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Environmental Impact Statement – Appendix J: World Heritage Assessment Report

Warragamba Dam Raising

Reference No. 30012078
Prepared for WaterNSW
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SMEC INTERNAL REF. 30012078

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Glossary

ACRONYM/TERM	DEFINITION
ACHA	Aboriginal Cultural Heritage Assessment
ACHMP	Aboriginal Cultural Heritage Management Plan
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BOS	Biodiversity Offset Strategy
BSA	Biodiversity Stewardship Agreement
CHL	Commonwealth Heritage List
DAWE	Department of Agriculture, Water and the Environment (Cth)
DPIE	Department of Planning, Industry and Environment (NSW)
DoEE	Former Department of the Environment and Energy (Cth), now DAWE
EES	Environment, Energy and Science Group (part of DPIE)
EIS	Environmental impact statement
EMP	Environmental management plan
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
FMZ	Flood mitigation zone
FSL	Full supply level
GBMWHA	Greater Blue Mountains World Heritage Area
IUCN	International Union for Conservation of Nature
LGA	Local government area
mAHD	Metres above Australian Height Datum
MNES	Matter(s) of national environmental significance
NHL	National Heritage List
NPEMP	Environmental Management Plan
NPW Act	*National Parks and Wildlife Act 1974* (NSW)
NPWS	National Parks and Wildlife Service (NSW)
NSW	New South Wales
PEA	Preliminary environmental assessment
PCT	Plant community type
PMF	Probable Maximum Flood
RAP	Registered Aboriginal Party
SEARs	Secretary's Environmental Assessment Requirements
SSI	State significant infrastructure
TEC	Threatened ecological community
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
WHL	World Heritage List

1 Introduction

WaterNSW is a New South Wales (NSW) state-owned corporation and is the owner and operator of Warragamba Dam. The NSW Government has requested that WaterNSW seek project planning approval for the Warragamba Dam Raising Project (the Project). As part of the Project, WaterNSW is also seeking approval for the installation of environmental flow infrastructure at Warragamba Dam. The Project is declared State Significant Infrastructure (SSI) under section 5.12(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and approval is required for the Project under Part 5, Division 5.2 of the EP&A Act.

The Project is being assessed by the NSW Government on behalf of the Australian Government in accordance with the bilateral agreement in relation to environmental assessment. As such the EIS must include an assessment of matters protected under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) in relation to the controlling provisions; World Heritage, National Heritage, and threatened species and communities. On 17 July 2017, the Minister made a decision that the Project is a controlled action and noted that it would be assessed under the bilateral agreement.

This report provides an assessment of the potential impacts of the Project on World Heritage Areas. World Heritage Areas are also on the National Heritage List and this report considers legislative requirements relevant to both World Heritage and national heritage. Other national heritage listed items (which are not World Heritage Areas) are assessed in Appendix I (Non-Aboriginal Heritage Assessment Report) of the EIS[1].

The report addresses the relevant issues with the Secretary's Environmental Assessment Requirements (SEARs) and has informed the EIS. A preliminary environmental assessment (PEA) report was provided to the Secretary of the Department of Infrastructure, Planning and Environment (DPIE), with DPIE subsequently issuing SEARs on 30 June 2017. An updated version of the SEARs was issued on 13 March 2018 which clarified assessment requirements.

Items for the SEARs Key Issue 10 - Heritage and Attachment A of the SEARs are directly relevant to the World Heritage Areas and this report and are documented in Table 1-1.

Table 1-1. SEARs – World Heritage Areas

Secretary's Environmental Assessment Requirements	Where addressed
10. Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places.	
1. The Proponent must identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of: (d) items listed on the National and World Heritage lists. Investigations including surveys and identification of cultural heritage values should be conducted in consultation with OEH regional officers.	Sections 6.1, 6.2, 6.3
6. Where land is declared wilderness under the *Wilderness Act 1987* or on the World Heritage List as part of the Greater Blue Mountains World Heritage Area (GBMWHA) and lands declared as Wild Rivers under the NPW Act the Proponent: (a) must define the area and extent of impact on such lands; (b) provide evidence that the proposal is consistent with the *Wilderness Act 1987* and the management principles for wilderness areas; (c) assess impacts on land to be included on the National Heritage List.	Section 3.4.5 Section 6.1.7 Note: at the time of preparation of the EIS, there were no NHL nominations relevant to the Project

[1] This report includes references to other technical reports prepared for the environmental assessment. Relevant information has been summarised in this report and it is not considered necessary for readers to refer to these reports to inform their understanding of the potential impacts of the Project on World Heritage.

Secretary's Environmental Assessment Requirements	Where addressed
Attachment A	
5. The title of the action, background to the development of the action and current status.	Sections 1.1, 1.2
6. The precise location and description of all works to be undertaken (including associated offsite works and infrastructure), structures to be built or elements of the action that may have impacts on MNES.	Sections 1.2.1, 1.2.2
7. How the action relates to any other actions that have been, or are being taken in the region affected by the action.	Section 12.3
8. How the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts on MNES.	Sections 1.2.3, 1.3
9. The EIS must include an assessment of the relevant impacts of the action on the matters protected by the controlling provisions, including:	
i. a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts, including short term and long-term relevant impacts	Sections 6.1.7 to 6.1.13 Section ?
ii. a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible	Section 6.1.9
iii. analysis of the significance of the relevant impacts	Section 6.1.7 to 6.1.13 Section ?
iv. any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	Sections 3–11
Avoidance, mitigation and offsetting 10. For each of the relevant matters protected that are likely to be significantly impacted by the development, the EIS must provide information on proposed avoidance and mitigation measures to manage the relevant impacts of the action including:	
i. a description, and an assessment of the expected or predicted effectiveness of the mitigation measures,	Section 13
ii. any statutory policy basis for the mitigation measures	Sections 3, 13
iii. the cost of the mitigation measures	Section 8
iv. an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing	Section 13.1
v. the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.	Section 13
11. Where a significant residual adverse impact to a relevant protected matter is considered likely, the EIS must provide information on the proposed offset strategy, including discussion of the conservation benefit associated with the proposed offset strategy.	Section 13
12. For each of the relevant matters likely to be significantly impacted by the development the EIS must provide reference to, and consideration of, relevant Commonwealth guidelines and policy statements including any: v. management plan for a World Heritage property or National Heritage place	Section 13

Secretary's Environmental Assessment Requirements	Where addressed
Heritage (World and National Heritage) 17. The EIS must identify and describe the characteristics and values, including Outstanding Universal values, of any World Heritage property(s), and/or any National Heritage places that are likely to be impacted by all stages of the proposed development with appropriate reference to relevant management plans.	Sections 6, 9, 10
18. The assessment of impacts should include information on:	
i. the modification, destruction, fragmentation, isolation, disturbance of an important or substantial area of habitat	Sections 6.1.9 to 6.1.13
ii. impacts on other users of the area	Section 6.1.19.3
iii. the potential impacts on important amenities, navigation, culturally or historically significant sites, threatened or migratory species or sensitive habitat	Sections 6.1.15, 6.2, 6.3
iv. the potential visual impacts	Section 6.1.13
v. a description of any specific mitigation and management measures proposed to protect or enhance the affected values of the World Heritage property or National Heritage place.	Section 13
19. Where a significant residual adverse impact to a World Heritage property and/or a National Heritage place is considered likely the EIS must provide information on the proposed offset strategy. The offset strategy must:	
i. include a discussion and supporting evidence of the conservation benefit associated with the proposed offset strategy. The conservation benefit must demonstrate, at a minimum, how the proposed offset will improve the integrity and resilience of the heritage values of the impacted heritage place or property; and	Section 13
ii. be consistent with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy (2012): www.environment.gov.au/epbc/publications/epbc-actenvironmental-offsets-policy or an endorsed state policy	Section 13
20. Information in relation to any other approvals or conditions required must include the information prescribed in Schedule 4 Clause 5 (a) (b) (c) and (d) of the EPBC Regulations 2000	Sections 3, 13
21. Information in relation to the environmental record of a person proposing to take the action must include details as prescribed in Schedule 4 Clause 6 of the EPBC Regulations 2000.	EIS Appendix R
22. For information given in an EIS, the EIS must state the source of the information, how recent the information is, how the reliability of the information was tested; and what uncertainties (if any) are in the information.	Throughout EIS and appendices

1.1 Project background

The Hawkesbury-Nepean Valley (the valley) in western Sydney has the highest flood risk in New South Wales, if not Australia. The potential for significant flooding of the Hawkesbury-Nepean Valley was known by the local Aboriginal community before the first European settlement of the area in the 1790s. In the early years of European settlement, the risk of flooding was recognised and a series of proclamations were issued that warned of the risk of flooding. This high flood risk arises from the river being confined by narrow sandstone gorges, creating rapid deep backwater flooding over extensive floodplains. The floodplains are home to a large existing population who would be impacted in a major flood.

During the 1980s and 1990s updated flood investigation techniques and new geological evidence predicted that floods significantly larger than any historically recorded could occur in the Hawkesbury-Nepean Valley. The dam was raised by five metres in the late 1980s to meet modern dam safety requirements. Further investigations into flooding and flood mitigation were undertaken and culminated in 1995 in a proposal to raise Warragamba Dam by 23 metres primarily for dam safety but also to provide for flood mitigation. The 1995 proposal did not proceed. In the late 1990s, major upgrades of Warragamba Dam were undertaken to prevent dam failure during extreme flooding events, to protect Sydney's water supply, and to prevent catastrophic downstream floods from dam failure. This resulted in the construction of the auxiliary spillway. However, these works only dealt with dam safety issues and did not address the major flood risks to the people and businesses in the Hawkesbury-Nepean Valley and the NSW economy.

In 2011, an approximately 1 in 100 chance in a year flood impacted Brisbane, resulting in significant damage, economic costs, and social disruption. The substantial impacts of the 2011 Brisbane flood led the NSW Government to recommence investigations into flood mitigation options for the Hawkesbury-Nepean Valley.

In 2013, the NSW Government in response to the State Infrastructure Strategy and community concerns, initiated the Hawkesbury-Nepean Valley Flood Management Review to consider flood planning, flood mitigation and flood response in the Hawkesbury-Nepean Valley. The review found that current flood management and planning arrangements could be improved, and no single mitigation option could address all the flood risks present in the Hawkesbury-Nepean Valley (Department of Primary Industries (DPI) 2014a). The review concluded that raising Warragamba Dam to capture inflows is the most effective infrastructure measure that could have a major influence on flood levels during those events, when most of the damages occur. Other complementary and non-infrastructure options were also identified to mitigate flood risks (DPI 2014a).

Under the direction of Infrastructure NSW (INSW), the Hawkesbury-Nepean Valley Flood Management Taskforce was established to investigate feasible flood options to reduce overall risk to the Hawkesbury-Nepean Valley. In June 2016, the former Premier and Minister for Western Sydney, Mike Baird MP, announced the NSW Government plan to raise Warragamba Dam to significantly reduce the risk of flooding in the Hawkesbury-Nepean Valley. The cost-benefit analysis demonstrated that the Warragamba Dam Raising would provide a 75 percent reduction in flood damages on average, and reduce current levels of flood damages from $8 billion to $2 billion (2018 dollars).

Raising Warragamba Dam would significantly reduce flood risk; however, it would not eliminate the risk completely. Regardless of the increase in the dam's height, flooding can be generated from catchments other than Warragamba Dam. The raising of Warragamba Dam would therefore be complemented with other non-infrastructure and policy actions. In May 2017, INSW released Resilient Valley, Resilient Communities, which outlines the Hawkesbury-Nepean Valley Flood Risk Management Strategy (the Flood Strategy) (INSW 2017). The Flood Strategy covers the geographic region between Bents Bridge and the Brooklyn Bridge, encompassing areas within the Local Government Areas (LGAs) of Liverpool City, Penrith City, Hawkesbury City, The Hills Shire Blacktown City, Central Coast, and Hornsby Shire.

The objective of the Flood Strategy is to reduce flood risk to life, property and social amenity from floods in the Hawkesbury-Nepean Valley. The strategy includes nine key outcomes; a combination of infrastructure and non-infrastructure initiatives to mitigate the flood risk to the Hawkesbury-Nepean Valley floodplain downstream of Warragamba Dam. Actions include:

- coordinated flood risk management across the Hawkesbury-Nepean Valley now and in the future
- strategic and integrated consideration of flood risk in land use and emergency planning
- engaging and providing flood risk information for an aware, prepared and responsive community.

The Flood Strategy provides the context and policy impetus to mitigate flood risk in the Hawkesbury-Nepean Valley.

1.2 The Project

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 the existing full supply level (FSL) for temporary storage of inflows. 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 NSW Government announcement in 2016 proposed that the dam wall be raised by 14 metres. Subsequently, the then NSW Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs)

required the Project to be designed, constructed and operated to be resilient to the future impacts of climate change and incorporate specific adaptation actions in the design.

Peer reviewed climate change research found that by 2090 it is likely an additional three metres of spillway height would be required to provide similar flood mitigation outcomes as the current flood mitigation proposal. Raising the dam side walls and roadway by an additional three metres may not be feasible in the future, both in terms of engineering constraints and cost. The current design includes raising the dam side walls and roadway by 17 metres now to enable adaptation to projected climate change. Any consideration of raising spillway heights is unlikely before the mid to late 21st century and would be subject to a separate planning approval process.

The 17-metre raising height of the dam abutments (side walls) and roadway have been considered and accounted for in the EIS and design. The potential maximum height and duration of upstream inundation remains consistent with what was originally proposed in 2016.

The Project also includes providing infrastructure to facilitate variable environmental flows to be released from Warragamba Dam.

The Project would include the following main activities and elements:

- 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 to control discharge of water from the flood mitigation zone (FMZ)
- modifications to the auxiliary spillway
- operation of the dam for flood mitigation
- environmental flow infrastructure.

The Project would take the opportunity, during the construction period for the dam raising, to install the physical infrastructure to allow for management of environmental flows as outlined in the NSW Government's 2017 Metropolitan Water Plan. However, the actual environmental flow releases themselves do not form part of the Project and are subject to separate administration under the *Water Management Act 2000*.

1.2.1 Location

Figure 1-1 shows the local and regional context of the Project. The Project site is located approximately 65 kilometres west of the Sydney Central Business District in the Wollondilly Local Government Area (LGA). To the west of the Project site are the Blue Mountains, various national parks and state conservation areas and the Greater Blue Mountains World Heritage Area (GBMWHA), which make up part of the catchment of Lake Burragorang, the water storage formed by Warragamba Dam. To the east of the Project site are the Warragamba and Silverdale townships and surrounding rural residential areas.

1.2.2 Main activities and elements

Figure 1 2 shows the existing dam with relevant key features. Figure 1-3 shows the modified dam after the Project works have been completed.

The Project would include the following main activities and elements:

- demolition or removal of parts of the existing Warragamba Dam, including the existing drum and radial gates, to allow for the new works
- thickening and raising of the dam abutments
- thickening and raising of the central spillway
- new gates or slots for discharge of water from the dam
- modifications to the auxiliary spillway
- other infrastructure and elements including new roads, bridges, and ancillary facilities
- environmental flows infrastructure
- operation of the dam for flood mitigation.

1.2.3 Operation of the dam for flood mitigation

There would be two different modes of operation for the raised Warragamba Dam: normal and flood operations. In both modes Warragamba Dam would continue to store and supply up to 80 percent of Sydney's drinking water. The water supply storage capacity, which is the dam's full supply level (FSL), would not change. The current and future operation of the dam is shown in Figure 1-4 and Figure 1-5 respectively. During flood operations, areas of the GBMWHA may experience temporary inundation. Some areas of the GBMWHA already experience temporary inundation during flood events due to the existing dam, however the Project would increase the extent and duration of temporary inundation.

Operational objectives in order of priority are to:

- maintain the structural integrity of the dam
- minimise risk to life
- maintain Sydney's water supply
- minimise downstream impact of flooding to properties:
- minimise environmental impact
- minimise social impact.

1.2.3.1 Normal operation

Normal operation would occur when the dam storage level is at or below FSL. This would be essentially the same as current operation. Inflows would be captured up until the FSL after which flood operation procedures would be implemented.

1.2.3.2 Flood operation

During large rainfall events when the storage level rises above FSL, flood operation mode would commence. In this mode, inflows to Lake Burragorang would be captured and temporarily stored (increasing water levels in Lake Burragorang and upstream tributaries). The raised dam would provide capacity in the FMZ to capture temporarily around 1,000 gigalitres of water during a flood event.

Once flood levels had peaked downstream, water would be discharged in a controlled manner via the gated conduits until the dam level returns to FSL. Operating protocols for the FMZ would guide this process and would be developed for approval by the relevant regulatory authorities.

The raised dam would not be able to fully capture inflows from all floods. For floods that exceed the capacity of the FMZ, water would spill firstly over the central spillway and then, depending on the size of the flood, the auxiliary spillway.

Figure 1-1. Location of the Project

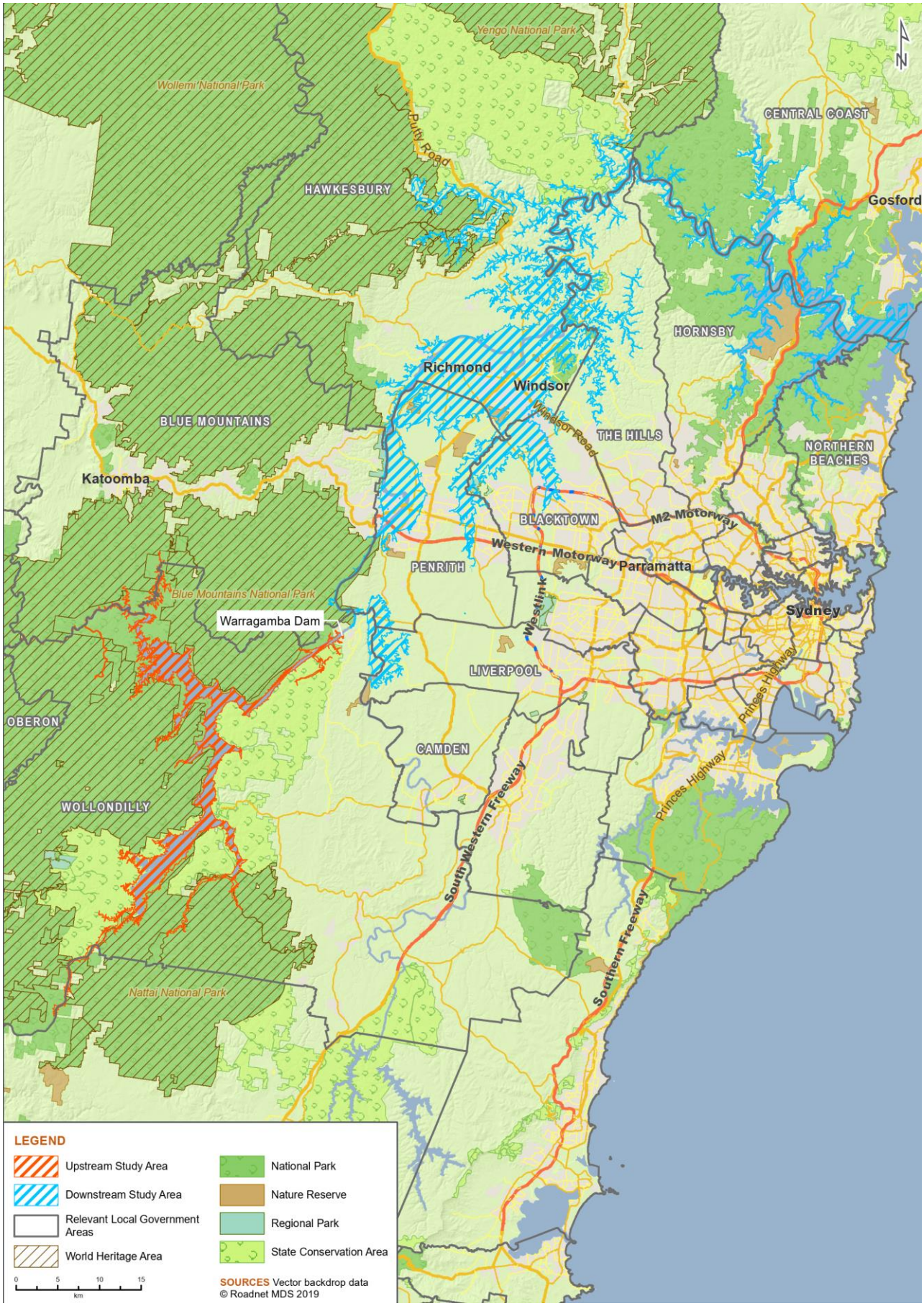


Figure 1-2. Existing dam and features

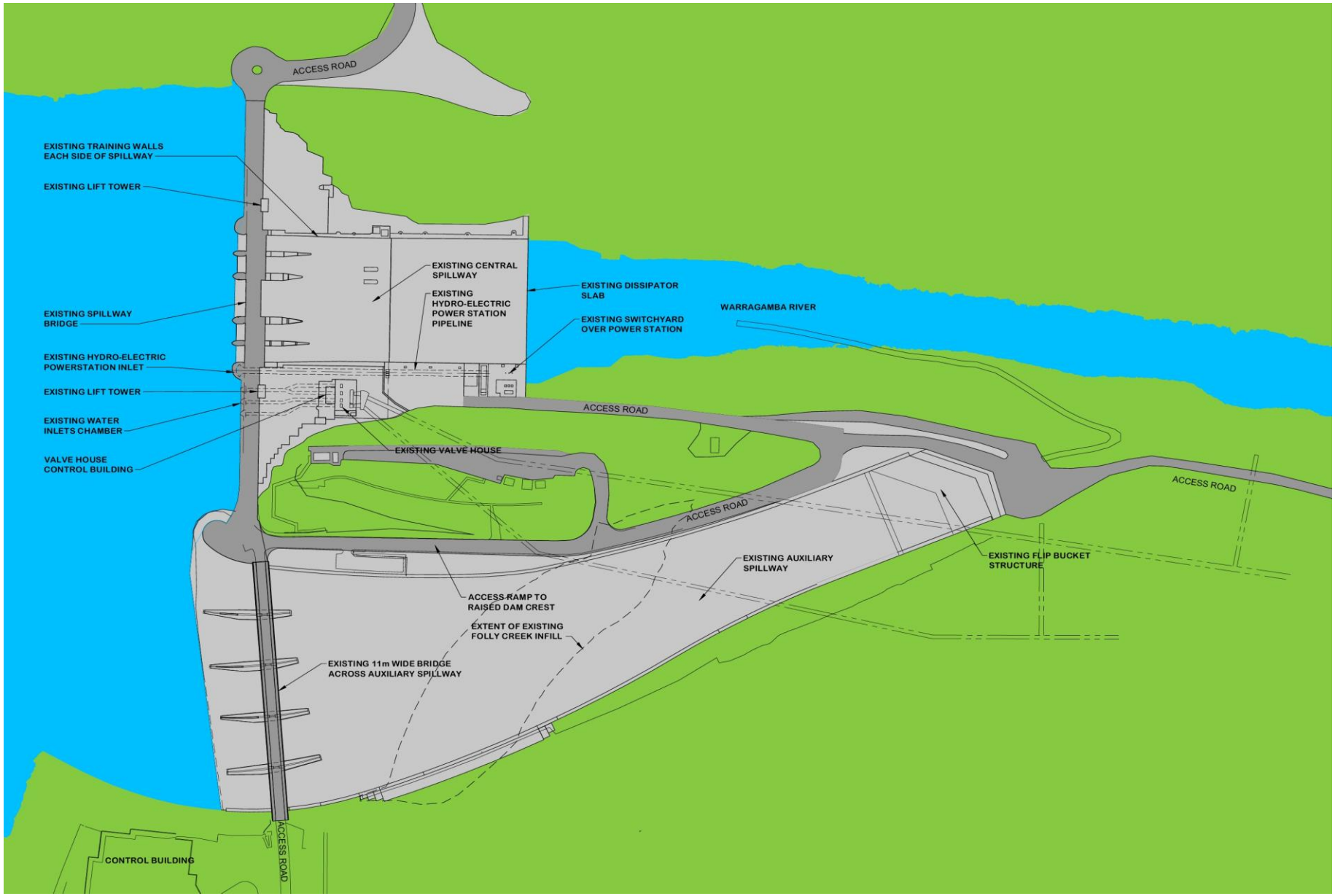


Figure 1-3. Modified dam from the Project works

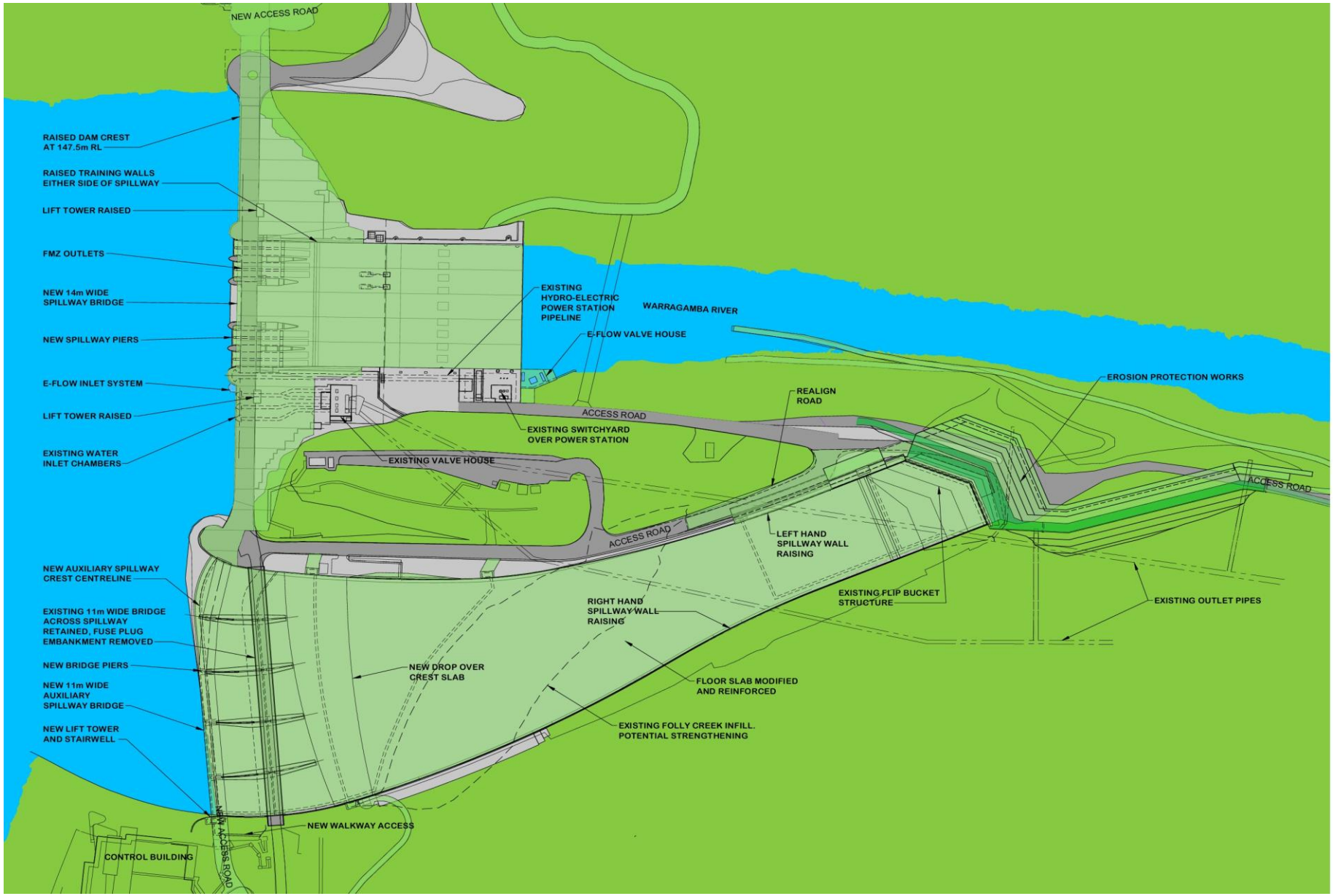


Figure 1-4. Existing operation of the dam

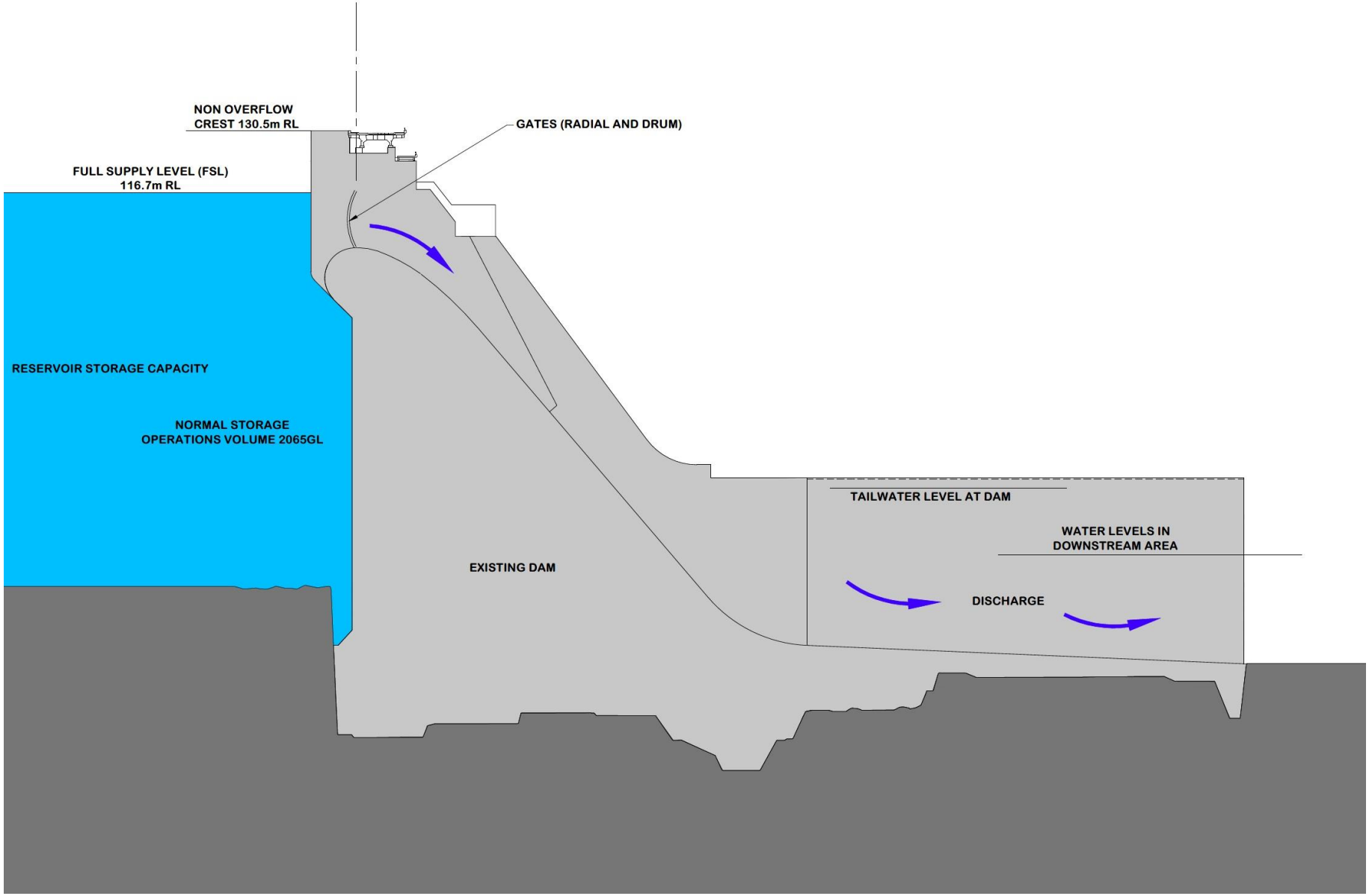
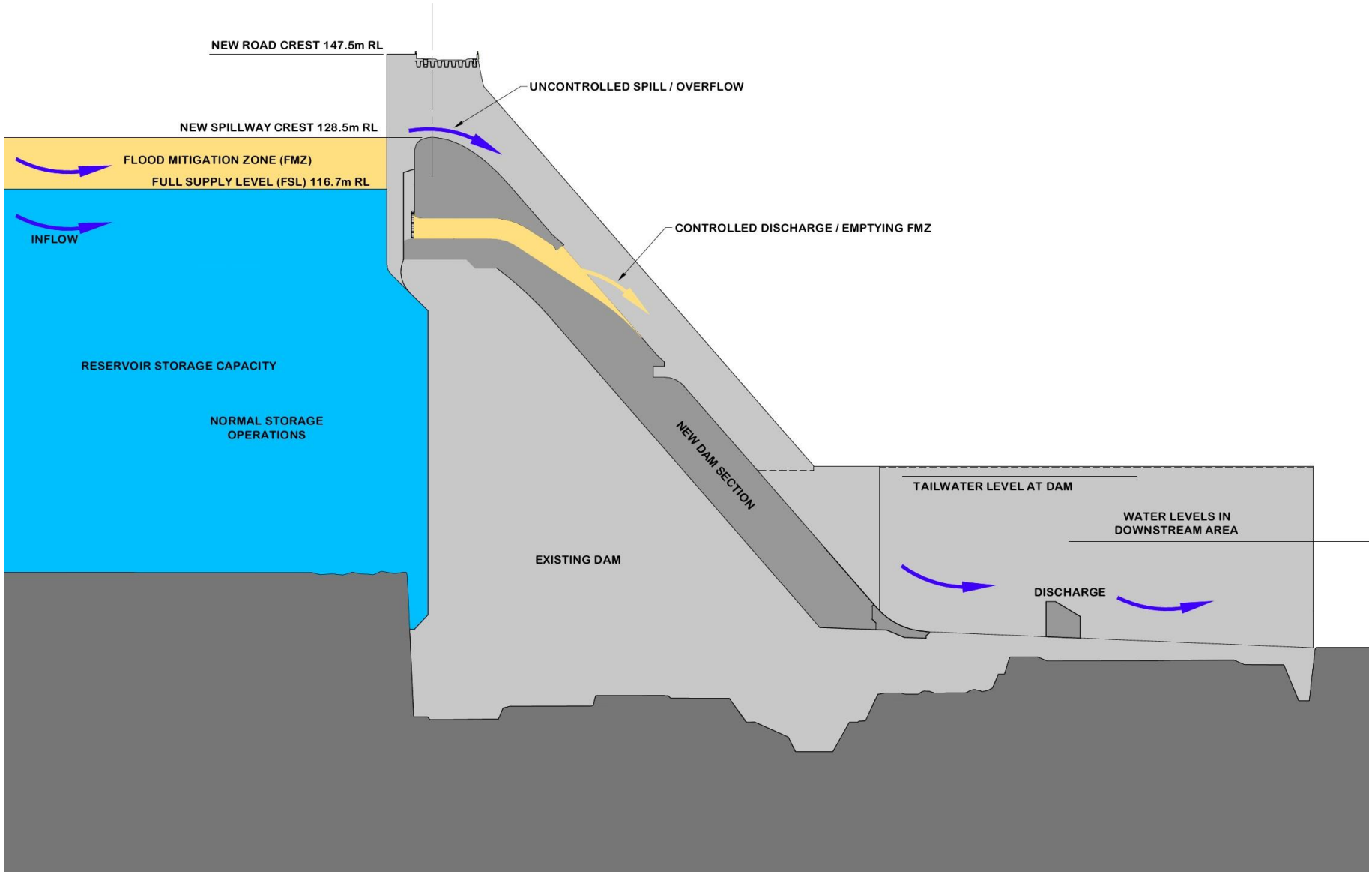


Figure 1-5. Future operation of the dam



1.3 Project construction

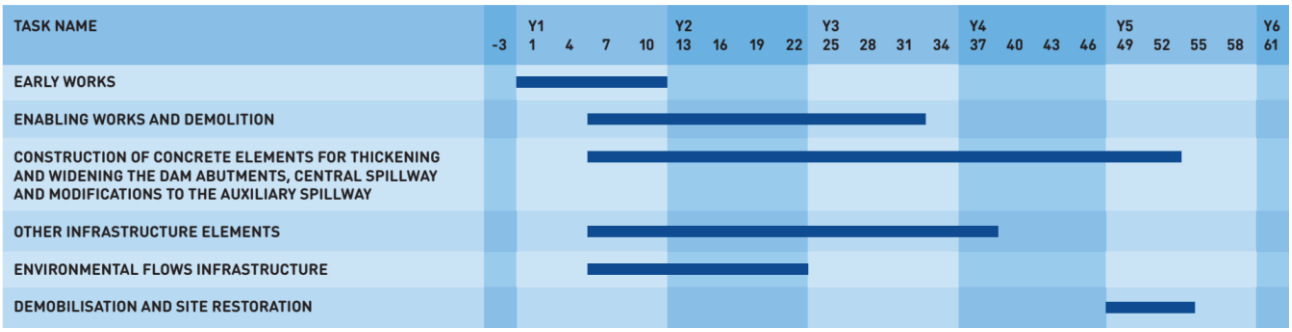
If the Project is approved, further detailed construction planning would take place prior to commencement of construction to inform preparation of a construction environmental management plan (CEMP). The CEMP would consider methods and the scheduling of activities to minimise impacts on the community and the environment such as noise, access, and amenity, and would detail mitigation and management measures.

