National recovery plan for the Purple Copper Butterfly (NPWS 2001): • *Prevent habitat removal, weed incursions, alteration of fire regimes, and vehicular access to habitat, that threaten the Purple Copper Butterfly.* • *Inform and educate the community of the significance of the species.* The removal of 0.33 hectares habitat for this species is unlikely to interfere with the recovery objective, as habitat to be removed is of low-quality; occurring next to the Great Western Highway, contains a very small number of Native Blackthorn plants and occurs outside of the normal range for the species. Given the context of the surrounding remnant vegetation in the Blue Mountains National Park, it is likely that if an unknown population of the Purple Copper Butterfly is residing in the area that this population would be utilising suitable habitat throughout the >200,000hectares of vegetation which makes up the Blue Mountains National Park. As such, it is unlikely that the works would significantly interfere with the recovery objectives of the National recovery Plan.
Conclusion Based on the factors above, it is concluded that the proposed works are unlikely to lead to a significant impact on the Purple Copper Butterfly as: • the works will result in the removal of 0.35 hectares of low-quality edge effected habitat • the works will not significantly reduce the availability of foraging resources in the broader locality as the study area occurs adjacent to large areas of remnant vegetation including the Blue Mountains National Park • habitat to be removed occurs outside the species known distribution • the works are not expected to result in any further fragmentation • the works will not result in the introduction of new invasive pest of diseases. As such, it is considered unlikely that the proposed action will significantly impact the Purple Copper Butterfly. However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Broad-headed Snake *Hoplocephalus bungaroides*

The Broad-headed Snake occurs in NSW from Wollemi National Park in the north to the Clyde River catchment (south-west of Nowra) in the south, east to Royal National Park and the Illawarra, and west to the upper Blue Mountains at Blackheath and Newnes (DoE 2014).

The Broad-headed Snake typically occurs on exposed rocky sites on sandstone outcrops and benching. It is found on Triassic and Permian sandstones of the Hawkesbury, Narrabeen and Shoalhaven groups. During autumn, winter and spring, the species shelters in rock crevices and under flat sandstone rocks on exposed cliff edges. In summer, it shelters in hollows of large trees within 200 m of escarpments. The Broad-headed Snake is known to feeds mostly on geckos and small skinks; will also eat frogs and small mammals occasionally.

Occurrence in the development footprint

The Broad-headed Snake is known to occur within the development footprint, with a total 11 records within 10 kilometres of the study area (DPE 2022g). Vegetation associated with this species including; 1.79hectares of PCT 708 and 7.33hectares of PCT 1248, total 9.12 hectares) was recorded within the development footprint, which may represent some potential dispersal habitat for the species. No breeding habitat was observed within the development footprint, as escarpments, outcrops and pagodas within the Sydney Sandstone geologies where absent from this area.

Significant impact assessment

An assessment against the criteria detailed in the *Matters of National Environmental Significance: Significant impact guidelines version 1.1* (Commonwealth of Australia 2013) has been undertaken and provided in Table App I-0-7.

Table App I-0-7: SIC assessment of Broad-headed Snake *Hoplocephalus bungaroides*

Significant impact criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of a species.
No important populations have been described for the Broad-headed Snake. As this species distribution is limited to within 250 kilometres of Sydney and as the Blue Mountains constitutes the west most range of this species, the local population would likely be important as it occurs at the edge of this species range. While the local population may be considered significant the removal of 9.12hectares of native vegetation (PCTs 708 and 1248) across the three subject sites, which represents dispersal habitat only, it is unlikely to result in the long-term decrease in size of the local population.
Reduce the area of occupancy of the species.
The removal of 9.12 hectares of potential dispersal habitat only is unlikely to reduce the area of occupancy for the Broad-headed Snake. Impacts associated with the proposed works are not expected to limit the overall range of the species. On a local scale vegetation to be removed (9,12 hectares) occurs along a linear alignment which is already subject to degradation from edge effects associated with the current Great Western Highway. Given the availability of habitat within the broader locality; including within the Blue Mountains National Park, it is unlikely that the removal of this vegetation would reduce the area of occupancy for the Broad-headed Snake within the Blue Mountains region.
Fragment an existing important population into two or more populations.
The development footprint largely follows the path of the existing Great Western Highway. As this highway already represents a barrier to movement for the Broad-headed Snake, it is therefore unlikely that the widening of this roadway would increase fragmentation. Vegetation surrounding the study area provides high levels of connectivity to both the Blue Mountains National Park and other remnant vegetation.

