9 Physical and biological environment impacts

This chapter assesses the project's physical and biological environmental impacts, including on terrestrial biodiversity, surface water, flooding, groundwater, soils and contamination.

9.1 Terrestrial biodiversity

This section describes the existing terrestrial biodiversity (both flora and fauna) near the project, and the project's potential impacts on that biodiversity during construction and operation. It provides an overview of the key findings of the detailed Biodiversity Development Assessment Report (BDAR) (Biosis, 2021) included in Appendix J.

Terrestrial biodiversity impact summary

The project has been designed to avoid and minimise impacts on native vegetation where possible, including the Lansdowne biodiversity stewardship site. The project's impacts occur primarily during construction as a result of removing vegetation and fauna habitat. Operational impacts are expected to be negligible.

During construction, the project will remove up to 13.77 ha of native vegetation. Although most of this vegetation is classified as threatened ecological communities, about 86% is thinned or scattered trees, rather than intact vegetation communities. Seven individual threatened plants will be removed as a result of the project. Most of the impact area represents marginal habitat for threatened fauna species but some habitat for threatened birds, bats and snails will be removed. The project also has the potential for indirect impacts, including creating edge effects. Edge effects occur when the perimeter of a patch of vegetation increases and can change vegetation community composition and environmental conditions for plants and animals. Although the project will create some edge effects, these are not expected to be significant.

Operation of the project is expected to have negligible impacts on terrestrial biodiversity. Treated water releases to Nepean River may result in some minor changes to the area or duration of vegetation inundation along river banks. However, the impact assessment has shown that these changes will be minor relative to natural inundation fluctuations.

As no significant impacts are predicted on threatened plants, animals or ecological communities, protected under NSW or Commonwealth legislation, the impacts are considered acceptable for the scale of the project.

Sydney Water will implement a range of management measures to minimise biodiversity impacts including pre-clearance surveys, delineating no-go zones to protect vegetation and

restoring areas where native vegetation is removed. Sydney Water will also implement a Biodiversity Offset Strategy to offset residual impacts, in accordance with NSW Government guidelines including the Biodiversity Offset Scheme.

9.1.1 Relevant Secretary's Environmental Assessment Requirements

Table 9-1 lists the Secretary's Environmental Assessment Requirements (SEARs) relevant to terrestrial biodiversity and where in this section they are addressed. The project is a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Table 9-2 therefore outlines the additional assessment requirements for terrestrial biodiversity added to the SEARs in January 2021, to address the matters of national environmental significance (MNES) under the EPBC Act.

Chapter 8 addresses SEARs related to aquatic biodiversity.

Table 9-1 Project SEARs relating to terrestrial biodiversity impacts

SEARs	EIS section where requirement addressed
8. An assessment of the biodiversity values and the likely biodiversity impacts of the project in accordance with the NSW Biodiversity Conservation Act 2016, the Biodiversity Assessment Method (BAM) and documented in a Biodiversity Development Assessment Report (BDAR). The BDAR must document the application of the avoid, minimise and offset framework including assessing all direct, indirect and prescribed impacts in accordance with the Biodiversity Assessment Method and including:	Section 9.1 and Appendix J
a) impacts to Commonwealth listed species and ecological communities, where relevant; and	Section 9.1.5 and section 9.1.6
b) impacts of changes to the operational regime of any reservoirs.	The project will not change any reservoir operational regimes.
9. A strategy to offset any residual impacts of the project in the medium to long term.	Section 9.1.10
10. An assessment of the impacts on groundwater dependent ecosystems.	Sections 8.6.2, 8.7.3, 9.1.5 and 9.1.6
11. Assessment of any impacts on the Lansdowne Reserve biobanking site	The project avoids direct impacts on this site. Potential indirect impacts addressed in Section 9.1.5

Table 9-2 Project SEARs relating to EPBC Act requirements for terrestrial biodiversity

EPBC Act SEARs	EIS section where requirement addressed
Impacts 9. The EIS must include an assessment of the relevant impacts of the action on the matters protected by the controlling provisions, including: i. a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short term and long term relevant impacts; ii. a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible; iii. analysis of the significance of the relevant impacts; and iv. any technical data and other information used or needed to make a detailed assessment of the relevant impacts	Biodiversity impacts to MNES addressed in section 9.1 and Appendix J.
Avoidance, mitigation and offsetting 10. For each of the relevant matters protected that are likely to be significantly impacted by the action, the EIS must provide information on proposed avoidance and mitigation measures to manage the relevant impacts of the action including: i. a description, and an assessment of the expected or predicted effectiveness of the mitigation measures, ii. any statutory policy basis for the mitigation measures; iii. the cost of the mitigation measures; iv. an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing; v. the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.	Avoidance to biodiversity MNES addressed in section 9.1.2, mitigation in section 9.1.9, and offsetting in section 9.1.10. The cost of mitigation measures is not known at this stage and is therefore not included. The cost of biodiversity offsets will depend on the market at the time of purchase and has also not been included. Chapter 14 describes the overall environmental management approach for the project.
11. Where a significant residual adverse impact to a relevant protected matter is considered likely, the EIS must provide information on the proposed offset strategy, including discussion of the conservation benefit associated with the proposed offset strategy	Table 9-14 shows significant residual impacts are not expected. However,offsetting of residual impacts is . addressed section 9.1.10.

EPBC Act SEARs	EIS section where requirement addressed
12. For each of the relevant matters likely to be impacted by the action the EIS must provide reference to, and consideration of, relevant Commonwealth guidelines and policy statements including any: i. conservation advice or recovery plan for the species or community, ii. relevant threat abatement plan for a process that threatens the species or community iii. wildlife conservation plan for the species iv. management plan for Ramsar wetland v. management plan for a World Heritage property or National Heritage place; vi. Marine Bioregional Plan; vii. any strategic assessment.	Section 9.1.4 includes the main Commonwealth guidelines referenced and considered. Appendix J addresses all the species or community-specific information considered. For this biodiversity assessment, only items i, ii, and vii are relevant.
14. The EIS must identify each EPBC Act listed threatened species and community and migratory species likely to be impacted by the action. For any species and communities that are likely to be impacted, the proponent must provide a description of the nature, quantum and consequences of the impacts. For species and communities potentially located in the project area or in the vicinity that are not likely to be impacted, provide evidence why they are not likely to be impacted. Based on consideration of available information, the proposed action is likely to have a significant impact on the following matters of national environmental significance: • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest – critically endangered. • Regent Honeyeater (*Anthochaera phrygia*) – critically endangered. • Swift Parrot (*Lathamus discolor*) – critically endangered. • Macquarie perch (*Macquaria australasica*) – endangered.	Section 9.1.5 and section 9.1.6 and Appendix J. Impacts on Macquarie Perch are addressed in Chapter 8.
15. For each of the EPBC Act listed threatened species and communities and migratory species likely to be impacted by the action the EIS must provide a separate:	Appendix J
a) description of the habitat (including identification and mapping of suitable breeding habitat, suitable foraging habitat, important populations and habitat critical for survival), with consideration of, and reference to, any relevant Commonwealth guidelines and policy statements including listing advice, conservation advice and recovery plans.	Appendix J

EPBC Act SEARs	EIS section where requirement addressed
b) details of the scope, timing and methodology for studies or surveys used and how they are consistent with (or justification for divergence from) published Australian Government guidelines and policy statements.	Section 9.1.2 and Appendix J
c) description of the relevant impacts of the action having regard to the full national extent of the species or community's range.	Section 9.1.5 and Appendix J
d) description of the specific proposed avoidance and mitigation measures to deal with relevant impacts of the action.	Section 9.1.9
e) identification of significant residual adverse impacts likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account.	No significant residual impacts are likely to occur as a result of the project as outlined in Table 9-14. Table 9-14.shows significant residual impacts are not expected. However, offsetting of residual impacts is addressed section 9.1.10.
f) a description of any offsets proposed to address residual adverse significant impacts and how these offsets will be established.	Section 9.1.10
g) details of how the current published NSW Biodiversity Assessment Method (BAM) has been applied in accordance with the objects of the EPBC Act to offset significant residual adverse impacts.	Section 9.1.2, section 9.1.10 and Appendix J
h) details of the offset package to compensate for significant residual impacts including details of the credit profiles required to offset the action in accordance with the FBA [sic] and/or mapping and descriptions of the extent and condition of the relevant habitat and/or threatened communities occurring on proposed offset sites.	Section 9.1.10 and Appendix J
16. Any significant residual impacts not addressed by the BAM may need to be addressed in accordance with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy. http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy.	No significant residual impacts are predicted.

9.1.2 Methodology

This section summarises the approach taken to complete the terrestrial biodiversity assessment which included:

- defining the study areas
- conducting desktop assessments
- conducting field surveys

- undertaking species expert assessment
- determining impact avoidance and minimisation solutions, primarily locating infrastructure away from sensitive areas
- impact assessment
- identifying management measures and offset requirements.

Each of these is described in more detail below.

Study areas

In the assessment of biodiversity impacts, disturbance and assessment has been undertaken within the following defined areas:

- Impact area: The area to be directly impacted by construction and operation of the project, including identified compound areas and access tracks. The impact area is generally 12.5 metres either side of the pipeline alignments but is wider or narrower in certain areas. For the AWRC site, this impact area comprises the entire 78 hectare (ha) site.
- Impact assessment area: A wider area, generally 12.5 metres either side of the impact area to allow for design flexibility after the EIS is approved.
- BDAR study area: The broader area in which the impact area and impact assessment area is located, including all areas of direct and indirect impact, the required 500 m buffer on the impact area (in accordance with Biodiversity Assessment Methodology (OEH, 2017)), and larger areas to provide context to the project.

Desktop assessment

A desktop assessment was undertaken to characterise the biodiversity values of the impact assessment area including threatened species, populations, communities and Groundwater Dependent Ecosystems (GDE). The BDAR in Appendix J details the databases and information sources accessed to inform the desktop assessment.

Field surveys

The impact assessment area was surveyed in accordance with the Biodiversity Assessment Methodology (BAM), which involved:

- the validation, identification and mapping of plant community types (PCTs) according to the structural definitions of The Native Vegetation of the Sydney Metropolitan Area (DPIE, 2016), the Remnant Vegetation of the western Cumberland subregion, 2013 Update (DPIE, 2013a), and the BioNet Vegetation Classification database (DPIE, 2020c)
- confirmation and mapping of vegetation condition states to determine vegetation zones
- completion of floristic plots within each vegetation zone in accordance with section 5 of the BAM. A total of 30 BAM plots were completed for the project of which 20 have remained relevant to the final impact assessment area. Additional plots were initially completed to help characterise sensitive biodiversity features to help inform design

- identification of native and exotic plant species
- identification of weed species
- incidental observations using the random meander method
- an assessment of the natural resilience of the vegetation of the impact assessment area
- identification of previous and current factors threatening the ecological function and survival of native vegetation within and adjacent to the impact assessment area
- identification of flora and fauna habitat features relevant to threatened species
- observations of animal activity and searches for indirect evidence of fauna (such as scats, nests, burrows, hollows, tracks, scratches and diggings).

A 650m long section of the impact assessment area at Kemps Creek could not be surveyed during the preparation of the BDAR due to access issues. To overcome this, it was assumed threatened species were present in place of detailed field survey.

The conservation significance of plant species and plant communities was determined according to:

- *Biodiversity Conservation Act 2016* (BC Act) for significance within NSW
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for significance within Australia.

Mapping was conducted using hand-held (uncorrected) GPS units (GDA94), mobile tablet computers running Collector for ArcGIS and aerial photo interpretation. The accuracy of this mapping is therefore subject to the accuracy of the GPS units (generally ± five metres) and dependent on the limitations of aerial photo rectification and registration.

Targeted species surveys

Targeted species surveys were undertaken for specific threatened flora and fauna species identified as being potentially present in the impact assessment area through the desktop assessment and field surveys. Threatened fauna species survey included habitat assessment to determine suitable microhabitats across the impact assessment area and, where necessary, targeted species survey to determine presence/absence of species and/or their habitats.

Targeted species surveys took place between April 2020 and January 2021, during the required surveying periods for the assessed species in accordance with Department of Planning Industry and Environment – Environment, Energy and Science (EES) requirements as outlined in Appendix J. A detailed list of survey dates and conditions at the time of survey is provided in Appendix J.

Species expert assessments

The BAM outlines that an expert report may be obtained instead of undertaking a species survey for a project, where the expert report is prepared by a person who, in the opinion of the Environment Agency Head, possesses specialised knowledge based on training, study or experience to provide an expert opinion in relation to the biodiversity values to which an expert report relates.

Species experts were used where impacts to threatened species were uncertain, or where a species' habitat was considered to potentially occur across large portions of the impact assessment area, and it is more efficient to use a species expert.

Table 9-3 outlines the four species and respective species experts used in the assessment. Each of these species experts has been approved to provide expert reports for the subject species by the Secretary of the Department of Planning, Industry and Environment.

Table 9-3 Species subject to assessment by experts

Threatened species	Threatened species expert
Spiked Rice-flower *Pimelea spicata*	Elizabeth Norris
Cumberland Plain Land Snail *Meridolum corneovirens*	Dr Stephanie Clark
Dural Land Snail *Pommerhelix duralensis*	Dr Stephanie Clark
Green and Golden Bell Frog *Litoria aurea*	Dr Francis Lemckert

Impact avoidance and minimisation

The main way to reduce impacts to biodiversity is to avoid or minimise the removal of native vegetation and native habitat. The following impact avoidance and minimisation measures were applied to the project to ensure that the residual impacts as assessed in section 9.1.5 and section 9.1.6 have been reduced as far as practicable:

- During design of the project, prior to any fieldwork, a preliminary constraints assessment (Biosis, 2020) was undertaken to identify any areas of high constraint within an initial landscape assessment area that was wider than the impact assessment area. The preliminary constraints assessment and further review undertaken throughout the project identified the presence of intact condition threatened ecological communities (TECs) for the design to avoid, where practical.
- A rapid visual inspection was undertaken to confirm the findings of the preliminary constraints assessment. These findings guided design refinements to avoid these biodiversity values where feasible.
- Initial detailed field investigations occurred over most of the impact assessment area between Lansdowne and Wallacia. These surveys identified multiple constraints for further avoidance during design refinements.

- Detailed mapping of all terrestrial biodiversity constraints was used to work with designers and constructability advisors to locate project infrastructure outside of areas higher biodiversity value where practical. This included relocating construction ancillary facilities and temporary activities outside sensitive areas. In some cases, this resulted in the realignment of the infrastructure to avoid disturbance. For example, within the biodiversity stewardship site at Lansdowne Reserve, conversations with the City of Canterbury-Bankstown and the design team resulted in changing project design to avoid this biodiversity stewardship site.
- Where practical tunnelling rather than trenching through riparian areas was proposed to avoid direct impacts to sensitive riparian habitats and water quality. Notably alteration of the design now allows for a long section of tunnelling between Bents Basin Road at Wallacia and Warragamba Dam. This has allowed for complete avoidance of Shale Sandstone Transition Forest (PCT 1395) and other intact, high quality native vegetation communities and threatened species habitats in this area.
- Micro-siting (defining impact areas in a high level of detail) of the impact envelope to further avoid patches of thinned to intact TEC's where possible. This method has allowed for avoidance of intact and thinned TECs and threatened species habitats.

Appendix J includes more detail about how these measures have avoided and minimised impacts to TECs and threatened species habitats. All terrestrial biodiversity impacts have been minimised to the fullest extent practical through this process.

Impact assessment and mitigation

After impact avoidance, the remaining residual impacts were considered in the following key categories:

- Direct impacts including removal of:
    - native vegetation and flora and fauna habitats
    - known habitat for threatened flora species, and individual plants
    - known and assumed habitat for threatened fauna species
    - BC Act listed TECs
    - EPBC Act listed TECs
    - habitats considered to be potential serious and irreversible impacts (SAIIs)
    - threatened flora habitat assumed present in unsurveyed section of the impact area at Kemps Creek
    - native vegetation, threatened flora, and TECs from 'Existing Certified' areas.
- Indirect impacts including:
    - where native vegetation and habitats are directly adjacent to the impact area and there is potential for those retained patches of vegetation and habitat to be negatively affected by the project (for example, through edge effects)

- landscape scale impacts to species habitat connectivity.

- Prescribed impacts – impacts to biodiversity values which are not related to, or are in addition to, native vegetation clearing and habitat loss. For example, impacts from non-native vegetation clearing and to habitat connectivity.
- Potential impacts to GDEs.
- Impacts to matters of national environmental significance (MNES).

The BDAR assessed these residual impacts in the impact area shown in Figure 9-1. Appropriate management measures were then developed in response to the identified impacts.

Offsetting

Where there are residual direct impacts, offsetting requirements were calculated in accordance with the NSW Biodiversity Offset Scheme (BOS). These calculations were done for:

- ecosystem credit requirements – for the offsetting of residual direct impact to threatened ecological communities (TECs)
- species credit requirements – for the offsetting of residual direct impacts to threatened flora and fauna species.

Assumptions

Ecological surveys provide a sampling of flora and fauna at a given time and season. Factors influencing detectability of species during survey include species dormancy, seasonal conditions, ephemeral status of waterbodies, and migration and breeding behaviours of fauna. In many cases, these factors do not present a significant limitation to assessing the overall biodiversity values of a site.

Field surveys for the project were conducted in autumn and spring during fine weather, which is a suitable time to determine the presence of most threatened species as it coincides with reproductive activities allowing increased chance of detection. Surveys undertaken, combined with habitat assessments and desktop analysis are considered sufficient to reach the conclusions made for species likely to occur in the study area. A conservative approach of assuming the presence of certain species was applied to capture their assessment if targeted surveys were inconclusive.

Database searches, and associated conclusions on the likelihood of species to occur within the study area, are reliant upon external data sources and information managed by third parties.

9.1.3 Existing environment

Site context and overview

Appendix J includes a detailed description of the existing environment including landscape features, bioregions, soils and geology, waterways, wetlands and biodiversity connectivity features. This section focuses on providing existing environment context in relation to:

- terrestrial flora, including native vegetation communities, threatened flora and weed species

- terrestrial fauna, including threatened fauna
- GDEs.

Terrestrial flora

Native vegetation communities

The impact area supports 15 hectares of native vegetation with varying levels of disturbance. 13.77 hectares of this occurs outside land certified under the biodiversity certification for the former South West Growth Centre. Certified Land that is within the former South West Growth Centre has been previously assessed under the former *Threatened Species Conservation Act 1995* and EPBC Act and therefore excluded from this assessment. Section 9.1.4 discusses this biodiversity certification in more detail. In summary, previously certified lands have been subject to a separate impact assessment and offsetting exercise to enable land uses which may disturb biodiversity as part of the South West Growth Centre development. Therefore, biodiversity impacts on these lands do not required additional offsetting.

Table 9-4 summarises the extent of PCTs and TEC in the impact assessment area and impact area, whether they are listed as threatened under the EPBC Act BC Act and whether they are located on certified land in the South West Growth Centre. Figure 9-1 shows the location of these communities in the impact assessment area and impact area.

Table 9-4 Plant community types in the impact assessment area and impact area

Plant community type	EPBC Act	BC Act	Impact area		Impact assessment area (outside the impact area)	
			Non-Certified	Existing Certified	Non-Certified	Existing Certified
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered Ecological Community [CEEC])	Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered Ecological Community (EEC))	1.58 ha	0.04 ha	1.03 ha	0.21 ha
725: Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain	Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion (CEEC)	Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion (EEC)	0.01 ha	0.13 ha	0.52 ha	0.38 ha
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	-	Sydney Freshwater Wetlands in the Sydney Basin Bioregion (EEC)	0.02 ha	0.00 ha	0.08 ha	0.00 ha

Plant community type	EPBC Act	BC Act	Impact area		Impact assessment area (outside the impact area)	
			Non-Certified	Existing Certified	Non-Certified	Existing Certified
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria (CEEC)	River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (EEC)	4.56 ha	0.02 ha	7.22 ha	0.07 ha
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (CEEC)	Cumberland Plain Woodland in the Sydney Basin Bioregion (CEEC)	4.83 ha	1.01 ha	12.29 ha	1.10 ha
883: Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion (EEC)	Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion (Vulnerable Ecological Community (VEC))	0.00 ha	0.03 ha	0.00 ha	0.20 ha

Plant community type	EPBC Act	BC Act	Impact area		Impact assessment area (outside the impact area)	
			Non-Certified	Existing Certified	Non-Certified	Existing Certified
1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	-	-	1.38 ha	0.00 ha	0.43 ha	0.00 ha
1105: River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	-	-	0.40 ha	0.00 ha	0.46 ha	0.00 ha
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	-	-	0.07 ha	0.00 ha	0.00 ha	0.00 ha

Plant community type	EPBC Act	BC Act	Impact area		Impact assessment area (outside the impact area)	
			Non-Certified	Existing Certified	Non-Certified	Existing Certified
1800: Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community (EEC)	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (EEC)	0.92 ha	0.00 ha	1.20 ha	0.02 ha

Threatened flora

Table 9-5 summarises the threatened flora species identified in the impact assessment area and impact area. It also includes species which are assumed to be present in the section of the impact assessment area at Kemps Creek that could not be surveyed due to access constraints.

Table 9-5 Threatened flora species identified in the impact assessment area and impact area

Scientific name	Common name	No. of individuals in impact area	No. of individuals in impact assessment area	Habitat in the impact area (ha)	Habitat in the impact assessment area (ha)
Species recorded in the impact assessment area and impact area					
Acacia pubescens	Downy Wattle	7	12	0.16	0.23
Eucalyptus benthamii	Camden White Gum	0	5	0.00	0.14
Marsdenia viridiflora subsp. *viridiflora*	Native Pear	0	4	0.03	0.11
Pultenaea parviflora	-	0	4	0.01	0.04
Species assumed present at Kemps Creek					
Callistemon linearifolius	Netted Bottle Brush	N/A	N/A	0.46	0.86
Dillwynia tenuifolia	-	N/A	N/A	0.05	0.05
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	N/A	N/A	0.05	0.05
Marsdenia viridiflora subsp. *viridiflora*	Native Pear	N/A	N/A	0.51	0.91
Pultenaea pedunculata	Matted Bush-pea	N/A	N/A	0.05	0.05

Weeds

Table 9-6 lists the 13 priority weed species for the Greater Sydney Local Land Service (LLS) region which have been identified in the impact assessment area.

Table 9-6 Priority weeds identified in the impact assessment area

Scientific name	Common name
Alternanthera philoxeroides	Alligator Weed
Anredera cordifolia	Madeira Vine
Asparagus aethiopicus	Ground Asparagus
Asparagus asparagoides	Bridal Creeper
Cestrum parqui	Green Cestrum
Lantana camara	Lantana
Lycium ferocissimum	African Boxthorn
Nassella neesiana	Chilean Needle Grass
Olea europaea subsp. *cuspidata*	African Olive
Opuntia stricta	Common Pear
Rubus fruticosus species aggregate	Blackberry
Salvinia molesta	Salvinia
Senecio madagascariensis	Fireweed

Terrestrial fauna

Terrestrial fauna habitats in the impact assessment area have been degraded by past land use practices. This has resulted in a loss of key habitat features such as large tree-hollows, high-quality connectivity corridors and large patches of intact, well-structured vegetation not subject to edge effects. More localised areas of higher quality fauna habitats are present in areas such as the biodiversity stewardship site at Lansdowne, Western Sydney Parklands, areas north of Kemps Creek Nature Reserve, and near Nepean River and Warragamba River. Although higher quality relative to the rest of the impact assessment area, fauna habitats in these locations are still disturbed by a range of urban and peri-urban impacts.

Based on the outcomes of the desktop database searches and survey of potential habitats threatened fauna species listed in Table 9-7 have been identified as present or potentially present in the impact assessment area. In accordance with the BAM, threatened fauna species have been identified in one of the following two categories:

- Predicted species – species expected to occur in the impact assessment area. Impacts to these species requires assessment but targeted surveys are not required as they are assumed to be present. Predicted species are also known as ecosystem credit species.
- Candidate species – species with potential to occur in the impact assessment area. These species require targeted surveys, or species expert reports, to confirm presence and inform further impact assessment. Candidate species are also known as species credit species (because impacts generate species credit requirements for the purposes of offsetting).

Table 9-7 also identifies the assessment methodology used to determine potential presence of the candidate species.

Table 9-7 Threatened fauna species identified as requiring assessment in the impact assessment area

Scientific name	Common name	Predicted species or Candidate species and method of establishing presence
Anthochaera phrygia	Regent Honeyeater	Predicted species
Artamus cyanopterus cyanopterus	Dusky Woodswallow	Predicted species
Botaurus poiciloptilus	Australasian Bittern	Predicted species
Calidris ferruginea	Curlew Sandpiper	Predicted species
Callocephalon fimbriatum	Gang-gang Cockatoo (foraging)	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Calyptorhynchus lathami	Glossy Black-Cockatoo (foraging)	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Chthonicola sagittata	Speckled Warbler	Predicted species
Circus assimilis	Spotted Harrier	Predicted species
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	Predicted species
Daphoenositta chrysoptera	Varied Sittella	Predicted species
Dasyurus maculatus	Spotted-tailed Quoll	Predicted species

Scientific name	Common name	Predicted species or Candidate species and method of establishing presence
Ephippiorhynchus asiaticus	Black-necked Stork	Predicted species
Epthianura albifrons	White-fronted Chat	Predicted species
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Predicted species
Glossopsitta pusilla	Little Lorikeet	Predicted species
Grantiella picta	Painted Honeyeater	Predicted species
Haliaeetus leucogaster	White-bellied Sea-Eagle	Candidate species Method: Targeted nest tree (stick nest) surveys and habitat assessment
Heleioporus australiacus	Giant Burrowing Frog	Candidate species Method: Threatened species habitat assessment, active searches, spotlighting, call play-back
Hieraaetus morphnoides	Little Eagle	Candidate species Method: Targeted nest tree (stick nest) surveys and habitat assessment
Hoplocephalus bungaroides	Broad-headed Snake	Candidate species Method: Threatened species habitat assessment, active searches, hollow-bearing tree assessment
Irediparra gallinacea	Comb-crested Jacana	Predicted species
Ixobrychus flavicollis	Black Bittern	Predicted species
Lathamus discolor	Swift Parrot	Predicted species
Litoria aurea	Green and Golden Bell Frog	Candidate species Method: Habitat assessment by species expert
Limicola falcinellus	Broad-billed Sandpiper	Predicted species
Limosa limosa	Black-tailed Godwit	Predicted species

Scientific name	Common name	Predicted species or Candidate species and method of establishing presence
Lophoictinia isura	Square-tailed Kite (foraging)	Candidate species Method: Targeted nest tree (stick nest) surveys and habitat assessment
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	Predicted species
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	Predicted species
Meridolum corneovirens	Cumberland Plain Land Snail	Candidate species Method: Active searches, habitat assessment by species expert
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	Predicted species
Miniopterus australis	Little Bent-winged-bat	Candidate species Method: Threatened species habitat assessment, microbat acoustic detection surveys, stag watch
Miniopterus orianae oceanensis	Large Bent-winged-bat	Candidate species Method: Threatened species habitat assessment, microbat acoustic detection surveys, stag watch
Myotis macropus	Southern Myotis	Candidate species Method: Threatened species habitat assessment, microbat acoustic detection surveys, stag watch
Chalinolobus dwyeri	Large-eared Pied Bat	Candidate species Method: Microbat acoustic detection surveys, stag watch
Neophema pulchella	Turquoise Parrot	Predicted species

Scientific name	Common name	Predicted species or Candidate species and method of establishing presence
Ninox connivens	Barking Owl (foraging)	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Ninox strenua	Powerful Owl (foraging)	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Nyctophilus corbeni	Corben's Long-eared Bat	Predicted species
Pandion cristatus	Eastern Osprey (foraging)	Candidate species Method: Targeted nest tree (stick nest) surveys and habitat assessment
Petaurus australis	Yellow-bellied Glider	Predicted species
Petroica boodang	Scarlet Robin	Predicted species
Petroica phoenicea	Flame Robin	Predicted species
Petrogale penicillata	Brush-tailed Rock-wallaby	Candidate species Method: Threatened species habitat assessment, baited remote camera survey
Phascolarctos cinereus	Koala (foraging)	Candidate species Method: Spot Assessment Technique (SAT) survey
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	Predicted species
Pommerhelix duralensis	Dural Land Snail	Candidate species Method: Active searches, habitat assessment by species expert
Pseudophryne australis	Red-crowned Toadlet	Candidate species Method: Threatened species habitat assessment, active searches, spotlighting, call play-back

Scientific name	Common name	Predicted species or Candidate species and method of establishing presence
Pteropus poliocephalus	Grey-headed Flying-fox (foraging)	Candidate species Method: Threatened species habitat assessment
Rostratula australis	Australian Painted Snipe	Predicted species
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Predicted species
Scoteanax rueppellii	Greater Broad-nosed Bat	Predicted species
Stagonopleura guttata	Diamond Firetail	Predicted species
Stictonetta naevosa	Freckled Duck	Predicted species
Tyto novaehollandiae	Masked Owl	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Tyto tenebricosa	Sooty Owl	Candidate species Method: Targeted tree hollow surveys and habitat assessment
Varanus rosenbergi	Rosenberg's Goanna	Predicted species
Vespadelus troughtoni	Eastern Cave Bat	Candidate species Method: Threatened species habitat assessment, microbat acoustic detection surveys, stag watch

Groundwater dependent ecosystems (GDE)

Table 9-8 lists the potential GDEs mapped in the Bureau of Meteorology (BOM 2021) GDE Atlas in and surrounding the impact assessment area. The PCTs and TECs are based on the mapping undertaken for the BDAR, with GDE Atlas mapping overlaid to determine the potential for groundwater interactions. The PCTs and TECs listed in Table 9-8 are therefore the equivalent ecological community to be considered in the assessment of impacts to GDEs. Although the GDE Atlas provides vegetation types, they are based on aerial mapping and the field verified mapping completed for the project is therefore considered more accurate.

Table 9-8 Potential GDEs mapped in and surrounding the impact assessment area

PCT	TEC	Location description
724	Shale Gravel Transition Forest	Kemps Creek north of Elizabeth Drive and south of Park Road. Both occurrences are part of larger patches adjacent to the impact assessment area.
781	Freshwater wetlands on coastal floodplains	Adjacent to Jerrys Creek.
835	River-flat Eucalypt Forest	Surrounding Kemps Creek watercourse, Cosgroves Creek, south of Park Road (with patch of PCT 724), and along Nepean River.
849	Cumberland Plain Woodland	Lansdowne Reserve, and south of Park Road.
883	Castlereagh Scribbly Gum Woodland	Kemps Creek adjacent to Western Road.
1083	Not a TEC	Environmental flows release structure.
1105	Not a TEC	Environmental flows release structure.
1181	Not a TEC	Adjacent to Bents Basin Road on the edge of a large patch of intact vegetation.
1800	Swamp Oak Floodplain Forest	Surrounding Cosgrove Creek and Oaky Creek.
724	Shale Gravel Transition Forest	Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.
725	Cooks River/Castlereagh Ironbark Forest	In the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek and north of Elizabeth Drive between South Creek and Badgerys Creek.
835	River-flat Eucalypt Forest	Surrounding Clear Paddock Creek.
849	Cumberland Plain Woodland	Along Park Road as part of a larger patch of vegetation.
883	Castlereagh Scribbly Gum Woodland	In the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.
1081	Not a TEC	Environmental flows release structure
1083	Not a TEC	Environmental flows release structure.
724	Shale Gravel Transition Forest	Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.

PCT	TEC	Location description
725	Cooks River/Castlereagh Ironbark Forest	In the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.
883	Castlereagh Scribbly Gum Woodland	On the edge of the large patch of vegetation between Elizabeth Drive and Cross Street at Kemps Creek.

9.1.4 Legislation and guidelines

Table 9-9 summarises the legislation and environmental planning instruments relevant to the assessment of terrestrial biodiversity impacts.

Table 9-9 Biodiversity legislation and planning instruments

Legislation / policy	Description	Relevance to the project
Commonwealth legislation		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act applies to developments and associated activities that have the potential to significantly impact on MNES protected under the Act. Under the EPBC Act, the minister may agree to undertake a strategic assessment on the impacts of actions under a policy, plan or program. An agreement was signed to undertake a strategic assessment of the Sydney growth centres on 11 November 2009. State Environmental Planning Policy (Sydney Region Growth Centres) 2006 was gazetted and granted biodiversity certification of the areas covered by the SEPP. This removes the need for threatened species assessment under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for areas that have been certified. In December 2011, the Commonwealth Government environment minister endorsed the	The project has been declared a controlled action under the EPBC Act due to its potential impacts on: • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest – critically endangered • Regent Honeyeater (*Anthochaera phrygia*) – critically endangered • Swift Parrot (*Lathamus discolor*) – critically endangered • Macquarie perch (*Macquaria australasica*) – endangered • the Blue Mountains World Heritage Area. This section assesses impacts on these with the exception of the Macquarie Perch which is assessed in Chapter 8 and the Blue Mountains World Heritage Area which is assessed in section 10.3. Threatened species and ecological communities protected by the EPBC Act and present in the impact

Legislation / policy	Description	Relevance to the project
	program document Sydney Growth Centres Strategic Assessment: Program report. The endorsement of this program allows the minister to consider giving approval to actions that are taken in accordance with the endorsed program. In February 2012, the Minister approved classes of actions associated with implementing the Sydney Growth Centres Strategic Assessment: Program report.	assessment area are outlined in section 9.1.2. The strategic assessment for the Sydney Growth Centres means assessment of impacts to MNES is not required in Existing Certified land in the project's impact area. Where impacts to MNES as a result of the project fall outside the strategic assessment area, they have been assessed in section 9.1.5.
NSW legislation		
Biodiversity Conservation Act 2016 (BC Act)	Key piece of legislation providing for the protection and conservation of biodiversity in NSW through the listing of threatened species and communities and key threatening processes.	Mandates the application of the NSW Biodiversity Offset Scheme (BOS) and BAM to state significant projects. This project has been assessed in accordance with the BAM and residual impacts offset in accordance with the BOS.
Fisheries Management Act 1994 (FM Act)	Provides for the protection and conservation of aquatic species and their habitat throughout NSW.	The BAM focuses on impacts to terrestrial ecology and excludes items listed under the FM Act. Aquatic biodiversity impacts are assessed in Chapter 8.
Biosecurity Act 2015	Outlines biosecurity risks and impacts and prescribes requirements for the management of risk to reduce the severity of impacts.	Biosecurity risks relevant to the project include weeds, pest animals and pathogens that are known to occur, or potentially occur, within the impact area. Further details of biosecurity risks present within the impact area and impact assessment area are provided in section 9.1.5.

Legislation / policy	Description	Relevance to the project
National Parks and Wildlife Act 1974 (NPW Act)	The intent of the NPW Act is to allow for conservation of the State's natural and cultural heritage; fostering public appreciation, understanding and enjoyment of their State's natural and cultural heritage; and managing any lands reserved for the purposes of conserving and fostering public appreciation and enjoyment of the State's natural and/or cultural heritage.	Four areas of land protected by the NPW Act occur within the vicinity of the study area; Blue Mountains National Park, Burragorang State Conservation Area, Kemps Creek Nature Reserve and Western Sydney Regional Park. However there will be no direct impacts on these areas. An assessment of potential implications of the NPW Act is outlined in section 9.1.5
NSW environmental planning instruments		
State Environmental Planning Policy No 19 – Bushland in Urban Areas 1986	This State Environmental Planning Policy (SEPP) aims to protect and preserve bushland in urban area because of its ecological, social and aesthetic values.	Most of the study area is subject to SEPP No 19 – Bushland in Urban Areas 1986 with the exception of Western Sydney Parklands. Under Part 6 clause 2 (c)(i) development consent is not required for the disturbance of bushland if being disturbed for the purposing of constructing, operating or maintaining sewerage pipelines.
SEPP (Sydney Region Growth Centres) 2006 and the Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006	This SEPP allows for the co-ordinated release of urban development in the North West and South West Growth Centres (as well as other area not relevant to the current assessment). Aligned with this SEPP, the Order to confer biodiversity certification on those growth centre areas designates land that has been assessed and approved for development in accordance with the former NSW *Threatened Species Conservation Act 1995* (TSC Act) and the EPBC Act.	About 10 km of the central portion of the project alignment occurs within land subject to the SEPP and the Order to confer biodiversity certification. Land within this location has been declared as either 'Existing Certified' or 'Existing Non Certified' under the SEPP and Order. In areas of Existing Certified land, assessment of impact in accordance with the BC Act and EPBC Act are not required due to their inclusion in previous biodiversity certification assessments under the former *Threatened Species Conservation Act 1995* and Strategic Assessment under the EPBC Act.

Legislation / policy	Description	Relevance to the project
		Area of Existing Non Certified land require assessment under the BC Act and EPBC Act. An assessment of the project in relation to the requirements of the Order to confer biodiversity certification on the SEPP (Sydney Region Growth Centres) 2006 is included in section 9.1.5.
SEPP (Vegetation in non-rural areas) 2017	This SEPP aims to protect the biodiversity values of trees and other vegetation in non-rural areas of the State, and to preserve the amenity of non-rural areas of the State through the preservation of trees and other vegetation.	The impact area occurs on land mapped under SEPP (Vegetation in Non-Rural Areas) 2017 based on its location in the Bankstown, Fairfield, Liverpool and Penrith local government areas (LGAs) as per Part 1, Section 5 of the SEPP. This SEPP is not relevant to the project within the Wollondilly LGA. Under Part 2, Section 8(1) of SEPP (Vegetation in Non-Rural Areas) 2017, the proposed vegetation clearance does not require an authority under the SEPP as it is of a kind authorised under Section 60O(b)(iii) of the NSW Local Land Services Act 2013 via assessment and approval under Part 5 Division 5.2 of the EP&A Act.
SEPP (Coastal Management) 2018	This SEPP aims to promote an integrated and co-ordinated approach to land use planning in the coastal zone in a manner consistent with the objects of the Coastal Management Act 2016, including the management objectives for each coastal management area.	The impact assessment area is located partially on land mapped as Proximity Area for Coastal Wetlands as defined by the Coastal Management SEPP, and adjacent to land mapped as Coastal Wetlands. The current project design will result in the removal of vegetation and disturbance to soil within the proximity area for coastal wetland.

