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Environmental Impact Statement – Chapter 10: Biodiversity – Construction area

Warragamba Dam Raising

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10 Biodiversity – construction area

This chapter provides an assessment of biodiversity during construction of the Warragamba Dam Raising. The relevant Secretary's Environmental Assessment Requirements (SEARs) are shown in Table 10-1.

Table 10-1. Secretary's Environmental Assessment Requirements (SEARs): Biodiversity – construction

Desired performance outcome	Secretary's environmental assessment requirements[1]	Where addressed
6. Biodiversity The Project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of Project construction and operation.	1. The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA), unless otherwise agreed by OEH, by a person accredited in accordance with s142B(1)(c) of the Threatened *Species Conservation Act 1995*.	Section 10.2 Chapter 8 (Biodiversity – Upstream) Chapter 9 (Downstream ecological assessment)
	2. The proponent must assess the downstream impacts on threatened biodiversity, native vegetation and habitats resulting from any changes to hydrology and environmental flows. This assessment should address the matters in Attachment B.	Chapter 9 (Biodiversity – downstream)
	3. The Proponent must assess impacts on the following: endangered ecological communities (EECs), threatened species and/or populations, and provide the information specified in s9.2 of the FBA. Specific environmental requirements are provided in Attachment C.	Section 10.6
	4. The Proponent must identify whether the Project as a whole, or any component of the Project, would be classified as a Key Threatening Process in accordance with the listings in the *Threatened Species Conservation Act 1997* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 2000* (EPBC Act).	Section 10.6.5

1. This chapter specifically addresses SEAR 6 in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1.1)

The construction area biodiversity assessment is supported by detailed investigations, which are documented in the Appendix F3: Biodiversity assessment report – construction area (SMEC 2021). Also relevant are:

- Appendix F1: Biodiversity assessment report – upstream (SMEC 2021)
- Appendix F2: Downstream ecological assessment (SMEC 2021)
- Appendix F6: Biodiversity offset strategy (SMEC 2021).

The proposed management and mitigation measures in this chapter are collated in Chapter 29 (EIS synthesis, Project justification and conclusion).

10.1 Project overview

10.1.1 Project description

A detailed description of the Project is provided in Chapter 5. Warragamba Dam Raising is a project to provide flood mitigation to reduce the significant existing risk to life and property in the Hawkesbury-Nepean Valley downstream of the dam. This would be achieved through raising the level of the central spillway crest by around 12 metres and the auxiliary spillway crest by around 14 metres above full supply level for temporary storage of inflows in the flood mitigation zone. The spillway crest levels and outlets control the extent and duration of the temporary upstream inundation. There would be no change to the existing maximum volume of water stored for water supply. The current

design includes raising the dam side walls and roadway by 17 metres to enable adaptation to projected climate change. The Project would delay downstream flooding, which would reduce current downstream flood peaks and increase the time taken for downstream water levels to recede.

The construction site covers an area of approximately 105 hectares and is shown on Figure 10-1. This includes those areas required for the proposed modifications as well as temporary construction areas. Key details of the Project are shown in Figure 10-2 and comprise:

- demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates
- thickening and raising of the dam abutments
- thickening and raising of the central spillway
- new gates or slots for discharge of water from the flood mitigation zone
- modifications to the auxiliary spillway
- operation of the dam for flood mitigation
- environmental flow infrastructure.

Other infrastructure and elements include:

- a new bridge would be built above the auxiliary spillway crest to provide access to the raised dam
- the raised abutments and central spillway bridge would allow for vehicle and pedestrian access across the top of the dam, connecting to the approaches and road network on either side of the dam
- new control and instrumentation equipment including mechanical, electrical and communications elements
- new landscaping and urban design features would be provided for areas disturbed by construction and for other areas that require improved integration to the new dam structure
- ancillary works to tie existing services into the raised dam
- the existing two lift towers would be modified to suit the raised dam
- the eel passageway on the left bank would be modified to continue to allow the migration of eels from the river to Lake Burragorang.

A preliminary construction program is presented in Figure 10-3 which shows the Project is anticipated to be completed between four to five years from commencement of construction.

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Figure 10-1. Construction area

Figure 10-2. Project details

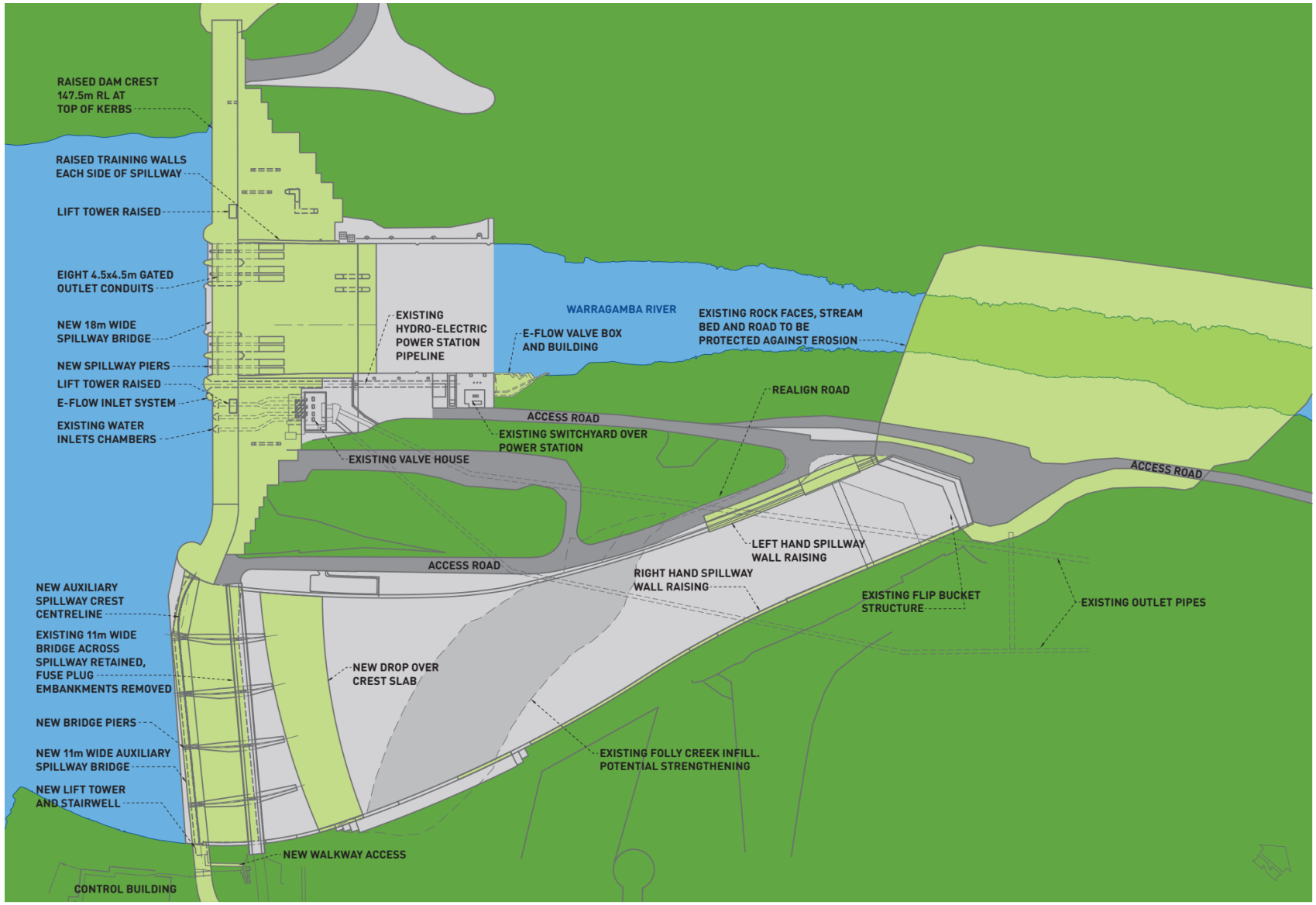
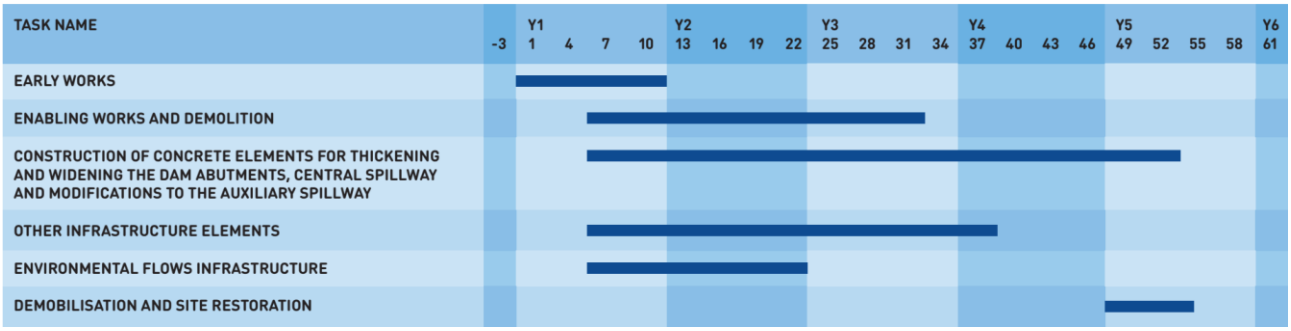


Figure 10-3. Preliminary construction program



10.1.2 Study area

Warragamba dam is located approximately 65 kilometres west of Sydney in a narrow gorge on the lower section of the Warragamba River, 3.3 kilometres upstream of the Nepean River confluence. The Nepean River then becomes the Hawkesbury River at the junction of the Grose River at Yarramundi. This entire river system is referred to as the Hawkesbury-Nepean River.

The dam is situated adjacent to the township of Warragamba, NSW within the Wollondilly Local Government Area (LGA). The dam is located on land zoned as SP2 Infrastructure (Water Supply) under the Wollondilly Local Environmental Plan (LEP) 2011. The land around the dam serves as operational support for the existing dam and consists of cleared and vegetated areas, dam support facilities, access roads and parks. The proposed works would be permissible within this land zone.

10.2 Assessment methodology

10.2.1 Assessment requirements

Project construction would require some clearing and disturbance, resulting in potential biodiversity impacts. Key objectives of this assessment are to address the:

- biodiversity matters raised in the Secretary's Environmental Assessment Requirements (SEARs)
- requirements of the Framework for Biodiversity Assessment (FBA) (OEH 2014), developed for major projects
- requirements of the Department of Planning, Industry and Environment (DPIE; formerly the Office of Environment and Heritage, OEH) requirements and relevant guidance documents.

Legislation and policies are discussed in Appendix F3 (Biodiversity assessment report – construction area, Section 2).

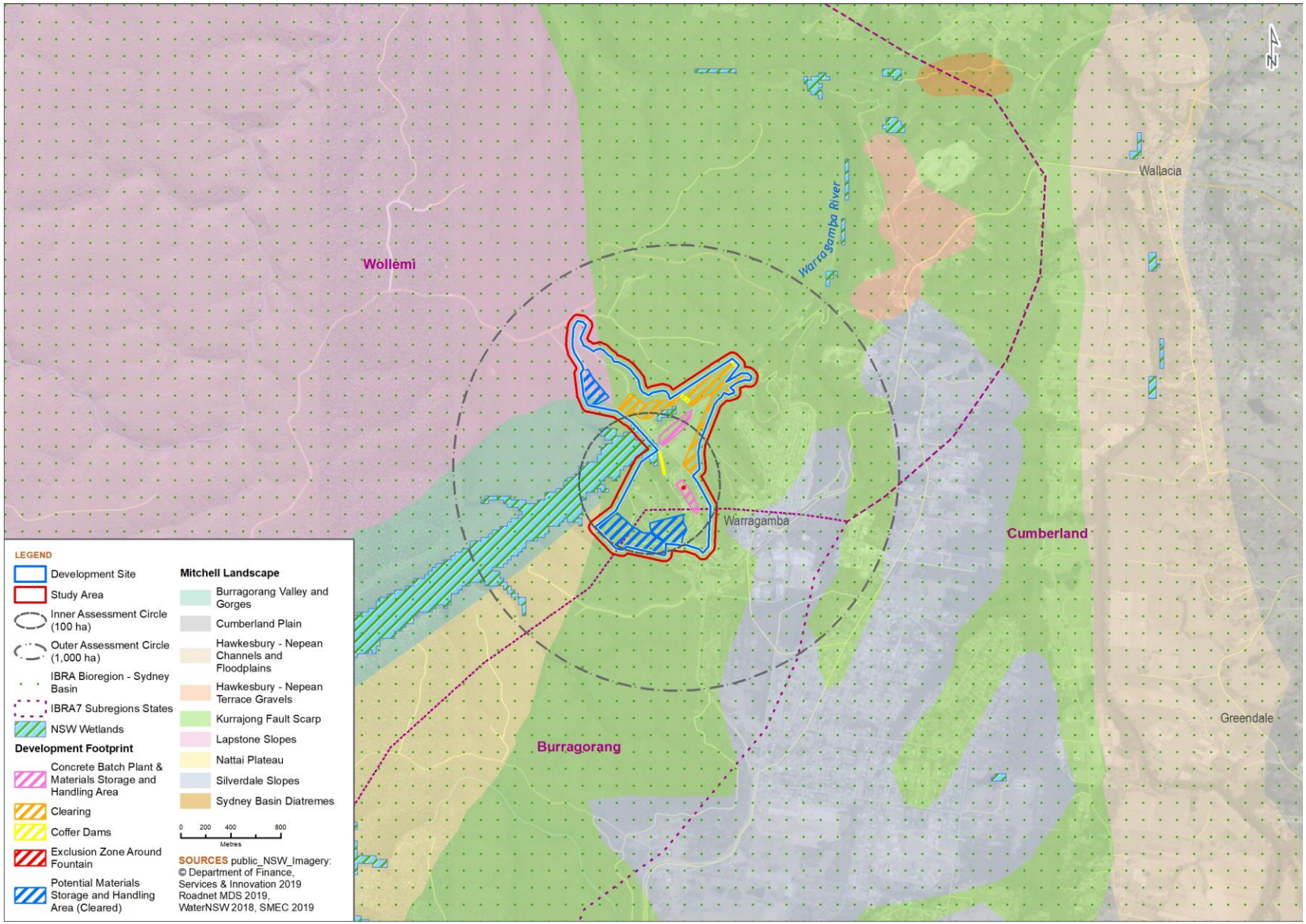
10.2.1.1 Framework for biodiversity assessment (FBA)

The FBA is the mechanism for implementing the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014). The SEARs (6.1) make specific reference to assessing Project impacts in accordance with the FBA. The FBA prescribes the methodology for the impact assessment and provides guidance for offsetting impacts. The FBA also sets out measures required to offset unavoidable impacts through a Biodiversity Offset Strategy (BOS), which is submitted with the BAR as part of the EIS and application for development consent or infrastructure approval.

The Framework for Biodiversity Assessment (FBA) establishes specific definitions for elements of the FBA, which inform the spatial extent of the assessment and associated methodology (see Section 10.2.1.1). Terminology used in this assessment relates to Figure 10-4 and includes the following:

- **Development footprint**: Area required for construction, including roads, laydown and storage areas, drainage and coffer dams, and support facilities. The development footprint has been refined through consideration of alternatives, which have reduced the potential for adverse impacts to the environment, including specific impacts on threatened ecological communities.
- **Development site**: Dam precinct, which includes the dam footprint, existing infrastructure and proposed construction areas ('blue' boundary). The development site covers approximately 105 hectares and comprises of the following elements:
  - native vegetation covers approximately 55 hectares (53 percent) of the site

Figure 10-4. Construction area layout and assessment area



  - the existing dam wall, and the areas in and around the existing Warragamba Dam face and abutment structures
  - auxiliary access roads, associated operational buildings, and landscaped areas.

  Most of the existing dam infrastructure is located on the south side of the river on a relatively flat area at an elevation of around 150 metres AHD (Australian Height Datum). The land gently slopes north towards the Warragamba River embankment, where it drops steeply to the river to about 45 metres AHD. The northern side of the river is relatively undeveloped with an upper elevation of around 195 metres AHD and a gradual slope to the river embankment.
- **Study area**: development site plus 50-metre buffer area ('red' boundary). This is used in the FBA assessment.
- **Inner and outer assessment circles**: Used for BioBanking calculations in accordance with the FBA methodology.

The FBA is undertaken in three stages:

Stage 1: Assessment of biodiversity values

Identification of the biodiversity values that would be impacted, both directly and indirectly, by the Project focussing on affected landscape values, native vegetation, and threatened species. These are addressed in Section 10.3 and comprise:

1) *Landscape values of the study area*. These include landscape features defined by their noted importance, IBRA bioregions and subregions, Mitchell landscapes, waterways, wetlands, native vegetation extent in the assessment circles, biodiversity links and any other landscape features.
2) *Biodiversity values of native vegetation on the study area*: Includes mapping the extent of native vegetation, identify Plant Community Types (PCTs) and ecological communities, undertake floristic site surveys, identify any threatened ecological communities, identify vegetation zones, assess site value (vegetation condition), undertake plot & transect site surveys, and assess site value score.
3) *Biodiversity values of threatened species*. This includes interrogating the Threatened Species Profile Database, assessing species that can be predicted by habitat surrogates (ecosystem credits), assessing species that cannot be predicted by habitat surrogates (species credits), undertake threatened species survey.

Stage 2: Impact assessment (biodiversity values)

Assessment of impacts on identified biodiversity values considering opportunities to avoid and minimise impacts, identification of thresholds for assessing and offsetting of unavoidable impacts and determining required offsets. These are addressed in Section10.5 and Section 10.6, and comprise:

4) *Avoid and minimise impacts on biodiversity values*. Sets out the actions that must be undertaken to demonstrate that reasonable measures are taken to avoid and minimise the direct and indirect impacts of a proposal on biodiversity values.
5) *Thresholds for the assessment and offsetting of unavoidable impacts of development*. Sets out the impact thresholds for landscape features, native vegetation, and threatened species and populations, and impacts on biodiversity that require further consideration.
6) *Determining offset requirement*. Includes calculating: credit requirement, the future site value score for vegetation zones on the study area and the change in the site value score for vegetation zones on the study area; and implement offset rules for biodiversity values.

Stage 3: Biodiversity offset strategy (BOS)

Development of a biodiversity offset strategy (BOS). This is documented separately in Appendix F6 (Biodiversity offset strategy), which is be submitted with the Biodiversity Assessment Report (BAR) as part of the EIS and application for development consent or infrastructure approval. This is addressed in Section 10.7 and comprises:

7) *Deliver long-term conservation gain for threatened entities impacted by the Project*. Includes sourcing credits from market, establishing an offset site, carrying out supplementary measures, payment into Biodiversity Conservation Trust Fund.

10.2.1.2 Legislation

Key assessment requirements are to address the requirements included in the SEARs (refer Table 10-1). The assessment also addresses relevant regulatory requirements which are discussed in detail in Appendix F3 (Biodiversity assessment report – construction area, Section 2). Key legislation is summarised in Table 10-2.

Table 10-2. Key legislation

Commonwealth legislation
***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)** The EPBC Act is the Commonwealth Government's principal piece of environmental legislation and is administered by the Department of Agriculture, Water, and the Environment (DAWE). Prior to the establishment of DAWE on 1 February 2020, the Act was administered by the Department of Environment and Energy (DoEE). The EPBC Act aims to protect national environmental assets, known as matters of national environmental significance (MNES), which include threatened species of flora and fauna, endangered ecological communities, and migratory species, as well as other protected matters. Among other things, it defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna, and communities. Among other things, the EPBC Act defines the categories of threat for threatened flora and fauna, identifies key threatening processes and provides for the preparation of recovery plans for threatened flora, fauna and EECs. This piece of legislation would only become relevant if it was considered that an impact on an MNES was likely, thus providing a trigger for referral of the Project to DAWE. MNES identified in the Act are: ▪ World Heritage properties ▪ National Heritage places ▪ Ramsar wetlands ▪ nationally threatened species and communities ▪ migratory species protected under international agreements ▪ the Commonwealth marine environment ▪ nuclear actions ▪ the Great Barrier Reef Marine Park ▪ a water resource, in relation to coal seam gas development and large coal mining development.
EPBC Act Environmental Offsets Policy This policy came into force in October 2012 and provides guidance on the role of offsets in environmental impact assessments and how DoEE considers the suitability of a proposed offset package. According to the policy, an offsets package is a "suite of actions that a proponent undertakes in order to compensate for the residual significant impact of a project". It can comprise a combination of direct offsets and other compensatory measures.

NSW legislation
***Environmental Planning and Assessment Act 1979* (EP&A Act)** The EP&A Act is the overarching planning legislation in NSW that provides for the creation of planning instruments that guide land use. The EP&A Act also provides for the protection of the environment, including the protection and conservation of native animals and plants. This includes threatened species, populations and ecological communities, and their habitats of biodiversity values. The Project is subject to assessment under Division 5.2 of the EP&A Act and requires the approval of the NSW Minister for Planning and Public Spaces under section 5.14.
***Threatened Species Conservation Act 1995* (TSC Act)** The TSC Act was repealed when the *Biodiversity Conservation Act 2016* (BC Act) commenced on 25 August 2017. However, the provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 provide for SSI projects to be assessed under the provisions of the TSC Act if the application for the SEARs was made prior to this date. The application was made prior to 25 August 2017 with the SEARs for the Project being issued on 30 June 2017. Updated SEARs for the Project were reissued on 13 March 2018. The biodiversity assessment has been carried out in accordance with the relevant provisions of the TSC Act through the effect of the Biodiversity Conservation (Savings and Transitional) Regulation 2017. Consideration has also been given to relevant matters under the BC Act, particularly about threatened species, populations and ecological communities that may have been listed, or existing listings that may have been amended subsequent to the BC Act coming into force.

NSW legislation
Biodiversity Conservation Act 2016 The BC Act and its supporting regulations commenced on 25 August 2017. The BC Act repeals the *Threatened Species Conservation Act 1995* (TSC Act) along with other natural resource management legislation, while retaining the TSC Act species list. The BC Act sets out the environmental impact assessment framework for threatened species, threatened ecological communities and areas of outstanding biodiversity value (formerly critical habitat) for major projects (amongst other types of development). However, the transitional provisions of the Biodiversity Conservation (Savings and Transitional) Regulation 2017 apply to this Project as application for the SEARs for the Project was made prior to the commencement of the new BC Act. Consequently, the Project has been assessed in accordance with the TSC Act. When referring to the planning assessment provisions used for this assessment, the report uses TSC Act. When referring to threatened species, populations, or ecological community listings, this report uses the BC Act.
***Water NSW Act 2014* (WaterNSW Act)** In 2018, an amendment to the *Water NSW Act 2014* (WaterNSW Act) was enacted that related specifically to the Project and the potential impacts of temporary inundation on national parks and state conservation areas in the Warragamba Dam catchment. Under previous legislation, inundation of national park land was not permitted, however, the amendment of the WaterNSW Act provided a special provision to allow the temporary inundation of national park and state conservation area land in the Warragamba Dam catchment. To ensure the mitigation of any impacts from temporary inundation, the special provisions also require: ▪ WaterNSW to prepare an Environmental Management Plan (EMP) in consultation with the Chief Executive of the OEH and NPWS if approval for the Project is given. ▪ The NPW Minister to determine the matters that are to be addressed by an EMP. ▪ The NPW Minister with the concurrence of the Minister for Water approve an acceptable EMP. ▪ The NPW Minister with the concurrence of the Minister for Water require an approved EMP to be updated or reviewed. The NPW Minister with the concurrence of the Minister for Water may direct Water NSW to take specified actions in relation to the temporary inundation of national park land resulting from the Warragamba Dam project, including action relating to the monitoring of risks associated with the temporary inundation and relating to the rehabilitation or remediation of land. WaterNSW is to implement and monitor the EMP. Water NSW to notify the Chief Executive of the OEH if it is of the opinion that a flood event that may affect national park land in the vicinity of Warragamba Dam is likely to occur.
Other: ▪ *Fisheries Management Act 1994* (FM Act) ▪ *National Parks and Wildlife Act 1974* (NPW Act) ▪ *Wilderness Act 1987* ▪ *Biosecurity Act 2015* ▪ NSW Biodiversity Offsets Policy for Major Projects ▪ State Environmental Planning Policy (Koala Habitat Protection) 2020

10.2.2 Key tasks

The Construction BAR (Appendix F3: Biodiversity assessment report – construction area) was prepared in accordance with the methods described in the NSW *Framework for Biodiversity Assessment* (OEH 2014) developed for major projects and biodiversity requirements raised in the SEARs. Work involved in preparing the Construction BAR included the following key tasks:

- consultation with the Department of Planning, Industry and Environment (DPIE, formerly the Office of Environment and Heritage - OEH)
- identification of the construction area footprint and study area
- review of available information including relevant databases, literature review and aerial photography
- general description of the study area, including soils, vegetation, hydrology and land uses

- review of relevant State and Commonwealth legislation
- determine landscape value score components and undertake a BioBanking credit assessment
- describe and map native vegetation and plant communities on the study site using existing data and site surveys
- describe threatened species using existing data and site surveys
- use the BioBanking Credit Calculator (BBCC) to determine the ecosystem credit species with the highest threatened species offset multiplier (TS Multiplier) in each vegetation zone
- determine candidate credit species for further investigation and undertake targeted field surveys
- assess potential construction area biodiversity impacts and propose mitigation measures to avoid or minimise potential impacts
- use the BBCC to determine offset credit liability for residual impacts to plant community types (PCTs) and species credit species found or assumed to occur within the development footprint.