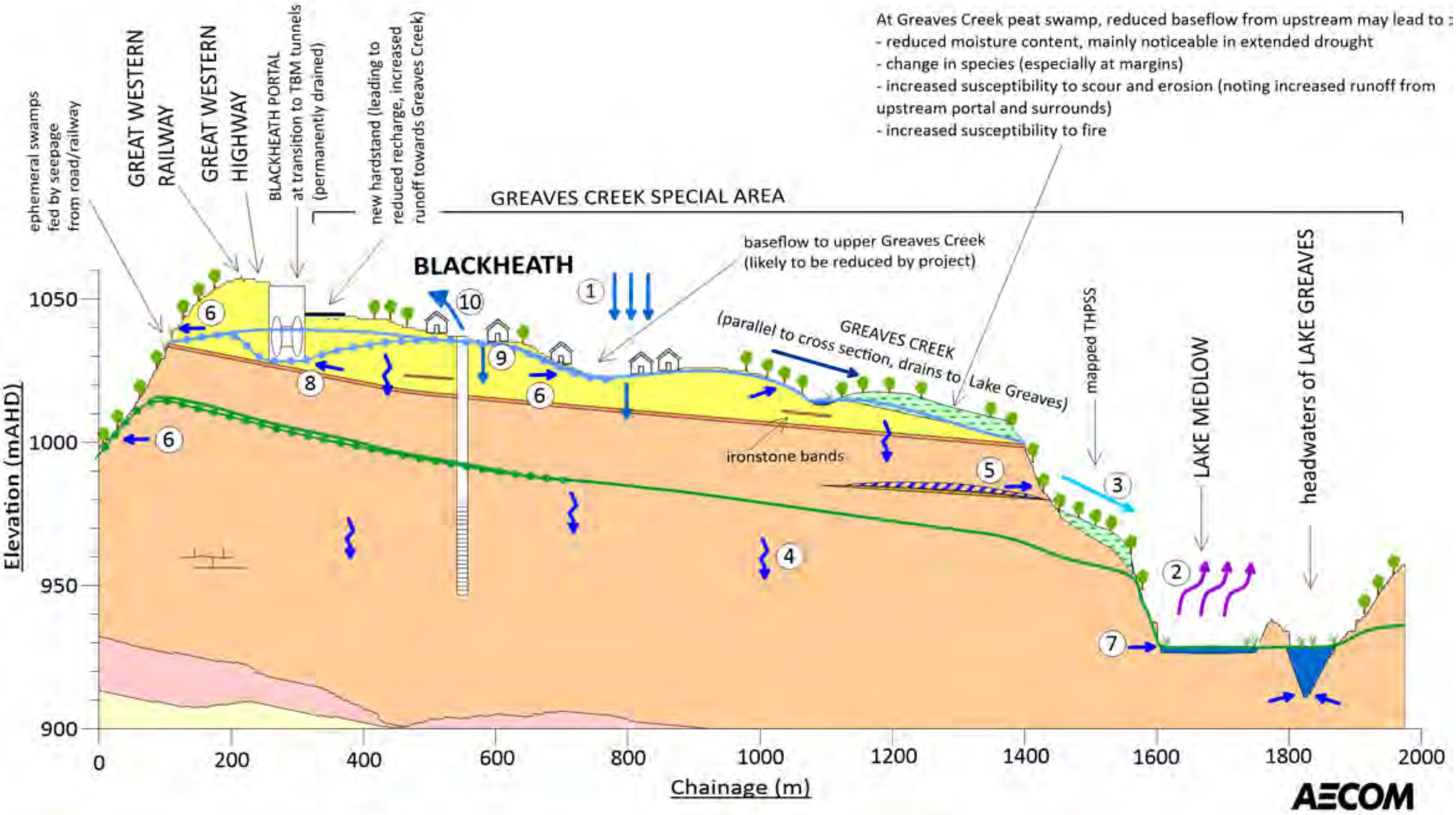
Significant impact criteria (vulnerable species)
Given that the Great Western Highway in itself exists as a barrier to the and given that connectivity will be maintained to remnant vegetation, it is unlikely that the proposed works would result in the fragmentation of an important population.
Adversely affect habitat critical to the survival of the species.
No habitat critical to the survival of the Broad-headed Snake has currently been defined. Given the threatened status of the Broad-headed Snake, all habitats within its current distribution that are known to be occupied are considered important and would include; foraging habitat, rock crevices, tree hollows, exposed cliff edges and exposed rocky sandstone outcrops and benching. As no rocky outcropping was observed within the development footprint, impacts to this species would be limited to dispersal habitat only. The works will require the removal of 9.12 hectares of potential dispersal and foraging habitat. However, given the context of the >200,000hectares of retained vegetation within the Blue Mountains National Park area, the removal of a relatively small amount of vegetation across three subject sites is unlikely significant impact or reduce the availability of habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population.
The proposed works are expected to impact on 9.12 hectares of dispersal habitat only. As the development footprint does not include breeding habitat such as escarpments or rocky outcrops, impact to the breeding cycle of an important population is considered unlikely.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
The works are not expected to impact on any habitat utilise for breeding, impacts to this species as a result of the proposed works will be limited to the removal of 9.12 hectares of dispersal habitat only, which may contain some suitable hollows. The removal of this vegetation and habitat resources are unlikely to significantly reduce the availability of foraging or sheltering (hollows) resources within the broader landscape given the extent of remnant vegetation within the broader locality. In addition to the high level of connectivity to the study area, vegetation to be removed largely occurs within the impacted road corridor of the Great Western Highway. As such vegetation within the development footprint would generally be considered to provide poor quality habitat in comparison to surrounding adjacent vegetation. The works are also unlikely to result in fragmentation of habitat or lead to the isolation of a local population as impacts will be largely limited to within close proximity to the Great Western Highway, which would represent a barrier to movement already for this species. Therefore, the removal of 9.12 hectares of potential habitat is unlikely to result in a decline of the species on either a local or national scale.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.
The proposed works are unlikely to result in an increase of invasive species within the remaining habitat for these species. Construction activities will be managed through standard practices to prevent increase in invasive species and spread of weeds outside of the proposed works area.