Construction of the Project would not directly impact upon World Heritage Areas and therefore no detailed information on the construction methodology has been provided.

Construction program

A preliminary construction program is presented in Figure 1-6 with the Project anticipated to be completed between four to five years from commencement.

Figure 1-6. Preliminary construction program



2 Existing regional environment

This section provides general details on the regional environment in which the Project and associated GBMWHA are located. Specific consideration of the interaction of the GBMWHA and these features is provided in Section 4.

2.1 Warragamba Dam and catchment

Warragamba Dam is on a narrow gorge on the Warragamba River. The damming of Warragamba River, completed in 1960, flooded the Burragorang Valley creating Lake Burragorang. The lake's capacity (2,027 gigalitres) is about four times that of Sydney Harbour and provides about 80 per cent of Sydney's water supply (WaterNSW 2018a). At present the dam is 142 metres high and 351 metres long, which makes it one of the largest metropolitan water supply dams in the world (WaterNSW 2018a). The Warragamba Dam catchment represents 80 per cent of the total Hawkesbury-Nepean catchment at Penrith and 70 per cent of the total catchment at Windsor (INSW 2017).

Warragamba Dam itself is located outside of the GBMWHA but much of the Warragamba Dam catchment is within the GBMWHA.

2.2 Hawkesbury-Nepean catchment

The Hawkesbury-Nepean catchment covers an area of about 21,400 square kilometres (DECC & WaterNSW 2010). For the purposes of this assessment the catchment affected by the Project was divided into two areas: upstream (of Warragamba Dam) and downstream, each of which comprises several smaller catchments.

The upstream catchment area encompasses the five main tributaries which drain into Lake Burragorang: the Coxs, Kowmung, Wollondilly, Nattai, and Kedumba Rivers. The upstream catchment area comprises about 9,050 square kilometres (WaterNSW 2018b).

The downstream catchment encompasses five rivers and four major creeks. The five rivers are the Hawkesbury, Nepean, Grose, Colo, and Macdonald Rivers. The four major creeks are the Erskine, Webbs, South, and Cattai Creeks. The downstream catchment area comprises about 12,350 square kilometres.

2.3 Landform and topography

The upstream catchment has unique topographic features, including extensive dissected sandstone plateaux; the most extensive sandstone canyon system in eastern Australia; karst landscapes with several cave systems of importance; prominent basalt-capped peaks and other significant features associated with periods of volcanic activity; quaternary alluvial deposits which support significant heath and woodland vegetation; perched perennial freshwater lakes, and; steep, narrow valleys surrounding watercourses (GHD 2016). The upstream catchment generally consists of deep sandstone gorges, which reach an escarpment via a single tributary, the Warragamba River.

The topography downstream from Warragamba Dam consists of floodplains, undulating valleys, narrow constrained gorges at confluences of major rivers, as well as along the Hawkesbury River downstream from Sackville. Below the escarpment (and dam wall) the Warragamba River meets the Nepean River, which crosses the mid-catchment floodplain. Erskine Creek and the Grose River enter the Nepean River to the south of Richmond, just before the point at which the Nepean River meets the Hawkesbury River. From Richmond, the Hawkesbury River flows across the floodplain through Windsor, where South Creek enters, until it reaches the first narrow sandstone gorge of the downstream catchment at Sackville. From Sackville, the Hawkesbury River winds through the narrow gorges of the downstream catchment, along the way joined by Webb Creek and the Colo and MacDonald Rivers, before it opens out at Broken Bay. This contrasts with other coastal floodplains and river valleys, which tend to progressively widen as the river approaches the estuary.

2.4 Land use

Land use in the upstream catchment area comprises protected areas including the GBMWHA, several national parks (Blue Mountains, Kanangra-Boyd, Nattai), state conservation areas (Jenolan Karst, Yerranderie, Nattai, and Burragorang), 'Special Areas' and 'Controlled Areas' declared under the *Water NSW Act 2014*. For Warragamba Dam, minor land uses adjacent to protected areas include urban development, tourism facilities, grazing, forestry, agriculture, manufacturing, and mining.

Land use in the downstream catchment area is dominated by urban development, commercial and manufacturing services, with protected areas in the far east of the catchment.

2.5 2019-2020 bushfires

New South Wales, including the catchment of Lake Burragorang, experienced severe wildfire between 2019 and 2020. These bushfires are described as unprecedented in their extent and intensity affecting at least 5.4 million hectares (seven percent of NSW) including 27 percent of national park estate, more than 81 percent of the World Heritage listed Greater Blue Mountains Area and 54 percent of the NSW components of the Gondwana Rainforests of Australia World Heritage property (DPIE 2020). The most affected ecosystems were rainforests (37 percent of their state-wide extent), wet sclerophyll forests (50 percent) and heathlands (52 percent) (DPIE 2020). The fires affecting the study area began in late October 2019 in remote bushland near Lake Burragorang, near Yerranderie, and in Kanangra-Boyd National Park. Due to the extreme isolation of the area and rugged 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. A total of 278,700 hectares in the Wollondilly area were affected by this fire 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.

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 in order to determine the extent, severity, and impact of the bushfires on native vegetation. This has produced the following mapping:

- Google Earth engine burnt area map (GEEBAM), which was developed in collaboration with University of NSW, was developed as a rapid mapping approach which detected how badly the tree canopy had burnt by measuring the change in colour in vegetation before and after fire (DPIE 2020). 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 2020).
- Fire extent and severity map (FESM), which was developed in collaboration with the RFS, was developed as a semi-automatic approach to mapping fire extent and severity through a machine learning framework based on Sentinel 2 satellite imagery (DPIE 2020). 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 2020). 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 the FESM be used in preference to 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. A description of each class, and the approximate extent (in terms of percentage area) of each burn severity class within the upstream study area and upstream impact area is provided in Table 2-1. The area of each burn severity class within the World Heritage area for the upstream study area and upstream impact area is provided in Table 2-2.

The extent of the fires and the burn severity with regard to the upstream study area and the broader upstream catchment is shown in Figure 2-1.

Table 2-1. FESM burn severity classes and approximate burn extent within the upstream study area and upstream impact area

Severity class	Description	Percent foliage fire affected	% of upstream study area	% of upstream impact area
Unburnt	Unburnt surface with unburnt canopy	0% canopy and understory burnt	26.9%	30.2%
Low	Burnt understory with unburnt canopy	>10% burnt understory >90% green canopy	27.7%	35.4%
Medium	Partial canopy scorch	20-90% canopy scorch	35.6%	25.4%
High	Full canopy scorch/partial consumption	>90% canopy scorched <50% canopy consumed	5.3%	4.6%
Extreme	Full canopy consumption	>50% canopy biomass consumed	4.5%	4.4%

Figure 2-1. Extent of 2019-2020 bushfires

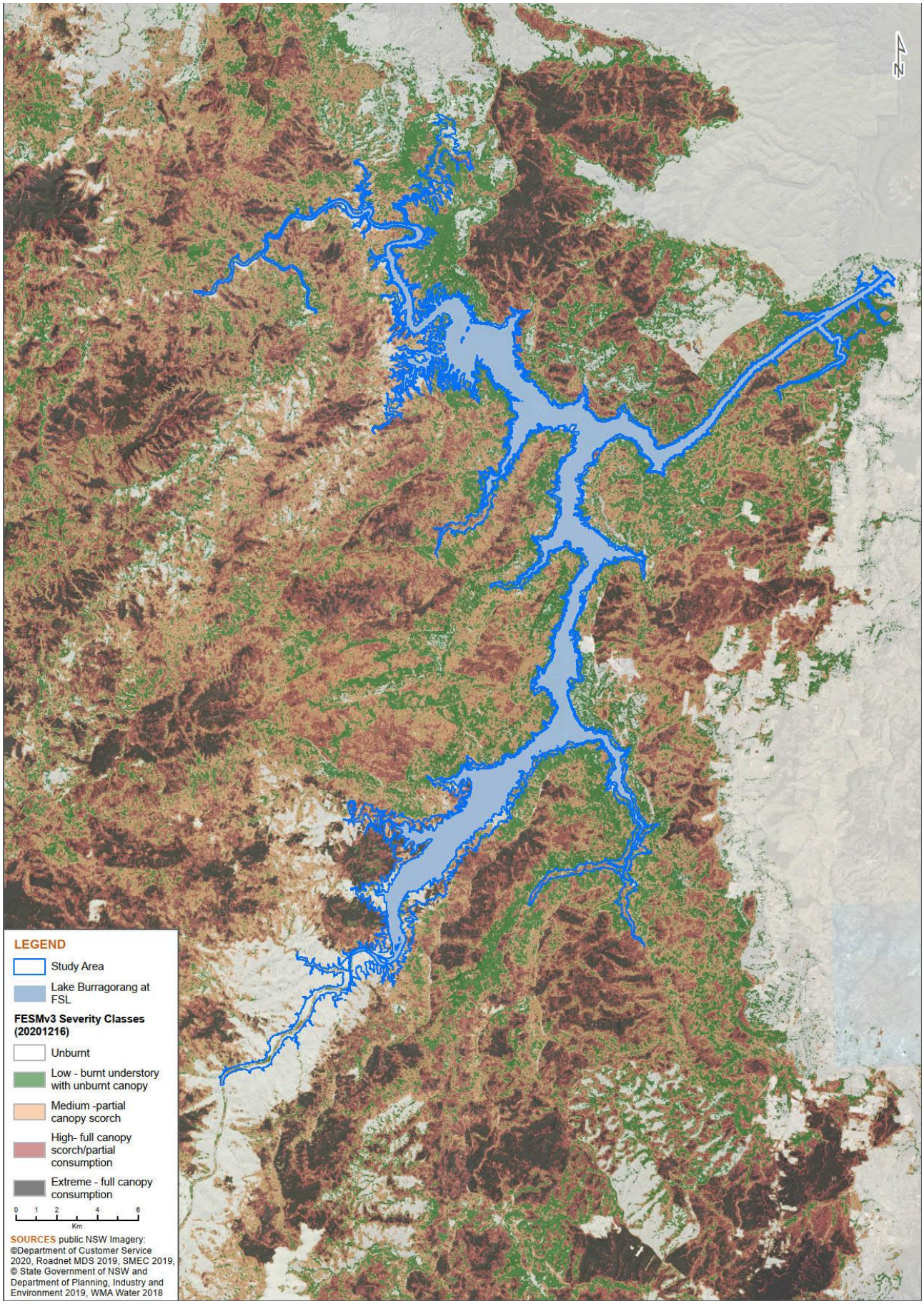


Table 2-2. FESM burn severity classes and approximate burn extent within the GBMWHA

Severity class	Description	Percent foliage fire affected	GBMWHA in upstream study area (ha/%)	GBMWHA in upstream impact area (ha/%)
Unburnt	Unburnt surface with green canopy	0% canopy and understory burnt	358 (28.8%)	98 (32.4%)
Low	Burnt understory with unburnt canopy	>10% burnt understory >90% green canopy	504 (40.5%)	56 (18.5%)
Medium	Partial canopy scorch	20-90% canopy scorch	237 (19.1%)	114 (37.5%)
High	Complete canopy scorch (+/- partial canopy consumption)	>90% canopy scorched <50% canopy consumed	78 (6.2%)	18 (6.1%)
Extreme	Complete canopy consumption	>50% canopy biomass consumed	67 (5.4%)	17 (5.6%)

The area of the GBMWHA within the upstream study area was relatively unaffected by the 2019-2020 bushfire event. Table 2-2 shows that less than 12 percent of the GBMWHA in the upstream study area experienced 'High' or 'Extreme' burning and almost 70 percent experienced 'Low' or no burning. The area of the GBMWHA within the upstream impact area was also relatively unaffected by severe burning with only about 12 percent mapped as 'High' or 'Extreme' and about 51 percent mapped as 'Low' or 'Unburnt'.

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 2020). According to this mapping, the majority of the upstream 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 earlier major wildfire events: 1964-65 1994-95 1997-98 and 2001-02 (DPIE 2020).

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 2020). Post-fire studies have found that a number of species (both threatened and not currently threatened) have had their entire global populations burnt in the 2019-2020 fires (DPIE 2020). This includes some species and ecological communities that are known to be sensitive to severe fire (DPIE 2020). 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 extirpated or significantly reduced in density over their affected ranges. Other ecological inputs following fire, 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.

This notwithstanding, a number of threatened ecological communities, threatened species, and non-threatened species are considered to have been disproportionately impacted by the 2019-2020 bushfires. The Department of Agriculture, Water and the Environment (DAWE)[2] has released an initial list of threatened and migratory species which have 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.

Of this list, 58 species either recorded during field surveys carried out for the Project, or predicted to occur based on habitat preferences, within the study area, including:

- Regent Honeyeater *(Anthochaera phrygia)*
- Spot-tailed Quoll *(Dasyurus maculatus)*

[2] The Department of Agriculture, Water and the Environment (DAWE) commenced operation on 1 February 2020, incorporating the Environment portfolio within the former Department of Energy and the Environment (DoEE).

- Black-faced Monarch *(Monarcha melanopsis)*
- Gang-gang Cockatoo *(Callocephalon fimbriatum)*
- Rockwarbler *(Origma solitaria)*
- Pilotbird *(Pycnoptilus floccosus)*
- Superb Lyrebird *(Menura novaehollandiae)*
- Red-browed Treecreeper *(Climacteris erythrops)*
- Koala *(Phascolarctos cinereus)*
- Yellow-bellied Glider *(Petaurus australis)*
- Greater Glider *(Petauroides volans)*
- Brush-tailed Rock-wallaby *(Petrogale penicillate)*
- Long-nosed Potoroo *(Potorous tridactylus tridactylus)*
- New Holland Mouse *(Pseudomys novaehollandiae)*
- Grey-headed Flying-fox *(Pteropus poliocephalus)*
- Golden-tipped Bat *(Phoniscus papuensis)*
- Platypus *(Ornithorhynchus anatinus)*
- Broad-headed Snake *(Hoplocephalus bungaroides)*
- Southern Water-skink *Eulamprus tympanum*
- Broad-tailed Gecko *(Phyllurus platurus)*
- Giant Burrowing Frog *(Heleioporus australiacus)*

A total of 709 plant taxa were prioritised as being at high risk from the impacts of these 2019-20 bushfires. Of these, 471 plant species have been identified by experts as the highest priorities for urgent management intervention in the weeks and months following these 2019-2020 bushfires to support recovery. These species were all already listed as critically endangered or endangered under the EPBC Act or equivalent state legislation, or had more than 80 percent of their range burnt, or were identified as at high risk under two or more prioritisation criteria requiring unique management actions. These 471 high priority plant species are from 127 genera and occur in a variety of vegetation types. One hundred and three of these priority plant taxa are either known to occur or predicted likely to occur within the upstream study area.

Table 2-3 lists the areas mapped as ‘moderate’, ‘high’ and ‘extreme’ under the FEMS mapping for each PCT in the upstream study area occurring in the upstream impact area. These are expressed as hectares and as a percentage of the PCT area within the upstream impact area.

Further assessment of the bushfire event on relevant priority-listed species is provided in Section 6.1.22.

Table 2-3. FEMS bushfire severity mapping (moderate to extreme) for upstream impact area

BVT code	Plant community type	Protection status*	Impact area	
			ha	%
HN517 (PCT 769)	Coachwood - Lilly Pilly warm temperate rainforest in moist sandstone gullies, Sydney Basin Bioregion	None	0.01	1.9
HN525 (PCT 832)	Forest Red Gum–Narrow-leaved Ironbark open forest of the southern Blue Mountains gorges Sydney Basin Bioregion	None	44.23	52.5.9
HN527 (PCT 840)	Forest Red Gum–Yellow Box woodland of dry gorge slopes southern Sydney Basin Bioregion and South Eastern Highlands Bioregion	CE - EPBC Act E - TSC Act	64.17	50.2
HN532 (PCT 860)	Grey Gum–Broad-leaved Ironbark dry open forest on gorge slopes on the Blue Mountains Sydney Basin Bioregion	None	73.63	32.6
HN533 (PCT 862)	Grey Gum - Hard Leaved Scribbly Gum woodland of the Cox River Valley	None	7.77	70.8
HN535 (PCT 870)	Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountain gorges Sydney Basin Bioregion	None	7.40	33.4
HN536 (PCT 871)	Grey Gum shrubby open forest on gorge slopes of the Blue Mountains Sydney Basin Bioregion	None	64.15	30.1
HN537 (PCT 875)	Grey Myrtle–Lilly Pilly dry rainforest in dry gullies of the Sydney Basin Bioregion and South East Corner Bioregion	None	0.26	4.7
HN538 (PCT 877)	Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East corner Bioregion	None	13.07	46.5
HN553 (PCT 941)	Mountain Blue Gum–Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion	E - TSC Act	42.16	39.4
HN557 (PCT 1401)	Narrow-leaved Ironbark–Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion	CE - EPBC Act E - TSC Act	182.44	60.2
HN564 (PCT 1081)	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	None	0.00	0
HN566 (PCT 1083)	Red bloodwood -scribbly gum heathy woodland on sandstone plateaux of the Sydney basin Bioregion	None	1.46	5.1
HN568 (PCT 1086)	Red Bloodwood–Sydney Peppermint–Blue-leaved Stringybark heathy forest of the southern Blue Mountains, Sydney Basin Bioregion	None	3.15	10.1
HN574 (PCT 1105)	River Oak open forest of major streams Sydney Basin Bioregion and South East Corner Bioregion	None	21.39	31.8
HN598 (PCT 1246)	Sydney Peppermint - Grey Gum shrubby open forest of the western Blue Mountains, Sydney Basin Bioregion	None	1.89	19.5
HN606 (PCT 1284)	Turpentine–smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion	None	0.40	1.1
HN607 (PCT 1292)	Water Gum–Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion	None	3.40	4.6

* E: Endangered; CE: Critically Endangered

3 Statutory and legislative context

3.1 The World Heritage Convention

The *Convention Concerning the Protection of World Cultural and Natural Heritage 1972* (the Convention), also referred to as the World Heritage Convention, provides State Parties (countries) with guidance on how to identify potential sites for inscription onto the World Heritage List, and what is required of each State Party in the protection and preservation of such sites. Signatories to the Convention pledge to conserve World Heritage sites situated on their territory, and to take active measures to protect their national heritage. The Convention aims to promote international cooperation to protect heritage that is of such outstanding universal value that its conservation is important for current and future generations. The Convention also sets out the criteria that a site must meet to be inscribed on the World Heritage List.

Encouragement is provided to each of the State Parties to ensure that the protection of world and national heritage is integrated into relevant planning process and programs, and provide sufficient resourcing to protect, conserve, and communicate the significant values of each place.

The United Nations Educational, Scientific and Cultural Organisation (UNESCO), summarises the importance of the Convention by stating:

> *The most significant feature of the 1972 World Heritage Convention is that it links together in a single document the concepts of nature conservation and the preservation of cultural properties. The Convention recognizes the way in which people interact with nature, and the fundamental need to preserve the balance between the two.*

The World Heritage Committee is responsible for the implementation of the World Heritage Convention. The committee meets once a year and consists of representatives from 21 of the States Parties to the Convention elected by their General Assembly. In 2019 at the 43rd Ordinary Session of the World Heritage Committee, the committee adopted a decision (N 917) relating to the Project and its potential impacts with regard to the GBMWHA. This is discussed further in Section 7.

3.2 International Union for Conservation of Nature

The International Union for Conservation of Nature (IUCN) is an international organisation based in Switzerland, involved in nature conservation and the sustainable use of natural resources. There are some 1400 member organisations including a number from Australia such as DAWE and the Blue Mountains World Heritage Institute.

The IUCN has published an Advice Note (IUCN 2013) to provide guidance on integrating natural World Heritage sites into environmental assessments. Section 3 of the Advice Note states:

> *An Environmental Assessment for a proposal affecting, or with the potential to affect, a natural World Heritage Site is intended to ensure that the proposal's likely impacts on the Outstanding Universal Value of the site are fully considered in land-use planning decisions with the objective of preserving these exceptional places for future generations. The assessment should also consider the site's links with the surrounding landscape as a natural World Heritage Site cannot be considered separately from the wider ecosystem.*

Section 4 of the Advice Note states that where developments affecting a natural World Heritage Site are under consideration, these should be subject to a rigorous environmental assessment, in line with the eight World Heritage Impact Assessment Principles. Further, reasonable alternatives to the proposal should be identified and assessed with the aim of recommending the most sustainable option to decision-makers, including in some cases the 'no project' option.

The eight World Heritage Impact Assessment Principles are as follows:

- Principle 1: All proposals that may adversely affect a natural World Heritage Site must undergo a rigorous Environmental Assessment early on in the decision-making process, whether they are located within or outside its boundaries.
- Principle 2: Experts with World Heritage, protected area and biodiversity knowledge must be closely involved in the assessment process in order to identify the issues that will need to be assessed.
- Principle 3: The likely environmental and social impacts of the development proposal on the site's Outstanding Universal Value must be assessed, including direct, indirect and cumulative effects.

- Principle 4: Reasonable alternatives to the proposal must be identified and assessed with the aim of recommending the most sustainable option to decision-makers.
- Principle 5: Mitigation measures should be identified in line with the mitigation hierarchy, which requires first avoiding potential negative impacts and secondly reducing unavoidable residual impacts through mitigation measures.
- Principle 6: A separate chapter on World Heritage must be included in the Environmental Assessment.
- Principle 7: The assessment must be publicly disclosed and subject to thorough public consultation at different stages.
- Principle 8: An Environmental Management Plan must be proposed, implemented and independently audited.

Consideration of the potential impacts of the Project on the GBMWHA with regard to these eight principles is provided in Section 8.

3.3 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides a legislative framework for the protection and management of matters of national environmental significance including flora, fauna, ecological communities, and heritage places of national and international importance. Heritage places are protected through their inscription on the World Heritage List (WHL), Commonwealth Heritage List (CHL) and/or the National Heritage List (NHL).

Under Part 9 of the EPBC Act, approval under the EPBC Act is required for any action occurring within, or outside, a heritage place that has, will have, or is likely to have a 'significant impact' on the heritage values of a world, national or Commonwealth heritage listed property (referred to as a 'controlled action' under the Act). A 'significant impact' is defined as:

> *an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.*

The EPBC Act stipulates that a person who has proposed an action that will, or is likely to, have a significant impact on a site that is listed on the World Heritage List, National Heritage List, or Commonwealth Heritage List, must refer the action to the relevant Minister (hereafter the Minister). The Minister will then determine if the action requires approval under the EPBC Act. If approval is required, an environmental assessment would need to be prepared. The Minister approves or declines the action based on this assessment.

The significance of the action is based on the sensitivity, value, and quality of the environment that is to be impacted, and the duration, magnitude, and geographic extent of the impact. If the action is to be undertaken in accordance with an accredited management plan, approval is not needed, and the matter does not need referral to the Minister.

Impacts to places listed on the World, National, and Commonwealth Heritage Lists have been assessed in accordance with the *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1* (DoE 2019).

The Project was referred (EPBC Act referral 2017/7940) to the then Australian Government Department of the Environment and Energy[3] (DoEE) under the EPBC Act and was deemed to be a controlled action due to potentially significant impacts to world heritage properties and national heritage places (as well as listed threatened species and communities).

3.3.1 Bilateral agreement made under Section 45 of the EPBC Act

The Australian Government provides the following statement on the bilateral agreement:

> *The bilateral agreement between the Commonwealth of Australia and the State of New South Wales relating to environmental assessment (the assessment bilateral agreement), allows the Commonwealth Minister for the Environment to rely on specified environmental impact assessment processes of the State of New South Wales in assessing actions under the EPBC Act.*

[3] The Environment portfolio within DoEE was transferred to the new Department of Agriculture, Water and the Environment (DAWE) which commenced operation on 1 February 2020. References to DoEE in this report should also be taken to refer to DAWE as relevant.

> *The current agreement enhances the streamlining benefits of the One-Stop Shop in advance of an approval bilateral agreement commencing. The current agreement will deliver on the objective of promoting efficient, thorough and transparent environmental regulation while minimising duplication*.[4]

The bilateral agreement allows the assessments of matters addressed under the EPBC Act through the formally accredited NSW process cited in the agreement. For development, this means a single assessment process is followed, instead of the former dual Commonwealth/State processes. The Australian Government has provided guidelines and identified key issues which must be addressed in the EIS for the Project. These have been included in the Secretary's Environmental Assessment Requirements prepared under EP&A Act, and are further discussed in Section 3.4.1.

3.3.2 Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1

The *Matters of National Environmental Significance Significant Impact Assessment Guidelines 1.1* (Impact Guidelines) provide overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under the EPBC Act, including the assessment of impacts to such matters as:

- listed threatened species and ecological communities
- World Heritage properties
- national heritage places.

The Impact Guidelines state that:

> *Approval under the EPBC Act is required for any action occurring within or outside a declared World Heritage property that has, will have, or is likely to have a significant impact on the World Heritage values of the World Heritage property.*
>
> *An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:*
>
> - *one or more of the World Heritage values to be lost*
> - *one or more of the World Heritage values to be degraded or damaged, or*
> - *one or more of the World Heritage values to be notably altered, modified, obscured or diminished.*

The approach above is also used in assessing impacts to places of national heritage significance.

3.3.3 World, national, and Commonwealth heritage principles

Under the EPBC Act, actions that have, will have, or are likely to have a significant impact on the values of a world, national, or Commonwealth heritage property must be in line with the Heritage Principles, as presented in Schedules 5, 5B, and 7B of the EPBC Act Regulations respectively.

The guiding statement for the three sets of principles is *'…to identify, protect, conserve, present and transmit, to all generations…'*[5] the values of the places on each list, and in the case of the WHL, '*…if appropriate, rehabilitate the World Heritage values of the property*.'[6]

3.3.4 World Heritage List

The Convention sets out the criteria that a site must meet to be inscribed on the World Heritage List (WHL) and the role of State Parties in the protection and preservation of world and their own national heritage. Places on the World Heritage List are protected in Australia through the EPBC Act.

The study area is located partially within the curtilage of three places listed on the WHL, as summarised in Table 3-1 and illustrated on Figure 3-1 and Figure 3-2.

[4] http://www.environment.gov.au/protection/environment-assessments/bilateral-agreements/nsw. Accessed 19/10/2017.

[5] National Heritage Management Principles. Accessed at http://www.austlii.edu.au/cgi-bin/viewdoc/au/legis/cth/consol_reg/epabcr2000697/sch5b.html on 23/10/2017

[6] Australian World Heritage Management Principles. Accessed at http://www.austlii.edu.au/cgi-bin/viewdoc/au/legis/cth/consol_reg/epabcr2000697/sch5.html on 23/10/2017

Table 3-1. World Heritage places within the Project study area

Name	Place ID*	Status	WH criteria	Address	Relationship to the study area
The Greater Blue Mountains Area	105127	Declared property	ix, x	Great Western Hwy, Katoomba NSW	About 1,675 hectares of GBMWHA in upstream study area About 351 hectares of GBMWHA in downstream study area Total area of GBMWHA is 1,032,649 hectares
Australian Convict Sites (Old Great North Road)	106209	Declared property	iv, vi	The Old Great Northern Rd, Wisemans Ferry NSW	About 1.1 hectares in downstream study area
Australian Convict Sites (Old Great North Road Buffer Zone)	106209	Buffer zone	iv, vi	The Old Great Northern Rd, Wisemans Ferry NSW	About 1.1 hectares in downstream study area

**Australian Heritage Database ID Number*

The general criteria that the World Heritage Committee found that the GBMWHA met for listing are:

- **Criterion ix** - to be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals;
- **Criterion x** - to contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

These criteria, which form part of the Outstanding Universal Value (OUV) for the site, were used to develop the specific values for the GBMWHA which are discussed further in Section 6.1.1.

The general criteria that the World Heritage Committee found that the Australian Convict sites met for listing are:

- **Criterion iv** - to be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history
- **Criterion vi** - to be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance.

These criteria were used to develop the specific values for the Australian Convict sites which are discussed further in Section 6.3.

Figure 3-1. Greater Blue Mountains World Heritage Area upstream of Warragamba Dam with the upstream study area, national parks, state conservation areas and Schedule 1 Special Area

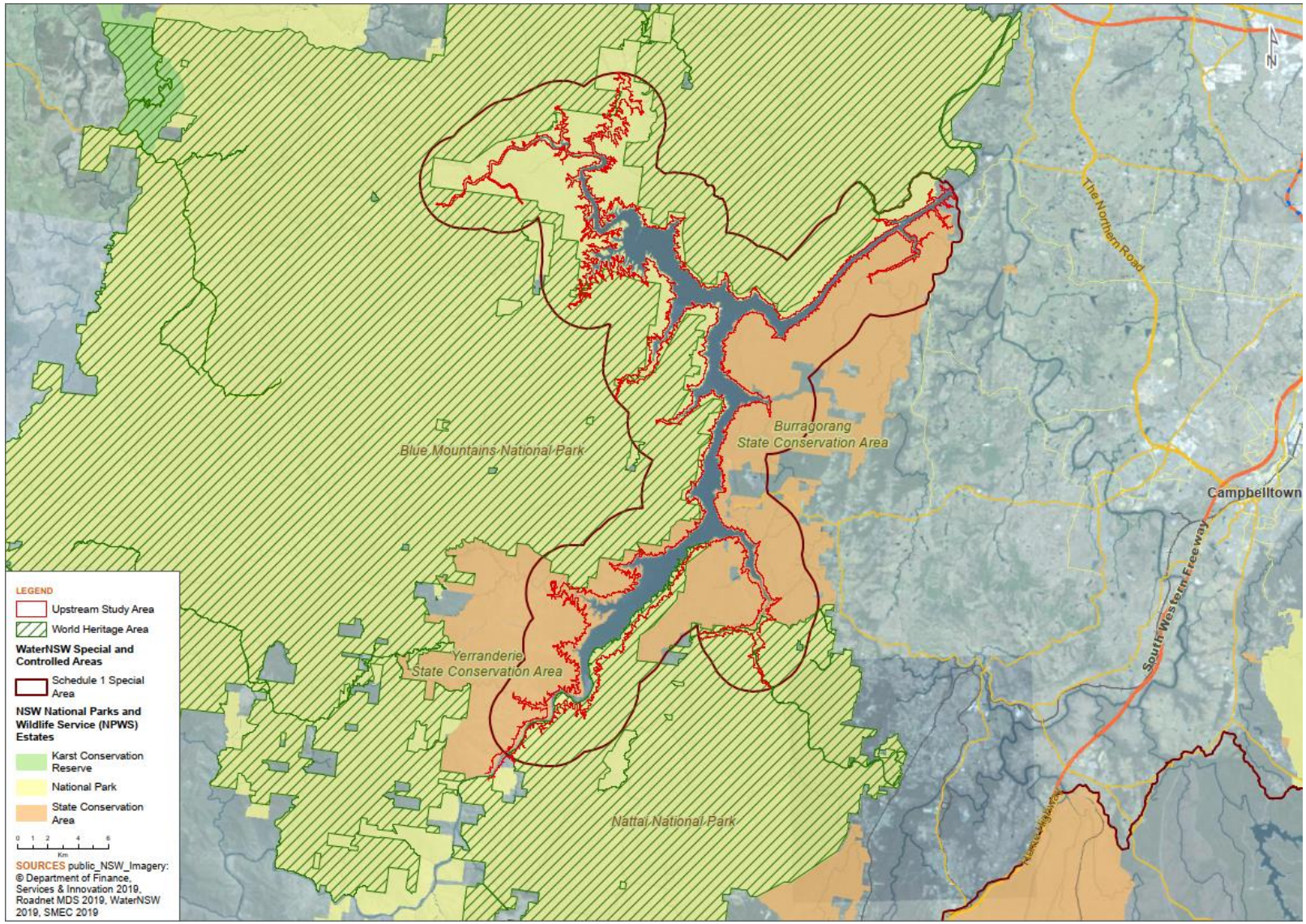


Figure 3-2. World Heritage areas in relation to the downstream study area (existing PMF)

3.3.5 Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy

The *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DoSEWPaC 2012) (Environmental Offsets Policy) outlines the Australian Government's approach to biodiversity offsets under the EPBC Act. The policy defined offsets as measures that compensate for the residual adverse impacts resulting from an action on the environment. The policy ensures that the process around determining the suitability of an offset is transparent. The suitability of a proposed offset is considered as part of the decision as to whether or not to approve a proposed action under the EPBC Act.

The Environmental Offsets Policy relates to all matters protected under the EPBC Act. For the Project, these matters are:

- World Heritage properties
- National heritage places
- listed threatened species and ecological communities.

Section 2.1 of the Environmental Offsets Policy notes

> *The use of offsets to compensate for adverse impacts to heritage values is appropriate in some circumstances. In cases where offsetting of adverse impacts on heritage values is considered possible and appropriate, the principles of this policy apply with regard to determining what constitutes a suitable offset. Offsets for impacts on heritage values should improve the integrity and resilience of the heritage values of the property involved. This may include offsets in areas adjacent to the property.*

There are two types of offsets under the policy:

- Direct Offset: Direct offsets are actions that provide a measurable conservation gain for an impacted protected matter. A minimum of 90 percent of the offset requirements for any given impact must be met through direct offsets. Direct offsets benefit from conservation gains delivered to the protected matter. Conservation gains can be achieved by:
  - Improving existing habitat for a protected matter
  - Creating new habitat for a protected matter
  - Reducing threats to a protected matter
  - Increasing values of a heritage place
  - Averting the loss of a protected matter or its habitat under threat.
- Compensatory measures: Compensatory measures are actions that do not directly offset the impacts on the protected matter but are expected to lead to benefits for the impacted protected matter. Compensatory measures may include research or educational programs.

Suitable offsets under the policy meet must eight requirements as discussed as follows.

Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter

Offsets must deliver a conservation outcome that improves or maintains the viability of the protected matter though directly contributing to its ongoing viability as compared to what would have likely happened under the status quo. This is achieved though offsets which specifically relate to the attribute of the protected matter impacted by the proposal. Offsets must:

- not be traded across different protected matters
- adequately compensate for the specific residual impact
- meet, as a minimum, the quality of the habitat on the impact site.