10.2.3 Review of existing data

Information sources are summarised in Table 10-3.

Table 10-3. Information sources

No.	Information sources
Information reviewed to identify and assess species and populations potentially occurring within the study area. Information was used to identify candidate ecosystem credit species and species credit species.	
1.	Aerial maps, project layers and environmental layers provided by WaterNSW and OEH.
2.	Department of the Environment and Energy Species Profiles and Threats database (SPRAT) (DoEE, n.d.b)
3.	Department of Environment and Climate Change NSW Landscapes (Mitchell) of NSW- Version 3 GIS dataset (DECCW 2010a)
4.	Department of the Environment and Energy Protected Matters Search Tool (DoEE 2015)
5.	Matters of National Environmental Significance Significant Impact Assessment Guidelines (DoE 2013)
6.	NSW BioBanking credit calculator (OEH n.d.a)
7.	NSW Atlas of NSW Wildlife (OEH 2017b)
8.	OEH Threatened Species Profiles (OEH 2017d)
9.	Mitchell Landscapes with percent cleared estimates (DECCW 2010a)
10.	Framework for Biodiversity Assessment (OEH 2018a)
11.	NSW Biodiversity Offsets Policy for Major Projects (OEH 2014)
12.	VIS 2.1 Vegetation Classification Database (OEH 2017c)
13.	Atlas of Groundwater Dependent Ecosystems (BOM 2019)
14.	NSW Government's Biodiversity Values Map and Threshold Tool (OEH 2019a)
15.	*Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003).
Other sources of information	
1.	Warragamba Dam EIS - Dam Site Environmental Studies, Fauna and Flora (Mount King Ecological Surveys 1992)
2.	Warragamba Dam Raising Preliminary Environmental Assessment (BMT WBM Pty Ltd 2016)
3.	Warragamba Dam Auxiliary Spillway Project – Construction Environmental Management Plan Framework (Australian Water Technologies & SKM 2003)

No.	Information sources
4.	Safeguarding Warragamba Dam: proposed auxiliary spillway (Sydney Water 1996)
5.	*Eucalyptus benthamii* Inundation Experiment – Reporting on stand health and soil properties over a 12-month monitoring period (Bush et al. 2018)
6.	Glasshouse evaluation of inundation tolerance of Camden White Gum (*Eucalyptus benthamii)* (Marcar 1995)
7.	The Native Vegetation of the Warragamba Special Area, Part A: Technical Report (NPWS 2003)
8.	Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 - Background Report (DECC 2007a)
9.	Threatened and pest animals of Greater Southern Sydney (DECC 2007b)
10.	Soil Landscapes of the Penrith 1:100,000 Sheet map and report, Soil Conservation Service of NSW, Sydney (Bannerman & Hazelton 1990)
11.	Descriptions for NSW (Mitchell) Landscapes, Version 2 (DECC 2002)
12.	*Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands*, Version 1.0 (Tozer et al. 2010)

10.2.4 Site surveys

Field surveys were conducted over 94 days and 93 nights in summer 2017-2018, two days in winter 2018 and two days in spring 2018. The field survey requirements and effort for this assessment have been carried out as part of the field survey requirements and effort for the upstream assessment. As such, some of the survey effort has been undertaken outside of the development site boundary, within the upstream biodiversity assessment survey area. In addition to the surveys undertaken, the full spectrum of flora and fauna species and ecological processes likely to occur in the development site were considered by identifying potential habitats for such species and assessing the potential for these species to occur in the development site based on previous records, the type and condition of habitats present, the land use of the development site and its landscape context.

As stated by the DEC (Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft 2004): *'The absence of a species from survey data does not necessarily mean it does not inhabit the survey area. It may simply mean that the species was not detected at that time with the survey method adopted and the prevailing seasonal or climatic conditions'*. On this basis, a precautionary approach was used in assessing the potential presence of species and the species was presumed present where survey guidelines had not been met.

The survey was limited at the construction site due to the following constraint:

- prescribed burns had been carried out across areas of the development site prior to vegetation mapping being completed
- vegetation mapping within these areas has relied on a combination of broad scale vegetation mapping and identification of canopy trees where available.

10.2.4.1 Identification of plant community types (PCTs)

A review of available information was undertaken, which included review of relevant publications, maps, aerial photographs and vegetation classification data.

Site surveys were undertaken between October 2017 and October 2018. For the purposes of assigning plant community types (PCTs) to native vegetation communities, plot based floristic surveys were undertaken in accordance with the FBA (Table 3) at 13 sites across the development site and adjoining land. These sites were also used for plot and transect surveys of vegetation zones. The field survey requirements and effort for this assessment have been carried out as part of the broader field survey requirements and effort for the upstream assessment. As such, some of the survey effort (plots 9-13) has been undertaken outside of the development site boundary.

Survey sites are shown on Figure 10-5. Identification of PCTs occurring within the development site considered the following:

- review of available information and site surveys

- occurrence within the Wollemi, Burragorang, and Cumberland IBRA subregions
- vegetation formation
- landscape position
- soil type and edaphics
- dominant upper, mid and ground strata species.

The PCTs occurring within the development site were initially stratified into areas represented by the locally-defined vegetation communities. These were subsequently divided into different condition classes, which resulted in the creation of five vegetation zones.

10.2.4.2 Targeted threatened species surveys

Habitat assessment

A general fauna habitat assessment was undertaken within the development site and adjoining land in December 2017. Fauna habitat assessments included consideration of important indicators of habitat condition and complexity including the occurrence of microhabitats such as tree hollows, fallen logs, bush rock and wetland/riparian areas and the presence of mistletoe and flowering trees for nectivorous bird species. Hollows were used as a general indication of habitat quality for arboreal fauna and for hollow dependent birds and bats.

Flora

Targeted threatened flora surveys were not completed within the development site, although incidental observations of threatened flora species were recorded using a GPS. Prescribed burns had been carried out within areas of the development site in 2018, preventing targeted surveys within these areas. Furthermore, because of drought conditions, presence was assumed for those threatened flora species that cannot be ruled out as requiring further assessment in line with the FBA (Section 6.5.1.9).

Fauna

General fauna surveys were conducted within the development site over five days and four nights during December 2017. Additional nights were surveyed using cameras. Fauna field surveys were based on the survey effort recommendations of *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - Working Draft* (DEC 2004) and relevant Commonwealth survey guidelines. Reference was made to the size of the development site, broad scale vegetation communities and major sampling stratification units. Surveys were undertaken assuming each area of suitable habitat was one stratification unit of less than 50 hectares. Survey methods and target species included:

- small-mammal traps: Common Planigale
- diurnal bird surveys: Regent Honeyeater
- ultrasonic call detection: Large-eared Pied Bat
- remote sensing cameras: Brush-tailed Rock-wallaby
- pitfall traps: Common Planigale.

The locations of threatened fauna surveys are shown in Figure 10-6.

Figure 10-5. Plot-based floristic survey points and plot transect survey points at the development site

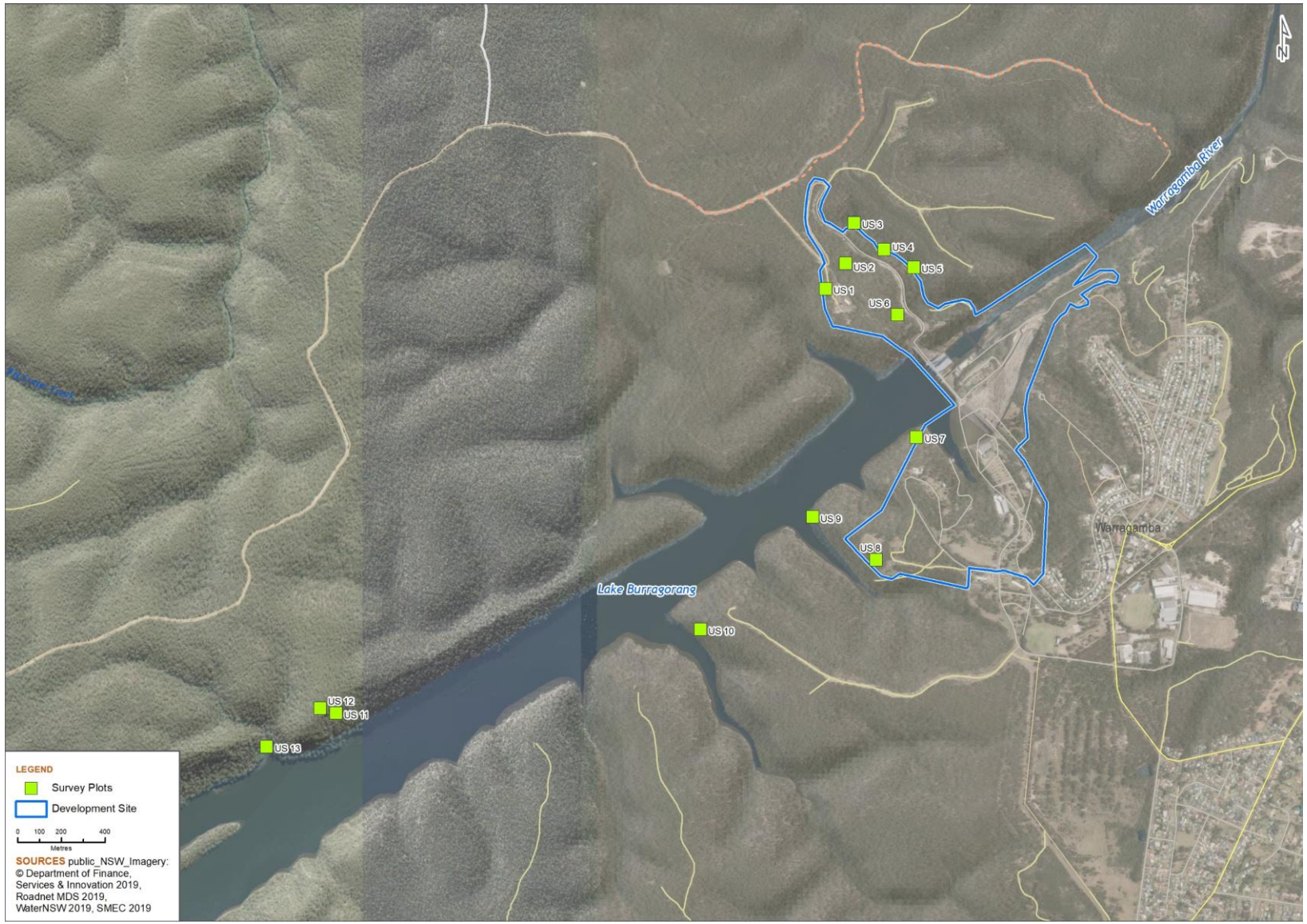


Figure 10-6. Threatened fauna survey locations

10.2.5 Presence of threatened species

The type and occurrence of threatened species and populations that could potentially be impacted by the proposal were appraised in accordance with the Framework for Biodiversity Assessment (FBA), which includes assessment of:

- **Existing data**: Develop a list of species and populations potentially occurring within the development site. This information was used to determine candidate ecosystem credit species and species credit species.
- **Ecosystem credits**: A measurement of the value of PCTs, endangered ecological communities (EECs), critically endangered ecological communities (CEECs), and threatened species habitat for species that can be reliably predicted to occur within a PCT. Ecosystem credits measure the loss in biodiversity values within the development site and the gain in biodiversity values at an offset site. Ecosystem credit species were determined using the following criteria:
  - IBRA subregions
  - associated PCTs
  - percentage native vegetation in outer assessment circle: 73 %
  - condition of vegetation: moderate to good (all vegetation zones)
  - patch size: 1,001+.
- **Species credit species**: The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Species Profile Database.

Candidate species were identified in accordance with the FBA (Section 6.5.1.2). The BBCC generates a list of candidate species based on the distribution of the species occurring within the same IBRA subregion as the development site and the presence of habitat features and components associated with these species. A wide range of habitat features and components have been used to assess the presence/absence of species within the development site.

10.3 Existing environment

10.3.1 Site description

The development site is shown in Figure 10-1 and comprises:

- native vegetation, which covers approximately 55 hectares (53 percent) of the site
- the existing dam wall, and the areas in and around the existing Warragamba Dam face and abutment structures
- auxiliary access roads, associated operational buildings, and landscaped areas.

Most of the existing dam infrastructure is located on the south side of the river on a relatively flat area at an elevation of around 150 metres AHD (Australian Height Datum). The land gently slopes north towards the Warragamba River embankment, where it drops steeply to the river to about 45 metres AHD. The northern side of the river is relatively undeveloped with an upper elevation of around 195 metres AHD and a gradual slope to the river embankment.

The mean rainfall for Lake Burragorang is 840 millimetres per year, with the highest rainfall occurring in the warmer months, particularly during the month of February (WaterNSW 2015).

The following environmental descriptions generally follow the methodology outlined in the FBA and includes:

- IBRA bioregions and IBRA subregions
- NSW landscape regions
- soil landscape
- state or regionally significant biodiversity links
- biodiversity values map
- hydrology and wetlands
- groundwater dependent ecosystems
- vegetation
- fauna habitats
- MNES.

Also described are the regional effects of historic bushfires, including the recent major bushfire that occurred in late 2019 and early 2020.

10.3.2 IBRA bioregions and IBRA subregions

10.3.2.1 Bioregion

Bioregions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities. Bioregions and subregions are the reporting unit for assessing the status of native ecosystems and their level of protection, and are used in the FBA to assist the assessment of landscape scale impacts of a development and predictions for distribution of threatened species. The study area is in the Interim Biogeographical Regionalisation of Australia (IBRA) Bioregion of the Sydney Basin and there are two subregions that are relevant to this assessment.

The Sydney Basin (SYB) Bioregion (DoEE 2018) is described as follows:

> *'The Sydney Basin Bioregion lies on the central east coast of NSW and covers an area of approximately 3.6 million hectares, which is the equivalent of 4.5 percent of NSW. The SYB Bioregion is one of two bioregions contained wholly within the state. It consists of a geological basin filled with near horizontal sandstones and shales of Permian to Triassic age that overlie older basement rocks of the Lachlan Fold Belt. The sedimentary rocks have been subject to uplift with gentle folding and minor faulting during the formation of the Great Dividing Range. Erosion by coastal streams has created a landscape of deep, cliffed gorges and remnant plateaux across which an east-west rainfall gradient and differences in soil control the vegetation of eucalypt forests, woodlands and heaths. The Sydney Basin Bioregion includes coastal landscapes of cliffs, beaches and estuaries.*
>
> *The frontal slope of the Blue Mountains (where the site is located) is formed along the Lapstone Monocline. A secondary flexure and similar escarpments occur at the coast forming the Hornsby Plateau and the Illawarra Escarpment. These structural features combine with different rock types and strong trends in joint patterns to control drainage patterns and the distribution of gorges and swamps'.*

10.3.2.2 Subregions

The development site is located across two IBRA subregions (DoEE 2018):

1. Burragorang subregion
2. Wollemi subregion.

The Cumberland subregion is located close to the development site and is considered in the landscape assessment. Bioregions are shown on Figure 10-4 and described in Table 10-4.

Table 10-4. Description of the Sydney Basin Bioregion subregions occurring within the development site

Subregion	Geology	Characteristic landforms	Typical Soils	Vegetation
Wollemi	Hawkesbury Sandstone and equivalent quartz sandstones of Narrabeen Group, sub-horizontal bedding, strong vertical joint patterns. There are also some scattered volcanic necks distributed throughout the Wollemi subregion.	Characterised by the highest part of the Blue Mountains and other sandstone plateaux with benched rock outcrops.	Typically, soils are thin sands or deep yellow earths on plateaux, with thin texture contrast soils on shale benches. Organic sands in line swamps and joint crevices, while slope debris are found below cliffs, and sandy alluvium in pockets along the streams. On basalts, soils are red brown structured loams.	*Corymbia gummifera*, *Corymbia eximia*, *Angophora floribunda*, *Angophora costata*, *Eucalyptus sclerophylla*, and *Eucalyptus punctata* with diverse shrubs and heaths on plateau. Additionally, *Angophora costata*, *Eucalyptus piperita*, *Eucalyptus agglomerata*, and *Syncarpia glomulifera* subsp. *glomulifera* and gully rainforests are present in gullies and canyon heads. *Eucalyptus viminalis* and Blaxland's Stringybark on basalt. *Casuarina cunninghamiana* is found along main streams.
Burragorang	Comprised of Permian and Triassic sandstones and shales on the western edge of the Sydney Basin.	Rolling hills on a sandstone plateau with deep gorges and sandstone cliffs in Burragorang valley	Typically, soils include rocky outcrops, texture contrast soils and uniform sands on sandstone. Cliff bases are generally pillowed with a sandy, clay matrix, alluviums contain rich loams.	Heath, shrubland and woodland with *Eucalyptus sieberi*, *Eucalyptus sclerophylla*, *Eucalyptus piperita* and *Corymbia gummifera* on sandstone similar to other parts of the Basin. *Eucalyptus deanei*, *Syncarpia glomulifera* subsp. *glomulifera*, *Eucalyptus agglomerata* immediately below escarpment passing to *Eucalyptus punctata*, *Eucalyptus crebra* and *Eucalyptus eugenioides* on rocky slopes. *Casuarina cunninghamiana* along main streams below the plateaux.
Cumberland	Triassic Wianamatta group shales and sandstones, which are intruded by a small number of volcanic vents and partly covered by Tertiary river gravels and sands. There is Quaternary alluvium along the mainstreams.	Low rolling hills and wide valleys in a rain shadow area below the Blue Mountains. Volcanics from low hills in the shale landscapes. Swamps and lagoons on the floodplain of the Nepean River.	Typically, soils include a mixture of clays on volcanics, poor stony soils on older gravels, and high-quality loams on floodplain alluvium.	*Eucalyptus moluccana, Eucalyptus tereticornis, Eucalyptus crebra* woodland with some *Corymbia maculata* on the shale hills. *Eucalyptus sclerophylla, Angophora floribunda*, and *Banksia serrata* on alluvial sands and gravels. *Angophora subvelutina, Eucalyptus amplifolia* and *Eucalyptus tereticornis* with abundant *Casuarina glauca* on river flats. Tall spike rush, and juncus with *Eucalyptus parramattensis* in lagoons and swamps.

10.3.3 NSW Landscape regions

Mitchell landscapes were developed by then DECC (2002) to provide a more detailed description of the landscape than bioregions and sub regions. They include consideration of landscape features such as geology and geomorphology to reflect common landscape features. Mitchell landscapes are used in the FBA to assist the assessment of landscape scale impacts of a development and predictions for distribution of threatened species.

Kurrajong Fault Scarp occurs over most of the development site followed by Lapstone Slopes, Burragorang Valley and Gorges, and Nattai Plateau. The Silverdale Slopes region adjoins the development site. These landscape regions are shown on Figure 10-4 and described in Table 10-5.

Table 10-5. Landscape regions (Mitchell Landscape, DECC 2002)

Mitchell landscape	Description
Kurrajong Fault Scarp	Dissected and broken slopes on Triassic quartz sandstone and shale across the Lapstone Monocline and Kurrajong Fault Scarp. Local dips on the sedimentary rocks up to 300 m, general elevation 100 to 250 m, local relief 100 m. Abundant rock outcrop with pockets of yellow-brown sand and occasional yellow texture-contrast soils. Open forest with a shrubby understorey of: *Eucalyptus agglomerata*, *Syncarpia glomulifera* subsp. *glomulifera*, Red *Corymbia gummifera*. *Angophora costata*, *Eucalyptus piperita*, *Eucalyptus radiata*, *Eucalyptus punctata*, *Eucalyptus pilularis* and *Allocasuarina* sp. Several streams have formed extensive reed swamps behind the fault block with deep organic sands and scattered *Eucalyptus tereticornis*, *Angophora floribunda* and *Eucalyptus globoidea* on the margins.
Lapstone Slopes	The frontal slope of the Blue Mountains formed by folding and faulting of Triassic quartz sandstone and shale with a veneer of Tertiary river gravels. A southern extension of the Kurrajong Fault Scarp landscape. Larger streams cut through the structural ridge in deep gorges, but smaller streams have accumulated organic sands in swamps and lagoons on the western side of the flexure. General elevation 50 to 300 m, local relief 180 m, steep dip slopes on the eastern face and benched faulted slopes on the west. Extensive rock outcrop, thin sandy soils with gravel and occasional white or yellow clay subsoils. Pockets of deep sand in some streams. *Corymbia gummifera*, *Corymbia eximia*, *Eucalyptus punctata*, *Allocasuarina torulosa*, *Eucalyptus sieberi*, *Eucalyptus radiata* with diverse shrubby understorey.
Burragorang Valley and Gorges	Deep steep sided benched slopes and gorge of the Wollondilly and Coxs Rivers incised into mostly horizontal Triassic quartz sandstone conglomerate, siltstone, and shale, cliffs to 150 m high with waterfalls, general elevation 50 to 220 m, local relief 150 m. The gorge widens upstream and exposes underlying Permian chert, mudstones and conglomerate. Very extensive rock outcrop, thin yellow to yellow-brown silty sand and gravel with occasional white clay layers forming either shallow yellow earths or gleyed texture-contrast profiles. *Corymbia gummifera*, *Syncarpia glomulifera*, and rainforest elements at the base of the gorge in sandstone. Steep debris slopes below cliffs upstream with *Eucalyptus tereticornis*, *Eucalyptus macrorhyncha*, *Eucalyptus crebra*, and *Eucalyptus mannifera*. Moist protected environments with *Eucalyptus saligna*, *Eucalyptus cypellocarpa*, *Eucalyptus muelleriana* and *Eucalyptus smithii*. Gallery forest of *Casuarina cunninghamiana* with *Eucalyptus deanei* and *Eucalyptus benthamii* along the main streams.
Nattai Plateau	Steeply dissected plateau remnants on lower Triassic lithic sandstone, shale and tuff, abundant rock outcrop and cliffs, steep debris slopes, general elevation 600 to 700 m, local relief 80 m. Shallow sand and occasional yellow texture-contrast soils. Forests of *Eucalyptus eugenioides*, *Eucalyptus fibrosa* subsp. *fibrosa*, *Callitris rhomboidea*, *Eucalyptus sieberi*, *Eucalyptus blaxlandii*, *Eucalyptus fastigata* and *Eucalyptus viminalis*.
Silverdale Slopes Outer: 120.4 ha	Moderately undulating slopes descending to the east on gently dipping Triassic shales and sandstones. General elevation 230 to 630 m, local relief 200 m. Brown to yellow-brown texture-contrast soils. Woodland to forest with a shrubby understorey, common species; *Eucalyptus punctata*, *Eucalyptus albens*, *Eucalyptus paniculata*, *Eucalyptus crebra*, *Eucalyptus fibrosa*, *Eucalyptus moluccana*, *Allocasuarina torulosa*, *Eucalyptus eugenioides*, and occasional *Syncarpia glomulifera*.

10.3.4 Soil landscape

The Soil Landscapes of Penrith 1:100,000 soil landscape sheet (Bannerman and Hazelton 1990) has mapped four soil landscapes within and adjoining the development site. These are outlined in Table 10-6.