Significant impact criteria (vulnerable species)
Introduce disease that may cause the species to decline.
The project is unlikely to introduce a disease that is harmful to the Broad-headed Snake.
Interfere substantially with the recovery of a species.
There is currently no official recovery plan for the Broad-headed Snake. However, the regional priority actions outlined in the *Approved Conservation Advice for Hoplocephalus bungaroides (broad-headed snake)* include the following objectives (DoE 2014): • *Minimising Habitat Loss, disturbance, and modification.* • *Development of a management plan to prevent trampling by feral goats.* • *Undertake measures to control introduced species (foxes and cats).* • *Implement fire management strategies.* 9.12 hectares of potential dispersal habitat for this species is expected to be removed as a result of the proposed work. The majority of vegetation to be impacted occurs along the edge of the Great Western Highway and is already therefore subjected to impacts associated with edge effects. No increase in the risk of predation by introduced species, increase the frequency of fires or increase the prevalence of feral goats within the study area. As such, it is unlikely to interfere with the recovery objectives.
Conclusion Based on the factors above, it is concluded that the proposed works are unlikely to lead to a significant impact on the Broad-headed Snake, as: • the project is unlikely to result in the long-term decrease in size of the local population • given the availability of habitat within the broader locality, it is unlikely that the removal of this vegetation would reduce the area of occupancy for the Broad-headed Snake within the Blue Mountains region • the Great Western Highway in itself exists as a barrier to the and given that connectivity will be maintained to remnant vegetation, it is unlikely that the proposed works would result in the fragmentation of an important population • the project is unlikely to significantly reduce the availability of habitat critical to the survival of the species • the project does not include breeding habitat such as escarpments or rocky outcrops, impact to the breeding cycle of an important population is considered unlikely • therefore, the removal of 9.12 hectares of potential habitat is unlikely to result in a decline of the species on either a local or national scale • the proposed works are unlikely to result in an increase of invasive species within the remaining habitat for these species • the project is unlikely to introduce a disease that is harmful to the Broad-headed Snake • no increase in the risk of predation by introduced species, increase the frequency of fires or increase the prevalence of feral goats within the study area. As such, it is unlikely to interfere with the recovery objectives. As such, it is considered unlikely that the proposed action will significantly impact the Broad-headed Snake. However, this Significant Impact Criteria assessment will form part of the EPBC Act referral being submitted for the project.