Suitable offsets must be built around direct offsets but may include other compensatory measures

Offsets should take the form of direct offsets over compensatory measures. Direct offsets should make up a minimum of 90 percent of the offset requirement, with compensatory measures making up to a minimum of 10 percent of the offset requirement. Where possible, an offset should reflect key priority actions for the protected matter, with higher priority action preferred over low priority actions.

Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter

Offsets for protected matters with a higher conservation status must be higher than offsets for protected matters with a lower conservation status. This is to account for the higher risk involved with protecting matters of greater conservation significance.

Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter

Offsets must adequately compensate for the impacts on the protected matter by being of proportionate size and scale of the residual impacts. The size and scale of the offset is determined by a number of different considerations, including but not limited to:

- level of statutory protection
- lag time between impact and the conservation gain of the offset
- risk of conservation gain not being achieved.

Suitable offsets must effectively account for and manage the risks of the offset not succeeding

Offsets should sufficiently consider the risk of the offsets not succeeding. This could be achieved by taking into account the nature of the impact, as well as the type, size, location, and timing of the offset.

Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs

Offsets must deliver a conservation gain which is new or additional to what is already required by a duty of care, or as a result of any other environmental planning laws at any level of government or paid for under other conservation schemes or programs. Where there is overlap between state and federal offset requirements, a state offset may count towards an offset under EPBC requirements to the extent to which it compensates for the residual impact on the protected matter.

Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable

Offsets which are most efficient and effective are those which maintain or improve the viability of the protected matter though the sound allocation of resources and aligned offset requirements. Offsets must also be implemented either before or at the same point in time as the impact arising from the action. Lastly, offsets must be based on scientifically rigorous, robust, and transparent information which documents how the offset benefits the protected matter.

Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced

The delivery of offsets must include appropriate and transparent governance arrangements. They must also be delivered with an appropriate monitoring, compliance, and audit program. Annual reports must track the success of the offset so that the condition of approval as varied if the offsets are not delivering their desired outcome.

3.4 NSW legislation

3.4.1 Environmental Planning and Assessment Act 1979

Section 5.12(2) of the EP&A Act provides that a State Environmental Planning Policy (SEPP) may declare any development or class of development to be SSI, which requires approval from the NSW Minister for Planning under section 5.14 of the EP&A Act.

The Project is SSI and accordingly requires approval from the NSW Minister for Planning and Public Spaces under Part 5, Division 5.2 of the EP&A Act for the reasons set out as follows:

- State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP) provides that works for the purpose of water storage facilities (clause 125(2)) and flood mitigation (clause 50(1)) could be undertaken by WaterNSW without obtaining development consent under Part 4 of the EP&A Act
- clause 14(1) of State Environmental Planning Policy (State and Regional Development) 2011 (State and Regional Development SEPP) declares development to be SSI if the development is permissible without consent under

Part 4 of the EP&A Act and is a type of development specified in Schedule 3 to the State and Regional Development SEPP. Schedule 3 includes:

- clause 1(1) Infrastructure or other development that … would be an activity for which the proponent is also the determining authority and would, in the opinion of the proponent, require an environmental impact statement to be obtained under Part 5 of the Act
- clause 4(1) development for the purposes of water storage … carried out by or on behalf of a public authority that has a capital investment value of more than $30 million.

WaterNSW prepared a preliminary environmental assessment (PEA) report for the Project under section 5.15 of the EP&A Act (WaterNSW 2016b). The PEA described the Project, identified and considered the potential environmental issues. The purpose of the PEA was to inform the request for the SEARs for the Project. The SEARs were issued by DPIE on 30 June 2017 and re-issued on 13 March 2018.

The SEARs contain assessment requirements for potential impacts on World Heritage areas. The relevant SEARs are provided in Table 1-1.

3.4.2 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act) provides for the protection of Aboriginal sites and designated conservation areas as well as the flora and fauna within conservation areas. Conservation areas include national parks, state conservation areas and regional parks.

The areas of the GBMWHA potentially impacted by the Project are contained within the Blue Mountains National Park, Nattai National Park, and Yengo National Park.

The areas of the Old Great North Road potentially impacted by the Project are contained within the Dharug National Park.

Under section 153B of the NPW Act, the relevant Minister is prohibited from granting a lease, licence, easement or right of way for the purposes of inundation of any land which is protected under the NPW Act and is land to which the *Sydney Water Catchment Management Act 1998* applies. The *Water NSW Amendment (Warragamba Dam) Bill 2018* assented in October 2018, amended the *Water NSW Act 2014* to make provision with respect to the temporary inundation of national park land resulting from the raising of the wall of Warragamba Dam and the operation of the dam for downstream flood mitigation purposes. This is further discussed in Section 3.4.4.

Potential impacts to Aboriginal heritage items and locations within the GBMWHA are assessed in Section .

3.4.3 Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) was repealed when the *Biodiversity Conservation Act 2016* commenced on 25 August 2017. However transitional arrangements allow SSI projects to be considered under previous legislation if the SEARs were issued before 25 August 2017. The initial SEARs for the Project were issued on 30 June 2017 and therefore the TSC Act still applies.

The TSC Act provides for the identification, conservation and recovery of threatened species and their populations and communities. A licence/approval is required under the Act, the NPW Act or the EP&A Act for any action which would harm a threatened species, population, or ecological community.

There are threatened ecological communities (TECs) and threatened flora and fauna species in the in the World Heritage areas that are potentially impacted by the operation of the Project. The presence and impacts of the project on TECs and threatened flora and fauna species are assessed in Section 5. Mitigation measures to minimise negative impacts are also discussed in this section.

3.4.4 Water NSW Act 2014

The *Water NSW Act 2014* (WNSW Act) establishes the powers and functions of WaterNSW and allows areas associated with water supply to be declared as special or controlled areas. These areas may include the catchment of water storages or other land used for water supply purposes (for example, pipeline and dam sites). Development and access to special or controlled areas can be restricted and can require approval from WaterNSW. Catchment special areas for Warragamba Dam were established before the GBMWHA was world heritage listed in 2000 and are shown in Figure 3-1. Large areas of the Warragamba Dam special areas overlap with the GBMWHA and associated NSW national parks.

In 2018, the *Amendment of Water NSW Act 2017* was enacted to make provision with respect to the temporary inundation of national park land resulting from the raising of the wall of Warragamba Dam and the operation of the dam for downstream flood mitigation purposes. Part 5A special provisions relating to Warragamba Dam was inserted into the legislation.

The special provisions included in sections 64C to 64F require:

- WaterNSW to prepare an environmental management plan (EMP) in consultation with DPIE, Environment Energy and Science group (former Office of Environment and Heritage, OEH) 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 WaterNSW 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 to implement and monitor the EMP
- Water NSW to notify DPIE, Environment Energy and Science group (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.

The areas of the GBMWHA potentially impacted by the Project are contained within National Parks and therefore would be subject to the special provisions including the EMP. The EMP would also consider national parks/state conservation areas outside the GBMWHA which are also potentially impacted by the Project. The EMP would need to be consistent with the existing management plans for the national parks and GBMWHA.

3.4.5 Wilderness Act 1987

The objectives of the *Wilderness Act 1987* (Wilderness Act) are:

- to provide for the permanent protection of wilderness areas
- to provide for the proper management of wilderness areas
- to promote the education of the public in the appreciation, protection, and management of wilderness.

Development cannot occur in a wilderness area subject to a wilderness protection agreement or conservation agreement unless subject to written consent under section 15 of the Wilderness Act from the Minister administering the Act. Development under the Wilderness Act is defined as 'the use of that area' and temporary inundation could be defined in this way. Some areas of the GBMWHA potentially impacted by the Project are in the Nattai and Kanangra-Boyd Wilderness Areas and would experience increased temporary inundation due to the operation of the Project. However, these areas are not subject to either a wilderness protection agreement or conservation agreement. Therefore, consent, under section 15 of the Wilderness Act from the Minister administering the Act, is not required.

4 Potential changes in hydrology and flooding

In any consideration of potential impacts associated with the Project, it is important to remember that there is already a potential flooding impact associated with the existing dam, and therefore the focus of the assessment is on the potential incremental impact associated with the Project.

This section provides a detailed discussion of the potential changes in hydrology and flooding associated with the Project for both the upstream and downstream environments. Further details are also provided in Appendix H1 (Flooding and Hydrology Assessment) and Chapter 15 (Flooding and Hydrology) of the EIS.

4.1 Methodology for flooding assessment

The flood modelling carried out for the Project is discussed in detail in Appendix H1 (Section 2.3). This describes the assessment methodology, data requirements and selection of computer simulation models. Modelling involved the use of a hydrological model to develop the inflow hydrographs to a hydraulic model to simulate the passage of various size floods through the river channels and floodplain to produce water levels and velocities.

A summary is provided as follows.

4.1.1 Hydrological model

The hydrological model simulates the rate at which rainfall runs off the catchment which is dependent on:

- catchment slope, area, vegetation, urbanisation, and other characteristics
- variations in the distribution, intensity, and amount of rainfall
- moisture conditions (dryness/wetness) of the catchment.

The interactive runoff and streamflow routing program RORB[7] was used for hydrological modelling with the catchment divided into 121 sub-areas. The model was calibrated to available streamflow and rainfall data, mainly at stations upstream of the dam, and the calibration parameters used to estimate suitable parameters in ungauged catchments in the downstream valley.

A special subroutine was added to the RORB program to model flows through Lake Burragorang, and which incorporates the gate operations at the dam. The subroutine was modified as part of the Regional Flood Study to also include simulation of the fuse plug operation on the auxiliary spillway (WMAwater 2019).

The model was calibrated to available streamflow and rainfall data, mainly at stations upstream of the dam, and the calibration parameters used to estimate suitable parameters in catchments in the downstream valley.

Outputs from the hydrological model are a series of flow hydrographs at selected locations, which are used by the hydraulic model to simulate the passage of various size floods through the river channels and floodplain to produce water levels and velocities. A modelling report was prepared that provided details of the data used, model development, and calibration and verification of the model (WMAwater 2019).

4.1.2 Hydraulic model

Hydraulic modelling of flood flows was carried out using the following models:

- *Upstream*: An existing MIKE11[8] one-dimensional hydraulic model, which was originally developed in the 1990s to assess flow behaviour prior to the dam construction. The MIKE11 model was used to assist in the calibration of the RORB model between the dam and the inflow gauges.
- *Downstream*: A quasi two-dimensional RUBICON model (hydrodynamic model software used to quantify the hydraulic aspects of flood behaviour) was used, which covered a river length of 360 kilometres and was

[7] RORB is a general runoff and streamflow routing program used to calculate flood hydrographs from rainfall and other channel inputs. The 'ROR' of 'RORB' stands for 'runoff routing'. The 'B' no longer has significance but at one time indicated that the program was developed and maintained on a Burroughs B6700 computer (RORB FAQ webpage).
Further information on RORB is available at https://www.monash.edu/engineering/departments/civil/research/themes/water/rorb

[8] MIKE 11 is a computer program that simulates flow and water level, water quality and sediment transport in rivers, floodplains, irrigation canals, reservoirs and other inland water bodies. Further information on the MIKE software suite is available from DHI Group.

calibrated and verified against 10 historical flood events. The model has been extensively reviewed and endorsed by numerous Australian and international experts (WMAwater 2019).

4.1.3 Modelling data and calibration

Data used in the modelling and location of data monitoring stations are discussed in detail in Appendix H1 (Section 2.3) and comprised the following:

- *Model cross sections*: model cross sections are generally located approximately one to two kilometres apart and the modelled branches extend up to where gauged inflows are recorded.
- *Rainfall data*: a comprehensive rainfall monitoring network has been installed in the catchment and in 1998 there were 93 pluviographs (real-time rainfall monitoring) and 376 daily rainfall gauges. For each calibration event a spatial pattern was created across the catchment. Temporal rainfall patterns were taken from available pluviographs for each event.
- *Stream flows*: there are over 100 stream gauging stations in the catchment. Ten representative gauging stations were chosen for use as calibration locations or for model verification.
- *Terrain*: a merged digital elevation model (DEM) was created across the catchment and was used to give an overview of the catchment and for calculation of the average slope of sub-catchments.
- *Dam operations and inflows*: WaterNSW supplied a daily time-series of Lake Burragorang lake levels from 1960 to 2017, and hourly time-series of releases for the period covering the calibration events.

Model calibration involved:

- increasing the number of model sub-areas
- calibrating the model at additional locations within the catchment
- inclusion of baseflows
- calibrating the model for significant flood events recorded in June 1964, June 1975, March 1978, August 1986, May 1988, August 1990, and August 1998. A plot of observed floods compared to Monte Carlo modelled events generally shows good correlation, and the model was deemed suitable for modelling potential Project impacts.

4.1.4 Approach to flood modelling

Every flood is different due to the variability in various factors including:

- *rainfall intensity and frequency*: the number of times, during a specified period of years, that rainfall of a certain magnitude or greater occurs
- *spatial pattern of rainfall*: where in the catchment rain falls
- *temporal pattern of rainfall*: when, during the event, rain falls
- *initial loss*: rain 'lost' at the beginning of an event through infiltration into the soil
- *pre-burst rainfall*: rain that occurs before the most intense storm burst
- *dam drawdown*: the level of Warragamba Dam before the start of an event
- *relative timings of dam inflows*: when water flows from rivers and streams to the dam
- *tides*: tidal influences in the Hawkesbury River.

To account for this variability, a Monte Carlo approach to modelling was undertaken. This involved varying the above factors, modelling the different scenarios and then statistically analysing the hydrographs.

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions.

The flood modelling framework and use of the Monte Carlo analysis considers antecedent conditions as a variable in the assessment of flooding conditions for existing and Project scenarios. Accordingly, the variability in both wet and dry conditions at the onset of flood producing rainfall is incorporated in the probabilistic estimation of the timing and response of surface water flows to rainfall, and subsequent estimation of peak flood levels and inundation extents.

About 20,000 model runs were undertaken to capture the variability in flood events. Using the Monte Carlo modelling approach, flood events along the whole flood frequency curve were generated. A detailed description of the Monte Carlo approach to modelling is provided in Appendix H1 (Section 2.4).

The Monte Carlo approach recognises that any design flood characteristic (e.g. peak flow) could result from a variety of combinations of flood-producing factors, rather than from a single combination. The approach mimics natural conditions in that the influence of all probability distributed inputs are explicitly considered, thereby providing a more realistic representation of the flood generation processes. The model outputs for a particular flood event with a specific chance of occurrence in any given year are therefore represented by an 'envelope' of events, which cover a wide range of flood durations and affected areas.

The hydraulic model is based on a series of discrete channel/floodplain cross sections that assume a uniform water level across the section perpendicular to the direction of flow. The model outputs include water level, flow rate and cross-section average flow velocity for each cross section for each model time-step. From these outputs, time-series of water levels, flow rates and flow velocities can be generated for each event, and peak values for each parameter identified, for each event simulated.

A slightly different approach was adopted for the upstream area. The MIKE11 model was not used to discretely simulate each of the Monte Carlo design flood scenarios. Rather, it was used to extract rating curves (flow-height relationships) under different dam raising scenarios. These rating curves were then used to derive hydrographs from flow inputs (from the RORB model) at all cross-sections for the 20,000 Monte Carlo runs of the existing dam and the Project. These hydrographs were then used to obtain estimates of inundation times upstream of the dam and to give an indication of the change in inundation time between the existing dam and the Project.

Flood modelling has considered a range of flood events up to the Probable Maximum Flood (PMF). The PMF is a hypothetical flood estimate relevant to a specific catchment whose magnitude is such that there is negligible chance of it being exceeded. It represents a notional upper limit of flood magnitude and no attempt is made to assign a probability of exceedance to such an event (Ball *et al.* 2019). The PMF is unlikely to occur in nature given the size of the Warragamba Dam catchment.

4.1.5 Climate change

There is strong evidence that increases in global temperatures will lead to an increase in the intensity of rare rainfall, and that extreme flooding globally has increased over the 20th century (CSIRO and BoM 2015, cited in WMAwater 2019). Climate change can alter flood behaviour in the Hawkesbury-Nepean system by changing:

- probability of long duration rainfall intensities
- storm type and frequency
- rainfall spatial and temporal patterns
- antecedent conditions
- dam levels prior to flood producing rainfall.

The interaction of these characteristics makes predicting the impact of climate change on flood behaviour complex (WMAwater 2019).

Nearly all major floods in the Hawkesbury-Nepean are caused by an east coast low or interaction of an east coast low with other rain-producing systems. An east coast low is an intense low-pressure weather system that can occur on average several times each year off the eastern coast of Australia. It is probable that climate change would cause the overall frequency of this weather system to change which may increase rainfall variability and intensity across the Hawkesbury Nepean catchment, and cause changes to flood regimes and dam operational protocols.

Flood modelling for the Hawkesbury-Nepean Valley Regional Flood Study (WMAwater 2019) considered four different climate change emission scenarios:

- 4.9 percent increase in rainfall (high emissions by 2030)
- 9.1 percent increase in rainfall (low emissions by 2090)
- 13.9 percent increase in rainfall (medium emissions by 2090)
- 18.6 percent increase in rainfall (high emissions by 2090).

The use of these emission scenarios for the flood modelling for the Project is in accordance with the approach recommended in Australian Rainfall and Runoff 2019 (and the previous 2016 version), and as required by the SEARs.

4.1.6 Truncation of flood extents

Figure 4-1 shows the depth-duration curves for representative SEARs events at the upstream-most cross section in the MIKE11 model on the Wollondilly River. The curves are essentially identical showing there is no material difference between the existing and Project curves at this location for all flood events shown.

Moving progressively downstream, the depth-duration curves start to diverge as shown in Figure 4-2 and Figure 4-3, reflecting the increasing influence of the Project. At cross section WOLLONDILLY_0 (about 10 kilometres downstream from cross section WOLLONDILLY_US_0), the depth-duration curve for the PMF has started to diverge and the curve for the 1 in 100 chance in a year event is also diverging slightly. At cross section WOLLONDILLY_3380, which is about a further 3.4 kilometres downstream, the divergence of the curves for the 1 in 10 chance in a year event and greater is clearly apparent. While not shown, a similar pattern occurs for the depth-duration curves for the Nattai River, Kowmung River and Coxs River.

The depth-duration curves were used to identify the cross sections beyond which the Project would not have any impact for the individual SEARs events. These locations were then used to truncate the flood events for the individual SEARs events to assess the potential impacts of the Project.

Figure 4-1. Depth-duration curves for SEARs events at WOLLONDILLY_US_0

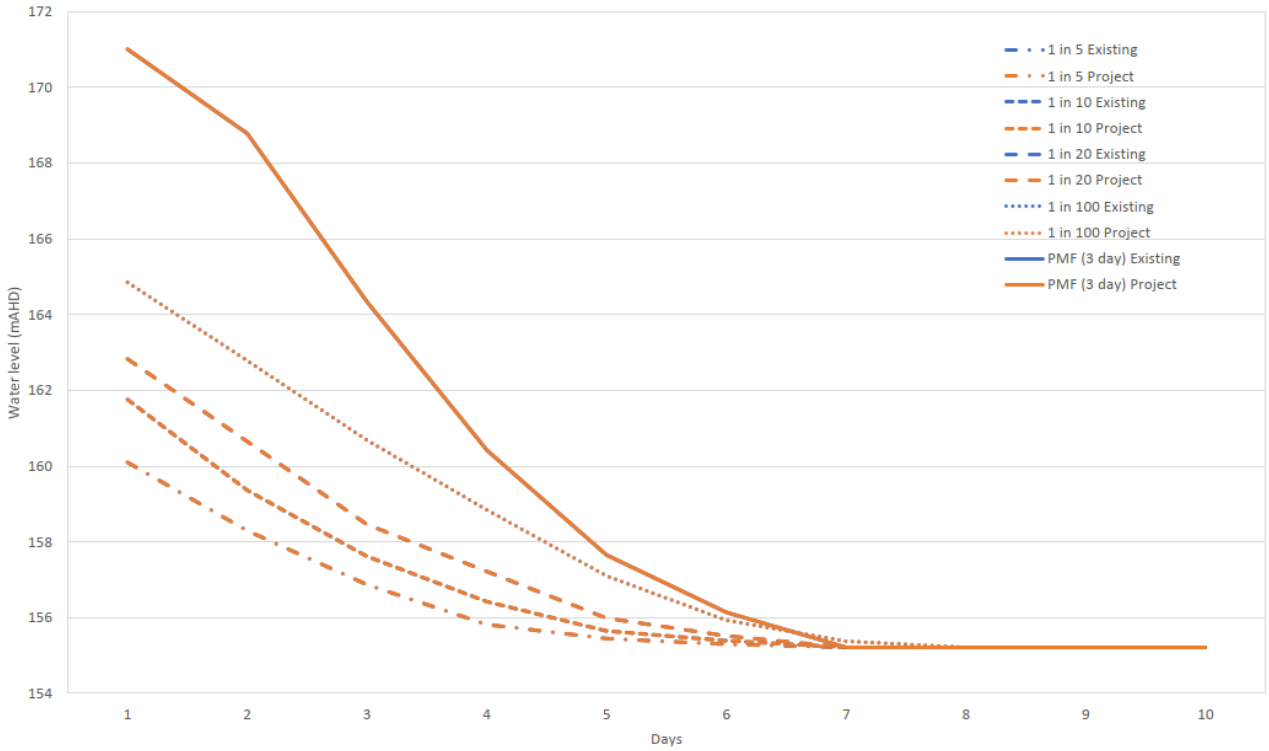


Figure 4-2. Depth-duration curves for SEARs events at WOLLONDILLY_0

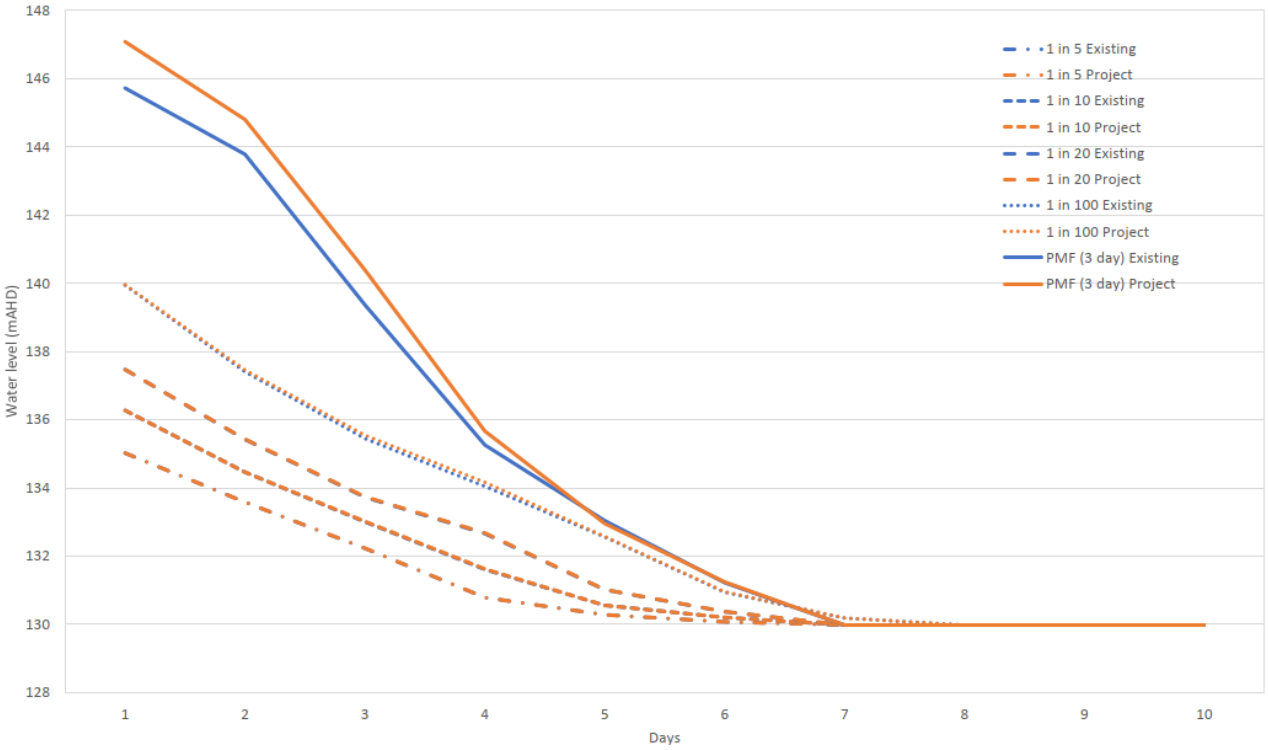
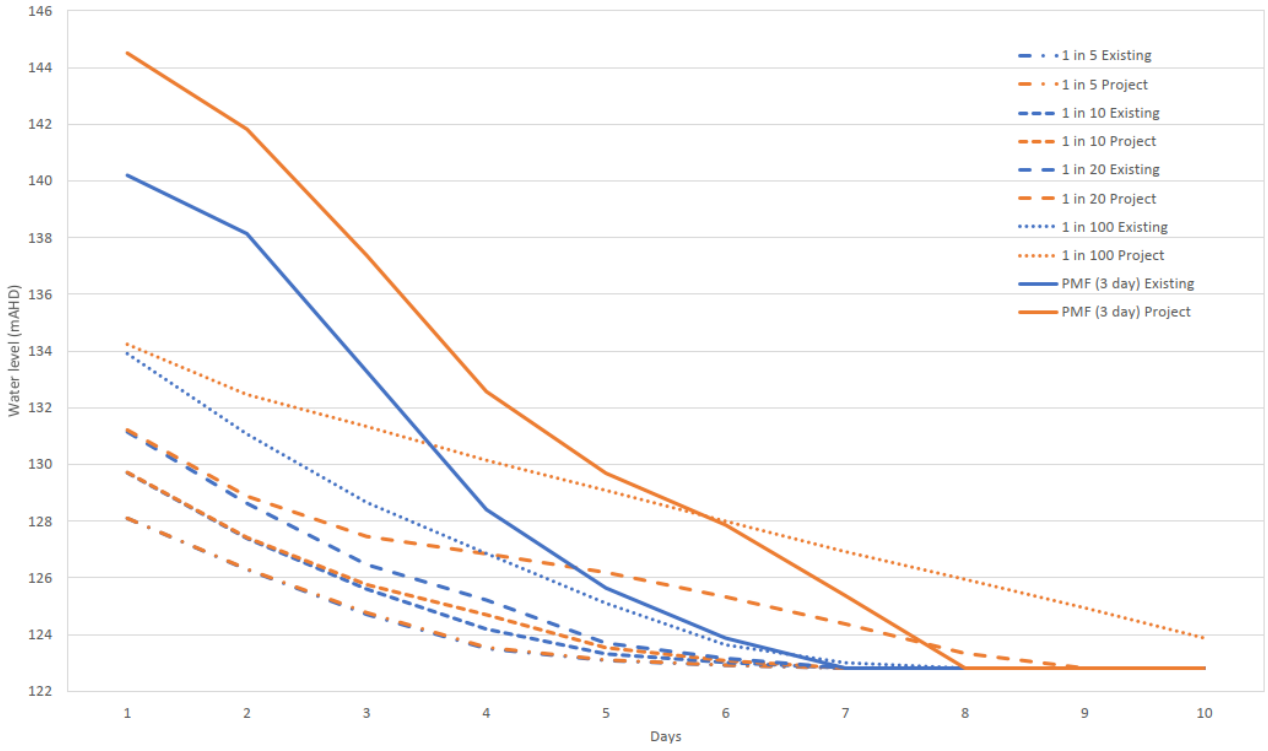


Figure 4-3. Depth-duration curves for SEARs events at WOLLONDILLY_3380



4.2 Upstream

4.2.1 Existing hydrology and flooding

The upstream environment includes the reservoir formed by Warragamba Dam (Lake Burragorang) and its tributaries. The catchment covers an area of about 9,050 square kilometres and includes State Conservation Areas, National Parks and areas of the Greater Blue Mountains World Heritage Area (GBMWHA). The catchment extends to the south near Lake Bathurst, where rainfall is comparatively low, and drains to Mulwaree Ponds near Goulburn and then to the Wollondilly River, which flows north-east to Lake Burragorang. A major tributary of the Wollondilly River is the Wingecarribee River, which rises in an area of high rainfall near Bowral to the east.

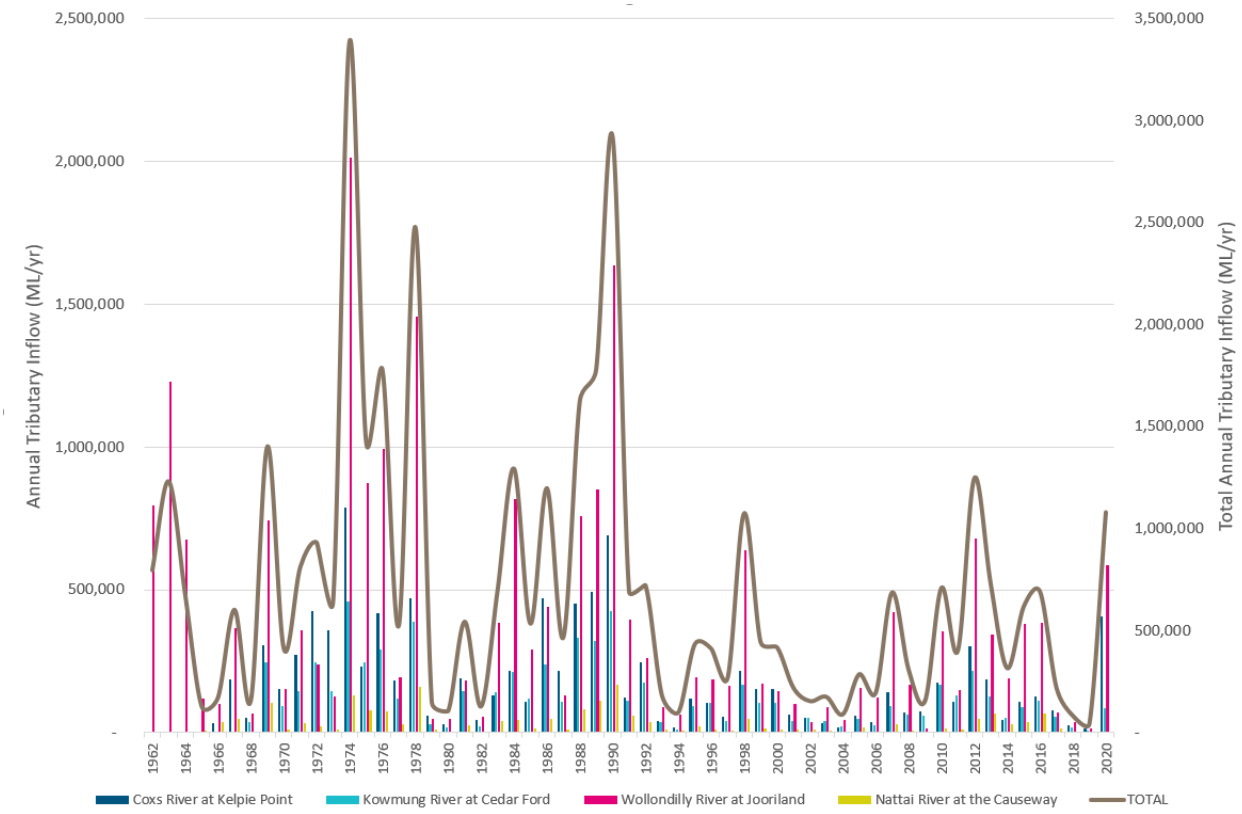
Lake Burragorang is 52 kilometres long, has 354 kilometres of foreshore and covers a waterway area of approximately 75 square kilometres. Warragamba Dam is situated in a steep, narrow gorge. Before the dam was built the gorge carried the Warragamba River from the junction of the Wollondilly and Coxs Rivers down to the Nepean River below Wallacia. The total length of the Warragamba River was 22 kilometres, though since the creation of Lake Burragorang it is currently 3.5 kilometres long.

Major tributaries have differing flow characteristics due to variable rainfall across the upstream catchment. WaterNSW records streamflow into Lake Burragorang for the Wollondilly River, Nattai River, Coxs River (upstream of Kowmung River confluence) and Kowmung River. Annual tributary inflows and combined total inflow to Lake Burragorang between 1962-2016 are shown in Figure 4-4. Total inflows to the reservoir have varied considerably since construction of Warragamba Dam, ranging from over 3,390,000 megalitres in 1974 to a low of 87,000 megalitres in 2004.

Historic dam levels (as percentages) are shown on Figure 4-5. Since 1960 the dam storage level has been above 80 percent full for most of the time, however the level has dropped to less than 60 percent full on several occasions, and in the early 2000s the dam storage level dropped below 40 percent. The dam storage level was at about 60 percent capacity in late 2018 and was at 100 percent capacity in mid-August 2020. The dam has also exceeded 100 percent capacity and spilled on numerous occasions during the 1960s and 1970s. Recent dam spills occurred in 2012, 2013, 2015, 2020 and 2021.

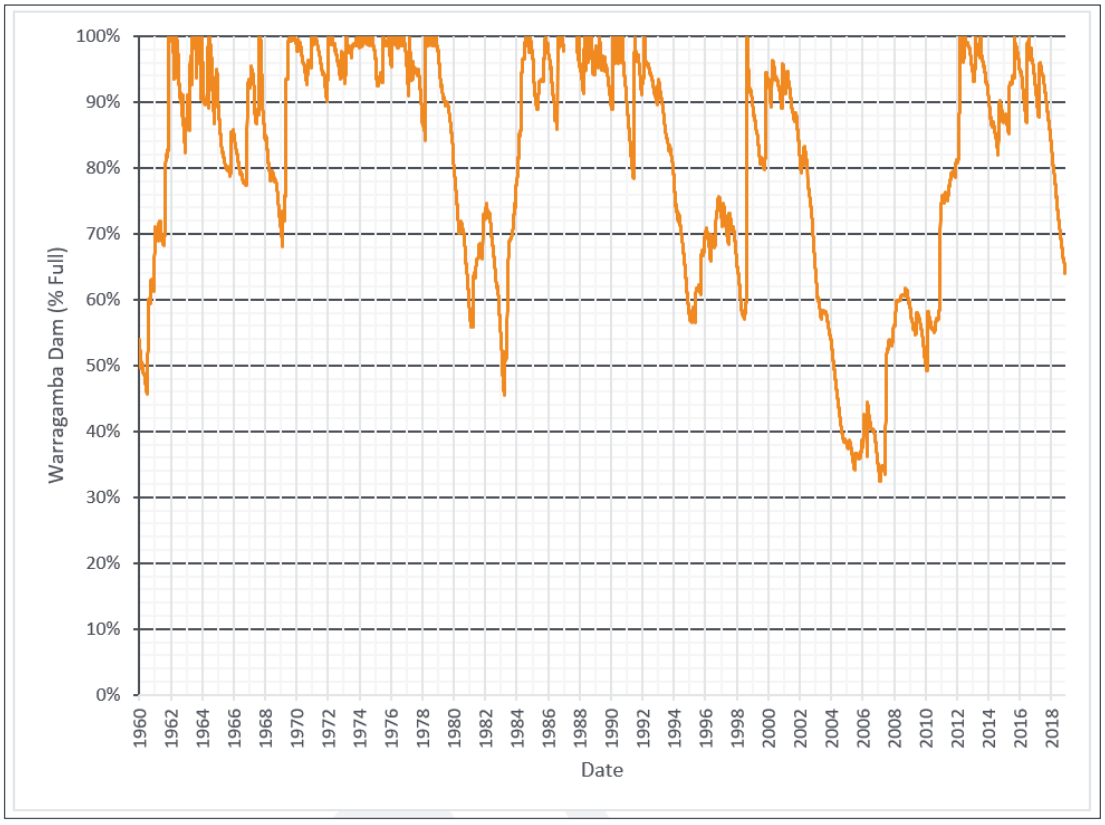
Lake Burragorang has altered hydrological and sediment transport regimes between the upstream catchment and downstream rivers and floodplain. The lake functions as a sediment ‘sink’ and reduces sediment loads downstream of the dam.