Table 10-6. Soil landscape description (Bannerman & Hazelton 1990)

Name	Landscape	Soils	Limitations
Gymea	Undulating to rolling rises and low hills on Hawkesbury Sandstone. Local relief 20-80 m, slopes 10-15%. Rock outcrop 25%. Broad convex crests, moderately inclined side slopes with wide benches, localised rock outcrop with broken scarps.	Shallow to moderately deep (30-100 cm) yellow earths and earthy sands on crests and on insides of benches; shallow siliceous sands on leading edges of benches; localised gleyed podzolic soils and yellow podzolic soils on shale lenses; shallow to moderately deep (<100 cm) siliceous sands and leached sands along drainage lines.	Steep slopes, water erosion hazard, rock outcrop, localised rockfall hazard, localised non-cohesive soils, shallow highly permeable soil, very low soil fertility.
Faulconbridge	Level to gently undulating crests and ridges on plateau surfaces on Hawkesbury Sandstone. Local relief <20 m, slopes <5%. Infrequent rock outcrop.	Shallow (<50 cm) earthy sands and yellow earths; some siliceous sands/lithosols associated with rock outcrop.	Shallow, highly permeable soil, localised non-cohesive soils, very low soil fertility, localised water erosion hazard, localised rick outcrop.
Hawkesbury	Rugged, rolling to very steep hills on Hawkesbury Sandstone. Local relief 40-200 m, slopes >25%. Rock outcrop >50%. Narrow crests and ridges, narrow incised valleys, steep side slopes with rocky benches, broken scarps and boulders.	Shallow (<30 cm) discontinuous lithosols/ siliceous sands, associated with rock outcrop; earthy sands, yellow earths and some locally deep sands on inside of benches and along joins and fractures; localised yellow and red podzolic soils associated with shale lenses, siliceous sands and secondary yellow earths along drainage lines.	Steep slopes, mass movement hazard, rockfall hazard, water erosion hazard, shallow soils, rock outcrop, non-cohesive soils (localised), stony, highly permeable soils of low fertility.
Blacktown	Gently undulating rises on Wianamatta Group shales. Local relief to 30 m, slopes usually >5%. Broad rounded crests and ridges with gently inclined slopes.	Shallow to moderately deep (>100 cm) hard setting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and drainage lines.	Localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil, localised surface movement potential.

10.3.5 State or regionally significant biodiversity links

State significant biodiversity links, regionally significant biodiversity links, very large area biodiversity links, large area biodiversity links or local area biodiversity links are defined in the FBA. To date, no biodiversity corridor plans have been approved by DPIE.

Appendix 2 to the FBA outlines the riparian buffer widths required for each order of stream classified in accordance with the Strahler system[1]. The Project would impact upon the 50-metre riparian buffer for a 9th order stream (see FBA, Section 10.3.7). Under the FBA, riparian buffers for 6th order streams or higher are a state significant biodiversity link. Consequently, the Project will affect a state significant biodiversity link.

10.3.6 Biodiversity values map

The biodiversity values (BV) map identifies land with high biodiversity value that is especially sensitive to impacts from development and clearing. Land types included on the BV map include:

- declared Ramsar wetlands defined by the EPBC Act
- land containing threatened species or threatened ecological communities identified as potential serious and irreversible impacts (SAII) under section 6.5 of the BC Act
- protected riparian land
- high conservation value grasslands or groundcover
- old growth forest identified in mapping developed under the National Forests Policy Statement but excluding areas not meeting the criteria published jointly by the Minister for the Environment and the Minister for Primary Industries
- rainforest identified in mapping developed under the National Forests Policy Statement but excluding areas not meeting the criteria published jointly by the Minister for the Environment and the Minister for Primary Industries
- declared areas of outstanding biodiversity value (listed critical habitat)
- council nominated areas with connectivity or threatened species habitat that the Minister for the Environment considers will conserve biodiversity at bioregional or state scale
- any other land that in the opinion of the Environment Agency Head is of sufficient biodiversity value to be included.

No areas of biodiversity value were identified within the development site.

10.3.7 Hydrology and wetlands

Lake Burragorang is the dominant hydrological feature of the study area, which was created by damming the Warragamba River and flooding the Burragorang Valley. Water flows into the Warragamba River when the dam spills or is released (downstream of the Warragamba Weir) to provide a secure water supply to North Richmond. The Warragamba River is a 9th order Strahler stream (see Section 10.3.5) and there are several small, unnamed ephemeral tributaries within the study area.

Lake Burragorang and part of the Warragamba River downstream of the dam wall have been mapped as a NSW wetland (NSW wetland shapefile, OEH 2010). No important or local wetlands occur within the development site. There are smaller dams mapped to the east of the development site, while the Nepean River and Penrith Lakes have been mapped to the north. No Ramsar Wetlands have been mapped within 10 kilometres of the development site.

10.3.8 Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) were initially identified by reviewing the Groundwater Dependent Ecosystem Atlas (BOM 2019) for the development site. Each GDE is classified as having a high, moderate, or low potential of interaction with groundwater. Five GDEs were identified within the development site, all within the

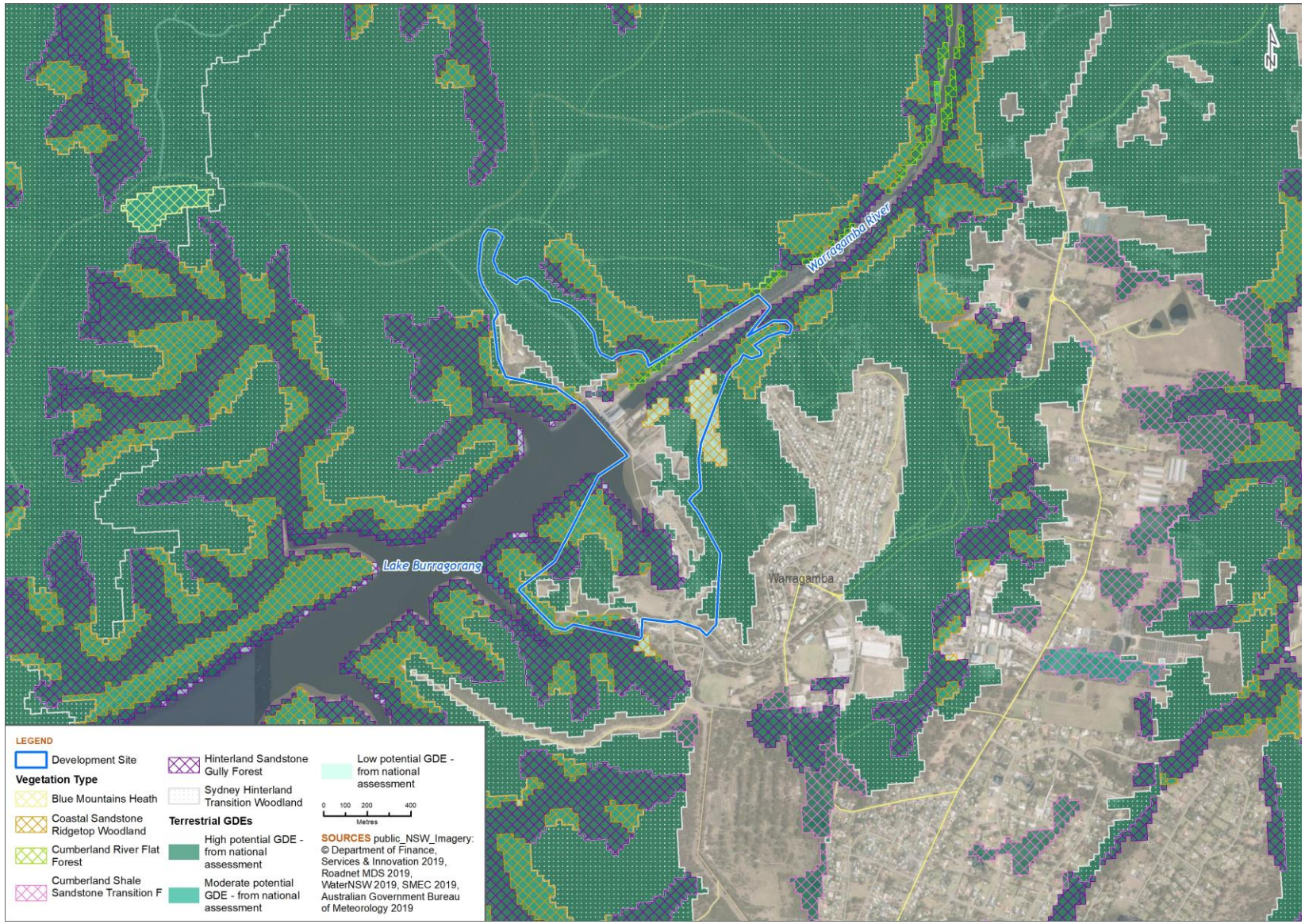
[1] Classification system where waterways are given an 'order' per the number of additional tributaries associated with each waterway (Strahler 1952). This system provides a measure of system complexity and therefore the potential for fish habitat to be present.

Greater Metropolitan Region Groundwater Sources – Sydney Basin area. These are described in Table 10-7 and shown on Figure 10-7.

Table 10-7. Groundwater dependent ecosystems

Vegetation type	Land-scape	Bioregion	Land use	Groundwater management area	GDE classification
Coastal Sandstone Ridgetop Woodland	Low Lying	Wollemi	Forestry	Blue Mountains Sandstone	Moderate potential GDE
			Minimal use	Nepean Sandstone	Moderate potential GDE
			Other protected areas including Indigenous uses	Nepean Sandstone	Moderate potential GDE
			Forestry	Blue Mountains Sandstone	Moderate potential GDE
	Plateau	Burragorang	Forestry	Nepean Sandstone	Moderate potential GDE
			Minimal use	Nepean Sandstone	Moderate potential GDE
	Slope	Wollemi	Other protected areas including Indigenous uses	Nepean Sandstone	Low potential GDE
			Forestry	Nepean Sandstone	Low potential GDE
			Forestry	Nepean Sandstone	Moderate potential GDE
Cumberland River Flat Forest	Low Lying	Wollemi	Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
Hinterland Sandstone Gully Forest	Low Lying	Wollemi	Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Nepean Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
	Slope	Wollemi	Forestry	Nepean Sandstone	High potential GDE
			Forestry	Nepean Sandstone	Low potential GDE
	Plateau	Wollemi	Forestry	Nepean Sandstone	High potential GDE
			Forestry	Nepean Sandstone	High potential GDE
		Burragorang	Minimal use	Nepean Sandstone	High potential GDE
Sydney Hinterland Transition Woodland	Low Lying	Wollemi	Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Nepean Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
			Forestry	Blue Mountains Sandstone	High potential GDE
	Plateau	Burragorang	Minimal use	Nepean Sandstone	Low potential GDE
			Minimal use	Nepean Sandstone	High potential GDE
			Minimal use	Nepean Sandstone	High potential GDE
			Minimal use	Nepean Sandstone	High potential GDE
		Wollemi	Minimal use	Nepean Sandstone	High potential GDE
			Forestry	Nepean Sandstone	High potential GDE
			Forestry	Nepean Sandstone	High potential GDE
	Slope	Wollemi	Forestry	Blue Mountains Sandstone	High potential GDE
			Other protected areas including Indigenous uses	Nepean Sandstone	High potential GDE

Figure 10-7. Groundwater dependent ecosystems within the development site



10.3.9 Vegetation

10.3.9.1 Overview

Native vegetation covers approximately 55 hectares (53 percent) of the development site, and includes some areas that were previously disturbed during dam construction and subsequent upgrades, and revegetated with native species. WaterNSW recently cleared approximately 0.15 hectares of vegetation from around built structures to reduce bushfire risk.

Vegetation cover is shown on Figure 10-8 and can be classified into three vegetation classes:

- Sydney hinterland dry sclerophyll forests
- Sydney coastal dry sclerophyll forests
- northern hinterland wet sclerophyll forests.

The site is centred around Warragamba Dam, which flooded Warragamba Gorge when it was constructed between 1948 and 1960. As such, vegetation surrounding Lake Burragorang is not typical riparian or flood plain vegetation. Instead, much of the site is comprised of vegetation typical of ridgetops on skeletal soils and most of the site supports dry sclerophyll forest of shrubby sub-formation, as well as a smaller area of wet sclerophyll forest.

Upstream of Warragamba Dam and on both sides of Lake Burragorang, the vegetation is dominated by species characteristic of ridgetop woodlands around the Sydney Basin, including *Angophora costata*, *Eucalyptus piperita*, *Eucalyptus eugenioides*, *Eucalyptus sieberi* and *Corymbia gummifera*. To the north-east of Warragamba Dam there is an area of wet sclerophyll forest that extends through a drainage line from just below the ridge line down to the dam infrastructure at the base of the dam wall. The canopy in this area is dominated by *Eucalyptus pilularis*, *Syncarpia glomulifera*, *Eucalyptus punctata* and *Angophora costata*. This vegetation conforms to the shale/sandstone transition forest critically endangered ecological community (CEEC).

A more detailed description of plant community types (PCTs) is provided in the following section.

10.3.9.2 Plant community types

The analysis determined that vegetation within the development site is aligned with four PCTs defined within the VIS Classification Database. PCTs identified and the justification for their selection are given in Table 10-8. PCTs within the development site are shown on Figure 10-9 and described in Table 10-9.

Figure 10-8. Native vegetation

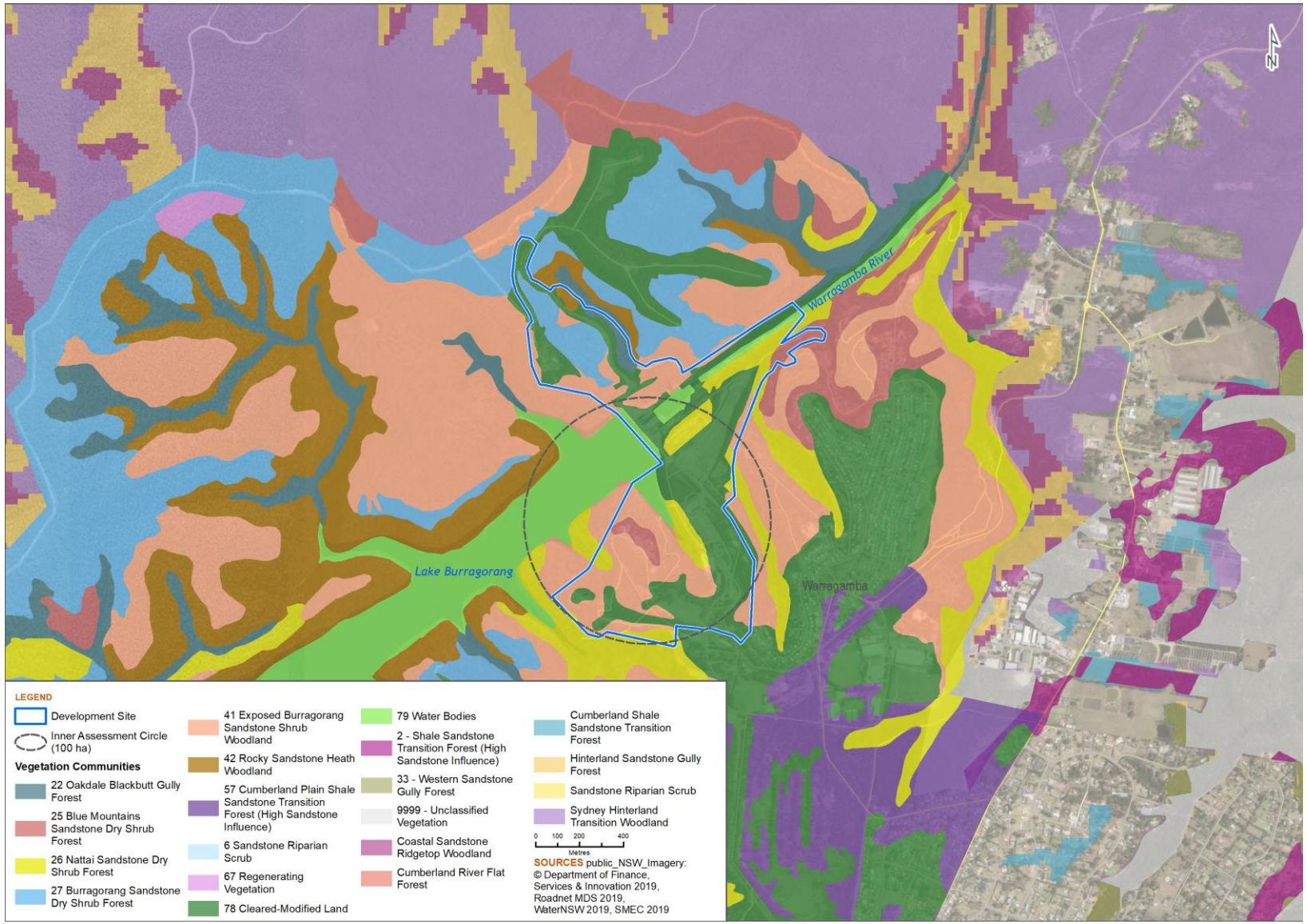


Figure 10-9. Plant community types within the development site

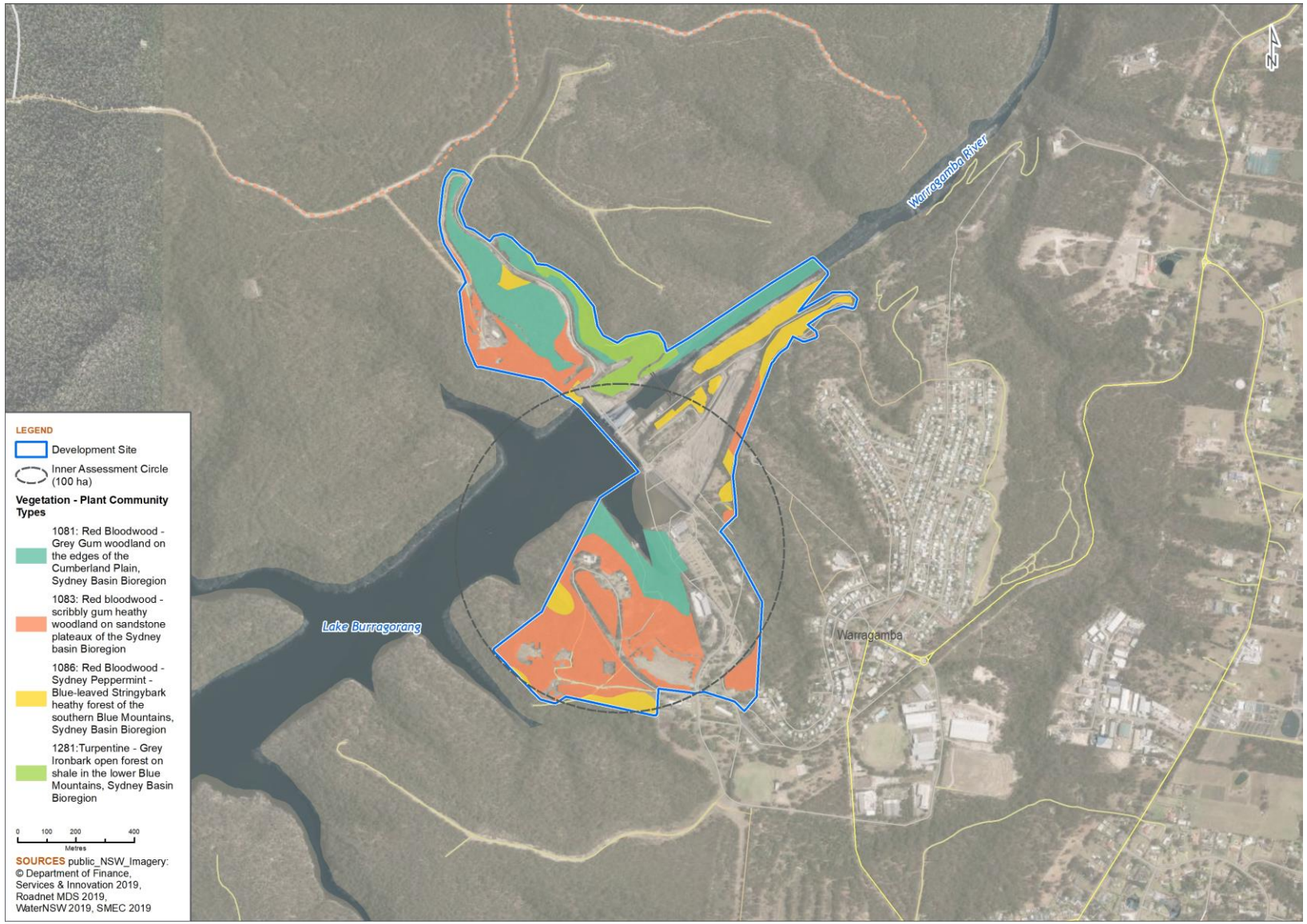


Table 10-8. PCTs within the development site

PCT code/ BVT code	PCT name	Evidence used for identification	Species relied upon for identification	% cleared within HN catchment	Area within development site (ha)
HN564 (PCT ID 1081)	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	**IBRA Subregion:** Occurs within the Burragorang and Wollemi IBRA subregions **Vegetation formation:** Dry sclerophyll (Shrubby sub-formation) **Landscape position**: Occurs on loamy soils on dry ridges below approximately 400 m in the rain shadow zone surrounding the Cumberland Plain	**Upper stratum species:** *Corymbia gummifera, Eucalyptus punctata, Angophora costata, Syncarpia glomulifera* **Mid stratum species:** *Phyllanthus hirtellus, Persoonia linearis, Leptospermum trinervium, Acacia ulicifolia* **Ground stratum species:** *Entolasia stricta, Lomandra obliqua, Pomax umbellata, Themeda australis*	40	17.0
HN566 (PCT ID 1083)	Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	**IBRA Subregion:** Occurs within the Burragorang and Wollemi IBRA subregions **Vegetation formation:** Dry sclerophyll (Shrubby sub-formation) **Landscape position:** Occurs on crests, ridges, and exposed slopes on coastal sandstone plateaux	**Upper stratum species:** *Corymbia gummifera, Eucalyptus haemastoma, Eucalyptus racemosa, Eucalyptus oblonga* **Mid stratum species:** *Acacia suaveolens, Acacia ulicifolia, Angophora hispida, Banksia ericifolia* **Ground stratum species:** *Actinotus minor, Caustis flexuosa, Cyathochaeta diandra, Dampiera stricta*	25	24.8
HN568 (PCT ID 1086)	Red Bloodwood – Sydney Peppermint - Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion	**IBRA Subregion:** Occurs within the Burragorang, Kanangra and Wollemi IBRA subregions **Vegetation formation:** Dry sclerophyll (Shrubby sub-formation) **Landscape position:** Occurs on sandy loams on elevated sandstone slopes between 250 and 800 m, mainly in the Nattai-Wingecarribee area	**Upper stratum species:** *Eucalyptus globoidea, Corymbia gummifera, Eucalyptus punctata, Eucalyptus sieberi* **Mid stratum species:** *Banksia spinulosa, Leptospermum trinervium, Lomatia silaifolia, Persoonia levis* **Ground stratum species:** *Billardiera scandens, Dampiera purpurea, Dianella caerulea, Entolasia stricta*	20	8.6
HN604 (PCT ID 1281)	Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	**IBRA Subregion:** Occurs within the Burragorang and Wollemi IBRA subregions **Vegetation formation:** Wet sclerophyll (Grassy sub-formation) **Landscape position:** Occurs in moist sheltered gully heads on shale up to 500 m around the edge of the Cumberland Plain and in the lower Blue Mountains	**Upper stratum species:** *Syncarpia glomulifera, Eucalyptus punctata, Eucalyptus pilularis, Eucalyptus paniculata* subsp. *paniculata* **Mid stratum species:** *Pittosporum undulatum, Polyscias sambucifolia, Acacia parramattensis, Breynia oblongifolia* **Ground stratum species:** *Dianella caerulea, Lomandra longifolia, Microlaena stipoides* var. *stipoides, Pratia purpurascens*	90	4.9

Table 10-9. Descriptions of PCTs occurring in the development site

PCT code/ BVT code PCT name	Vegetation class and formation	Description	
HN564 (PCT ID 1081) Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Sydney Hinterland Dry Sclerophyll Forests Dry Sclerophyll Forests (Shrubby sub-formation)	HN564 was recorded occurring on both sides of the Warragamba Gorge where it was found on moderately exposed, sloping sandstone terrain. This community was confirmed within the development site as occurring on sandy-clay soils. This PCT is equivalent to 'MU27 Burragorang Sandstone Dry Shrub Forest' within NPWS (2003) and 'DSF p146: Sydney Hinterland Transition Woodland' within Tozer (2010). This community is a dry sclerophyll woodland with a shrubby, open understorey. The canopy has been described in NPWS (2003) as consisting of *Eucalyptus punctata, Angophora costata, Syncarpia glomulifera* subsp. *glomulifera* and *Corymbia gummifera*, growing to a mean height of 20 metres. SMEC surveys found these species as occurring within the development site, as well as *Corymbia eximia* and *Eucalyptus pilularis*. The recorded shrub layer was comprised of *Persoonia linearis, Grevillea mucronulata, Acacia linifolia, Dodonaea triquetra, Leptospermum trinervium* and *Banksia spinulosa* var. *spinulosa*. A diverse ground cover occurs throughout the surveyed areas of this community including *Pomax umbellata, Entolasia stricta, Lepidosperma laterale, Xanthorrhoea media, Lomandra longifolia* and *Cyathochaeta diandra*.	