Annexure K – Blackheath portal groundwater drawdown schematic

Northwest-Southeast through Blackheath Portal, looking north

Illustrating pre-existing groundwater levels and predicted drawdown during operation



	UPPER BANKS WALL SANDSTONE (aquifer)
	WENTWORTH FALLS CLAYSTONE MEMBER
	LOWER BANKS WALL SANDSTONE (aquifer)
	MT YORK CLAYSTONE
	UPPER BURRA MOKO HEAD SANDSTONE (aquifer)
	PERCHED GROUNDWATER
	TEMPERATE HIGHLAND PEAT SWAMP ON SANDSTONE (THPSS)

GROUNDWATER PRESSURE PRE-CONSTRUCTION
- UPPER BANKS WALL SANDSTONE
- LOWER BANKS WALL SANDSTONE

GROUNDWATER PRESSURE DURING OPERATION (NUMERICAL MODEL 50th PERCENTILE PREDICTION)
- UPPER BANKS WALL SANDSTONE
- LOWER BANKS WALL SANDSTONE

HYDROGEOLOGICAL PROCESSES
1. Rainfall infiltration (limited by forest vegetation and steep slopes)
2. Evapotranspiration losses
3. Surface runoff
4. Vertical leakage (minor, likely higher through geological structures)
5. Discharge from perched aquifers via joints and bedding planes
6. Discharge from shallow groundwater system
7. Discharge from deep groundwater system
8. Groundwater inflow to cut-and-cover portal (permanently drained)
9. Irrigation and leakage from pipe networks
10. Groundwater extraction from private pumping bores

Annexure L – Biodiversity credit report

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00028460/BAAS18134/21/00029156	Blackheath to Little Hartley Burragorang sub-region	14/10/2022
Assessor Name	Report Created	BAM Data version *
Jane Raithby-Veall	19/12/2022	55
Assessor Number	BAM Case Status	Date Finalised
BAAS18134	Finalised	19/12/2022
Assessment Revision	Assessment Type	
2	Major Projects	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits

Carex sedgeland of the slopes and tablelands											
1	766_Low	Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions	24.1	24.1	0.43	Biodiversity Conservation Act listing status	High Sensitivity to Gain	Endangered Ecological Community	Not Listed	2.00		5
											Subtotal	**5**
Monkey Gum - Eucalyptus blaxlandii shrubby open forest on basalt of the Sydney Basin											
2	1615_Moderate	Not a TEC	62.2	62.2	0.18	PCT Cleared - 8%	High Sensitivity to Gain			1.50		4
3	1615_Low	Not a TEC	30.7	30.7	0.01	PCT Cleared - 8%	High Sensitivity to Gain			1.50		1
											Subtotal	**5**
											Total	**10**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00028460/BAAS22005/22/00035280	Burragorang indirect impacts	14/10/2022