Figure 4-4. Annual tributary inflows into Lake Burragorang



Note: During the period 2003 to 2007 the Wollondilly River inflows include transfers from the Shoalhaven.
Source: Appendix H1, Figure 3-7

Figure 4-5. Historic dam levels



Source: Appendix H1, Figure 3-11

Flooding in the upstream catchment is characterised by backwater inundation, with inflows building on the upstream side of the dam wall. The water level increases until the outflow exceeds the inflow, at which time the water level recedes to the FSL (116.7 mAHD). The extent and duration of inundation is dependent upon the magnitude of the flood-producing rainfall event, the water level in the dam storage at the time of the inflow event and the rate of release of water from the dam. Monte Carlo flood modelling results at the dam wall are shown in Table 4-1 (with the dam at FSL). Existing peak flood levels may be higher in the upper tributary reaches.

The extent of inundation is controlled by the peak flood level at the dam wall and the topography across the upstream catchment. Steep terrain extends upstream from the dam wall for at least 20 kilometres, so that the extent of land inundated changes at a relatively small rate with increasing magnitude floods. However, the rate of change and inundated area increases as terrain flattens about where the Wollondilly River and Coxs River enter Lake Burragorang. Flood hydrographs and corresponding water level time-series in Lake Burragorang are provided in Appendix H1 (Section 3.2.1.3).

Water levels in Lake Burragorang remain elevated for a period of about three to five days depending on the size of the event (see Table 4-1). Although lake levels remain elevated for a period of days, the period of inundation for specific locations would vary depending on where they are in the catchment, with duration decreasing with elevation.

Flood storage areas are characterised by deep, low velocity inflows, although relatively higher velocities would be expected where major tributaries discharge into the lake.

Table 4-1. Existing upstream peak flood events at dam wall

Flood event (1 in x chance in a year)	Water level (mAHD)	Approximate days above FSL
5	117.4	2.8
10	118.0	3.4
20	118.6	4.0
100	121.5	4.0
200	122.9	4.1
500	124.6	4.5
PMF (3 day)	131.2	4.2

4.2.2 Potential flooding with the Project

4.2.2.1 Changes to flood levels and duration of temporary inundation

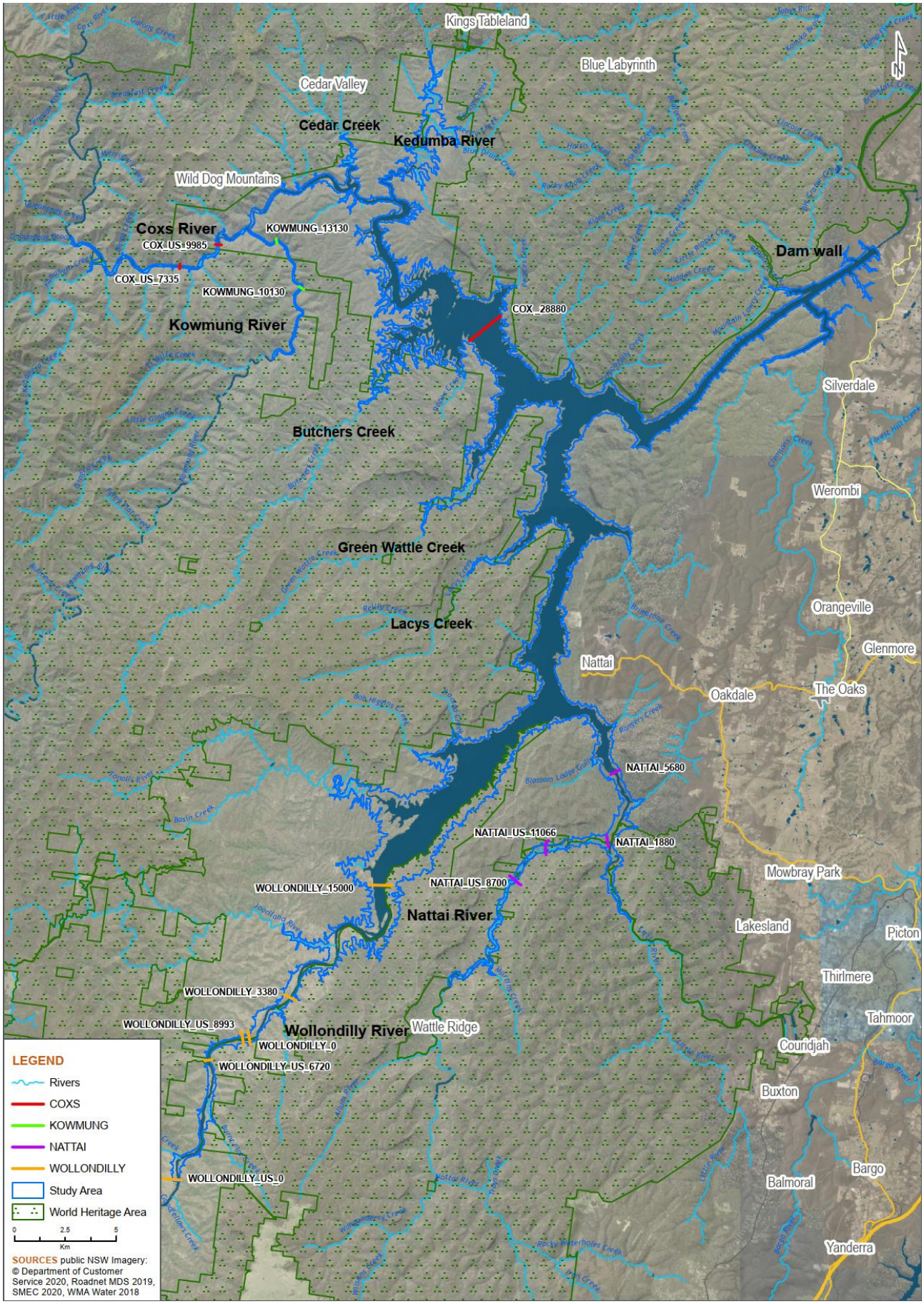
Modelling included development of depth-duration curves at numerous cross sections within the lake and along major tributaries. These curves show the amount of time that water levels are at or above a specific elevation, and are of use in comparing different flood events at a specific location or, in this case, comparing flood events of a specific chance of occurrence for the existing situation and the Project.

Representative depth-duration curves were examined for a selection of locations (shown in Figure 4-6) comprising:

- The dam wall as these nominally show the greatest influence of the Project
- Approximately where contributions from the local catchments begin to decline and the contribution to flooding by the Project for the largest hypothetical event begins to dominate representing the upstream limit of the Project
- Locations approximating to the extent of the 1 in 100 chance in a year flood event downstream of the upstream-most locations; these were used to examine the increasing influence of the Project (or otherwise) moving downstream
- Intermediate locations within Lake Burragorang, one on the Wollondilly River and one on the Coxs River; these were used to assess the influence of the Project nominally midway in the two main arms of Lake Burragorang
- Four cross sections on the Nattai River to examine changes in the pattern of the depth-duration curves moving downstream.

The results of the analyses are discussed as follows for the individual tributaries.

Figure 4-6. Upstream locations for depth-duration and flood frequency analyses



Dam wall

Predicted changes at the dam wall with the Project are shown in Figure 4-7 and summarised in Table4-2. It should be noted that the figures for the incremental depths and duration are based on representative hydrographs from the Monte Carlo analysis and could vary reflecting the inherent variability in the results of the Monte Carlo analysis.

Figure 4-7. Depth-duration curves for the dam wall

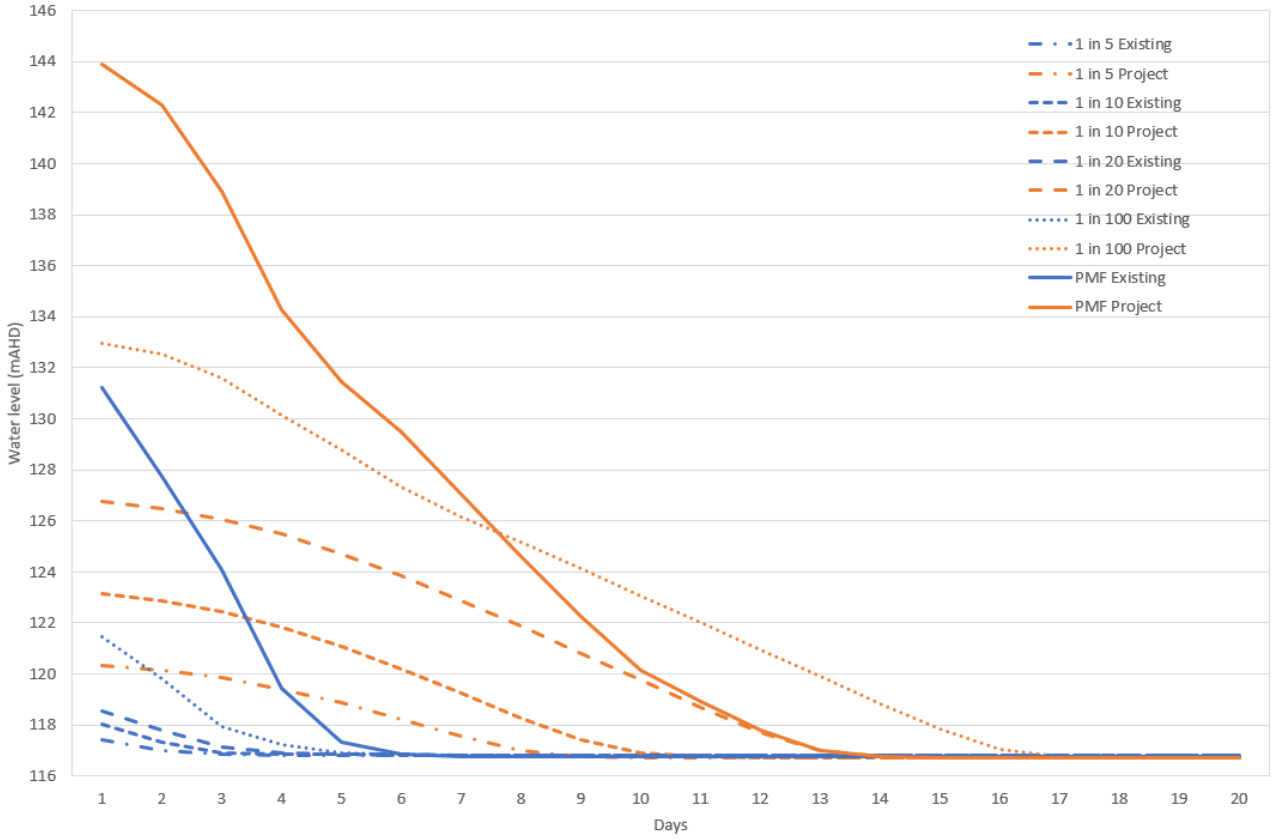


Table 4-2. Changes to temporary inundation levels and durations at dam wall

Event (1 in x chance in a year)	Existing			Project			
	Level (RL m)	Depth (m)	Inundation[1] (days)	Level (RL m)	Depth (m)	Increase in inundation (days)	Total inundation (days)
5	117.4	0.7	2.8	120.3	2.9	4.6	7.4
10	118.0	1.3	3.4	123.1	5.1	6	9.4
20	118.6	1.9	4.0	126.8	8.2	8.6	12.6
100	121.5	4.8	4.0	132.0	10.5	10.8	14.8
PMF	131.2	14.5	4.2	143.9	12.7	7	11.2

1: Duration of temporary inundation has been calculated as when the rising limb of the hydrograph exceeds FSL (116.7 metres) and the falling limb of the hydrograph reaches FSL.

The above analysis indicates that changes to the duration of upstream inundation at the dam wall would be up to about five days for the relatively more frequent 1 in 5 chance in a year flood, and up to about 11 days for a rarer 1 in 100 chance in a year flood event.

Wollondilly River

The Wollondilly River is one of the two main arms of Lake Burragorang (the other being the Coxs River). Representative depth-duration curves were examined for five cross-sections on the Wollondilly River as follows:

- WOLLONDILLY_US_0 is the upstream-most cross-section used in the MIKE11 model on the Wollondilly River and is located beyond the influence of the Project
- WOLLONDILLY_US_6720 represents the approximate location of the Project PMF event, and the limit of Project influence on the Wollondilly River
- WOLLONDILLY_8933 represents the approximate location of the Project for the 1 in 100 chance in a year event
- WOLLONDILLY_3380 and WOLLONDILLY_15000 are two further downstream cross-sections, the latter located within Lake Burragorang.

The results of the analysis are summarised in Table 4-3 and the associated depth-duration curves shown in Figure 4-8 to Figure 4-12. The table also includes the results for the dam wall to facilitate a comparison with the situation at the downstream-most location in the upstream study area.

Table 4-3. Upstream changes in temporary inundation depth and duration with the Project: Wollondilly River

Location (refer Figure 4-6)	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	E[1]	P[2]	E	P	E	P	E	P
WOLLONDILLY_US_0								
Depth (m)	4.3	<0.5	6.5	<0.5	8.5	<0.5	9.2	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	<0.5	5.2	<0.5
WOLLONDILLY_US_6720								
Depth (m)	4.4	<0.5	6.2	<0.5	9.0	<0.5	10.0	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	<0.5	5.2	<0.5
WOLLONDILLY_US_8993								
Depth (m)	4.0	<0.5	5.6	<0.5	7.9	<0.5	8.7	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	<0.5	5.2	<0.5
WOLLONDILLY_3380								
Depth (m)	4.7	<0.5	6.8	<0.5	9.6	<0.5	10.6	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	3.2	5.2	3.6
WOLLONDILLY_15000								
Depth (m)	0.7	2.5	1.3	5.0	2.3	9.0	5.2	10.7
Duration (days)	6.8	2.4	6.4	3.8	7.2	8.0	6.8	8.3
Dam wall								
Depth (m)	0.7	2.9	1.3	5.1	1.9	8.2	4.8	10.5
Duration (days)	2.8	4.6	3.4	6	4.0	8.6	4.0	10.8

Notes: 1 – E = existing; 2 – P = additional depth/duration with Project

The above summary shows:

- Increases in the depth and duration of temporary inundation are generally less than half a metre and half a day respectively for the three upstream most cross-sections for all events considered
- At cross-section WOLLONDILLY_3380, increases in depth are less than half a metre for all events up to the 1 in 100 chance in a year event

- At cross-section WOLLONDILLY_3380, increases in temporary inundation are less than half a day up to the 1 in 10 chance in a year event, then increasing up to 3.6 days for the 1 in 100 chance in a year event
- At WOLLONDILLY_15000, there is a clear increase in depths and durations for temporary inundation for all events conisdered, these broadly mirroring the those at the dam wall for respective flood events
- An increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation within Lake Burragorang generally reflecting that at the dam wall.

Figure 4-8. Depth-duration curves for WOLLONDILLY_US_0

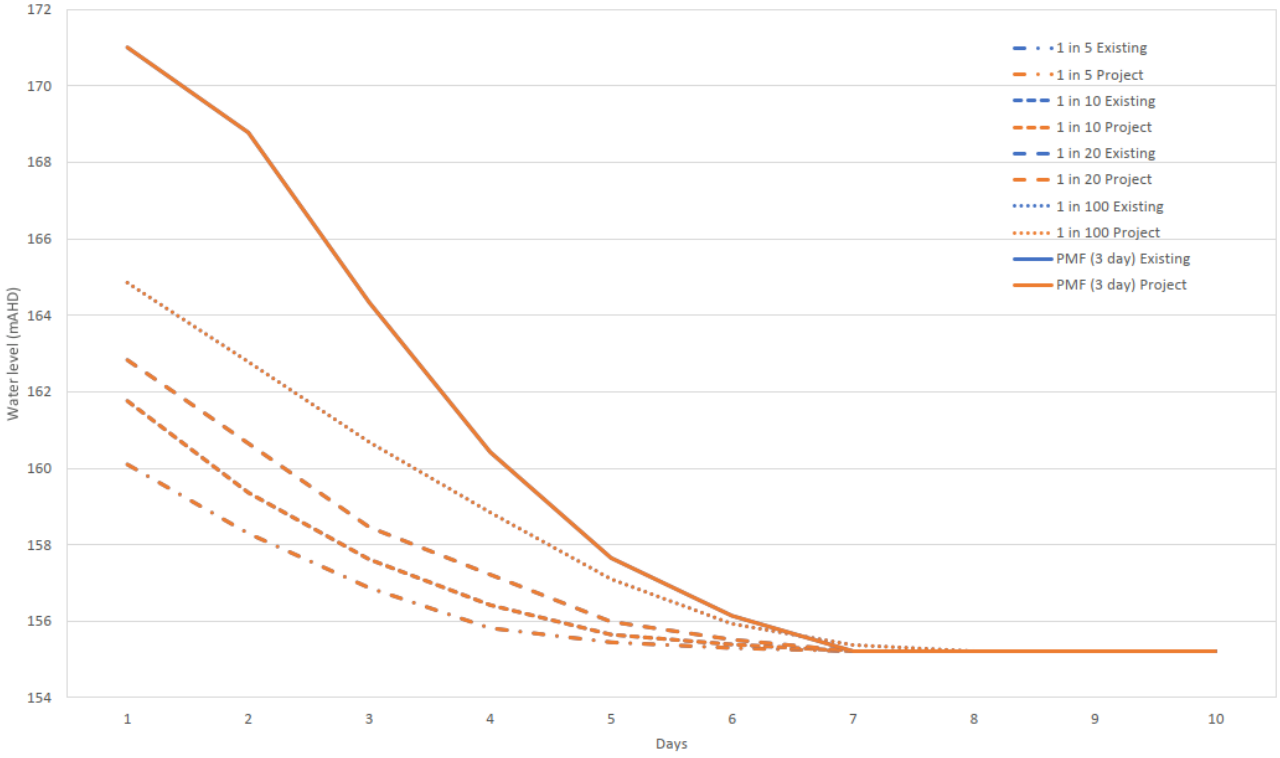


Figure 4-9. Depth-duration curves for WOLLONDILLY_US_6720

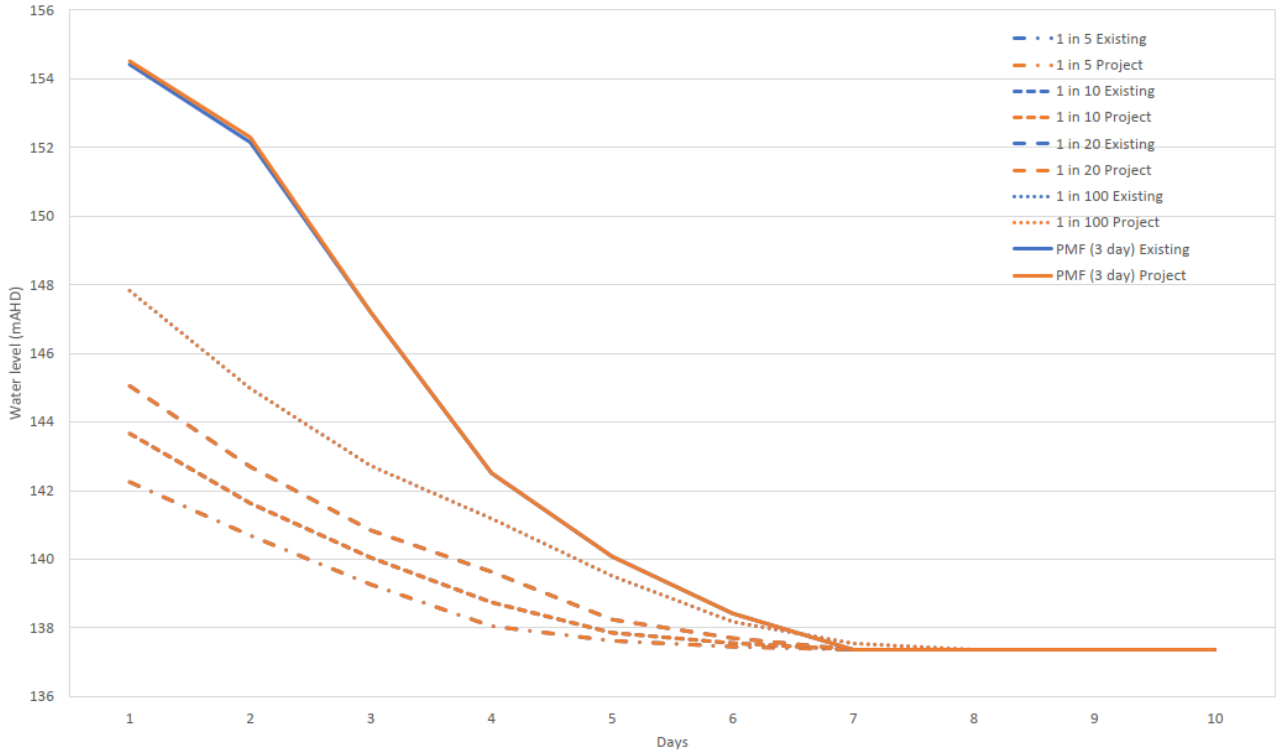


Figure 4-10. Depth-duration curves for WOLLONDILLY_US_8933

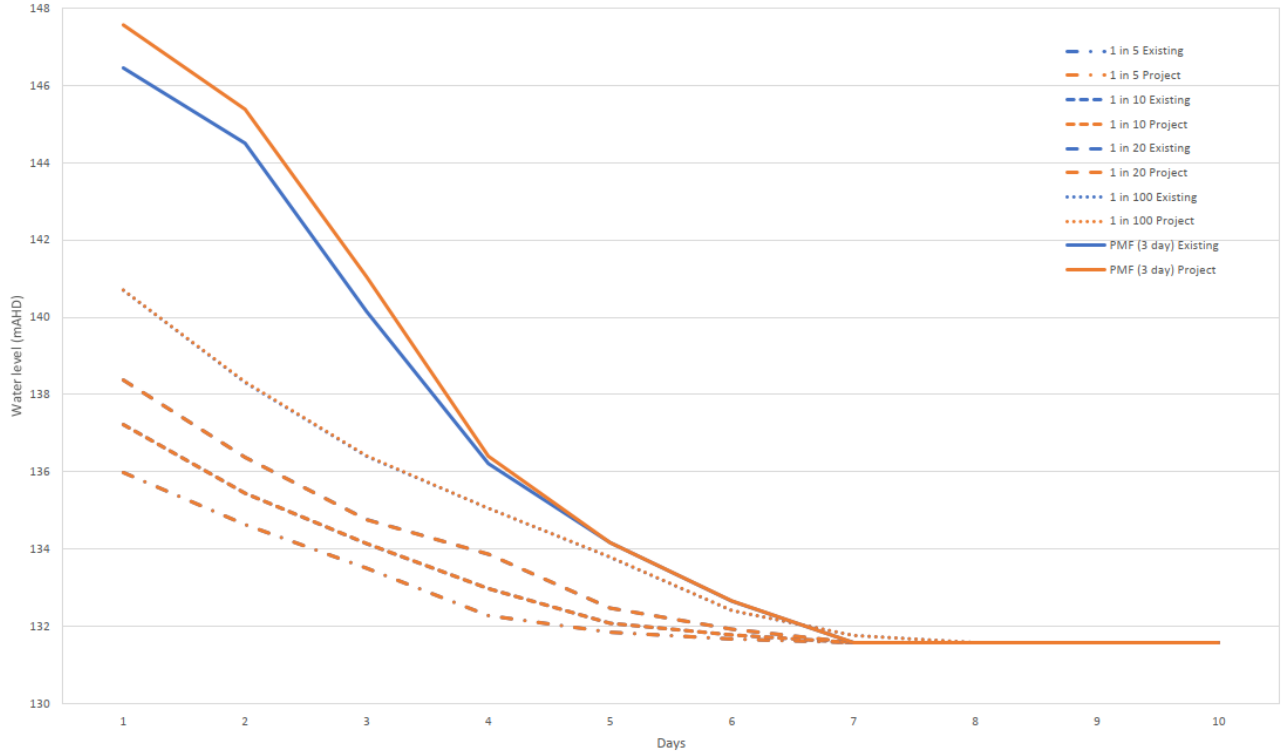


Figure 4-11. Depth-duration curves for WOLLONDILLY_3380

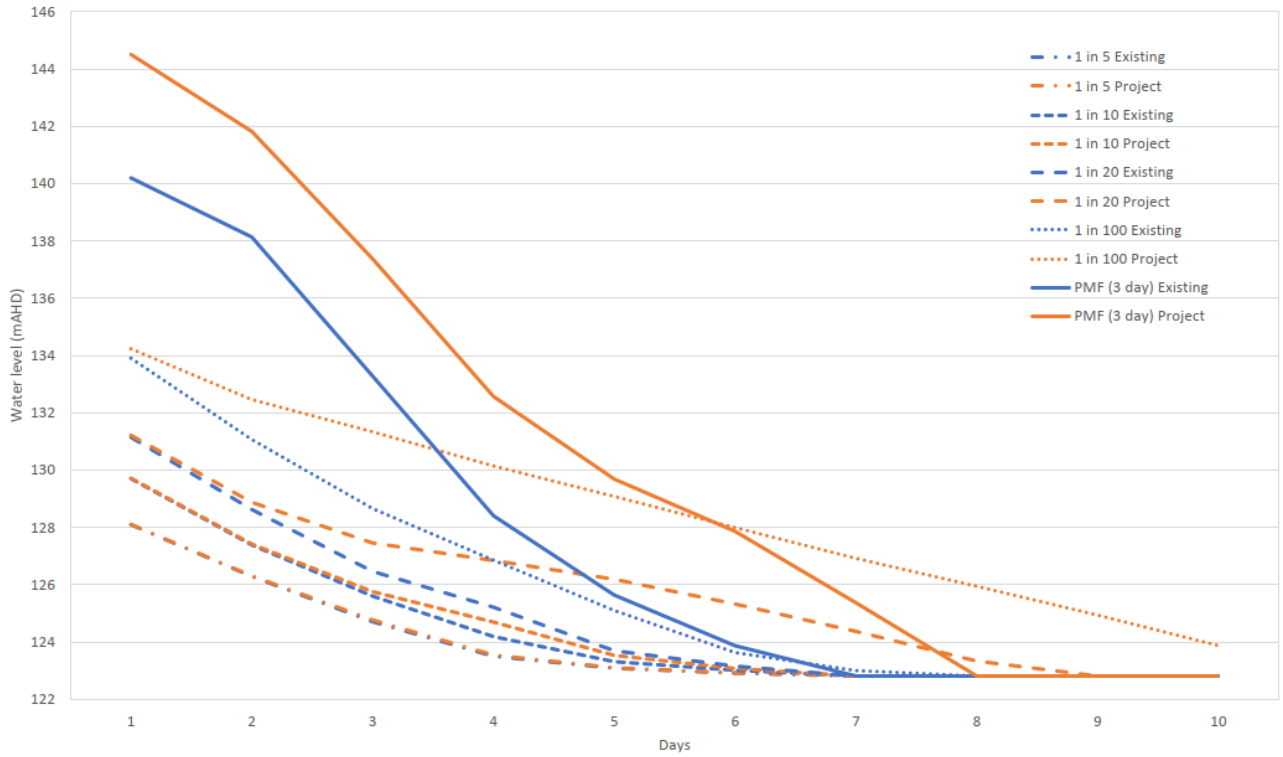
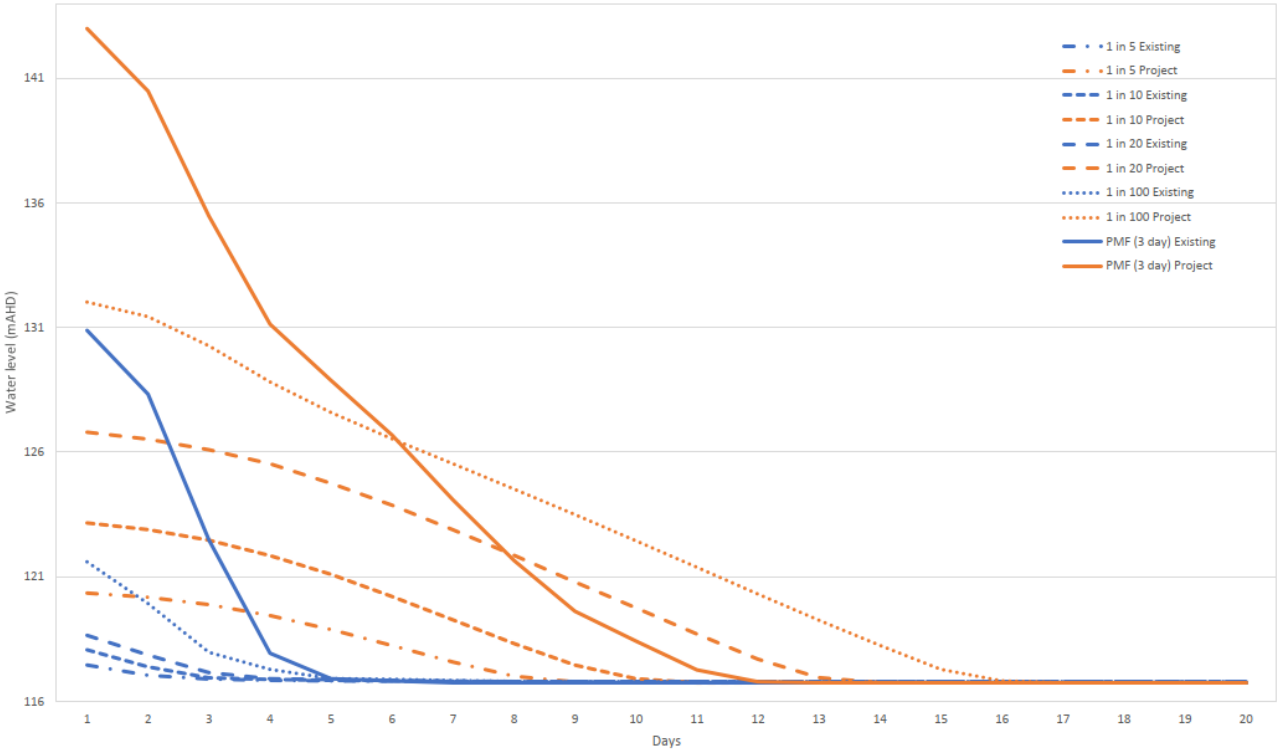


Figure 4-12. Depth-duration curves for WOLLONDILLY_15000



Coxs River

Representative depth-duration curves were examined for three cross-sections on the Coxs River as follows:

- COX_US_7335 represents the approximate location of the Project PMF event, and the limit of Project influence on the Coxs River

- COX_US_9985 represents the approximate location of the Project for the 1 in 100 chance in a year event and is about 2.5 kilometres downstream of COX_US_7335
- COXS_28800 is further downstream located within Lake Burragorang.

Of these, only cross-section COX_US_7335 is located within the GBMWHA.

The results of the analysis are summarised in Table 4-4; the associated depth-duration curves shown in Figure 4-13, Figure 4-14, and Figure 4-15. The table also includes the results for the dam wall to facilitate a comparison with the situation at the downstream-most location in the upstream study area.

Table 4-4. Upstream changes in temporary inundation depth and duration with the Project: Coxs River

Location (refer Figure 4-6)	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	E[1]	P[2]	E	P	E	P	E	P
COX_US_7335								
Depth (m)	2.4	<0.5	4.6	<0.5	5.3	<0.5	6.7	<0.5
Duration (days)	5.8	<0.5	5.4	<0.5	6.2	<0.5	5.3	<0.5
COX_US_9985								
Depth (m)	2.1	<0.5	4.5	<0.5	5.3	<0.5	6.9	0.5
Duration (days)	5.8	<0.5	5.4	<0.5	6.2	<0.5	5.1	0.7
COXS_28800								
Depth (m)	0.7	2.5	1.3	5.1	2.2	9.1	5.1	10.8
Duration (days)	6.8	2.4	6.4	3.8	7.2	8.0	6.4	8.3
Dam wall								
Depth (m)	0.7	2.9	1.3	5.1	1.9	8.2	4.8	10.5
Duration (days)	2.8	4.6	3.4	6	4.0	8.6	4.0	10.8

Notes: 1 – E = existing; 2 – P = additional depth/duration with Project

The analysis indicates:

- Increases in the depth and duration of temporary inundation are less than half a metre and less than half a day respectively for cross-section COX_US_7335 for all events considered
- Increases in the depth of temporary inundation for cross-section COX_US_9985 are half a metre or less up to for all events considered
- Increases in the duration of temporary inundation for cross-section COX_US_9985 are less than half a day up to the 1in 20 chance in a year event; this increases slightly to 0.7 days for the 1 in 100 chance in a year event
- At COXS_28800, there is a clear increase in depths and durations for temporary inundation for all SEARs events, these broadly mirroring the those at the dam wall for respective flood events
- An increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation within Lake Burragorang generally reflecting that at the dam wall.