PCT code/ BVT code PCT name	Vegetation class and formation	Description	
HN566 (PCT ID 1083) Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Sydney Coastal Dry Sclerophyll Forests Dry Sclerophyll Forests (Shrubby sub-formation)	HN566 occurs on ridgetops and upper valley slopes. The community consists of a low eucalypt forest characterised by a sclerophyll shrub layer and a sparse groundcover of sedges. The composition of the PCT throughout its range may vary between sites depending on the level of exposure, elevation, and parent geology. This PCT is broadly equivalent to 'MU41 Exposed Burragorang Sandstone Shrub Woodland' and 'MU42 Rocky Sandstone Heath Woodland' within NPWS (2003) and 'DSF p131 Coastal Sandstone Ridgetop Woodland' within Tozer (2010). The extent of this community across the development site includes ridgetops on skeletal soils, primarily within the north and south west of the development site. The canopy within the development site is made up of *Corymbia gummifera, Eucalyptus piperita, Corymbia eximia, Angophora costata,* and *Eucalyptus eugenioides*. The midstorey consisted of a diverse range of species including *Allocasuarina littoralis*, *Leptospermum trinervium*, *Banksia serrata*, *Banksia spinulosa*, and *Xylomelum pyriforme*. The groundcover extent and diversity within the development site is variable across the area, dependent upon seral stage and fire frequency. The stratum is comprised of a mixture of sclerophyllous shrubs, grasses, forbs, and graminoids including *Xanthorrhoea arborea*, *Xanthosia pilosa*, *Dillwynia retorta*, *Caustis flexuosa*, *Dianella caerulea*, *Entolasia stricta*, and various *Lomandra* species. Much of this PCT was burnt during a prescribed burn in early 2018. In these areas, the PCT was identified based on broadscale vegetation mapping and identification of remaining canopy trees.	

PCT code/ BVT code PCT name	Vegetation class and formation	Description	
HN568 (PCT ID 1086) Red Bloodwood – Sydney Peppermint – Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion	Sydney Hinterland Dry Sclerophyll Forests Dry Sclerophyll Forests (Shrubby sub-formation)	HN568 was recorded in several isolated pockets within the development site and occurs as an open forest on sandy loams that have accumulated adjacent to sandstone ridges and outcrops. This PCT is broadly equivalent to 'MU25 Blue Mountains Sandstone Dry Shrub Forest' and 'MU26 Nattai Sandstone Dry Shrub Forest' within NPWS (2003). Within Tozer (2010) it is equivalent to 'DSF p144: Wingecarribee-Burragorang Sandstone Forest'. Within the development site, the canopy of this community is open and between 15 to 25 metres tall, consisting of species such as *Corymbia gummifera*, *Corymbia eximia*, *Angophora costata* and *Syncarpia glomulifera* subsp. *glomulifera* and stringybark species like *Eucalyptus eugenioides*. The shrub layer contained species such as *Persoonia linearis*, *Banksia spinulosa*, *Boronia ledifolia*, *Lomatia silaifolia* and *Lambertia formosa*. A patchy yet diverse ground cover occurs throughout the community comprising of species such as *Lomandra obliqua*, *Lomandra multiflora*, *Xanthorrhoea media*, *Cyathochaeta diandra* and *Patersonia glabrata*.	

PCT code/ BVT code PCT name	Vegetation class and formation	Description	
HN604 (PCT ID 1281) Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Northern Hinterland Wet Sclerophyll Forests Wet Sclerophyll Forests (Grassy sub-formation)	HN604 occurs in the north of the development site, immediately north-east of the dam wall. The community occurs on sandy-clay soil, thus the floristic composition of the PCT is transitional with a mix of species typical of both sandstone and clay soils. This PCT is equivalent to MU22 Oakdale Blackbutt Gully Forest in NPWS (2003). Within the development site, the canopy of this PCT is dominated by *Eucalyptus pilularis* and *Eucalyptus punctata*, with *Syncarpia glomulifera* subsp. *glomulifera*, *Angophora costata*, *Corymbia eximia* common throughout the area. *Eucalyptus deanei*, *Eucalyptus sieberi*, and *Eucalyptus fibrosa* occur occasionally. The midstorey is comprised of *Allocasuarina torulosa*, *Syncarpia glomulifera* subsp. *glomulifera*, *Xylomelum pyriforme*, *Persoonia linearis*, and *Acacia prominens*. The understorey contains a mixture of shrubs, grasses, and graminoids including *Grevillea mulcronulata*, *Breynia oblongifolia, Lomatia silaifolia*, *Banksia spinulosa*, *Lepidosperma laterale*, *Dianella longifolia*, *Cyathochaeata diandra*, *Entolasia stricta*, *Microlaena stipoides* var. *stipoides*, and *Pteridium esculentum*.	

10.3.9.3 Vegetation zones

PCTs occurring within the development site were initially stratified into areas represented by the locally-defined vegetation communities. These were subsequently divided into different condition classes, which resulted in the creation of five vegetation zones. These are described in Table 10-10 and shown on Figure 10-10.

Table 10-10. Vegetation zones within the development site

Vegetation zone	PCT Name	Condition	Area in development site (ha)	Area in development footprint (ha)
1	HN564: Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	14.1	0.3
2	HN566: Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Moderate/ Good	24.8	12.3
3	HN568: Red Bloodwood – Sydney Peppermint – Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion	Moderate/ Good	8.6	5.8
4	HN604: Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Moderate/ Good	4.9	1.6
5	HN564: Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good-poor	2.9	2.5

Figure 10-10. Vegetation zones within the development site

10.3.9.4 Threatened ecological communities

Based on the VIS Classification Database, one PCT within the development site (HN604: Turpentine – Grey Ironbark open forest) has potential to be a component of three different Threatened Ecological Communities (TEC) listed under both the BC Act and EPBC Act (Figure 10-11):

- **Shale/Sandstone Transition Forest (SSTF)** in the Sydney Basin Bioregion listed as Critically Endangered under both the BC Act and EPBC Act (NSW Scientific Committee 2014).
- **Sydney Turpentine Ironbark Forest (STIF)** listed as Endangered under the BC Act and Critically Endangered under the EPBC Act (NSW Threatened Species Scientific Committee 2019).
- **Blue Mountains Shale Cap Forest (BMSCF)** in the Sydney Basin Bioregion listed as Endangered under the BC Act and Critically Endangered under the EPBC Act (NSW Scientific Committee 2011).

Vegetation within the development site was compared against:

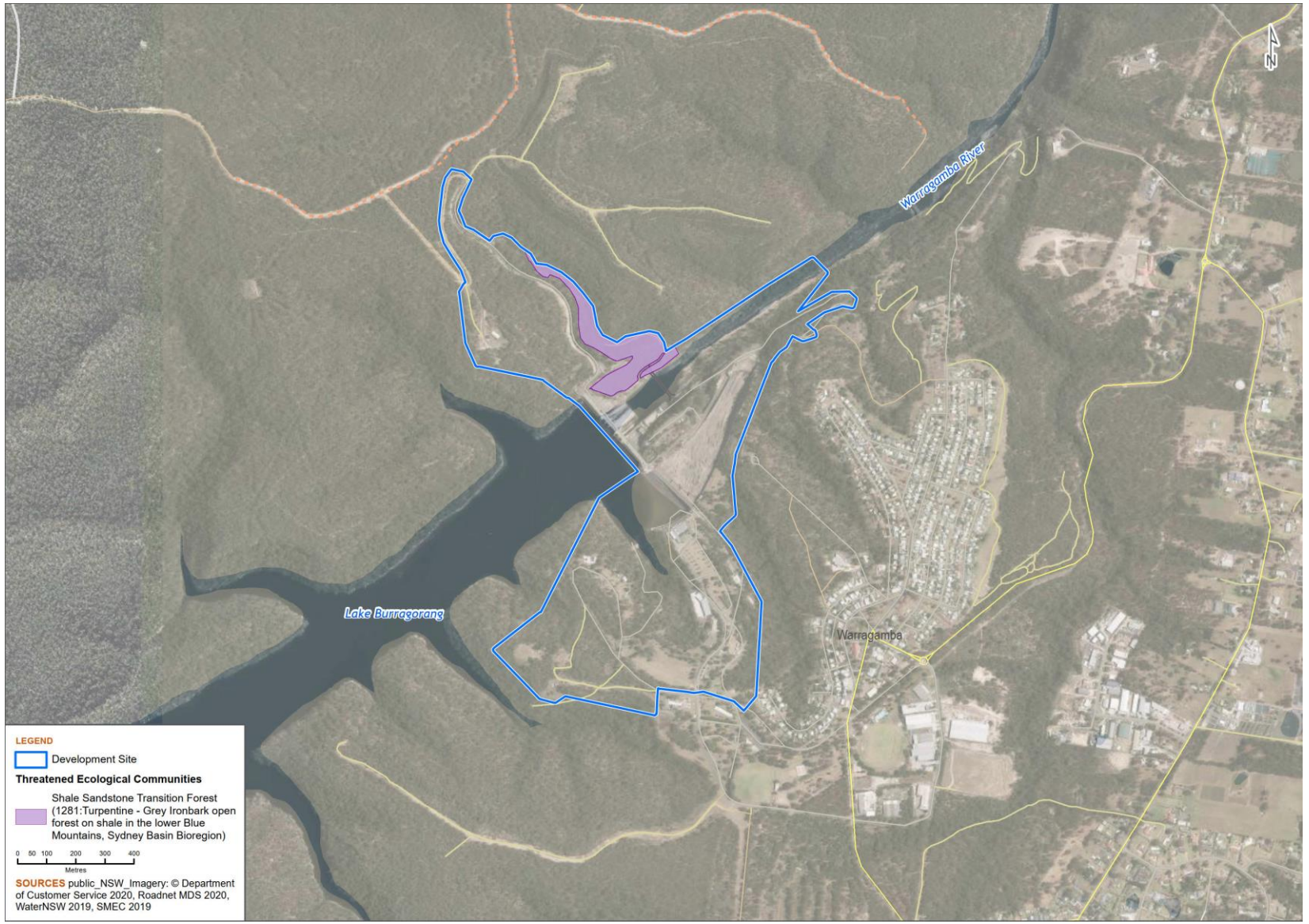
- **BC Act**: The assemblage of species, area of occupancy and supplementary descriptors outlined within the NSW Scientific Committee's Scientific Determination.
- **EPBC Act**: The listing advice and/or conservation advice, especially in relation to relevant size and condition thresholds pertinent to EPBC Act listings.

The comparisons and assessment as to whether the PCT conforms to either the BC Act or EPBC Act listings are detailed in Appendix F3 (Biodiversity assessment report – construction area, Section 4.4) and summarised in Table 10-11.

Table 10-11. TECs associated within PCTs occurring within the development site

PCT code	PCT name	TEC (BC Act)	TEC (EPBC Act)	TEC status	Assessed as associated TEC
HN604	Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	BC Act – Critically Endangered EPBC Act – Critically Endangered	Yes
The NSW Scientific Committee Final Determination lists characteristic species of this assemblage. The Final Determination also includes plant species that may be part of the assemblage but are atypical of its broader distribution, particularly on the margins of the community's distribution. Further details are provided in Appendix F3 (Biodiversity assessment report – construction area, Section 4.4.4).					

Figure 10-11. Threatened ecological communities within the development site



10.3.10 Fauna habitats

Fauna habitat assessments included consideration of important indicators of habitat condition and complexity including the occurrence of microhabitats such as tree hollows, fallen logs, bush rock and wetland/riparian areas, and the presence of mistletoe and flowering trees for nectivorous bird species. Hollows were used as a general indication of habitat quality for arboreal fauna and for hollow-dependent birds and bats. A list of fauna species recorded during the survey effort is provided in Appendix F3 (Biodiversity assessment report – construction area, Appendix E).

Fauna habitats of the development site are assessed in two main categories:

- fauna habitat features and resources at a locality scale that form part of the broader landscape of the development site to a five-kilometre radius
- site specific fauna habitat features and resources that provide the key elements required by native fauna for the maintenance of life cycles.

Fauna habitats identified are described in greater detail in the following sections.

10.3.10.1 Dry sclerophyll forest

The canopy of the dry sclerophyll forest is typically up to 20 metres high and is dominated by Red Bloodwood (*Corymbia gumifera*), Scribbly Gums (*Eucalyptus haemastoma* and *E. racemosa*), Narrow-leaved Stringybark (*E. oblonga*) and Grey Gum (*E. punctata*). The mid-storey includes acacia, banksia, persoonia and leptospermum species.

The flooding of the Burragorang Valley by Warragamba Dam has resulted in an atypical distribution of habitat that would normally occur around waterways, namely that habitat that would usually occur only on ridgetops, occurs close to the surface level of the lake. Dry sclerophyll forest is the most common fauna habitat within the development site, occurring throughout the area and to the lake edges.

Fallen logs and leaf litter are common. Rocks are abundant throughout this habitat, providing sheltering habitat for small mammals and reptiles. Overhangs and cliffs also provide habitat for microbats. Hollow-bearing trees are present, although likely to occur at a lower abundance due to historical logging. Threatened woodland birds are likely to use this habitat for foraging, nesting, and roosting; as are hollow-roosting microbats.

10.3.10.2 Wet sclerophyll forest

This tall, open forest occurs in on the western side of the Warragamba River, below the dam wall. The canopy is dominated by Turpentine (*Syncarpia glomulifera*), Grey Gum (*Eucalyptus punctata*), Blackbutt (*E. pilularis*) and Smooth-barked Apple (*Angophora costata*). The mid-storey is open, comprising of shrubs and small trees including Pittosporum, Acacia, Allocasuarina and Leucopogon species. The understorey is formed by a diverse array of shrubs, grasses and graminoids.

Within this habitat, fallen logs, leaf litter and rocks are common. As is the case with other habitats in the study area, hollow-bearing trees are present, although likely to occur at a lower abundance due to historical logging. This vegetation provides suitable nesting, roosting and foraging habitat for threatened woodland birds and foraging and roosting habitat for microchiropteran bats.

10.3.10.3 Cleared/modified land

Cleared and modified areas provide habitat where scattered canopy trees occur over grassland, including areas used for recreation and areas that have been impacted by construction and operation of the dam and spillway. Trees provide foraging and sheltering habitat for birds and microbats that can occupy disturbed habitat. The Large-eared Pied Bat was detected in modified vegetation near the auxiliary spillway.

10.3.10.4 Aquatic habitat

Aquatic ecology is addressed in Chapter 11. WaterNSW (2015) reports that Lake Burragorang supports an abundance of aquatic flora and fauna (BMT 2018). Within the development site, a small, high gradient rocky stream connecting Warragamba River to Lake Burragorang occurs. This stream is important fish habitat, providing the only upstream movement corridor for juvenile eels into Lake Burragorang (BMT 2018). Immediately below the dam wall, some aquatic vegetation occurs amongst the rocky river bed. Flows are limited by the daily volumes released from the dam.

10.3.11 Matters of national environmental significance (MNES)

MNES are separately addressed in Chapter 12 (MNES – biodiversity) and summarised as follows.

The Protected Matters search tool (search date: 26 April 2019) for the development site with a 10-kilometre buffer identified the following:

- 12 threatened ecological communities
- 78 threatened species
- 16 migratory bird species.

The following MNES species were identified as having a moderate or high likelihood of occurring within the development site or were recorded during surveys:

- Giant Burrowing Frog (*Heleioporus australiacus*) – Vulnerable
- Littlejohn's Tree Frog (*Litoria littlejohni*) – Vulnerable
- Regent Honeyeater (*Anthochaera phrygia*) – Critically Endangered
- Australasian Bittern (*Botaurus poiciloptilus*) – Endangered
- Painted Honeyeater (*Grantiella picta*) – Endangered
- White-Bellied Sea-Eagle (*Haliaeetus leucogaster*) – Migratory
- White-throated Needletail (*Hirundapus caudacutus*) – Migratory
- Swift Parrot (*Lathamus discolor*) – Critically Endangered
- Dural Land Snail (*Pommerhelix duralensis*) – Endangered
- Large-Eared Pied Bat (*Chalinolobus dwyeri*) – Vulnerable
- Spotted-Tailed Quoll (*Dasyurus maculatus*) – Endangered
- Brush-Tailed Rock-Wallaby (*Petrogale penicillata*) – Vulnerable
- Koala (*Phascolarctos cinereus*) – Vulnerable
- Grey-Headed Flying-Fox (*Pteropus poliocephalus*) – Vulnerable
- Broad-headed Snake (*Hoplocephalus bungaroides*) – Vulnerable
- *Acacia bynoeana* – Vulnerable
- *Asterolasia elegans* – Endangered
- *Cryptostylis hunteriana* – Vulnerable
- *Melaleuca deanei* – Vulnerable
- *Persoonia acerosa* – Vulnerable
- *Persoonia hirsuta* – Endangered
- *Pomaderris brunnea* – Vulnerable.

A preliminary environmental assessment (BMT WBM Pty Ltd 2016) of the MNES present within the development site indicated that there are likely to be impacts on areas of White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC and Shale-sandstone Transition Forest in the Sydney Basin Bioregion CEEC as well as individuals of Camden White Gum (*Eucalyptus benthamii*), Kowmung Hakea (*Hakea dohertyi*) and Few-seeded Bossiaea (*Bossiaea oligosperma*). In addition, the Project may have additional impacts on suitable habitat for other EPBC Act listed species and as such, a referral to DoEE was required for further consideration.

The Project is a controlled action (ref 2017/7940) as it has the potential to significantly impact on MNES, and as such requires assessment under the EPBC Act. In accordance with the Bilateral Agreement reached between the NSW and Commonwealth Governments, an environmental impact statement (EIS) under the EP&A Act for State Significant Infrastructure (SSI) can also be used for an EIS under the EPBC Act for a controlled action, where directed by the Commonwealth Minister. The direction was given for the Project to be assessed under the Bilateral Agreement on 17 July 2017. The Project will be assessed by relevant NSW departments in the first instance followed by assessment by the Commonwealth Minister for final determination.

10.3.12 Bushfires

10.3.12.1The 2019-2020 bushfire event

Following completion of biodiversity field surveys, New South Wales, including the Lake Burragorang catchment, experienced severe bushfires between 2019 and 2020. These bushfires have been described as unprecedented in their extent and intensity affecting at least 5.4 million hectares (seven percent of NSW) including 27 percent of the national park estate, more than 81 percent of the Greater Blue Mountains World Heritage Area and 54 percent of the NSW

components of the Gondwana Rainforests of Australia World Heritage property (DPIE 2020a). The most affected ecosystems were rainforests (37 percent of their state-wide extent), wet sclerophyll forests (50 percent) and heathlands (52 percent) (DPIE 2020a).

The fires affecting the study area began in late October 2019 in remote bushland near Lake Burragorang, near Yerranderie, and in the Kanangra-Boyd National Park. Due to rugged and inaccessible terrain, the fire spread and merged to eventually become the Green Wattle Creek Fire on 27 November 2019. This fire rapidly affected the study area where it burnt out of control for at least nine weeks. The fire affected around 278,700 hectares in the Wollondilly area until it was officially declared as 'contained' on 30 January 2020. The fire was declared as 'extinguished' by the NSW Rural Fire Service (RFS) on 10 February 2020 following a torrential rain event over the preceding week.

Bushfire mapping

The NSW DPIE Remote Sensing and Landscape Science team has, in collaboration with other organisations, developed fire mapping and modelling of the 2019-2020 bushfire event to determine the extent, severity, and impact of the bushfires on native vegetation. There are two fire maps:

- The Google Earth engine burnt area map (GEEBAM) was developed in collaboration with the University of NSW, as a rapid mapping approach that detected how badly the tree canopy had burnt by measuring the change in colour of vegetation before and after fire (DPIE 2020b). GEEBAM's rapid assessment of vegetation post-fire made information quickly available on the likely impacts of the fire event on biodiversity, supporting important conservation and environmental management decisions (DPIE 2020b).
- The fire extent and severity map (FESM) was developed in collaboration with RFS as a semi-automatic approach to mapping fire extent and severity through a machine learning framework based on Sentinel 2 satellite imagery (DPIE 2020c). Machine learning uses algorithms and statistical models to understand patterns in the data. FESM has a standardised classification system of fire severity and can predict and compare the severity of fires across different landscapes (DPIE 2020c). The finalised version of the FESM for the 2019-2020 bushfire season was produced in April 2020. A further update was issued in December 2020.

The NSW DPIE Remote Sensing and Landscape Science team has recommended that FESM be utilised over the rapid GEEBAM product for assessing the impacts of the fire event within the study area. The FESM classifies the fire severity into five burn severity classes, which are described in Table 10-12.

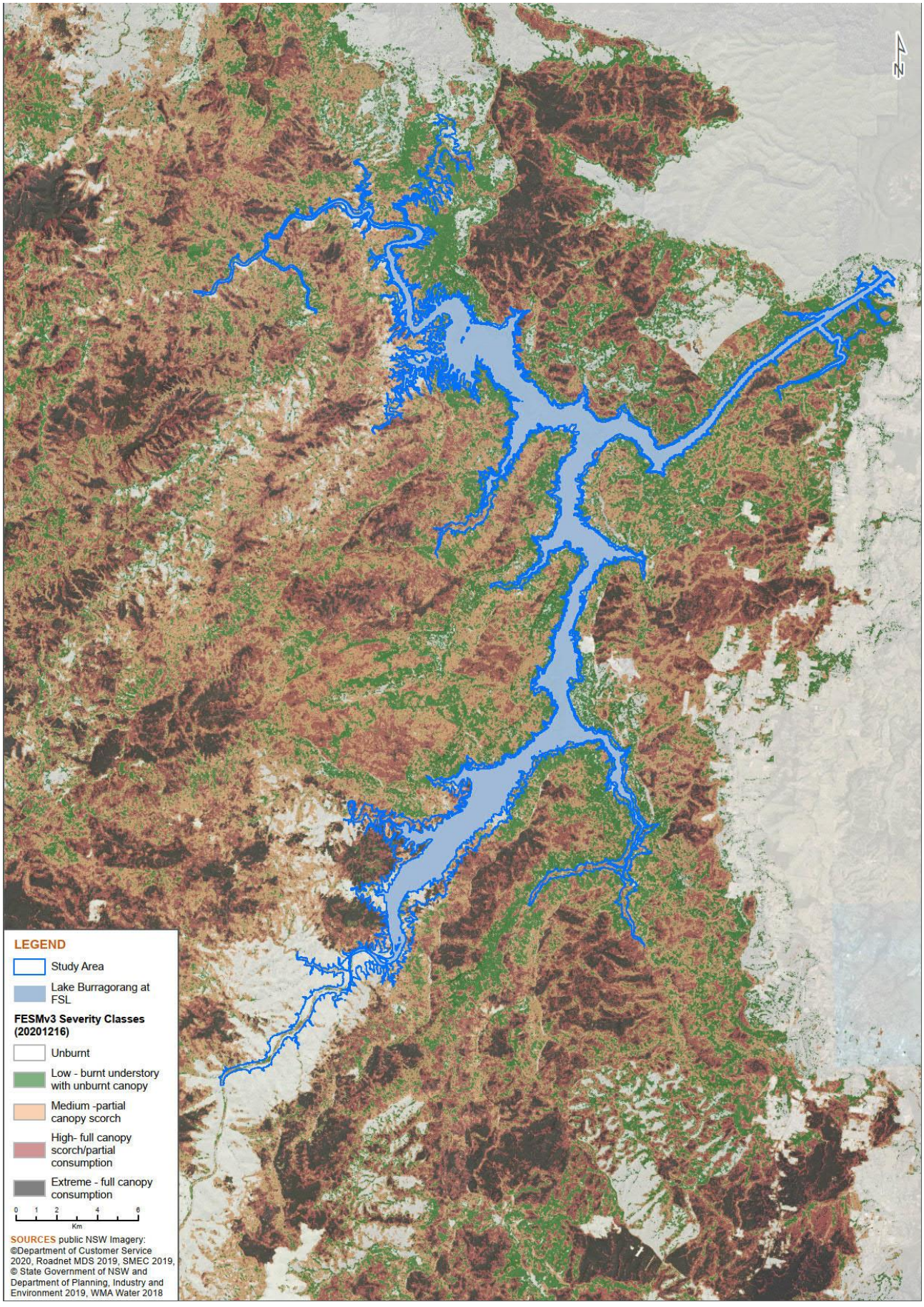
Table 10-12. FESM burn severity classes

Severity class	Description	Percent foliage fire affected
Unburnt	Unburnt surface with unburnt canopy	0% canopy and understory burnt
Low	Burnt understory with unburnt canopy	>10% burnt understory >90% green canopy
Moderate	Partial canopy scorch	20-90% canopy scorched
High	Full canopy scorch/partial consumption	>90% canopy scorched <50% canopy consumed
Extreme	Full canopy consumption	>50% canopy biomass consumed

The FESM shows an area of fire activity within the development site, immediately north of the dam wall. However, the area is not shown on the GEEBAM mapping as being affected by fire. Updated aerial imagery and drone video footage of the area confirms that the development site was not burnt. Consequently, it appears that the fire activity on the FESM within the development site is an artefact of the image processing.