Assessor Name	Report Created	BAM Data version *
Jane Raithby-Veall	19/12/2022	55

Assessor Number	BAM Case Status	Date Finalised
BAAS18134	Finalised	19/12/2022

Assessment Revision	Assessment Type
0	Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits

Carex sedgeland of the slopes and tablelands												
1	766_Low-indirect-patch	Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions	24.1	24.1	0.03	Biodiversity Conservation Act listing status	High Sensitivity to Gain	Endangered Ecological Community	Not Listed	2.00		1
											Subtotal	**1**
											Total	**1**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00028460/BAAS18134/21/00028461	Blackheath to Little Hartley Wollemi sub-region	14/10/2022
Assessor Name	Report Created	BAM Data version *
Jane Raithby-Veall	19/12/2022	55
Assessor Number	BAM Case Status	Date Finalised
BAAS18134	Finalised	19/12/2022
Assessment Revision	Assessment Type	
3	Major Projects	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion												
1	708_High	Not a TEC	86.8	86.8	1.3	PCT Cleared - 5%	High Sensitivity to Gain			1.50		42

2	708_Moderate	Not a TEC	47	47.0	0.5	PCT Cleared - 5%	High Sensitivity to Gain			1.50		9
											Subtotal	**51**
Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion												
3	1248_High	Not a TEC	77.3	77.3	6.1	PCT Cleared - 20%	High Sensitivity to Gain			1.50		178
4	1248_Moderate	Not a TEC	51.2	51.2	0.86	PCT Cleared - 20%	High Sensitivity to Gain			1.50		17
5	1248_Low	Not a TEC	34.3	34.3	0.33	PCT Cleared - 20%	High Sensitivity to Gain			1.50		4
											Subtotal	**199**
											Total	**250**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)									
708_High	86.8	86.8	1.3			Vulnerable	Vulnerable	True	84
708_Moderate	47.0	47.0	0.5			Vulnerable	Vulnerable	True	18

1248_High	77.3	77.3	6.1			Vulnerable	Vulnerable	True	356
1248_Moderate	51.2	51.2	0.86			Vulnerable	Vulnerable	True	33
1248_Low	34.3	34.3	0.33			Vulnerable	Vulnerable	True	8
								Subtotal	**499**
Paralucia spinifera / Purple Copper Butterfly, Bathurst Copper Butterfly (Fauna)									
1248_High	77.3	77.3	0.23			Endangered	Vulnerable	False	9
1248_Low	34.3	34.3	0.12			Endangered	Vulnerable	False	2
								Subtotal	**11**

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00028460/BAAS22005/22/00035279	Wollemi indirect impacts	14/10/2022
Assessor Name	**Report Created**	**BAM Data version ***
Jane Raithby-Veall	19/12/2022	55
Assessor Number	**BAM Case Status**	**Date Finalised**
BAAS18134	Finalised	19/12/2022
Assessment Revision	**Assessment Type**	
0	Major Projects	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	Sensitivity to loss (Justification)	Species sensitivity to gain class	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Blue Mountains Mallee Ash - Dwarf Casuarina heath of the upper Blue Mountains, Sydney Basin Bioregion												
1	708_High-indirect-edge	Not a TEC	86.8	17.3	0.22	PCT Cleared - 5%	High Sensitivity to Gain			1.50		1

2	708_Mod-indirect-patch	Not a TEC	47	47.0	0.08	PCT Cleared - 5%	High Sensitivity to Gain			1.50		1
											Subtotal	**2**
Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion												
3	1248_High-indirect-edge	Not a TEC	77.3	15.5	2.6	PCT Cleared - 20%	High Sensitivity to Gain			1.50		15
4	1248_Low-indirect-patch	Not a TEC	34.3	34.3	0.01	PCT Cleared - 20%	High Sensitivity to Gain			1.50		1
											Subtotal	**16**
											Total	**18**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	Sensitivity to loss (Justification)	Sensitivity to gain (Justification)	BC Act Listing status	EPBC Act listing status	Potential SAII	Species credits