Figure 4-13. Depth-duration curves for COXS_US_7335

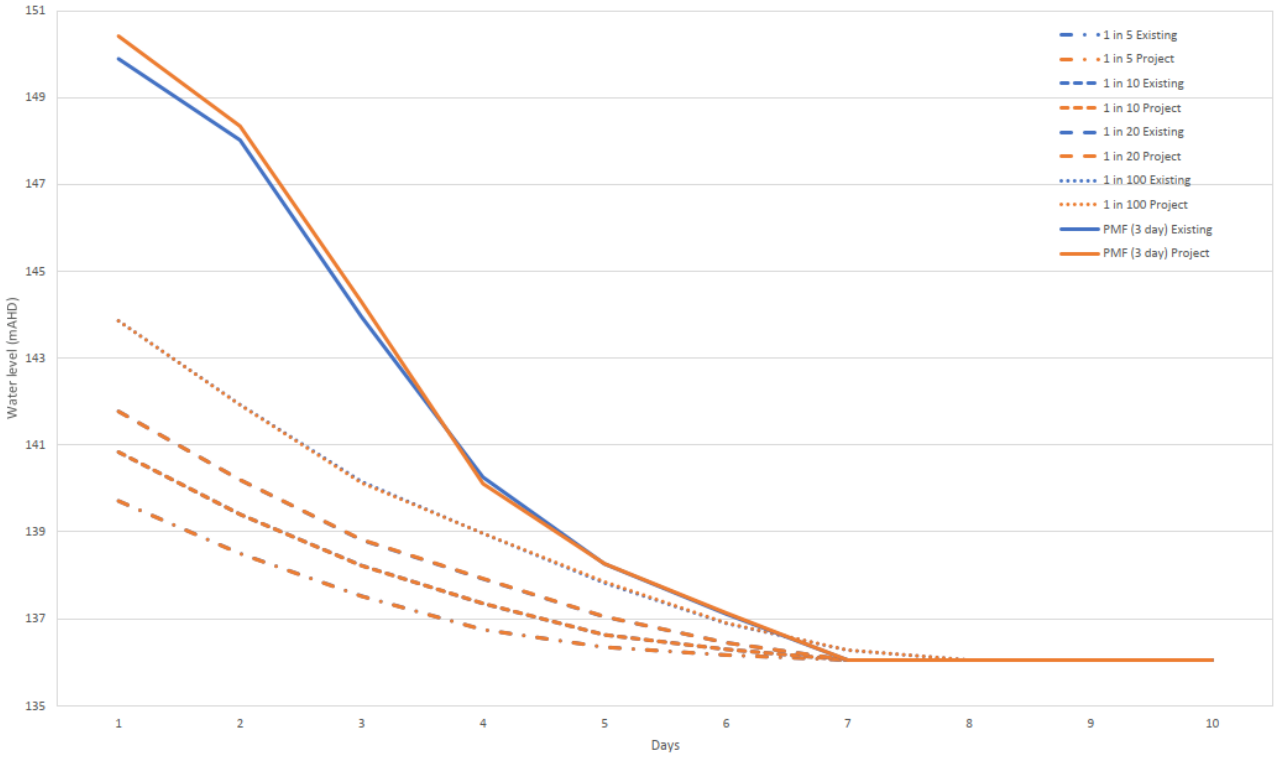


Figure 4-14. Depth-duration curves for COXS_US_9985

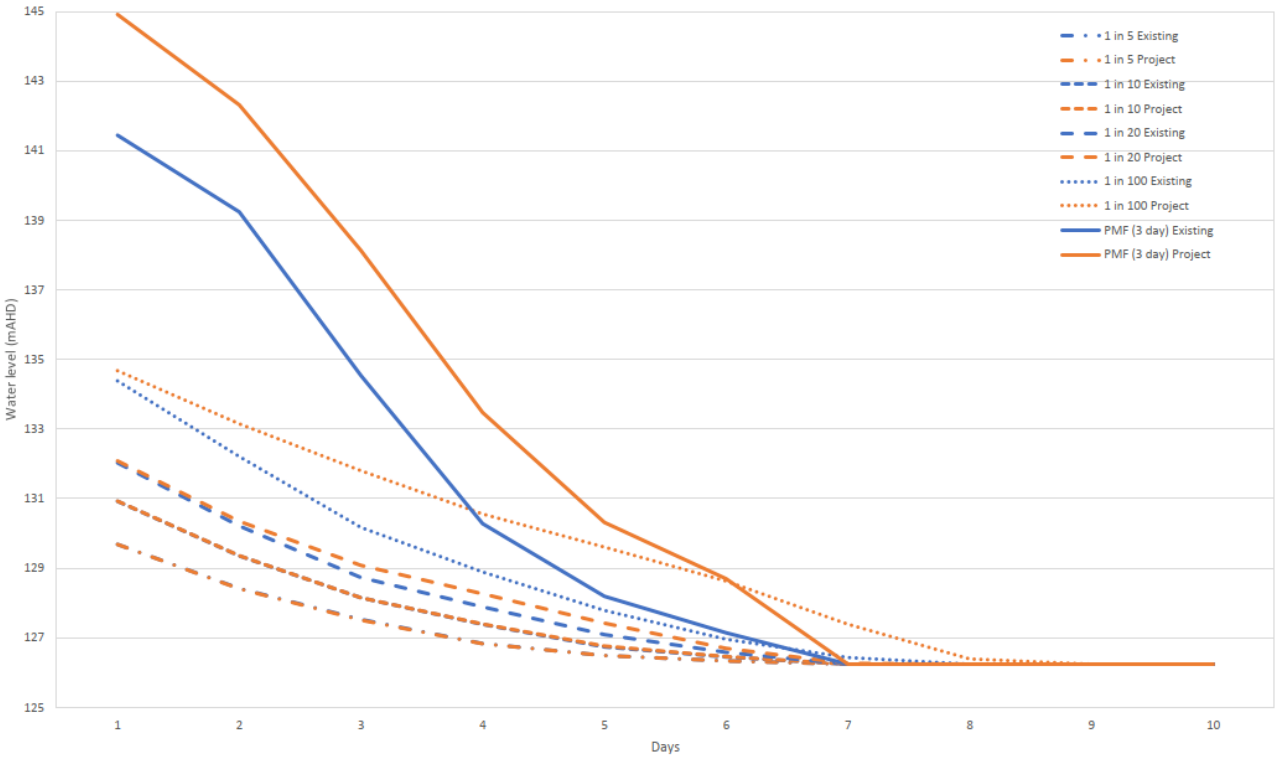
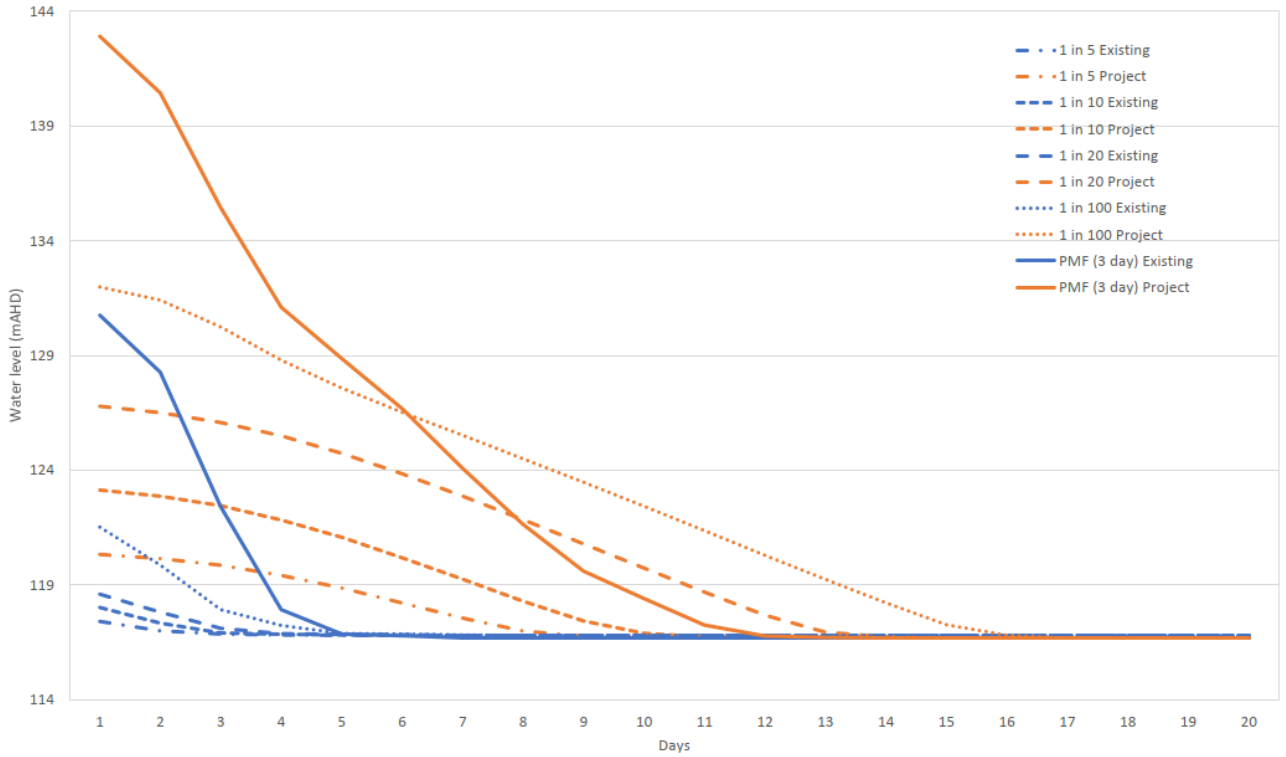


Figure 4-15. Depth-duration curves for COXS_28880



Nattai River

Representative depth-duration curves were examined for four cross-sections on the Nattai River as follows:

- NATTAI_US_8700 represents the approximate location of the Project PMF event, and the limit of Project influence on the Nattai River
- NATTAI_US_11066 is about 2.4 kilometres downstream of NATTAI_US_8700 and represents the approximate location of the Project for the 1 in 100 chance in a year event
- NATTAI_1880 is about 2.6 kilometres downstream of cross-section NATTAI_US_11066
- NATTAI_5680 is a further 3.8 kilometres downstream and is where the Nattai River broadens out into Lake Burragorang.

Of these cross-sections, NATTAI_US_8700 and NATTAI_US_11066 are wholly within the GBMWHA. The right bank of cross-section NATTAI_1880 is also within the GBMWHA.

The results of the analysis are summarised in Table 4-5 and the associated depth-duration curves shown in Figure 4-16 to Figure 4-19. The table also includes the results for the dam wall to facilitate a comparison with the situation at the downstream-most location in the upstream study area.

The analysis indicates:

- Increases in the depth and duration of temporary inundation for cross-sections NATTAI_US_8700 and NATTAI_US_11066 are less than half a metre and half a day respectively for all events considered up to the 1 in 100 chance in a year event
- Increases in the depth and duration of temporary inundation are more noticeable at cross-section NATTAI_1880, particularly for the 1 in 20 chance in a year and larger events
- At NATTAI_5680, there is also a clear increase in depths and durations for temporary inundation for all SEARs events, these broadly mirroring the those at the dam wall for the respective 1 in 20 chance in a year and larger flood events.

Table 4-5. Upstream changes in temporary inundation depth and duration with the Project: Nattai River

Location (refer Figure 4-6)	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	E[1]	P[2]	E	P	E	P	E	P
NATTAI_US_8700								
Depth (m)	3.4	<0.5	3.7	<0.5	4.3	<0.5	4.3	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	<0.5	6.2	<0.5
NATTAI_US_11066								
Depth (m)	3.8	<0.5	4.1	<0.5	4.8	<0.5	5.9	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.2	<0.5	5.2	<0.5
NATTAI_1880								
Depth (m)	2.8	0.5	3.1	3.2	4.0	7.4	5.9	10.0
Duration (days)	6.8	2.4	6.4	3.8	6.7	8.0	6.4	8.3
NATTAI_5680								
Depth (m)	0.8	2.4	1.3	5.0	2.4	9.0	5.2	10.6
Duration (days)	6.8	2.4	6.4	3.8	7.2	8.0	6.4	8.3
Dam wall								
Depth (m)	0.7	2.9	1.3	5.1	1.9	8.2	4.8	10.5
Duration (days)	2.8	4.6	3.4	6	4.0	8.6	4.0	10.8

Notes: 1 – E = existing; 2 – P = additional depth/duration with Project

Figure 4-16. Depth-duration curves for NATTAI_US_8700

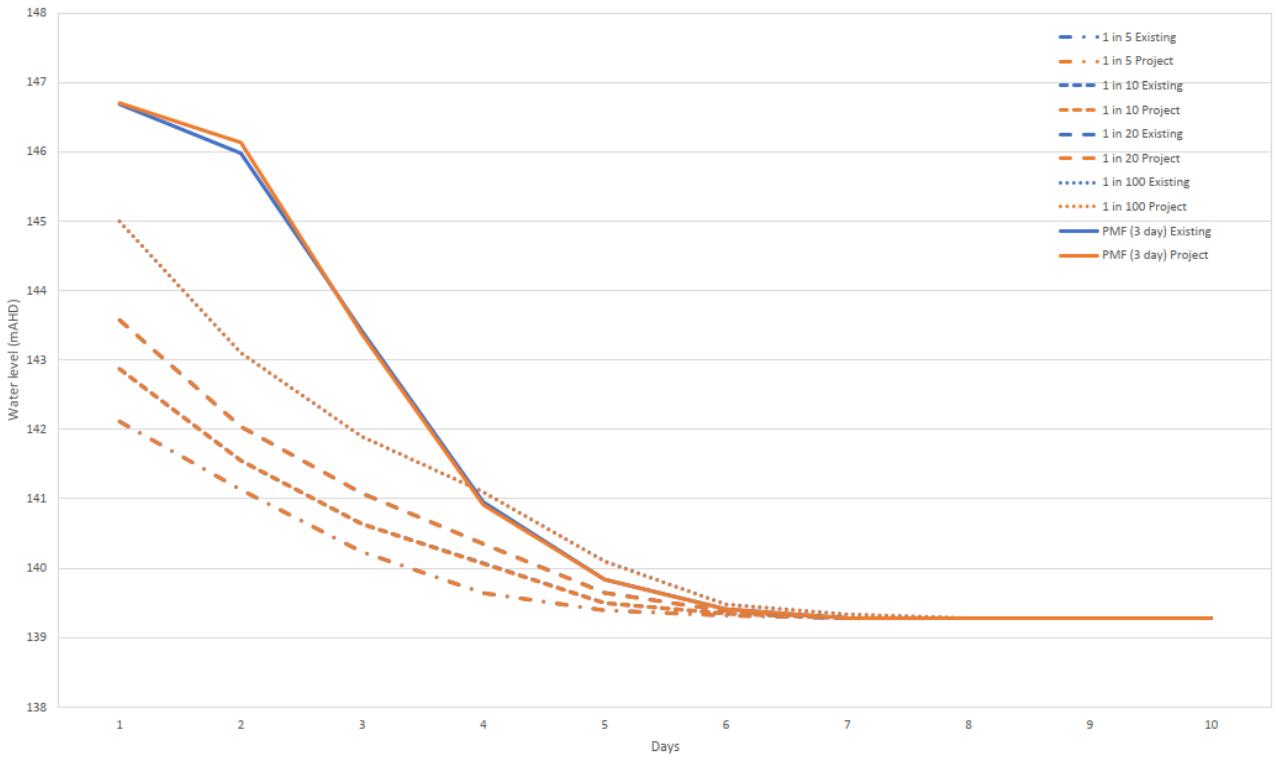


Figure 4-17. Depth-duration curves for NATTAI_US_11066

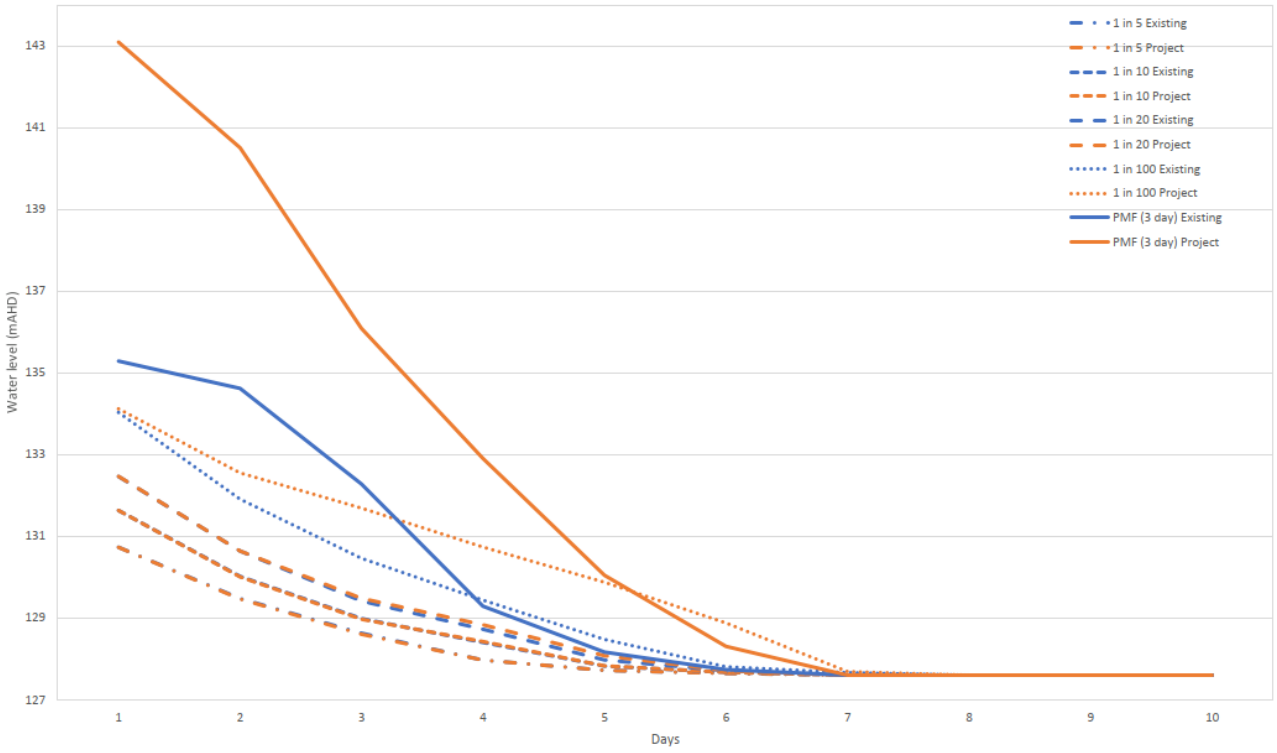


Figure 4-18. Depth-duration curves for NATTAI_1880

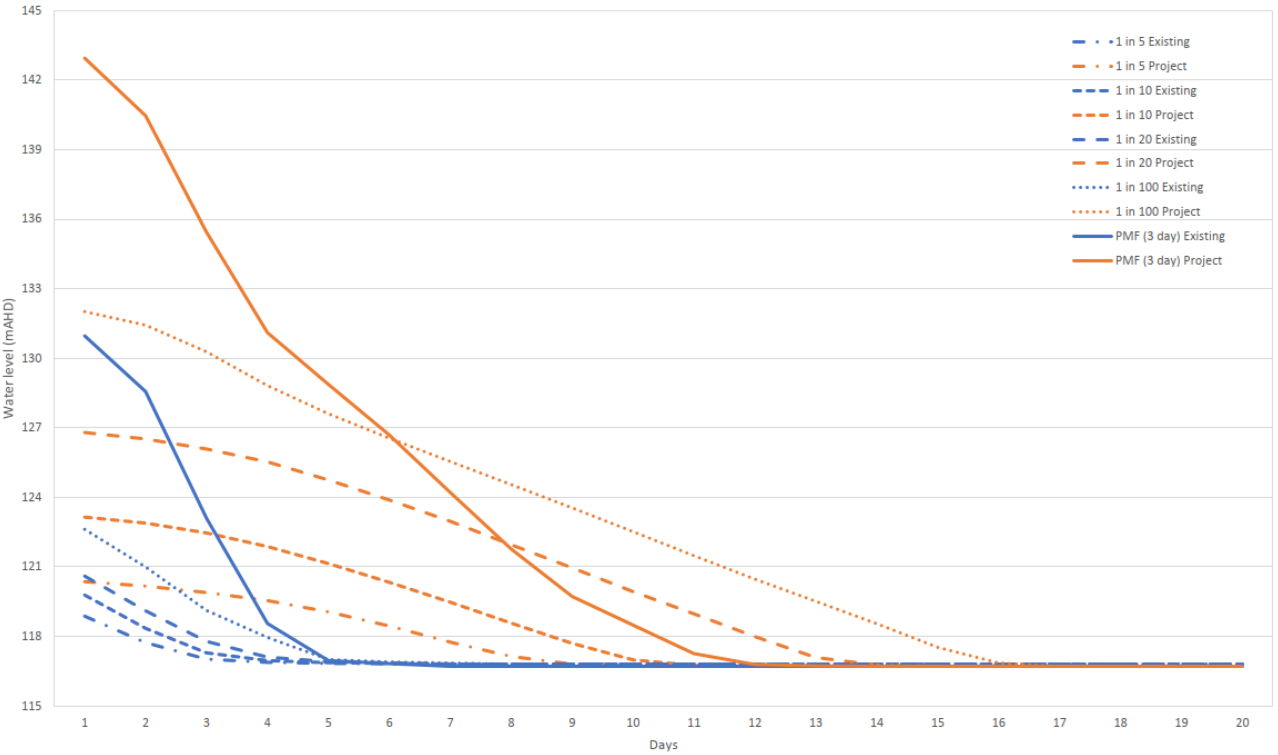
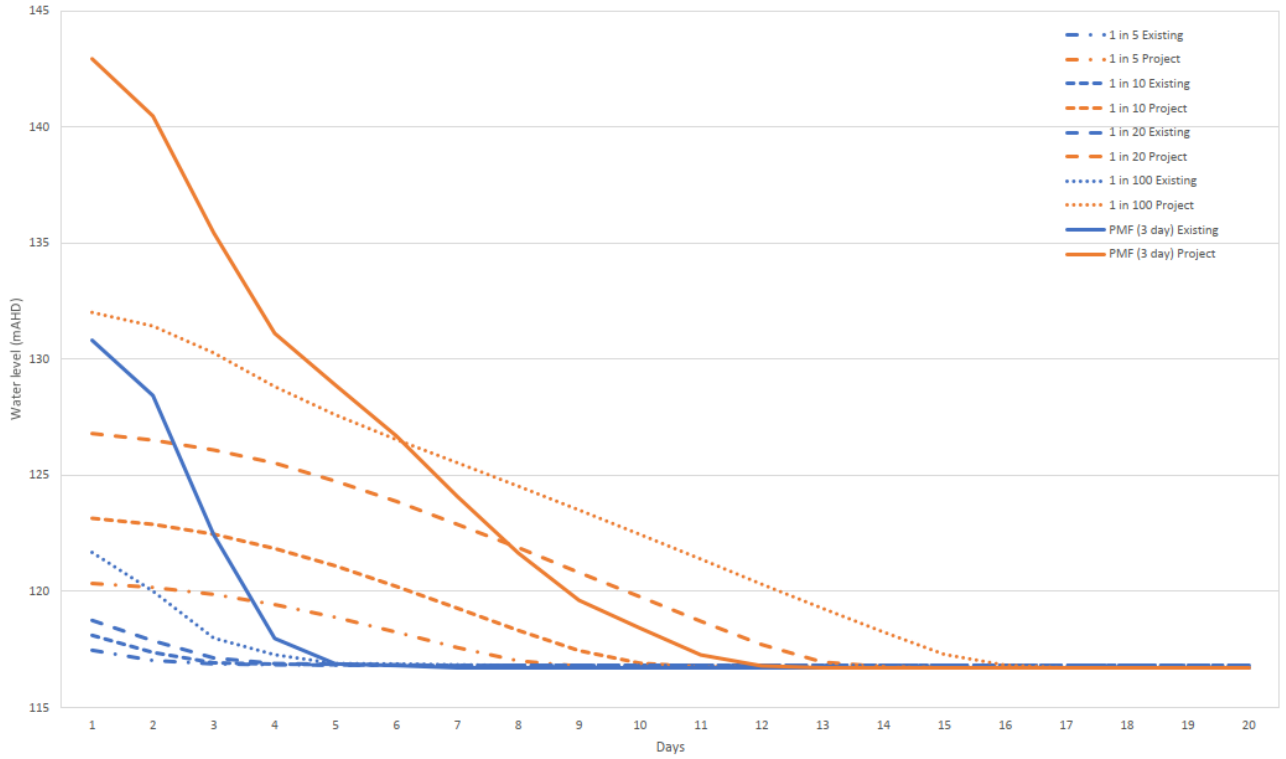


Figure 4-19. Depth-duration curves for NATTAI_5680



Kowmung River

The Kowmung River joins the Coxs River above cross-section COX_1475. Representative depth-duration curves were examined for two cross-sections on the Kowmung River as follows:

- KOWMUNG_10130 represents the approximate location of the Project PMF event, and the limit of Project influence on the Kowmung River
- KOWMUNG_13130 is about three kilometres further downstream and represents the approximate location of the Project for the 1 in 100 chance in a year event.

Both cross-sections are in the GBMWHA.

The results of the analysis are summarised in Table 4-6 and the associated depth-duration curves shown in Figure 4-20 and Figure 4-21.

The table also includes the results for the dam wall to facilitate a comparison with the situation at the downstream-most location in the upstream study area, and for cross-section COXS_28800 as an intermediate location within Lake Burragorang.

The analysis indicates:

- Increases in the depth and duration of temporary inundation for cross-section KOWMUNG_10130 are less than half a metre and half a day respectively for all events
- Increases in the depth of temporary inundation for cross-section KOWMUNG_13130 are less than half a metre up to the 1 in 100 chance in a year event
- Increases in the duration of temporary inundation for cross-section KOWMUNG_13130 are less than half a day up to the 1 in 20 chance in a year event, increasing to 1-2 two days for the larger events.

Table 4-6. Upstream changes in temporary inundation depth and duration with the Project: Kowmung River

Location (refer Figure 4-6)	Flood event (1 in x chance in a year)							
	1 in 5		1 in 10		1 in 20		1 in 100	
	E[1]	P[2]	E	P	E	P	E	P
KOWMUNG_10130								
Depth (m)	3.8	<0.5	4.9	<0.5	6.8	<0.5	7.4	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.1	<0.5	5.1	<0.5
KOWMUNG_13130								
Depth (m)	4.1	<0.5	5.6	<0.5	7.0	<0.5	9.4	<0.5
Duration (days)	5.9	<0.5	5.4	<0.5	6.1	<0.5	5.3	2.0
COXS_28800								
Depth (m)	0.7	2.5	1.3	5.1	2.2	9.1	5.1	10.8
Duration (days)	6.8	2.4	6.4	3.8	7.2	8.0	6.4	8.3
Dam wall								
Depth (m)	0.7	2.9	1.3	5.1	1.9	8.2	4.8	10.5
Duration (days)	2.8	4.6	3.4	6	4.0	8.6	4.0	10.8

Notes: 1 – E = existing; 2 – P = additional depth/duration with Project

Figure 4-20. Depth-duration curves for KOWMUNG_10130

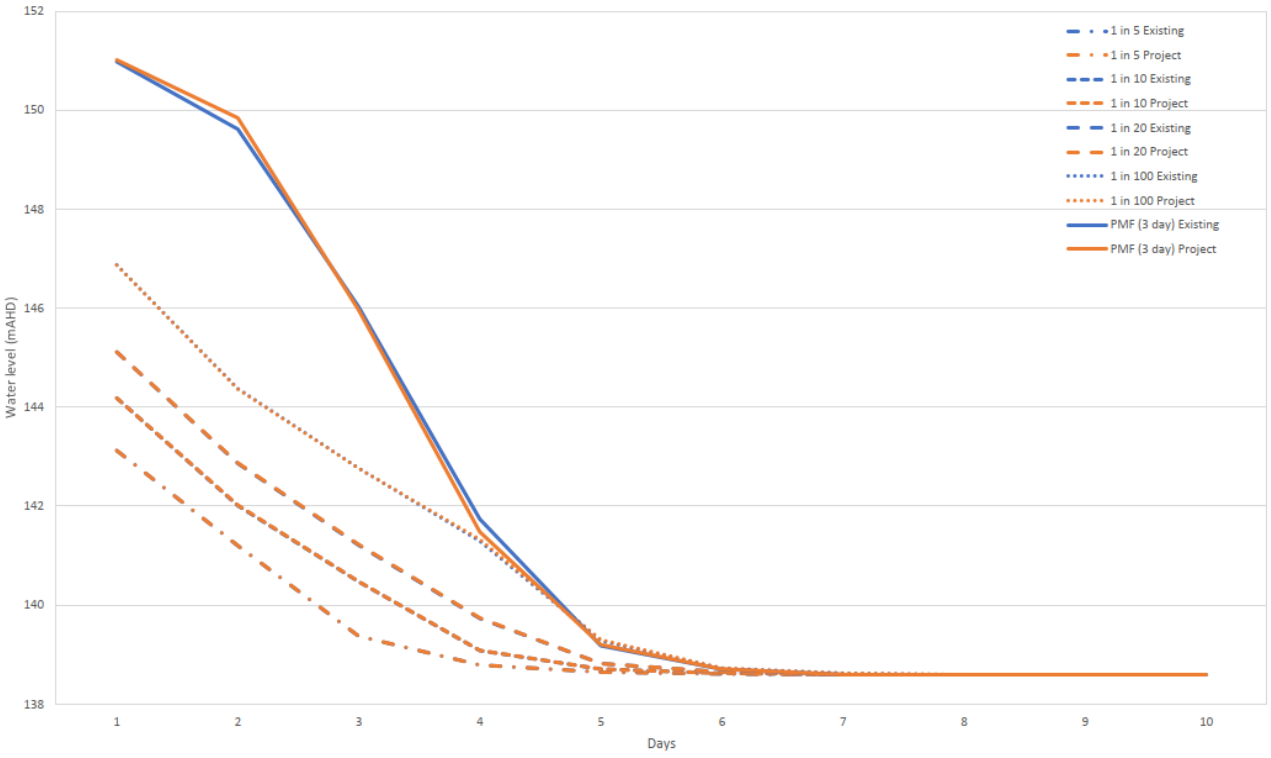
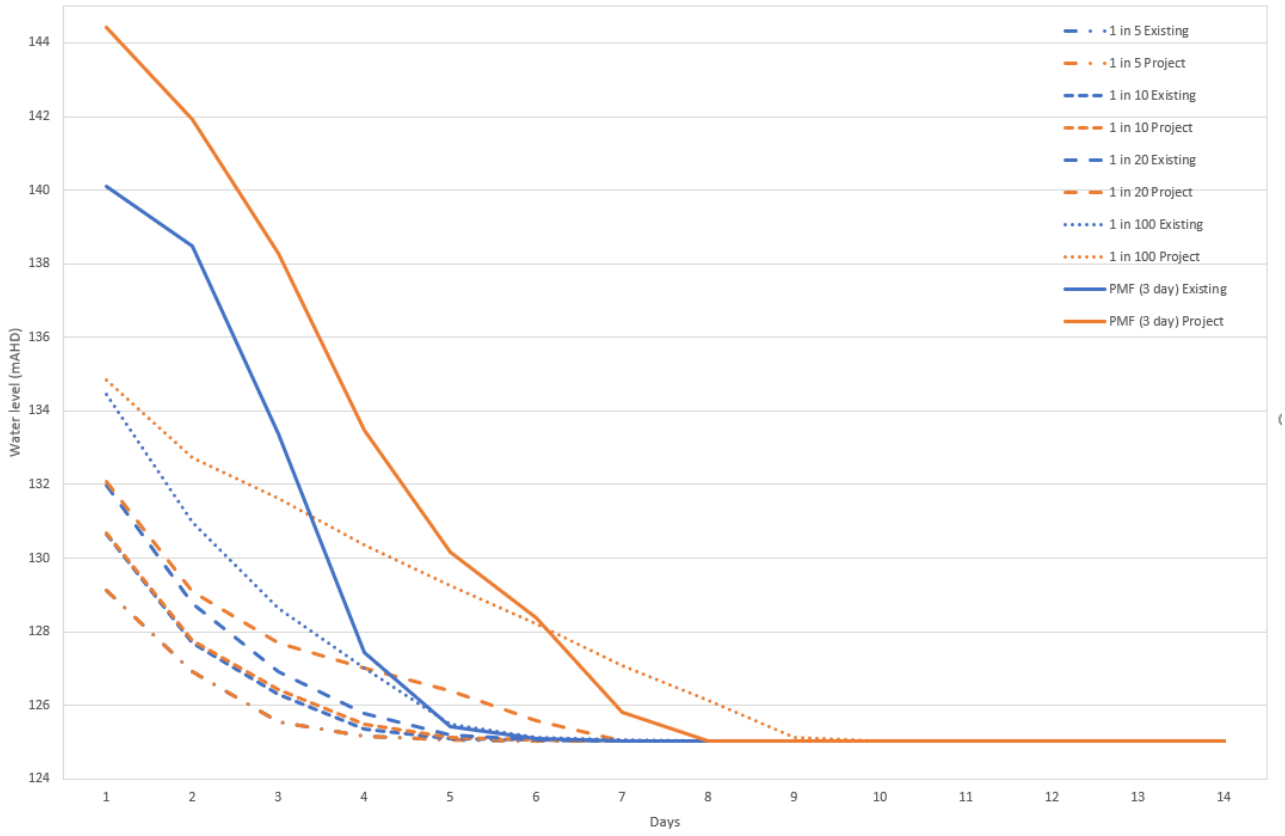


Figure 4-21. Depth-duration curves for KOWMUNG_13130



Summary

For the locations approximating the limit of the 1 in 100 chance in a year event, the analysis shows:

- Increases in the depth of temporary inundation with the Project for all events up to the 1 in 100 chance in a year event would be half a metre or less
- Increases in duration of temporary inundation for all events for the Nattai River and Wollondilly River would be less than half a day
- Increases in temporary inundation for the Kowmung River would be less than half a day up to the 1 in 20 chance in a year event, and about two days for the 1 in 100 chance in a year event
- Increases in temporary inundation for the Coxs River would be less than half a day for up to the 1 in 20 chance in a year event, and then slightly over half a day up to the 1 in 100 chance in a year event (these would not affect the GBMWHA).

There is an increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation with locations within Lake Burragorang generally reflecting the pattern of changes in depth and duration of temporary inundation for the same flood events at the dam wall.

It should be noted that the analysis is based on individual events from the 20,000 scenarios used in the Monte Carlo analysis and therefore there will be variability across individual events. However, this is not expected to overly influence the trend showing the increasing influence of the Project moving down the catchment toward the dam wall.

4.2.2.2 Changes to flood frequencies

A frequency analysis of the peak flood levels in Lake Burragorang at the dam wall under both existing case and with Project scenarios is presented in Figure 4-22. The frequency analysis shows the increase in peak flood levels for all events considered.

The frequency analysis shows a change in the shape of the frequency curve, with a change in grade occurring between the 1 in 20 chance in a year event to the 1 in 100 chance in a year event. This shows that the relative impact during

these smaller order design events is higher than that of the rarer events (that is, greater than the 1 in 100 chance in a year event).

Figure 4-22 also shows a leftward shift in the frequency of existing flood levels, with an increase in the frequency of all events of a specified level. For example, the water level associated with a 1 in about 50 chance in a year event under existing conditions would be equivalent to the same level for about a 1 in 5 chance in a year event with the Project (that is, a water level that currently occurs on average about once every 50 years would occur on average once every five-years with the Project).

However, the pattern of the leftward shift in the with Project flood frequency curve is not uniform across the upstream catchment and is substantially less further up the catchment as illustrated in Figure 4-22 to Figure 4-26.

These show that for the Wollondilly River and Nattai River there is effectively no material change in flood frequencies. For the Kowmung River, the flood frequency curves start to diverge at about the 1 in 50 chance in a year event. The current 1 in 100 chance in a year event would occur on average about once every 85 years with the Project. For the Coxs River, the curves start to diverge between the 1 in 10 chance in a year and the 1 in 20 chance in a year events. The current 1 in 100 chance in a year event would occur on average about once every 70 years with the Project.

The convergence of the flood frequency curves (reducing leftward shift) with distance up the catchment is better illustrated through Figure 4-27, Figure 4-28 and Figure 4-29. The pattern of the flood frequency curves in Figure 4-27 is very similar to the curves for the dam wall with the flood frequency curves progressively converging moving up the Nattai River.