The extent of the fires and the burn severity is shown on Figure 10-12.

Figure 10-12. Extent of 2019/2020 bushfires



10.3.12.2 Historic bushfires

The 'NPWS Fire History – Wildfires and Prescribed Burns' is a mapping layer released by DPIE on the history of fire in national parks based on data captured by the RFS and Forestry Corporation NSW (DPIE 2020d). According to this mapping, most of the study area has been affected by wildfire historically and at least 30 percent of the extent has been subjected to a prescribed burn. Wildfires have affected the catchment variably since 1964-65 however none has been as extensive in size as the 2019-2020 fire. Historically, the catchment has experienced at least four major wildfire events: 1964-65, 1994-95, 1997-98 and 2001-02 (DPIE 2020d).

The effects of the 2019-2020 bushfires on the environment, including the ecological consequences, are not yet fully understood. Though bushfires are not uncommon in Australia, they are usually of a lower scale and intensity that only affect small parts of the overall distribution of ecosystems and habitats (DPIE 2020e). Post-fire studies have found that several species (both threatened and not currently threatened) have had their entire populations burnt in the 2019-2020 fires (DPIE 2020e). This includes some species and ecological communities that are known to be sensitive to severe fire (DPIE 2020e). The long-term fire regime including fire frequency, intensity and seasonality influence the ecosystem in various ways, including having both positive and negative effects. If fires are too frequent, plants may be killed before they have matured or before they have set sufficient seed to ensure population recovery. Alternatively, infrequent fires can impact negatively on plants that rely on fire to regenerate. If fire is too infrequent, these species can grow old and die, and their seeds rot in the soil before germinating. In this way, plant community species richness and composition can be shaped by the fire regime. Some plant species have no or limited natural fire tolerance and may be significantly reduced in density over their affected ranges. Other ecological inputs following fire, in particular widespread and intense fires, can have additional effects on post-fire ecology. These inputs may include soon recurrent fire, drought, intense rainfall, flood, erosion and predation.

Notwithstanding, several threatened ecological communities, threatened species, and non-threatened species are considered to have been disproportionately impacted by the 2019-2020 bushfires. Consequently, DoEE has released an initial list of threatened and migratory species that have had more than 10 percent of their known or predicted distribution in areas affected by bushfires in southern and eastern Australia from 1 August 2019 and 13 January 2020. Examples of species on this list that were recorded during current field surveys, or predicted to occur based on habitat preferences, within the development site include:

- *Pomaderris brunnea* (50 to <80 percent)
- Regent Honeyeater (10 to <30 percent)
- Koala (10 to <30 percent)
- Brushtail Rock Wallaby (30 to <50 percent)
- Broad-headed Snake (50 to <80 percent).

In addition to the above, DoEE/DAWE has released an initial list of fauna species which require urgent management intervention (DoEE 2020). The Regent Honeyeater and Koala are on the initial list and based on habitat preferences were predicted to occur within the development site.

In March 2020, DPIE released a set of guidelines relating to carrying out biodiversity assessments, specifically Biodiversity Assessment Method (BAM) based assessments, at severely burnt sites. The guidelines aim to provide assessors with a reasonable, evidence-based and transparent process for identifying severely burnt native vegetation and provides a range of approaches for applying the BAM on land impacted by severe bushfire as identified on the GEEBAM. As the development site is not severely affected by fire as identified on the GEEBAM, the guidelines do not need to be applied.

10.4 Presence of threatened species

10.4.1 Overview

Threatened species potentially occurring within the development site were assessed in accordance with the FBA and site surveys. The FBA process is outlined in Section 10.2.1.1, while definitions for Ecosystem credit species and species credit species are provided in Section 10.2.5. The type and occurrence of threatened species and communities that could potentially be impacted by the Project are detailed in Appendix F3 (Biodiversity assessment report – construction area, Section 5).

10.4.2 Predicted ecosystem credit species

The BBCC generates a list of predicted ecosystem credit species from numerous inputs. The FBA defines values as the ability of a species to respond to improvement in site value or other habitat improvement at a biobanking site with management actions, and is based on an assessment of effectiveness of management actions, life history characteristics, naturally rare species, and poorly known species.

Specific criteria are:

- IBRA subregions: Wollemi.
- Associated PCTs: HN564, HN566, HN568 and HN604.
- Percentage native vegetation in outer assessment circle: 75 percent.
- Condition of vegetation: moderate to good (all vegetation zones).
- Patch size: 1001+.
- Credit type: Ecosystem.

Four ecosystem credit species were recorded within one kilometre of the development site (Figure 10-13) and include the White-bellied Sea-eagle, Little Bent-winged Bat, Eastern Coastal Free-tailed Bat and Eastern False Pipistrelle. A list of predicted ecosystem credit species is provided in Appendix F3 (Biodiversity assessment report – construction area, Section 5.2, Table 5.2).

10.4.3 Candidate species credit species

Candidate species were identified in accordance with the FBA (Section 6.5.1.2). The BBCC generates a list of candidate species based on the distribution of the species occurring within the same IBRA subregion as the development site and the presence of habitat features and components associated with these species. The habitat features and components that have been used to assess presence/absence within the development site are:

- land within 250 metres of termite mounds or rock outcrops
- heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 metres of, ephemeral or intermittent drainage lines
- land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels
- land within 40 metres of heath, woodland or forest
- land within 500 metres of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping
- Moist wet forest and rainforest gullies
- land within one kilometre of rock outcrops or cliff lines
- land containing bark or leaf litter accumulation.

Species credit species have also been included within the list of candidate species if they:

- have been recorded within a 10-kilometre radius of the development site on the Atlas of NSW Wildlife Database
- are known or predicted to occur within the IBRA subregions within which the development site is located
- have been confirmed as occurring within the development site due to previous surveys.

The list of candidate species was also assessed against the criteria outlined in the FBA (Section 6.5.1.3), which was used to determine if the species required further assessment. Species were not considered to require further assessment where:

- a habitat assessment has determined that habitat components required by the species as determined by the TSPD or OEH Threatened Species Profile do not occur, or have been substantially degraded such that the species is unlikely to occur, on the development site
- an expert report has stated that the species is unlikely to occur
- the species is a vagrant species and unlikely to occur within the development site.

Three species credit species were recorded within the development site (Figure 10-13) and include Small-flower Grevillea, Large-eared Pied Bat and Red-crowned Toadlet. Expert reports were also prepared for five species, which

include Red-crowned Toadlet, Giant Burrowing Frog, Green and Golden Bell Frog, Littlejohn's Frog, Stuttering Frog, Giant Barred Frog and *Pterostylis saxicola* (orchid commonly called Sydney plains rustyhood).

Assessment of potential presence of species credit species is provided in Appendix F3 (Biodiversity assessment report – construction area, Section 5.3, Table 5.3). A list of species credit species is given in Table 10-28 (see Section 10.7.1.2).

10.4.4 Biodiversity requiring further consideration

The SEARs (OEH submission in Attachment C) identified species and communities that require further assessment. Appendix F3 (Biodiversity assessment report – construction area) makes the following conclusions:

10.4.4.1 No further assessment

- **Impacts on threatened species**: One additional threatened species (White fronted chat; *Epthianura albifrons*) is listed as requiring further consideration. This assessment found that there is no suitable habitat for this species and no further assessment is required.
- **Impacts on endangered populations**: One additional population (*Marsdenia viridiflora* R. Br. subsp.) is listed as requiring further consideration beyond the FBA Assessment. This assessment found that this population does not occur within the Wollondilly LGA and no further assessment is required.
- **Impacts on threatened ecological communities**: No additional TECs require further consideration beyond those determined through the FBA assessment process.
- **Matters excluded from further consideration**: Six threatened ecological communities and associated species and populations were specifically excluded from further consideration in the SEARs.

10.4.4.2 Further assessment

The SEARs provided by OEH require consideration of eight additional threatened entities (seven species and one TEC). One of these was recorded during site field surveys and the rest are assumed to be present in line with the FBA (Section 6.5.1.9). Additional entities are listed in Table 10-13.

Prescribed burns had been carried out within areas of the development site in 2018, preventing targeted surveys within these areas. Furthermore, due to drought conditions, presence was assumed for those threatened flora species that cannot be ruled out as requiring further assessment in line with the FBA (Section 6.5.1.9).

Figure 10-13. Threatened species records

Table 10-13. Biodiversity requiring further consideration

Species name	Species population or EEC	BC Act status[1]	EPBC Act status[2]	Included within Attachment C of SEARs (y/n)?	Applicable IBRA subregion (SEARs)	Recorded during current surveys (y/n)?	Justification for inclusion as matter for further consideration
Ancistrachne maidenii	Species	V	-	Y	Wollemi	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Dillwynia tenuifolia	Species	V	-	Y	Wollemi	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Epacris purpurascens var. *purpurascens*	Species	V	-	Y	Wollemi Burragorang Cumberland	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Gyrostemon thesioides	Species	E	-	Y	Burragorang Cumberland	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Hibbertia puberula	Species	E	-	Y	Wollemi, Burragorang	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Rhodamnia rubescens	Species	CE	-	N	-	Assumed present	Species is listed as Critically Endangered thus meets the requirements for inclusion as per section 9.2.4.1 of the FBA.
Tetratheca glandulosa	Species	V	-	Y	Burragorang	Assumed present	Threatened species has been specifically nominated in the SEARs as a species that is to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted upon by the development.
Shale Sandstone Transition Forest CEEC	TEC	CE	CE	N	Wollemi	Yes	TEC is listed as Critically Endangered thus meets the requirements for inclusion as per section 9.2.4.1 of the FBA. Note this TEC is only excluded from consideration when within Cumberland IBRA subregion.

[1] BC Act Status: CE Critically Endangered (Schedule 1A); E1 – Endangered (Schedule 1); V – Vulnerable (Schedule 2). [2] EPBC Act Status: CE – Critically Endangered; E – Endangered; V – Vulnerable.

10.5 Avoid and minimise impacts

10.5.1 Avoid impacts

In accordance with the FBA, the Construction Area BAR must outline the actions that have been undertaken to demonstrate that reasonable measures have been taken to avoid and minimise the potential direct and indirect impacts of the Project on biodiversity values.

10.5.1.1 Alternative analysis

Chapter 4 (Project development and alternatives) discusses alternatives for flood mitigation in the Hawkesbury-Nepean Valley. These include:

- infrastructure upgrades to enhance drainage or protect downstream communities
- new flood mitigation dams, including new dams built and operated only for flood mitigation
- operational alternatives using existing infrastructure
- evacuation road upgrades
- non-infrastructure alternatives, such as changes to planning controls, improved flood monitoring and response and better coordination between agencies.
- strategies combining two or more of the above alternatives.

10.5.1.2 Avoidance of direct impacts

The FBA (Section 8.3.1.3) aims to avoid direct biodiversity impacts on defined biodiversity values, which together with proposed avoidance mechanisms are summarised in Table 10-14.

Table 10-14. Avoidance of direct impacts on biodiversity values at the development site

FBA section	FBA criterion	Avoidance mechanism proposed
8.3.1.3 (a)	*Impacts to endangered ecological communities (EECs) and critically endangered ecological communities (CEECs).*	The scale and nature of the development type means that options to avoid impacts to EECs within the development site are very limited. The development site is necessarily tied to the current dam wall and direct impacts resulting from the footprint of any newly built section of dam wall cannot be avoided.
8.3.1.3 (b)	*Impacts to PCTs that contain threatened species habitat.*	Due to the location, size and nature of the development, impacts associated with the dam, including abutments and spillway, cannot be avoided. However, where feasible, ancillaries such as batch plants, laydowns, and worker amenities have been located within areas which do not contain native vegetation or threatened species habitat.
8.3.1.3 (c)	*Impacts to areas that contain habitat for vulnerable, endangered or critically endangered threatened species or populations.*	Due to the location, size and nature of the development, impacts associated with the dam, including abutments and spillway, cannot be avoided. However, where feasible, ancillaries such as batch plants, laydowns, and worker amenities have been located within areas which do not contain native vegetation or threatened species habitat.
8.3.1.3 (d)	*Impacts to an area of land that the Minister for Environment has declared as critical habitat in accordance with section 47 of the TSC Act.*	There are no areas of critical habitat within the development site.
8.3.1.3 (e)	*Impacts to the riparian areas of 4th order or higher streams and rivers, important wetlands and estuaries.*	As the Project is situated at Warragamba Dam, and surrounding Lake Burragorang, which is a 9th order stream at that point along its extent. As such, any impacts to the riparian buffers of a 4th order stream or higher cannot be avoided.

FBA section	FBA criterion	Avoidance mechanism proposed
8.3.1.3 (f)	*Impacts to state significant biodiversity links.*	There is no record available of any state significant biodiversity link within or adjacent to the development site. No information regarding such links has been provided in the SEARS. It should be noted that in accordance with Appendix 4 of the FBA, the connectivity value class 'State significant biodiversity link' includes impacts to riparian buffers of 6th order stream or higher. The Project will impact upon the riparian buffer of Lake Burragorang, which is a 9th order stream at that point along its extent.

10.5.1.3 Site selection and planning

The construction layout is shown on Figure 10-1 and has been refined through careful consideration of the construction footprint. Biodiversity analysis was done to inform concept planning, design and siting of proposed infrastructure and construction activities. This included assessing locations of temporary construction infrastructure such as roads, camps, stockpile sites and concrete batching works. Temporary construction works would be located wholly within the development site. The area around the dam where construction facilities are planned is significantly disturbed because of construction of the current dam and auxiliary spillway, as well as ongoing maintenance and tourism activities.

The FBA (section 8.3.2.8) aims to consider biodiversity issues during site planning, which is summarised in Table 10-15.

Table 10-15. Consideration of the proposed development during site planning

FBA section	FBA criterion	Considerations of the FBA guidelines at the site
8.3.2.8 (a)	*The Major Project should be located in areas where the native vegetation or threatened species habitat is in the poorest condition, or which avoid an EEC or CEEC.*	Due to the location, scale and nature of the development, impacts to Shale Sandstone Transition Forest CEEC cannot be avoided. However, ancillary activities such as batch plants, laydowns, and worker amenities have been located within areas which do not contain the CEEC. There will be opportunities to further reduce the impact on the CEEC during detailed design.
8.3.2.8 (b)	*The Major Project and associated construction infrastructure should be located in areas that do not have native vegetation, or in areas that require the least amount of vegetation to be cleared, and/or in areas where other impacts to biodiversity will be lowest.*	Due to the location, size and nature of the development, impacts associated with the dam, including abutments and spillway, cannot be avoided. However, where feasible, ancillary activities such as batch plants, laydowns, and worker amenities have been located within areas which do not contain native vegetation or threatened species habitat.
8.3.2.8 (c)	*Major Projects can impact on the connectivity and movement of species through areas of adjacent habitat. Minimisation measures may include providing structures that allow movement of species across barriers or hostile gaps.*	The proposed development will widen a hostile barrier created when the dam wall was built. A drainage line which enable eels to migrate from the base of the dam to Lake Burragorang, to facilitate the movement of this species across the hostile barrier. No additional fauna crossing structures are proposed. The drainage line that provides for eel movement would be reinstated if damaged during construction.
8.3.2.8 (d)	*Any other constraints that the assessor has considered in determining the siting and layout of the Major Project.*	No additional constraints have been considered. A discussion of Project siting is included within Chapter 4 of the EIS.

10.5.2 Minimise impacts

10.5.2.1 Minimise impacts during construction phase

A construction environmental management plan (CEMP) will be prepared, which will identify reasonable measures necessary to further avoid and minimise potential impacts. The CEMP will consider:

- method of clearing
- clearing operation protocols
- timing of construction
- other measures that minimise inadvertent impacts on the biodiversity values during the construction phase.

A site-specific flora and fauna management plan (FFMP) will provide a framework for biodiversity management and mitigation during construction, and will detail management requirements to further reduce impacts on flora and fauna such as:

- vegetation pre-clearance and clearance supervision
- rehabilitation and habitat restoration
- sediment and erosion control
- weed and feral animal management
- required ecological monitoring.

The FBA (Section 8.3.2.10 and Section 8.4.1.3) aims to consider mitigation measures to prevent or minimise direct and indirect impacts on biodiversity during construction, which are summarised in Table 10-16 and Table 10-17 respectively.

10.5.2.2 Minimise site impacts during operational phase

The FBA (Section 8.3.2.12) aims to avoid and minimise direct impacts on biodiversity values during the operational phase; these are summarised in

Table 10-18.

Table 10-16. Considerations to minimise direct impacts of the proposed development during construction

FBA section	FBA criterion	Considerations of the FBA guidelines at the site
8.3.2.10 (a)	*Method of clearing – using a method of clearing during the construction phase that avoids damage to retained native vegetation and reduces soil disturbance. For example, removal of native vegetation by chain-saw, rather than heavy machinery, is preferable in situations where partial clearing is proposed*	Most of the clearing will be completed by heavy machinery. Chainsaws will be used within 10 metres of clearing boundaries to ensure that damage to retained vegetation and soil disturbance is minimised. Where the presence of fauna is confirmed during additional surveys and pre-clearing surveys the method of clearing will be modified, with the changes detailed in the flora and fauna management plan (FFMP). An example would be to use tree climbers to remove detected fauna and so minimise direct impacts to fauna.
8.3.2.10 (b)	*Clearing operations – minimising direct harm to native fauna during actual construction operations through onsite measures such as undertaking pre-clearing surveys, daily fauna surveys and the presence of a trained ecologist during clearing events*	The clearing protocol will be clearly outlined in the FFMP and include the following: ▪ Following pre-clearing surveys, the direct clearing of vegetation will take place in two stages. During Stage 1, all habitat trees will be marked and left standing, while the vegetation surrounding them will be cleared. This will be followed by an interim period of 24 to 48 hours where the site is left undisturbed to allow any fauna using the hollows to vacate the areas. Stage 2 will occur after the interim period has finished and will involve the felling of the habitat trees. The two-stage clearing process allows for minimising disturbance whilst clearing occurs around habitat trees, and allows fauna a chance to self-relocate upon nightfall, prior to the habitat tree being removed. In areas of mapped frog habitat, the two-stage clearing protocol includes nocturnal active searches and relocating of individuals, followed by active searches the following day before clearing takes place. ▪ A licensed wildlife carer and/or ecologist will capture and/or remove fauna that have the potential to be disturbed because of clearing activities. Disturbed fauna will be relocated into habitat that has been designated by relevant experts as suitable for release of the captured fauna (not all areas will work for all species). This work will be undertaken by a carer/ecologist with demonstrated previous experience in handling and relocating the fauna likely to be present and must have animal ethics approval to handle and relocate native fauna. Where fauna habitat has been identified, fencing should be installed at the boundary of this habitat and the clearing area to prevent fauna sheltering within the construction area and compounds. ▪ An ecologist with demonstrated experience, skill and licensing in relevant fauna handling will also be present during all clearing activities to rescue animals injured during the operation. Any unharmed fauna found will be captured and relocated to nearby remnant vegetation and released (if a nocturnal species) after nightfall and in a suitably sheltered habitat to minimise the risk of predation by diurnal predators. Any animals that are injured will be taken to the nearest prequalified veterinary clinic (to be nominated prior to clearing commencing) for treatment. If assessed by a vet as unlikely to survive, it will be humanely euthanized. Otherwise, once healed, fauna will be released at the nearest suitable location from their capture point, again taking into consideration of the timing of release and the location having suitable cover. ▪ All persons working on the vegetation clearing will be briefed about the possible fauna present at the time of construction, and what procedures should be undertaken in the event of an animal being injured or disturbed. This briefing would be included within an induction to be completed before workers commence work on site. ▪ Results and outcomes of pre-clearing and clearing fauna surveys shall be documented by the nominated project ecologist and submitted to the proponent.

FBA section	FBA criterion	Considerations of the FBA guidelines at the site
8.3.2.10 (c)	*Timing of construction – identifying reasonable measures that minimise the impacts on biodiversity. For example, timing construction activities for when migratory species are absent from the site, or when particular species known to or likely to use the habitat on the site are not breeding or nesting, can minimise the impacts of construction activities on biodiversity.*	Where feasible, vegetation clearing should be timed to minimise disturbance when fauna is most sensitive to disturbance. For most species, this is during breeding season, but it also includes periods of low activity (that is, torpor) for microchiropteran bats. The breeding/low activity seasons of fauna species are outlined below: ▪ Giant Burrowing Frog: most often in late summer or autumn following heavy rains ▪ Red-crowned Toadlet: warmer months, following heavy rains ▪ Dusky Woodswallow: August – January ▪ Gang-Gang Cockatoo: October – January ▪ Glossy Black-cockatoo: March – August ▪ Varied Sittella: September – January ▪ White-bellied Sea-eagle: June – January ▪ Powerful Owl: May – September ▪ Eastern Freetail-Bat: July – January ▪ Common Planigale: October – January ▪ Threatened microchiropteran bats: July – August. Given that it is not feasible to avoid breeding seasons for all threatened species recorded within the development site, it is recommended that the bulk of clearing is undertaken as far as is practicable in autumn, to minimise impacts on breeding activities of most of the threatened species. The timing of vegetation clearing will be clearly detailed in the FFMP.
8.3.2.10 (d)	*Other measures that minimise inadvertent impacts of the Major Project on the biodiversity values – measures such as installing temporary fencing to protect significant environmental features such as riparian zones, promoting the hygiene of construction vehicles to minimise spread of weeds or pathogens, appropriately training and inducting project staff and contractors so that they can implement all measures that minimise inadvertent adverse impacts of the Major Project on biodiversity values.*	▪ Temporary fencing should be installed prior to clearing works to delineate impact from protected areas. ▪ The location of temporary fencing and signage will be documented in the FFMP. ▪ Nest-boxes should be installed to provide short-term replacement for the loss of habitat for displaced hollow-dependent fauna. Nest-box requirements are further discussed in ▪ Table 10-18. ▪ All mobile plant and equipment being brought onto the development site must be inspected and cleaned prior to commencing work to prevent the spread of weeds or pathogens. ▪ Salvage of cleared vegetation. ▪ Environmental personnel will be trained on the identification of priority weed species for the Greater Sydney region so that the development site can be monitored for the introduction or spread of priority weed species every 12 weeks from April to September and every four weeks from October to March. Any outbreak of priority weeds will be controlled and eradicated as required under the *Biosecurity Act 2015* by a suitably qualified bush regeneration contractor. Weed management requirements including treatment methods, timing, and monitoring will clearly detailed in the FFMP.

Table 10-17. Considerations to minimise indirect impacts of the proposed development during construction

Indirect impacts	Proposed measures to minimise impacts
Sedimentation and run-off	▪ Sediment barriers, sedimentation ponds and detention basins will be incorporated into the Project design to protect adjacent waterways from sediment and run-off. This measure will protect surrounding vegetation and the Warragamba, Nepean and Hawkesbury Rivers. ▪ Erosion and sediment control measures are to be implemented during the construction phase and be in accordance with the guidelines set out in the 'Blue Book' (Landcom 2004). ▪ The construction contractor should include daily checks of all sediment and erosion controls and their sediment and erosion plan will include additional checks when high rainfall and strong winds are forecast. ▪ Sediment and erosion controls would be included in monthly environmental audits for the Project. ▪ Specific requirements pertaining to sedimentation and run-off will be included within the CEMP.
Noise, dust, or light spill	Where feasible construction should be limited to daylight hours to mitigate for noise and light spill impacts to nocturnal fauna in adjacent vegetation.
Blasting and vibration	Habitats sensitive to vibration such as sandstone rock outcrops should be monitored for deterioration of structural integrity and loss of habitat value. The risk to rock hangs would be identified within the construction noise and vibration management plan.
Inadvertent impacts on adjacent habitat or vegetation	Fencing should be erected to delineate the extent of the clearing boundary, development site and protect adjacent vegetation from impacts such as vehicular traffic. Additional fencing and signage should be erected around areas of TECs. Set down areas and lay down areas that are located outside of areas of native vegetation, should be prioritised for use. If vegetation clearing is required, it should be demonstrably minimised.
Pest, weed and/or pathogen encroachment into vegetation on land adjoining the development site	Light vehicles and mobile plant should all be cleaned when entering the development site to prevent the introduction of pathogens that may impact vegetation outside the development site. Stockpiles will be separated to avoid contamination. The CEMP will include reference to guidelines to management of weeds and pathogens that would include, but not be confined to: ▪ Management of *Phytophthora* for biodiversity conservation in Australia: Part 2 - National Best Practice Guidelines (O'Gara *et al*. 2005). ▪ Hygiene protocol for the control of disease in frogs, Information Circular Number 6 (Wellington and Haering 2008). ▪ Management of Myrtle Rust on national parks estate (OEH 2011). ▪ New South Wales Weed Control Handbook – A guide to weed control in non-crop, aquatic and bushland situations 7th Edition (NSW DPI 2018). A weed management plan for the Project should include progressive weed management and monitoring within the development site and adjacent bushland throughout construction and for a period post-construction, with a focus on managing weeds within the threatened ecological communities that occur on adjoining land.