Field surveys and impact assessments were undertaken in accordance with the following guidelines:

- Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians (DECC, 2009b).
- Survey guidelines for Australia Threatened Reptiles (DSEWPC, 2011a).
- EPBC Act referral guidelines for the vulnerable Koala (DoE, 2014).
- Species credit threatened bats and their habitats: NSW survey guide for the Biodiversity Assessment Method (OEH, 2018).
- Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the EPBC Act (DSEWPC, 2011b).
- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DoE, 2013).
- EPBC Act Environmental Offsets Policy (DSEWPC, 2012).
- Bionet Atlas of NSW (DPIE, 2020d).
- Cumberland Plan Recovery Plan (DECCW, 2011)
- National Recovery Plan for the Regent Honeyeater (DoE, 2016).

9.1.5 Construction impact assessment

Overview and impact assessment approach

As outlined in section 9.1.2 the project has been assessed against impact types including:

- direct impact
- indirect impacts
- prescribed impacts
- impacts to GDEs
- summary of impacts to MNES.

This section summarises these impacts and Appendix J includes a detailed assessment of these impacts including Serious and Irreversible Impact Assessments (SIIA) and Significant Impact Criteria Assessments (SIC) which inform the level of potential impact.

Direct impacts

Table 9-10 identifies the PCTs, corresponding TECs and threatened species which will be directly impacted by the project. Figure 9-1 shows the locations of impacted TECs in the impact area. Figure 9-2 shows the threatened flora and fauna that will be directly impacted by the construction of the project. The conclusions presented in Table 9-10 regarding the level and significance of the project impacts to biodiversity are supported by the impact and significance assessments in the BDAR in Appendix J.

Table 9-10 Assessment of potential construction-related direct impacts

Potential direct impact	Description of impact	Significance of impact
Removal of native vegetation and flora and fauna habitats	Removal of 13.77 ha of native vegetation from eight PCTs throughout the impact area, supporting habitat for a range of threatened and non-threatened flora and fauna species.	The impact area equates to about 213 ha, spanning over 40 km of linear project area, and removal of 13.77 ha of native vegetation equates to 6% of the total area impacted by the project. The majority of the vegetation and habitats impacted by the project have been modified through clearing and other detrimental land use practices, with 86% of the vegetation impacted considered to be in 'Thinned' of 'Scattered Trees' ecological condition, and only 14% recorded as 'Intact'. Significance assessments concluded that when considered in the context of the size of the project area, and the general landscape through which the alignment traverses, the impact of native vegetation removal is not considered to be significant. **Summary: Impact not significant.**
Removal of known and expert mapped habitat for threatened flora species and individual plants	Removal of the following threatened flora individuals / habitat: • Downy Wattle – seven individuals, 0.16 ha of known habitat • Native Pear – 0 individuals, 0.03 ha of known habitat • Sydney Bush-pea – 0 individuals, 0.01 ha of known habitat • Spiked Rice-flower – 0 individuals, 2.99 ha of expert mapped habitat	Direct impacts to a total of seven individual plants, and 3.19 ha of known habitat are considered to be an acceptable outcome for a project over about 213 ha and spanning over 40 km. These impacts to threatened flora species and habitats are not considered significant when assessed in the context of the scale of the project. None of the project impacts to threatened flora are considered 'significant impacts' for the purposes of the EPBC Act. **Summary: Impact not significant.**

Potential direct impact	Description of impact	Significance of impact
Removal of known habitat for threatened fauna species	Removal of the following 'known' threatened fauna habitat: • 13.77 ha of native vegetation forming forage habitat for highly mobile bird and bat BAM ecosystem credit species (includes potential forage habitat for Regent Honeyeater and Swift Parrot listed as Critically Endangered under the EPBC Act). • Removal of 1.56 ha low potential breeding habitat for Large Bent-winged-bat. • Removal of 3.48 ha additional species credit forage habitat for Large –eared Pied Bat • Removal of 7.62 ha of species credit habitat for Southern Myotis. • Removal of 8.95 ha of expert mapped habitat for Cumberland Plain Land Snail. • Removal of 1.45 ha of expert mapped habitat for Dural Land Snail.	Targeted surveys and habitat assessments concluded that most of the impact area supports only marginal quality habitat for threatened fauna species, having undergone degradation through historical landuse. Impacts to potential microbat breeding habitat at the environmental flows release structure have been assumed based on the presence of potential habitat, and the recording of species credit microbats on ultrasonic detectors. It should be noted that no bats were recorded exiting the man-made habitat features during stag watches undertaken in October 2020 and January 2021. SAIIs and significant impact criteria assessment have been undertaken for the species listed in the previous column with the exception of the Cumberland Plain Land Snail and Dural land Snail which have been assessed by species experts. These assessments concluded that there will be no significant impacts to these species. Overall direct impacts to threatened fauna habitats are not considered significant when assessed in the context of the scale of the project. None of the project impacts to threatened fauna are considered 'significant impacts' for the purposes of the EPBC Act. **Summary: Impact not significant.**

Potential direct impact	Description of impact	Significance of impact
Removal of BC Act listed TECs (excluding 'Existing Certified')	The project will result in the removal of the following BC Act listed TECs: • 4.37 ha of Cumberland Plain Woodland (CEEC) • 0.02 ha of Freshwater wetlands on coastal floodplains (EEC) • 4.39 ha of River-flat Eucalypt Forest (EEC) • 1.54 ha of Shale Gravel Transition Forest (EEC) • 0.88 ha of Swamp Oak Floodplain Forest (EEC)	Impacts to BC Act listed TECs have been avoided and minimised throughout the design phase of the project, which most noticeably includes the total avoidance of impacts to BC Act listed CEEC Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Shale Sandstone Transition Forest). Residual impacts to TEC vegetation are considered generally unavoidable in the locational context of the project, with almost all vegetation types present within the broader project area related to BC Act listed vegetation. Where impacts occur they have been designed in lower quality or thinned extents of TEC where possible. Impacts to less than five hectares of any one TEC, within a project area of 213 ha, and to vegetation that is generally in lower ecological condition, are considered an acceptable level of impact for a project of this scale. Offsetting of residual impacts to TECs is proposed in accordance with the BAM as outlined in Section 9.1.10. **Summary: Impact not significant.**
Removal of EPBC Act listed TECs (excluding 'Existing Certified')	The project will result in the removal of the following EPBC Act TECs: • 0.22 ha of Coastal Swamp Oak Forest (EEC) • 1.88 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (CEEC)	Residual impacts will occur to two EPBC Act listed TECs. Due to the largely degraded nature of the vegetation impacted by the project, most of the vegetation meeting the requirements for listing under the BC Act did not meet the minimum requirements for listing under the EPBC Act. Significant impact criteria assessment have been undertaken as detailed in Appendix J. Impacts to 1.88 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest and 0.22 ha of Coastal Swamp Oak Forest are considered acceptable for a project of this scale. None of the impacts to TECs are considered 'significant impacts' for the purposes of the EPBC Act as outlined in the significance assessments in Appendix J. Offsetting of residual impacts to TECs is proposed in accordance with the BAM as outlined in section 9.1.10. **Summary: Impact not significant.**

Potential direct impact	Description of impact	Significance of impact
Removal of habitats considered to be potential SAIIs (excluding 'Existing Certified')	The project will result in the removal of habitat for the following, which is considered to be a potential SAII: • Direct removal of 4.37 ha of BC Act listed Cumberland Plain Woodland vegetation • Direct removal of 1.56 ha of low potential breeding habitat for Large Bent-winged-bat and very low potential breeding habitat for Large–eared Pied Bat and Little Bent-winged Bat.	Project impacts considered potential SAIIs relate to small areas, and small proportions of potential habitat in both the immediate vicinity and broader locality to each of the species considered. Impacts are also based on the assumption of presence of breeding habitat for microbats, as required by the BAM, where analysis of call data clearly shows the presence of roosting/breeding bats is highly unlikely. Survey to exclude species from breeding on the western side of Warragamba River was not possible due to access difficulties and restrictions. Impacts to Cumberland Plain Woodland (assessed as SAII as opposed to assessment under the EPBC Act above) have been avoided and minimised throughout the project design phase, such that residual impact has been restricted to 4.37 ha. Direct impacts to microbat breeding habitat include 1.56 ha around the Warragamba treated water environmental flows outlet which equates to very small portion of the extent of the potential habitat available in the locality, particularly downstream along Warragamba River on both side of the gorge. Further detailed SAII assessments are provided in Appendix J. **Summary: Impact not significant.**
Removal of threatened flora habitat assumed present in unsurveyed section of the impact area at Kemps Creek	The project will result in the removal of habitat assumed present for the following species, between Brandown Quarry and Cross Street, Kemps Creek: • *Dillwynia tenuifolia* – 0.05ha of assumed habitat • Juniper-leaved Grevillea – 0.05ha of assumed habitat • Native Pear – 0.51ha of assumed habitat	Species presence has been assumed as access could not be gained to survey this location. Habitat present in the area where presence has been assumed for the listed species ranges from thinned, degraded and patchy PCT 849 vegetation to higher quality intact PCT 835 vegetation closer to the Kemps Creek watercourse. Therefore, these impacts will not be significant. **Summary: Impact not significant.**

Potential direct impact	Description of impact	Significance of impact
	• Matted Bush-pea – 0.05ha of assumed habitat • Netted Bottle Brush – 0.46ha of assumed habitat	
Removal of native vegetation, threatened flora, and TECs from 'Existing Certified' areas	The project will result in the removal of the following biodiversity values from Existing Certified (and Strategically Assessed) areas: • BC Act listed TECs including: – 0.98 ha of Cumberland Plain Woodland (CEEC) – 0.02 ha of River-flat Eucalypt Forest (EEC) – 0.04 ha of Shale Gravel Transition Forest (EEC) – 0.02 ha of Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion (VEC) – 0.12 ha of Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion (EEC) • EPBC Act listed TECs including: – 0.03 ha of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (CEEC)	All impacted biodiversity values within Existing Certified land have been assessed and offset in accordance with existing State and Commonwealth provisions under the biodiversity certification and strategic assessment. Section 9.1.10 provides a summary of the biodiversity offsetting requirements for the project. **Summary: Impact not significant.**

Potential direct impact	Description of impact	Significance of impact
	– 0.01 ha of Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion (VEC) – 0.03 ha of Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion (EEC) • Dillwynia tenuifolia – 134 individuals • Sydney Bush-pea – 100 individuals	
Removal of potential Koala habitat	The project will remove 13.77 ha of habitat containing Koala feed tree species that has the potential to be used for dispersal foraging and possibly breeding by Koalas.	The EPBC Act Koala referral guidelines (DoE 2014) have been applied to the project and the habitats supported were found not to be critical to the survival of the species. Targeted surveys for the presence of Koala found no signs of the species. This is supported by a lack of records of the species within 10 kilometres of the project, across most of the alignment, over the last 20 years. Based on the habitats in the impact area not being considered critical to the survival of the species, the lack of detection during targeted surveys, and the negligible impacts to potential movement of Koalas, the project is considered unlikely to result in any substantial impacts to the species, or local populations. The project will not result in the creation of permanent barriers to the movement of Koalas. If Koalas were to move through the area in the future a cleared easement of up to 30 m would not present a substantial barrier for a dispersing Koala to cross. **Summary: Impact not significant.**

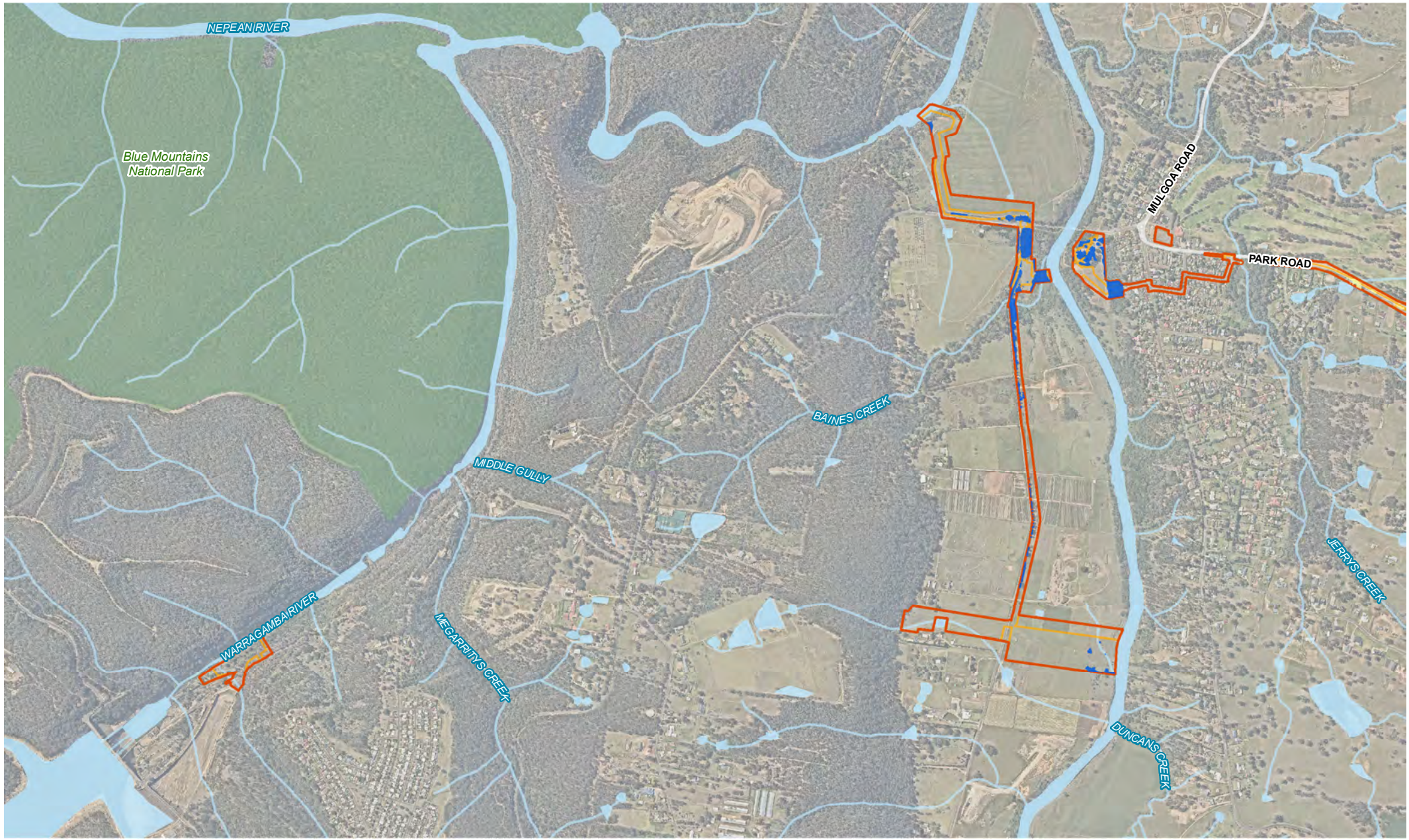
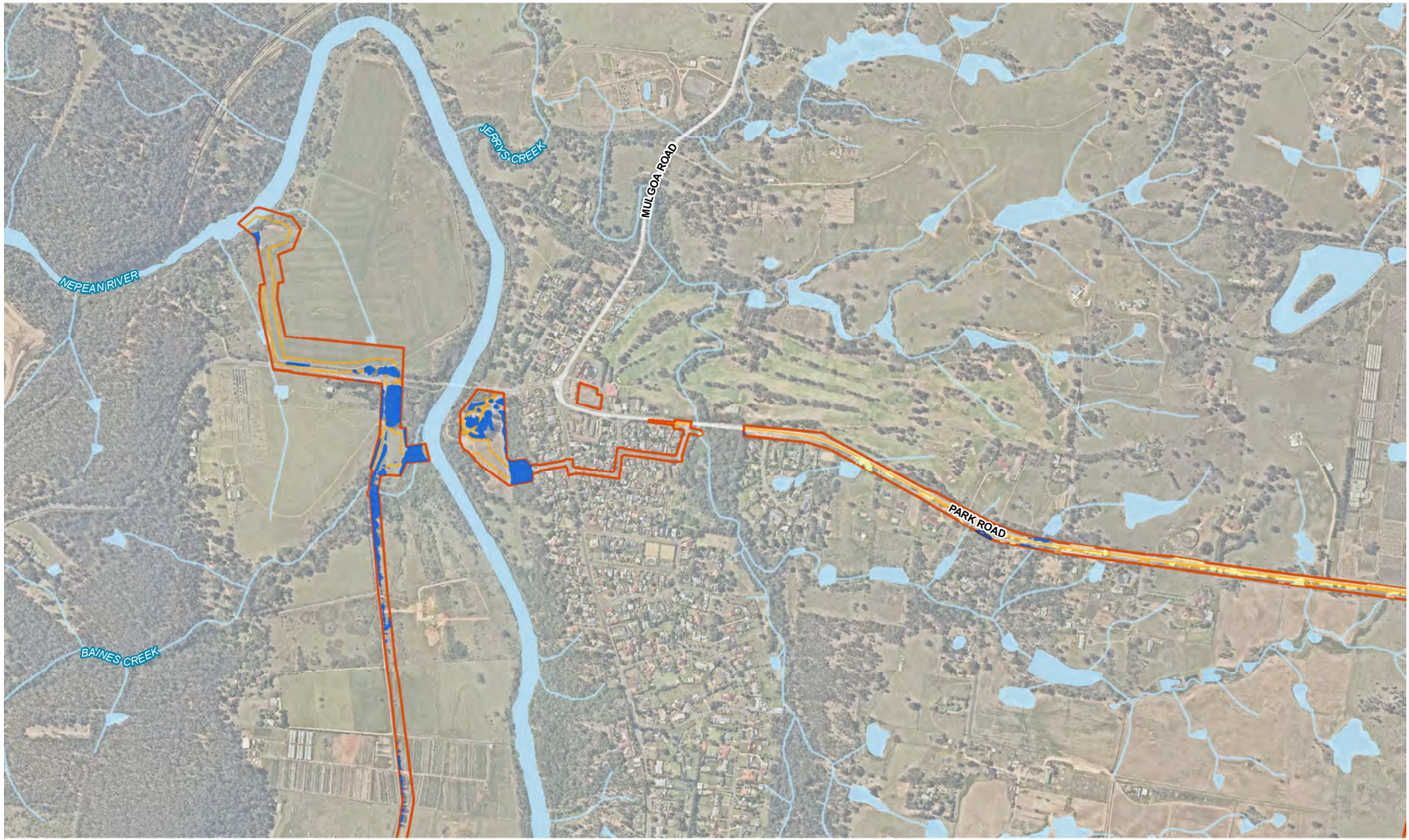


Figure 9-1a Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

EPBC Act TEC

Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)

BC Act TEC

Cumberland Plain Woodland (CEEC)

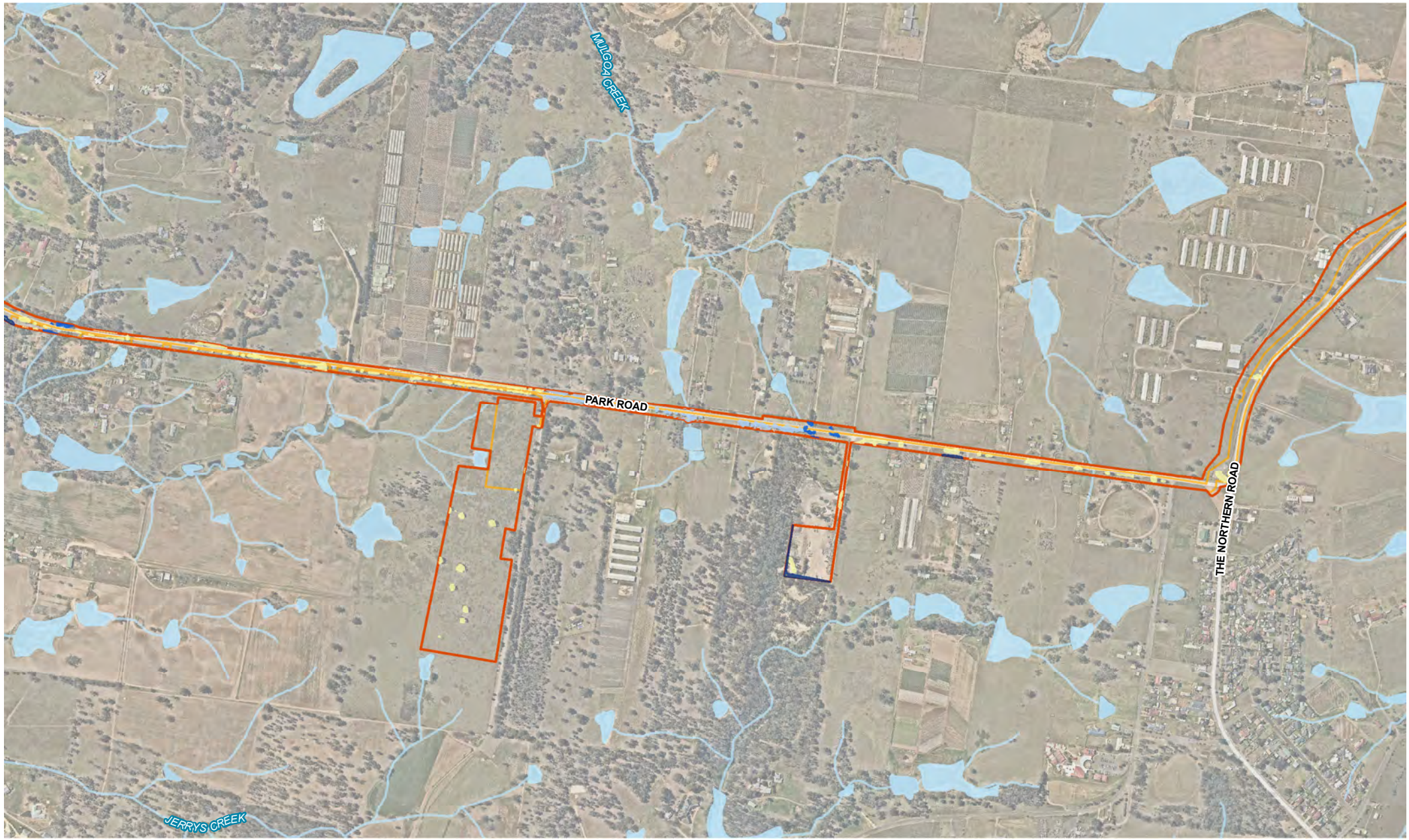
Freshwater wetlands on coastal floodplains (EEC)

River-Flat Eucalypt Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1b Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

EPBC Act TEC

Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)

BC Act TEC

Cumberland Plain Woodland (CEEC)

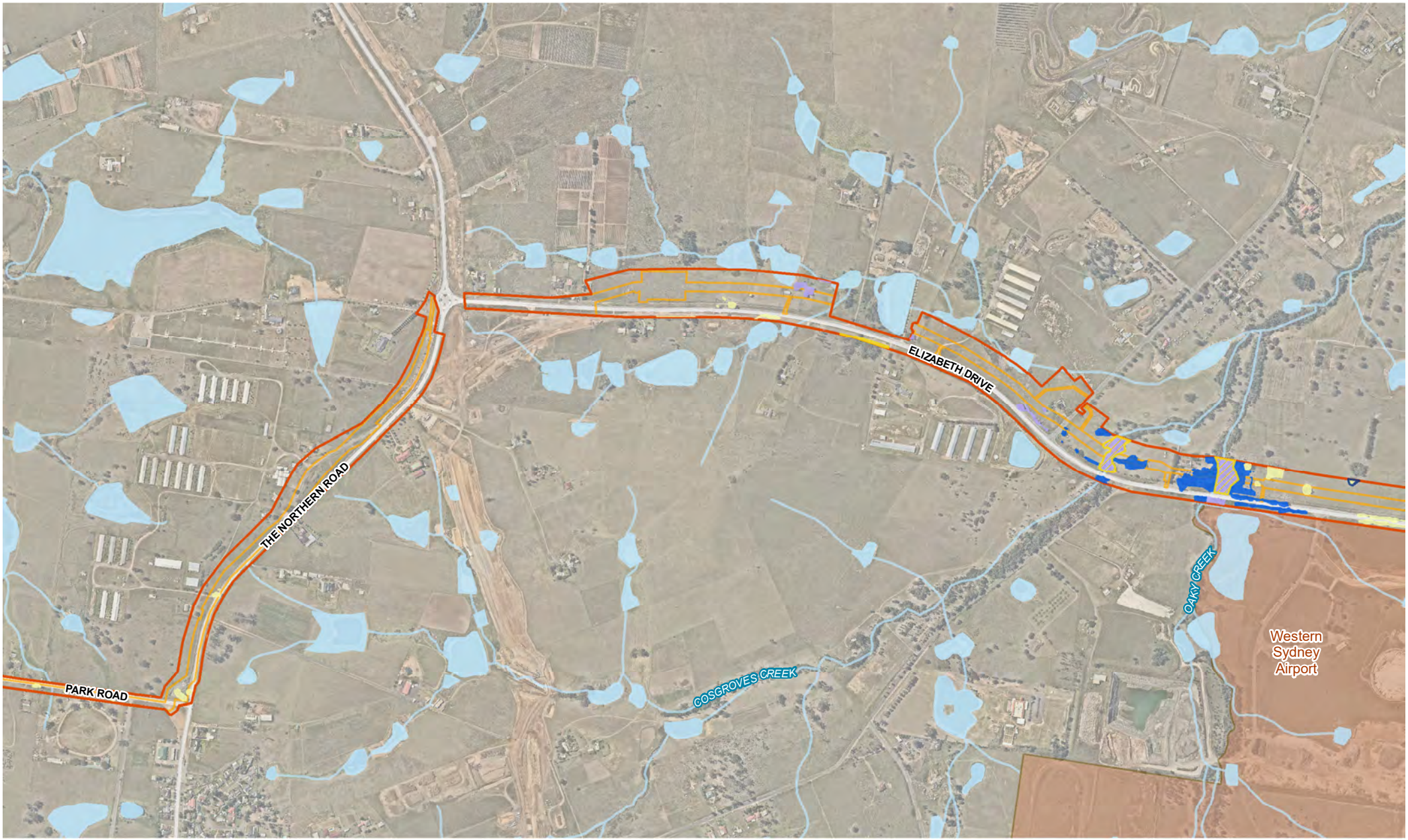
River-Flat Eucalypt Forest (EEC)

Shale Gravel Transition Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1c Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

EPBC Act TEC

Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)

Coastal Swamp Oak Forest (EEC)

BC Act TEC

Cumberland Plain Woodland (CEEC)

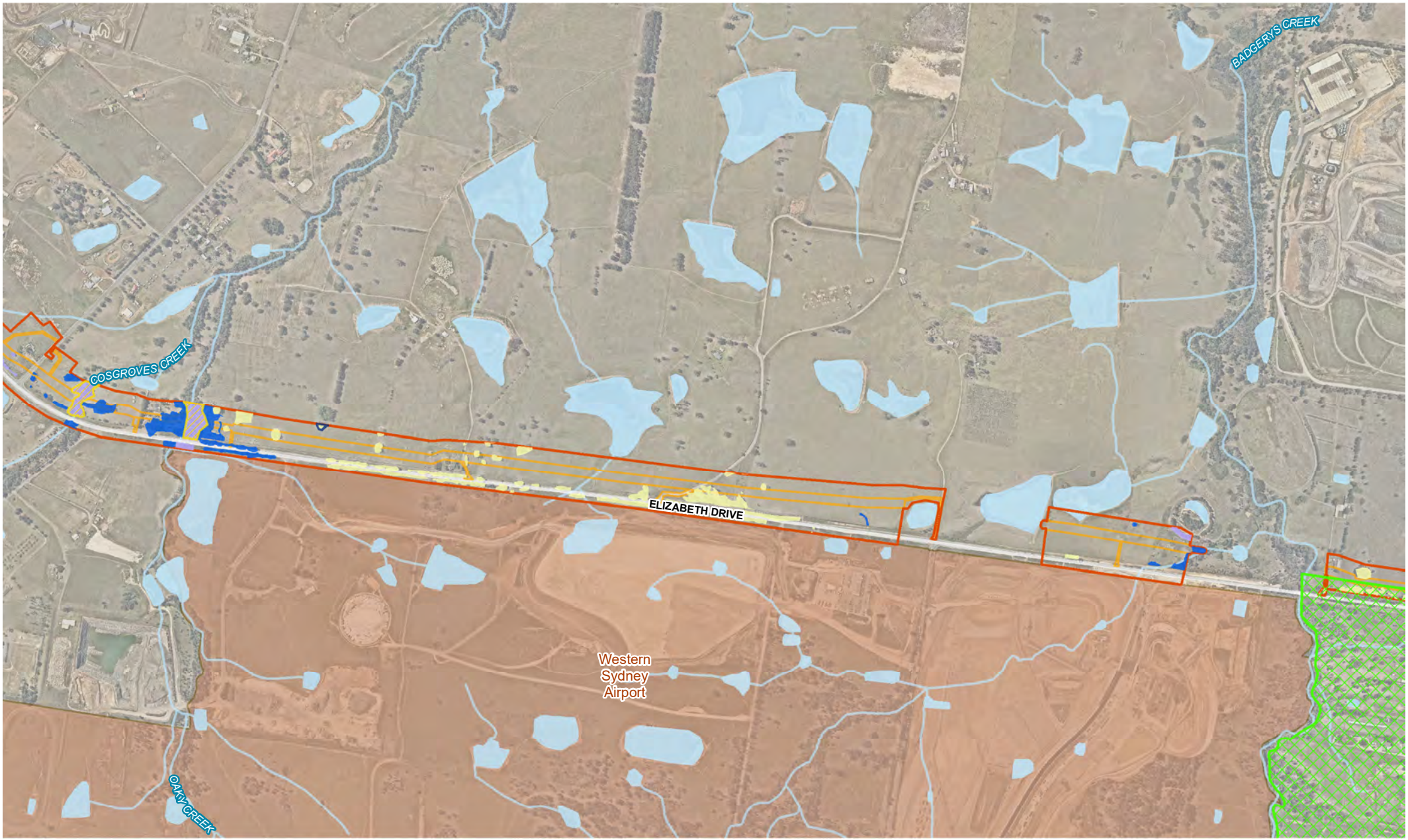
River-Flat Eucalypt Forest (EEC)

Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1d Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

Biocertification
Existing Certified

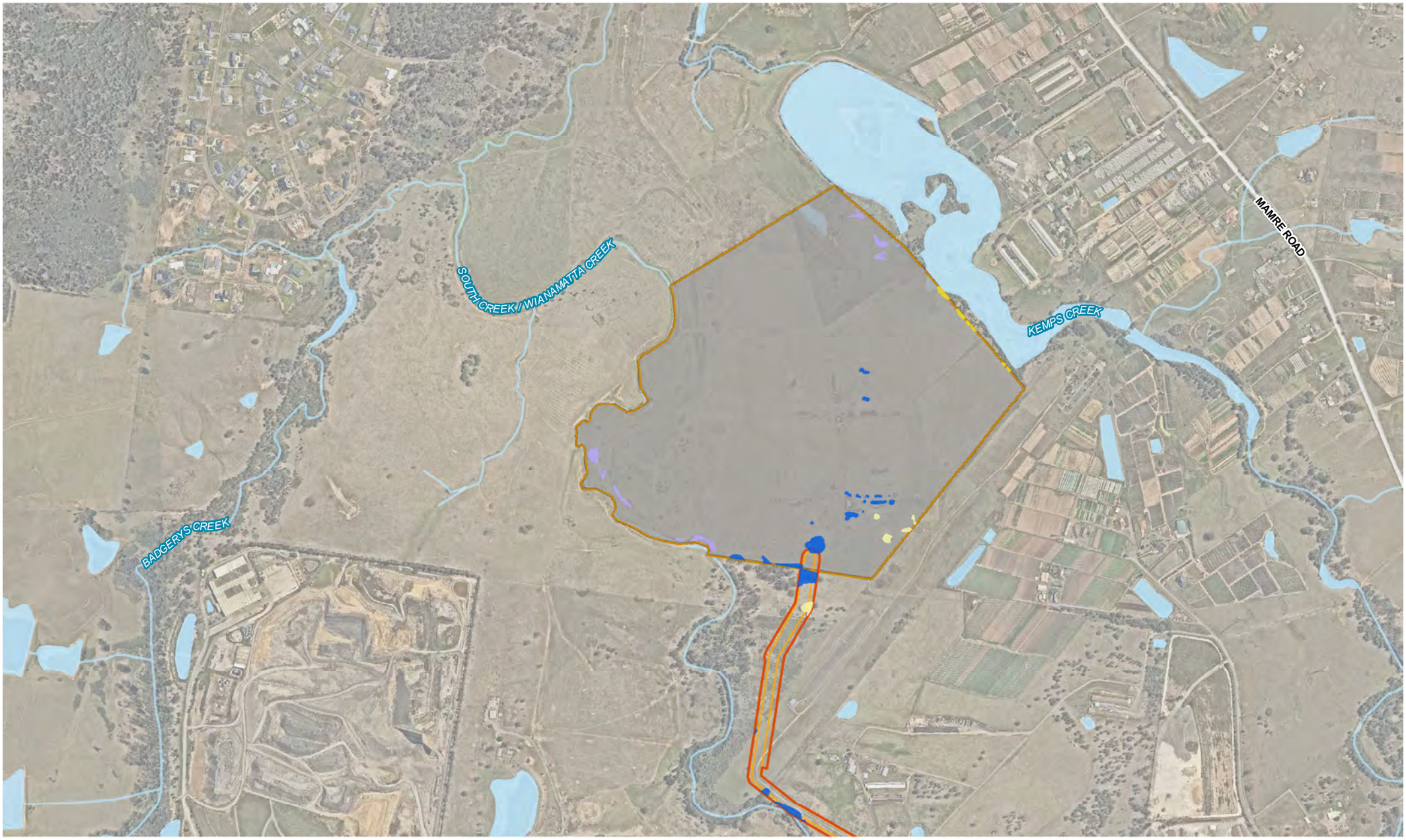
EPBC Act TEC
Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)
Coastal Swamp Oak Forest (EEC)

BC Act TEC
Cumberland Plain Woodland (CEEC)
River-Flat Eucalypt Forest (EEC)
Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1e Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

EPBC Act TEC

Coastal Swamp Oak Forest (EEC)

BC Act TEC

Cumberland Plain Woodland (CEEC)

River-Flat Eucalypt Forest (EEC)

Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1f Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