Figure 4-22. Upstream flood frequency distributions: existing and with Project scenarios at the dam wall

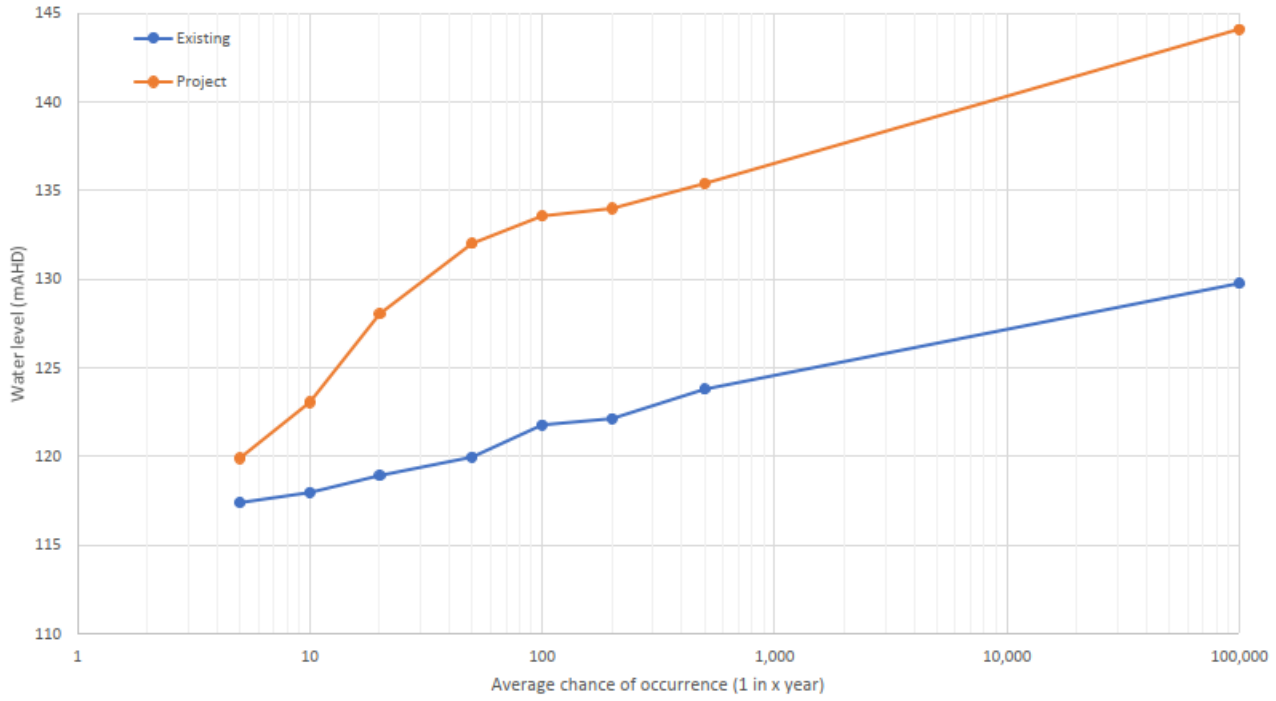


Figure 4-23. Upstream flood frequency distributions: existing and with Project scenarios at NATTAI_US_8700

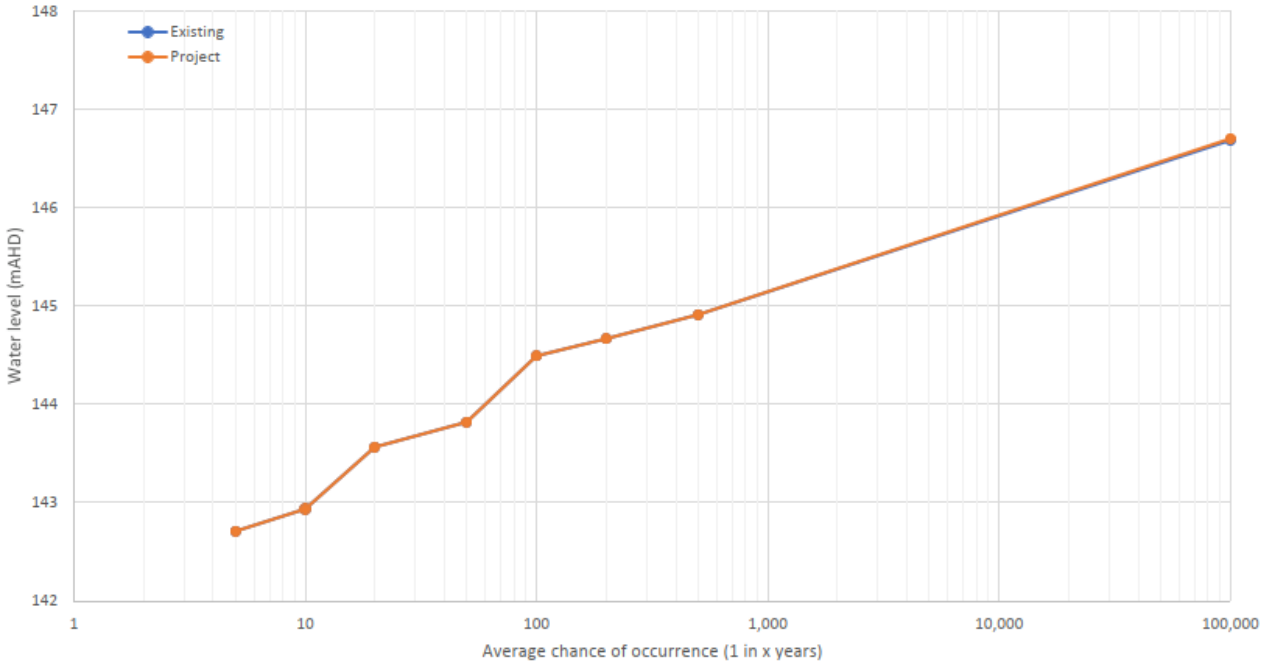


Figure 4-24. Upstream flood frequency distributions: existing and with Project scenarios at WOLLONDILLY_US_6720

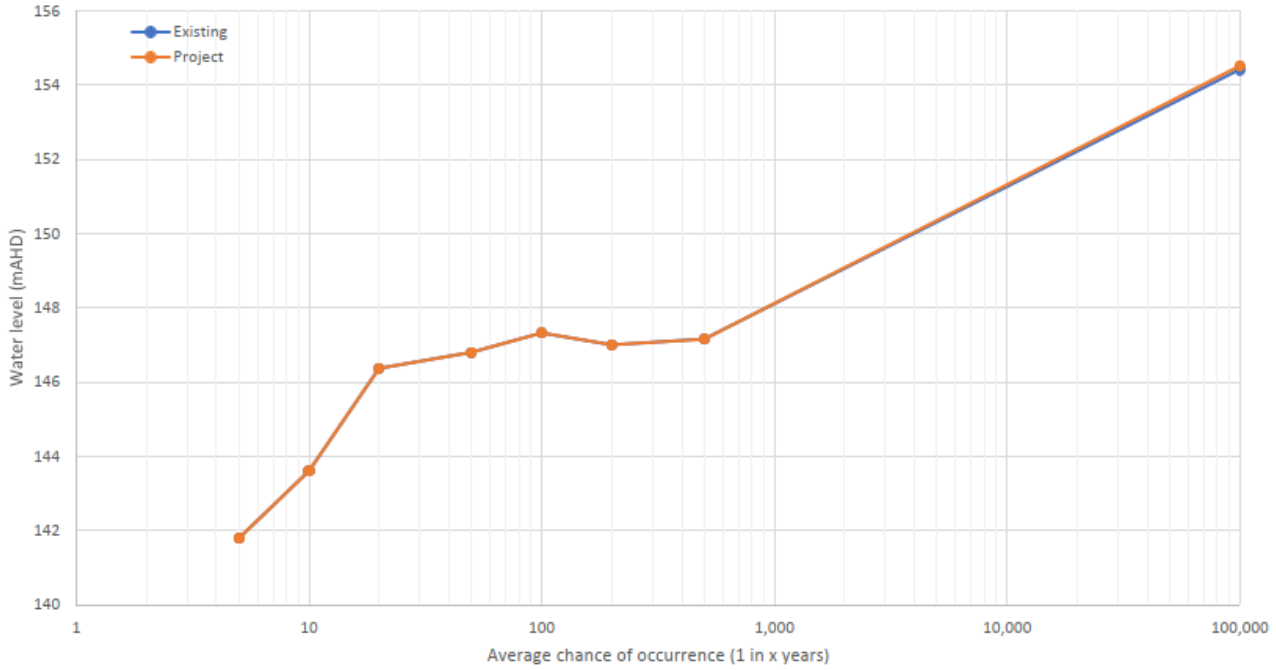


Figure 4-25. Upstream flood frequency distributions: existing and with Project scenarios at KOWMUNG_10130

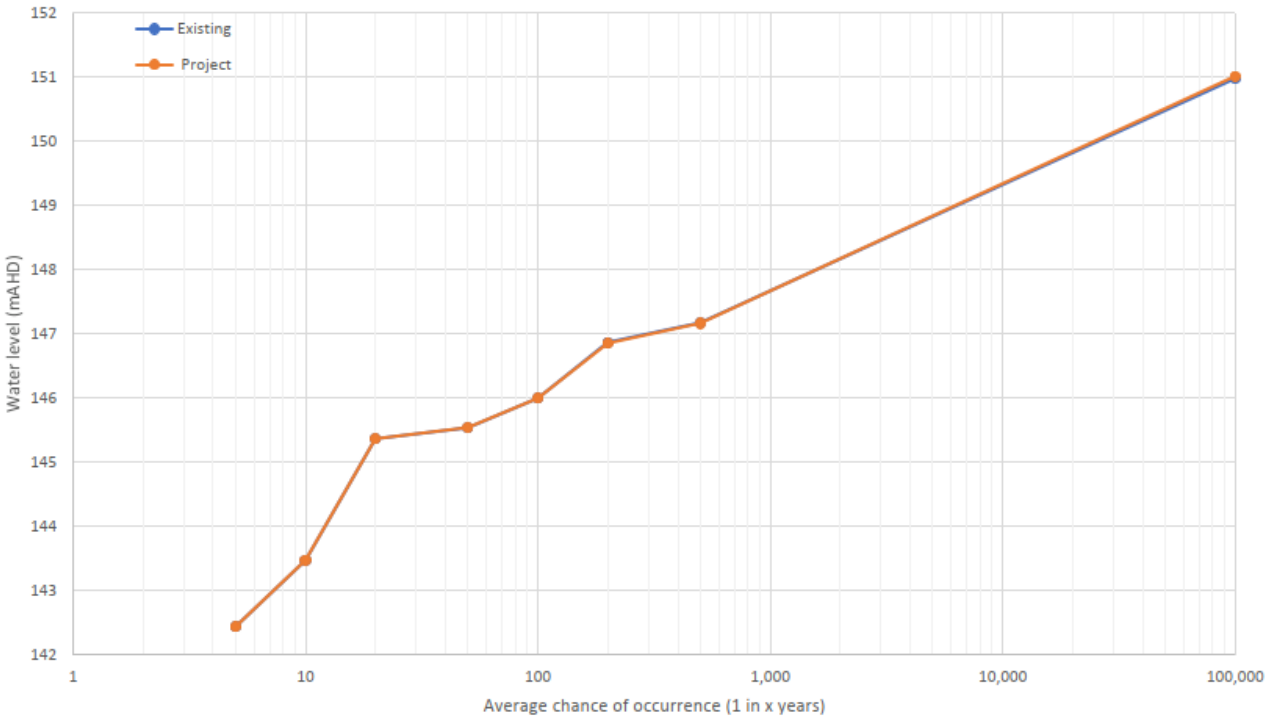


Figure 4-26. Upstream flood frequency distributions: existing and with Project scenarios at COX_US_7335

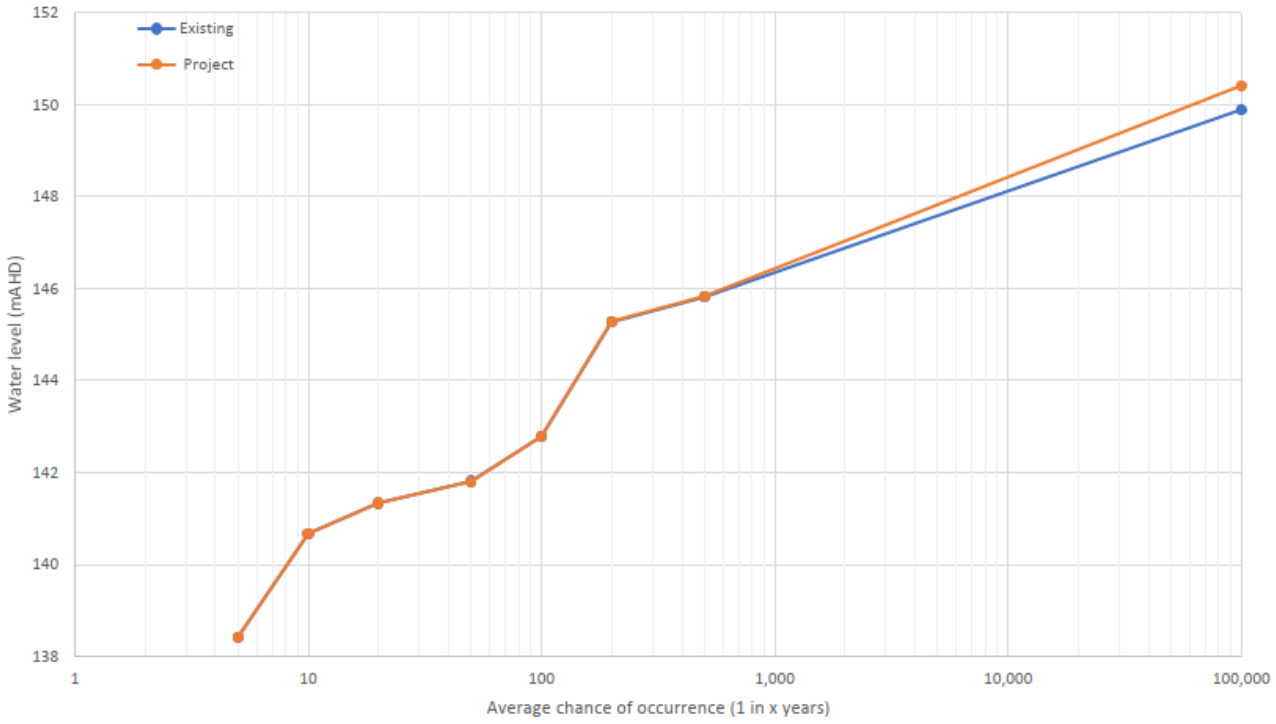


Figure 4-27. Upstream flood frequency distributions: existing and with Project scenarios at NATTAI_5680

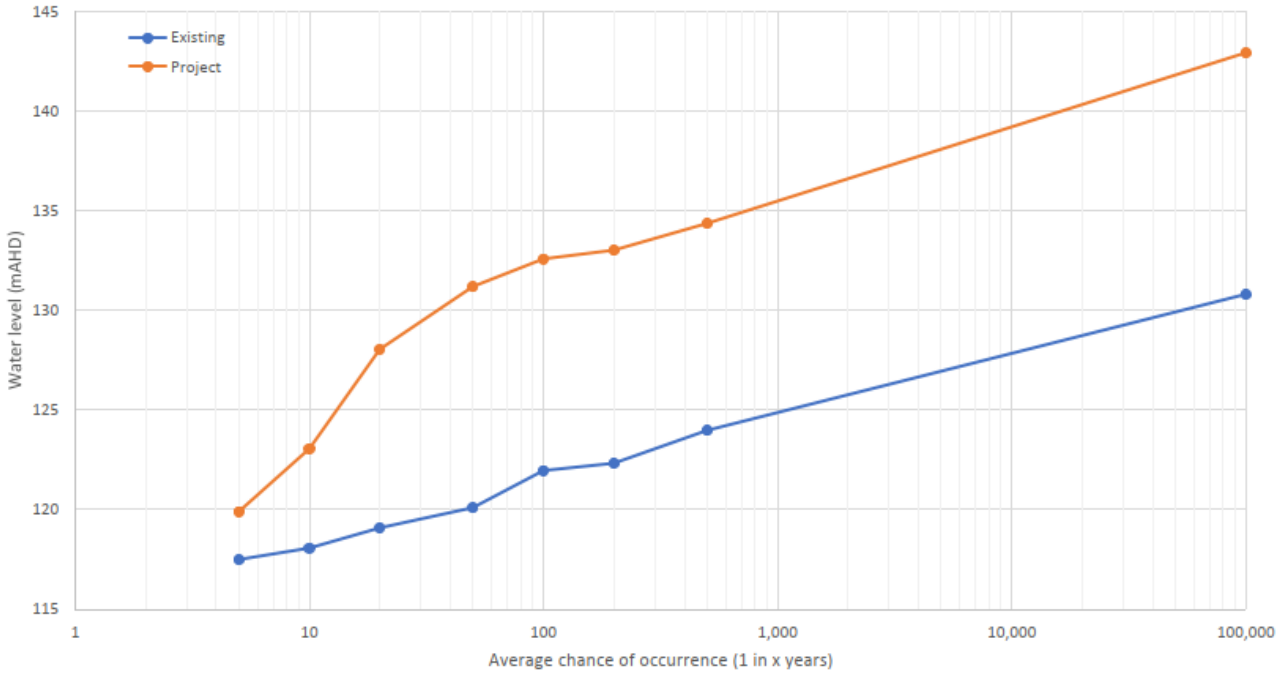


Figure 4-28. Upstream flood frequency distributions: existing and with Project scenarios at NATTAI_1880

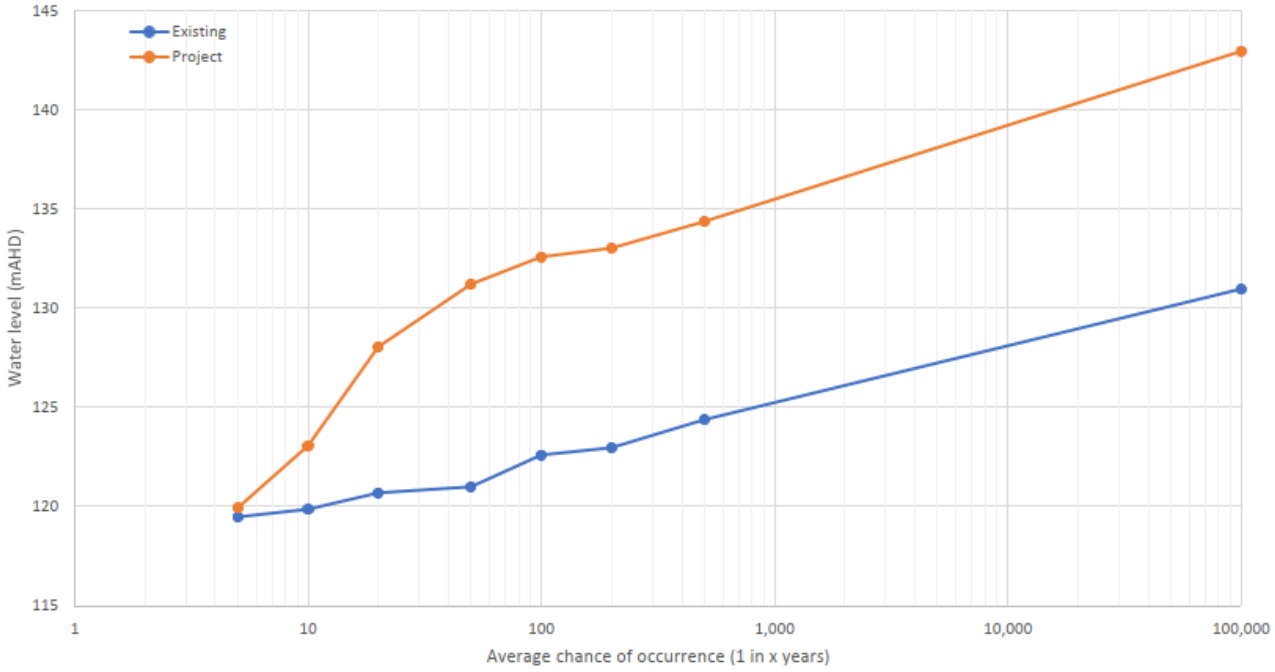
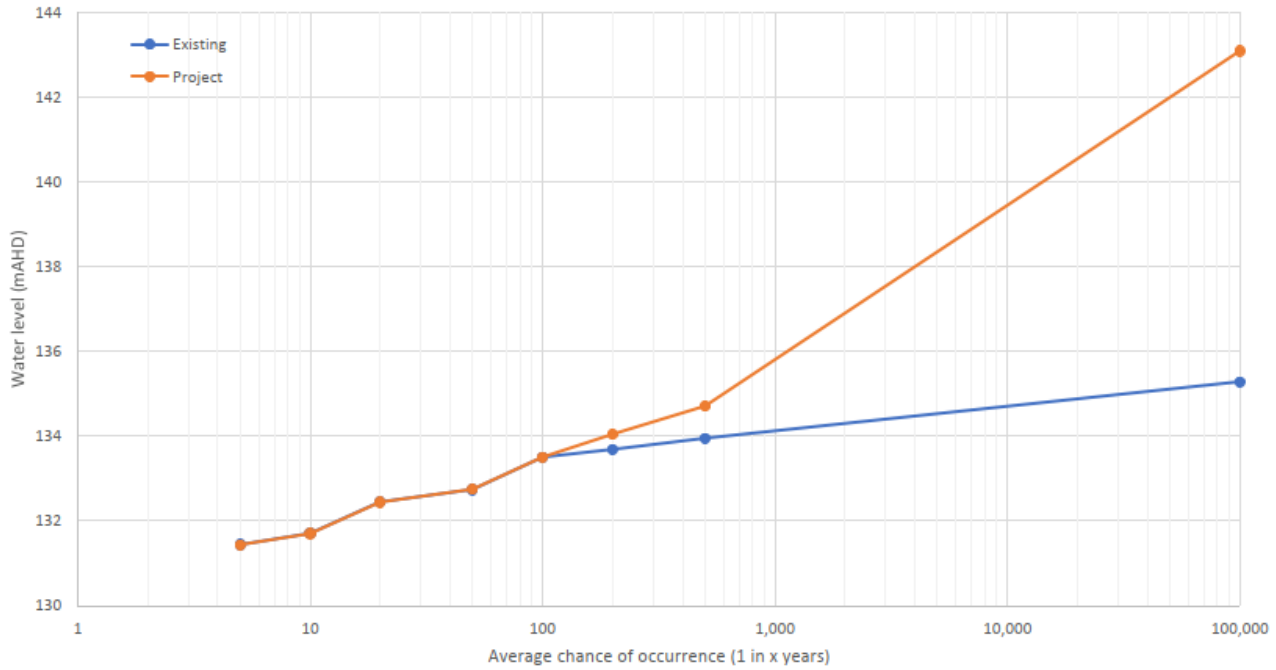


Figure 4-29. Upstream flood frequency distributions: existing and with Project scenarios at NATTAI_11066



4.2.2.3 Changes to flood extents

The inundation extent upstream of Warragamba Dam is controlled by the peak flood level at the dam wall and the topography across the upstream catchment. Areas with steep terrain would have minor increases in flood extent compared to the areas with flatter terrain. The steep valley terrain surrounding Lake Burragorang, which extends from the dam wall upstream for at least 20 km results in the peak flood level inundation extent being contained to a small total land area. Further upstream where key tributaries the Wollondilly River and Coxs River enter Lake Burragorang is notable flatter terrain. As a result, the increase in peak flood level inundation extent from the existing to Project scenario encompasses a larger total area (as elevation increases more gradually).

A comparison of existing flood extent and with Project flood extent for individual flood events identified that the upstream flood extent in tributaries resulted from a combination of the Project and from contributions from the local catchment of the tributary. In order to accurately characterise the potential impacts of the Project, it was therefore necessary to remove the flood extent contributed from the local catchments. This was done through an analysis of representative depth-duration curves for individual cross sections for each tributary. This allowed identification of the cross-section where the Project started to contribute to the extent of inundation.

Approximate changes to the SEARs flood event extents for the GBMWHA is summarised in Table 4-7.

Table 4-7. Changes to flood extents within the GBMWHA

Flood event (1 in x chance in a year)	Existing (ha)	Project (ha)	Additional area (ha)
5	28	115	87
10	113	279	166
20	153	446	293
100	288	703	415

4.2.3 Summary

The following is a summary of the changes to flooding and hydrology in the catchment upstream of Warragamba Dam. It is stressed that these should not be considered in isolation and it is necessary to consider them holistically when assessing potential impacts of the Project on the GBMWHA (considered in Section 6).

The PMF event is used principally as an input to design and, given the scale of the catchment of Lake Burragorang, is highly unlikely to occur in nature. Accordingly, more weight should be given to the flood events with a relatively greater chance of occurrence (and areas that would experience an increased risk of likely inundation due to the Project).

Depth and duration of temporary inundation

For the locations approximating the limit of the 1 in 100 chance in a year event, increases in the depth of temporary inundation with the Project for all events would be half a metre or less.

Increases in duration of temporary inundation for all events considered for the Nattai River and Wollondilly River would be less than half a day.

Increases in temporary inundation for the Kowmung River would be less than half a day up to the 1 in 5 and 1 in 10 chance in a year events, about 1.3 days for the 1 in 20 chance in a year event, and about two days for the 1 in 100 chance in a year event (these would not affect the GBMWHA).

Increases in temporary inundation for the Coxs River would be less than half a day for up to the 1 in 20 chance in a year event and then slightly over half a day up to the 1 in 100 chance in a year event (these would not affect the GBMWHA).

There is an increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation, with locations within Lake Burragorang generally reflecting the pattern of changes in depth and duration of temporary inundation for the same flood events at the dam wall.

Flood frequencies

- The Project would result in a shift in the flood frequency curves resulting in events of a specified depth occurring more frequently than currently occurs; this is most pronounced at the dam wall and in Lake Burragorang, and decreases moving up the tributaries
- There is no material difference in the existing and Project flood frequency curves at upstream locations that approximate the extent of the Project PMF (as would be expected).

Flood extents

- The additional flooding for flood events up to the 1 in 100 chance in a year event potentially affecting the GBMWHA would occur principally along the Wollondilly River within Lake Burragorang (eastern shoreline) and the main river channel (on the right/eastern bank), and the upper reaches of the Nattai River
- There are no areas of the GBMWHA in proximity to the Coxs River and Kowmung River that would be affected by additional flooding for flood events up to the 1 in 100 chance in a year event.

Other Lake Burragorang tributaries

There are a number of other tributaries that drain to Lake Burragorang whose upper reaches extend into or are in proximity to the GBMWHA. The catchments for these tributaries represent very minor contributions to Lake Burragorang relative to the overall Warragamba Dam catchment and accordingly were not included in the upstream modelling. As such, information such as depth-duration curves is not available for any of these tributaries.

The following is noted with regard to these tributaries:

- Lacys Creek: about 18 hectares of the GBMWHA lies within the study area (defined by the Project PMF). The existing 1 in 100 chance in a year event does not affect the GBMWHA, the same event for the Project would affect about 11 hectares. Small areas of the 1 in 20 and 1 in 10 chance in a year events (about 2.3 and 0.1 hectares respectively) with the Project also lie within the GBMWHA; none of these events for the existing situation affect the GBMWHA.
- Green Wattle Creek: the existing 1 in 100 chance in a year event does not affect the GBMWHA; the Project would affect about 0.3 hectares.

- Butchers Creek: the existing 1 in 100 chance in a year event affects less than one hectare of the GBMWHA, the Project would affect about an additional 7.7 hectares. None of the other more frequent flood events extend into the GBMWHA in this location.
- Kedumba River: about 1.8 kilometres of the right bank of the Kedumba River is located immediately adjacent to the GBMWHA. This part of the GBMWHA is generally unaffected by the existing 1 in 100 chance in a year event; the Project would affect about 20 hectares of the GBMWHA. None of the other more frequent flood events would affect the GBMWHA.
- Cedar Creek: none of the other existing or Project flood events up to the 1 in 100 chance in a year flood event extend into the GBMWHA in this location.

4.3 Downstream

4.3.1 Existing hydrology and flooding

Floodwaters flowing into the Hawkesbury-Nepean Valley come from several different river catchments. The largest of these is the Warragamba River catchment, which drains into Lake Burragorang and represents about 80 percent of the catchment at Penrith and 70 percent of the catchment at Windsor. Further inflows downstream of the dam originate from the Nepean River (up to 37 percent), the Grose River (up to 11 percent), South and Eastern Creeks (up to seven percent), and other tributaries (up to 12 percent). While floods can occur without contribution from the Warragamba catchment, larger floods (above the 1 in 100 chance in a year flood) would include significant floodwater inflows from the Warragamba River catchment. However, each flood event is unique due to the timing of rainfall across the Hawkesbury-Nepean Valley catchment.

The inundation extent is controlled by the topography across the floodplain, with floodwaters primarily contained within the channel and highly incised valley floor for some reaches, and widespread inundation in other sections of the floodplain. There are also significant step changes in inundation extents between flood events, for example the reach of the Nepean River from the dam wall to immediately upstream of Penrith is characterised by steep terrain with a highly incised channel, resulting in a narrow flood extent, while near the regional localities of Penrith, Windsor, and Richmond the floodplain is notably flatter and wider, and flood inundation extends over a greater area.

Flooding within the Hawkesbury-Nepean Valley has been described as a ‘bathtub’ effect, where floodwaters are constrained by river channel choke points to form three main floodplains around Wallacia, Penrith/Emu Plains, and Richmond/Windsor (including backwater flooding in South Creek and Eastern Creek). Downstream from the Richmond/Windsor floodplain, the river winds its way through around 100 kilometres of confined, sandstone gorges to Brooklyn. Along this stretch, numerous small floodplains form in the narrow areas between the river and the steep valley sides.

The Hawkesbury-Nepean Valley has one of the most significant flood risk exposures within Australia. The risk to property and life due to flood exposure is well known and has been the subject of numerous studies, including the Hawkesbury-Nepean Valley Flood Risk Management Strategy (INSW 2017), which was prepared on behalf of the NSW Government. Additional flood modelling was undertaken as part of the Project assessment; the outcomes are presented in Appendix H1 (Section 3.20) and summarised below.

Since records began in the 1790s, there have been about 130 moderate to major floods in the valley. The largest flood in living memory was in November 1961 (about a 1 in 50 chance in a year flood), when the water reached 15.7 metres above normal river height at Windsor. The largest flood on record was in 1867 (about a 1 in 500 chance in a year flood), and reached 19.7 metres above normal river height at Windsor, causing massive damage and loss of life (Hawkesbury-Nepean Valley Regional Flood Study 2019). Palaeoflood investigations examined deposits from floods in Fairlight Gorge near the junction of the Nepean and Warragamba Rivers (Saynor and Erskine 1993). Analysis of minerals and radiocarbon dating found that a flood at least eight metres higher than the 1867 flood had occurred in the Holocene (about within the last 10,000 years).

The period from 1901 to 1948 had fewer and smaller floods compared to the 1857–1900 period. However, the period from 1949 to 1992 had more frequent and larger floods, despite the completion of Warragamba Dam for water supply in 1960. Six of the top nine flood events in the continuous period of record (1893–present) occur in the last 50 years. While 1867 is the highest ranking event 1961 is the highest in the continuous record. No moderate or major floods have been observed at Windsor since 1992.

Of interest is a recent significant rain event that occurred in February 2020. Downstream flooding was estimated to be about a 1 in 5 chance in a year event. At the time dam was less than 50 percent full, and all upstream inflow was

trapped by the dam with no spill. Downstream flooding was therefore wholly a result of local flooding, with no contribution from the Warragamba Dam catchment. This highlights the relative importance of local downstream flooding in contributing to existing landforms, biodiversity and groundwater characteristics.

4.3.2 Potential flooding with the Project

4.3.2.1 Changes to flood levels and duration of temporary inundation

The FMZ would delay and attenuate the progression of inflows coming from the upstream Warragamba catchment, which in turn would reduce the severity of regional flood events impacting on the downstream Hawkesbury-Nepean Valley. While the Project would significantly reduce flood risk, it would not eliminate it completely. Flooding from other catchments such as the Nepean, Grose, Colo and South Creek can also contribute significantly to downstream flooding. Peak dam outflows for existing and Project scenarios are given in Table 4-8 and show a reduction in peak outflow at the dam wall for all modelled events.

Table 4-8. Peak dam outflows for existing and Project scenarios for selected flood events

Flood event (1 in x chance in a year)	Existing scenario (m^3/s)	Project scenario (m^3/s)	Peak outflow change at dam wall (m^3/s)
5	2,271	810	-1,461
10	4,430	1,160*	-3,270
20	6,860	1,160*	-5,700
100	9,660	3,800	-5,860
200	11,061	5,943	-5,118
500	13,019	8,862	-4,157

* Discharge rate of flood mitigation zone (100 gigalitres per day)

Figure 4-30 shows the discharge (outflow) hydrographs from Warragamba Dam for the 1 in 20 and 1 in 100 chance in a year events for existing and with Project. As can be seen, the FMZ substantially reduces the peak of the hydrographs but this is offset by an extended period where downstream flows remain above normal until the FMZ is emptied.

Figure 4-30. Discharge hydrographs at Warragamba Dam: 1 in 20 and 1 in 100 chance in a year flood events

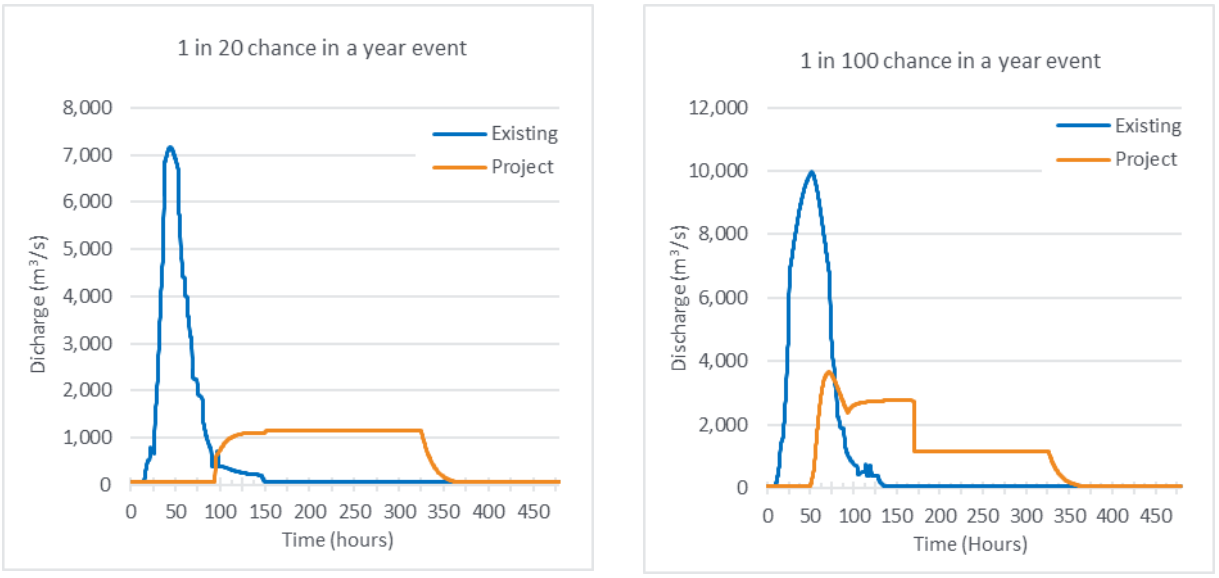
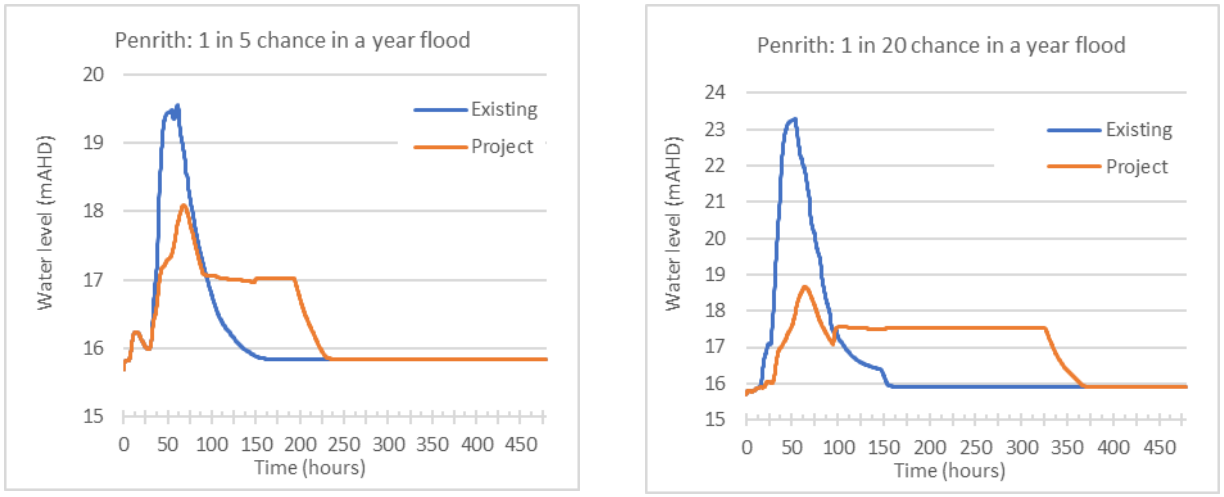


Figure 4-31 shows the hydrographs (as water levels) further downstream of the dam at Penrith for the 1 in 5 and 1 in 20 chance in a year events. As can be seen, the general shape of the existing and Project hydrographs are generally similar to the outflow hydrographs at Warragamba Dam shown in Figure 4-30.