Table 10-18. Considerations to minimise direct impacts of the proposed development during operation

FBA section	FBA criterion	Considerations of the FBA Guidelines at the site
8.3.2.12a	*Seasonal impacts – whether there are likely to be any impacts that occur during specific seasons. Minimisation measures may include amending operational times to minimise impacts on biodiversity during periods when seasonal events such as breeding, or species migration occur.*	The timing and flood mitigation operations of these events will be dependent on dam levels, flows and upstream precipitation.
8.3.2.12b	*Artificial habitats – using 'artificial habitats' for fauna where they may be effective in minimising impacts on such fauna. These include nest boxes, glider-crossings or habitat bridges.*	Nest-boxes are useful in reducing the impact to fauna habitat within the development site. Equivalent nest-boxes should be erected for each natural hollow that is removed during the construction phase. Replacement nest-boxes should be suitable for all threatened and non-threatened fauna inhabiting the development site. Nest-boxes are to be erected before removal of hollow bearing trees. Prior to vegetation clearing, a nest-box plan should be prepared, which should sit as a sub-plan within the FFMP. The nest-box plan should provide the following details: ▪ the number and size of the hollow bearing trees to be removed as part of the clearing works ▪ the number and types (target species) of boxes required to compensate for the loss of both threatened and protected fauna habitat ▪ specifications of nest box size and material ▪ details for nest box monitoring, maintenance, and replacement. This is particularly important as the life of nest boxes is well below that of the time taken to produce new hollow and a schedule of replacement is required to ensure that the number of hollows available is monitored and maintained. Where feasible replacement habitat should be consistent with existing plans and programs run by WNSW with National Parks and Wildlife Service.
8.4.2.4f	*Impacts during the operational phase – measures to avoid or minimise the indirect impacts on threatened species and threatened species habitat on land adjoining the Project area, migratory species or flight pathways as a result of the operation of the development. Such measures may include those adopted to avoid and minimise:* *(i) trampling of threatened flora species* *(ii) rubbish dumping* *(iii) noise* *(iv) light spill* *(v) weed encroachment* *(vi) nutrient runoff* *(vii) increased risk of fire, and* *(viii) Pest animals.*	▪ Signs warning workers of the presence of threatened species and their habitat will be placed in relevant areas of the development site. ▪ The proposed development will also have suitable security measures in place to prevent illegal dumping. ▪ Noise will be managed onsite in line with the CEMP. ▪ No long-term increased light spill is anticipated to result from this Project. ▪ There will not be an increased long-term risk of fire because of the development. The dam wall will only be raised and therefore represents a similar level of impact as is currently in place. ▪ Weed encroachment and nutrient runoff are to be managed through the provisions in the CEMP. The occurrence of feral cats and foxes might increase and a feral animal management plan will be incorporated into the FFMP, which will include fencing, baiting or trapping options for the control of feral animals.

10.6 Construction impacts

10.6.1 Introduction

Project construction activities can cause both direct and indirect impacts, as summarised below:

Direct impacts: The FBA defines direct impacts as

> *impacts on biodiversity values that are a direct result of vegetation clearance from a development. It is predictable, usually occurs at or near to the Project area and can be readily identified during the planning, design, construction, and operational phases of a development*.

Biodiversity values include the composition, structure and function of ecosystems, and includes (but is not limited to) threatened species, populations and ecological communities, and their habitats. Direct impacts relating to the construction phase of the development site include:

- loss and fragmentation of native vegetation
- loss of threatened ecological communities
- loss of threatened flora species and their habitat
- loss of threatened fauna species and their habitat
- fauna mortality
- degradation of riparian and aquatic habitats
- changes to natural fire regimes
- cumulative impacts.

Indirect impacts: The FBA defines indirect impacts as

> *an impact on biodiversity values that occurs when development related activities affect threatened species, threatened species habitat, populations or ecological communities in a manner other than direct impact*.

Indirect impacts relating to the development site include:

- loss and fragmentation of native vegetation
- loss of threatened ecological communities
- loss of threatened flora species and their habitat
- loss of threatened fauna species and their habitat
- fauna mortality
- degradation and changes to hydrology including surface water, groundwater, riparian and aquatic habitats
- edge effects
- weed invasion and encroachment
- creating habitat conducive to invasive animals
- introduction or spread of diseases and pathogens
- alteration of noise environment
- alteration of light environment
- dust impacts
- effects of blasting and vibration
- erosion and sedimentation
- changes to natural fire regimes
- cumulative impacts.

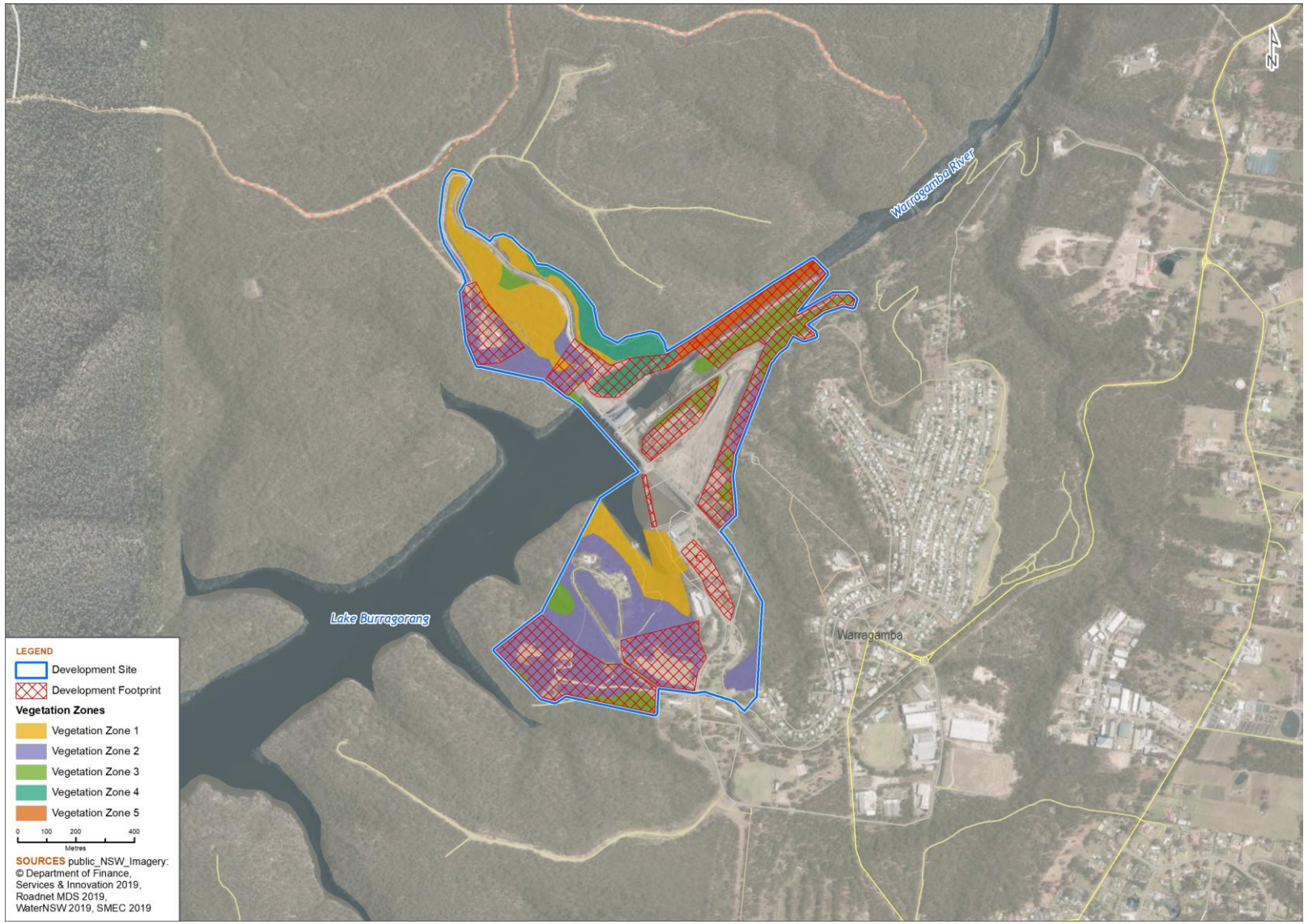
Potential direct and indirect construction impacts are summarised in Table 10-19 and shown on Figure 10-14.

Table 10-19. Construction site impacts

Potential impacts	Direct	Indirect	Details	Extent/scale
Loss and fragmentation of native vegetation	Y	Y	Clearing of wet and dry sclerophyll forest communities.	A total of 22.42 ha of native vegetation will be cleared.
Loss of threatened ecological communities	Y	Y	Clearing of HN604, which is equivalent to Shale Sandstone Transition Forest in the Sydney Basin Bioregion, listed as a CEEC under the BC Act and EPBC Act.	A total of 1.64 ha of Shale Sandstone Transition Forest in the Sydney Basin Bioregion CEEC will be cleared.
Loss of threatened flora species and their habitat	Y	Y	*Grevillea parviflora* subsp. *parviflora*, listed as Vulnerable under both the BC Act and EPBC Act were recorded within the development site and may be affected by clearing. This species is known to reproduce by suckering, making an assessment of numbers difficult without genetic testing. Potentially suitable habitat for 41 threatened flora species (as defined as having a moderate or higher likelihood of occurrence) has also been identified within the development site and so may be affected by clearing.	A total of 14.19 ha of suitable habitat for *Grevillea parviflora* subsp. *parviflora* will be cleared. A total of 22.42 ha of suitable habitat (inclusive of the 20.06 ha) for other threatened flora species will be cleared.
Loss of threatened fauna species and their habitat	Y	Y	At least two individual Red-crowned Toadlets (*Pseudophryne australis*), listed as Vulnerable under the BC Act, were recorded within the development site. Suitable habitat is widespread and may be impacted by the development. Suitable habitat (by PCT) for 49 threatened fauna species has also been identified within the development site and may be impacted by the development.	About 8.25 ha of habitat suitable for Red-crowned Toadlet (*Pseudophryne australis*) will be cleared. A total of 22.42 ha of habitat suitable for other threatened fauna species will be cleared.
Fauna mortality	Y	Y	Clearance works, earthworks or collisions with machinery could cause fauna mortality.	Fauna mortality is most likely to occur during vegetation clearance activities.
Degradation and changes to hydrology including surface water, groundwater, riparian and aquatic habitats	Y	Y	Caused by changes in runoff, infiltration, pollution and erosion.	7.01 hectares of riparian vegetation (as the riparian buffer) will be cleared. Impacts to aquatic habitat are described in detail in the aquatic ecology assessment. There will be both direct and indirect impacts to GDEs due to the Project.
Edge effects	N	Y	The completed section of raised dam wall will not increase any edge effects over what is currently present. The impact of the construction works will cause at least temporary changes to edge areas.	May occur during clearance activities.
Weed invasion and encroachment	N	Y	Vehicles and plant may transport weed propagules into the development site.	May occur during construction and post-construction phases.

Potential impacts	Direct	Indirect	Details	Extent/scale
Creating habitat conducive to invasive and overabundant fauna	N	Y	Clearing of native vegetation and increased human activity increase the risk of pest animal species increasing.	May occur during construction and operational phases.
Introduction or spread of diseases and pathogens	N	Y	Vehicles and plant may transport pathogens into the development site.	May occur during construction and post-construction phases.
Alteration of noise environment	N	Y	May impact upon the roosting, breeding and foraging activities of locally occurring fauna.	Temporary and localised scale of impacts during construction.
Alteration of light environment	N	Y	May impact upon the roosting, breeding and foraging activities of locally occurring fauna.	Temporary and localised scale of impacts during construction.
Dust impacts	N	Y	May impact upon plant functionality	Temporary and localised scale of impacts during construction.
Effects of blasting and vibration	N	Y	May impact upon the roosting, breeding and foraging activities of locally occurring fauna.	Temporary and localised impact during construction of the raised dam wall and spillway.
Erosion and sedimentation	N	Y	Disturbance of native vegetation and ground increases risk of erosion and sedimentation.	May occur during construction phases.
Changes to natural fire regimes	N	N	No changes are proposed the management of bushfires at the Dam.	It is not anticipated that the construction of the Project will result in any change to the management of bushfires or natural fire regimes.
Cumulative impacts	Y	Y	Cumulative impacts on biodiversity values from the Project include the construction area, upstream area, and downstream area, as well as projects and proposals within the same IBRA subregions as the Project have been considered. Table 7 3 provides a summary of these projects and their determined/proposed impact,	Clearing for the construction of the Project totals approximately 22 ha. This compares to clearing for Western Sydney Airport of 318 ha about 8 km east of the construction site. Revegetation works post construction will assist in reducing the cumulative impact of the dam construction.

Figure 10-14. Extent of development and native vegetation clearing



10.6.2 Assessment of direct impacts

10.6.2.1 Loss and fragmentation of native vegetation

Construction works would result in clearing 22.42 hectares of native vegetation. This direct clearing includes four different vegetation communities, one of which is listed under both the BC and EPBC Acts. The clearing of native vegetation within the development site would fragment both native vegetation generally, and discrete plant community types, through the creation of discontinuities of vegetation extent.

Clearing and retaining of vegetation communities within the development site and broader study area are summarised in Table 10-20.

Table 10-20. PCTs within study area directly cleared by the proposed works

Vegetation	TSC Act status	EPBC Act status	Cleared in development footprint (ha)	Retained in development site (ha)	Total area of PCT in study area (ha)
HN564: Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion.	-	-	2.76	14.20	21.64
HN566: Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion.	-	-	12.25	12.53	38.40
HN568: Red Bloodwood – Sydney Peppermint – Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion.	-	-	5.77	2.84	17.03
HN604: Turpentine – Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion.	Shale Sandstone Transition Forest in the Sydney Basin Bioregion (CE)	Shale Sandstone Transition Forest of the Sydney Basin Bioregion (CE)	1.64	3.24	8.12
Total area of all PCTs (ha)			**22.42**	**32.81**	**85.19**

10.6.2.2 Loss of threatened ecological communities

Construction would cause the loss of 1.64 hectares of HN604 immediately downstream of the existing dam wall. This PCT is considered a component of Shale Sandstone Transition Forest (SSTF) in the Sydney Basin Bioregion, listed as Critically Endangered under both the BC Act and EPBC Act.

10.6.2.3 Direct loss of threatened flora species and their habitat

Observations of *Grevillea parviflora* subsp. *parviflora*, listed as Vulnerable under both the BC Act and EPBC Act, was recorded within the development site and may be affected by clearing. This species can reproduce by suckering and may persist in disturbed areas. BioNet lists this species as being associated with the PCTs HN564, HN566 and HN604. The combined clearing of these areas within the development site is 16.65 hectares (see Table 10-20).

Potentially suitable habitat for 41 threatened flora species (as defined as having a moderate or higher likelihood of occurrence) has also been identified within the development site and may be affected by clearing.

As noted in Section 10.2.4.1 targeted threatened flora surveys were not completed within the development site due to prescribed burns that had been carried out within the development site in 2018 and to drought conditions. It is recommended that targeted surveys be carried out in line with relevant guidelines for threatened flora species currently assumed as present within the development site. Targeted surveys should focus on areas that have been subject to recent prescribed burning within the development footprint. These surveys would likely refine the quantification of impacts and associated credit liability generated by the Project.

In accordance with the FBA (Section 6.5.1.14), threatened species polygons were derived for each of the threatened flora candidate species using the following filters:

- associated PCTs in BioNet Vegetation Classification System and Threatened Biodiversity Data Collection
- associated PCTs based on field observations
- distribution patterns from field observations
- distributions patterns further refined by geographical/abiotic features/barriers
  - known and/or predicted IBRA subregions
  - species-specific habitat features or components listed within the Threatened Species Profile Database
  - catchments
  - landforms
  - soils
  - aspect
  - known microhabitats where known (that is, riparian areas, cliffs, etc).

Threatened species habitat polygons for flora candidate species are given in Appendix F3 (Biodiversity assessment report – construction area, Appendix B).

10.6.2.4 Loss of threatened fauna species and their habitat

Fauna habitat features that would be removed include:

- *Understorey vegetation*: This includes the clearing of grasses, sedges, forbs, herbs, and small shrubs. Understory vegetation could be used as foraging habitat, breeding habitat and shelter for invertebrates, amphibians, reptiles, small birds, and terrestrial mammals.
- *Fallen logs, woody debris, and leaf litter*: Intact vegetation within the development footprint has produced large amounts of fallen logs, woody debris, and leaf litter. These habitat features may be used as foraging habitat, breeding habitat and shelter for invertebrates, amphibians, reptiles, small birds, and terrestrial mammals.
- *Hollow-bearing living trees and stags*: Used as habitat by a range of fauna species for shelter, breeding and roosting. Loss of mature hollow-bearing trees has the potential to impact on breeding and shelter habitat for threatened species of birds, arboreal mammals, frogs, reptiles, and microbats.
- *Nectar-producing trees and shrubs*: These are a food resources for blossom-dependant birds, arboreal mammals, and mega chiropteran bats.
- *Ephemeral drainage lines*: Used for shelter and breeding habitat for threatened amphibians.

During surveys, at least two individual Red-crowned Toadlets (*Pseudophryne australis*), listed as Vulnerable under the BC Act, were recorded within the development site. Suitable habitat is widespread and may be impacted by the development. The PCTs HN564, HN566 and HN568 are listed by BioNet as associated with this species. Approximately 8.25 hectares of suitable habitat for the Red-crowned Toadlet (*Pseudophryne australis*) would be cleared.

Suitable habitat (by PCT) for 49 threatened fauna species (See Section 10.3.12.2) has also been identified within the development site and may be impacted by the development. A total of 22.42 hectares of suitable habitat would be cleared.

As noted above (Section 10.6.2.3) additional survey is recommended to refine the quantification of impacts and associated credit liability generated by the Project.

10.6.2.5 Fauna mortality

Vegetation clearance and vehicle access to the site may result in fauna mortality during construction. Examples could include injury to roosting animals during tree removal or vehicular strike.

10.6.3 Assessment of indirect impacts

10.6.3.1 Loss and fragmentation of native vegetation

As well as direct clearing impacts on native vegetation, indirect impacts may include edge effects, changes to hydrology, weed invasion and encroachment, introduction or spread of diseases and pathogens, and erosion and sedimentation.

10.6.3.2 Loss of threatened ecological communities

Indirect impacts to Shale Sandstone Transition Forest would be limited to edge effects where adjoining vegetation may be directly cleared. These include weed invasion and encroachment, introduction or spread of diseases and pathogens, erosion and sedimentation, and changes to natural fire regimes.

10.6.3.3 Loss of threatened flora species and their habitat

Grevillea parviflora subsp. *parviflora*, listed as vulnerable under both the BC Act and EPBC Act, was incidentally identified in the development site. Forty (40) other threatened flora species have been identified as having a medium or high likelihood of occurring in the development site. These species may be indirectly impacted through degradation and changes to hydrology, edge effects, weed invasion and encroachment, creating habitat conducive to invasive fauna, introduction or spread of diseases and pathogens, and dust impacts.

10.6.3.4 Loss of threatened fauna species and their habitat

Project construction may indirectly impact fauna and their habitats. Fauna habitat features that may be indirectly impacted include:

- *Sandstone caves, cliffs and overhangs*: Construction blasting may cause vibrations and potential to damage sandstone caves, crevices, cliffs and overhangs that could be used as habitat for threatened microchiropteran bats, reptiles and mammals such as the Brush-tailed Rock-wallaby. Vibrations may disturb roosting bats regardless of any damage that may occur to their habitat.
- *Sandstone drainage lines*: Construction blasting may cause vibrations that have potential to damage ephemeral drainage lines occurring on sandstone. Vibrations have potential to break off or dislodge sandstone and disturbing the fauna habitat within these drainage lines. The Red-crowned Toadlet is an example that could be affected by the disturbance of sandstone drainage lines.

10.6.3.5 Fauna mortality

Fauna mortality in habitat adjacent to the construction footprint may continue in the short term after vegetation clearance due to stress and competition leading to illness, injury and disease. The presence of large areas of habitat adjacent to the site should reduce the potential for this to occur. There may be an increase in roadkill due to increase traffic outside of the construction site.

10.6.3.6 Degradation and changes to hydrology including surface water, groundwater, riparian and aquatic habitats

Proposed construction activities have potential to alter the overland and subterranean water flows through the development site and study area. Potential impacts to water quality could occur from erosion and sedimentation, accidental spillage of chemicals, fuels, lubricating and hydraulic oils from mobile construction equipment, and runoff from equipment and vehicle wash-down. Introduction of pollutants into surrounding waterways may cause:

- changes to pH, electrical conductivity, dissolved oxygen and temperature
- reduction of light penetration due to increased sediments
- increased sediment load, organic matter and turbidity
- introduction of pollutants such as construction fuels, oil, grease and chemicals.

There is potential for indirect impacts on areas of GDEs adjacent to the construction area due to potential Project impacts on groundwater levels. However, any changes to groundwater levels are expected to be temporary and minor, and minimal risk or impacts are expected on GDEs.

10.6.3.7 Edge effects

Edge effects are identifiable changes in soil moisture, light intensity and microclimate within areas of vegetation that may to lead to secondary changes in plant and animal densities (Murcia 1995). Edge effects may be created due to

vegetation clearance. However, the extent of the effect is difficult to predict as this is often highly variable and dependent on many factors such as vulnerability of edge ecosystem, degree of change in land use, intensity of this use and chance events (Murcia 1995). Clearing for construction would create new edges noting that the existing dam and operational facilities have created existing edges between operational land and native vegetation.

10.6.3.8 Weed invasion and encroachment

Machinery and vehicles may introduce and disperse weed species (Khan *et al*. 2017). Vehicles, plant and equipment may transport weed propagules into the development site or spread existing weed propagules that may impact on adjacent vegetation.

10.6.3.9 Creating and driving habitat change conducive to invasive and overabundant fauna

Clearing may offer increased opportunity for invasive species to move into the development site and subsequently adjacent vegetation.

10.6.3.10 Introduction or spread of diseases and pathogens

Vehicles and plant may transport pests and pathogens such as Amphibian Chytrid Fungus, *Phytophthora cinnamomi* and myrtle rust into the development site.

- *Phytophthora cinnamomic*: Vegetation in the development site or study area did not appear to be affected by dieback and hence may potentially become susceptible to infection with *Phytophthora cinnamomi* should appropriate hygiene measures not be adopted where construction vehicles move from infected to non-infected areas.
- Myrtle rust: Vegetation within the development site and study area did not appear to be affected by myrtle rust. Myrtle rust is a serious pathogen that affects plants belonging to the family Myrtaceae including Australian natives like bottle brush (*Callistemon* spp.), tea tree (*Melaleuca* spp.) and eucalypts (*Eucalyptus* spp.). These plants occur throughout both the development site and study area and appropriate mitigation measures should be taken to minimise the risk of myrtle rust spreading into these areas.
- Chytrid Fungus: Red-crowned Toadlets were recorded within the development site. Amphibians are susceptible to the amphibian chytrid fungus. Activities associated with this Project have the potential risk of introducing or spreading chytrid to the study sites so appropriate mitigation measures to manage the possibility of introduction of this disease should be taken.

10.6.3.11 Alteration of noise environment

The operation of vehicles, plant and equipment may create additional noise near the development site, while blasting may impact on the roosting, breeding and foraging activities of locally occurring fauna outside of the construction site. This impact would occur during the construction of the raised dam wall and spillway and during operation of ancillary equipment such as the batch plants. Noise sources related to construction would cease following construction, and therefore impacts from construction related noise would be a short-term impact.

10.6.3.12 Alteration of light environment

Operation of vehicles, plant and equipment may create additional light and there may be extended periods of night works in summer months. This may impact upon the roosting, breeding and foraging activities of locally occurring fauna. This impact would occur during the construction of the raised dam wall and spillway and during operation of ancillary equipment such as the batch plants. Light sources related to construction would cease following construction, and therefore impacts from alterations to the light environment would be a short-term impact.

10.6.3.13 Dust impacts

Dust resulting from batch plant operation, materials movement and storage, vegetation clearance, road use and exposed soil, may settle on vegetation and habitats, which may impact plants through soil and foliar deposition pathways. Responses to exposure would vary between different plant species, soil buffering capacities, drainage, slope and cumulative impacts of ongoing exposure regimes. The impacts would principally be in or near the development footprint. Dust related impacts would cease following construction, and therefore would be a short-term impact.