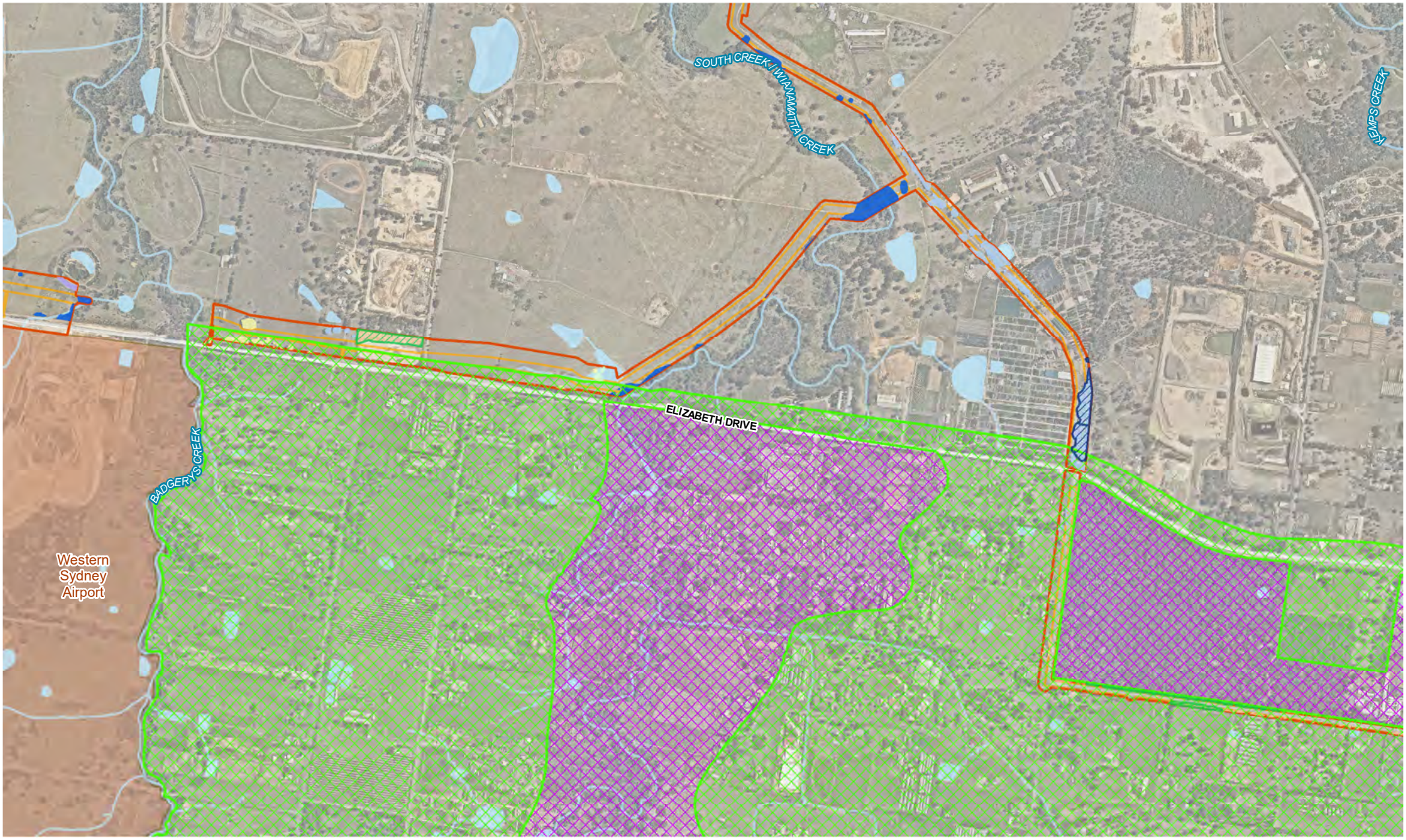


Figure 9-1g Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

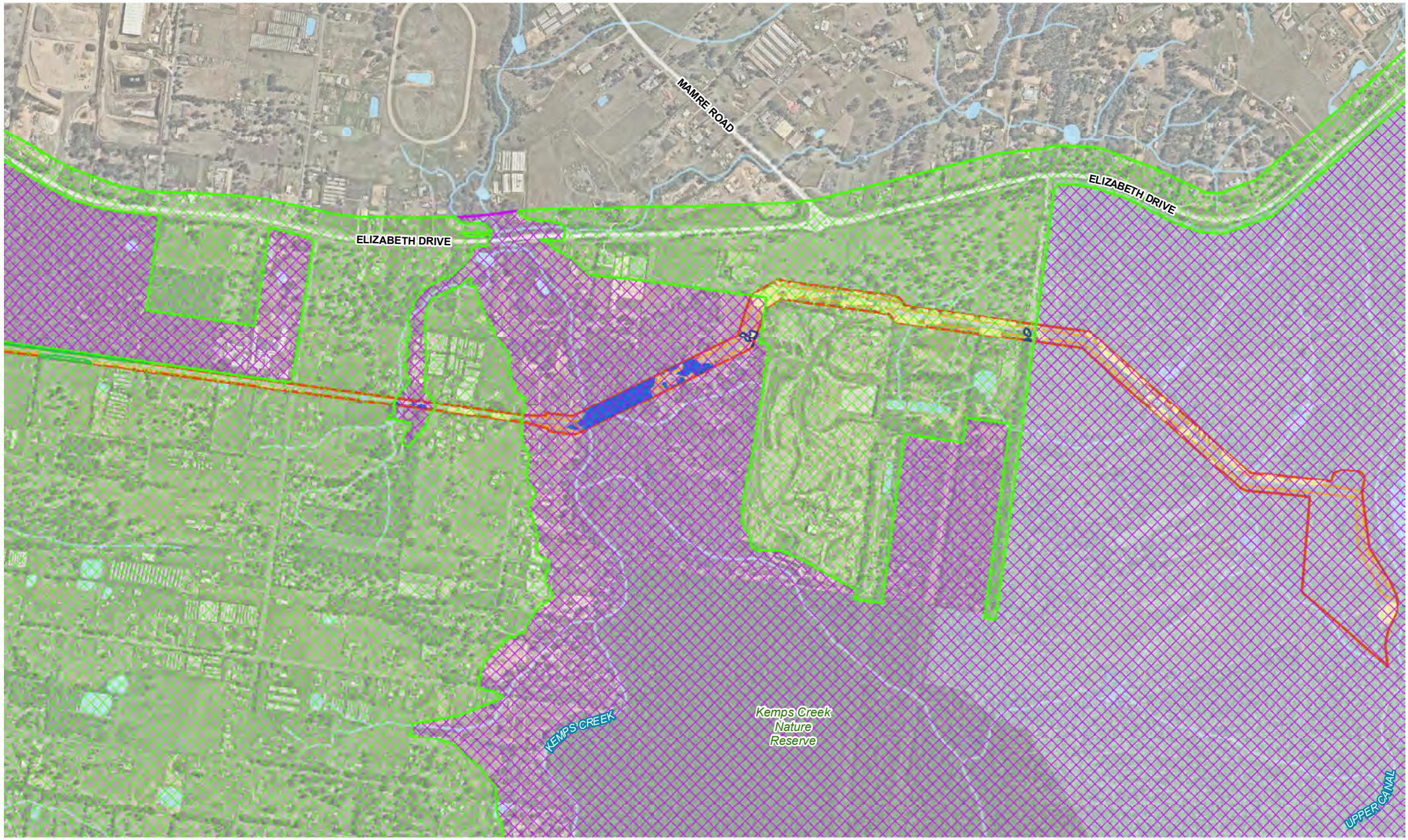
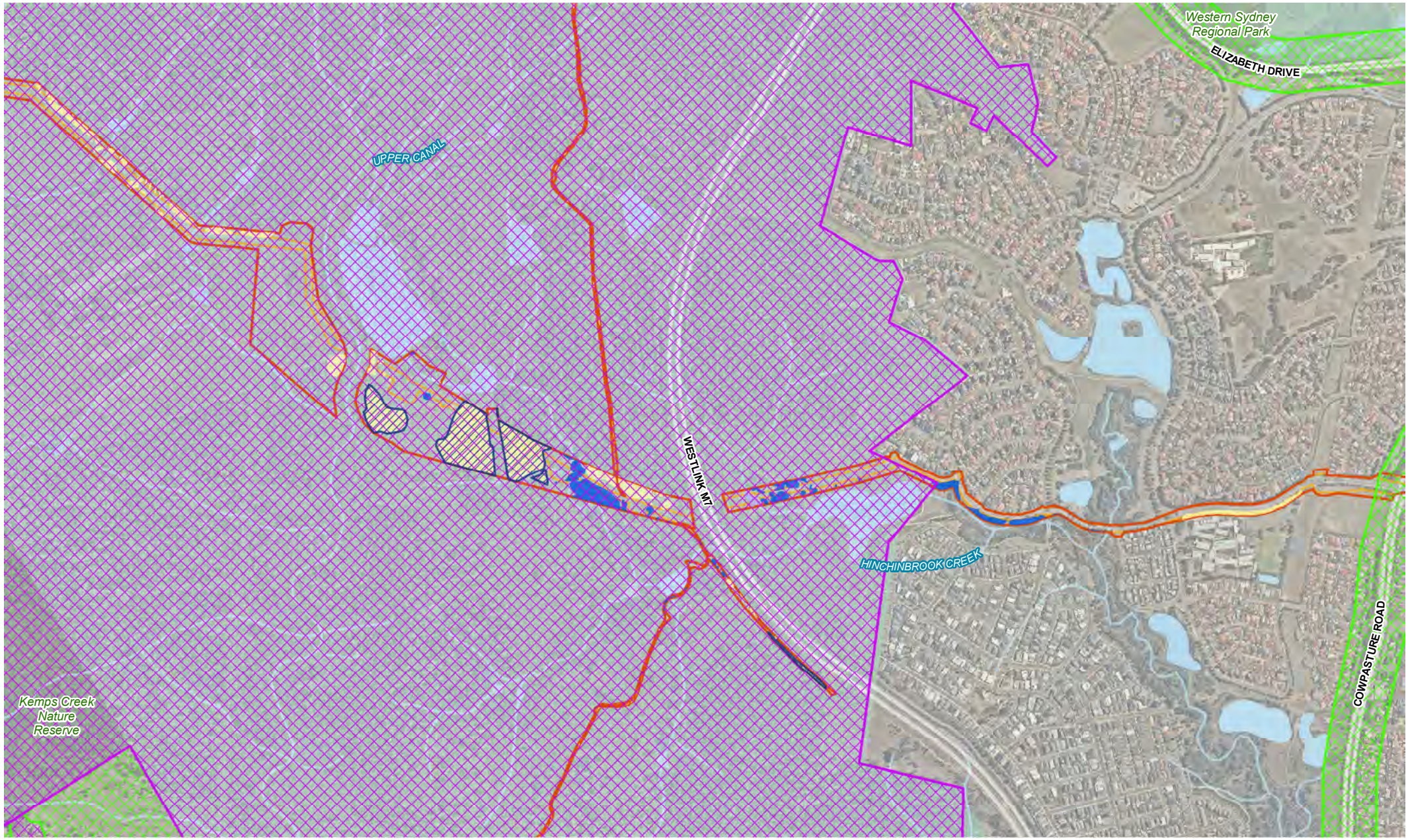


Figure 9-1h Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

Biocertification
Existing Certified
Existing Non Certified

EPBC Act TEC
Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)

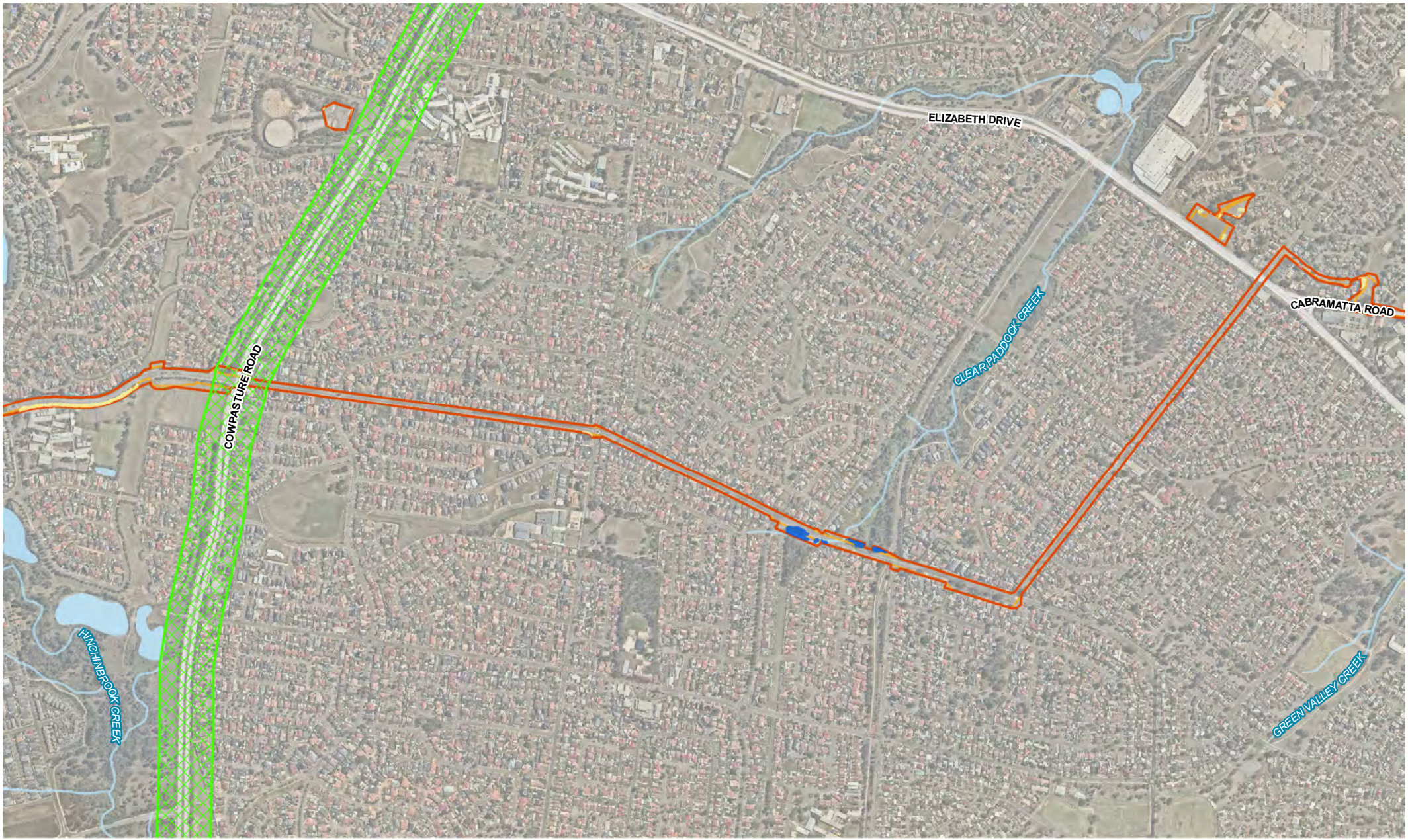
BC Act TEC
Cumberland Plain Woodland (CEEC)

Freshwater wetlands on coastal floodplains (EEC)
River-Flat Eucalypt Forest (EEC)
Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1i Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

Biocertification
Existing Certified

BC Act TEC
Cumberland Plain Woodland (CEEC)
River-Flat Eucalypt Forest (EEC)
Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1j Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Impact Assessment
Impact Area
Watercourse
Waterbody

BC Act TEC

Cumberland Plain Woodland (CEEC)

Swamp Oak Floodplain Forest (EEC)

1:14,000
0 0.25 0.5km

Figure 9-1k Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

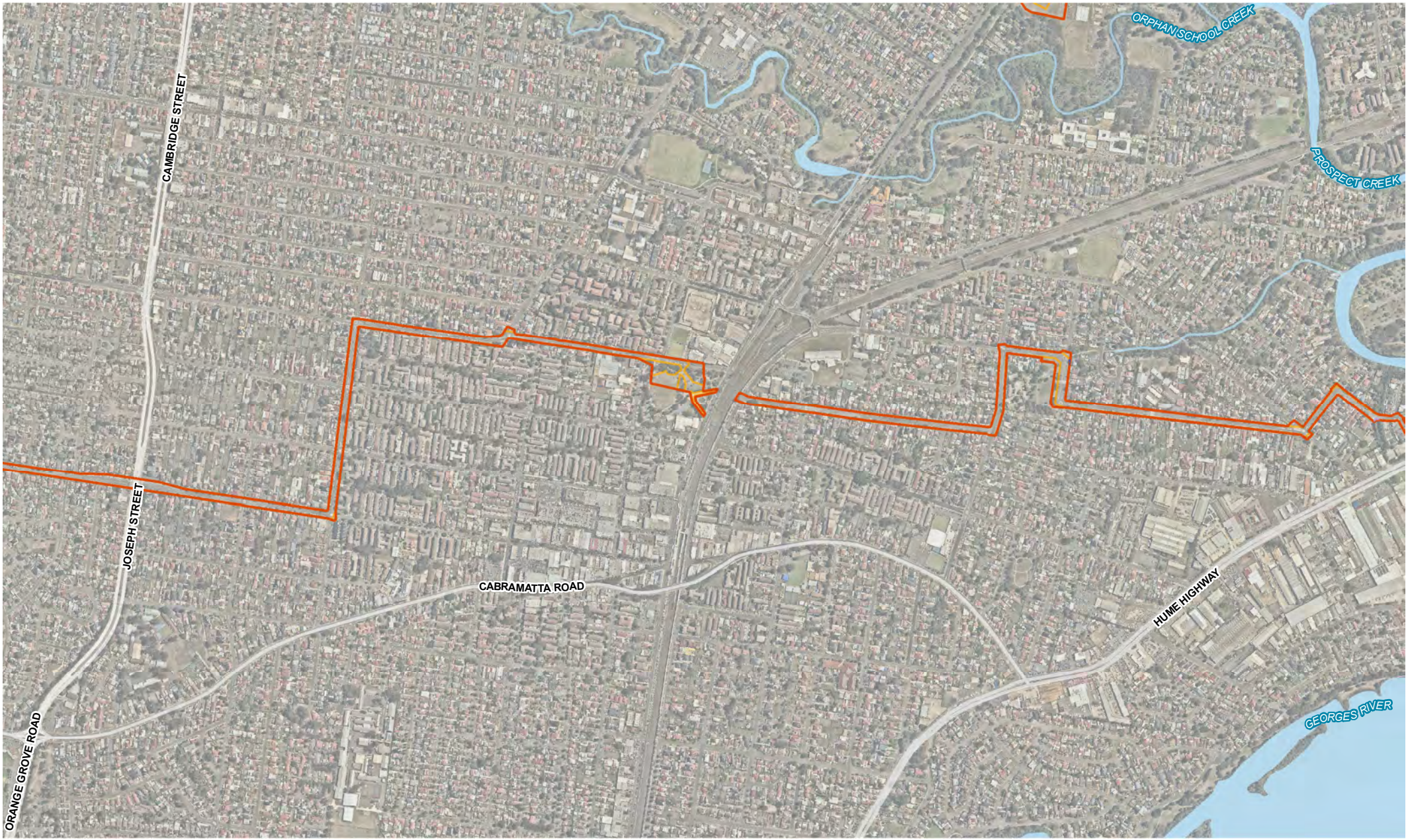
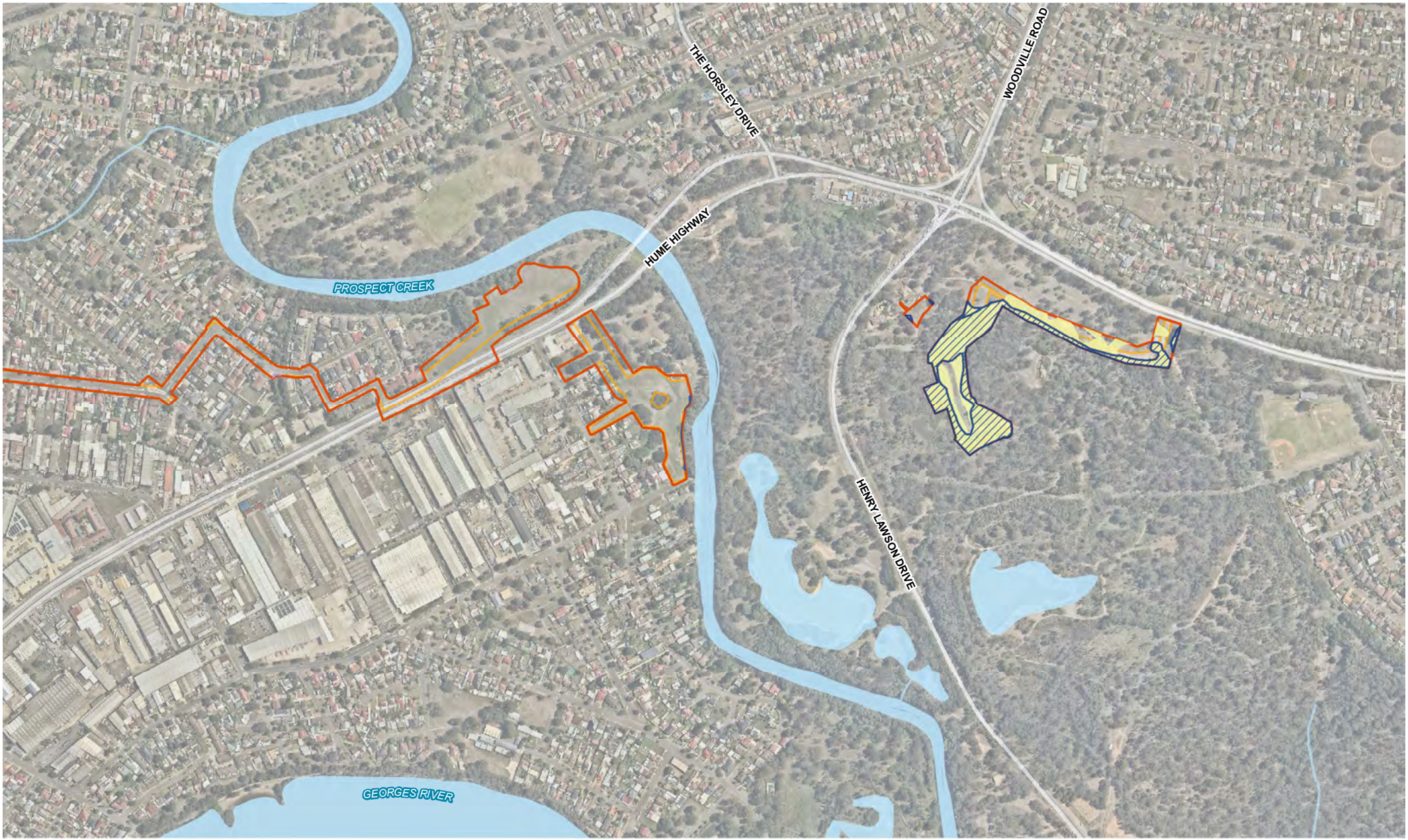


Figure 9-1l Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

EPBC Act TEC

Cumberland Plain Woodland and Shale-Gravel Transition Forest (CEEC)

BC Act TEC

Cumberland Plain Woodland (CEEC)

River-Flat Eucalypt Forest (EEC)

Swamp Oak Floodplain Forest (EEC)

1:9,000

0 0.25 0.5km

Figure 9-1m Existing vegetation communities, threatened flora and direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

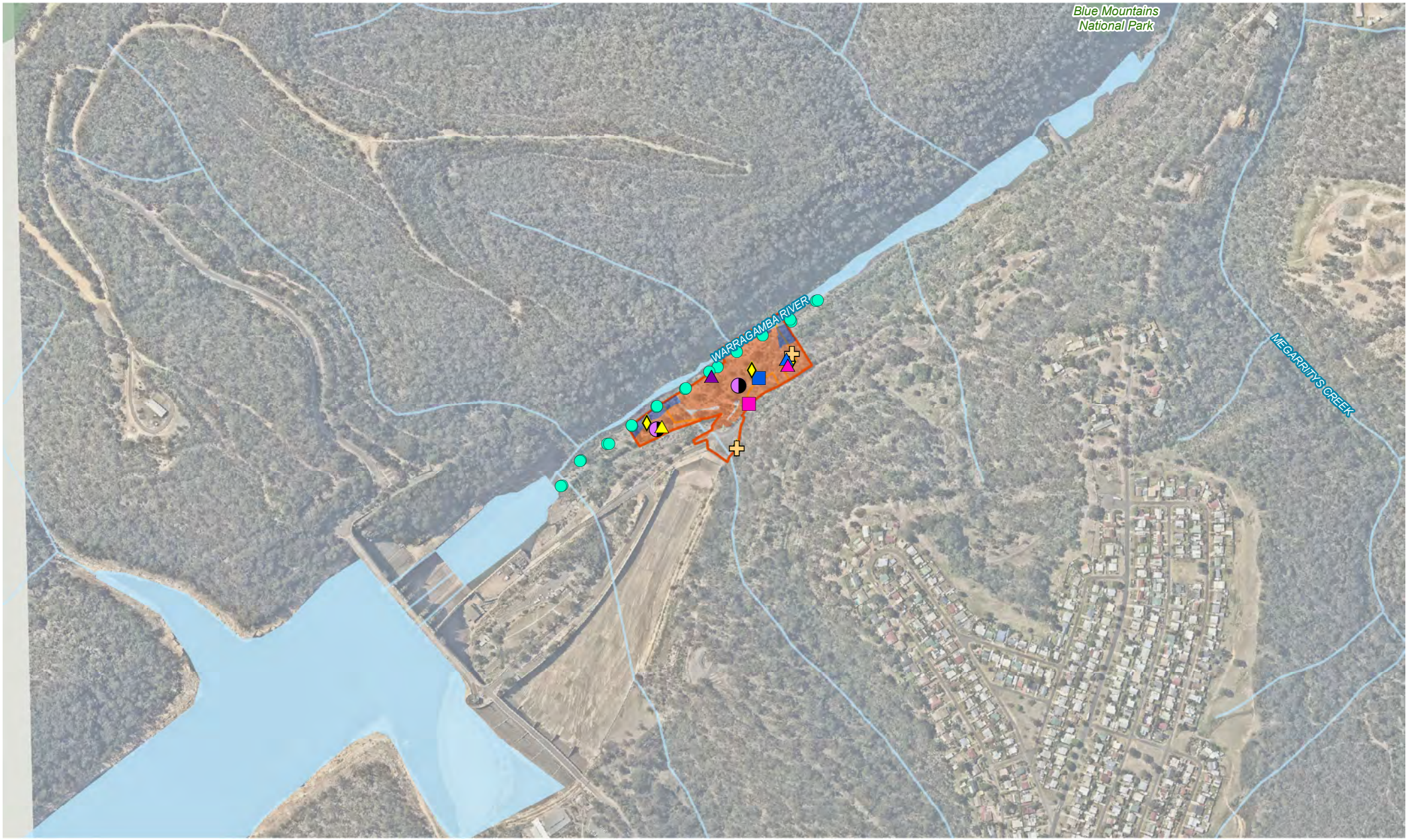


Figure 9-2a Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Impact Assessment
Impact Area
Watercourse
Waterbody

Koala SAT survey

Vegetation zones

Urban Native/Exotic

835: Forest Red Gum - Rough-barked Apple grassy woodland - Thinned

835: Forest Red Gum - Rough-barked Apple grassy woodland - Scattered Trees

1105: River Oak open forest - Thinned

1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest - Intact

1:11,000

0 0.25 0.5km

Figure 9-2b Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

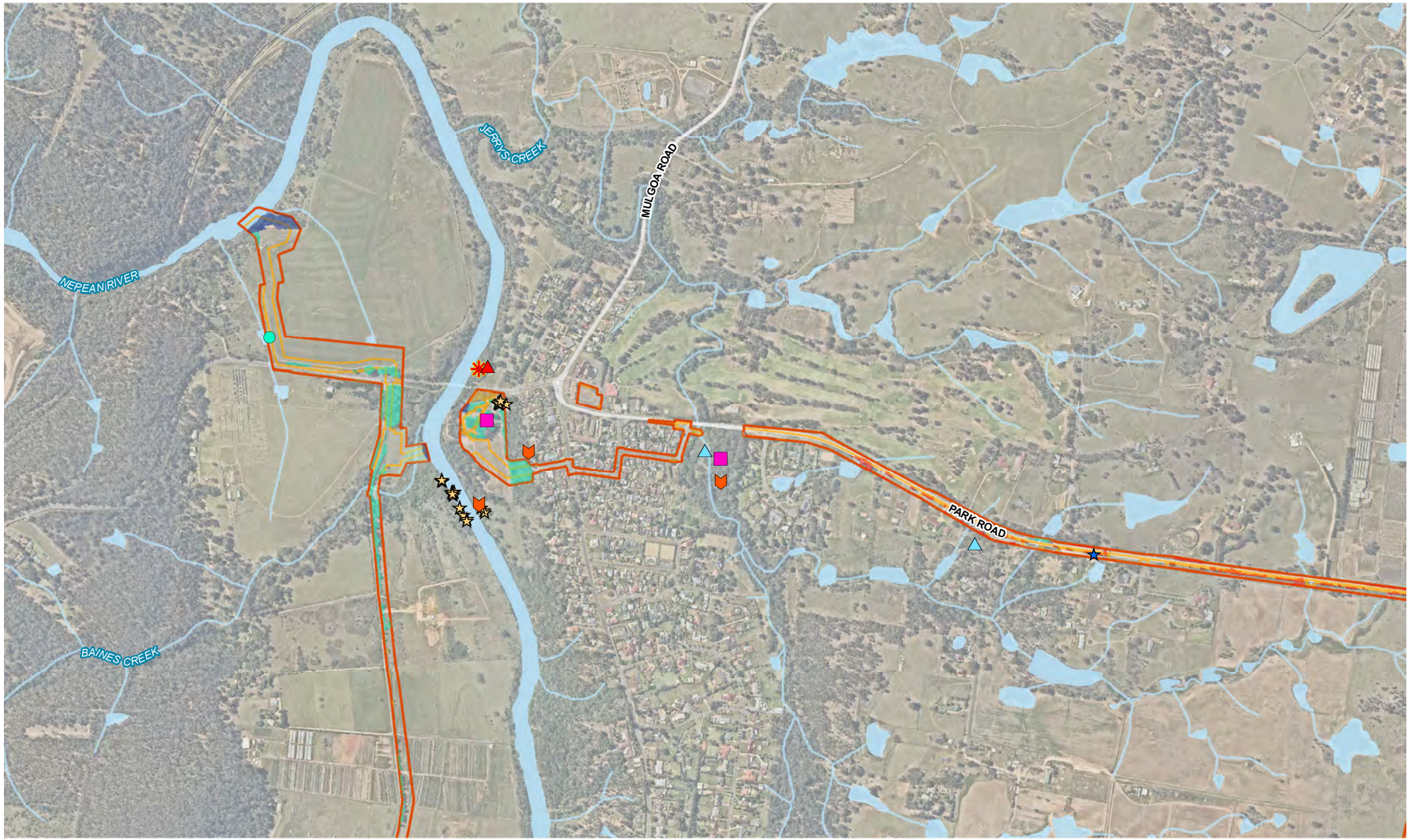
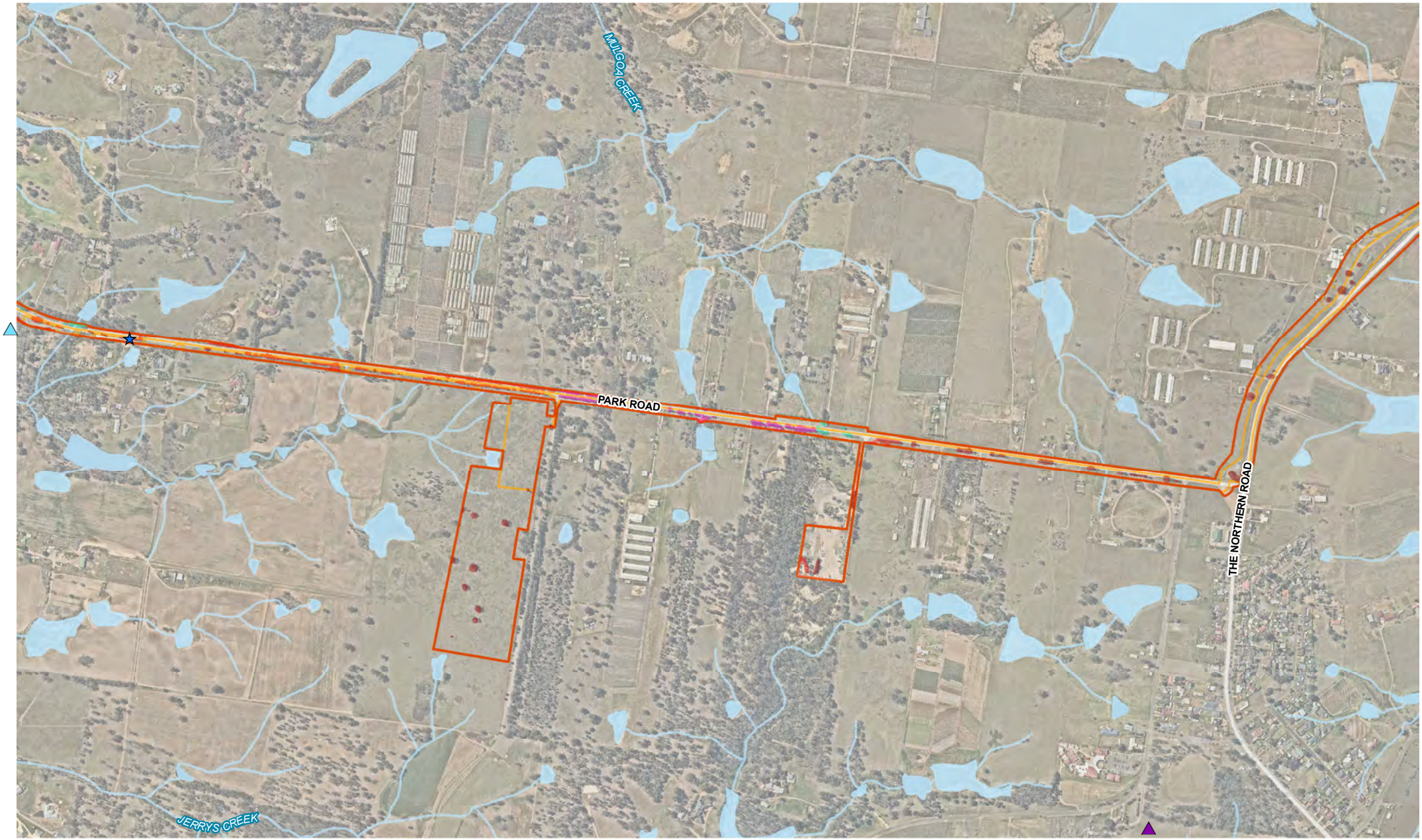


Figure 9-2c Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

Threatened flora record
Marsdenia viridiflora subsp. viridiflora

Threatened fauna record
Square-tailed Kite
White-bellied Sea-Eagle

Vegetation zones
Urban Native/Exotic
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest - Thinned
724: Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest - Scattered Trees
835: Forest Red Gum - Rough-barked Apple grassy woodland - Thinned
835: Forest Red Gum - Rough-barked Apple grassy woodland - Scattered Trees
835: Forest Red Gum - Rough-barked Apple grassy woodland - Intact
849: Grey Box - Forest Red Gum grassy woodland - Scattered Trees
849: Grey Box - Forest Red Gum grassy woodland - Intact
849: Grey Box - Forest Red Gum grassy woodland - Thinned

1:14,000
0 0.25 0.5km

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Figure 9-2d Threatened flora and fauna direct impacts