Figure 4-31. Flood hydrographs at Penrith: 1 in 5 and 1 in 20 chance in a year floods

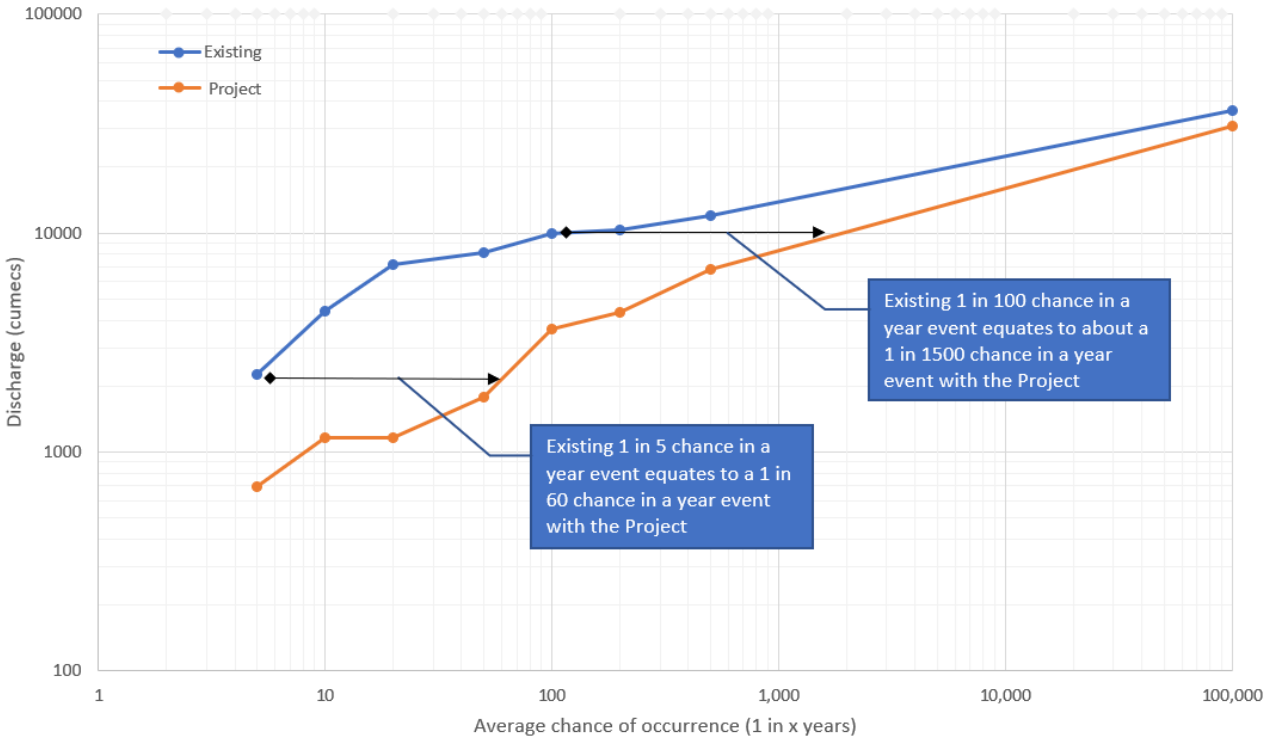


Operation of the FMZ is reflected in the 'plateau' in the falling limb of the Project hydrographs. For the 1 in 5 chance in a year event, the additional duration of elevated water level would be about 3.2 days; for the 1 in 20 chance in a year event, it would be about 8.8 days. These elevated flows would remain within the main channel of the Hawkesbury River and not spill onto the floodplain.

4.3.2.2 Changes to flood frequencies

Figure 4-32 shows the frequency distributions of dam outflows for the existing and Project scenarios (a nominal 1 in 100,000 chance in a year has been used to represent the PMF event).

Figure 4-32. Frequency distributions of dam outflows for existing and Project scenarios



This shows:

- A reduction in magnitude for an outflow event of a specific chance of occurrent; for example, a 1 in 5 chance in a year outflow event reduces from about 2260 m^3/s (cubic metres per second or cumecs) to about 690 m^3/s while the 1 in 100 chance in a year outflow event reduces from about 9970 m^3/s to about 3650 m^3/s
- An overall shift to the right for the Project flood frequency curve representing a lesser chance of occurrence for an outflow event of a specific magnitude.

As illustrated by the annotations, the existing 1 in 5 chance in a year outflow event becomes a relatively less frequent event with the Project, having about a 1 in 60 chance in a year of occurring. Similarly, the existing 1 in 100 chance in a year outflow event becomes a rarer 1 in 1500 chance in a year outflow event.

4.3.2.3 Changes to flood extents

Greater Blue Mountains World Heritage Area

The Project would result in the reduced extent and duration of large floods in both the Warragamba/Nepean River area and the Lower Colo area. Estimated changes in flooding extents for the SEARs floods events for the Nepean/Warragamba Rivers (Blue Mountains National Park) and the Lower Colo River (Yengo National Park) are presented in Table 4-9.

Table 4-9. Areas of downstream GBMWHA in the study area affected by flooding

Location	Flood event (chance in a year)	Existing area affected within study area (ha)	Area affected within study area with Project (ha)	Change in area (ha)
Blue Mountains National Park	1 in 5	80.5	32.1	-48.4
	1 in 10	87.3	51.4	-35.9
	1 in 20	120.8	75.8	-45.0
	1 in 100	177.0	147.8	-29.2
Yengo National Park	1 in 5	0.0	0.0	0.0
	1 in 10	0.0	0.0	0.0
	1 in 20	0.0	0.0	0.0
	1 in 100	0.4	0.1	-0.3

Old Great North Road World Heritage Area

The Old Great North Road World Heritage Area is currently unaffected by all SEARs events up to the 1 in 100 chance in a year event and this would not change with the Project.

4.3.3 Summary

- The area downstream of Warragamba Dam would experience a reduction in the height of flood peaks compared to the existing situation
- Operation of the FMZ would result in an increase in elevated water levels until the FMZ had been emptied; these flows would remain within the main channel of the Hawkesbury River and would not spill onto the floodplain
- Downstream flood events would continue to be influenced by inflows from other catchments
- The frequency of flood events of a specific chance of occurrence in a given year would reduce, i.e. they would be less frequent than currently occurs
- The downstream area of the GBMWHA would experience a reduction in the extent of flooding with the Project compared to the existing situation
- The Old Great North Road World Heritage area is currently unaffected by all flood events considered, and this would be unchanged with the Project.

5 Upstream impact area

The upstream study area comprises the maximum extent of flood prone land estimated from the probable maximum precipitation and resultant inundation. The probabilistic nature of flooding in the upstream study area presents a challenge in identifying appropriate flood events to inform an assessment of potential impacts, and noting that for a specific flood event of a particular chance of occurrence, there is already an existing potential impact associated with that particular flood event.

For the upstream study area, potential impacts would be principally associated with the effects of temporary inundation from operation of the FMZ, the lower limit of which is the FSL. The exact nature of the impacts would be dependent on multiple factors such as:

- the timing and magnitude of the rainfall events
- catchment conditions at the time of the rainfall event
- the existing storage level
- the duration, depth and extent of inundation for an individual flood event
- the potential change in vegetation integrity as a result of the differing responses of individual plant species to different inundation regimes
- the type and condition of Aboriginal cultural heritage items and places.

These and other factors contribute to substantial uncertainty with regard to quantifying the potential impacts on World Heritage values, notably biodiversity values and Aboriginal cultural heritage.

In view of this, it was determined that a different approach to assessing potential impacts was required in order to provide relative greater certainty around potential impacts and importantly, to provide a more objective basis for identification and development of mitigation measures. The approach taken has been to identify an 'impact area' that takes account of the variability of flood events and their extent over time.

Floods are all uniquely different depending on the conditions in place when the event occurs. For example, if a flood occurs during a drought when a dam is half empty, upstream inundation levels would be lower than if the dam had been full. Conversely, if a flood occurs soon after previous rain then greater inflows would occur and with the dam being already quite full, more upstream inundation would result.

Flood behaviour in the Hawkesbury Nepean Valley has been shown to have distinct multi-decade wet and dry periods that have been quite consistent since records began in 1799 (Infrastructure NSW 2019). Table 5-1 lists the large flood events that have occurred over the life of Warragamba Dam. The November 1961 flood is the flood of record since the dam was constructed.

Table 5-1. Summary of large historical flood events for Warragamba Dam

Event	Peak dam level (mAHD)	Inundation depth above FSL (m)	Downstream probability of occurrence (1 in x chance in a year)
November 1961	119.51	2.79	37
June 1964	118.89	2.17	25
June 1975	118.15	1.43	13
March 1978	118.01	1.29	19
April 1988	118.06	1.34	13
August 1990	118.72	2.00	22
March 2021	118.26	1.54	10 to 20[1]

1. At the time of preparation of this report, the probability of occurrence for this event had still to be confirmed.

A review of the historical record identified at least one large flood above FSL would occur within a 20-year period. Building on previous hydrological modelling carried out for the Project, further modelling was undertaken to assess the likely level of inundation upstream of the dam. Around 20,000 Monte Carlo simulated events were used to

generate a 200,000 year flood record. This included the full range of possible events based on the latest hydrology analyses. This was then analysed by selecting the maximum inundation level in 20-year periods to determine an 'average' or likely inundation level. This was also undertaken for the existing dam scenario so that a comparison of inundation levels could be made.

Since flood behaviour in the Hawkesbury Nepean Valley has distinct multi-decade wet and dry periods, the inundation assessment modelled potential outcomes considered:

- randomly selected periods
- half wet / half dry periods
- wet dominated periods
- dry dominated periods.

The results from all these hypothetical flood sequences were then analysed to determine what the average or likely inundation outcomes would be. In terms of predicted inundation, a sample of key results is provided in Table 5-2 for the existing and raised dam. Sensitivity assessments of the results for the 10th, 50th and 90th percentiles, and the average of all probability outcomes are also provided in Table 5-2 for the existing and raised dam.

Table 5-2. Inundation depths for selected flooding scenarios

Percentile	Existing dam		Raised dam		Increase in depth of inundation (m)	
	Random sequence	Flood/drought sequence	Random sequence	Flood/drought sequence		
	Level (mAHD)	Level (mAHD)	Level (mAHD)	Level (mAHD)	Random sequence	Flood/drought sequence
10	117.94	117.10	122.77	119.12	4.83	2.02
50	119.11	118.77	129.10	128.04	9.99	9.27
90	122.77	122.70	133.09	133.05	10.32	10.35
Average	119.54	119.50	127.05	126.97	7.51	7.47

The average results for the flood/drought sequence were then used to define the upper and lower elevations for the impact area as these were considered to provide the most likely outcome on a statistical basis. These are:

- Lower extent: 2.78 metres above FSL (119.5 mAHD)
- Upper extent: 10.25 metres above FSL (126.97 mAHD).

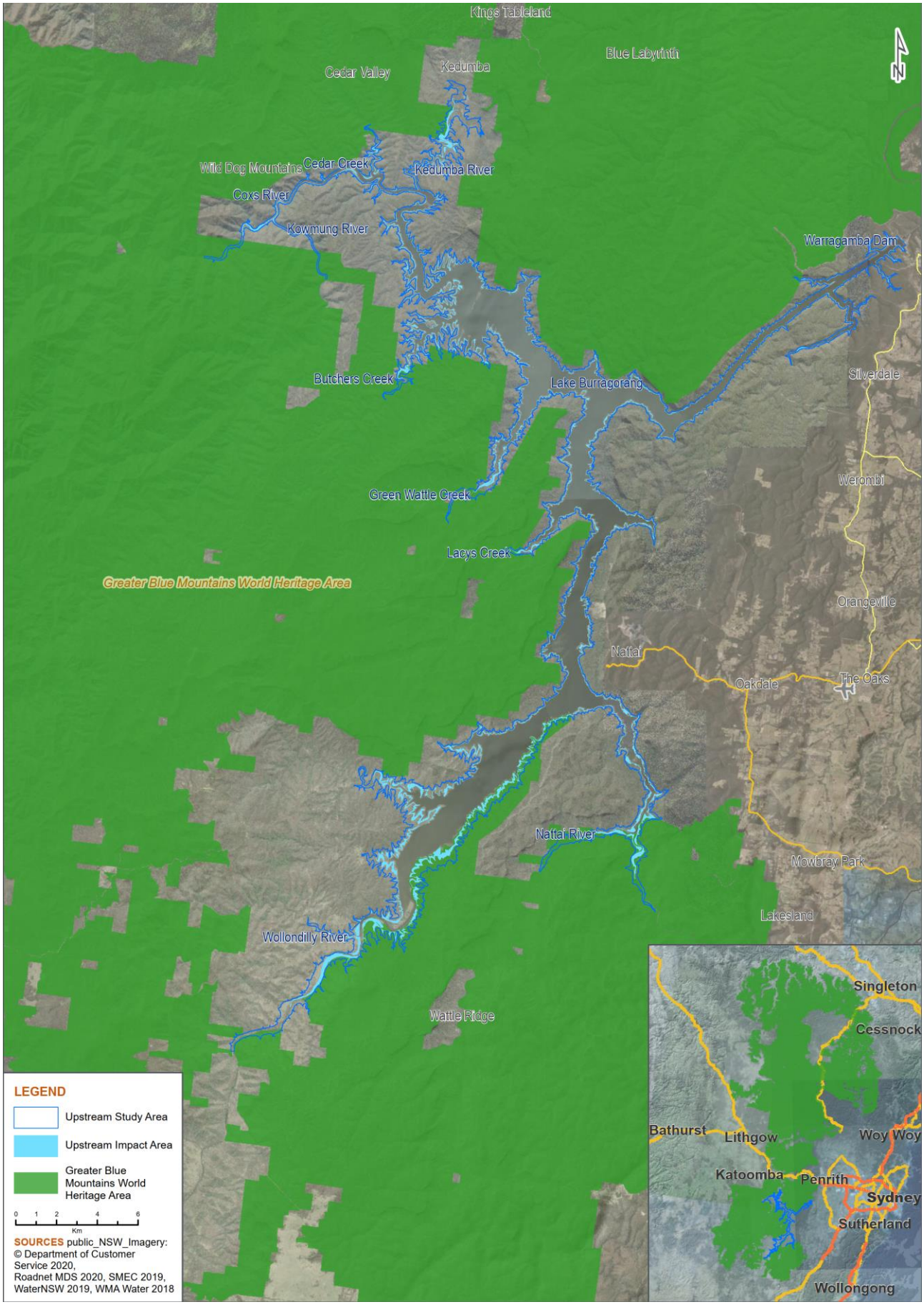
The likely inundation level for the existing dam is also about the maximum recorded level since construction of Warragamba Dam. For the purposes of the Project, the area between these two levels has been adopted as the upstream impact area.

With regard to changes in duration of temporary inundation in the upstream impact area, this would be similar to Lake Burragorang, i.e. an additional duration of about eight and a half days.

The size of the upstream impact area is about 1400 hectares with 304 hectares occurring within the GBMWHA. This represents about 0.03 percent of the total area (1,032,649 hectares) of the GBMWHA. The upstream impact area is shown in Figure 5-1. More detailed views are provided in Figure 6-3, Figure 6-4 and Figure 6-5.

The upstream impact area has been used as a means to offset the potential impacts of the Project on World Heritage values, particularly with regard to biodiversity and heritage values that form a significant part of the OUV of the GBMWHA. For the purposes of offsetting the potential impacts of the Project, a precautionary approach has been taken and it has been assumed that there would be a complete loss of environmental values in this area. In reality, this is unlikely as sensitive areas/sites would have differing risks of impact depending on their respective locations in terms of elevation. Areas/sites at lower elevations would have a greater risk of temporary inundation than areas/sites at higher elevations within the upstream study area.

Figure 5-1. Upstream impact area relative to GBMWHA



6 World Heritage areas

There are three World Heritage areas potentially impacted by the operation of Project:

- The GBMWHA, both upstream and downstream of Warragamba Dam
- Australian Convict Sites (Old Great North Road)
- Australian Convict Sites (Old Great North Road Buffer Zone).

These World Heritage areas and potential impacts of the Project are described in greater detail in the following sections. It should be noted that the focus of the assessment is on the GBMWHA as impacts to the Australian Convict Sites would be positive and therefore detailed assessment of impacts is not considered relevant.

The Project would have a positive impact on the Old Great Northern Road World Heritage area, and would provide a benefit through a small reduction in flood risks to 1.1 hectares of the total site within the study area (refer Section 6.3).

6.1 Greater Blue Mountains World Heritage Area

6.1.1 Background

The GBMWHA is one of the largest and most intact tracts of protected bushland in Australia. It is a deeply incised sandstone tableland covering over one million hectares spread across eight adjacent conservation reserves and is to the west of Sydney and extends almost 250 kilometres from the edge of the Hunter Valley to the Southern Highlands near Mittagong[9].

Brief synthesis

The listing for the GBMWHA includes the following brief synthesis:

> *The Greater Blue Mountains Area (GBMA) is a deeply incised sandstone tableland that encompasses 1.03 million hectares of eucalypt-dominated landscape just inland from Sydney, Australia's largest city, in south-eastern Australia. Spread across eight adjacent conservation reserves, it constitutes one of the largest and most intact tracts of protected bushland in Australia. It also supports an exceptional representation of the taxonomic, physiognomic and ecological diversity that eucalypts have developed: an outstanding illustration of the evolution of plant life. A number of rare and endemic taxa, including relict flora such as the Wollemi pine, also occur here. Ongoing research continues to reveal the rich scientific value of the area as more species are discovered.*
>
> *The geology and geomorphology of the property, which includes 300 metre cliffs, slot canyons and waterfalls, provides the physical conditions and visual backdrop to support these outstanding biological values. The property includes large areas of accessible wilderness in close proximity to 4.5 million people. Its exceptional biodiversity values are complemented by numerous others, including indigenous and post-European-settlement cultural values, geodiversity, water production, wilderness, recreation and natural beauty.*

Outstanding Universal Value criteria

The GBMWHA was inscribed onto the World Heritage list against the following two criteria :

- Outstanding examples of ongoing ecological and biological processes
- Significant natural habitats for the in situ conservation of biological diversity.

The following discussion provides an assessment of the potential impacts of the Project against the two criteria for Outstanding Universal Value of the GBMWHA.

The first criterion that the GBMWHA was listed for is:

> *Criterion (ix): The Greater Blue Mountains include outstanding and representative examples in a relatively small area of the evolution and adaptation of the genus Eucalyptus and eucalypt-dominated vegetation on the Australian continent. The site contains a wide and balanced representation of eucalypt habitats including wet and dry sclerophyll forests and mallee heathlands, as well as localised swamps, wetlands, and grassland. It is a centre of*

[9] https://www.environment.nsw.gov.au/topics/parks-reserves-and-protected-areas/types-of-protected-areas/world-heritage-listed-areas/greater-blue-mountains

diversification for the Australian scleromorphic flora, including significant aspects of eucalypt evolution and radiation. Representative examples of the dynamic processes in its eucalypt-dominated ecosystems cover the full range of interactions between eucalypts, understorey, fauna, environment, and fire. The site includes primitive species of outstanding significance to the evolution of the earth's plant life, such as the highly restricted Wollemi pine (Wollemia nobilis) and the Blue Mountains pine (Pherosphaera fitzgeraldii). These are examples of ancient, relict species with Gondwanan affinities that have survived past climatic changes and demonstrate the highly unusual juxtaposition of Gondwanan taxa with the diverse scleromorphic flora.

The second criterion that the GBMWHA was listed for is:

Criterion (x): The site includes an outstanding diversity of habitats and plant communities that support its globally significant species and ecosystem diversity (152 plant families, 484 genera and c. 1,500 species). A significant proportion of the Australian continent's biodiversity, especially its scleromorphic flora, occur in the area. Plant families represented by exceptionally high levels of species diversity here include Myrtaceae (150 species), Fabaceae (149 species), and Proteaeceae (77 species). Eucalypts (Eucalyptus, Angophora and Corymbia, all in the family Myrtaceae) which dominate the Australian continent are well represented by more than 90 species (13% of the global total). The genus Acacia (in the family Fabaceae) is represented by 64 species. The site includes primitive and relictual species with Gondwanan affinities (Wollemia, Pherosphaera, Lomatia, Dracophyllum, Acrophyllum, Podocarpus and Atkinsonia) and supports many plants of conservation significance including 114 endemic species and 177 threatened species

The diverse plant communities and habitats support more than 400 vertebrate taxa (of which 40 are threatened), comprising some 52 mammal, 63 reptile, over 30 frog and about one third (265 species) of Australia's bird species. Charismatic vertebrates such as the platypus and echidna occur in the area. Although invertebrates are still poorly known, the area supports an estimated 120 butterfly and 4,000 moth species, and a rich cave invertebrate fauna (67 taxa).

Statement of Integrity

The Statement of Outstanding Universal Value prepared for the GBMWHA also provides additional context on other important values, particularly within the Statement of Integrity which is presented in full below. The Statement of Integrity identified Aboriginal Cultural Heritage as an important value of the GBMWHA.

The listing for the GBMWHA includes the following Statement of Integrity:

The seven adjacent national parks and single karst conservation reserve that comprise the GBMA are of sufficient size to protect the biota and ecosystem processes, although the boundary has several anomalies that reduce the effectiveness of its 1 million hectare size. This is explained by historical patterns of clearing and private land ownership that preceded establishment of the parks. However parts of the convoluted boundary reflect topography, such as escarpments that act as barriers to potential adverse impacts from adjoining land. In addition, much of the property is largely protected by adjoining public lands of State Forests and State Conservation Areas. Additional regulatory mechanisms, such as the statutory wilderness designation of 65% of the property, the closed and protected catchment for the Warragamba Dam and additions to the conservation reserves that comprise the area further protect the integrity of the GBMA. Since listing, proposals for a second Sydney airport at Badgerys Creek, adjacent to the GBMA, have been abandoned.

Most of the natural bushland of the GBMA is of high wilderness quality and remains close to pristine. The plant communities and habitats occur almost entirely as an extensive, largely undisturbed matrix almost entirely free of structures, earthworks and other human intervention. Because of its size and connectivity with other protected areas, the area will continue to play a vital role in providing opportunities for adaptation and shifts in range for all native plant and animal species within it, allowing essential ecological processes to continue. The area's integrity depends upon the complexity of its geological structure, geomorphology and water systems, which have created the conditions for the evolution of its outstanding biodiversity and which require the same level of protection.

An understanding of the cultural context of the GBMA is fundamental to the protection of its integrity. Aboriginal people from six language groups, through ongoing practices that reflect both traditional and contemporary presence, continue to have a custodial relationship with the area. Occupation sites and rock art provide physical evidence of the longevity of the strong Aboriginal cultural connections with the land. The conservation of these associations, together with the elements of the property's natural beauty, contributes to its integrity.

Since this Retrospective Statement of Outstanding Universal Value was approved by the World Heritage Committee in 2013, the Australian Government approved the Western Sydney Airport project in 2016. The approval included 42 environmental conditions for the project, addressing biodiversity, noise, and heritage.

In the World Heritage nomination for the GBMWHA, the presence and function of Warragamba Dam was recognised including the important role that the protection of catchment to maintain drinking water quality had made in also protecting biodiversity and other values. The 1995 proposal to raise Warragamba Dam by 23 metres and the temporary storage of water for up to five weeks for flood mitigation was also mentioned. The current Project while having the same flood mitigation objectives, would have a significantly lower potential impact than the 1995 dam raising proposal as it has a smaller FMZ and a shorter duration for the temporary storage of flood waters ranging from hours up to around two weeks.

Statement of protection and management requirements

The listing for the GBMWHA includes the following Statement of protection and management requirements:

> *The GBMA is protected and managed under legislation of both the Commonwealth of Australia and the State of New South Wales. All World Heritage properties in Australia are 'matters of national environmental significance' protected and managed under national legislation, the Environment Protection and Biodiversity Conservation Act 1999. This Act is the statutory instrument for implementing Australia's obligations under a number of multilateral environmental agreements including the World Heritage Convention. By law, any action that has, will have or is likely to have a significant impact on the World Heritage values of a World Heritage property must be referred to the responsible Minister for consideration. Substantial penalties apply for taking such an action without approval. Once a heritage place is listed, the Act provides for the preparation of management plans which set out the significant heritage aspects of the place and how the values of the site will be managed.*
>
> *Importantly, this Act also aims to protect matters of national environmental significance, such as World Heritage properties, from impacts even if they originate outside the property or if the values of the property are mobile (as in fauna). It thus forms an additional layer of protection designed to protect values of World Heritage properties from external impacts. In 2007, the GBMA was added to the National Heritage List, in recognition of its national heritage significance under the Act.*
>
> *A single State government agency, the New South Wales Office of Environment and Heritage, manages the area. All the reserves that comprise the GBMA are subject to the National Parks and Wildlife Act 1974 and the Wilderness Act 1987. Other relevant legislation includes the Threatened Species Conservation Act 1995, the Environmental Planning and Assessment Act 1979, the Sydney Water Catchment Management Act 1998 and the Heritage Act 1977.*
>
> *At the time of nomination statutory management plans for the constituent reserves of the GBMA were in place or in preparation, and these are reviewed every 7-10 years. Currently all management plans have been gazetted, and those for three component reserves (Wollemi, Blue Mountains, and Kanangra-Boyd National Parks, which constitute 80% of the property) are under revision for greater emphasis on the protection of identified values. An over-arching Strategic Plan for the property provides a framework for its integrated management, protection, interpretation and monitoring.*
>
> *The major management challenges identified in the Strategic Plan fall into six categories: uncontrolled or inappropriate use of fire; inappropriate recreation and tourism activities, including the development of tourism infrastructure, due to increasing Australian and overseas visitor pressure and commercial ventures; invasion by pest species including weeds and feral animals; loss of biodiversity and geodiversity at all levels; impacts of human-enhanced climate change; and lack of understanding of heritage values.*
>
> *The set of key management objectives set out in the Strategic Plan provides the philosophical basis for the management of the area and guidance for operational strategies, in accordance with requirements of the World Heritage Convention and its Operational Guidelines. These objectives are also consistent with the Australian World Heritage management principles, contained in regulations under the Environmental Protection and Biodiversity Conservation Act.*

6.1.2 Management of the GBMWHA

6.1.2.1 Management responsibilities

The Australian Government, as signatory to the World Heritage Convention, works in cooperation with the NSW Government (and other states) to ensure management of World Heritage is consistent with the Convention, and administers the EPBC Act under which World Heritage is a matter of national environmental significance.

The NSW Government is directly responsible for the day-to-day management of the GBMWHA and there is a Management Committee which consists of:

- Director Jenolan Caves Reserve Trust
- Director National Parks and Wildlife Service (NPWS) Blue Mountains Branch
- Director NPWS Cultural Values Planning
- a representative from DAWE.

As all the GBMWHA is contained within national parks, day-to-day management activities within the GBMWHA are undertaken by NPWS.

There is also an advisory committee which provides input to the management committee. World Heritage advisory committees in New South Wales advise managing agencies and government ministers responsible for world heritage on matters relating to the identification, protection, conservation, and presentation of World Heritage values. This includes strategic policies in relation to Australia's obligations under the World Heritage Convention. The committees may also be asked to consider and provide advice on issues that may have a significant impact on the area or on natural and cultural-heritage conservation.

Committee chairs are jointly appointed by NSW and Australian Government ministers responsible for World Heritage. Committee members are appointed by State minister/s responsible for World Heritage. Committee members are appointed in their own right and not as representatives of a particular organisation, institution, discipline, interest sector or Aboriginal language group.

The Greater Blue Mountains Area World Heritage Advisory Committee has 12 members. Current members represent:

- local Indigenous/traditional owner
- local government
- tourism
- non-government conservation/heritage organisation
- outdoor, self-reliant, nature-based recreation
- water quality/aquatic environment
- botanical/ecological sciences
- zoological/ecological sciences
- archaeological/cultural heritage.

Committee meetings may also attended by observers drawn from NPWS and the three Regional National Parks Advisory Committees as set out in Appendix 3 of the GBMWHA Strategic Plan (DECC 2009).

6.1.2.2 Strategic plan

The *Greater Blue Mountains World Heritage Area Strategic Plan* (Strategic Plan) (DECC 2009) provides the framework for the management of the World Heritage Area. The Strategic Plan was prepared to meet Australia's international responsibilities under the World Heritage Convention. It aims to ensure that appropriate consideration is given to the GBMWHA's world heritage values in managing the national parks that form the GBMWHA, and that management measures are developed and implemented in a consistent and coordinated way. The document is also a public statement of the commitment of the management agencies to the long-term survival of the GBMWHA. The Strategic Plan is part of the overall planning framework for the GBMWHA and does not attempt to provide detailed management prescriptions for the individual reserves in the GBMWHA, which are provided by national parks and state conservation area plans of management.

The Strategic Plan was reviewed in about 2014 and an addendum was subsequently issued in 2016. The mid-term review made required readjustments and updates to relevant government policy or legislation.

The Strategic Plan is discussed in greater detail in Section 7 and the impacts of the Project are assessed in relation to the various aspects of the Strategic Plan (and the 2016 addendum) in this section.

6.1.2.3 Gundungurra Indigenous land use agreement

Indigenous land use agreements (ILUAs) are agreements under the *Native Title Act 1993* between the Australian Government and Native Title claimants or holders. These agreements may be used to resolve native title claims and establish access and management arrangements between native title claimants and other landowners within a claim area.

The Gundungurra ILUA was signed in 2014 by the Gundungurra people and relevant government agencies and ministers and registered with the Native Title Tribunal. The ILUA acknowledges the Gundungurra people's custodianship, use and management of their traditional land and waters across an area of about 6,942 square kilometres (about eight kilometres south of Lithgow and 18 kilometres north of Goulburn). The Gundungurra people's traditional land and waters include 20 national parks and reserves and some of the GBMWHA. The Gundungurra people agreed to withdraw their native title claim on registration of the agreement.

6.1.3 NSW Protected Areas and the GBMWHA

The GBMWHA is protected at a State level through inclusion of its areas in National Parks or State Conservation Areas which have been created under the NPW Act. The GBMWHA is contained in part or all of the following State protected areas:

- Blue Mountains National Park
- Nattai National Park
- Thirlmere Lakes National Park
- Kanangra-Boyd National Park
- Jenolan Karst Conservation Reserve
- Wollemi National Park
- Yengo National Park
- Gardens of Stone National Park.

Areas of Yengo National Park, Blue Mountains National Park and Nattai National Park are within the GBMWHA and are potentially impacted by the Project.

6.1.4 GBMWHA and Lake Burragorang and Warragamba Dam

6.1.4.1 Historical background

The construction of Warragamba Dam commenced in 1948 with the dam formally opened in 1960. The dam and its reservoir (Lake Burragorang) existed before the 1972 World Heritage Convention was ratified by the Australian Government and before the GBMWHA was World Heritage listed in 2000. To protect the water quality in Lake Burragorang, large areas of the catchment immediately around Lake Burragorang were protected from development through enacting legal protections (that is, Special Areas) which limited further development and allowed for the voluntary resumption of privately-owned land. In the 1970s and 1980s, some areas of the Lake Burragorang catchment were added to various national parks and management of these areas was undertaken jointly by the NPWS and the dam owner/manager (WaterNSW). In June 2002, the majority of the Special Areas were transferred to NPWS and included in existing national parks or state conservations areas, if they were not already protected lands under the NPW Act.

6.1.4.2 Special Areas

The Special Areas around Lake Burragorang have been created under the *Water NSW Act 2014* with the objective of (section 47(2)):

(a) protecting the quality of stored waters, whether intended for use for drinking or other purposes,

(b) maintaining the ecological integrity of an area of land to be declared to be a special area in a manner that is consistent with WaterNSW's objectives.

Management responsibility for the Special Areas (both within and outside of the GBMWHA) is undertaken by NPWS in consultation with WaterNSW. Access to the Special Areas around the Lake Burragorang is highly controlled and restricted.

There are two types of Special Areas (with different levels of access restrictions):

- **Schedule 1** Special Areas are a three-kilometre area around the shore of Lake Burragorang and have the most restrictive access. No one is permitted to access the Schedule 1 Special Areas unless they have approval from NPWS and WaterNSW. There are locked gates on access roads, signage and regular patrols to ensure that the security of the Schedule 1 Special Areas is maintained.
- **Schedule 2** Special Areas range from six to about 20 kilometres from Lake Burragorang and its tributaries. Access by foot is permitted to Schedule 2 land, however apart from a small number of private land owners in Schedule 2 lands, access via vehicle is not permitted. There are also restrictions on the activities which can be undertaken and the requirement not to damage any aspect of the environment in Schedule 2 lands.

Apart from the catchment of some short reaches of the Wollondilly and Nattai Rivers, all areas potentially impacted by the Project in the GBMWHA (including the upstream impact area) are also Schedule 1 Special Areas. The catchments of the short reaches of the Wollondilly and Nattai Rivers noted above are in Schedule 2 Special Areas. These areas are shown in Figure 6-1.

6.1.4.3 Spatial extent of GBMWHA in relation to Lake Burragorang and National Parks

The boundary of the GBMWHA does not always correspond with the boundaries of the National Parks around Lake Burragorang and its tributaries. In most locations around Lake Burragorang there is a 'buffer' or strip of land which is in a National Park, but not part of the GBMWHA. The major exception to this is along the southern bank of the Wollondilly River arm of Lake Burragorang where the GBMWHA and the Nattai National Park boundary extends down to the FSL of Lake Burragorang (see Figure 3-1).

Other areas where the GBMWHA boundary extends to the FSL or to the bank of a potentially impacted waterway include:

- the Nattai River near the Little River confluence (Nattai National Park)
- a small reach of the Kedumba River (Blue Mountains National Park)
- reaches of the Kowmung River and Coxs River about three kilometres upstream of their confluence (Blue Mountains National Park)
- a number of minor tributaries which flow directly into Lake Burragorang (Blue Mountains National Park).

Temporary inundation impacts of the Project on these areas are described and mapped in Section 6.1.7.