10.6.3.14 Effects of blasting and vibration

Blasting may disturb cave-roosting microchiropteran bats. Excessive vibrations may damage sandstone habitat for threatened fauna such as the Large-eared Pied-bat, Red-crowned Toadlet and Brush-tailed Rock-wallaby. Blasting would occur at certain times during construction, and therefore would be a short-term impact.

10.6.3.15 Erosion and sedimentation

Disturbance to vegetation and soil, movement and storage of materials, and changes to hydrological flow could increase risks of erosion and/or sedimentation within habitats. Erosion and sediment control planning will reduce this risk but stochastic events would retain some risk. During construction, risks would be temporary and related primarily to movement and storage of materials, vegetation clearance and earthworks. Risks associated with operation would be limited to failed mitigation measures or other stochastic impacts such as adverse weather.

10.6.3.16 Changes to natural fire regimes

It is not anticipated that the construction of the Project would result in any material change to the management of bushfires or natural fire regimes.

10.6.4 Cumulative impacts

Cumulative impacts on biodiversity values from the Project across the construction area, upstream operational area, and downstream area, as well as projects within the same IBRA subregions have been considered. These are discussed in Appendix F1 (Biodiversity assessment report – upstream), Appendix F2 (Downstream ecological assessment) and Chapter 28 (Cumulative impact assessment), and summarised in Table 10-21. The impacted areas encompass all types of impacts, including the impacts associated with temporary inundation and alterations to hydrological flows.

It should be noted that only key infrastructure projects have been included within the assessment. Therefore, this assessment is not a comprehensive assessment of all other proposed or determined projects within the IBRA subregions associated with the Project. Furthermore, for some projects, there is no publicly available information about the extent of the construction and operational impacts of the Project, or they are yet to be determined. Lastly, only impacts to threatened biota across multiple projects, or areas of the Project are included within the cumulative impact assessment.

Table 10-21. Past, present, and future projects

Project	Construction impact	Operational Impact
Warragamba Dam Raising – Upstream ▪ upstream operational impacts associated within the Project.	▪ Appendix F1(Upstream BAR)	▪ Appendix F1 (Upstream BAR)
Warragamba Dam Raising – Construction ▪ construction impacts associated within the Project.	▪ Appendix F3 (Biodiversity assessment report – construction area – this report)	▪ N/A
Warragamba Dam Raising – Downstream ▪ downstream operational impacts associated within the Project.	▪ Appendix F2 (Downstream ecological assessment)	▪ Appendix F2
Western Sydney Airport ▪ located approximately 8.5 km east of Warragamba Dam ▪ construction commenced.	▪ removal of 318.5 ha of native vegetation ▪ removal of 141.8 ha of fauna habitat ▪ direct and indirect impacts to threatened biota.	▪ bird and bat strike ▪ terrestrial fauna strike ▪ noise and vibration ▪ light ▪ alterations to hydrology and GDEs.
M12 Motorway ▪ 16 km motorway between M7 at Cecil Hills and Northern Road, Luddenham	▪ removal of 118.0 ha of native vegetation ▪ removal of 334 threatened plants ▪ removal of 1.6 ha of threatened fauna habitat.	▪ changes to hydrology ▪ habitat fragmentation ▪ edge effects ▪ fauna mortality

Project	Construction impact	Operational Impact
▪ located approximately 10 km east of Warragamba Dam ▪ proposal under assessment.		▪ risk of establishment of weeds and pathogens.
Northern Road Upgrade ▪ upgrade of Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park ▪ located approximately 10 km east of Warragamba Dam ▪ construction commenced.	▪ removal of 39.6 ha of native vegetation ▪ removal of threatened flora and fauna habitat ▪ removal of 39 threatened plants.	▪ changes to hydrology ▪ habitat fragmentation ▪ edge effects ▪ fauna mortality ▪ establishment of weeds and pathogens.
Hume Coal Project ▪ development of an underground mine to extract metallurgical and industrial coal ▪ located approximately 70 km south-west of Warragamba Dam ▪ proposal under assessment.	▪ removal of 64 paddock trees ▪ removal of 8.3 ha of threatened fauna habitat.	▪ potential changes to surface and subterranean hydrology ▪ habitat fragmentation ▪ edge effects ▪ fauna mortality ▪ establishment of weeds and pathogens.
Gunlake Quarry Extension ▪ extension of operations at Gunlake Quarry ▪ located approximately 170 km south-west of Warragamba Dam. ▪ proposal determined.	▪ removal of 54.1 ha of native vegetation ▪ removal of threatened flora and fauna habitat.	▪ erosion and sedimentation ▪ habitat fragmentation ▪ edge effects ▪ fauna mortality ▪ establishment of weeds and pathogens.

10.6.5 Key threatening processes

In accordance with Section 6.4 of the SEARs, the assessment must identify whether the Project as a whole, or any component of the Project, would be classified as a key threatening process (KTP) in accordance with the listings in the TSC Act, FM Act or EPBC Act.

Under Part 2 of the TSC Act, KTPs are described as those threatening processes that are most likely to jeopardise the survival of those species, populations and ecological communities listed under that Act. Under section 4.32 of the BC Act, a threatening process is eligible to be listed as a KTP if, in the opinion of the Scientific Committee:

- it adversely affects threatened species or ecological communities, or
- it could cause species or ecological communities that are not threatened to become threatened.

DECC (2007c, p. 11) requires consideration as to *'whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process'*. Schedule 3 of the TSC Act provides a list of KTPs, with Schedule 4 of the BC Act listing KTPs under that Act. There is one additional KTP listed under the BC Act compared to the TSC Act, namely Habitat degradation and loss by Feral Horses (brumbies, wild horses), *Equus caballus* Linnaeus 1758, which has also been considered in the current report.

Impacts to KTPs associated with the FM Act are provided in Chapter 9 of the EIS.

Under the EPBC Act a threatening process is defined as a KTP if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. A process can be listed as a key threatening process if it could:

- cause a native species or ecological community to become eligible for inclusion in a threatened list (other than the conservation dependent category); or
- cause an already listed threatened species or threatened ecological community to become more endangered; or
- adversely affect two or more listed threatened species or threatened ecological communities.

All KTPs listed under the EPBC Act that are associated with the Project have equivalent KTPs listed under the BC Act, however not all KTPs listed under the BC Act have equivalent KTPs listed on the EPBC Act.

The Project would result in actions that constitute, or are part of, may result in the operation of or increase the impact of one KTP as noted in Table 10-22

Table 10-22. Key threatening processes associated with the Project

Key threatening process	TSC Act	BC Act	EPBC Act equivalent	Details
Clearing of native vegetation	Yes	Yes	Land clearance	The construction of the Project will result in the removal of 22.42 ha of native vegetation.

Changes to vegetation community and structure that may result from temporary inundation may create conditions more conducive to the operation of a range of additional KTPs (refer Table 10-23). The operation of these KTPs would depend on a range of factors including presence of catchment sources for weeds, pests and diseases and the extent to which the inundation makes the vegetation communities or species more susceptible to the threatening process.

Table 10-23. Other key threatening processes

Key threatening process	TSC Act	BC Act	EPBC Act equivalent
Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miners (*Manorina melanocephala*).	Yes	Yes	Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala)*
Anthropogenic climate change	Yes	Yes	Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
Competition and grazing by the feral European Rabbit, *Oryctolagus cuniculus* (L.)	Yes	Yes	Competition and land degradation by rabbits
Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758	Yes	Yes	Competition and land degradation by unmanaged goats
Competition from feral honey bees, *Apis mellifera* L.	Yes	Yes	-
Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments	Yes	Yes	Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris
Habitat degradation and loss by Feral Horses (brumbies, wild horses), *Equus caballus* Linnaeus 1758	No	Yes	-
Herbivory and environmental degradation caused by feral deer	Yes	Yes	-
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	Yes	Yes	Not listed (Fire regimes that cause biodiversity decline currently on the finalised priority assessment list)
Infection by Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species and populations	Yes	Yes	Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	Yes	Yes	Infection of amphibians with chytrid fungus resulting in chytridiomycosis
Infection of native plants by *Phytophthora cinnamomi*	Yes	Yes	Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	Yes	Yes	-
Invasion and establishment of exotic vines and scramblers	Yes	Yes	-

Key threatening process	TSC Act	BC Act	EPBC Act equivalent
Invasion and establishment of Scotch Broom (*Cytisus scoparius*)	Yes	Yes	-
Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (Wall. ex G. Don) Cif.	Yes	Yes	-
Invasion of native plant communities by *Chrysanthemoides monilifera*	Yes	Yes	-
Invasion of native plant communities by exotic perennial grasses	Yes	Yes	-
Invasion, establishment and spread of Lantana (*Lantana camara* L. *sens*. Lat)	Yes	Yes	-
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Yes	Yes	Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Loss of hollow-bearing trees	Yes	Yes	-
Predation by *Gambusia holbrooki* Girard, 1859 (Plague Minnow or Mosquito Fish)	Yes	Yes	-
Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)	Yes	Yes	-
Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)	Yes	Yes	-
Predation, habitat degradation, competition and disease transmission by Feral Pigs, *Sus scrofa* Linnaeus 1758	Yes	Yes	Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs
Removal of dead wood and dead trees	Yes	Yes	-

10.6.6 Thresholds for assessing unavoidable impacts

Unavoidable construction impacts have been considered and a determination made of the assessment and offsetting requirements of predicted impacts. FBA requirements include assessment of:

(i) impacts that require further consideration by the consent authority

(ii) impacts for which the assessor is required to determine an offset

(iii) impacts for which the assessor is not required to determine an offset

(iv) impacts that do not require further assessment.

A discussion of each of these components is provided in Table 10-24 and their locations shown on Figure 10-14. The Biodiversity Credit Report generated by the Project is provided in Appendix F3 (Biodiversity assessment report – construction area, Appendix A).

Table 10-24. Summary of areas directly impacted by the proposed works

Threshold	Biodiversity value	Criterion	Applicable to the project
(i) Impacts that require further consideration by the consent authority	Landscape Features	Impacts that would substantially reduce the width of vegetation in the riparian buffer zone bordering rivers and streams, 4th order or greater.	Yes – The Project would impact and remove vegetation within the riparian buffer zone of a 9th order stream.
		Impacts in state biodiversity links.	No.
		Impacts on important wetlands and their buffers.	No.
		Impacts in the buffer zone along estuaries.	No.
	Native Vegetation	Any impact on a CEEC (unless specifically excluded in the SEARs) because it is likely to: ▪ cause the extinction of the CEEC from the IBRA subregion, or ▪ significantly reduce the viability of the CEEC.	Yes – The Project would impact upon HN604 which is a component PCT of SSTF CEEC nominated within the SEARs. The occurrence of SSTF is considered an important area of the CEEC being on the edge of the community's range. As such, the Project has the potential to significantly reduce the viability of the CEEC in the IBRA subregion.
		Any impact on an EEC nominated in the SEARs because it is likely to: ▪ cause the extinction of the EEC from the IBRA subregion, or ▪ significantly reduce the viability of the EEC.	No.
	Species and Populations	Impacts on areas of land that the Minister for Environment has declared as critical habitat in accordance with section 46 of the TSC Act and which is listed on the Register of Critical Habitat in NSW.	No.
		Any impact on a critically endangered species (unless specifically excluded in the SEARs).	No.
		Any impact on a threatened species or population nominated in the SEARs because it is likely to: ▪ cause the extinction of a species or population from an IBRA subregion, or ▪ significantly reduce the viability of a species or population.	No.
		Any impact on a threatened species or population that has not previously been recorded in the IBRA subregion according to records in the NSW Wildlife Atlas.	No.

Threshold	Biodiversity value	Criterion	Applicable to the project
(ii) Impacts for which the assessor is required to determine an offset	Landscape Features	Not applicable to the FBA.	N/A.
	Native Vegetation	Impacts on CEECs that are specifically excluded from requiring further consideration in the SEARs.	No. The SSTF CEEC occurring within the Wollemi IBRA subregion is not excluded from further consideration in the SEARs.
		Impacts on PCTs that are EECs not specifically nominated as requiring further consideration in the SEARs.	No.
		Impacts on PCTs associated with threatened species habitat and which have a site value score ≥17.	Yes. All PCTs have a site value score of ≥17 and are associated with threatened species habitat.
	Species and populations	Impacts on a critically endangered species that is specifically excluded from requiring further consideration in the SEARs.	No.
		Impacts on threatened species, populations and threatened species habitat not specifically nominated as requiring further consideration in the SEARs.	Yes. The Project would impact upon threatened species and their habitat not specifically nominated requiring further consideration in the SEARs.
		Impacts on threatened species habitat associated with a PCT and which has a site value score of ≥17.	Yes. All PCTs have a site value score of ≥17 and are associated with threatened species habitat.
(iii) Impacts for which the assessor is not required to determine an offset	Landscape Features	Not applicable to the FBA.	N/A.
	Native Vegetation	Impacts on PCTs that: ▪ have a site value score <17, or ▪ are not identified as CEECs/EECs.	No – all PCTs have a site value score >17.
		Impacts on PCTs that are not associated with threatened species habitat and are not identified as CEECs/EECs.	No – All PCTs within the development site are associated with threatened species habitat.
	Species and Populations	Impacts on non-threatened species and populations that do not form part of a CEEC or EEC.	Yes – The Project would impact upon non-threatened species within the three non-threatened PCTs.
		Impacts on threatened species habitat associated with a PCT within a vegetation zone with a site value score of <17.	No – All PCTs have a site value score >17.
(iv) Impacts that do not require further assessment by the assessor	Landscape Features	Areas of land without native vegetation, unless the area of land requires assessment under the SEARs issued for the major project.	No areas of cleared land have been specifically outlined within the SEARs are requiring assessment.
	Native Vegetation	Areas of land without native vegetation, unless the area of land requires assessment under the SEARs issued for the Major Project.	No areas of cleared land have been specifically outlined within the SEARs are requiring assessment.
	Species and populations	Not applicable since all areas of land must be assessed for threatened species, even if they do not contain native vegetation.	N/A.

10.6.7 Impacts that require further consideration

10.6.7.1 Landscape features

This includes impacts reducing the width of riparian buffer of important rivers, streams and estuaries. This consideration applies to impacts of development on areas within native vegetation within:

a) 20 metres either side of 4th or 5th order stream
b) 50 metres either side of a 6th order stream or higher
c) 50 metres around an estuarine area.

The Project would impact upon native vegetation within 50 metres of the riparian buffer of a 9th order stream (the Warragamba River). As such, the matters outlined in the FBA (Section 9.2.3.3) are considered in Table 10-25.

10.6.7.2 Native vegetation

Impacts on native vegetation that require further consideration include impacts on:

a) any CEEC, unless the CEEC is specifically excluded by the SEARs
b) an EEC specifically nominated in the SEARs as an EEC that is likely to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted on by the development.

The Project would directly impact upon HN604: Turpentine – Grey Ironbark Open Forest on shale in the lower Blue Mountains, Sydney Basin Bioregion, equivalent to Shale Sandstone Transition Forest in the Sydney Basin Bioregion, listed as an EEC under the BC Act and as a CEEC under the EPBC Act. As such, the matters outlined in the FBA (Section 9.2.4.2) are considered in Table 10-26.

Table 10-25. Further consideration of impacts to riparian buffers

FBA section	Criterion	Consideration
9.2.3.3 (a)	*The name and stream order of the riparian buffer being impacted.*	The Warragamba River is an 9th order stream at the extent at which the impact will occur.
9.2.3.3 (b)	*The total area of the riparian buffer that is impacted by the Major Project, the extent to which the width of the link will be reduced and over what length, and size of the gaps being created or expanded.*	The Project will remove 7.01 ha of the riparian buffer.
9.2.3.3 (c)	*The PCT and condition of the vegetation in the riparian buffer being impacted.*	The Project will remove a total of 7.01 ha of vegetation from within the riparian buffer. Specifically, this includes the removal of: ▪ 0.66 ha of HN604: Turpentine - Grey Ironbark Open Forest on shale in the lower Blue Mountains, Sydney Basin Bioregion (moderate to good condition) ▪ 3.11 ha of HN568: Red Bloodwood - Sydney Peppermint - Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion (moderate to good condition) ▪ 3.06 ha of HN564: Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion (low condition) ▪ 0.18 ha of HN566: Red Bloodwood - Scribbly Gum Heathy woodland on sandstone plateaux of the Sydney Basin Bioregion (moderate to good condition).
9.2.3.3 (d)	*Any direct impacts on wetlands or watercourses downstream of the development site.*	A comprehensive soil and water management plan would be prepared which would include the following considerations to minimise downstream water quality impacts: ▪ erosion and sedimentation control measures for cleared areas around the dam ▪ water management systems for the concrete batch plant sites and other auxiliary construction features ▪ coffers dams and water management systems for the concrete works on the dam wall ▪ construction flood management plan.

FBA section	Criterion	Consideration
9.2.3.3 (e)	*Mitigation measures proposed to minimise the impact on the biodiversity values of the riparian or downstream area.*	Mitigation measures proposed to minimise the impact on the biodiversity values of the riparian area are discussed in section 10.7. Mitigation measures proposed to minimise the impact on the biodiversity values of the downstream area are discussed in Appendix F2 (Downstream ecological assessment).

Table 10-26. Further consideration of impacts to Shale Sandstone Transition Forest CEEC

Criterion (FBA Section 9.2.4.2)	Consideration
(a) the area and condition of Shale Sandstone Transition Forest CEEC to be impacted directly and indirectly by the proposed development	The Project will directly impact (via removal) 1.64 ha of moderate to good condition Shale Sandstone Transition Forest CEEC. A further 8.12 ha of moderate to good condition HN604 occurring within the study area may be indirectly impacted by the Project due to edge effects and weed invasion. It should be noted that there is the potential for impacts to the CEEC to be minimised during detailed design phase of the Project.
(b) the extent and overall condition of Shale Sandstone Transition Forest CEEC within an area of 1000 ha and then 10,000 ha surrounding the proposed development footprint.	The GIS layer 'Map of Critically Endangered Ecological Communities NSW Version 5' (OEH 2018b) was used to calculate the area of Shale Sandstone Transition Forest CEEC within 1,000 ha and 10,000 ha of the development footprint. According to this mapping there is approximately: ▪ 0 ha of the CEEC within a buffer of 1,000 ha of the development footprint ▪ 509.91 ha of the CEEC within a buffer of 10,000 ha of the development footprint. It should be noted that the Shale Sandstone Transition Forest CEEC within the study area was not mapped by the OEH GIS layer. As such, it is possible that additional extents of the CEEC occur within the buffered 1,000 ha and 10,000 ha areas. However, according to the Approved Conservation Advice, the total area of occupancy for this CEEC is less than 1000 ha (DECCW 2010a) (DoE 2014). The GIS layer 'Map of Critically Endangered Ecological Communities NSW Version 5' does not provide information on the 'vegetation condition' for each mapped occurrence of the CEEC. However, according to the Approved Conservation Advice, Shale Sandstone Transition CEEC '*has been identified as one of the most fragmented communities in the Sydney region, with substantial exposure of edges to cleared or degraded land*' (NSW Scientific Committee 2014). A desktop analysis of the mapped occurrences of the CEEC within the 1,000 ha and 10,000 ha buffered areas identified many patches occurring as linear fragments along roads or fragmented patches occurring adjacent urban development or cleared land. Most of these mapped occurrences occur on private landholdings in Silverdale and Wallacia, to the east of the development site. The condition of these patches is likely to be of lower quality than the mapped occurrence within the development site due to such pressures as edge effects, weed invasion, rubbish dumping or disturbance regimes (i.e. mowing or grazing). Some of these mapped occurrences appear to be on land where the tree canopy cover is sparse. Of the total 509.91 ha of Shale Sandstone Transition Forest CEEC mapped within the 10,000 ha buffered areas, approximately 107 ha is conserved in Gulguer Nature Reserve. This patch of the CEEC within the 1,000 ha and 10,000 ha buffer is likely to be in good condition due to being largely intact with a relatively dense tree canopy cover.
(c) an estimate of the extant area and overall condition of Shale Sandstone Transition Forest CEEC remaining in the IBRA subregion after the impact of the proposed development has been taken into consideration	The GIS layer 'Map of Critically Endangered Ecological Communities NSW Version 5' was used to calculate the area of Shale Sandstone Transition Forest CEEC in the IBRA subregions which overlap with the development site. According to this mapping there is approximately 0.001 ha of Shale Sandstone Transition Forest CEEC within the Burragorang IBRA subregion and approximately 203.94 ha within the Wollemi IBRA subregion. According to the mapping, the majority of Shale Sandstone Transition Forest CEEC occurs within the Cumberland IBRA subregion (approximately 11,313.78 ha). This GIS layer is likely to contain inaccuracies in extent and does not provide an indication of the condition of the mapped occurrences of the CEEC. It is likely that condition is variable depending on the level of disturbance within and surrounding the CEEC however it is believed that the majority of CEEC would be in a disturbed or degraded condition. According to

Criterion (FBA Section 9.2.4.2)	Consideration
	the Approved Conservation Advice, Shale Sandstone Transition CEEC '*has been identified as one of the most fragmented communities in the Sydney region, with substantial exposure of edges to cleared or degraded land* (NSW Scientific Committee 2014*).*
(d) the development proposal's impact on: (i) abiotic factors critical to the long-term survival of Shale Sandstone Transition Forest CEEC. For example, will the impact lead to a reduction of groundwater levels or substantial alteration of surface water patterns?	In addition to vegetation removal, the Project may alter abiotic factors such as hydrological processes (including surface water patterns) and fire regimes (such as frequency or intensity) which in turn have an impact on the CEEC's floristic and structural complexity through the loss of characteristic and functionally important species associated with the CEEC.
(ii) characteristic and functionally important species through impacts such as, *but not limited to*, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants	The Project will directly impact (via removal) 1.64 ha of moderate to good condition Shale Sandstone Transition Forest CEEC resulting in a loss of all characteristic and functionally important species. A further 8.12 ha of moderate to good condition HN604 occurring within the study area is likely to be indirectly impacted by the Project. Although 8.12 ha of Shale Sandstone Transition Forest CEEC within the study area will be retained, these areas of CEEC have the potential to be affected by indirect impacts including but not limited to, edge effects, weed invasion, altered hydrological processes and loss of structural and floristic complexity though inappropriate fire regimes over the long term. This may lead to a loss of characteristic and functionally important species associated with the CEEC.
(iii) the quality and integrity of an occurrence of Shale Sandstone Transition Forest CEEC through impacts such as, *but not limited to*, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the Shale Sandstone Transition Forest CEEC	Although 8.12 ha of Shale Sandstone Transition Forest CEEC within the study area will be retained, these areas of CEEC have the potential to be affected by indirect impacts associated with the operation and construction of the Project including but not limited to, edge effects, weed invasion, and altered hydrological processes s. The CEEC within the study area was found to be moderate to good quality due to having high species diversity, structural intactness and a demonstrated resilience to existing disturbances posed by the current operation of the dam.
(e) direct or indirect fragmentation and isolation of an important area of the Shale Sandstone Transition Forest CEEC	An important area is defined in the FBA as being '*an area of the CEEC that is necessary for the entities' long-term persistence and recovery. This may include areas identified in recovery plans, and/or an area large in comparison to other stands of the CEEC or occurrences of the CEEC at the limit of the community's range*'. The Shale Sandstone Transition Forest within the study area meets the definition of 'important area' as defined by FBA because the occurrence of the CEEC within the development site occurs at the edge of the communities known range. This is further supported by the presence of Blackbutt (*Eucalyptus pilularis*) within the CEEC mapped in the study area is atypical of this CEEC's broader distribution which also indicates that the community in the study area is occurring on the margin of its distribution (NSW Scientific Committee's Final Determination). Area of this CEEC near or at the limit of its range are also considered important due to its compositional rarity and potential genetic significance. Moreover, the area of CEEC within the development site meets the threshold as defined within the Commonwealth Conservation Advice as an area which is critical to the survival of the CEEC. The proposal will result in the direct removal of 1.64 ha. Given the connectivity of native vegetation to the north of the development site, the Project will not isolate the CEEC from other areas of native vegetation as the patch of Shale Sandstone Transition Forest will stay contiguous with vegetation around the development site.
(f) the measures proposed to contribute to the recovery of the Shale Sandstone Transition Forest CEEC in the IBRA subregion	The Proponent of the Project intends to acquire offsets in the form of BioBanking Credits commensurate to the exact credit requirement prescribed by the BBCC. A summary of the credit requirements for this CEEC is outlined in Table 10-27.