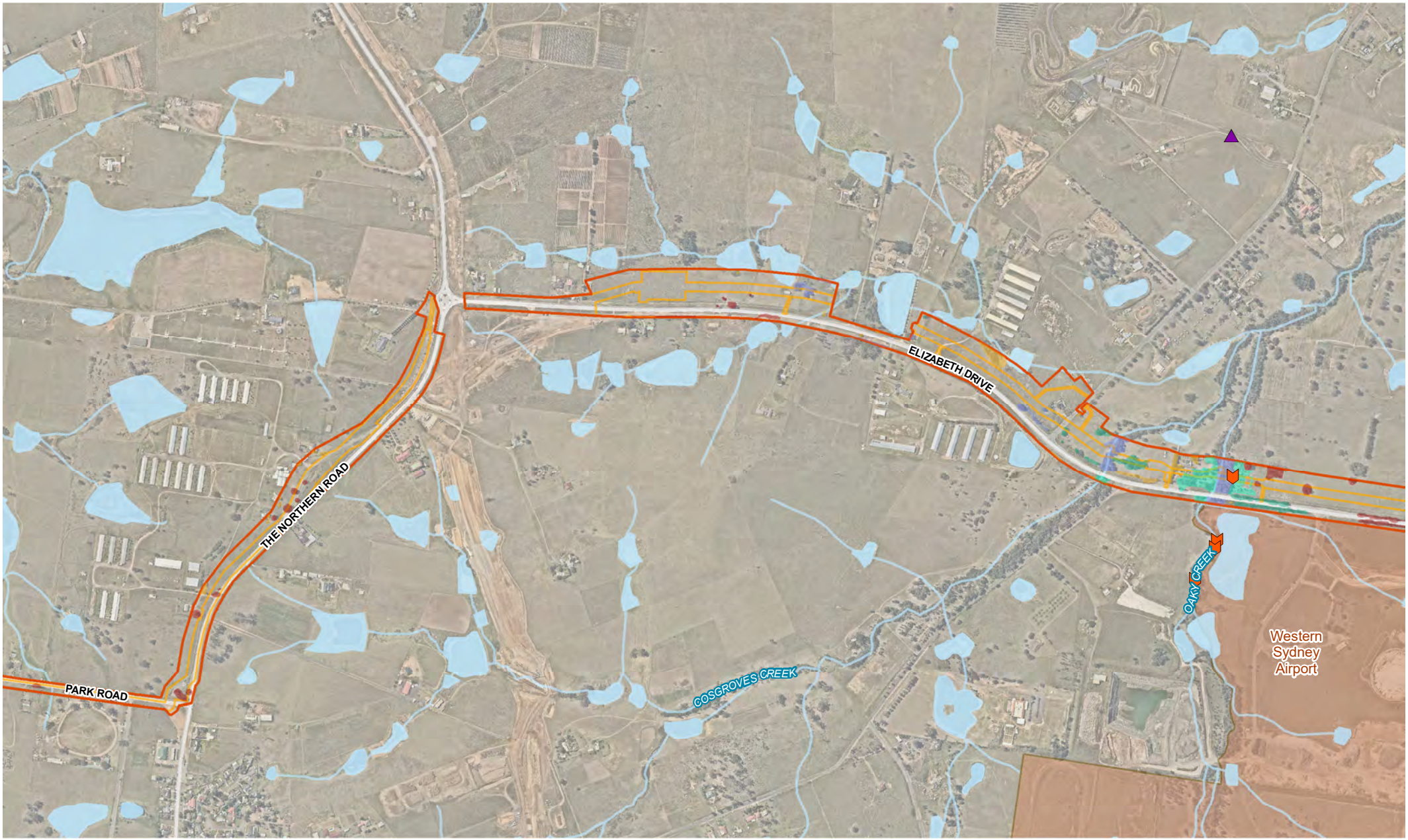


Figure 9-2e Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

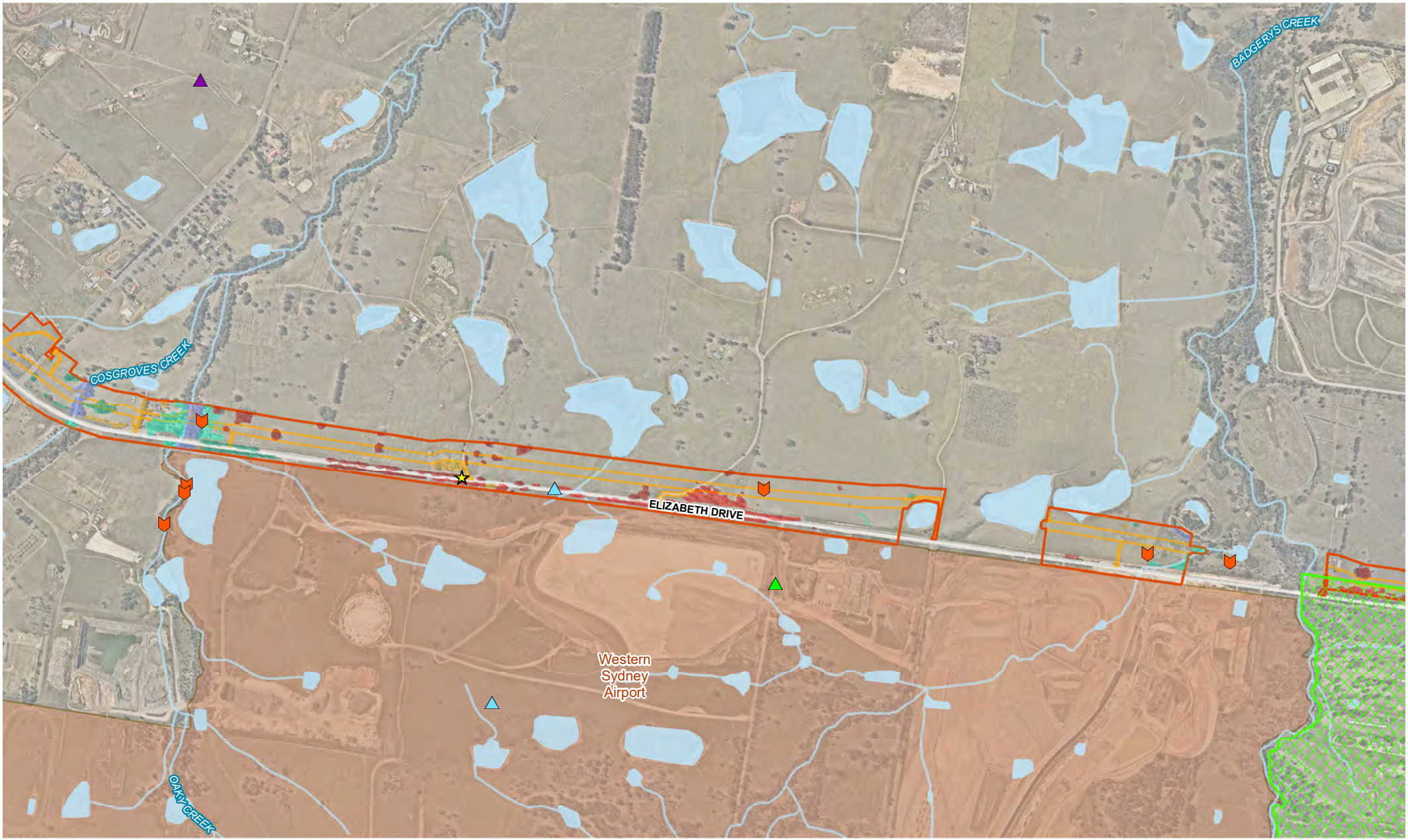
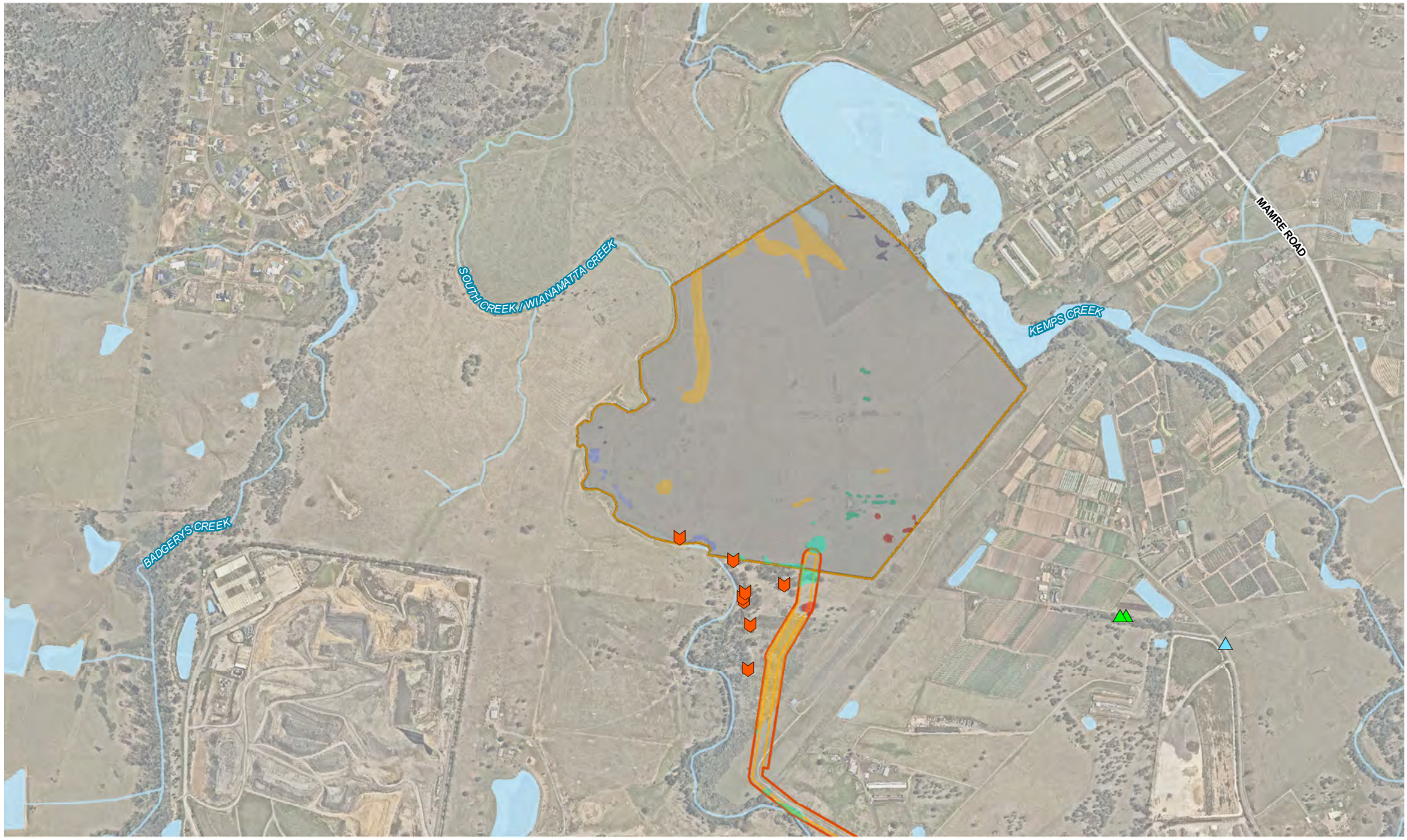


Figure 9-2f Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody
Hollow-bearing tree

Threatened fauna record
Cumberland Plain Land Snail
Square-tailed Kite

Vegetation zones
Urban Native/Exotic

835: Forest Red Gum - Rough-barked Apple grassy woodland - Thinned
835: Forest Red Gum - Rough-barked Apple grassy woodland - Scattered Trees
849: Grey Box - Forest Red Gum grassy woodland - Scattered Trees
849: Grey Box - Forest Red Gum grassy woodland - Thinned
1800: Swamp Oak open forest - Scattered Trees
1800: Swamp Oak open forest - Thinned

1:14,000
0 0.25 0.5km

Figure 9-2g Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

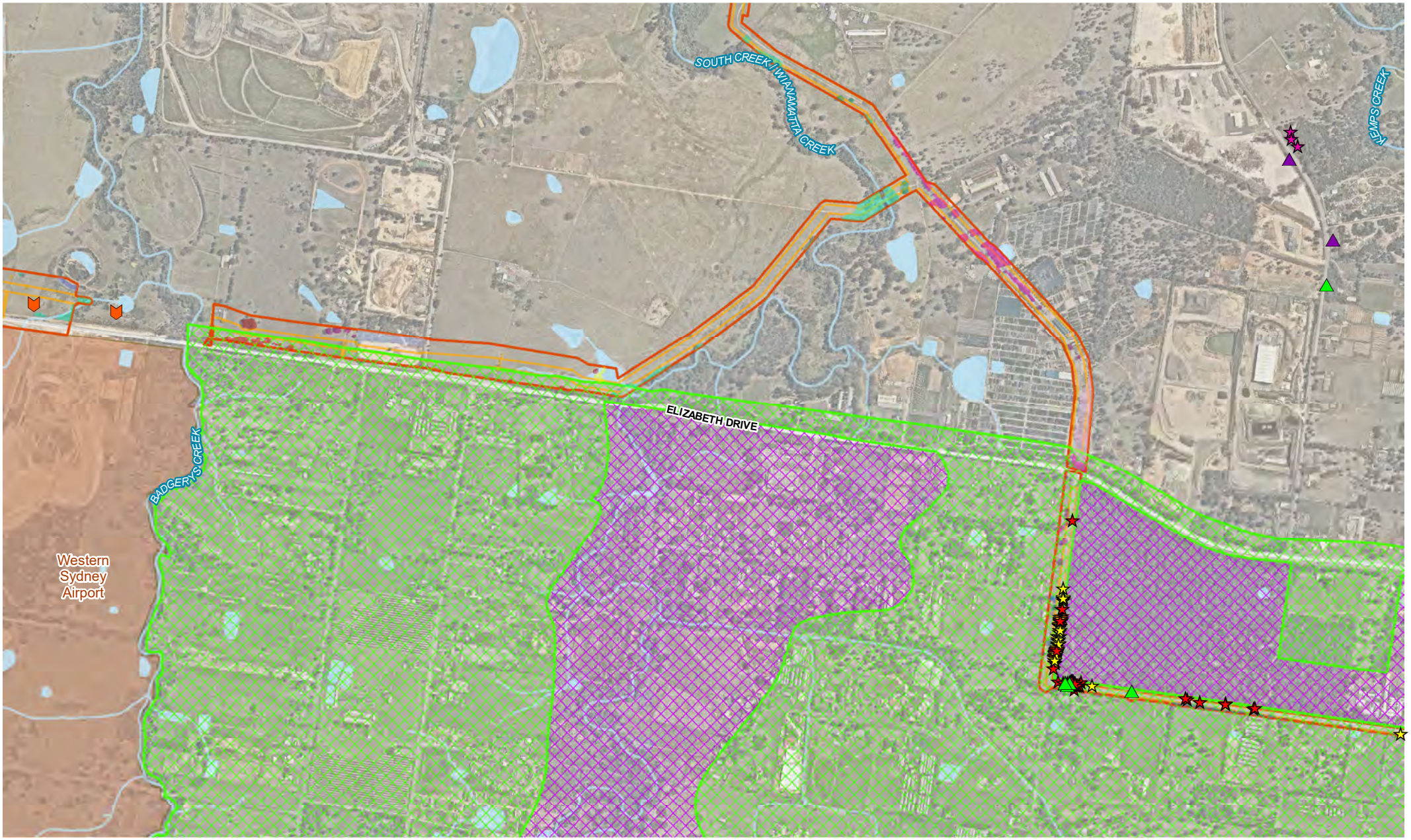


Figure 9-2h Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

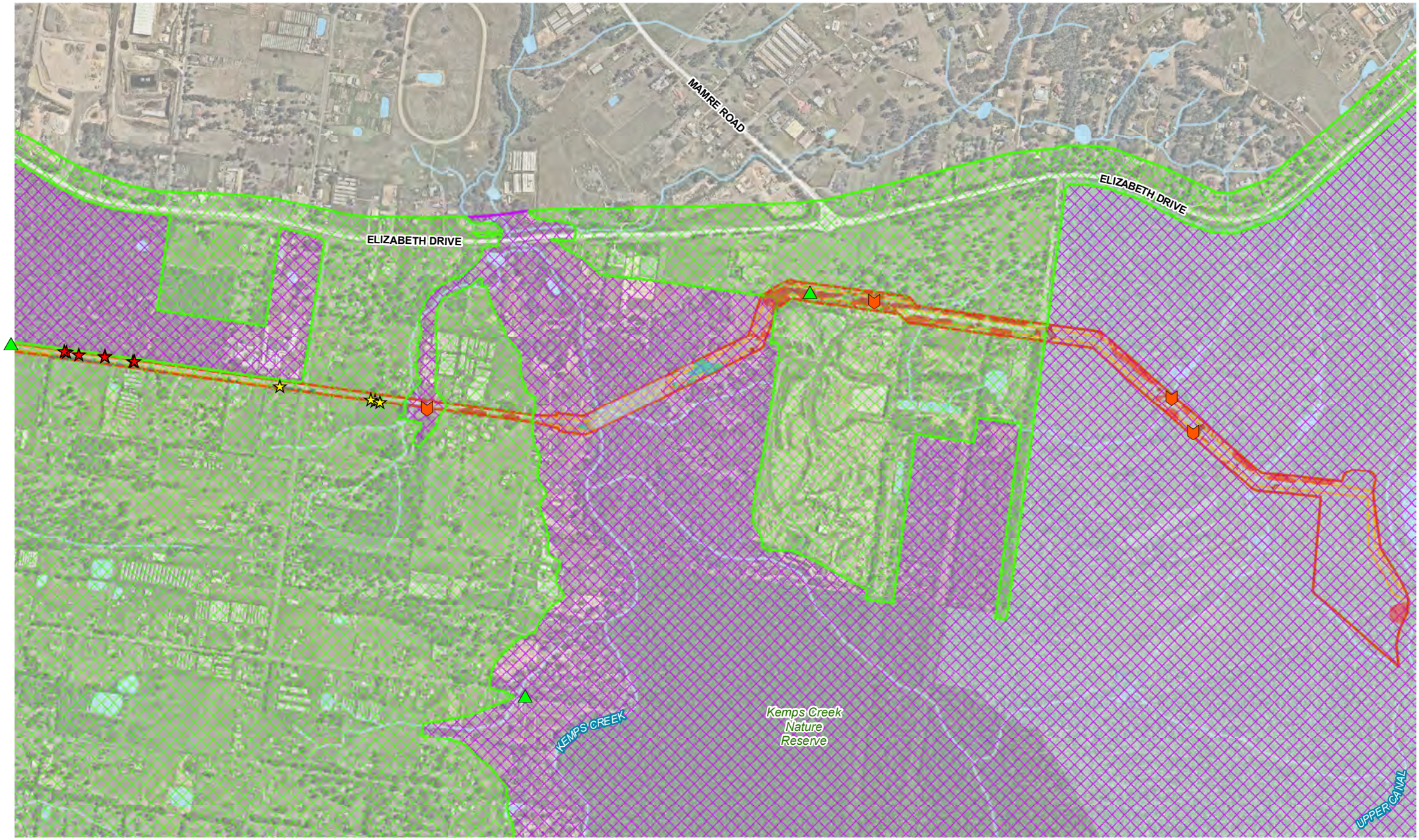


Figure 9-2i Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

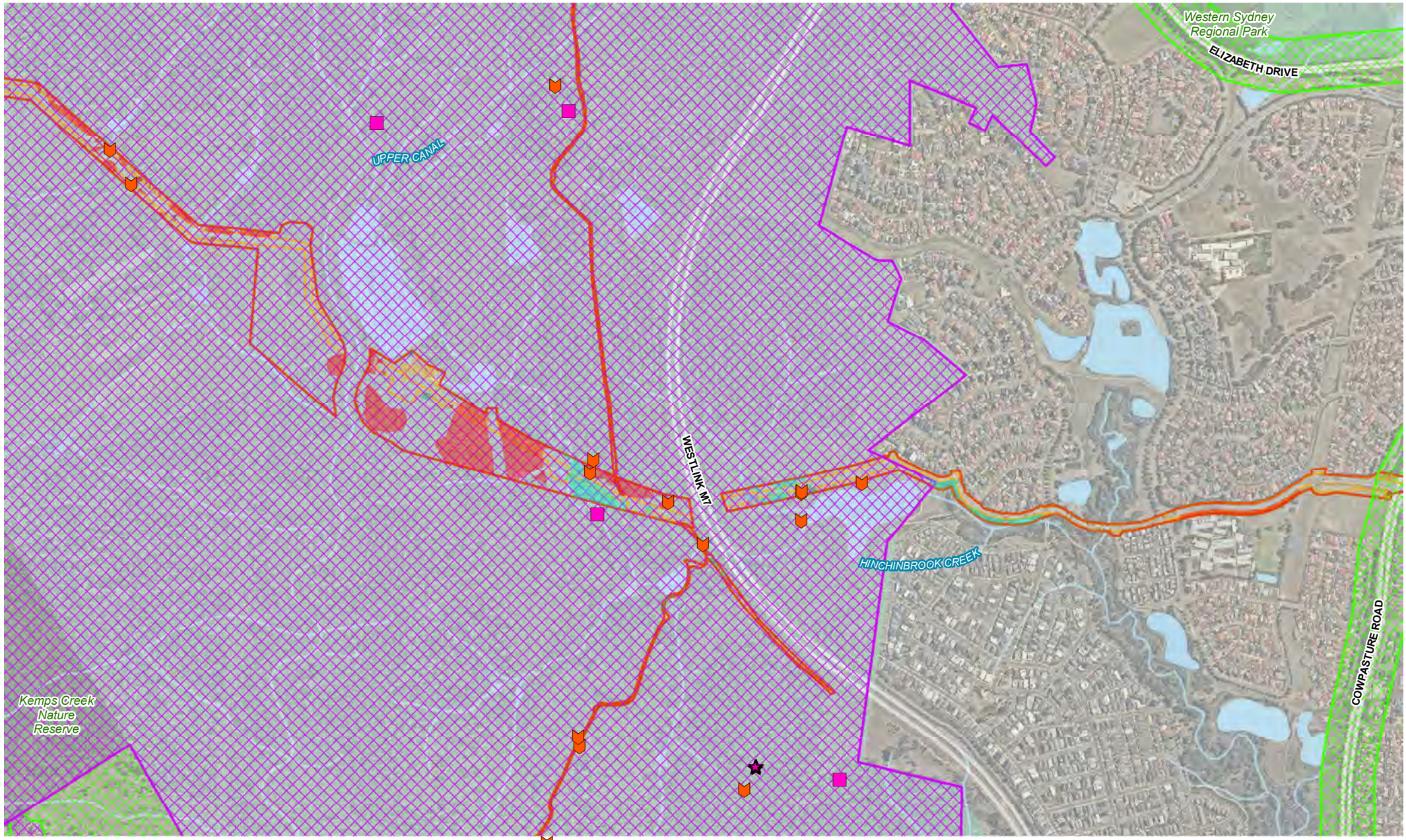


Figure 9-2j Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Figure 9-2k Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Impact Assessment
Impact Area
Watercourse
Waterbody

Vegetation zones

Urban Native/Exotic
849: Grey Box - Forest Red Gum grassy woodland - Scattered Trees
849: Grey Box - Forest Red Gum grassy woodland - Thinned
1800: Swamp Oak open forest - Thinned

1:14,000
0 0.25 0.5km

Figure 9-2I Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

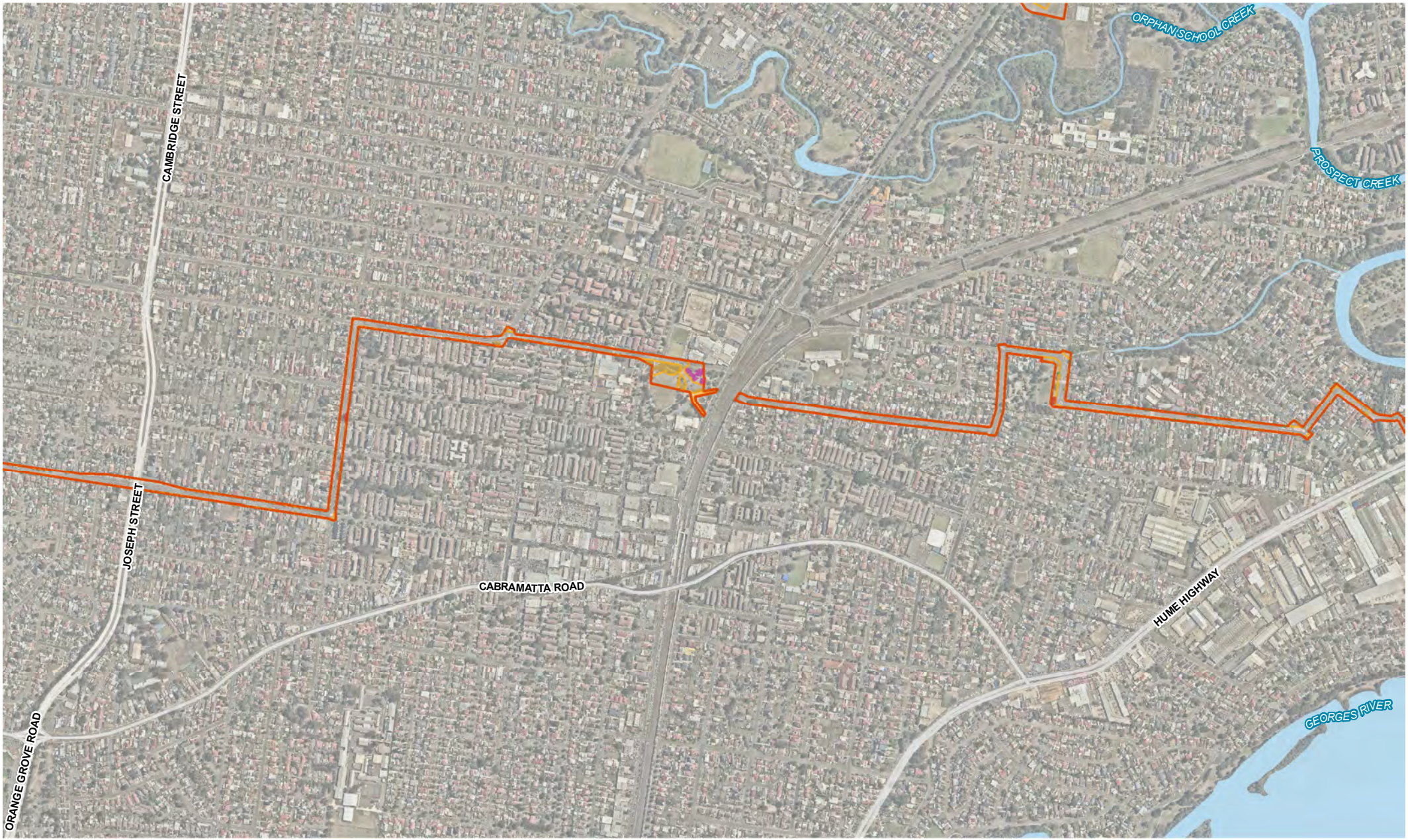
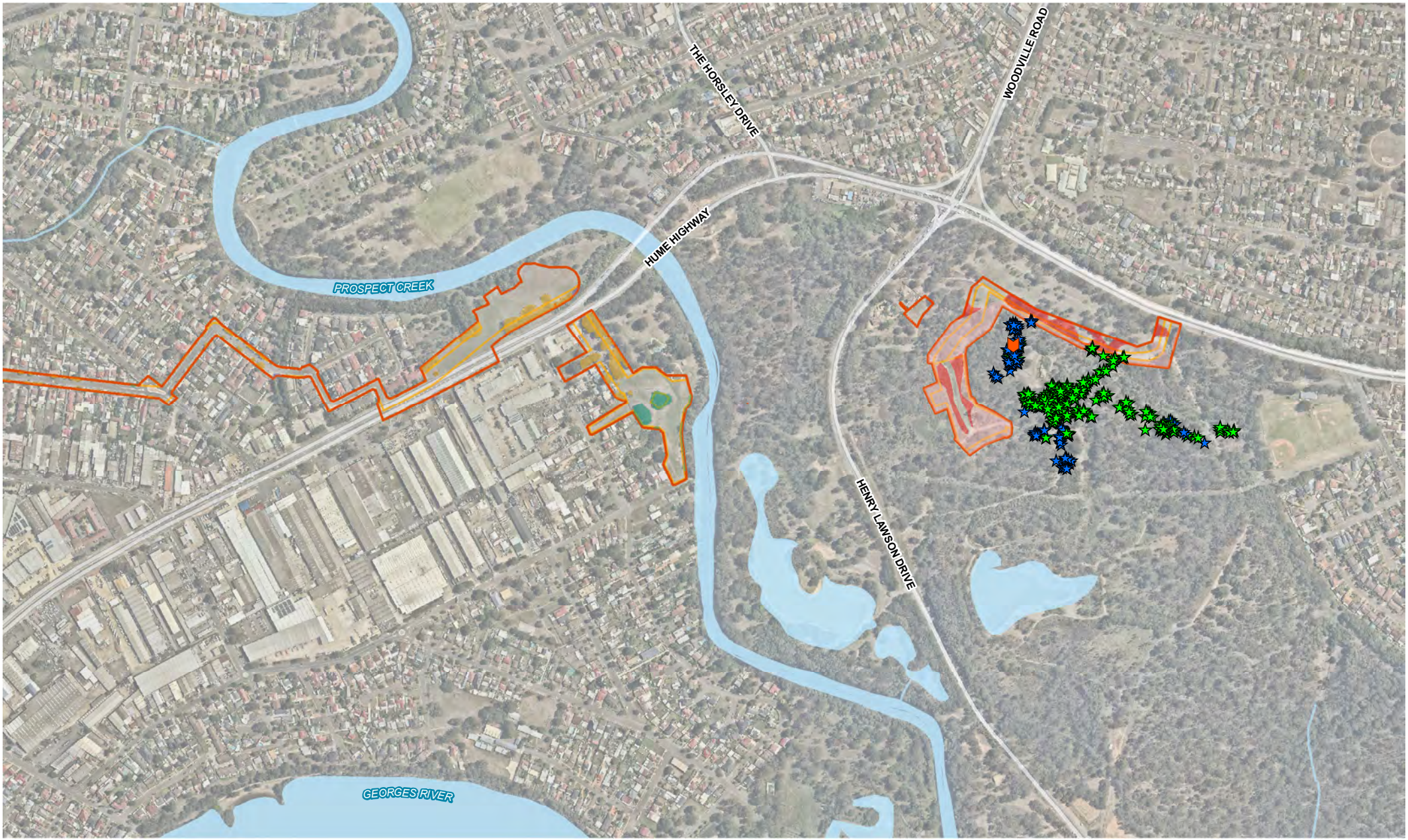


Figure 9-2m Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56



Impact Assessment
Impact Area
Watercourse
Waterbody

Hollow-bearing tree

Threatened flora record

Acacia pubescens

Marsdenia viridiflora subsp. viridiflora

Vegetation zones

Urban Native/Exotic

835: Forest Red Gum - Rough-barked Apple grassy woodland - Thinned

835: Forest Red Gum - Rough-barked Apple grassy woodland - Scattered Trees

849: Grey Box - Forest Red Gum grassy woodland - Intact

849: Grey Box - Forest Red Gum grassy woodland - Thinned

1800: Swamp Oak open forest - Thinned

1:9,000

0 0.25 0.5km

Figure 9-2n Threatened flora and fauna direct impacts

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Indirect impacts

Table 9-11 identifies the PCTs, corresponding TECs and threatened species which may be indirectly impacted by the project.

Table 9-11 Assessment of potential construction-related indirect impacts

Potential indirect impact	Description of impact	Significance of impact
Indirect impacts on adjacent habitat or vegetation within the impact assessment area.	Inadvertent impacts that may occur within this wider area are expected to be most likely during the construction phase of the project, and include: • clearing, or excavation, of vegetation and habitats (including threatened species habitats) outside the approved extents • soil compression, trampling and dumping via access to the impact area • stockpiling of materials outside approved areas • sedimentation • introduction and/or spreading of exotic weed species.	Any inadvertent impacts are likely to be minor and indirect and with the management measures listed in Section 9.1.9 implemented any impacts are also likely to be of low significance. **Summary: Impact not significant.**
Reduced viability of adjacent habitat due to edge effects.	The impact assessment area comprises an additional 23.23 ha of native vegetation (excluding Existing Certified areas), which occurs generally within a further 12.5 m either side of the impact area. As linear infrastructure utilising mainly open trenching construction methods, the project has the potential to increase edge effects to the 23.23 ha of native vegetation in the impact assessment area.	An increase in edge effects will not be significant to the 23.23 ha of vegetation immediately adjacent to the impact area, along the majority of the project alignment, due to the already disturbed and edge effected nature of the vegetation. This assessment also assumes that all remaining native vegetation within the impact assessment area would be impacted by edge effects. With the management measures listed in section 9.1.9 implemented, specifically the requirements to limit disturbance areas to the smallest area practical, edge effects will be further reduced and any residual impacts are also likely to be low. **Summary: Impact not significant.**

Potential indirect impact	Description of impact	Significance of impact
Reduced viability of adjacent habitat due to noise, dust or light spill	The project will emit noise, dust and light during construction. Impacts associated with dust are expected to be negligible as a result of standard construction safeguards, and the construction program not requiring large areas of land to be 'opened-up' at any one time. Noise and light spill impacts at the environmental flows release structure have been addressed above, however the potential for impacts may occur elsewhere along the project alignment. Tunnelling will be used at several locations along the alignment. In these locations noise and light impact will occur 24 hours per day while drilling is undertaken and there is the potential for this to disturb fauna species in the vicinity. Trenching and associated construction activities, such as plant access and deliveries, has the potential to disturb fauna species during the day through noise impacts and may alter foraging or roosting activities.	Where the impact area is in suburban and semi-rural areas, and the construction method consists predominantly of daytime activities, the project's potential impacts associated with noise and light (and potentially vibration) are considered to be minor. There is potential for disturbance to the Grey-headed Flying-fox camp at Nepean River, which occurs at least 160 m from the impact area. Construction activities in this location will include open trenching, and tunnelling across Nepean River, with works to occur during both daytime construction hours, and at night, for a period of 8 to 12 weeks. Construction activities have the potential to disturb the Grey-headed Flying-foxes in this location due to noise and vibration impacts, which depending on the severity of the disturbance, could in a worst-case scenario result in the abandonment of the camp. The noise and vibration assessment in section 11.2 found that noise disturbance is below the threshold for Highly Noise Affected Noise Management Levels (Aurecon Arup, 2020b). As the camp is not a breeding camp, or considered important in accordance with the EPBC Act, no offsetting of potential impacts is required, and no specific management of construction activities to protect the camp is considered necessary. Appendix 6 of the BDAR (Appendix J) provides a detailed assessment of the project's impacts to the Grey-headed Flying Fox in accordance with the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DoE, 2013). **Summary: Impact not significant.**

Potential indirect impact	Description of impact	Significance of impact
Transport of weeds and pathogens to/from the site to/from adjacent vegetation	Indirect impacts associated with the transport of weeds and/or pathogens is considered to be minor as a result of the construction of the project. Standard construction safeguards will be in place to prevent this impact and biosecurity risk from occurring.	While there is a minor potential for the transport of weeds and pathogens to and from areas outside of the impact area, with the proposed management measures in place the potential for substantial novel outbreaks of weeds or pathogens is not considered likely to be at a level that would result in substantial change to ecosystem function. Section 9.1.9 includes management measures to prevent the transport of weeds and pathogens to and from site. **Summary: Impact not significant.**
Loss of breeding habitats	Potential breeding habitats associated with the project's impact area include hollow-bearing trees, and other large old trees that may provide raptor nesting opportunities. Targeted surveys for breeding habitats for those species considered likely to occur within the study area found such resources to be limited within the impact area.	Tree hollows of various sizes were recorded throughout the impact area and will be removed by the project. Hollows identified in the impact assessment area as part of the field survey are shown on Figure 9-2. However, hollows suitable to support breeding of threatened owl and/or cockatoo species were highly limited. Tree hollows that may support potential breeding habitat for threatened microbat species also occur within the impact area and will be removed as a result of the project. The proportion of hollows removed by the project compared to those present within the broader landscape is not considered to be high, based on the hollows mapped during fieldwork, and the data collected as part of the detailed fauna habitat assessments. There is also higher quality habitat adjoining the impact area that is more suitable breeding habitat for hollow dependent species. In particular there is higher quality habitat adjoining the western end of the impact area where the majority of impacted hollows are located. Indirect impacts associated with the loss of breeding habitats are not considered likely to be substantial or significant to any locally occurring threatened, or non-threatened, species. **Summary: Impact not significant.**

The following indirect impacts have also been considered in the assessment and were found to be negligible:

- Inadvertent impacts on adjacent habitat or vegetation within the Lansdowne Reserve biodiversity stewardship site – with proposed measures in place to limit impacts to approved areas, any inadvertent impacts on adjacent habitat and vegetation is negligible.
- Fragmentation of movement corridors – construction activities will be limited to the impact area. While some clearing is required it has been minimised to the extent possible and will be of a width that will not lead to fragmentation of movement.
- Disturbance to specialist breeding and foraging habitat (for example, beach nesting for shorebirds) – breeding habitats have been avoided or where they are near the impact area, measures are proposed to limit indirect impacts such as light and noise.
- Increased risk of fire – construction methodologies will not cause an increased risk of fire. If required, hot works will be undertaken in accordance with Rural Fire Service fire danger rating advice.
- Increase in pest animal populations – construction works will not introduce of provide for an increase in populations of pest animals.
- Increase in predatory species populations – construction activities will not lead to an increase in predatory species populations.
- Bush rock removal and disturbance - no bush rock removal will take place. Bush rock will be maintained onsite to provide microhabitats as part of site rehabilitation.
- Wood collection – no wood collection will occur as a result of the project. Wood will be kept onsite and re introduced as part of site rehabilitation works.
- Rubbish dumping – measures to manage waste, including no disposal on site, will be in place during construction.
- Fertiliser drift – no fertiliser use is anticipated.
- Inhibition of nitrogen fixation and increased soil salinity - based on the low proportion of vegetation removal across the relatively large impact area, and the rehabilitation of areas post-construction, indirect impacts associated with inhibition of nitrogen fixation and increased soil salinity are considered to be negligible.
- Trampling of threatened flora species – disturbance areas will be clearly marked to limit impact to approved areas.
- Increased risk of starvation, exposure and loss of shade or shelter – the impact area has been designed to limit impacts to habitats. In addition, there is higher quality habitat on adjoining land such that increased risk of starvation, exposure and loss of shade or shelter is considered negligible.

Appendix J includes further analysis of these indirect impacts.

Prescribed impacts

Table 9-12 identifies the PCTs, corresponding TECs and threatened species which will experience prescribed impacts from the project.

Table 9-12 Assessment of potential construction prescribed impacts

Potential prescribed impacts	Description of impact	Significance of impact
Impacts on the habitat of threatened species or ecological communities associated with karst, caves, crevices, cliffs, rocks and other features of geological significance.	Sandstone cliffs occur along Warragamba River around the environmental flows release structure, and have the potential to support several threatened species including: • Large-eared Pied Bat • Large Bent-winged-bat • Little Bent-winged-bat • Sooty Owl.	Potential habitat supported by caves, crevices and cliffs occurs in the impact area around the environmental flows release structure at Warragamba. Habitats on the opposite side of the river are supported by similar caves, crevices and cliffs, appear to occur in high condition vegetation and as such are more likely to support higher quality habitats for the target species. Ground survey in this area was not possible. The project has the potential to impact on fauna utilising the high-quality habitats in and surrounding the impact area including impacts to approximately 1.56 ha of vegetation supporting rocky areas. However, these habitats are not limited in the locality, with vegetation of equal or better quality surrounding the site, and the rocky sandstone cliff line habitat being present both upstream and downstream from Warragamba Dam. **Summary: Impact not significant.**

Potential prescribed impacts	Description of impact	Significance of impact
Impacts of development on the habitat of threatened species or ecological communities associated with human made structures and non-native vegetation.	The disused tunnel and existing man-made vertical shaft present at the environmental flows release structure have the potential to support threatened microbat species. It has been assumed these support Large-eared Pied Bat, Large Bent-winged-bat and Little Bent-winged-bat. An abandoned building present on the AWRC site has the potential to support roosting habitat for threatened microbat species, as do any large culverts present along the project alignment. Non-native vegetation has been mapped across the impact area however never in sufficient quantities, or suitable locations to provide valuable habitat to threatened species.	The disused tunnel will not be impacted by the project. The vertical shaft will be impacted by tunnelling and construction of the environmental flows release structure and ancillary structures. Stag watching undertaken in October 2020 did not record any microbats exiting the man-made structure, and analysis of ultrasonic call data suggests no roosting activity is occurring in the impact area. Impacts to threatened species of microbats associated with the man-made structures around the environmental flows release structure are not considered to be substantial or significant. Any potential impacts can be mitigated through installation of passive exclusion measures on the open shaft prior to any impact occurring. Impacts to any microbats present within the abandoned building or possible large culverts can also successfully mitigated through pre-clearance surveys and/or installation of passive exclusion measures prior to any impact. The project will not result in impacts to threatened species or ecological communities associated with non-native vegetation. **Summary: Impact not significant.**

Potential prescribed impacts	Description of impact	Significance of impact
Impacts of development on the connectivity of different areas of habitat for threatened entities	The impact area crosses several features that provide limited opportunities for movement of biodiversity across the landscape. Major connectivity features associated with the impact area include: • Prospect Creek and Lansdowne Reserve • Western Sydney Parklands, Kemps Creek and Hinchinbrook Creek • South Creek and Badgerys Creek • Nepean River • Warragamba River and the Greater Blue Mountains Area. The project will not result in the creation of barriers which would prevent the movement of threatened species between habitats critical for the maintenance of their life cycle.	None of the connectivity features listed form key components that link areas of habitat for threatened species, and the project will not result in a permanent barrier to connectivity in any of these locations. Connectivity will be generally disrupted by the 15 m to 30 m wide pipeline corridor, however this will only represent an obstacle to the least mobile of species, such as Cumberland Plain Land Snail and Dural Land Snail. The pipeline corridor will be revegetated following construction. This will alleviate connectivity impacts to ground-dwelling snails and other less mobile species. **Summary: Impact not significant.**
Impacts of development on water quality, water bodies or any hydrological processes that sustain threatened entities	The project will result in an increased water volume in the Nepean River as a result of the proposed 50 ML/day and 100 ML/day treated water releases. This aspect of the project has the potential to impact upon Camden White Gum and River-flat Eucalypt Forest TEC.	Appendix J includes a detailed analysis of the potential for the project to impact upon threatened entities as a result of changes to water quality, water bodies and hydrological processes. This analysis was supported by the water quality and hydrological technical assessment prepared for the project as summarised in Chapter 8. This assessment concluded that the project is unlikely to result in significant impact to any threatened entities. **Summary: Impact not significant.**

Potential prescribed impacts	Description of impact	Significance of impact
Impacts of vehicle strikes on threatened fauna or fauna that are part of a TEC as a result of the project	The project may result in increased vehicle traffic during the construction phase of the project along the entire alignment, and during the operational phase. However, the majority of the alignment occurs in locations that are generally urbanised, with only isolated areas free of traffic at the current time.No threatened species of animals, or animals that make up part of a TEC, are commonly associated with the project area to the degree where an increase in vehicle strike is likely to occur.	The likelihood of vehicle strike occurring as a result of the project is considered very low, and will not negatively impact upon the persistence of native fauna species at the local or bioregional scale. **Summary: Impact not significant.**

The following prescribed impacts were assessed but are considered not relevant to the project:

- Impacts of development on the habitat of threatened species or ecological communities associated with non-native vegetation.
- Impacts of vehicle strikes on threatened species of animals or on animals that are part of a TEC.
- Impacts of wind turbine strikes on protected animals.
- Impacts of the development on movement of threatened species that maintains their life cycle.

Further analysis of these prescribed impacts is provided in Appendix J.

Groundwater dependent ecosystems

Potential impacts to GDEs from the project have been assessed by Aurecon Arup in the Upper South Creek AWRC Groundwater Impact Assessment (Aurecon Arup, 2021c). The report notes that construction of the proposed AWRC and pipelines have the potential to impact the groundwater systems in several ways, including:

- induced drawdowns from required dewatering activities during trenching works, temporarily reducing the availability of groundwater for GDEs and surrounding groundwater users
- disruption of surface water and groundwater connectivity.

Table 9-13 lists the GDEs which will be potentially impacted by the project. Given the scale and nature of the excavations, Table 9-13 indicates the potential for low level impacts to occur. Where GDEs listed in section 9.1.3 are not listed in Table 9-13 no impact is anticipated to occur to those GDEs.

Table 9-13 Potential impacts to GDEs within and surrounding the impact assessment area

PCT	TEC	Location description	Direct impacts to GDEs (ha)
High potential for groundwater interaction			
724	Shale Gravel Transition Forest	At Kemps Creek north of Elizabeth Drive and south of Park Road. Both occurrences are part of larger patches adjacent to the impact area.	0.19
835	River-flat Eucalypt Forest	Surrounding the Kemps Creek watercourse, Cosgroves Creek, south of Park Road (with patch of PCT 724), and along Nepean River.	0.83
849	Cumberland Plain Woodland	In Lansdowne Reserve, and south of Park Road.	0.66

PCT	TEC	Location description	Direct impacts to GDEs (ha)
1083	Not a TEC	At the environmental flows release structure at Warragamba River.	0.89
1105	Not a TEC	At the environmental flows release structure at Warragamba River.	0.02
1181	Not a TEC	Adjacent to Bents Basin Road on the edge of a large patch of intact vegetation.	0.02
1800	Swamp Oak Floodplain Forest	Surrounding Cosgrove Creek and Oaky Creek.	0.12
Moderate potential for groundwater interaction			
724	Shale Gravel Transition Forest	Present at Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.	0.07
835	River-flat Eucalypt Forest	Present surrounding Clear Paddock Creek.	0.07
849	Cumberland Plain Woodland	Present along Park Road as part of a larger patch of vegetation.	0.02
Low potential for groundwater interaction			
724	Shale Gravel Transition Forest	Present at Kemps Creek north of Elizabeth Drive as part of larger patches adjacent to the impact area.	0.17

Section 9.1.9 includes management measures for impacts on GDEs. With these measures in place impacts will be localised to trenching activities, launch and receival pits and where other excavations take place on the AWRC site. The impacts will be temporary during construction. Measures such as reinstating natural ground level and minimising the time excavations remain open will reduce the duration and level of impact such that overall construction impacts on GDE's will be low.

Impacts to MNES

Appendix J provides a detailed description of the impact to MNES. Table 9-14 summarises the residual impacts to MNES. These impacts are part of, and not in addition to, the direct, indirect and prescribed impacts outlined in section 9.1.5. The species and communities that have triggered the project being declared a controlled action are asterisked, with areas of habitat or individuals impacted identified.

Table 9-14 Residual impacts to MNES

Residual project impact	Habitat or individuals impacted	Impact to MNES
Removal of 13.77 ha of native vegetation	• * Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (1.88 ha) • Coastal Swamp Oak (Casuarina glauca) Forest • Camden White Gum • Downy Wattle • Spiked Rice-flower • Sydney Bush-pea • Dural Land Snail • Grey-headed Flying-fox • Koala • Large-eared Pied Bat • * Regent Honeyeater (13.77 ha potential forage habitat) • * Swift Parrot (13.77 ha potential forage habitat)	Habitat removal, loss of individuals, loss of connectivity. Impact not significant.
Indirect impacts: noise, vibration, dust, weed invasion	• Downy Wattle • Sydney Bush-pea • Dural Land Snail • Grey-headed Flying-fox • * Regent Honeyeater • * Swift Parrot	Temporary disturbance to individuals and/or permanent impacts to habitat quality. Impact not significant.
Altered hydrology	Camden White Gum	Loss of individuals and habitat. Impact not significant.
Fragmentation of habitats	• Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest • Coastal Swamp Oak (*Casuarina glauca*) Forest • Spiked Rice-flower • Sydney Bush-pea • Dural Land Snail	Increased edge effects and potential isolation. Impact not significant.

Impacts of the project on terrestrial biodiversity related MNES have been determined to not be significant, in accordance with Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DoE, 2013). As such, offsetting in accordance with the EPBC Act Environmental Offsets Policy (DSEWPC, 2012) and the EPBC Act is not required. This impact assessment has been made based on the technical data and detailed assessment provided in the BDAR in Appendix J. The assessment has not identified any impacts which are unknown, unpredictable or irreversible.

Impacts to all MNES will however be offset in accordance with the NSW BOS through either direct establishment of biodiversity stewardship sites to generate biodiversity credits to offset the project's impacts, through securing biodiversity credits from the open market, or from payment to the Biodiversity Conservation Fund. Section 9.1.10 provides a summary of the offsets required for the project.

Management measures and offsetting have been proposed and are considered to effectively manage the level of impact expected from the project. They are based on statutory and guideline requirements with Sydney Water committed to funding the measures and offsetting as outlined in section 9.1.10. With the proposed measures and offsetting in place residual impacts to MNES are not expected as a result of the project.

Biodiversity certification

Specific Relevant Biodiversity Measures (RBMs) prescribed by the Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006 (Biodiversity Certification Order) have been addressed in the BDAR and are summarised below. The Biodiversity Certification Order outlines 41 conditions, known as the RBMs, to ensure consistency with the biodiversity certification for the growth centres during future development. Several of these RBMs are relevant to the project including:

- RBM 8 and RBM 11 relating to removal of vegetation in non-certified land
- RBM 12 relating to removal of vegetation within special provision area
- RBM 17 relating to potential population of Downy Wattle (*Acacia pubescens)*.

RBM 8 and RBM 11 relate to the removal of 'existing native vegetation' from Existing Non-Certified land and provide details on offsetting requirements for any impacts that may occur.

RBM 8 states that the clearing of any existing native vegetation in the Existing Non-Certified land will be offset by:

a) *the protection of an equal or greater area of existing native vegetation elsewhere in the Growth Centres; and/or*

b) *the revegetation and/or restoration of an area of land elsewhere in the Growth Centres, subject to a number of additional conditions relating to the protection, size, ongoing management, and any potential additionality of proposed revegetation/restoration.*

RBM 11 states that for essential infrastructure proposals (which includes the project), clearing of existing native vegetation in Non-certified areas, will be subject to the offsetting requirements outlined in RBM 8.

RBM 12 states that within lands marked by a red hatching on the biodiversity certification maps (including the land surrounding Kemps Creek) existing native vegetation must not be cleared unless it is in accordance with a plan of management or unless such clearance has been agreed to by the former Department of Environment and Climate Change (now Department of Planning, Industry and Environment (DPIE)).

The project will impact 0.33 hectares of existing native vegetation subject to RBM 8, RBM 11 and RBM 12, where the impact area crosses Kemps Creek. Impacts to this vegetation will occur as a result of open trenching across the waterway. Underboring the waterway was considered as a crossing option however geotechnical field investigations identified a fault line under Kemps Creek. The fault line increases the risk of frac-out during underboring. A frac-out could have a high impact to vegetation and water quality in Kemps Creek. For this reason, trenching has been identified as the preferred construction method. To reduce impacts to existing native vegetation in this location, the impact area has been narrowed to 15 metres wide, from the standard 30 metres wide over most of the alignment. This has reduced the potential impacts in this location by 0.21 hectares, or almost 40%.

9.1.6 Operational impact assessment

Operational impacts to flora and fauna

The full extent of ground disturbance works proposed will occur during the construction phase so direct impacts to terrestrial biodiversity will be limited to the construction phase. There is potential for indirect impacts to occur during the operational phase, as outlined in Table 9-15.

Table 9-15 Potential operational impacts

Impact	Description
Impacts on adjacent habitat or vegetation along the banks of Nepean River due to inundation.	Releases of treated water to Nepean River have the potential to alter inundation depth and duration along some sections of the river banks. A review of potential impacts to biodiversity values during the operational phase of as a result of alteration of inundation depth and duration, based on the Ecohydrology and Geomorphology Assessment (Streamology, 2021) was found to have the potential to impact • Coastal Upland Swamp TEC • Cumberland Plain Woodland TEC • River-flat Eucalypt Forest TEC • Sydney Turpentine-Ironbark Forest TEC • Camden White Gum individuals and habitats • Non-threatened riparian and floodplain vegetation providing habitat for habitat for threatened and non-threatened flora and fauna species such as White-bellied Sea Eagle, Southern Myotis, Platypus, numerous frog and bird species. A detailed assessment of the potential operational inundation impact of the project is provided in Appendix J. This found that the impacts to Camden White Gum individuals and habitat as a result of permanent

Impact	Description
	inundation, and associated impacts resulting from changes to flooding regimes known to be important for seedling recruitment were unlikely to be significant, both for Stage 1 and future stages of the project. Impacts to the other TECs listed above where found to not be significant.
Indirect impact from reduced viability of adjacent habitat due to noise, dust or light spill	The primary source of operational noise and light spill will be from the AWRC site. Assessments undertaken in relation to noise and vibration (in section 11.2) and visual impacts, including light (in section 11.3) concluded that with the proposed management measures in place, these impacts will be minor. In preparing the BDAR, Biosis have reviewed these reports in relation to residual impacts to terrestrial biodiversity which were also found to be minor. During the operational phase of the project potential noise from the treated water releases to waterways will be limited, as the release is through a weir structure which is elevated and situated back from the river edge, such that water will flow down the river edge, rather than cascade directly into the river like a waterfall. Associated noise and vibration impact are minimal.
Indirect impact from transport of weeds and pathogens to/from the site to/from adjacent vegetation	There is potential for increased spread of propagules through the waterway either from areas previously less frequently inundated, or into areas not currently inundated. However, the potential for substantial novel outbreaks of weeds or pathogens is unlikely to be at a level that would result in substantial change to ecosystem function.
Impacts of vehicle strikes on threatened species of animals or on animals that are part of a TEC.	Increased vehicle movement from the project will generally be along major roads with negligible chance for wildlife interaction. Maintenance vehicles traversing bushland areas on established tracks will do so at low speeds minimising the chance of vehicle strike.

Operational impacts to groundwater dependent ecosystems

Operation of the proposed AWRC and pipelines has the potential to impact the groundwater systems by causing induced drawdowns from any drainage systems employed for underground structure floatation management, reducing the availability of groundwater for GDEs and surrounding groundwater users (Aurecon Arup, 2021c). There is greater potential for this to occur in relation to the PCTs with higher potential for groundwater interaction as shown in Table 9-13. Despite this, due to the relatively small size of the excavated areas required during operation, any induced drawdown that may occur is likely to result in an equilibrium that will ultimately preclude ongoing impact.

9.1.7 Impact of future stages

The BDAR has assessed the full impact area for the AWRC site and associated pipelines for Stage 1 and future stages. Section 9.1.6 assessed the operational impacts of the project including potential inundation impacts to the Camden White Gum and its habitat from environmental and treated water releases. This inundation impact assessment included consideration of the potential impact of the AWRC operating at both 50 ML/day and 100 ML/day. It concluded that that impacts for both stages are unlikely to be significant.

9.1.8 Cumulative impacts

A cumulative impact assessment has been undertaken considering other major projects currently occurring or planned in Western Sydney in the near future. The projects most relevant for the cumulative biodiversity impact assessment and the sources of information used to inform the cumulative assessment are listed below:

- Western Sydney International Airport:
  - Western Sydney Airport Environmental Impact Statement (Commonwealth Department of infrastructure and Regional Development, 2016).
- Sydney Metro - Western Sydney Airport:
  - Sydney Metro – Western Sydney Airport Environmental Impact Statement (Sydney Metro, 2020a)
  - Sydney Metro – Submission Report (Sydney Metro, 2020b).
- M12 Motorway:
  - M12 Motorway Environmental Impact Statement (RMS, 2019)
  - M12 Motorway Amendment Submissions Report (Transport for NSW, 2021).
- The Northern Road Upgrade – Glenmore Road to Bringelly:
  - The Northern Road Upgrade – Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park (RMS, 2017a)
  - The Northern Road Upgrade – Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park Submissions and Preferred Infrastructure Report (RMS, 2017b).
- Warragamba Dam Raising – EIS not currently available. Estimation made from vegetation mapping.

Table 9-16 provides an analysis of the potential cumulative biodiversity impacts of these projects. It is likely that the project makes only a minimal contribution to cumulative biodiversity impacts in the region.

Table 9-16 Summary of cumulative terrestrial biodiversity impacts

Projects	Western Sydney International Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Raising[1]	Upper South Creek AWRC	Cumulative impact
Plant Community Type and fauna habitat (ha) impacted							
PCT 724 Castlereagh Shale – Gravel Transition Forest	10.6	7.27	6.91	-	Unlikely	1.58	26.36
PCT 725 Castlereagh Ironbark Forest	-	-	-	-	Unlikely	0.01	0.01
PCT 781 Coastal Freshwater Wetland	35.4	-	-	-	Likely	0.02	35.42
PCT 835 Cumberland River-flat Forest	110.7	15.93	3.23	4.29	Likely	4.56	138.71
PCT 849 Cumberland Shale Plains Woodland	250.9	33.32	6.09	6.67	Possible	4.83	301.81
PCT 1083 Coastal Sandstone Ridgetop Woodland	-	-	-	-	Likely	1.38	1.38
PCT 1105 River Oak Open Forest	-	-	-	-	Likely	0.40	0.40
PCT 1181 Hinterland Sandstone Gully Forest	-	-	-	-	Likely	0.07	0.07
PCT 1800 Cumberland Swamp Oak Riparian Forest	-	4.11	2.53	2.53	Likely	0.92	10.09

Projects	Western Sydney International Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Raising[1]	Upper South Creek AWRC	Cumulative impact
Threatened ecological communities (ha) impacted - BC Act							
Cumberland Plain Woodland CEEC	242.8	11.67	60.16	29.14	Possible	4.37	348.14
Freshwater wetlands on coastal floodplains EEC	-	-	-	-	Likely	0.02	0.02
River-flat Eucalypt Forest EEC	42.1	6.64	3.23	4.29	Likely	4.39	60.65
Shale Gravel Transition Forest EEC	5.0	7.27	6.91		Unlikely	1.54	20.72
Swamp Oak Floodplain Forest EEC	-	4.11	2.53	-	Likely	0.88	7.56
Threatened ecological communities (ha) impacted - EPBC Act							
Coastal Swamp Oak Forest EEC	Not listed at time of assessment	3.67	Not listed at time of assessment	Not listed at time of assessment	Likely	0.22	3.89
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC	158.4	6.12	38.48	16.37	Possible	1.88	221.25
Acacia pubescens	5.0	12.27	-	-	Possible	0.16	17.4

Projects	Western Sydney International Airport	Sydney Metro Western Sydney Airport	M12 Motorway	The Northern Road Upgrade – Glenmore to Bringelly	Warragamba Dam Raising[1]	Upper South Creek AWRC	Cumulative impact
Pultenaea parviflora	-	4.18	-	0.98	Unlikely	0.01	5.2
Callistemon linearifolius	-	-	-	-	Possible	0.46	0.5
Dillwynia tenuifolia	5.0	21.48	3.63	-	Unlikely	0.05	30.2
Grevillea juniperina subsp. *juniperina*	255.7	18.43	-	-	Possible	0.05	274.2
Marsdenia viridiflora subsp. *viridiflora*	255.7	14.79	-	0.68	N/A	0.54	271.7
Pultenaea pedunculata	-	-	-	-	Possible	0.05	0.1
Pimelea spicata	-	8.06	-	-	Possible	2.99	11.0
Known threatened fauna impacts (Ha)							
Chalinolobus dwyeri	-	-	-	26.25	Likely	3.48	29.7
Meridolum corneovirens	141.8	1.64	1.86	16.37	Unlikely	8.95	170.6
Miniopterus orianae oceanensis	-	-	-	-	Likely	1.56	1.5
Myotis macropus	-	9.83	0.92	-	Likely	7.62	18.4

1 – No project data was publicly available at the time of reporting.

9.1.9 Management measures

Table 9-17 outlines management measures Sydney Water proposes to manage terrestrial biodiversity impacts.

Table 9-17 Terrestrial biodiversity management measures

ID	Impact	Management measure	Timing
TB01	Biodiversity impacts	Prepare and implement a Biodiversity Management Plan as part of the project's CEMP. The plan will include: • identification of no go zones and physical delineation of vegetation to be cleared and/or protected on site, including installation of appropriate signage prior to works commencing • construction phase terrestrial biodiversity measures from this table • roles and responsibilities • monitoring and auditing requirements • measures to prevent the spread of weeds, pathogens and to manage biosecurity.	Prior to construction During construction
TB02	Removal of native vegetation and fauna habitats, including threatened species	Vegetation trimming or removal is not to proceed without written authorisation from the Sydney Water Project Manager or delegate.	Prior to construction During construction
TB03	Removal of native vegetation and fauna habitats, including threatened species	Minimise vegetation clearance and disturbance, including impacts to standing dead trees and riparian zones. Where possible, limit clearing to trimming rather than the removal of whole plants.	Prior to construction During construction
TB04	Removal of native vegetation and fauna habitats, including threatened species	Adjust construction methodology (for example avoid area, hand excavate, implement exclusion fencing) to protect sensitive areas where possible (such as mature trees, known threatened species, populations or ecological communities).	Prior to construction During construction

ID	Impact	Management measure	Timing
TB05	Removal of native vegetation and fauna habitats, including threatened species	Protect trees in accordance with the requirements of Australian Standard 4970-2009 for the Protection of Trees on Development Sites. Engage a qualified arborist where roots >50mm are impacted within the Tree Protection Zone.	Prior to construction During construction
TB06	Impacts to fauna	Engage qualified ecologists to undertake pre-clearance inspections (including fauna relocation) of vegetation for potential fauna prior to clearing or trimming, including the banks of larger watercourses to be impacted.	Prior to construction During construction
TB07	Impacts to fauna - microbats	Where practicable do not undertake works that impact directly on potential microbat habitat at Warragamba River during breeding season (November to February).	During construction
TB08	Impact to vegetation outside impact area	If any damage occurs to vegetation outside of the impact area stop work in that area and notify the Sydney Water Project Manager or delegate.	During construction
TB09	Impacts on the habitat of threatened species associated with human made structures at the Warragamba environmental flows release structure.	Install passive roost exclusion measures over the vertical shaft as follows: • Install during either spring (March to May) or autumn (September to October). • Undertake repeated stag watching surveys prior to installation of exclusion measures to confirm the presence of microbats within the habitat, and to determine when all bats have left the potential roost. • Once all bats have exited the habitat, install a permanent cap over the opening of the shaft using material such as spray polyurethane foam or foam concrete seals (used for capping mine shafts / adits). • Undertake repeat stag watching post installation of the exclusion measures to confirm the successful exclusion of microbats.	Prior to construction
TB10	Residual impacts to biodiversity	Prepare a Biodiversity Offset Strategy in accordance with the NSW Biodiversity Offset Scheme to address the species and ecosystem credit requirements outlined in section 9.1.10.	Prior to construction

ID	Impact	Management measure	Timing
	Inadvertent impacts on grey-headed flying fox habitat or vegetation near the environmental flows release structure	This impact is appropriately managed by measures in section 11.2 (Noise and vibration) and section 11.3 (Landscape character and visual).	Prior to construction During construction

Sydney Water will approve the Biodiversity Management Plan and the measures proposed to manage biodiversity. Conditions of approval for the project may also specify other agencies such as DPIE as having a role in approving this plan and management measures. Conditions of approval may also specify independent auditing requirements across the project as a whole, including in relation to biodiversity management.

9.1.10 Terrestrial biodiversity offsets

Where residual impacts cannot be avoided, minimised or mitigated they must be offset in accordance with the NSW BOS. This section summarises the ecosystem and species offset credits requirements for the project.

Credit requirements

Table 9-18 outlines the ecosystem credits required to offset project impacts to threatened ecological communities.

Table 9-18 Terrestrial biodiversity offsets – ecosystem credits

Vegetation zone - condition	Area (ha)	Credit requirement
724: Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion (Shale Gravel Transition Forest TEC)	1.58	40
725: Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	0.01	1
781: Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion (Freshwater wetlands on coastal floodplains TEC)	0.02	0

Vegetation zone - condition	Area (ha)	Credit requirement
835: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (River-flat Eucalypt Forest TEC)	4.56	162
849: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (Cumberland Plain Woodland TEC)	4.83	117
1083: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	1.38	19
1105: River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	0.40	3
1181: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	0.07	1
1800: Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley (Swamp Oak Floodplain Forest TEC)	0.92	15

Table 9-19 outlines the species credits required to offset project impacts to threatened flora and fauna species.

Table 9-19 Terrestrial biodiversity offsets – species credits

Scientific name	Common name	Area (ha) / Count	Credits required
Threatened flora species			
Acacia pubescens	Downy Wattle	0.16	4
Callistemon linearifolius	Netted Bottle Brush	6 (assumed)	9
Dillwynia tenuifolia	-	0.05	2
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	0.05	2
Marsdenia viridiflora subsp. *viridiflora* - endangered population	-	0.54	19
Pimelea spicata	Spiked Rice-flower	2.99	75

Scientific name	Common name	Area (ha) / Count	Credits required
Pultenaea parviflora	Sydney Bush-pea	0.01	1
Pultenaea pedunculata	Mated Bush-pea	0.05	2
Threatened fauna species			
Chalinolobus dwyeri	Large-eared Pied Bat	3.48	137
Meridolum corneovirens	Cumberland Plain Land Snail	8.96	259
Miniopterus orianae oceanensis	Large Bent-winged-bat	1.56	41
Myotis macropus	Southern Myotis	7.62	202
Pommerhelix duralensis	Dural Land Snail	1.45	27

Biodiversity offset strategy

Under the NSW Biodiversity Offset Scheme (BOS) there are three main avenues for securing biodiversity offsets for the project including:

- payment to the Biodiversity Conservation Fund managed by the Biodiversity Conservation Trust
- purchasing (transfer) and retiring credits from existing credit holders
- establishing a Biodiversity Stewardship Site to generate credits required by the project.

Appendix J includes a summary of the trading options available to Sydney Water for the retiring through purchase, or generation through stewardship sites, to meet offsetting credit requirements. Sydney Water will also consider the specific requirements of offsets required in the area covered by the Biodiversity Certification Order.

Sydney Water is committed to securing the required number and type biodiversity credit to offset residual impact of the project, either through retirement of like for like credits via a combination of the above listed options, or if unavailable though implementation of the variation rules. If approved a detailed Biodiversity Offset Strategy will be developed outlining how offsetting requirements will be met.

9.2 Surface water

This section describes the existing surface water environment near the project and potential surface water impacts during project construction and operation. It provides an overview of the key findings of the detailed Surface Water Impact Assessment (Aurecon Arup, 2021d) included in Appendix K. Impacts of treated water releases, flooding and groundwater are not addressed in this section and are covered in Chapter 8, section 9.3 and section 9.4 respectively.

Surface water impact summary

The project has the potential to impact surface water during construction and operation, but overall the significance of the impacts is expected to be low.

Excavation and earthworks during construction at the AWRC site and along the pipeline alignments has the potential to cause localised erosion and increased sediment loads to local waterways. In addition, any accidental chemical spills or inappropriate management of waste and stockpiles during construction has the potential to result in contaminants entering waterways. These construction impacts can be effectively managed through standard erosion and sediment control measures to ensure the potential impacts on surface water are low.

Pipelines will be designed and maintained to avoid leaks, and release structures will result in only a small increase in runoff causing impervious surfaces. The operation of the pipelines and release structures will therefore have limited potential to cause surface water impacts and the impacts related to the operation of the AWRC is the focus of the assessment.

Once built, the AWRC will increase the extent of impervious surfaces on the site. Without mitigation, this would likely increase runoff, peak flows and pollutant loads to South Creek. Sydney Water has modelled the water balance at the AWRC site and the effectiveness of stormwater management and water sensitive urban design (WSUD) measures in managing additional runoff, peak flows and pollutant loads. WSUD measures can include features such as tree planting, wetlands, gross pollutant traps, stormwater harvesting. Detention basins can be used to manage increases in peak flows. By implementing a range of WSUD measures at the AWRC site, modelling shows the project can:

- meet draft NSW Government water quality and flow objectives for South Creek and Penrith Council pollution reduction targets
- maintain peak flows from the AWRC site at pre-development levels
- reduce runoff by about 45% and slowly release stormwater to support baseline flows in South Creek
- reduce pollutant loads to acceptable levels.

Irrigation of the green space area on the AWRC site also has the potential to increase saline groundwater levels and result in saline runoff. Runoff will be managed by measures including controlling the irrigation rate.

9.2.1 Relevant Secretary's Environmental Assessment Requirements

Table 9-20 summarises the Secretary's Environmental Assessment Requirements (SEARs) relevant to surface water and where in this section they are addressed. This table only references content relating to surface water.

Table 9-20 Project SEARs relating to surface water impacts

SEARs	EIS section where requirement addressed
1. Describe background conditions for any water resource likely impacted by development, including	
a) existing surface and groundwater.	Section 9.2.3
b) hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	Section 9.2.3 and 9.2.6 describe volume, frequency and quality of stormwater runoff from AWRC site.
e) Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions.	Section 9.2.2 describes waterway health objectives and application to the surface water environment.
2. Assess the impact of the development on water quality including:	
a) The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Sections 9.2.5 and 9.2.6 demonstrate how stormwater discharges from the AWRC will contribute to achieving water quality objectives in South Creek.
b) identification of proposed monitoring of water quality.	Section 9.2.9 indicates construction monitoring requirements for surface water management measures. Chapter 8 identifies proposed baseline and operational water quality monitoring.

SEARs	EIS section where requirement addressed
3. Assess the impact of the development on hydrology, including:	
a) water balance including quantity, quality and source.	Pre and post development water balance completed for AWRC site. Sections 9.2.3, 9.2.6 and Appendix K provide the pre and post development water balance including volumes and pollutant loads.
b) effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	Sections 9.2.5 and 9.2.6 discuss impacts to stormwater runoff and effects to downstream flow conditions, rivers and floodplain areas. Downstream wetlands, estuaries and marine waters are not relevant.
d) impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	Sections 9.2.5 and 9.2.6 assess impacts on stormwater runoff and impacts to downstream flow conditions, flooding and floodplains. Sections 8.7.1, 8.7.2 and 8.7.3 discusses nutrients loads, hydrological and hydraulic changes, aquatic connectivity, access to habitat for spawning and refuge
e) changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Section 9.2.6
f) mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and reuse options.	Sections 9.2.5, 9.2.6 and 9.2.9 assess surface water impacts and management measures

SEARs	EIS section where requirement addressed
g) identification of proposed monitoring of hydrological attributes.	Section 9.2.9 includes construction monitoring requirements for surface water management measures, section 8.11 outlines monitoring of geomorphological impacts from releases
4. Map	
c) proposed intake and discharge locations	Section 9.2.6 and Figure 9.5 show the AWRC stormwater discharge release locations.
7. Consult/coordinate with the Department of Planning, Industry and Environment (and Planning Partnership Office) in respect to environmental impacts on the South Creek catchment and the Wianamatta South Creek program. This includes:	
c) assess the potential impacts on the quantity and quality of surface and groundwater resources along South Creek, including the implications of dry and wet weather flows from the Project.	Sections 9.2.5 and 9.2.6 describe potential impacts of stormwater discharges on quantity and quality of South Creek.
d) details about how the Project will be designed, operated and maintained to ensure post-development flows do not exceed pre-development flows into and through the Pipelines Corridor and additional surface and groundwater entering the Pipelines Corridor must be prevented.	Sections 9.2.6 and 9.2.9

9.2.2 Methodology and assumptions

The assessment considered the AWRC site and a defined impact assessment area centred along the pipeline alignments, including the construction compounds and temporary access roads. This included a buffer area to allow for uncertainty within the current pipeline alignment and changes that may occur during detailed design.

The key steps taken for the surface water impact assessment included:

- data collection and desktop review of available information. The study area included the AWRC site and the impact assessment area for the pipeline alignments. Watercourses and

catchments potentially impacted by the project may extend beyond the AWRC site and impact assessment area, and where relevant were considered as part of the assessment

- a site walkover and inspection to verify the desktop assessment
- assessing construction impacts where they may impact waterways
- modelling of operational impacts from the AWRC site including a frequent low flow assessment using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) model, and a peak storm discharge assessment using a hydrological model called XP-RAFTS and a hydraulic model called DRAINS. This included testing the effectiveness of design measures such as detention basins proposed in the reference design
- assessing operational impacts associated with runoff from release structures and access roads to Warragamba River and Nepean River. This involved an initial assessment which identified the contributing operational area associated with each release structure that may generate surface runoff. The contributing area was identified as very small and likely to cause only minor increases to surface runoff so no further modelling was undertaken
- comparing modelled outcomes against water quality and flow objectives and guidelines
- assessing impact significance for construction and operational phases, either as negligible, low, moderate, high, or major as shown in Table 9-21. The impact assessment considered the sensitivity of the environment and the magnitude of the expected change. The sensitivity of environmental values was based on the condition of the environmental value, uniqueness or rarity of the environmental value and sensitivity to change. For quantitative assessment, the magnitude of expected change was based on how the results compare to objectives. For qualitative assessment, the magnitude of expected change was based on the duration of the impact, the extent of the impact and the estimated degree of change from pre-development conditions
- identifying management measures.

Table 9-21 Assessing impact significance for surface water

		Sensitivity of environmental values		
		High	**Moderate**	**Low**
Magnitude of impact	**High**	Major	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Negligible

The assessment took different approaches to construction and operational impacts as outlined below.

Construction impacts

The construction assessment considered temporary construction impacts with potential to change the surface water environment. It focused on potential runoff to receiving waterways including:

- South Creek at the AWRC site
- waterways crossed by the brine pipeline and treated water pipeline
- Nepean River at the treated water release location
- Warragamba River at the environmental flows release location.

Management measures to reduce construction impacts were guided by the goals and objectives in Managing Urban Stormwater: Soils and Construction Guide Volume 1, 4th Edition (Landcom, 2004).

Operation impacts

Most of the pipeline infrastructure will be underground which means negligible impacts on surface water are expected. However, the assessment considered impact of runoff to waterways associated with the main above-ground infrastructure, which includes the release structures and access roads at Nepean and Warragamba Rivers.

Given the extent of above-ground structures, buildings, roads, and impervious areas at the AWRC, all with the potential to change the long-term surface water environment, the operational assessment focused on the surface water impacts associated with the AWRC site.

Frequent low flow assessment

Frequent low flow modelling was undertaken in MUSIC. To model frequent low flows, six months of continuous hourly rainfall data, rather than discrete storm events, was used to generate frequent low flows. This data included storm events up to and including the six-month notional worst storm. MUSIC was used to develop an environmental water balance for the AWRC site for the pre- and post-development scenarios, which allowed an assessment to be undertaken of the surface water conditions once the AWRC is built. The AWRC site water balance considered the AWRC operational area and the expected changes to the site runoff rates that may occur because of increases in impervious area. Modelled outputs were also used to verify effectiveness of water sensitive urban design (WSUD) measures, to manage impacts resulting from these changes at the site. In the post-development scenario, the green space area adjacent to the operational area is included as an end use for irrigation.

MUSIC modelling results provided flow metrics and an indicative measure of pollution generation, in surface water runoff, from the AWRC site. These were compared against flow and water quality objectives in the Draft Aerotropolis Precinct Plan (Western Sydney Planning Partnership, 2020b) for Wianamatta South Creek. Table 9-22 and Table 9-23 summarise these objectives. The Department of Planning, Industry and Environment (DPIE) developed these objectives by applying the Risk-based Framework for considering waterway health outcomes in strategic land use planning decisions (OEH and EPA, 2017). These objectives aim to preserve the hydrologic

condition of South Creek and its tributaries and, although currently in draft, consultation with DPIE suggests they are unlikely to change.

MUSIC modelling results were also compared against the Penrith City Council Development Control Plan (DCP) pollution reduction targets in Table 9-24.

Table 9-22 contains two sets of flow objectives. The baseline objectives describe the ideal response of a waterway not impacted by land use changes and provide the baseline performance outcomes for South Creek at the AWRC site in a pristine condition. The tipping point objectives describe the upper limit of a changed response that result from mixed land use changes within a catchment and provide performance outcomes for South Creek at the AWRC site in a changed condition. The objectives have been specified to limit erosion in the downstream waterway. Results (flow metrics) from MUSIC were compared to the two sets of objectives.

Table 9-22 Wianamatta – South Creek waterway health (flow) criteria

Flow Variable	Unit	Baseline hydrology (1st -2nd Order Streams) Ideal	Tipping point (3rd Order Streams) Upper limit of changed hydrology
Median Daily Flow Volume	L/ha/d	71.8 ± 22.0	1,095.0 ± 157.3
Mean Daily Flow Volume	L/ha/d	2,351.1 ± 604.6	5,542.2 ± 320.9
High Spell ≥ 90th Percentile Flow Volume	L/ha/d	2,048.4 ± 739.2	10,091.7 ± 769.7
High Spell - Frequency	number/y	6.9 ± 0.4	19.2 ± 1.0
High Spell - Average Duration	days/y	6.1 ± 0.4	2.2 ± 0.2
Freshes ≥ 75th and ≤ 90th Percentile Flow Volume	L/ha/d	327.1 to 2048.4	2,642.9 to 10,091.7
Freshes - Frequency	number/y	4.0 ± 0.9	24.6 ± 0.7
Freshes - Average Duration	days/y	38.2 ± 5.8	2.5 ± 0.1
Cease to Flow	proportion of time/y	0.34 ± 0.04	0.03 ± 0.007
Cease to Flow - Duration	days	36.8 ± 6	6 ± 1.1

MUSIC modelling was used to provide an indication of pollution generation in surface water runoff at the AWRC site for Total Phosphorus (TP), Total Nitrogen (TN) and Total Suspended Solids (TSS). Model predictions were compared against the objectives in Table 9-23 for TN, TP and TSS to determine the effectiveness of WSUD measures. The objectives in Table 9-23 are for ambient water quality. MUSIC software can only report water quality for stormwater, which does not necessarily represent ambient water quality. It is therefore appropriate to demonstrate that WSUD measures can deliver high-quality discharges and can contribute to meeting ambient water quality objectives. This is done by demonstrating that stormwater discharge achieves these objectives 85% of the time.

Table 9-23 Wianamatta-South Creek water quality objectives for ambient water quality

Quality Variable	Unit	Performance Criteria
Total Nitrogen (TN)	mg/L	1.72
Dissolved Inorganic Nitrogen (DIN)	mg/L	0.74
Ammonia (NH_3-N)	mg/L	0.08
Oxidised Nitrogen (NO_x)	mg/L	0.66
Total Phosphorus (TP)	mg/L	0.14
Dissolved Inorganic Phosphorus (DIP)	mg/L	0.04
Turbidity (NTU)		50
Total Suspended Solids (TSS)	mg/L	37
Conductivity	µS/cm	1103
pH		6.20 – 7.60
Dissolved Oxygen (DO)	%SAT	43 – 75
Dissolved Oxygen (DO)	mg/l	8

Table 9-24 shows Penrith City Council DCP pollution load reduction targets. Although the Western Sydney Planning Partnership is developing drainage and WSUD guidelines for the Western Sydney Aerotropolis Growth Area (WSAGA), these have not yet been finalised. For this reason, Penrith City Council's pollution load reduction targets also apply to the AWRC and stormwater discharges to South Creek. MUSIC outputs report pollution load reductions achieved by WSUD management measures. These outputs were compared against Penrith City Council pollution load reduction targets to determine the effectiveness of WSUD measures at the AWRC.