10.6.7.3 Threatened species and populations

Impacts on threatened species that require further consideration include impacts on:

a) any impacts on critically endangered species, unless the critically endangered species is specifically excluded in the SEARs
b) on a threatened species or population that is specifically nominated by the SEARs as a species or population that is likely to become extinct or have its viability significantly reduced in the IBRA subregion if it is impacted on by the development or
c) where the survey or expert report undertaken confirms that the threatened species is present in the proposed development site, and the threatened species has not previously been recorded in the IBRA subregion according to records in the NSW Wildlife Atlas.

Targeted threatened species searches were not undertaken because the size and extent of the areas to be impacted by the Project made this approach impractical. Eight (8) threatened species listed within Attachment C on OEH's input into the SEARs are therefore 'assumed present' based on the presence of suitable habitat within the development site and known records within the Wollemi IBRA subregion and Burragorang IBRA subregion. As such, the matters outlined in the FBA (Section 9.2.5.2) are to be considered for the following species:

- *Epacris purpurascens var. purpurascens*
- *Hibbertia puberula*
- *Melaleuca deanei*
- *Ancistrachne maidenii*
- *Tetratheca glandulosa*
- *Gyrostemon thesioides*
- *Dillwynia tenuifolia*
- *Rhodamnia rubescens.*

FBA considerations for these species are documented in Appendix F3 (Biodiversity assessment report – construction area, Section 7.7.3).

10.7 Environmental management measures

10.7.1 Impacts requiring offsetting

The BBCC was used to determine offset requirements for native vegetation and species and populations, and a Biodiversity credit report prepared. Details are provided in Appendix F3 (Biodiversity assessment report – construction area, Section 7.8) and summarised as follows.

10.7.1.1 Native vegetation

Impacts of the Project that fall into the threshold of impacts that require offsetting include:

- The removal of 2.76 hectares of HN564: Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion
- The removal of 12.25 hectares of HN566: Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion
- The removal of 5.77 hectares of HN568: Red Bloodwood - Sydney Peppermint - Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion
- The removal of 1.64 hectares of HN604: Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion

A summary of the vegetation zone impacted, threatened species associated with that vegetation zone, loss landscape value, loss in site value, and the number of ecosystem credits required for the impacts is given in Table 10-27.

Table 10-27. Ecosystem credit requirements of the proposed works

Vegetation zone	PCT	Condition	Area impacted (ha)	Current site value	Future site value	Credit requirement
1	HN564	Moderate/Good	0.31	60.63	0.00	16
2	HN566	Moderate/Good	12.25	77.08	0.00	691
3	HN568	Moderate/Good	5.77	91.06	0.00	430
4	HN604	Moderate/Good	1.64	60.14	0.00	84
5	HN564	Moderate/Good_poor	2.45	30.68	0.00	72

10.7.1.2 Species and populations

Three species credit species were recorded within the development site, however 54 candidate species credit species are assumed to be present, which would require offsets using the BBCC. Details relating to vegetation zone impacted, threatened species associated with that vegetation zone, loss of landscape value, loss in site value, and the number of ecosystem credits required for the impacts is presented in Table 10-28.

It is recommended that targeted surveys be carried out in line with relevant guidelines for threatened flora species currently assumed as present within the development site. Targeted surveys should focus on areas that had been subject to resent prescribed burning, as well as within the development footprint. These surveys would likely refine the quantification of impacts and associated credit liability generated by the Project.

Table 10-28. Credit requirement of the project for species credits.

	Species name	Common name	BC Act status	EPBC Act status	Area (Ha) to be removed	Credit requirement
	FLORA		Key: CE = Critically Endangered; E = Endangered; V = Vulnerable			
1.	*Acacia baueri* subsp. *Aspera*	*Acacia baueri* subsp. *aspera*	V	-	12.25	520
2.	*Acacia bynoeana*	Bynoe's Wattle	E	V	19.96	520
3.	*Acacia flocktoniae*	Flockton's Wattle	V	V	6.07	126
4.	*Acacia gordonii*	*Acacia gordonii*	E	E	12.25	338
5.	*Acacia pubescens*	Downy Wattle	V	V	19.66	380
6.	*Ancistrachne maidenii*	*Ancistrachne maidenii*	V	-	12.55	286
7.	*Asterolasia elegans*	*Asterolasia elegans*	E	E	12.55	234
8.	*Astrotricha crassifolia*	Thick-leaf Star-hair	V	V	12.25	1,001
9.	*Caesia parviflora* subsp. *Parviflora*	Small Pale Grass-lily	E	-	12.55	182
10.	*Cryptostylis hunteriana*	Leafless Tongue-orchid	V	V	12.25	520
11.	*Darwinia biflora*	*Darwinia biflora*	V	V	12.55	260
12.	*Darwinia peduncularis*	*Darwinia peduncularis*	V	-	12.25	234
13.	*Dillwynia tenuifolia*	*Dillwynia tenuifolia*	V	-	12.55	234
14.	*Epacris purpurascens var. purpurascens*	*Epacris purpurascens var. purpurascens*	V	-	300*	5,100
15.	*Genoplesium bauera*	Bauer's Midge Orchid	V	E	12.25	169
16.	*Grammitis stenophylla*	Narrow-leaf Finger Fern	E	-	1.64	26
17.	*Grevillea evansiana*	Evan's Grevillea	V	V	12.25	195
18.	*Grevillea parviflora subsp. Parviflora*	Small-flower Grevillea	E	-	14.19	210
19.	*Gyrostemon thesioides*	*Gyrostemon thesioides*	E	-	1.95	154
20.	*Haloragodendron lucasii*	Hal	E	E	12.25	1,001
21.	*Hibbertia puberula*	*Hibbertia puberula*	E	-	19.96	800

	Species name	Common name	BC Act status	EPBC Act status	Area (Ha) to be removed	Credit requirement
22.	*Hygrocybe anomala* subsp. *Ianthinomarginata*	*Hygrocybe anomala* subsp. *ianthinomarginata*	V	-	13.89	1,078
23.	*Kunzea rupestris*	*Kunzea rupestris*	V	V	12.55	338
24.	*Lastreopsis hispida*	Bristly Shield Fern	E	-	5.79	462
25.	*Leucopogon exolasius*	Woronora Beard-heath	V	V	18.32	266
26.	*Leucopogon fletcheri* subsp. *Fletcheri*	*Leucopogon fletcheri* subsp. *fletcheri*	E	-	12.55	208
27.	*Melaleuca deanei*	Deane's Paperbark	V	V	12.55	1,001
28.	*Melaleuca groveana*	Grove's Paperbark	V	-	13*	1,560
29.	*Micromyrtus blakelyi*	*Micromyrtus blakelyi*	V	V	12.55	338
30.	*Olearia cordata*	*Olearia cordata*	V	V	12.55	169
31.	*Persoonia acerosa*	Needle Geebung	V	V	18.02	247
32.	*Persoonia hirsute*	Hairy Geebung	E	E	19.96	1,540
33.	*Pimelea curviflora var. curviflora*	*Pimelea curviflora var. curviflora*	V	V	14.19	1,155
34.	*Pomaderris brunnea*	Brown Pomaderris	V	V	0.31	15
35.	*Pterostylis saxicola*	Sydney Plains Greenhood	E	E	12.55	520
36.	*Pultenaea glabra*	Smooth Bush-Pea	V	V	18.02	285
37.	*Pultenaea parviflora*	*Pultenaea parviflora*	E	V	12.25	180
38.	*Pultenaea sp.* Olinda	*Pultenaea sp.* Olinda	E	-	12.25	520
39.	*Rhodamnia rubescens*^#	Scrub Turpentine	CE	-	1*	154
40.	*Syzygium paniculatum*	Magenta Lilly Pilly	E	V	10*	130
41.	*Tetratheca glandulosa*	*Tetratheca glandulosa*	V	-	19.96	320
42.	*Velleia perfoliata*	*Velleia perfoliata*	V	V	12.55	221
43.	*Zieria involucrata*	*Zieria involucrata*	E	E	1.64	30
44.	*Zieria murphyi*	Velvet Zieria	V	V	12.55	195

	Species name	Common name	BC Act status	EPBC Act status	Area (Ha) to be removed	Credit requirement
	FAUNA					
45.	*Anthochaera phrygia*	Regent Honeyeater	CE	CE	19.96	1,537
46.	*Cercartetus nanus*	Eastern Pygmy-possum	V	-	19.32	386
47.	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	V	19.96	259
48.	*Heleioporus australiacus*	Giant Burrowing Frog	V	V	3.60	47
49.	*Hoplocephalus bungaroides*	Broad-headed Snake	E	V	10.24	338
50.	*Isoodon obesulus* subsp. *obesulus*	Southern Brown Bandicoot (eastern)	E	E	12.25	318
51.	*Meridolum corneovirens*	Cumberland Plain Land Snail	E	-	1.64	21
52.	*Petaurus norfolcensis*	Squirrel Glider	V	-	19.66	433
53.	*Petrogale penicillata*	Brush-tail Rock-wallaby	E	V	17.38	452
54.	*Phascogale tapoatafa*	Brush-tailed Phascogale	V	-	13.89	278
55.	*Phascolarctos cinereus*	Koala	V	V	19.96	519
56.	*Pseudophryne australis*	Red-crowned Toadlet	V	-	8.25	107
57.	*Varanus rosenbergi*	Rosenberg's Goanna	V	-	19.96	659

**Credit requirement calculated by number of individuals impacted.*

^# Rhodamnia rubescens could not be entered into the BBCC. As such, the calculations have substituted in Acronychia littoralis with a multiplier of 7.7 into the BBCC to complete the offset calculation

10.7.2 Impacts that do not require further assessment

The development site includes areas of paddocks and existing roads/tracks that are not considered to comprise native vegetation or habitat for threatened species and populations. In accordance with of the FBA (Section 9.5.1.1) this area of land does not require further assessment.

10.7.3 Management plan

Although the Project has sought to avoid and minimise impacts, not all biodiversity impacts can be avoided. A construction environmental management plan (CEMP) will be prepared, which will include a site-specific flora and fauna management plan (FFMP). The FFMP will provide a framework for biodiversity management and mitigation, and will detail management requirements for the following:

- vegetation pre-clearance and clearance supervision
- rehabilitation and habitat restoration
- sediment and erosion control
- weed and feral animal management
- required ecological monitoring.

The broad sets of measures, timing and responsibilities are described in Table 10-29. These will be implemented to mitigate impacts as far as possible during construction and operation phases.

Management measures have been incorporated in the Environmental Management measures in Chapter 29 (EIS synthesis, Project justification and conclusion).

Table 10-29. Management measures

Impact		Mitigation measure	Outcome	Timing	Responsibility
General flora and fauna	BC1	A flora and fauna management plan (FFMP) would be prepared as part of the CEMP. Native vegetation clearing would not occur until the FFMP is approved.	Flora and fauna would be managed in accordance with the requirements of the Flora and Fauna Management Plan	Pre-construction and construction	Proponent and Construction Contractor
	BC2	The FFMP would be prepared to manage the vegetation retained within the development site. The plan would include details on weed and pest management, nest boxes and fauna habitat maintenance and monitoring procedures.	The vegetation within the development site surrounding the storage area would be managed in accordance with the FFMP	Pre-construction, construction and post-construction phases	Proponent and Construction Contractor
Degradation of freshwater wetland habitats	BC3	Install appropriate drainage infrastructure (for example, sediment basins, diversion drains), sediment and erosion controls prior to the commencement of construction.	Prevention of sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction	Proponent and Construction Contractor
	BC4	Clearing of vegetation would be timed to avoid periods when rain is forecast	Prevention of sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction and construction	Proponent and Construction Contractor
	BC5	Dust suppression activities to be undertaken where appropriate.	Prevents sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction and construction	Proponent and Construction Contractor
	BC6	Stabilisation of disturbed areas, including revegetation in accordance with the FFMP, is to be undertaken as soon as practicable after disturbance.	Prevents sedimentation and erosion leading to a reduction in water quality and degradation of aquatic habitats	Pre-construction, construction and post-construction phases	Proponent and Construction Contractor
	BC7	Emergency response protocols and procedures for implementation in the event of a contaminant spill or leak to be clearly articulated in the construction and operational environmental management plans.	Prevents pollution of waterways.	Pre-construction and construction	Proponent and Construction Contractor
	BC8	Spill kits to be located to allow for timely response to uncontained spills. Site inductions are to include a briefing on the use of spill kits.	Prevents pollution of waterways.	Pre-construction and construction	Proponent and Construction Contractor
	BC9	Bio-retention installed in base of channels and swales to capture and store stormwater consisting of bio-filtration layers, planting and subsoil collection and drainage.	Reduces impacts from altered hydrological regimes leading to an increase in impervious surface such as changes in runoff and infiltration, redirection of flows.	Pre-construction and construction	Proponent and Construction Contractor

Impact		Mitigation measure	Outcome	Timing	Responsibility
Vegetation removal or disturbance	BC10	Clearly identifying sensitive areas ('no-go zones') which cannot be impacted by construction and managing clearing such that clearing activities are constrained to these approved areas only.	Prevention of over clearing of vegetation.	Pre-construction and construction	Construction Contractor
	BC11	Site inductions are to include a briefing regarding the local threatened species and communities on the site, and protocols to be undertaken if they are encountered.	Prevention of impacts to threatened species and communities.	Construction and post-construction.	Proponent and Construction Contractor
Weed invasion and spread	BC12	Management of weeds in and adjacent to cleared areas will occur in accordance with the FFMP, CEMP, and operational environmental management plan (OEMP). The plan would include details relating to the monitoring, management, and where necessary, eradication of weeds, disposal of green waste, and vehicle/plant weed wash down protocols, if required.	Prevention of weed establishment and weed invasion.	Pre-construction, construction, and post-construction.	Proponent and Construction Contractor
	BC13	Management of noxious weeds is to be undertaken in accordance with the Biosecurity Act 2015.	Prevention of weed establishment and weed invasion	Pre-construction and construction	Proponent and Construction Contractor
	BC14	Equipment used for treating weed infestation will be cleaned prior to moving to a new area within the development site to minimise the likelihood of transferring any plant material and soil.	Prevention of weed spread	Pre-construction and construction	Proponent and Construction Contractor
	BC15	Soil stripped and stockpiled from areas containing known weed infestations are to be stored on cleared land at least 40 m from native vegetation.	Prevention of weed establishment and weed invasion	Construction	Construction Contractor
Impacts to fauna and flora	BC16	Fauna microhabitat such as hollow logs and dead trees should be removed from areas to be cleared and relocated to adjacent woodland habitat.	Retaining fauna habitat resources	Pre-construction and construction	Construction Contractor
	BC17	A nest box and connectivity management strategy would be prepared prior to clearing of hollow bearing trees and connecting links. The strategy would inform the installation of nest boxes and fauna crossings in and between retained native vegetation adjacent to the site, and the on-going monitoring and maintenance of nest boxes and crossings through the construction and operational phases. This strategy would be included within the FFMP.	Replaces lost hollow resources in the landscape	Pre-construction and construction	Construction Contractor
	BC18	High visibility plastic fencing is to be installed to clearly define the limits of the works area.	Prevents disturbance or over clearing of fauna habitat and native vegetation outside the construction area	Construction	Construction Contractor

Impact		Mitigation measure	Outcome	Timing	Responsibility
	BC19	Undertake a prestart-up check for sheltering native fauna of all infrastructure, plant and equipment and/or during relocation of stored construction materials.	Prevents fauna injury/mortality	Construction	Construction Contractor
	BC20	Site inductions are to include a briefing regarding the local fauna of the site and protocols to be undertaken if fauna is encountered.	Prevents fauna injury/mortality	Construction	Construction Contractor
	BC21	If any animal is injured, contact the relevant local wildlife rescue agency (for example, WIRES) and/or prequalified veterinary surgery as soon as practical. Until the animal can be cared for by a suitably qualified animal handler, minimise stress to the animal and reduce the risk of further injury by: ▪ handling fauna with care and as little as possible ▪ covering larger animals with a towel or blanket and placing in a large cardboard box ▪ placing smaller animals in a cotton bag or plastic bag (smaller reptiles and frogs), tied at the top ▪ keeping the animal in a quiet, warm and ventilated space.	Prevents fauna injury/mortality	Pre-construction, construction, and post-construction.	Proponent and Construction Contractor
	BC22	If any pits/trenches are to remain open overnight, they are to be securely covered, where reasonable and feasible. Alternatively, fauna ramps (logs or wooden planks) are to be installed to provide an escape for trapped fauna. Pits will be inspected prior to work recommencing and any fauna removed by the project ecologist or designated suitably qualified and licensed representative.	Prevents fauna injury/mortality	Construction	Construction Contractor
	BC23	The extent of vegetation clearing is to be clearly identified on construction plans.	Prevents impacts to fauna habitat and native vegetation outside the development footprint	Pre-construction	Proponent and Construction Contractor
	BC24	In circumstances where native vegetation or mature tree clearing is required outside of the biodiversity development site, the project ecologist will inspect the proposed area and provide advice on the impact to flora and fauna and appropriate management.	Prevents impacts to fauna habitat and native vegetation outside the development footprint	Construction	Proponent, Construction Contractor, and appointed project ecologist
	BC25	Directional lighting will be used where lighting is required in construction areas.	Minimises disruption to fauna foraging, nesting or roosting behaviours	Construction	Construction Contractor

Impact		Mitigation measure	Outcome	Timing	Responsibility
	BC26	Maintenance of construction machinery and plant will be undertaken to minimise unnecessary noise.	Prevents fauna injury/mortality	Construction	Construction Contractor
	BC27	Speed limits will be developed so as to minimise the potential for fauna to be struck by a vehicle within the development site. All vehicles and plant in operation during construction are to adhere to site rules relating to speed limits.	Prevents fauna injury/mortality	Construction	Construction Contractor
	BC28	Where suitable for the species, and in line with established conservation programs (such as Saving our Species), threatened species translocation will be carried for species occurring within the development site (Red-crowned Toadlet and *Grevillea parviflora* subsp. *parviflora*). Translocation will be carried out in line with Office of Environment and Heritage Translocation operational policy (OEH 2019) and will involve stakeholders from relevant government agencies, and subject matter experts.	Minimising impacts to threatened species, and securing populations of threatened species	Pre-construction	Proponent and appointed project ecologist
Bushfire risk connectivity	BC29	Bushfire awareness included in staff induction and in toolbox talks pre-commencement.	Reduces risk of possible bushfire events impacting on biodiversity values	Pre-construction and construction	Construction Contractor
Invasion and spread of pathogens and disease	BC30	Implementation of hygiene protocols to minimise risk of spreading pathogens and disease. Mitigations include vehicle and equipment washdowns, and follow relevant guidelines including: ▪ *Best Practice Management Guidelines for Phytophthora cinnamomic within the Sydney Metropolitan Catchment Management Authority Area* (Suddaby & Liew 2008) ▪ *Hygiene protocol for the control of disease in frogs* (DECC 2008) ▪ *Management plan for myrtle rust on national parks estate* (OEH 2011).	Prevents the spread and establishment of disease and pathogens	Pre-construction and construction	Construction Contractor

10.8 Risk assessment

An environmental risk assessment was carried out in accordance with the SEARs, using the methodology provided in Appendix C (Risk assessment procedure). A Project risk matrix was developed and risk ranking evaluated by considering:

- the likelihood (L) of an impact occurring
- the severity or consequence (C) of the impact in a biophysical and/or socio-economic context, with consideration of:
  - whether the impact will be in breach of regulatory or policy requirements
  - the sensitivity of receptors
  - duration of impact, i.e. whether the impact is permanent or temporary
  - the areal extent of the impact and/or the magnitude of the impact on receptors.

The likelihood and consequence matrix is shown on Figure 10-15.

Once the consequence and likelihood of an impact are assessed, the risk matrix provides an associated ranking of risk significance: **Low**; **Medium**; **High** or **Extreme,** as shown in Table 10-30**.** The residual risk was determined after the application of proposed mitigation measures.

The risk analysis for potential construction biodiversity impacts is provided in Table 10-31. This includes the residual risk of the potential impact after the implementation of mitigation measures.

Table 10-30. Risk ranking definitions

Risk definitions	
Extreme 21 – 25	Widespread and diverse primary and secondary impacts with significant long-term effects on the environment, livelihood and quality of life. Those affected will have irreparable impacts on livelihoods and quality of life.
High 15 – 20	Significant resources and/or Project modification would be required to manage potential environmental damage. These risks can be accommodated in a Project of this size, however comprehensive and effective monitoring measures would need to be employed such that Project activities are halted and/or appropriately moderated. Those impacted may be able to adapt to change and regain their livelihoods and quality of life with a degree of difficulty.
Medium 9 – 14	Risk is tolerable if mitigation measures are in place, however management procedures will need to ensure necessary actions are quickly taken in response to perceived or actual environmental damage. Those impacted will be able to adapt to changes.
Low 1 – 8	On-going monitoring is required however resources allocation and responses would have low priority compared to higher ranked risks. Those impacted will be able to adapt to change with relative ease.

Figure 10-15. Risk matrix

		Consequence				
		Negligible	Minor	Medium	Major	Extreme
	LEGAL	No legal consequences	No legal consequences	Incident potentially causing breach of licence conditions	Breach of licence conditions	Breach of licence conditions resulting in shutdown of Project operations.
	SOCIO-ECONOMIC	Impacts that are practically indistinguishable from the social baseline, or consist of solely localised or temporary/short-term effects with no consequences on livelihoods and quality of life.	Short-term or temporary impacts with limited consequences on livelihoods and quality of life. Those affected will be able to adapt to the changes with relative ease and regain their pre-impact livelihoods and quality of life.	Primary and secondary impacts with moderate effects on livelihoods and quality of life. Will be able to adapt to the changes with some difficulty and regain their pre-impact livelihoods and quality of life.	Widespread and diverse primary and secondary impacts with significant long-term effects on livelihoods and quality of life. Those affected may be able to adapt to changes with a degree of difficulty and regain their pre-impact livelihoods and quality of life.	Widespread and diverse primary and secondary impacts with irreparable impacts on livelihoods and quality of life and no possibility to restore livelihoods.
	HEALTH	No health consequences	Accident or illness with little or no impact on ability to function. Medical treatment required is limited or unnecessary.	Accident or illness leading to mild to moderate functional impairment requiring medical treatment.	Accident or illness leading to permanent disability or requiring a high level of medical treatment or management.	Accident, serious illness or chronic exposure resulting in fatality.
	ENVIRONMENT	Localised (on-site), short-term impact on habitat, species or environmental media	Localised or widespread medium-term impact to habitat, species or environmental media	Localised degradation of sensitive habitat or widespread long-term impacts on habitat, species or environmental media. Possible contribution to cumulative impacts.	Widespread and long-term changes to sensitive habitat, species diversity or abundance or environmental media. Temporary loss of ecosystem function at landscape scale. Moderate contribution to cumulative impacts.	Loss of a nationally or internationally recognised threatened species or vegetation community. Permanent loss of ecosystem function on a landscape scale. Major contribution to cumulative effects
		A - negligible	**B** - minor	**C** - medium	**D** - major	**E** - extreme
Expected to occur during the Project or beyond the Project	**a** - expected	**13**	**14**	**20**	**24**	**25**
May occur during the Project or beyond the Project	**b** - may	**8**	**12**	**19**	**22**	**23**
Possible under exceptional circumstances	**c** - possible	**6**	**7**	**11**	**18**	**21**
Unlikely to occur during the Project	**d** - unlikely	**4**	**5**	**10**	**16**	**17**
Rare or previously unknown to occur	**e** - rare	**1**	**2**	**3**	**9**	**15**

Risk Definition (see Table 10-30)	**Low**	**Medium**	**High**	**Extreme**

Table 10-31. Biodiversity construction area: risk assessment

Biodiversity								
Key impacts	Risk before mitigation			Mitigation and management	Risk after mitigation			Residual risk
	L	C	R		L	C	R	
Construction								
Impacts associated with: ▪ clearing approximately 22 ha of native vegetation ▪ loss or degradation of ecologically important habitat ▪ loss of threatened flora and fauna species ▪ fauna mortality ▪ changes to natural fire regimes ▪ weed and feral animal invasion	a	C	20	BC1 to BC30	a	B	14	There is certainty that native vegetation will be cleared, which will result in the loss of ecological habitat and threatened species. This creates a High impact because of the local degradation of sensitive habitat. Mitigation will not affect the likelihood of the impact occurring, however the consequence can be reduced by reducing the extent of impacts and restoring affected areas. This results in a Medium residual impact, which will reduce as rehabilitated areas become established.

local people
global experience

SMEC is recognised for providing technical excellence and consultancy expertise in urban, infrastructure and management advisory. From concept to completion, our core service offering covers the life-cycle of a project and maximises value to our clients and communities. We align global expertise with local knowledge and state-of-the-art processes and systems to deliver innovative solutions to a range of industry sectors.

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