Table 9-24 Penrith City Council pollution load reduction targets

Total Suspended Solids	Total phosphorus	Total Nitrogen	Gross pollutants	Free oils and Grease
85%	60%	45%	90%	90% no visible discharge

Peak storm discharge assessment

Peak storm discharges are peak runoff rates and volumes associated with discrete storm events. To assess impacts of the AWRC site on peak runoff rates and volumes and determine the need for detention and performance of discharge controls, a hydrological model using XP-RAFTS was developed. To inform detention basin hydraulics (conduit size and stage discharge relationship) a hydraulic model in DRAINS was developed. These models were used to size and test the effectiveness of site detention basins in managing increases in peak flows from the 50%, 5% and 1% Annual Exceedance Probability (AEP) storm events, by comparing current pre-development conditions with post-development conditions (once the AWRC is built). The reference design has explicitly sized detention basins to detain runoff volumes associated with a 1% AEP storm event, whilst ensuring that post development peak flows do not exceed pre-development peak flows. Penrith City Council's Stormwater Drainage Guidelines for Building developments (PCC, 2018) were used to guide the assessment of the on-site detention basins in managing peak flows. Modelled results from XP-RAFTS were used to verify the detention basins could achieve:

- on-site detention to contain 1% AEP flood level at the discharge point
- maximum depths of 1200mm for above-ground storage in industrial basins.

Assumptions and limitations

Key assumptions and limitations for the surface water impact assessment were:

- For the post-development scenario the modelling assessed the ultimate footprint with the AWRC sized to 100 ML/day. This is because operational stormwater management facilities including detention basins and drainage will need to be constructed to accommodate future stages of the AWRC.
- A water balance for the pipelines was not undertaken because during operation, the pipeline infrastructure will be mostly underground so ongoing changes to the water balance are not expected.

9.2.3 Existing environment

This section describes the catchment characteristics, hydrology, water quality and water balance near the project.

Catchment characteristics and hydrology

The AWRC site is located in the South Creek catchment at the confluence of South Creek and Kemps Creek. South Creek is a significant tributary of the Hawkesbury River and part of the Hawkesbury-Nepean catchment. It originates around Oran Park, flowing north where it is joined by Badgerys Creek and Kemps Creek downstream of the AWRC site, before reaching its confluence with the Hawkesbury River near Windsor.

There are several smaller watercourses along the pipeline alignments in the Hawkesbury-Nepean and Georges River catchments. These include Oaky Creek, Cosgroves Creek, Jerrys Creek and Baines Creek for the treated water pipeline; Baines Creek and Megarrity's Creek for the environmental flows pipeline; and Kemps Creek, Hinchinbrook Creek, Green Valley Creek and Prospect Creek for the brine pipeline. There are several farm dams and minor waterbodies in the project area.

The treated water release structure is located at Nepean River near Wallacia Weir and the environmental flows release structure at Warragamba River downstream of Warragamba Dam.

Figure 9-3 shows these waterways in relation to the project. Table 9-25 lists the key watercourses, their Strahler order and riparian corridor width based on the Guideline for Riparian corridors on waterfront land (DPI, 2012). Strahler orders have been estimated for smaller unnamed watercourses and are identified in Appendix K.

Table 9-25 Key watercourses in the project area

Watercourse	Strahler Order	Riparian corridor width (m)
South Creek	6	40
Kemps Creek	4	40
Badgerys Creek	4	40
Oaky Creek	3	30
Cosgroves Creek	4	40
Jerrys Creek	4	40
Nepean River	7	40
Baines Creek	3	30
Megarritys Creek	3	30
Warragamba River	9	40
Hinchinbrook Creek	2	20
Green Valley Creek	2	20

Watercourse	Strahler Order	Riparian corridor width (m)
Prospect Creek	4	40

The AWRC site is predominantly flat with a gentle slope towards the north. Elevations across the centre of the site generally range between 35 and 40m AHD. A natural ridgeline runs through the site and is the catchment divide between South and Kemps Creek. Figure 9-4 shows the existing drainage lines on the AWRC site. Most of the site runoff flows to South Creek (drainage line 1 and 3), west of the ridgeline. Drainage line 2 drains towards Kemps Creek.

Elevations along the treated water pipeline alignment range from 30-90 m AHD (Australian Height Datum) from the low-lying areas of South Creek and Kemps Creek through Luddenham (90 m AHD) to the Nepean River valley (35 m AHD).

The brine pipeline alignment follows gently sloping topographies rising from 40m AHD to a high point of 80m AHD at Cecil Hills before sloping down to 10m AHD at Georges River and Prospect Creek.

Section 9.5 describes existing soil landscape type and characteristics for the AWRC site and the pipeline alignments.

Historic rainfall and evaporation data from Orchard Hills Treatment Works (gauge ID 67084) indicates a wet season from November to May and a dry season from June to October. Wetter years experience rainfall in excess of 1200mm and drier years less than 500mm. Evaporation rates fluctuate from between 1200mm and 1900mm indicating an overall deficit, which is greater during drier years.

Creek and stream flow (water flow within the creek) in the South Creek catchment is monitored by flow gauges. The AWRC site is located between two flow gauges on South Creek. An analysis of gauged data and a discussion on streamflow patterns is provided in Chapter 8.

Waterways crossed by the pipeline alignments are shown in Appendix K and most have Strahler stream orders greater than 2. Most waterways have intermittent flows throughout the year and in drier periods their beds may be completely dry. Generally, a higher stream order means higher flows in the waterway.

Chapter 8 includes further consideration of hydrology of Nepean River and Warragamba River, and specifically addresses the impact of treated water releases on those watercourses.

Environmental water balance

Appendix K includes an environmental water balance modelled for the AWRC site. In summary, the key components of the water balance are rainfall source (162 ML/year), evaporation (142 ML/year), infiltration (6 ML/year) and surface (stormwater) runoff (14 ML/year). This shows that evaporation represents the largest losses and that infiltration is relatively low reflecting the relatively impermeable nature of soils present at the site and a deficit of 20ML between rainfall and evaporation indicated by the climate data. Section 9.2.6 describes the impact of the AWRC site on runoff, including impacts to stormwater quality.

Baseline water quality

Sydney Water has undertaken water quality monitoring in the Hawkesbury Nepean river system over many years, focused on assessing impacts of releases from existing wastewater treatment plants (WWTPs) and water recycling plants (WRPs). As part of the project, in March 2020, Sydney Water started monitoring additional sites in South Creek, Nepean River and Warragamba River to understand baseline conditions upstream and downstream of proposed treated water releases. Sites were also added in Kemps Creek and Badgerys Creek to understand baseline conditions in nearby waterways. Chapter 8 provides further detail about water quality results from this monitoring.

There is limited long-term water quality data available for most other waterways in Table 9-25. Desktop review of available information indicates that water quality often exceeds guideline trigger values in the ARMCANZ (2000) guideline. Chapter 8 provides more detail of existing water quality data reviewed.

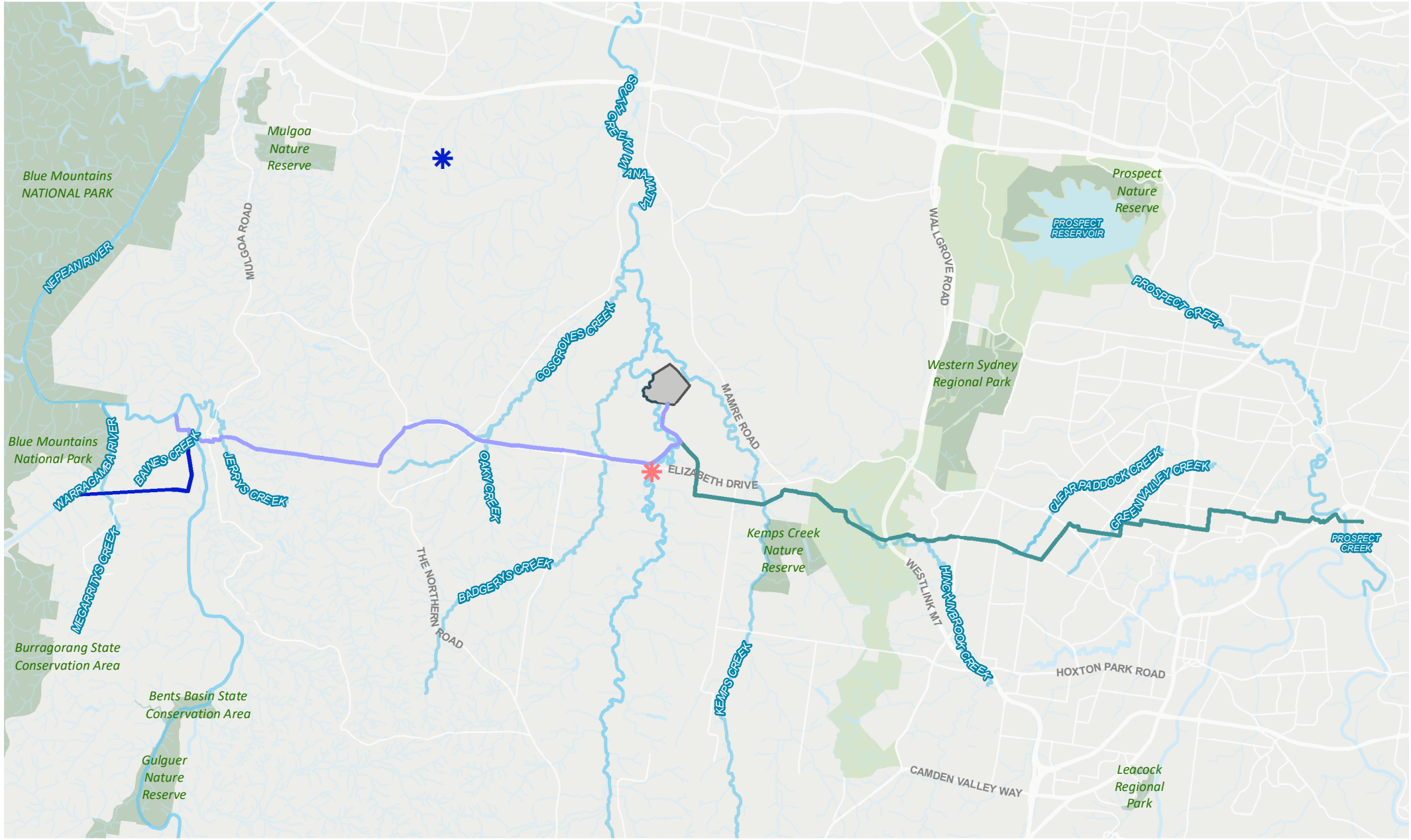


Figure 9-3 Catchment and hydrological features

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

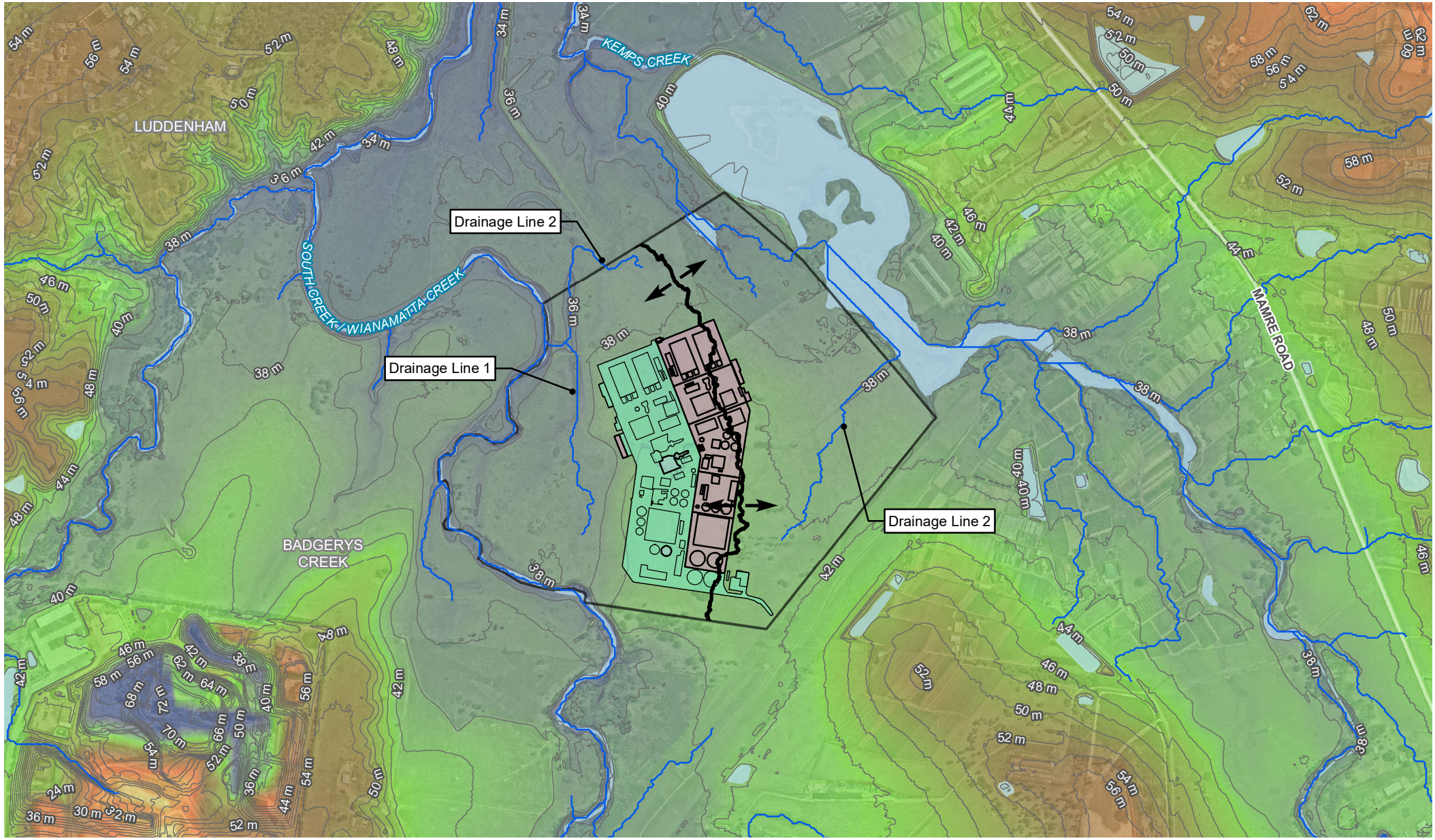


Figure 9-4 Drainage lines AWRC

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Peak stormwater discharge rates

Modelling undertaken in XP-RAFTS predicts that existing peak stormwater discharge flow rates at the AWRC site will be 0.47 m^3/s for the 50% Annual Exceedance Probability (AEP) event, 1.17 m^3/s for the 5% AEP event and 2.0 m^3/s for the 1% AEP event. Appendix K includes detail about the current peak stormwater discharge flow rates.

9.2.4 Legislation and guidelines

Table 9-26 summarises the legislation, guidelines and waterway objectives relevant to the project.

Table 9-26 Legislation, guidelines and waterway objectives relevant to the project

Legislation/Guideline	Relevance to the project
Protection of the Environment Operations Act 1997	Environment Protection Licences (EPLs) are required for scheduled development work (construction EPL) and the scheduled activity (operational EPL). The construction EPL may include requirements relating to surface water management, including the management of discharges from the sediment basins.
Water Management Act 2000	Section 90 provisions relate to controlling works situated in or in the vicinity of a river, estuary, lake or within a floodplain that are likely to have an effect on the flow of water to or from a river, estuary or lake or the distribution or flow of floodwater in times of flood. The project is exempt from section 90 provisions under Section 5.23 (1) (g) of the *Environmental Planning and Assessment Act 1979* because the project is State significant infrastructure.
Aerotropolis waterway health objectives (Western Sydney Planning Partnership, 2020)	These include water quality and flow objectives relevant to waterways within the WSAGA. They have been used to assess the acceptability of surface water impacts to South Creek at the AWRC site. The modelled results for the AWRC site are compared against these to determine if the implementation of Water Sensitive Urban Design can achieve acceptable outcomes.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000)	The guidelines are relevant to waterways other than South Creek that interact with the project and form the basis of the project waterway objectives. Chapter 8 includes further detail on the project waterway objectives and how they apply to the operational treated water releases.
Penrith City Council Development Control Plan (DCP) (2014)	The DCP contains pollution load reduction targets. Developments are required to demonstrate that stormwater discharges leaving the site can meet these targets. The targets apply to the AWRC site until Western Sydney Aerotropolis DCPs are finalised. They have been used to compare against modelled results to assess the effectiveness of WSUD measures in reducing pollution loads in stormwater runoff at the site.
Penrith City Council drainage guidelines for developments (2018)	The guidelines have been used to guide the drainage design at the AWRC site. They have been used to assess against modelled results for to ensure the detention basins function to meet the requirements of the design guidelines.

Legislation/Guideline	Relevance to the project
Managing Urban Stormwater, Soils and Construction Volume 1, 4th Edition (Landcom, 2004)	The guidelines aim to reduce the impacts of land disturbance activities on waterways. The guidelines have been used to undertake initial calculations for construction sedimentation basin storage requirements

9.2.5 Construction impact assessment

During construction, key impacts for the project are associated with activities such as clearing vegetation, excavation, earthworks and stockpiling, leading to the potential for erosion, increased sediment loads in surface runoff and sedimentation in receiving waterways (including via stormwater systems). For the AWRC site, impacts are also associated with the gradual increase in impervious area through the establishment of sealed surfaces as construction progresses, leading to changes in stormwater runoff characteristics and increases in low and peak flows with potential impacts to downstream rivers, the natural process of flooding and floodplain areas.

Appendix K includes a summary of the calculations undertaken to demonstrate that adequately sized construction sediment basins can be provided on the AWRC site.

Table 9-27 summarises potential construction impacts on surface water, their location and significance. All moderate impacts associated with construction are temporary and implementing the management measures in section 9.2.9 will reduce the impact significance to low.

Table 9-27 Summary of potential construction surface water impacts

Location	Impact summary	Impact significance
AWRC site (C8) and compounds (C1 – C7, C9 to C15), waterway crossing work sites and construction along pipeline alignments	Sediment laden surface runoff from stockpiles, excavated and cleared areas may enter waterways. The impact is moderate because: • sedimentation may increase turbidity in waterways • increased loading of nutrients in surface runoff may occur, increasing levels of TN and TP in receiving waterways • tannin leachate from clearing and mulching may enter receiving waterways resulting in eutrophication, reduced water pH and visual aesthetic issues.	Moderate
AWRC site (C8) and waterway crossing work sites and construction along pipeline alignments	Contaminated waste material may enter waterways. The impact significance is moderate because ACM material has been identified in surface soils across the project area and within existing structures at the AWRC site.	Moderate

Location	Impact summary	Impact significance
AWRC site (C8) and compounds (C1 – C7, C9 to C15), waterway crossing work sites and construction along pipeline alignments	Runoff from stockpiles and excavations containing contaminated material may enter waterways. The impact significance is moderate because contamination has been identified across the project area and within existing structures at the AWRC site.	Moderate
Compound C14 and construction of the brine pipeline near Georges River and Prospect Creek areas	Potential ASS risk areas are present around Georges River and Prospect Creek in the eastern portion of the desktop assessment area. If saturated materials in these areas were exposed to oxygen (for example stockpiled and excavated areas exposed to rainfall), sulfuric acid and iron can be released from the ASS entering surface water runoff. This potentially results in impacts including: • leaching/mobilisation of metals from otherwise stable soils, increasing the concentration of heavy metals in the surface water runoff to potentially toxic levels • degradation of soil quality in affected areas, preventing vegetation growth. The impact significance is low because the presence of ASS is localised and not expected outside of these locations.	Low
AWRC site (C8) waterway crossing work sites and construction along pipeline alignments	Groundwater encountered during excavation may be saline and may enter surface water systems during dewatering activities. The impact is temporary however the impact significance is moderate because saline groundwater may adversely impact the quality of receiving waterways.	Moderate
AWRC site (C8)	Discharges from the sedimentation basins may mobilise sediments and increase turbidity of South Creek. The impact significance is low because the impact is expected to be temporary and localised.	Low
Compounds C1 and C3	Overtopping of cofferdams during higher river flow events may mobilise sediments inside the work zone and increase the turbidity of receiving waterway. During dry weather when lower flows will occur overtopping is less likely. The impact significance is low because overtopping is only likely to occur during wetter weather during higher flow events when background turbidity levels are likely to be elevated.	Low

Location	Impact summary	Impact significance
AWRC site (C8)	Increased peak flows including changes in volumes and rates of flow may exacerbate downstream flooding conditions (including floodplain areas) in South Creek as impervious areas increase across the site. The impact significance is low. This is because limited compaction, installation of impervious surfaces and maintenance of low grades at the site mean that significant increases in peak flows are not expected in the early construction stages or until hard surfaces become established. Provided the management measures in section 9.2.9 are implemented, the impact resulting from the progressive increase in impervious surfaces can be managed and the impact will remain low.	Low
AWRC site (C8) and compounds (C1 – C7, C9 to C15), waterway crossing work sites and construction along pipeline alignments	The operation of machinery storage, transport, use, handling and spills of chemicals mean contaminants may be present at the surface and can enter runoff. The impact significance is moderate because contaminated runoff may adversely impact the water quality of surface waters through stormwater discharge.	Moderate
AWRC site (C8) and compounds (C1 – C7, C9 to C15), waterway crossing work sites and construction along pipeline alignments	There is potential for leakage from construction worker ablution and toilet facilities to contaminate surface water runoff and enter receiving waterways. The impact significance is low because the impact is temporary and very localised	Low
AWRC site (C8)	Water required for construction activities such as earthworks and dust suppression may impact local or regional water resources. The impact significance is low because it is temporary and where practicable, harvested and reuse of stormwater from temporary sedimentation basins at the AWRC site may be used to supplement mains water.	Low
Waterway crossings constructed by trenching across South, Oaky, Cosgrove and Kemps Creeks	Temporary obstruction and interference of normal drainage channels may cause localised upstream ponding and sedimentation which may increase turbidity in watercourses. The impact significance is low because any increases will be temporary and localised for the duration of works. In addition, Oaky Creek, Kemps Creek and Cosgrove Creek are historically subject to periods of ponding close to the crossing during the dry season.	Low

Location	Impact summary	Impact significance
AWRC site (C8) and compounds (C1, C2, C3, C4) and waterway crossing work sites	Vegetation removal on or near watercourses may cause bank damage and expose soil surfaces leading to erosion with sediment laden runoff entering the adjacent waterway. This impact significance is moderate because exposed riparian areas can continue to deteriorate over time leading to ongoing sediment and erosion impacts to waterways.	Moderate
Compounds C1, C2, C4 and water crossings constructed by tunnelling	An uncontrolled release of drilling fluid escaping from the borehole through fissures or weakness in the substrate and returning to the surface is known as a 'frac out'. This impact significance is moderate because if drilling fluid enters surface water runoff there is potential for increased turbidity and contamination in nearby watercourses.	Moderate
Waterway crossings constructed by tunnelling	There is potential for surface water impacts to occur from tunnelling beneath waterways which may lead to the disruption of surface water and groundwater connectivity. The impact significance is low because any disruption in connectivity would be very localised.	Low

9.2.6 Operational impact assessment

AWRC site

This section summarises the results of modelling undertaken to demonstrate that the AWRC site can be designed to manage operational impacts consistent with Wianamatta-South Creek waterway health objectives (Western Sydney Planning Partnership, 2020b) and Penrith City Council DCP (2014) pollution load reduction targets and drainage guidelines. Appendix K includes the full assessment. While the modelling demonstrates the effectiveness of a particular design, Sydney Water may refine or change this during detailed design to align with overall design of the AWRC. However, any alternative design will also need achieve the above objectives and guidelines.

Figure 9-5 shows the indicative stormwater management and WSUD design measures that could be implemented to meet the water quality and flow objectives for South Creek. It also shows an indicative concept for urban design of the site, a design that presents an integrated solution which will reduce surface water impacts. This is covered in more detail in Chapter 4. The modelling for this assessment assumes standard stormwater management and WSUD measures are implemented at the AWRC, including:

- first flush capture to manage the risk of spills and chemical leaks during handling and transport that will be designed to intercept the first 10mm rainfall from the hardstand areas. The first flush capture will be treated with wastewater at the AWRC

- street trees
- gross pollutant traps to provide pre-screening of stormwater prior to filtration
- bioretention systems located within the on-site detention (OSD also known as detention) basins
- constructed wetland in the green space area to slowly release stormwater so that it contributes to base flow in South Creek
- stormwater harvesting for irrigation to reduce stormwater runoff volumes. The modelling assumes an irrigation rate of 4.5ML/ha/year for a 16ha area which will make up the existing local deficit between rainfall and potential evapotranspiration
- grassed swales which are vegetated or grass lined channels that can convey high or low flows. A rip rap lined swale releases stormwater and wet weather overflows to South Creek
- detention basins located on the northern and south-western boundary above the 1% AEP flood level for South Creek. The detention basins have been designed to have sufficient storage to ensure site based peak flows do not exceed peak flows from the pre-development condition for the 1% AEP storm event.

The post-development environmental water balance (without WSUD measures) predicts an overall increase in runoff (also known as the Mean Annual Runoff Volume or MARV) and reductions in evaporation and infiltration. This is expected because there will be less opportunities for groundwater recharge and evapotranspiration with the increase in impervious surfaces on the AWRC operational area. The model predicts that with WSUD measures implemented at the site, post-development runoff is about 45.5 ML/yr which represents an increase from the existing condition but an overall MARV reduction of 45% from the post-development (without WSUD measures) scenario.

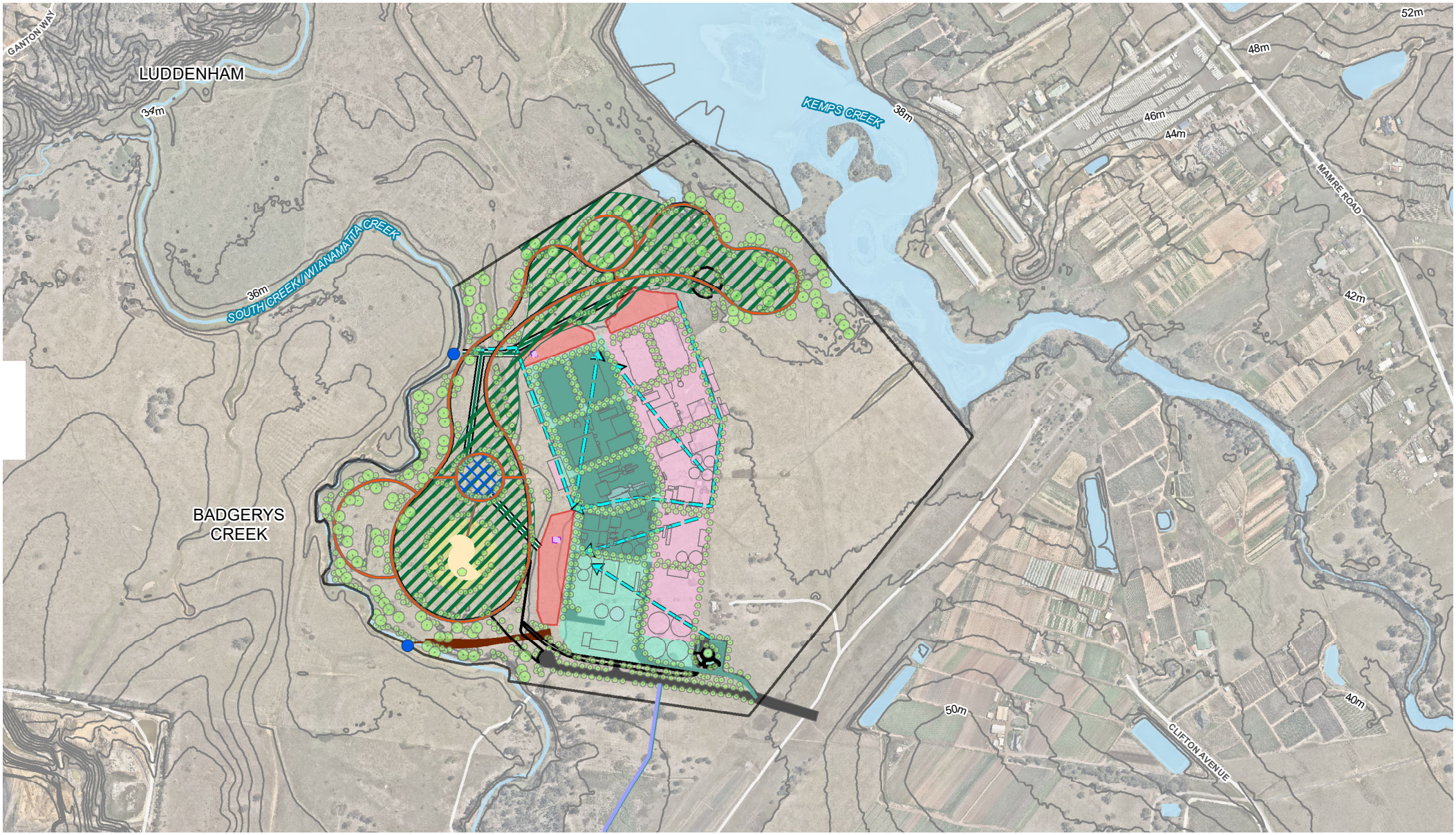


Figure 9-5 Indicative landscape plan with surface water management features

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Frequent low flows

Modelled flow metrics from MUSIC when compared against the adopted objectives in Table 9-22 indicate that by implementing WSUD measures on the AWRC site, flow metrics (including MARV) are between the ideal and tipping point objective values which is considered acceptable. The exception is the 'cease to flow' metric, which is outside the stated limits. This is also considered acceptable at the AWRC site outlet since the delivery of low flows via the wetland and irrigation will contribute to groundwater top up in the local creeks, and also contribute to the local and regional water table providing base flow to South Creek downstream.

The modelling demonstrates that the adopted flow objectives are achievable, and the impact of increased impervious surfaces can be managed through the implementation of a range of WSUD approaches presented above. By achieving the flow objectives, the management of stormwater on the AWRC site contributes to the preservation of existing flow conditions in waterways with an acceptable impact on existing hydrology and water availability limiting impacts on downstream rivers. It is therefore unlikely that the AWRC will adversely impact environmental water availability or access to water.

MUSIC modelling predicts that pollution load reductions of 88.6% for TSS, 72.3% for TP, 77.7% for TN, and 100% for gross pollutants in surface water runoff can be achieved by implementing WSUD design measures at the AWRC site. The modelling demonstrates the adopted objectives identified in Table 9-24 can be achieved. The MUSIC modelling results represent long term discharges of stormwater to South Creek and when compared to the ambient water quality objectives in Table 9-23, modelling indicates that concentrations of TSS and TN in stormwater discharges are below the ambient objectives for 90% of the time. Modelling also indicates concentrations of TP in stormwater discharges are below ambient objectives for 85% of the time.

Peak stormwater discharge

Modelling predicts that peak flows from the AWRC will increase from about 2 m^3/s for the pre-development conditions to about 8 m^3/s for the post-development conditions during a 1% AEP storm event. Modelled performance of the detention basins indicates peak flows can be reduced back to the pre-development existing conditions for storms up to and including the 1% AEP event and will function under flood conditions in South Creek. This means that for the AWRC site, increases in peak flows will have negligible impacts to downstream rivers, the natural process of flooding and floodplain areas.

Pipelines

The pipeline infrastructure will primarily be below ground, with the exception of the release structures, associated access roads and scour valves. Because of this, operational surface water impacts associated with the pipelines are expected to be minimal.

There is no water use associated with the release structures during operation.

Table 9-28 summarises operational impacts that may be expected for the project. Overall, with the implementation of a range of stormwater management design measures as part of the stormwater management approach, the project is expected to have minimal impacts on the surface water environment during the operational phase.

Table 9-28 Summary of potential operational surface water impacts

Location	Impact summary	Impact significance
AWRC operational area	Increased runoff and reduced infiltration may occur because of the increased impervious surfaces. This may alter frequent low flow patterns and baseflow to South Creek. Modelling of the environmental water balance predicts that with WSUD measures at the AWRC operational and green space area, post-development runoff is about 45.5 ML/yr. This represents an increase from the existing condition but an overall MARV reduction of 45% from the post-development (without WSUD measures) scenario. The impact significance is low because modelling indicates that by implementing a range of WSUD measures on the AWRC site, frequent low flows discharged from the site will be preserved as far as is practicable to achieve the objectives in Table 9-22.	Low
AWRC operational area	Increased runoff with increased pollutant loads (TSS, TP and TN) due to the increase in impervious surfaces discharging to South Creek. The impact significance is low because modelling indicates that implementing a range of WSUD measures within the AWRC operational and green space area pollutant loads will reduce for TSS by 89%, TP by 72% and TN by 78%. This outcome means that the objectives in Table 9-24 can be achieved. Modelling also indicates that post-development stormwater discharge will contribute to achieving water quality objectives (Table 9-23) by discharging pollutants (TSS, and TN) at concentrations below ambient objectives for South Creek up to 90% of the time.	Low
AWRC green space area	Excessive irrigation may lead to localised increases in saline groundwater levels and saturated saline soils. Salts found in saline soils can mobilise (salinisation) and may enter runoff and discharge to South Creek which would adversely affect water quality. Increases in groundwater levels are likely to remain localised and soils are generally non-saline at the surface with increasing salinity with depth to the water table at the site. As a result, salinisation impacts are expected to remain localised across the irrigation area, and impact significance is considered moderate. Modelling assumes an irrigation rate of 4.5ML/year to meet the local deficit between rainfall and evapotranspiration which will retain water in the catchment and avoid excessive infiltration into soils. Provided the management measures to control irrigation rates in section 9.2.9 are implemented, the impact significance will reduce to low.	Moderate

Location	Impact summary	Impact significance
AWRC operational area	Post-development peak flow discharges (volumes and rates of flow) may increase due to the increase in impervious surfaces. This may exacerbate flooding conditions in South Creek downstream of the AWRC. Modelling predicts that during a 1% AEP event pre-development peak flows will increase from about 2 m^3/s to about 8 m^3/s for the post-development scenarios. The assessment has shown that on site detention basins will provide storage so that post development flows will not exceed pre-development flows for all events up to and including the 1% AEP event. The impact significance is negligible as there will be no impact to downstream flooding conditions or the floodplain in South Creek. This means there will be no increase in downstream peak flows within South Creek and no increase in peak flows into and through the Pipeline Corridor downstream of the AWRC site.	Negligible
AWRC operational area	The operation of machinery storage, transport, use, handling and spills of chemicals and spills of partially treated wastewater on the site mean contaminants may be present at the surface and enter runoff adversely impacting surface water quality of South Creek. Because a first flush system designed to intercept the first 10 mm rainfall from the hardstand areas will be implemented as part of the stormwater management approach, the impact significance is considered low. The implementation of management measures in Table 9-29 will further reduce the significance of this impact.	Low
Nepean and Warragamba release locations and associated access roads	Increased runoff with increased pollutant loads (TSS, TP and TN) due to the minor increase in impervious surfaces. Operational areas at the Warragamba River release location include an access road and headwall structure. There may be a small increase in runoff however because the existing steep rocky valley will be relatively impervious the impact significance is considered negligible. Operational areas at the Nepean River release location include an access road and headwall structure recessed into the riverbank. Because any increase in runoff from these areas will be minor, the impact significance is considered negligible. The implementation of management measures in Table 9-29 will further reduce any impacts.	Negligible

Location	Impact summary	Impact significance
Treated water and brine pipelines	Water leaking from the pipelines during operation may impact water quality in South Creek and other waterways that intersect with the pipelines. Because water being conveyed via the treated water pipeline will be of high quality it is unlikely to cause significant impacts. The brine being transferred via the brine pipeline will have much higher concentrations of total dissolved solids and nutrients with potential to cause adverse impacts to the surface water environment. Sydney Water designs its pipelines to a high standard to minimise the risk of leaks with design measures taken to prevent leaks and failures from the brine pipeline as described in Chapter 4. The impact significance is low because any remaining impacts will be local and temporary. Further, Sydney Water's standard procedures include regular inspections and incident response procedures which will also manage this potential risk and impact.	Low
Scour valves discharging to waterways	During routine pipe cleaning activities discharges will occur via scour valves to waterways. For the treated water pipeline water will be of high quality and unlikely to cause significant impacts. For the brine pipeline, any brine discharged will be collected and disposed of at an appropriate facility. The impact significance is low because impacts will be local and temporary and procedures, as prescribed in Sydney Water's Discharge Protocols Standard Operating Procedure will be followed ensuring potential localised impacts are managed.	Low

9.2.7 Impact of future stages

Detention and WSUD infrastructure at the AWRC site has been sized to manage impacts from future stages. This is to avoid the additional impacts associated with upgrading the drainage system when the future stages become operational. This assessment has demonstrated that DPIE South Creek flow and quality objectives and Penrith City Council pollution load reduction targets can be achieved for future stages of the AWRC development.

9.2.8 Cumulative impacts

The assessment has considered the project's cumulative impacts with:

- Western Sydney International Airport
- M12 Motorway
- Sydney Metro - Western Sydney Airport
- Western Sydney Aerotropolis Growth Area (WSAGA)

- Northern Road Upgrade – Glenmore Road to Bringelly
- Warragamba Dam wall raising.

The potential for cumulative construction impacts are associated with the Western Sydney International Airport and the M12 Motorway projects.

The M12 Motorway will align with the southern boundary of the AWRC site and Western Sydney Airport is located about 3.2 km south west of the AWRC site. Both of these projects would implement erosion and sedimentation control measures so impacts resulting from construction activities are not expected. Provided construction management measures are implemented at the AWRC site, cumulative impacts are not expected to be significant.

During operation, increased runoff from the M12 Motorway is expected. However, the pollutant loads in runoff are expected to decrease with the implementation of water quality controls. Provided management measures are implemented at the AWRC site, cumulative impacts are not expected to be significant. During operation the increase in impervious area at the Western Sydney International Airport has potential to increase pollutant loads in Badgerys Creek and South Creek downstream of the site. However, the Western Sydney Airport EIS surface water quality assessment (GHD, 2016a) concluded that water quality discharged from the airport site to downstream waterways is expected to improve compared to existing conditions for TSS, TN and TP. The AWRC site will not contribute to cumulative water quality impacts downstream of the site provided management measures are implemented.

Sydney Metro – Western Sydney Airport will be a new railway which will link St Marys to Western Sydney Airport and the Western Sydney Aerotropolis. The project footprint is primarily located within the South Creek catchment. The Sydney Metro EIS indicates that during operation the project has potential to further degrade the water quality within the South Creek catchment. However, mitigation measures which include detention basins and WSUD features at stations to treat stormwater runoff will be incorporated into the design to mitigate impacts and achieve the stated project performance outcomes. Provided management measures are implemented at the AWRC site cumulative impacts within the South Creek catchment are not expected to be significant.

As precincts across the WSAGA are developed there is potential for cumulative operational impacts to occur across the growth area. Currently, operational management measures that will be implemented at the AWRC site mean there will be no cumulative impacts associated with surface runoff or increased pollutant loads downstream of the site. An integrated water management plan for WSAGA is currently being developed which will identify measures and control mechanisms to ensure sustainable water management practices are established across the growth area and limit regional cumulative impacts to the surface water environment.

The Northern Road Upgrade intersects the treated water pipeline at Park Road and Elizabeth Drive. The road may increase surface runoff rates however as the treated water pipeline will be underground, during operation cumulative impacts will be negligible.

Warragamba Dam wall raising is a project that will provide temporary storage capacity for large inflow events into Lake Burragorang to facilitate downstream flood mitigation. There is not expected to be a cumulative impact resulting from the environmental flows release location.

9.2.9 Management measures

Table 9-29 summarises management measures for the project's impacts on surface water.

Table 9-29 Management measures for surface water impacts

ID	Potential impact	Management measure	Timing
SW01	Construction surface water impacts	Prepare and implement a Soil and Water Management Plan as part of the project's CEMP. The plan will include: • construction phase surface water, groundwater, contaminated land and soils and waterways management measures from this table • roles and responsibilities • monitoring and auditing requirements	Detailed design During construction
SW02	Increased runoff, reduced infiltration and pollutant loading to South Creek, including exacerbated downstream flooding conditions	Design, install and maintain stormwater management measures on the AWRC site (including a range of Water Sensitive Urban Design measures) to ensure: • operational releases to South Creek achieve water quality and flow objectives (Western Sydney Planning Partnership, 2020) for South Creek and pollution load reduction targets in Penrith City Council DCP (2014) • operational efficiency of installed measures • post-development peak flows do not exceed pre-development peak flows for the 50%, 5% and 1% AEP storm events.	Detailed design During construction During operation
SW03	Increased runoff may exacerbate flooding conditions in South Creek downstream of AWRC	Progressively construct operational stormwater management measures for potential use and contribution to stormwater management during construction, if practical.	Detailed design During construction
SW04	Excessive irrigation of the green space area on AWRC site may lead to localised increases in saline groundwater levels and saturated saline soils	Develop and implement an irrigation procedure that as a minimum: • identifies an irrigation rate that considers the local deficit between rainfall and evapotranspiration identified in the Surface Water Impact Assessment (Aurecon Arup, 2021d) to avoid salinisation • avoids watering areas without vegetation cover • is tailored to address the ultimate landscape and site design.	Detailed design During operation

ID	Potential impact	Management measure	Timing
SW05	Sediment laden and contaminated surface runoff, including releases from sedimentation basins, entering waterways	Implement and maintain sediment and erosion control measures and install sedimentation basins in appropriate locations considering the guidance (including any monitoring) in Managing Urban Stormwater, Soils and Construction Volume 1, 4th Edition (Landcom, 2004). Management measures will be developed considering the guidance provided in the project's Surface Water Impact Assessment (Aurecon, Arup, 2021d).	Prior to construction During construction
SW06	Spills of chemicals, fuels and partially treated wastewater on the AWRC site mean contaminants may enter waterways	Store chemicals, fuels and oils in bunded areas on the AWRC site.	During operation
SW07	Spills of chemicals, fuels and partially treated wastewater on the site mean contaminants may enter waterways	Develop and implement the following as part of the CEMP: • spill response procedure in accordance with Australian Spill Control Industry Standard for Spill Response Kits (ASCIS 2695) • vehicle, plant and equipment maintenance and refuelling procedure.	During construction
	Discharges occurring via scour valves to waterways	This impact is appropriately managed by measures in this table and G02 in Chapter 15 (Project synthesis).	During operation
	Stockpiles and excavations with acid sulfate soils (ASS)	This impact is appropriately managed by measures in this table and section 9.2 (Contaminated land and soils) and applies to compound C14 and brine pipeline construction near Georges River and Prospect Creek.	During construction
	Saline groundwater encountered during excavation may enter surface water	This impact is appropriately managed by measures in section 9.4 (Groundwater).	During construction
	Contaminated waste material entering waterways	This impact is appropriately managed by measures in section 12.2 (Waste management).	During construction

ID	Potential impact	Management measure	Timing
	Water required for construction activities such as dust suppression may impact local or regional water resources	This impact is appropriately managed by other measures in this table.	During construction
	Overtopping of coffer dams during higher river flow events may mobilise sediments	This impact is appropriately managed by measures in Chapter 8 (Key waterways impacts).	During construction
	Drilling fluid escaping to the surface enters surface water runoff	This impact is appropriately managed by measures in section 9.4 (Groundwater).	During construction
	Disruption of surface water connectivity where waterway crossings constructed by tunnelling	This impact is appropriately managed by measures in section 9.4 (Groundwater)	During construction
	Vegetation removal on or near watercourses may cause bank damage and expose soil surfaces	This impact is appropriately managed by measures in section 9.1 (Terrestrial biodiversity) and Chapter 8 (Key waterways impacts).	During construction
	Temporary obstruction and interference of normal drainage channels during trenching causing upstream ponding and sedimentation	This impact is appropriately managed by measures in Chapter 8 (Key waterways impacts).	During construction
	Water leaking from the pipelines during operation	This impact is appropriately managed by measure G02 in Chapter 15 (Project synthesis).	During operation

9.3 Flooding

This section describes the existing flood environment around the project and the project's potential flooding impacts during construction and operation. This includes consideration of the extent to which the construction and operation of the project increases flooding risk to its surrounds, and the extent to which natural flooding may impact on the project. It provides an overview of key findings of the detailed Flood Impact Assessment (Aurecon Arup, 2021e) included in Appendix L.

Flood impact summary

Although some project activities will occur on flood-prone land, the project will have a negligible impact on flood behaviour and downstream flooding and will not result in detrimental impacts to other developments or land. In addition, since most project infrastructure will be built outside areas of flood risk, it has a very small chance of being affected by floods.

There is potential for the project to have a small impact on flooding where construction activities encroach on flood-prone land on South Creek, Nepean River and other waterways. This includes activities at the AWRC site, the treated water and environmental flows release locations and some site compounds and waterway crossings along the pipeline alignment.

Construction activities on flood-prone land may change local flooding characteristics, displacing floodwaters and causing downstream flood levels to increase. Flooding has the potential to impact construction activities by creating hazardous working conditions, and displacing temporary buildings, equipment or materials. However, construction impacts are temporary and the chance of a large flood event during the three-year construction period is low. In addition, the project's potential construction impacts on flooding can be effectively managed through a range of management measures.

Once built, pipelines will be below ground so these structures are not expected to impact on flooding during operation. The main consideration for operational flooding impacts is therefore at the AWRC site and the treated water and environmental flows release locations.

At the AWRC site, the operational area of the site is outside and above the 1% Annual Exceedance Probability (AEP) flood planning level, which includes an allowance for flood level increases resulting from climate change. The operational area does not encroach on the 1% AEP flood extent so there is no impact on downstream flood levels and the operational area does not flood during a 1% AEP event.

Even at the largest flood (the Probable Maximum Flood - PMF), the AWRC operational area is not flooded. However, the operational area has a minor encroachment into the PMF flood extent, resulting in minor increases (100 mm) in upstream flood levels on Kemps Creek. These flood level increases will be localised and will not impact on any other assets, development or land. The impact of flooding from the AWRC and associated infrastructure is therefore considered negligible.

For Warragamba River and Nepean River, the release structures are expected to have negligible impacts on flow conveyance (flow carrying capacity of the channel). The contribution of treated water releases to flood flows in these waterways is also negligible, with flows contributing to 0.04% of the 1% AEP flood event for the environmental flows pipeline

and 0.02% of the 1% AEP flood event for the treated water pipeline. This represents an increase of only up to five millimetres in flood levels.

Sydney Water has consulted with the State Emergency Service (SES), Wollondilly Shire Council and Penrith City Council about flood evacuation for workers during construction and operation, and this can be effectively managed with the measures outlined in this section.

9.3.1 Relevant Secretary's Environmental Assessment Requirements

Table 9-30 summarises the Secretary's Environmental Assessment Requirements (SEARs) relevant to flooding and where in this section they are addressed.

Table 9-30 Project SEARs relating to flooding impacts

SEARs	EIS section where requirement addressed
29. Mapping the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including:	
a) Flood prone land	Section 9.3.3
b) Flood planning area, the area below the Flood Planning Level	Section 9.3.3
c) Hydraulic categorisation (floodways and flood storage areas)	Section 9.3.3
d) Flood hazard.	Section 9.3.3
30. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (considering sea level rise and storm intensity due to climate change).	Sections 9.3.2, 9.3.5, 9.3.6
31. Modelling must consider and document	
e) Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies.	Section 9.3.2
f) The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood or an equivalent extreme flood	Section 9.3.6
g) Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazard categories and hydraulic categories	Section 9.3.6
h) Relevant provisions of the NSW Floodplain Development Manual 2005	Section 9.3.4

SEARs	EIS section where requirement addressed
i) Consideration of scenarios where the pipelines are shut down or used infrequently	Table 9-36 discusses potential impacts to South Creek in the event of a total power failure, which is the only relevant scenario. Power supply is discussed in section 4.5.3. Chapter 4 describes infrequent maintenance activities that may occur on the pipelines and these are not expected to have flooding impacts'
j) Impacts to South Creek under all scenarios specifically where South Creek and the Warragamba pipelines intersect	Section 9.3.6. Section 9.2.6 for impacts to peak flows from AWRC site. Section 8.7.2 for impacts to Warragamba pipeline from treated water releases.
k) Consideration of backflow impacts during flood events	Section 9.3.6
32. The EIS must assess the impact on the proposed development on flood behaviour including:	
a) Whether there will be detrimental increases in the potential flood affectation of other properties assets and infrastructure	Section 9.3.6
b) Consistency with Council Floodplain Risk Management Plans	Section 9.3.2
c) Compatibility with any Rural Floodplain Risk Management Plans	No Rural Floodplain Risk Management Plans relevant to this study.
d) Compatibility with the flood hazard of the land	Section 9.3.6
e) Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of land	Section 9.3.6
f) Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site	Section 9.3.6
h) Any impacts the development may have upon existing community emergency management arrangements for flooding, these matters are to be discussed with the NSW SES and Council	Section 9.3.5, 9.3.6 Consultation with SES is also outlined in Chapter 6
i) Whether the project incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and Council.	Sections 9.3.5 and 9.3.6 Consultation with SES is also outlined in Chapter 6

SEARs	EIS section where requirement addressed
j) Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the NSW SES.	Sections 9.3.5 and 9.3.6
k) Any impacts the development may have on the social and economic costs to the community as a consequence of flooding	Section 9.3.6

9.3.2 Methodology and assumptions

The assessment considered the requirements of the NSW Floodplain Development Manual (DIPNR, 2005) to assess changes in flood conditions and potential impacts to flood-prone land from building the project. The assessment involved:

- desktop review of previous flood studies and flood data including adopted flood risk management studies for Penrith City Council (WorleyParsons, 2015a) and Camden City Council (WorleyParsons, 2015b), Hawkesbury-Nepean Valley Regional Flood Study (WMA, 2019a), State Emergency Service (SES) data (May 2021) and spillway data for the Warragamba Dam (Water NSW, 2020)
- initial assessment to compare existing available flood flow data for Warragamba and Nepean Rivers with the maximum expected flows from the treated water releases to assess the potential impacts of releases on river flood flows. This included comparing channel geometry to the location and scale of the release structures to define potential impacts on conveyance, which is the flow carrying capacity of the channel or floodway
- developing hydrologic and hydraulic models using the flood modelling software XP-RAFTS and TUFLOW. The models were used to identify pre-development (baseline) flood characteristics (flood depths, levels, velocities and hazards) in South Creek and Kemps Creek adjacent to the AWRC site and to identify changes in post-development flood characteristics once the AWRC is built
- a climate change sensitivity analysis using the TUFLOW model
- consulting with the SES, Penrith City Council and Wollondilly Shire Council on emergency management and evacuation arrangements for the project
- assessing each of the potential impacts to identify their significance for the construction and operational phases.

Different approaches were taken for construction and operation and for the AWRC and pipelines as described below.

Construction impacts

Construction impacts are associated with the impact on the existing flooding environment of temporary project components. These include construction compounds, stockpiles, equipment storage and temporary access roads, and associated activities such as land clearing, excavation, building infrastructure at the AWRC site and building pipelines across waterways. Using SES flood data (May 2021) and publicly available flood data, the assessment considered whether the construction component or activity will encroach on a documented flood extent obtained from the desktop review or TUFLOW outputs. For locations where existing flood data was not available, surrounding topography and proximity to waterways were reviewed to assess susceptibility to flooding and to define potential impacts.

Operational impacts

AWRC

To define baseline (pre-development) flood conditions a hydrological model was developed for the South Creek catchment in XP-RAFTS using the Australian Rainfall Runoff (ARR 2016) (Ball et al, 2016) method to estimate flows for the 10%, 1%, 0.5%, 0.2% Annual Exceedance Probability (or AEP) events and the Probable Maximum Flood (PMF). The AEP is the chance of a flood from a rainfall event occurring in any given year. For example, the 1% AEP event has a 1% chance of occurring in any given year (and is sometimes called the 1 in 100 year event) and the PMF is the largest possible flood that can occur at this location. As flood events become rarer (that is, they have less chance of occurring in a given year) they increase in magnitude.

These flow estimations from XP-RAFTS were input into a hydraulic model developed in TUFLOW which was used to define local flood characteristics for South and Kemps Creek. Both the hydrologic and hydraulic baseline models were validated against Penrith City Council's adopted flood study (Worley Parsons, 2015a). This showed agreement between the two models and demonstrates consistency with Penrith City Council's Flood Risk Management Plans. The hydrologic model was also validated against the 1% AEP event using the ARR 2016 data reviewed as part of the WMA report 'Review of ARR design Inputs for NSW, (WMA 2019b) and also showed good agreement.

The hydraulic model was then tested with the 1% AEP flow event equivalent to the flow derived from Flood Frequency Analysis (FFA) of gauged streamflow data on South Creek upstream of Elizabeth Drive. This event, known as the 1% AEP FFA event, was modelled so that the peak flow within South Creek arriving at Elizabeth Drive upstream of the AWRC site was equal to 540m^3/s. This was done to capture any associated impacts and to ensure the conclusions of the study remain valid and are consistent with the recommendations of the Wianamatta (South) Creek Catchment Flood Study – Existing Conditions report (Advisian, 2020).

To define flood hazard associated with flood waters at the AWRC site the flood hazard classifications below were used, based on ARR 2016 (Ball et al, 2016). The hazard classifications are based on a relationship between depth and velocity, and TUFLOW results for these parameters were used to identify hazard classes within flood-prone land at the AWRC site.

- H1 – Generally safe for vehicles, people and buildings.

- H2 – Unsafe for small vehicles.
- H3 – Unsafe for vehicles children and the elderly.
- H4 – Unsafe for vehicles and people.
- H5 – Unsafe for vehicles and people. All buildings vulnerable to structural damage, some less robust buildings subject to failure.
- H6 – Unsafe for vehicles and people. All building types considered vulnerable to failure.

These were used to map flood hazard for the AWRC site.

To define post-development flood conditions, elevation data from the bulk earthworks reference design for the AWRC operational area was used to develop a post-development model in TUFLOW. The AWRC operational site area is located outside the 1% AEP flood extent, therefore the operational area will be above the 1% AEP flood level for South and Kemps Creek. The AWRC operational area will be elevated above existing ground level at this location to provide the appropriate grade for drainage and operation of the site-based detention basins.

A comparison of the pre- and post- development TUFLOW model results was used to assess any changes to the flood characteristics for South and Kemps Creek and identify potential impacts.

Key assumptions for flood assessment at the AWRC site included:

- The AWRC site location in the South Creek catchment is sufficiently upstream from the Hawkesbury-Nepean and not considered to be impacted by climate related changes in sea levels.
- For the post-development scenario the modelling assessed the ultimate footprint with the AWRC sized to 100 ML/day. This is because operational stormwater management facilities including detention basins and drainage will need to be constructed to accommodate future stages of the AWRC.

Impacts and associated management measures related to increases in peak flows and volumes during construction and operation are presented in section 9.2.

Pipelines

For both Warragamba and Nepean Rivers the potential flooding impacts relate to:

- whether the project changes the flow carrying capacity (available space) in the channel or floodway. If the flow carrying capacity is reduced, this has potential to increase downstream flood levels
- how treated water releases contribute to increased flows in the river. If the treated water release contribution is significant then this has potential to increase downstream flood levels.

To assess impacts on flow carrying capacity, a cross section (showing available space for water to pass through the river channel) of the river at the release location was compared to the size of the release structures within the channel.

To assess the impacts of releases on flows, flood flow data from the Nepean River Flood Study (Worley Parsons, 2015) and Warragamba Dam spillway data from WaterNSW (2020) were used. These were compared with the maximum release flow rate (50 ML/day for Stage 1) from the treated water and environmental flows pipelines.

Section 9.3.6 discusses the results of this analysis. Given this analysis demonstrated the project will not lead to an increase in downstream flood levels, further assessment using numerical models was not undertaken.

Climate change

The release locations in Warragamba and Nepean Rivers are upstream of the tidal limit and are not impacted by climate related changes in sea levels.

The flooding impacts at the AWRC site were also assessed for two climate change scenarios to identify the resilience of the AWRC to climate change conditions such as higher intensity storm events. Climate change impacts to flooding were assessed in accordance with recommendations of the 'Practical Consideration of Climate Change' Floodplain Risk Management Guideline (OEH, 2007). A sensitivity analysis applied 10% and 20% increases to design rainfall intensities in the XP-RAFTS hydrological model. These results were input into the TUFLOW model to assess the changes to the South Creek and Kemps Creek flood characteristics for the 1% AEP event and the resilience of the AWRC to climate related flooding impacts.

Flood evacuation

The modelled outputs of the pre- and post- development flood scenarios were used to identify potential flood evacuation routes for workers at the AWRC site and flood evacuation routes were also considered for the release structures. Proposals for flood evacuation were presented to Penrith City Council, Wollondilly Shire Council and the SES for consideration to ensure that the proposed evacuation routes aligned with council flood risk management planning and SES emergency planning procedures.

9.3.3 Existing environment

This section focuses on existing flooding conditions near the project. Further description of the South Creek, Kemps Creek and Hawkesbury Nepean river system catchments is included in Chapter 8.

Existing flooding in South Creek and Kemps Creek

This section provides an overview of the existing flood conditions for South Creek and Kemps Creek based on model outputs. Appendix L includes further detail including maps of flood level, depth, velocity and hazard classification for the 10%, 1%, 0.5%, 0.2%, 1% FFA AEP events and the PMF.

Table 9-31 shows existing modelled peak flows in South and Kemps Creek at the AWRC site, just upstream of the confluence of South and Kemps creek. Peak flows increase from the 10% AEP event through to the PMF. The peak flow associated with the PMF is the maximum flow that would be expected at the AWRC site.

Table 9-31 Existing modelled peak flows (m^3/s) for South and Kemps Creek at the AWRC

Flood event	10% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Peak flows at the AWRC site (m^3/s) (South Creek)	116	296	338	396	1814
Peak flows at the AWRC site (m^3/s) (Kemps Creek)	100	237	263	306	1402

During the 1% AEP event, about 45 hectares (ha) of the AWRC site remains relatively free of flood waters. This area represents the area of developable land at the AWRC site.

Flood levels and depths increase gradually from the 10% AEP event through to the PMF. Under the 1% AEP event flood levels range from 37.5 m AHD to about 38.5 m AHD on the western edge of the AWRC site near South Creek and 37.5 m AHD to 39.2 m AHD on the eastern boundary near Kemps Creek. For the 1% AEP FFA event flood levels along the western side of the site range from 38.0 to 39.0 m AHD and along the eastern side from 38.0 to 39.5 m AHD. During a PMF flood levels may range from 39.5 m AHD along the northern boundary to 41.2 m AHD in the southwest corner of the site. Flood water is generally deepest within the existing river channels of South and Kemps Creeks.

During a PMF event the site may become inundated with water depths of up to 2 m, except for an area of about 13 ha which remains free of flood waters as shown on Figure 9-8.

Maximum flood water velocities generally occur at the lowest point in the South and Kemps Creeks channels. Velocity then decreases in the shallower flood waters across the AWRC site.

For the 10% AEP event, maximum in-channel velocities are about 1 m/s and most inundated areas on the AWRC site have flood velocities of less than 0.6 m/s. Maximum flood water velocities gradually increase up to the 0.2% AEP event to 1.7 m/s and 2 m/s for the in-channel areas of South and Kemps Creek respectively. Under the 1% AEP FFA event there are localised areas in along sections of South and Kemps Creek channels where velocities of 2.1 m/s and 2.4 m/s may occur.

Under the PMF, flood water velocities across inundated areas of the site may be between 1 m/s and 2 m/s.

Flood hazard classification

Figure 9-6 and Figure 9-7 show flood hazard classification for the 1% AEP and PMF events.

Flood hazard is a relationship between velocity and depth and flood hazard classes (H1 – H6) are described by a set of curves and thresholds (ARR, 2016).

Generally, as flood magnitude increases, the extent of areas classified as higher hazard also increases. For the 10% AEP event the flooded areas of the AWRC site are classified as H1 to H3. For the 1% AEP event most of the flooded areas are classified as H1 to H3 with areas of higher hazard (H4 to H5) generally found in areas of high flow depth such as the channel of South Creek.

Under the 1% AEP FFA event, about one third of the inundated area is classified H1 to H3. A larger portion of the area is classified as H4 and H5 where higher depths and velocities can be found, and creek centre lines are generally classified as H6.

The extent of areas classified as H4 and H5 increases slightly for both the 0.5% and 0.2% AEP events. During the PMF most of the flooded areas at the AWRC site would be classified as H5.

Climate change

Water levels and flow rates were assessed under proposed climate change scenarios of 10% and 20% rainfall increase. Under a 1% AEP event with a 10% rainfall increase, water levels increase across the site by about 0.1m. With a 20% rainfall increase water levels increase across the site by about 0.2m. Similarly, under the climate change scenarios, existing velocities increase slightly by about 0.1m/s for a 10% and 20% increase in rainfall.

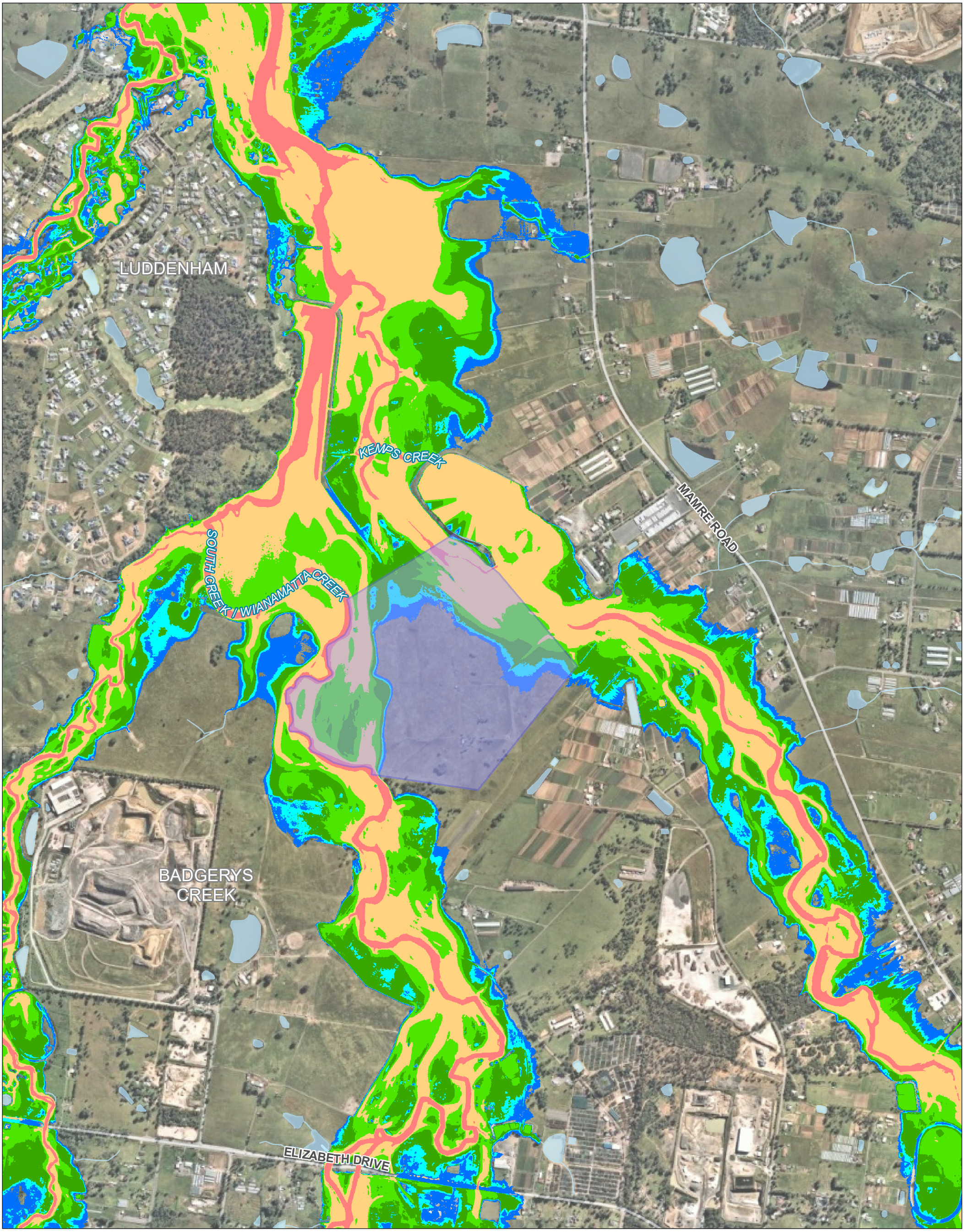
Flood-prone land, hydraulic categories and flood planning area

Figure 9-8 shows flood-prone land, hydraulic categories and flood planning area.

Flood-prone land is defined by the PMF extent (WorleyParsons, 2015a). The NSW Floodplain Development Manual (DIPNR, 2005) describes flood-prone areas according to hydraulic categories, which provide an indication of the potential for development across different sections of the floodplain to impact on existing flood behaviour.

Hydraulic categorisation of the 1% AEP flooded area (WorleyParsons, 2015a) is based on a relationship between velocity and depth. ‘Floodways’ are generally found in the main channels of South and Kemps Creeks, ‘flood storage’ areas are located throughout the flooded area and ‘flood fringe’ areas are located outside the main channel but in remaining areas not already categorised as ‘flood storage’.

The flood planning level is defined as the 1% AEP flood level plus 500 mm. The flood planning area (the area within which land can be developed) is the area above the flood planning level and for the AWRC site is shown on Figure 9-8.



Advanced Water Recycling Centre

Design 1% AEP Hazard Classification

H1
H2
H3
H4
H5
H6
Watercourse
Waterbody

1:15,000
0 250 500 m

Figure 9-6 Pre development 1% AEP flood hazard classification

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

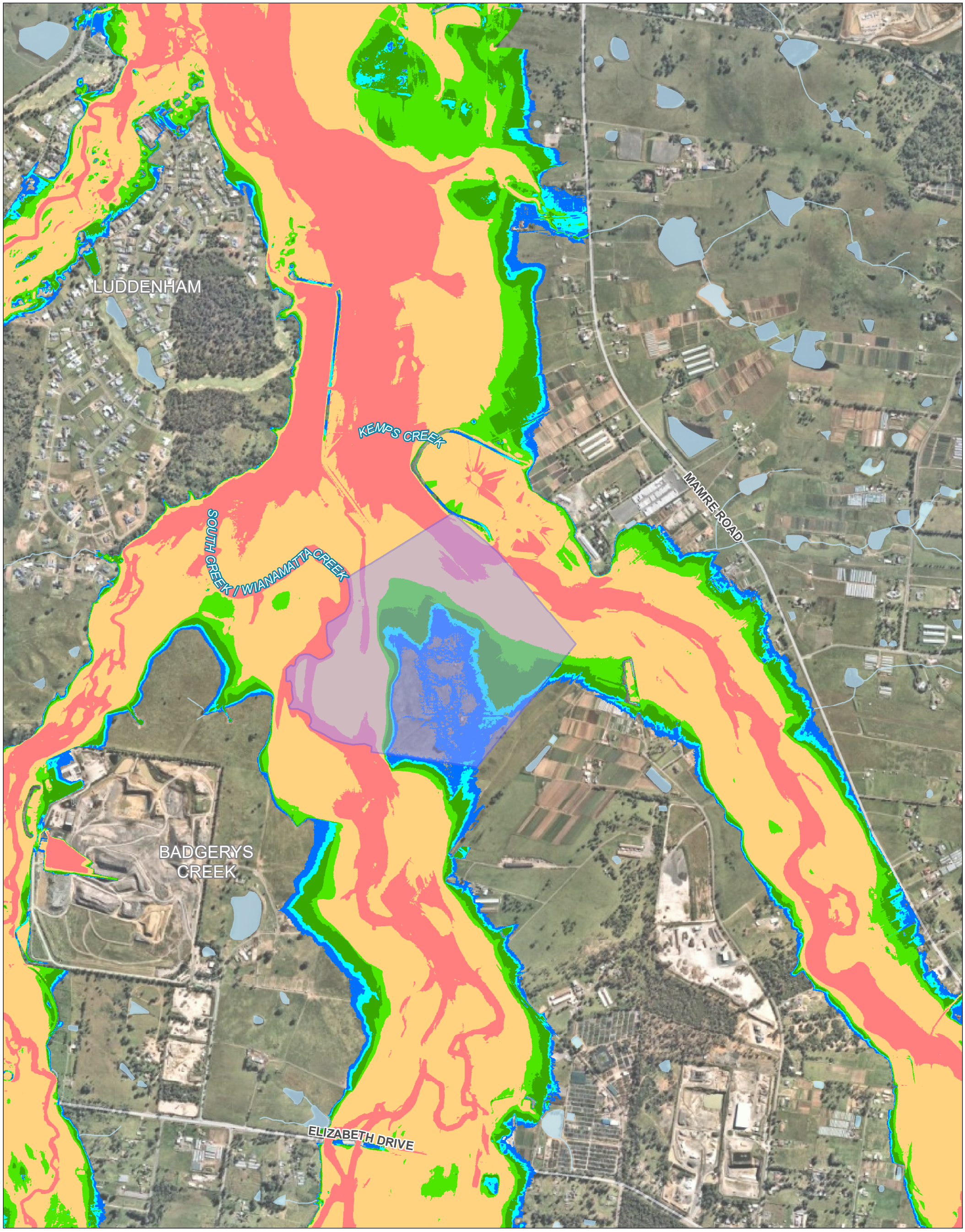


Figure 9-7 Pre-development PMF flood hazard classification

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

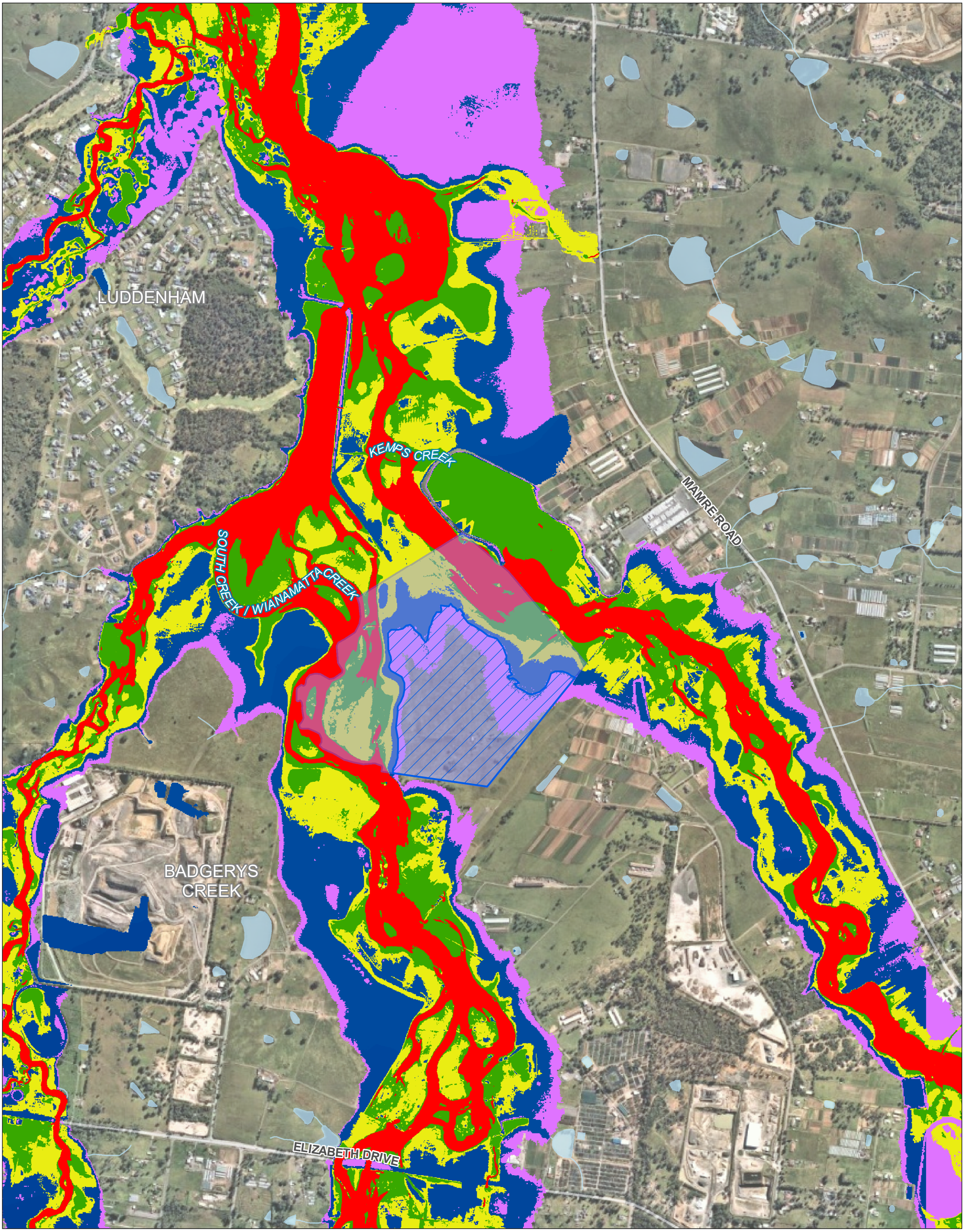


Figure 9-8 Hydraulic categories,flood prone land and flood planning area (WorleyParsons 2015a)

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

Existing flooding in Warragamba and Nepean Rivers

Flood event data shown in Table 9-32 and Table 9-33 are drawn from different studies. The flood AEP events reported in each study depends on the terms of reference and may therefore differ between studies.

Table 9-32 shows existing peak flows in Nepean River at the treated water release location. Peak flows increase from the 50% AEP through to the PMF. The peak flow associated with the PMF is the maximum flow that would be expected at this location.

Table 9-32 Existing flows – Nepean River (Nepean River flood study, WorleyParsons, 2015)

Flood event	50% AEP	20% AEP	5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Peak flows (m^3/s)	1074	2447	5220	8314	9469	11048	18421

The Nepean River flood study (WorleyParsons, 2015b) does not detail peak flood levels for Wallacia but indicates broad ranges from Wallacia to Bents Basin upstream. Based on this study the 1% AEP event flood levels range from 35 to 45 m AHD. The most recent study on Nepean River is the Hawkesbury- Nepean Valley Flood Study (WMA Water, 2019a). Based on this study existing peak flood levels at Blaxlands Crossing are about 35 m AHD for the 20% AEP event, 45 m AHD for the 1% AEP event and 66 m AHD for the PMF. During a 1% AEP event, flood water extends across Mulgoa Road to the north and Park Road to the east of Wallacia. The junction of Silverdale, Mulgoa, Park Road and Greendale Road heading south remain outside the 1% AEP flood extent and flood free. Flood mapping (WMA Water, 2019a) for the 1% AEP and PMF are shown in Appendix L.

Table 9-33 shows existing peak flows in Warragamba River at the environmental flows release location. Peak flows increase from the 10% through to the 0.0001% AEP event.

Table 9-33 Existing flows – Warragamba Dam spillway outflow (Water NSW, 2020)

Flood event	5% AEP	1% AEP	0.5% AEP	0.2% AEP	0.001% AEP
Peak flows (m3/s)	4800	8300	9300	10100	44000

The 1% AEP water level in Warragamba River immediately downstream of the Warragamba Dam spillway is about 44 m AHD. The flow conditions downstream of the dam are typically highly dynamic with waves and surface disturbances associated with the highly turbulent flow expected at this location.

Existing flooding in waterways along pipeline alignments

For the treated water pipeline, mapping accessed from the SES data portal in November 2020 indicates Badgerys Creek, Cosgroves Creek, Oaky Creek, Jerrys Creek and Baines Creek may be subject to flooding during a 1% AEP event. For the brine pipeline, flood studies for Orphan School Creek, Green Valley Creek and Clear Paddock Creek (SKM, 2008) and Prospect Creek (Bewsher Consulting, 2010) indicate the waterways may be subject to flooding in a 1% AEP event. No flood information was available for Hinchinbrook Creek.

9.3.4 Legislation and guidelines

Table 9-34 summarises the legislation, guidelines and policy relevant to the project's flood impact assessment.

Table 9-34 Guidelines, policy and legislation relevant to the project

Legislation/Guideline	Relevance to the project
New South Wales Floodplain Development Manual (DIPNR, 2005)	The manual is a statutory document that guides the management of flood - prone land in NSW. The manual incorporates the NSW Government's Flood Prone Land Policy. The main objective of the Flood Prone Land Policy is to reduce the impact of flooding and flood liability on owners and occupiers of flood-prone property and reduce public and private losses. The manual guides councils through the floodplain risk management process and development of flood-prone land for the purposes of Section 733 *of the Local Government Act 1993.* Provisions of the policy relevant to the project are: • A merit-based approach to the selection of flood planning levels. This recognises the need to consider the full range of floods up to and including the PMF whilst noting that with few exceptions it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis of the Flood Planning Level (FPL). • Recognition of the importance of the continuing flood risk addressed in the State Emergency Service Act 1989 and State Flood Plan and the close relationship between emergency management and the floodplain risk management process. • Recognition of the potential implications of climate change on flooding behaviour. • Reducing the social and financial costs from the risks associated with occupying the floodplain. The provisions of the manual guide councils in preparing and implementing flood plain risk management plans. They have been used to guide and inform the preferred modelling methodology for the assessment of flood impacts for the project.

Legislation/Guideline	Relevance to the project
Practical Consideration of Climate Change – Flood Risk Management Guideline (DECC 2007)	The guideline is intended to complement the provisions of the NSW Flood Plain Development Manual. It provides guidance on how to incorporate climate change considerations when assessing floodplain risks.
Australian Rainfall and Runoff – A guide to flood estimation (ARR 2016)	ARR is a national guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. The ARR has been used to support the modelling exercise undertaken for the project.
Water Management Act 2000	Section 90 provisions relate to controlling works situated in or in the vicinity of a river, estuary, lake or within a floodplain that are likely to have an effect on the flow of water to or from a river, estuary or lake or the distribution or flow of floodwater in times of flood. The project is exempt from section 90 provisions under Section 5.23 (1) (g) of the *Environmental Planning and Assessment Act 1979* because the project is State significant infrastructure.

9.3.5 Construction impact assessment

Several construction activities can potentially change flooding conditions by inhibiting flood flows or displacing flood waters if located in flood-prone land. These activities include temporary earthworks, stockpiles, portable buildings and site sheds, construction plant or equipment and materials storage. Portable buildings and large unsecured construction objects have the greatest potential to affect flooding. They can be carried away by deeper floodwaters and worsen local flood conditions by blocking bridges, culverts and flood control structures downstream. For all construction compounds and activities, including those located outside of 1% AEP flood-prone areas, overland flow paths during storm events may create hazardous conditions for workers, dislodge machinery and wash stockpiles away.

Where temporary works (such as waterway crossings) are required close to watercourses during the construction phase, these could also potentially alter flooding conditions.

The likelihood of a 1% AEP flood event during a three-year construction period is relatively low, with a 3% chance of occurrence. Appendix L includes more detail about the construction impact assessment and datasets used.

AWRC site

The AWRC site is partially located within flood-prone land and will be the main construction compound for the project (C8). As the AWRC will be above the 1% AEP flood level, during construction most of the bulk earthworks will also occur above the 1% AEP flood level. Where construction activities occur below the 1% AEP flood level there is potential for impacts on the flood regime to occur. These activities will be limited to establishing the green space area and building release infrastructure to South Creek. Stockpiling or construction activities in the 1% AEP flood-prone areas has potential to displace floodwaters increasing downstream flood levels. Stockpiles, portable buildings and large construction objects such as machinery located in 1% AEP flood-prone areas have potential to be carried away by deeper flood waters.

If a 1% AEP flood event occurred during construction, the impact of construction activities on the flooding regime is expected to be low, provided the management measures in section 9.3.9 are implemented.

Evacuation and emergency management

Due to the proximity of the AWRC to the confluence of South Creek and Kemps Creek, access roads into the site will be affected by certain flood events.

Access to the site is via Clifton Avenue which, based on the results of flood modelling is the safest site evacuation route. Model results suggest that the AWRC operational area and access road from Clifton Avenue will remain flood-free for events up to 1% AEP.

During the 0.2% AEP, 0.5% AEP and PMF events, the site access road may be partially flooded, and Elizabeth Drive will also be flooded (both eastbound and westbound). Early warning and evacuation of the site prior to the access routes being inundated during flood events higher than 1% AEP will need to be considered prior to construction.

The evacuation route from the AWRC site was discussed with Penrith City Council (April 2021) and the SES (May 2021). The SES concluded the proposed evacuation route for the AWRC was in line with current SES planning and had no specific concerns. SES indicated that adequate flood warning would need to be considered as part of an evacuation plan prepared prior to construction. Penrith City Council also had no specific concerns.

There were no concerns that the AWRC would impact existing community emergency management arrangements for flooding.

Pipelines

Potential impacts are associated with changes to flooding conditions caused by construction activities within areas susceptible to flooding and the potential for equipment and temporary buildings to be carried away in flood waters when located in areas susceptible to flooding.

Compounds

Based on NSW SES flood datasets accessed in May 2021, the construction compounds C1 to C4 of the treated water pipeline may be affected by the 1% AEP floodwaters of the Hawkesbury-Nepean River System.

The C9 compound sites located on the brine pipeline are close to Hinchinbrook Creek in Western Sydney Parklands and may be subject to flooding in a 1% AEP event. No flood information was available for Hinchinbrook Creek to identify the extent of floods at this location. However, examination of local topography indicated that they are close enough to Hinchinbrook Creek main channel to be affected by floodwaters.

Based on the flood data available for Prospect Creek, the construction compound C14 is in vicinity of the main waterway channel and may be flooded in a 1% AEP event or may impact flood conditions.

Based on NSW SES datasets accessed in November 2020, construction compounds C5 – C7, located near Cosgrove Creek, and Jerrys Creek on the treated water pipeline are not within the 1% AEP floodplain. This means they are unlikely to be affected by flooding or affect flooding with compound construction activities.

The examination of existing flood data sets indicated that all other remaining compounds (C10, C11, C12, C13, and C15) are unlikely to be affected by flooding or affect flooding with compound construction activities.

Waterway crossings and temporary access roads

Based on NSW SES datasets accessed in November 2020 and current flood modelling for South Creek, construction of the treated water and environmental flow pipelines may be subject to flooding in a 1% AEP event at several waterway crossings including South Creek, Badgerys Creek, Nepean River, Baines Creek, Jerrys Creek and their tributaries. Construction of the brine pipeline may be subject to flooding at several waterway crossings including Hinchinbrook Creek and its tributaries, Clear Paddock Creek, Green Valley Creek and Prospect Creek. Trenched crossings at Oaky Creek, Cosgroves Creek and Kemps Creek are unlikely to be subject to flooding during a 1% AEP event.

Temporary access roads required for construction may be impacted by flooding at these creek locations.

There may be potential to change local flooding conditions during the construction of the Warragamba and Nepean release locations through the use of low-lying flow barriers and coffer dams. However, the reduction in channel capacity is expected to be minor and the impact on flood conditions at these locations is not expected to be significant.

Evacuation and emergency management

Construction of the treated water release structure and environmental flows release structure require a small workforce and small increase in traffic movements. The treated water release location is impacted by flooding from Nepean River and early evacuation of the site can occur via Wallacia and Park Road. The environmental flows release location is impacted by flooding but high ground is close by and evacuation can occur via Core Park Road to the village of Warragamba.

Evacuation and emergency management were discussed with Wollondilly Shire Council in April 2021 and the SES in May 2021. Wollondilly Shire Council did not raise any specific concerns and referred to SES plans for evacuation procedures. SES did not raise any specific concerns with evacuation from worksites at these locations given the small workforce and would expect negligible impacts to the local community. As Park Road is susceptible to flooding from the Nepean during a 1% AEP event the SES indicated there was an alternative evacuation route via private property on Greendale Road connecting with Park Road further east of Wallacia that could be used as a contingency if Park Road becomes flooded. Provided early flood warning (including the use of Flood Watch and the Early Warning Network) is included as part of an early evacuation plan prepared prior to construction, the SES considered it unlikely the project would impact existing community emergency management plans for Wallacia.

Table 9-35 summarises potential construction flooding impacts including location and significance for the project. Provided the management measures in Table 9-37 are implemented, all impacts with moderate significance can be reduced to low.

Table 9-35 Summary of potential temporary construction flooding impacts

Location	Description of potential impact	Impact significance
Compounds C1, C3 and C8 (AWRC site)	Working on or near flood-prone land at the AWRC site, and Warragamba River and Nepean River release locations. The impact is moderate because flooding has potential to cause hazardous working conditions due to inundation however will be short term and temporary in duration.	Moderate
Compounds C1, C2, C3, C4, C8, C9, C14	Compounds and compound construction activities have potential to change local flooding conditions. The impact is moderate because these construction compounds are located within identified 1% AEP flood extents or located near watercourses that may be susceptible to flooding.	Moderate
Compounds C5, C6, C7, C10, C11, C12, C15	These compounds are not located within identified 1% AEP flood extents or are located on locally elevated land. The impact is low because they are not likely change local flood conditions or to be affected by floodwaters.	Low
South Creek, Badgerys Creek, Nepean River, Baines Creek, Jerrys Creek, Hinchinbrook Creek, Green Valley Creek and Prospect Creek	Waterway crossings (tunnelling and trenching activities) have potential to change flooding conditions. The impact is moderate because the crossings are subject to flooding during a 1% AEP event.	Moderate

Location	Description of potential impact	Impact significance
Release structure at Nepean River	In stream construction works using coffer dams and flow barriers at Warragamba River and Nepean River have potential to change flooding conditions. For works on Nepean River the impact is moderate because coffer dams will reduce the channel capacity however will not have a significant impact on the flow carrying capacity of the floodplain.	Moderate
Release structure at Warragamba River	For works at Warragamba River, although the structure is located below the 1% AEP flood level, flow at this location is already highly turbulent and construction of the release structure is unlikely cause significant impacts to existing flooding conditions. The impact is therefore low.	Low
C1, C2, C3, C4, C8, C9, C14 South Creek, Badgerys Creek, Nepean River, Baines Creek, Jerrys Creek, Hinchinbrook Creek, Green Valley Creek and Prospect Creek)	Compounds and construction near waterways may be impacted by flooding because equipment, sheds and stored materials may get carried away in flood waters. The impact is moderate because these locations are within identified 1% AEP flood extents or located near watercourses that may be susceptible to flooding.	Moderate

9.3.6 Operational impact assessment

Table 9-36 provides an overview of the potential impacts and risk rating of the project in relation to flooding. Appendix L includes more detailed results, including for the AWRC site, mapping of flood level, depth, velocity, hazard classification for the 10%, 1%, 0.5%, 0.2%, 1% FFA AEP events and the PMF.

AWRC site

Overall, because the AWRC operational area is located outside the 1% AEP event, modelling has demonstrated it will not change the existing flooding environment for the 10%, 1%, 0.5% and 0.2% AEP events and will not result in detrimental impacts to the AWRC site or other developments or land. Figure 9-9 and Figure 9-10 show the post- development flood hazard classification for the 1% AEP event and the PMF and Figure 9-11 and Figure 9-12 show post-development flood levels for the 1% AEP and PMF events.

Figure 9-13 shows the proposed evacuation route for the AWRC. As discussed in section 9.3.5, emergency management and evacuation were discussed with the SES and Penrith City Council in May 2021. Penrith City Council had no specific concerns relating to emergency management. The SES indicated the AWRC would not impact on community emergency planning arrangements and the proposed evacuation route for the AWRC is in line with current SES plans.

Pipelines

For impacts relating to the pipeline, overall, the impact of the release structures to the flooding regime and the contribution to flood flows from releases to Warragamba River, Nepean River and South Creek are expected to be negligible. With the exception of the release structures the majority of the pipeline infrastructure will be underground, so they are not expected to impact flooding during operation.

The assessment of flow carrying capacity of the channel shows that the proportion of the cross-sectional area taken up by the release structures in both Warragamba and Nepean Rivers once built is extremely small. This means changes to the flow carrying capacity of the channel are expected to be negligible and will not increase downstream flood levels in either waterway.

The assessment showed that the proportion of the overall flow in the channel from the treated water releases was extremely small. The assessment concluded that increases to existing flood flows resulting from pipeline releases were negligible and would not increase downstream flood levels. Flood levels would only increase by up to five millimetres.

Table 9-36 describes these potential impacts in more detail.

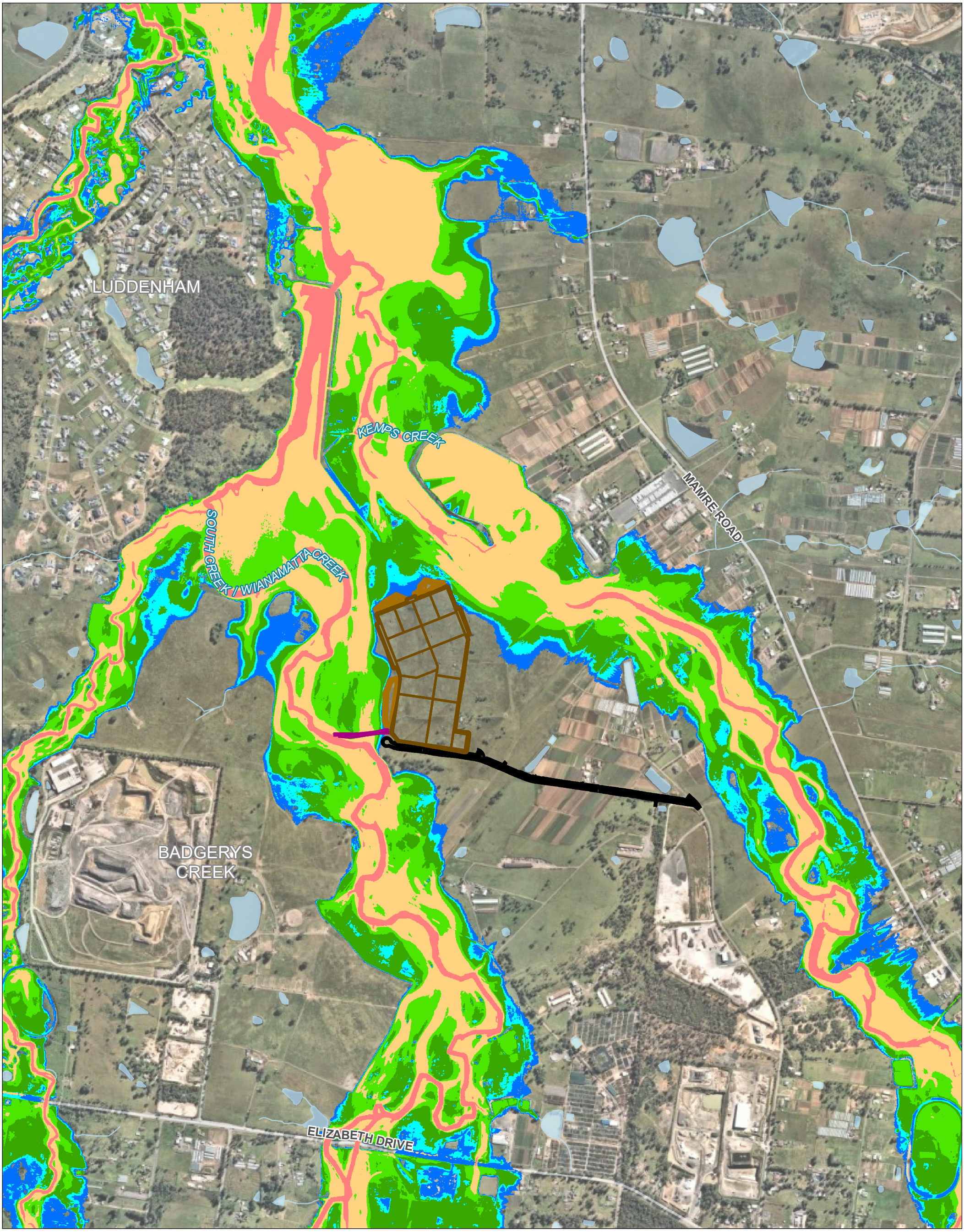


Figure 9-9 Post-development 1% AEP flood hazard classification

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

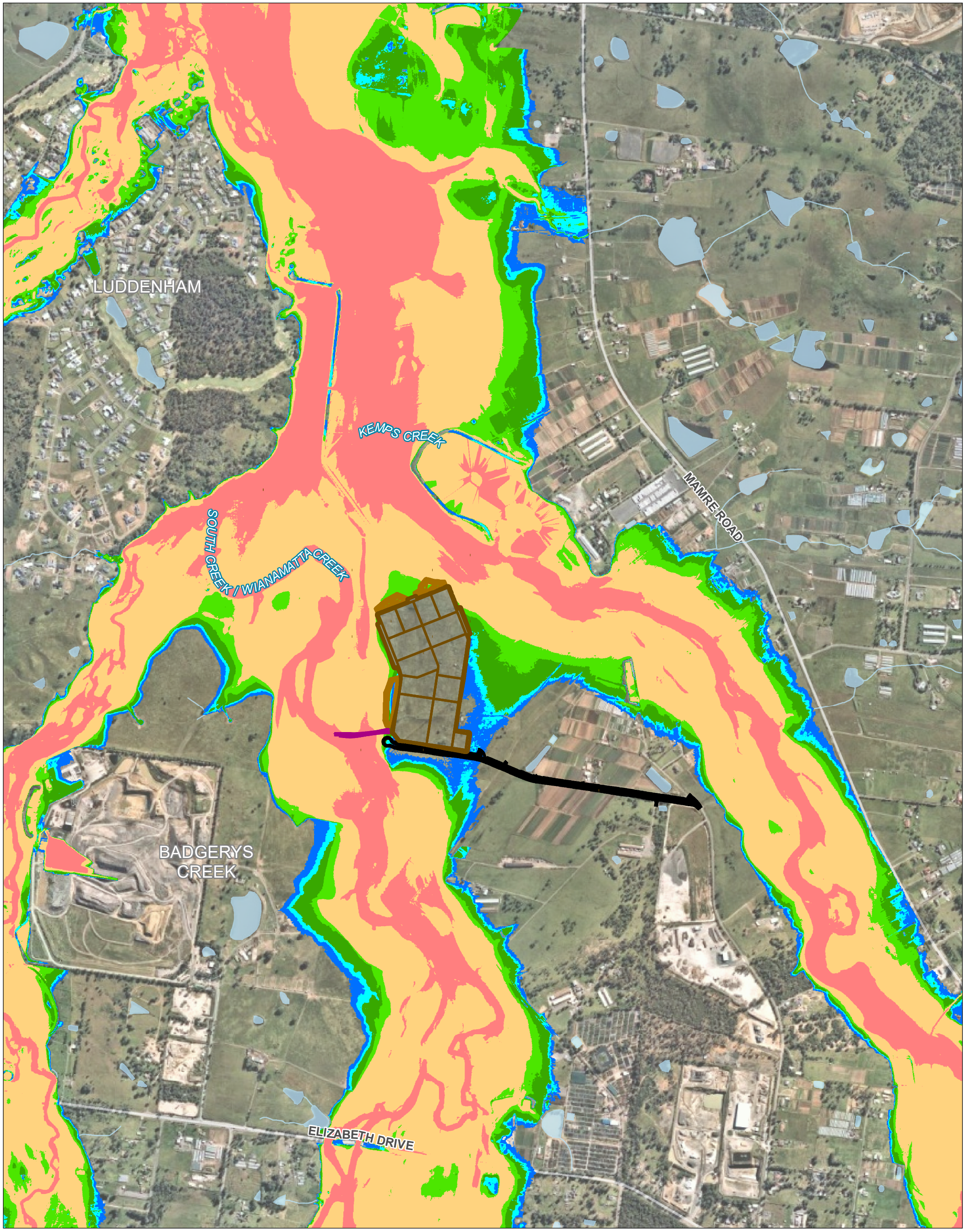


Figure 9-10 Post-development PMF flood hazard classification

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

LUDDENHAM
KEMPS CREEK
SOUTH CREEK / WIANAMATTA CREEK
MAMRE ROAD
BADGERYS CREEK
ELIZABETH DRIVE

Advanced Water Recycling Centre
AWRC
Basins

1% AEP Afflux (m)

<= -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
Was Dry Now Wet
Was Wet Now Dry

1:15,000
0 250 500 m

Figure 9-11 Post-development 1% changes to flood level (afflux)

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI

LUDDENHAM

KEMPS CREEK

SOUTH CREEK / WIANAMATTA CREEK

MAMRE ROAD

BADGERYS CREEK

ELIZABETH DRIVE

Advanced Water Recycling Centre

AWRC

Basins

PMF Afflux (m)

<= -0.1

-0.1 - -0.05

-0.05 - -0.01

-0.01 - 0.01

0.01 - 0.05

0.05 - 0.1

>0.1

Was Wet Now Dry

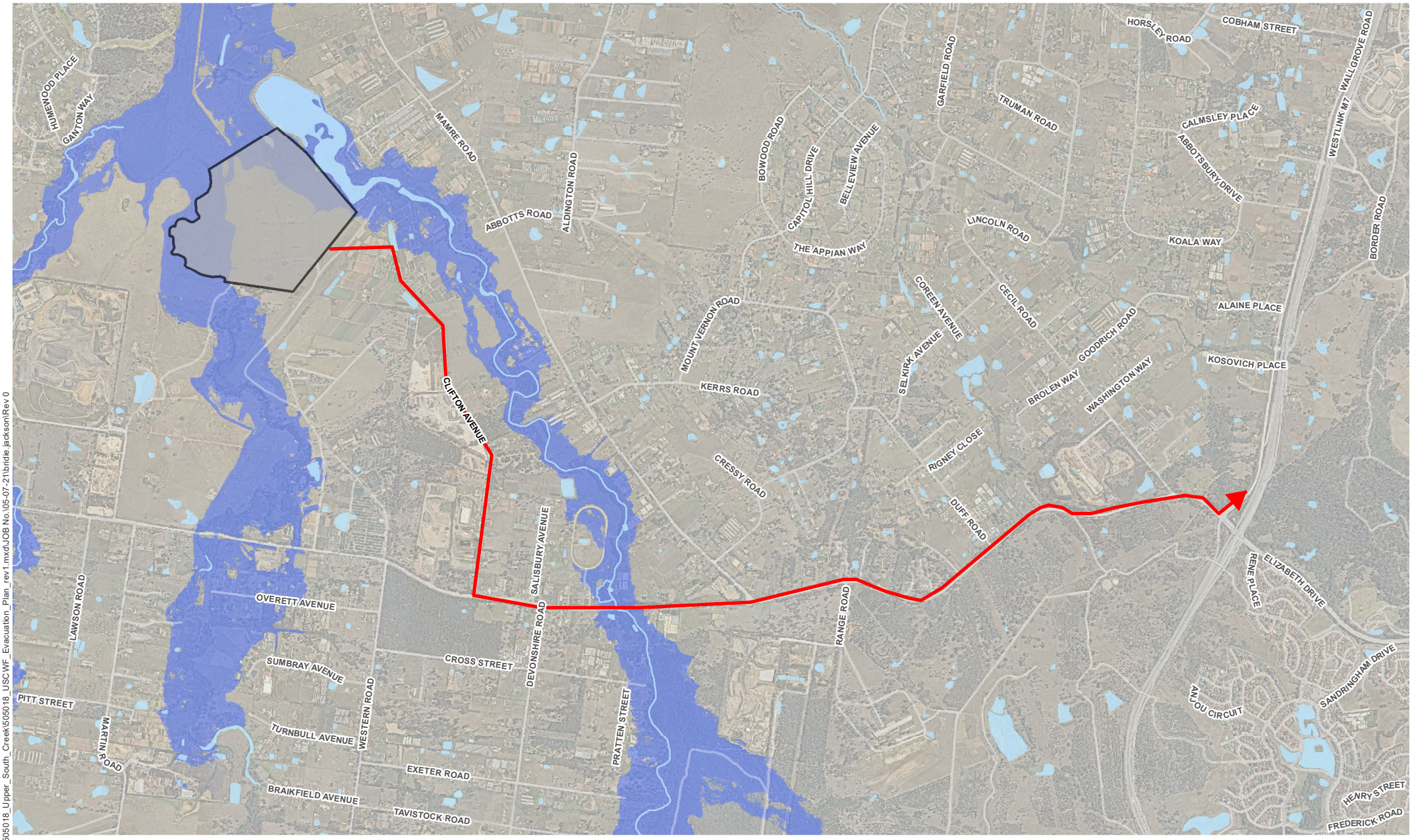
Was Dry Now Wet

1:15,000

0 250 500 m

Figure 9-12 Post-development PMF changes to flood level (afflux)

Projection: GDA 1994 MGA Zone 56
Source; Aurecon, Sydney Water, Nearmap, LPI, ESRI



Advanced Water Recycling Centre

Evacuation Route

1% AEP Flood extent

Waterbody

Watercourse

1:33,500

0 0.5 1km

P:\GIS\Project-4\project\505018_Upper_South_Creek\505018_USCWF_Evacuation_Plan_rev1.mxd\JOB No.\05-07-21\bridie.jackson\Rev 0

Figure 9-13 AWRC Evacuation route

Source: Aurecon, Sydney Water, LPI, Nearmap, ESRI
Projection: GDA2020 MGA Zone 56

Table 9-36 Summary of potential operational flooding impacts

Location	Baseline flood	Description of potential impact	Impact Significance
South and Kemps Creek at the AWRC site	10%, 1%, 0.5%, 0.2% AEP events	Changes to baseline flood characteristics due to encroachment on flood extents. Based on the modelled results, the impact is negligible because: • there are no changes to flood-prone land • there is no change to the hazard classification of flood extents up to the 0.2% AEP event. • there is no change to the flood planning area • there are no changes to upstream water levels (backflows) • there is negligible impact on floodways, flood conveyance or flood storage zones up to the 0.2% AEP event. The AWRC is compatible with the flood hazard, the hydraulic functions of flow conveyance in floodways and flood storage of flood-prone land because the modelling has demonstrated no change from the existing scenarios. There are no impacts to the downstream flood environment therefore no impacts to WaterNSW's Warragamba pipelines where they intersect South Creek • there is no adverse impact on beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. Modelling indicates improved flood storage immediately downstream of the site in South Creek, which enhances beneficial inundation of the floodplain.	Negligible
South and Kemps Creek at the AWRC site	1% AEP FFA scenario of 540m^3/s peak flow at Elizabeth Drive	Changes to baseline flood characteristics due the AWRC encroaching on the 1% AEP FFA flood extent. Modelling indicates a small localised area where the flood level is reduced by up to 100mm in one area and increased by up to 30mm immediately next to the AWRC site in Kemps Creek. Flood levels in South Creek mostly decrease between 10 to 30 mm due to the increased floodplain storage created by constructing the swale in the floodplain to the west of the AWRC. The impact is negligible because there is a minor localised change to flow patterns but no overall impact on flood ways, flood conveyance, flood storage or flood levels outside of the AWRC site.	Negligible

Location	Baseline flood	Description of potential impact	Impact Significance
South and Kemps Creek at the AWRC site	PMF	Changes to baseline flood characteristics due the AWRC encroaching on the PMF extent. Modelling indicates the AWRC operational area encroaches into the PMF flood extent, blocking the movement of flood waters and causing some loss of flood storage. This has the effect of increasing flood levels (backflow) upstream of the site along Kemps Creek by about 100mm. The impact is low because: • the increase in upstream flood level remains localised • there are no detrimental impacts to other developments, assets or land • there will be no impacts on the social and economic costs to the community as a consequence of flooding.	Low
AWRC operational area	10%, 1%, 0.5%, 0.2% AEP and PMF events	The AWRC operational area has potential to be inundated by floodwaters. This area is located outside the 1% AEP flood extent and is elevated to accommodate site drainage requirements at this location. Because modelling indicates that the AWRC operational area is not inundated by flood waters for all the modelled storm events up to and including the PMF event, the impact is negligible.	Negligible
AWRC operational area	Climate change increase on 1% AEP flood levels	The AWRC operational area has potential to be inundated from an increase in flood levels caused by climate change impacts. The impact is considered negligible. This because although modelling indicates a slight increase in flood levels across the site for a 20% increase in rainfall intensity to the 1% AEP event, there will be no inundation of the AWRC for all floods including climate change. Given the impact assessment is showing insignificant changes to flooding conditions under PMF, the impacts will remain insignificant for all less-severe events, including any possible climate change scenario. This is because the PMF is the largest possible flood at the AWRC location, larger than even the most severe flood resulting from climate change. In addition, the AWRC operational area will be elevated by about one metre above existing ground level to allow for appropriate site drainage and operation of the detention basins, which means operational areas of the AWRC will be designed to withstand flooding from the 1% AEP + climate change event.	Negligible

Location	Baseline flood	Description of potential impact	Impact Significance
AWRC operational area	10%, 1%, 0.5%, 0.2% AEP and PMF events	Safe evacuation has potential to be limited during larger flood events. Modelling indicates the AWRC operational area remains flood free up to and including the 1% AEP event meaning safe evacuation in line with current SES arrangements can continue via Clifton Avenue and turning left on Elizabeth Drive. Between the 1% AEP to the PMF, modelling indicates the site access road is partially flooded along with sections of Elizabeth Drive east and west of Clifton Avenue. This means that evacuation may not safely occur beyond the 1% AEP event Modelling has shown that the AWRC operational area remains flood free up to the PMF and workers will be able to shelter in place if needed. The impact is therefore moderate. Provided the management measures in section 9.3.9 are implemented (which include the implementation of plans to evacuate prior to flood waters preventing safe access) the risk to loss of life is managed and the significance of the impact will be reduced to low.	Moderate
South Creek at the AWRC site	1% AEP event	Changes in flooding characteristics caused by wet weather releases from the AWRC to South Creek. The maximum flow rate expected from the South Creek wet weather release is 2.5 m^3/s and when compared to the modelled peak flow rates in South Creek the contribution of wet weather flows are about 1% of the 10% AEP event and 0.5% of the 1% AEP event. The pipelines are not expected to be shutdown or used infrequently. In the extremely unlikely event of a total AWRC power failure (discussed further in Chapter 4) during a storm event the maximum flow rate expected to release to South Creek is 3.4 m^3/s comprising wastewater and stormwater runoff. When compared to the modelled peak flow rates in South Creek the contribution of the release under this scenario is about 2% of the 10% AEP event and 1% of the 1% AEP event. Therefore, the impact of wet weather releases on the flooding regime of South Creek is considered negligible.	Negligible

Location	Baseline flood	Description of potential impact	Impact Significance
Nepean River release structure	All floods up to the PMF	Changes in flooding characteristics due to the release structure located at Nepean River. As the Nepean River release structure will be partly recessed into the channel bank, it will not protrude into the river so will not alter the cross sectional area and will not cause loss of conveyance (flow carrying capacity), flood storage or change flood levels around the structure or downstream. Therefore, the impacts to flood flows in Nepean River are expected to be negligible.	Negligible
Nepean River release structure	All floods up to the PMF	Worsening of flood conditions due to contribution of treated water flows to Nepean River. The maximum flow rate expected from the treated water pipeline is 3 m^3/s. When compared to the existing flows in Nepean River during a flood event the contribution of the treated water release ranges from 0.06% of the 5% AEP (1 in 20 year chance of occurrence) event, 0.04% of the 1% AEP (1 in 100 year chance of occurrence) and 0.02% of the PMF. The impact of releases from the treated water pipeline on the flooding regime in Nepean River is expected to be negligible with no worsening of existing flood conditions.	Negligible
Warragamba River downstream of Warragamba Dam	Dam spillway outflows up to the 0.001% AEP event	Changes in flooding characteristics due to the environmental flows release structure. The environmental flows release structure and access roads are located below the 1% AEP Warragamba River flood levels. In addition, the release structure will be partly recessed into the channel wall and will not protrude into the river. There will be no change to conveyance, flood storage or flood levels in the vicinity of the structure or downstream. Therefore, the impact to flood flows in Warragamba River are expected to be negligible.	Negligible
Warragamba River downstream of Warragamba Dam	Dam spillway outflows up to the 0.001% AEP event	Worsening flood conditions due to contribution of treated water flows to Warragamba River. The maximum flow rate expected from the environmental flows pipeline is $3m^3/s$ and when compared to the existing flows from the Warragamba Dam spillway during a flood event the contribution of the project release ranges from 0.04% for the 5% AEP (1 in 20 year chance of occurrence) event, 0.04% for the 1% AEP (1 in 100 year chance of occurrence) event to 0.007% for the 0.001% AEP (1 in 1000 year chance of occurrence) event. The impact of releases from the environmental flows pipeline on the	Negligible

Location	Baseline flood	Description of potential impact	Impact Significance
		flooding regime in Warragamba River will be negligible with no worsening of existing flood conditions.	

9.3.7 Impact of future stages

Modelled impacts discussed in this section include the assessment of future stages and have concluded there will be negligible impact to the existing flood environment.

9.3.8 Cumulative impacts

Cumulative impacts have been considered for the following projects:

- Western Sydney International Airport
- M12 Motorway
- Western Sydney Aerotropolis Growth Area (WSAGA)
- Sydney Metro – Western Sydney Airport
- The Northern Road Upgrade – Glenmore Road to Bringelly
- Warragamba Dam raising.

Western Sydney International Airport is about 3.2 km south west and upstream of the AWRC site and construction has already commenced. The site is primarily drained by Badgerys Creek and Cosgrove Creek. Any increase in surface runoff downstream of the Western Sydney International Airport site will result in cumulative impact on flood levels upstream of the AWRC site. The hydrology and geomorphology assessment (GHD, 2016b) indicated that during construction flooding impacts will be managed through the implementation of a detailed surface water management plan. As flood levels upstream of the AWRC site will not change significantly during construction, any cumulative impacts on flood levels around Elizabeth Drive will be minor.

During operation the Western Sydney International Airport will implement a detention basin strategy to manage increases in runoff during the operational stage which will be effective at limiting downstream impacts. As flood levels upstream of the site resulting from the project will not change significantly, the cumulative impacts on flood levels around Elizabeth Drive are expected to be minor.

The southern boundary of the AWRC site is located close to the proposed M12 Motorway. The M12 EIS (RMS, 2019b) indicates that during construction, flood impacts will be managed by the implementation of a flood management plan. As flood levels upstream of the AWRC site will not change significantly during construction any cumulative impacts on flood levels around Elizabeth Drive will be minor. During operation, any potential changes to baseline flooding conditions resulting from the M12 Motorway will likely be in form of flood level changes south of the motorway, which means cumulative impacts associated with the AWRC are unlikely.

As precincts progressively develop throughout WSAGA there is potential for cumulative impacts to occur from increases in impervious areas and encroachment on the South Creek floodplain throughout the catchment. As part of precinct planning, DPIE is developing integrated water management and flood management strategies to target increases in runoff in high and low storm events. One outcome of this work is to determine flood detention requirements and flow management requirements that will ensure no cumulative increase in flood risk across the region. The current study has demonstrated that during operation, the AWRC will not impact existing flooding in the South Creek catchment, therefore cumulative impacts from the AWRC and the development of WSAGA are not expected.

The Sydney Metro – Western Sydney Airport is located within the South Creek catchment. The EIS (Sydney Metro, 2020a) has indicated that there is potential for minor but localised changes to the catchment including impacts to flooding. During operation the project proposes the implementation of detention basins to mitigate potential flooding impacts. The current study has demonstrated that during operation there will no impacts to existing flooding within the South Creek catchment, therefore cumulative impacts from the AWRC the Sydney Metro – Western Sydney Airport are not expected.

The Northern Road upgrade is adjacent to the treated water pipeline near Luddenham. During operation, as the pipeline will be below ground at this location there will be no increases in surface runoff resulting from the project and cumulative impacts are not expected.

The Warragamba Dam raising is a project to provide temporary storage capacity and to facilitate downstream flood mitigation. During operation cumulative effects are expected to be minimal as the dam is located upstream of the environmental flows release location and raising the dam is aimed at storing large flood events.

9.3.9 Management measures

Table 9-37 summarises management measures proposed to minimise the project's flood impacts

Table 9-37 Summary of management measures

ID	Potential Impact	Management measure	Timing
FL01	Working on or near flood-prone land	Develop and implement a construction and operational flood preparedness procedure in consultation with NSW SES, Wollondilly Shire Council and Penrith City Council and in accordance with the Flood Impact study in Appendix L. As a minimum, this will include: • monitoring procedures for rainfall and flood warnings (Flood Watch, Early Warning Network) • actions to be completed prior, during and post flood events	Prior to construction During construction During operation

ID	Potential Impact	Management measure	Timing
		• identifying evacuation routes, rescue procedures and steps to resume normal operations. • reporting requirements and corrective actions.	
	Construction activities near waterways have potential to change local flooding conditions	This impact is appropriately managed by measure G06 in Chapter 15 (Project synthesis).	Prior to construction During construction
	Coffer dams and flow barriers at Warragamba River and Nepean River have potential to change flooding conditions.	This impact is appropriately managed by measures in Chapter 8 (Waterways) and measure G06 in Chapter 15 (Project synthesis).	During construction