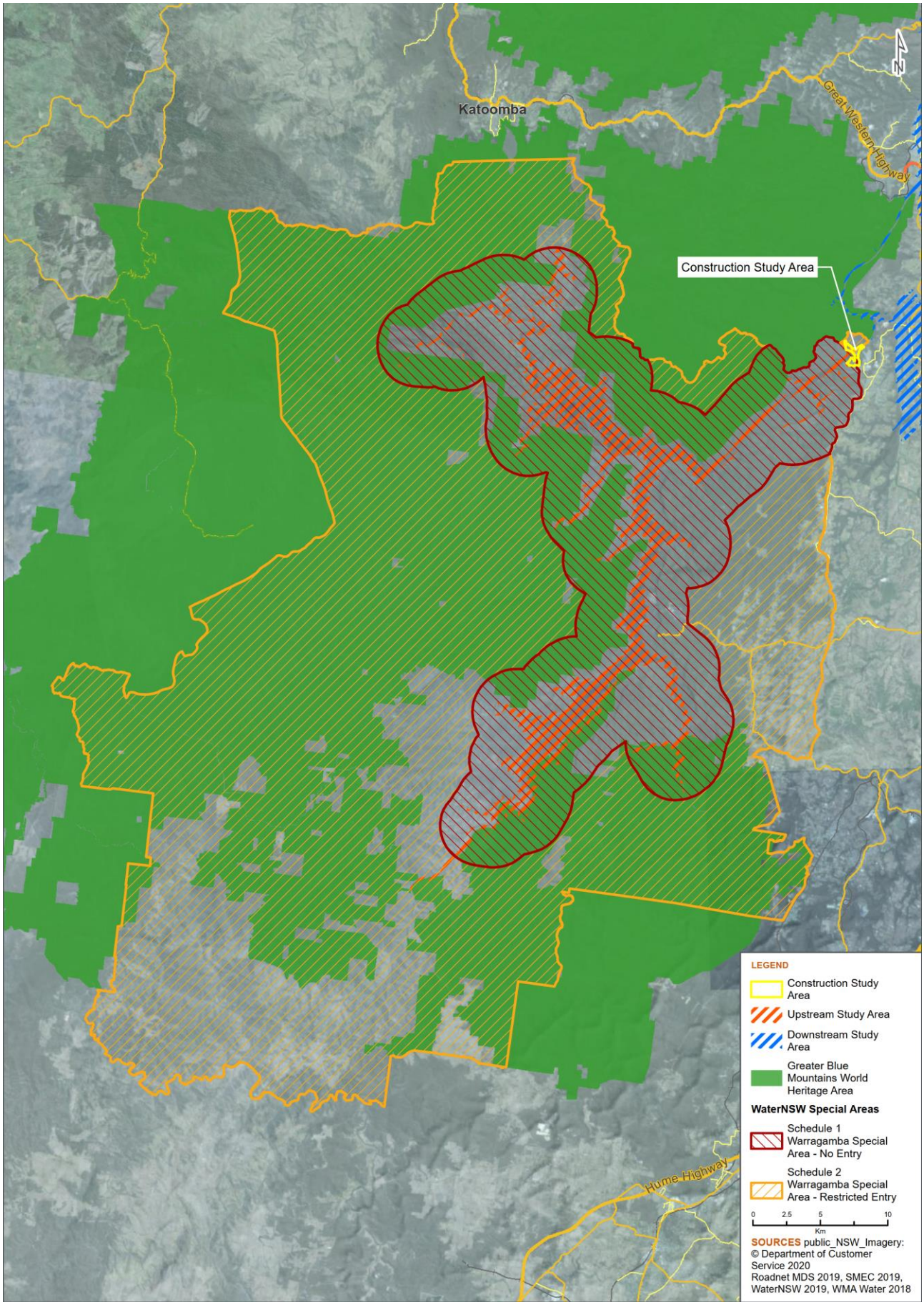
6.1.5 Areas of GBMWHA downstream of Warragamba Dam

Downstream of Warragamba Dam there are areas of the GBMWHA which are immediately adjacent to the main river channel of the Hawkesbury-Nepean River or one its main tributaries, notably:

- an approximately 13 kilometre reach of the Nepean River from its junction with the Warragamba River to Lapstone; this stretch of river passes through a section of the Blue Mountains National Park which is also part of the GBMWHA
- the lower reaches of the Colo River and Wheehy Creek. These waterways pass through Yengo National Park which is also part of the GBMWHA.

There are other areas of the GBMWHA which are part of the catchments of other tributaries of the Hawkesbury-Nepean River (for example, Grose River). However, these areas of the GBMWHA would not be affected by the Project as they are too far upstream and therefore have not been further discussed.

Figure 6-1. Locations of Special Areas relative to the GBMWHA



6.1.6 Relationship to potential Project impacts

There are areas of the GBMWHA both upstream and downstream of Warragamba Dam that could be potentially impacted by the Project. These are:

- upstream – catchment areas of Lake Burragorang which include areas of the Blue Mountains National Park and Nattai National Park within the GBMWHA would experience an increase in the extent and duration of temporary inundation during flood mitigation operations
- downstream – areas of the Blue Mountains National Park (the banks of the Nepean River between Wallacia and Lapstone) and the Yengo National Park would experience a reduction in peak flood extents and durations but may experience increased low-level flooding during the discharge of the FMZ.

These impacts and potential benefits are discussed in greater detail in the following sections.

The construction area lies outside of the GBMWHA but is in close proximity to the GBMWHA (refer Figure 6-2). At its closest point it is about 50 metres from the GBMWHA, however, construction activities would generally be located at a distance of 300 metres or more from the GBMWHA.

Figure 6-2. Location of construction area relative to the GBMWHA

Changes in temporary flooding extents in the upstream study area

The flooding and hydrology assessment for the Project is presented in Appendix H1 and Chapter 15 of the EIS and a detailed summary has been provided in Section 4 of this report. Information from this assessment has been used to assess the potential impacts on the GBMWHA.

Areas of the GBMWHA currently experience temporary inundation during significant rainfall events. In the study area for the Project, temporary inundation is caused by local catchments inflows (and would occur irrespective of Warragamba Dam's construction) and from the effects of the existing dam which causes flood waters to back up along the tributaries. However, as Warragamba Dam was constructed and was operational before the GBMWHA was World Heritage listed, the existing temporary inundation conditions with the current dam are the baseline for any assessment of impacts.

Figure 6-3 to Figure 6-5 show the temporary inundation extents of key areas of the GBMWHA for the upstream impact area. Three hundred and four hectares of the upstream impact area (about 1400 hectares in total) occurs within the GBMWHA. This represents about 0.03 percent of the total area of the GBMWHA.

The majority of the additional GBMWHA land temporarily inundated due to the Project is adjacent to the Wollondilly and Nattai Rivers, with smaller areas along the Kedumba River and creek catchments which flow directly into Lake Burragorang. The area of additional GBMWHA land temporarily inundated due to the Project along the Coxs River and Kowmung River is negligible.

Changes in flooding durations in the upstream study area

The overall objective of the Project is to temporarily capture flood inflows and then release them after peak flood levels in the waterways downstream have receded. The temporary storage of flood inflows would result in some upstream areas experiencing a greater duration of temporary flooding compared to existing conditions. The time and extent of increased duration of flooding from the Project would depend upon the size of the flood event and the specific location being assessed in relation to the waterway. The increased duration of flooding may range from hours to around two weeks.

Figure 4-7 shows the increases in temporary inundation at Warragamba Dam for a range of flood events based upon elevation.

6.1.7 Impacts on wilderness areas and wild rivers in the GBMWHA

The *Greater Blue Mountains World Heritage Area Strategic Plan Addendum 2016* notes that the wilderness quality of the GBMWHA makes a significant contribution to its outstanding universal value and has historically ensured the integrity of the property. It further notes that The GBMWHA Strategic Plan identifies the management response to 'maintain and enhance the wilderness and wild river quality and values of the GBMWHA through formal declaration and appropriate management programs' (OEH 2018).

Some areas of the GBMWHA which are potentially impacted by the Project are part of declared wilderness areas under the NSW *Wilderness Act 1987* (refer Figure 6-3 to Figure 6-5) and could experience increased temporary inundation from the Project. However, these wilderness areas are not subject to either a wilderness protection agreement or conservation agreement.

The area of declared wilderness areas in the GBMWHA within the upstream impact area that could be impacted by the Project is about 36 hectares (refer Figure 6-3 to Figure 6-5). This is less than 0.01 percent of the total declared wilderness area in the GBMWHA. There are no declared areas of wilderness downstream of Warragamba Dam that would be affected by the Project.

Under section 6.1 of the *Wilderness Act 1987*, wilderness is areas of land that are:

- substantially unmodified by humans
- of sufficient size to retain their natural values
- capable of providing opportunities for solitude and appropriate self-reliant recreation.

While the Project assumes a total loss of biodiversity and other values in the upstream impact area, it is considered that the Project would not materially alter these values with regard to declared wilderness areas potentially affected by temporary inundation for the following reasons:

- The Warragamba Special Area was declared in 1942 to protect the water supply catchment (Sydney Catchment Authority 2010); land within the area, including declared wilderness which would have had limited human impact since that time. Potential human modification of the declared wilderness area within the GBMWHA would related principally to the existing operation of Warragamba Dam. As noted in Table 5-1, there have been eight significant flood events since the dam was constructed which would have caused temporary inundation to varying degrees in the upstream study area. While there has not been a detailed investigation of the potential impacts of temporary inundation associated with these events, a review of aerial imagery prior to the 2019-202 bushfire event would suggest there has been minimal effect on vegetation.
- As noted, the potentially affected area of declared wilderness within the GBMWHA is less than 0.01 percent of the total declared wilderness area in the GBMWHA. The remaining unaffected area is considered to be of a sufficient size for the retention of its natural values.

Figure 6-3. Upstream impact area: Kedumba River, Coxs River and Kowmung River locality

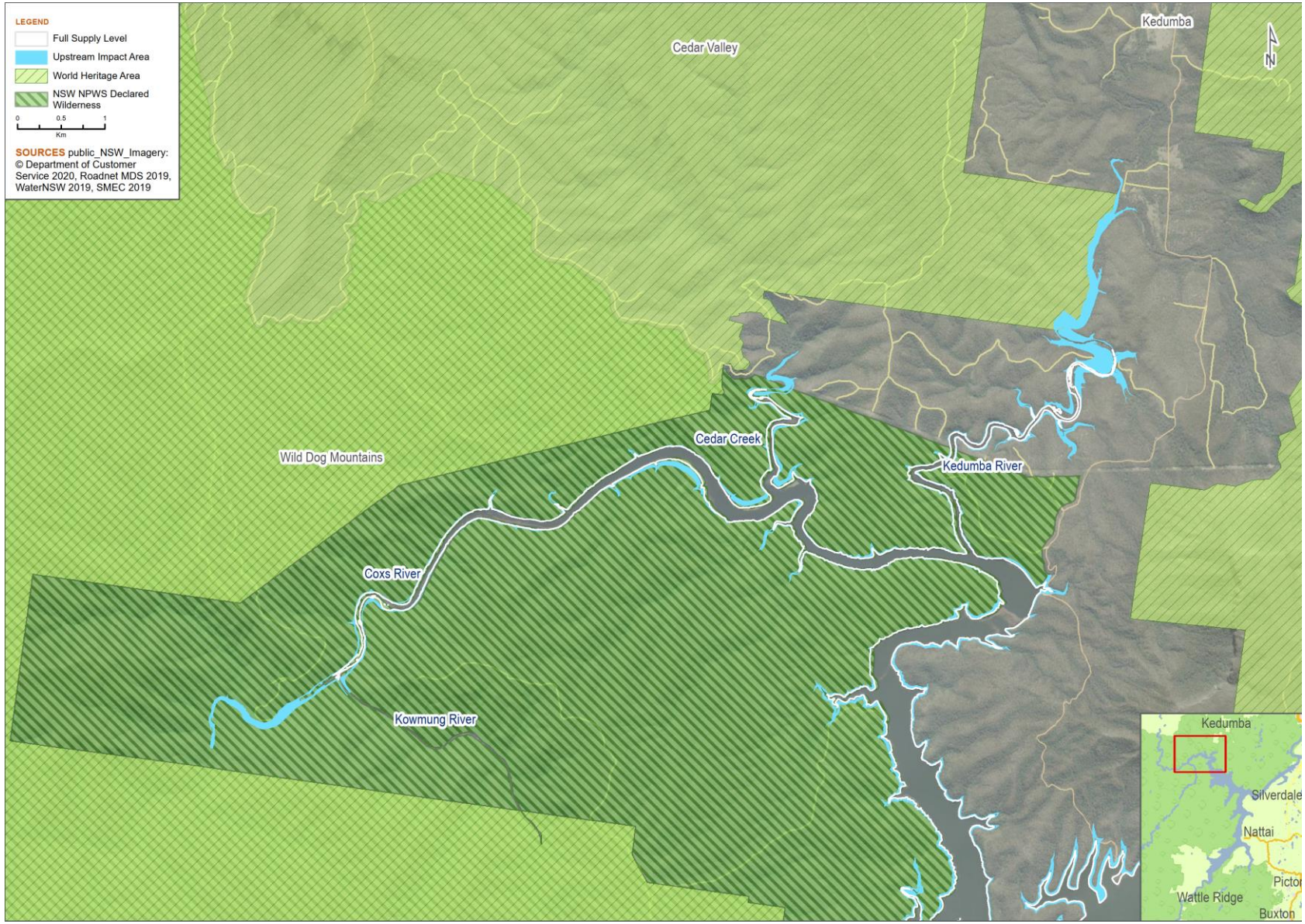


Figure 6-4. Upstream impact area: Lake Burragorang tributaries locality

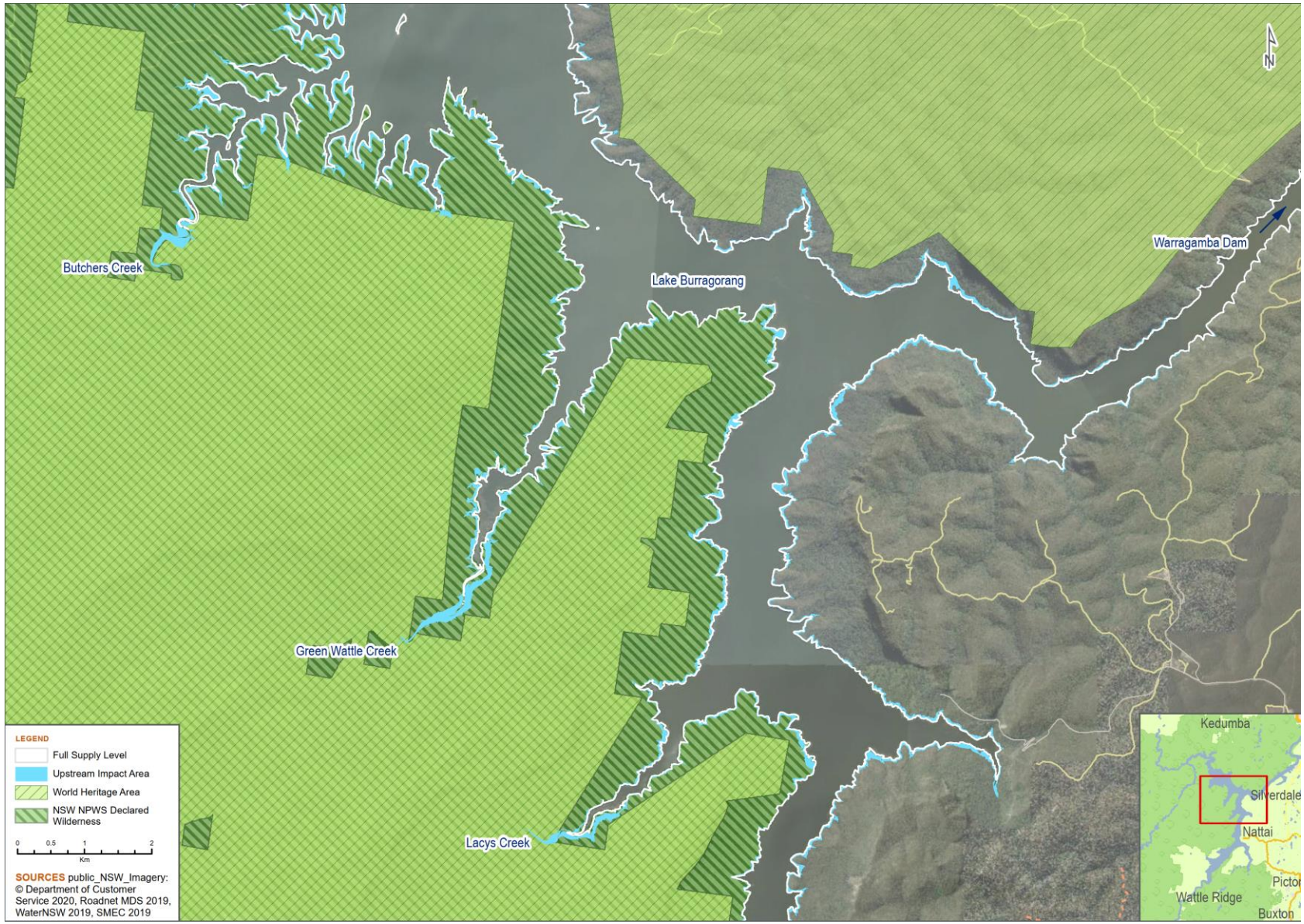
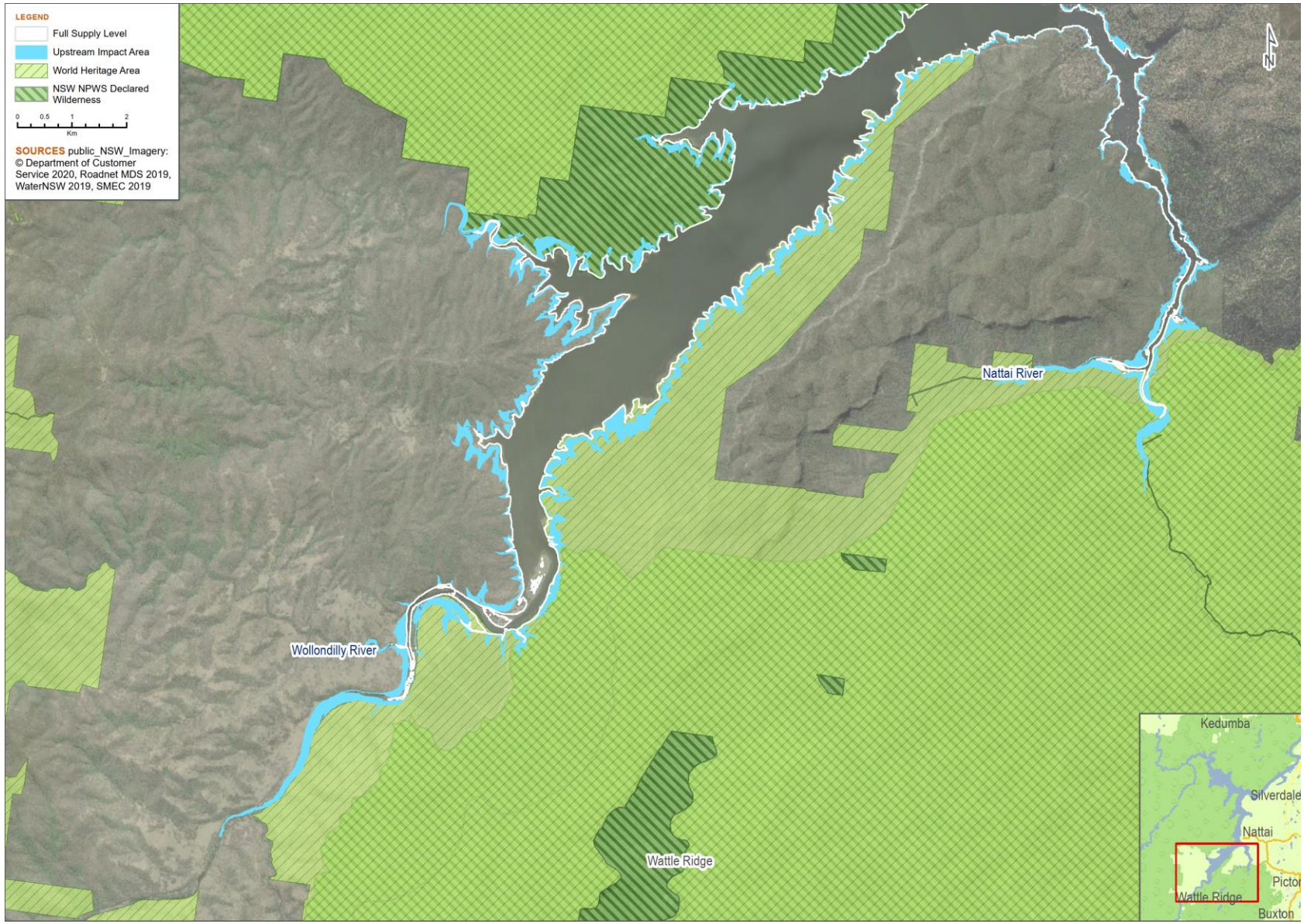


Figure 6-5. Upstream impact area: Wollondilly River and Nattai River locality



- The potentially affected area of declared wilderness within the GBMWHA is located in the Schedule 1[10] Special Area where public access is not permitted; as such this would not impact opportunities for solitude and appropriate self-reliant recreation.

Part of the Kowmung River has been declared a wild river under the NPW Act. GIS analysis using spatial data sourced from NSW Spatial Services identified a small section of the Kowmung River (about 1,250 metres) within the Project study area but well above the upstream impact area (refer Figure 6-6). An analysis of depth-duration curves for the closest cross section downstream of the declared wild river catchment (about 250 metres downstream) showed no material difference between the existing situation and with the Project for all flood events up to the 1 in 100 chance in a year event and a very small difference (less than 0.3 metres) up to the 1 in 1,000 chance in a year event. In real world terms, the Project would not impact on the declared wild river section of the Kowmung River.

The assessment for declaration of the Kowmung River as a wild river (DEC 2005) considered the river's geomorphic condition, its biological condition, and its hydrological condition. Comment on the potential impact of the Project with regard to each of these aspects is provided as follows:

- Geomorphic condition: the wild river assessment concluded that the river was considered to be geomorphically natural within the Kanangra-Boyd National Park boundary. The geomorphological assessment carried out for the Project (Appendix N2) concluded that the potential for an increase in out of bank erosion risk in the upstream study area was low. The assessment also considered the potential for a decrease in channel velocity to result in depositional features within channels. It was noted that due to the gradient of the Kowmung River, the likelihood of this was very low.
- Biological condition: the wild river assessment concluded that both the high AUSRIVAS[11] scores and high aquatic biodiversity supported the view that the Kowmung River was suitable for listing as a wild river. Given the geomorphological assessment concluded that the Project would have negligible impact, it is expected there would be similar limited impacts on aquatic habitat.
- Hydrological condition: the wild river assessment concluded that the river was considered to be sufficiently natural to be declared a wild river. As noted above, the declared wild river section of the Kowmung River would not be affected by the Project.

There are no other designated wild rivers in the part of the GBMWHA potentially affected by the Project.

6.1.8 Impacts on Aboriginal cultural heritage in the GBMWHA

The Aboriginal Cultural Heritage Assessment report for the Project is provided as Appendix K to the EIS. Findings applicable to the upstream GBMWHA are presented as follows.

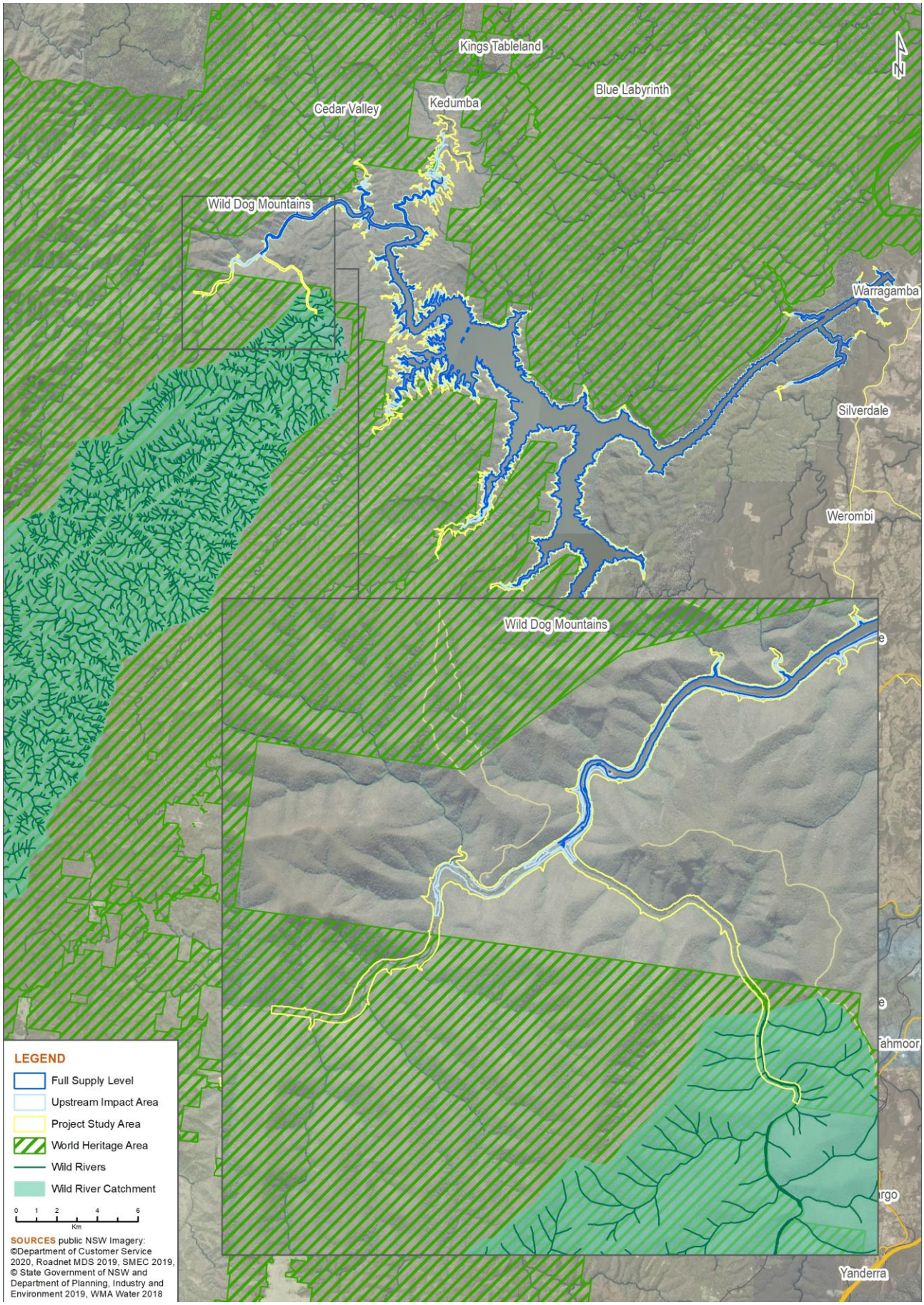
The Aboriginal Cultural Heritage Assessment was undertaken in compliance with relevant NSW guidelines and consisted of the following activities:

- identification and registration of local Aboriginal individuals and groups that have a connection to land in the Project area (that is, Registered Aboriginal Parties or RAPs)
- review of existing information on the location and type of known archaeological and cultural heritage sites
- development of predictive models to guide field survey work
- development of methodology to undertake heritage assessment and consultation with RAPs on methodology
- field survey with RAPs including identification and recording of any new sites
- assessing the scientific and cultural value of new archaeological and cultural heritage sites
- assessing other cultural and historical information
- assessing the impact of the Project on archaeological and cultural heritage sites
- developing mitigation measures to minimise impacts

[10] Water NSW Regulation 2013

[11] **Au**stralian **R**iver **A**ssessment **S**ystem; refer https://ausrivas.ewater.org.au/index.php/home

Figure 6-6. Location of the wild river section of the Kowmung River relative to the upstream Project study area



- preparing a draft Aboriginal Cultural Heritage Assessment Report and draft Cultural Values Assessment Report, and providing these to the RAPs for their, review, comment, and input
- preparing a final Aboriginal Cultural Heritage Assessment Report and final Cultural Values Assessment Report (which forms an appendix to the Aboriginal Cultural Heritage Assessment Report) incorporating RAP input, where appropriate.

Forty-three archaeological sites were identified in the GBMWHA between the FSL and the upstream Project study area boundary, comprising previously recorded sites and new sites identified by investigations for the Project. A summary breakdown of these by site type, location, scientific and cultural significance, and potential impact is provided in Table 6-1. As noted in Section 5, the Project has taken a precautionary approach and assumed a complete loss of environmental values in the upstream impact area.

Table 6-1. Known Aboriginal sites in the GBMWHA and potential impacts

Site type	Number of sites	Scientific significance	Cultural significance	Potential impact
Sites between FSL (116.7 mAHD) and the upstream impact area (RL 119.5 mAHD)[1]				
Aboriginal Resource and Gathering	1	Low	High	Total loss of value
Open Camp Site	19	Low – 15 sites Moderate – 1 site High – 3 sites	High	Total loss of value
Subtotal	**20**			
Sites within the upstream impact area (RL 119.5 mAHD to RL 126.97 mAHD)[2]				
Axe Grinding Grooves	1	High	High	Total loss of value
Isolated Artefact	1	Low	High	Total loss of value
Open Camp Site	6	Low	High	Total loss of value
Subtotal	**8**			
Sites between RL 126.97 mAHD and the Project area boundary				
Open Camp Site	9	Low	High	No loss of value
Shelter with Deposit and Art	1	High	High	No loss of value
Shelter with Deposit and Artefacts	5	Low	High	No loss of value
Subtotal	**15**			

1. This area and the area below FSL is referred to the as the 'Existing Upstream Impact Area' (EUIA) in the Aboriginal Cultural heritage Assessment (Appendix K).
2. This area is referred to the as the 'Project Upstream Impact Area' (PUIA) in the Aboriginal Cultural heritage Assessment (Appendix K).

It should be noted that many of these sites, particularly those lower down in the catchment are already subject to temporary inundation from flooding, and the principal potential impact of the Project would be an increase in the depth and duration of temporary inundation. The Aboriginal cultural heritage assessment (Appendix K) identifies that all the sites between FSL and the upstream impact area have already been harmed by flooding.

The Aboriginal cultural heritage assessment noted that potential impacts would depend on the site type and provided the following examples:

- stone artefact sites would be subject to changed ground conditions such as waterlogging, movement of objects or erosion
- sandstone shelter sites would be subject to altered conditions that may detrimentally effect deposits and rock art
- scarred trees would be subject to more frequent flooding
- axe grinding grooves and engravings would be more frequently submerged, altering natural conditions and possibly their preservation

- Aboriginal ceremony and dreaming sites and Aboriginal resource and gathering sites would have their accessibility altered, and physical aspects of the sites may also change.

All potentially affected sites have been identified as having 'High' cultural significance. The majority (33) of the potentially affected sites are open camp sites with 19 of these being located below the upstream impact area, and four of these being of 'High' or 'Moderate' scientific significance. Other types of sites are resource gathering, isolated artefacts, axe grinding grooves, shelters with artefacts/deposits and shelters with art.

Generally, the art site would be most vulnerable to temporary inundation impacts as the water may degrade the drawing materials. The risk of this relative to the other sites is considered low given the higher elevation of this site and the archaeological assessment identified that there would be no loss of value to this site. The materials at the other sites are generally rock (that is, artefacts, axe grinding grooves) and would not be directly affected by temporary inundation, however indirect impacts such as changes in erosion and deposition of sediments may affect the integrity and access to the sites.

The cultural values assessment considered 19 sites within and in proximity to the upstream Project study area. The majority of the sites are located outside of the GBMWHA where it sits inside the upstream Project study area. Noting the constraints associated with assessing impacts, the cultural values assessment noted that from the perspective of the Aboriginal cultural knowledge holders, it was understood that the potential impacts of the Project on identified cultural values would be harmful.

There was considerable difference in the inputs and overall views of the RAPs to the Project and its potential impacts. Some RAPs accepted the need for the Project and the mitigation measures proposed, while other RAPs were strongly against the Project, its potential impacts on cultural heritage and the mitigation measures proposed.

Mitigation measures for Aboriginal cultural heritage are presented in Section 13.5.

6.1.9 Impacts on plant communities

The primary values for inscription of the GBMWHA on the World Heritage list relate to biodiversity. The principal potential impact of the Project with regard to plant communities relates to temporary inundation when the FMZ is in operation. Depending on the magnitude of the inflow event and the depth to which the FMZ fills, the incremental duration of temporary inundation would range from hours up to about two weeks. The incremental depth of temporary inundation would similarly relate to the magnitude of the inflow event.

Assessment of potential impacts on plant communities in the upstream and construction study areas was undertaken in accordance with the NSW 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 Biodiversity Assessment Report (BAR) as part of the EIS and application for approval. The FBA is undertaken in three stages as follows.

- Stage 1: Assessment of biodiversity values: this comprises dentification 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.
- Stage 2: Impact assessment (biodiversity values): this comprises 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.
- Stage 3: development of a biodiversity offset strategy.

The FBA includes provisions for assessment where there are likely to be impacts on biodiversity that are infrequent, cumulative or difficult to measure over time. This was identified as being of relevance to the Project for assessment of impacts on biodiversity values in the upstream area in view of the uncertainty regarding potential temporary injunction, particularly for less frequent events.

Assessment of potential impacts on plant communities in the downstream study area was undertaken in accordance with the matters identified in Attachment B to the SEARs. This involved interrogation of publicly available databases, reviews of publicly available documents, vegetation mapping, and flora and fauna surveys.

A detailed breakdown of the plant communities within the GBMWHA in the upstream impact area (304 hectares) is presented in Table 6-2. The areas of the plant communities within the broader upstream study area (5,280 hectares) are also provided for context.

Table 6-2. Plant community types, protection status and areas potentially impacted by temporary inundation

BVT code	Plant community type	Protection status[1]	Area within GBMWHA in upstream impact area (ha)	Area within upstream study area (ha)
HN525 (PCT 832)	Forest Red Gum–Narrow-leaved Ironbark open forest of the southern Blue Mountains gorges Sydney Basin Bioregion	None	1.95	544.90
HN527 (PCT 840)	Forest Red Gum–Yellow Box woodland of dry gorge slopes southern Sydney Basin Bioregion and South Eastern Highlands Bioregion	CE - EPBC Act E - TSC Act	23.48	490.47
HN532 (PCT 860)	Grey Gum–Broad-leaved Ironbark dry open forest on gorge slopes on the Blue Mountains Sydney Basin Bioregion	None	47.33	963.64
HN536 (PCT 871)	Grey Gum shrubby open forest on gorge slopes of the Blue Mountains Sydney Basin Bioregion	None	12.87	800.41
HN538 (PCT 877)	Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East corner Bioregion	None	6.64	231.16
HN553 (PCT 941)	Mountain Blue Gum–Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion	E - TSC Act	42.51	378.04
HN557 (PCT 1401)	Narrow-leaved Ironbark–Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion	CE - EPBC Act E - TSC Act	149.57	957.26
HN574 (PCT 1105)	River Oak open forest of major streams Sydney Basin Bioregion and South East Corner Bioregion	None	12.30	368.15
HN607 (PCT 1292)	Water Gum–Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion	None	6.67	36.58

1. Protection status: E = endangered; CE = critically endangered

The response of plant communities and individual plant species to temporary inundation is likely to be variable and would depend upon a number of factors including:

- inherent tolerance to temporary inundation impacts
- size and frequency of the flood event
- duration and depth of temporary inundation
- natural regeneration
- additional management actions to mitigate any impacts.

These are further discussed in the following sections. More detailed information on the research undertaken for the Project, the tolerance of individual communities and species and the methodology for assessment is presented in Appendix F1 (Biodiversity assessment report - upstream) to the EIS.

6.1.9.1 Tolerance to temporary inundation

The inherent characteristics of individual plant species and some vegetation communities as a whole may allow them to tolerate temporary inundation. Generally riparian and wetland species and communities have a higher tolerance to inundation but other dryland species can also have specific tolerance characteristics.

A recent review of the environmental impacts of temporary inundation upstream of flood inundation dams in Queensland (Hydrobiology 2019) noted that temporary inundation may impact certain aspects of ecosystem health but that the extent to which this may occur is substantially dependent on a large range of independent variables such as geology, frequency and duration of flooding, geographic setting, ecosystem characteristics, land use, germination from flood-borne seeds, edge effects and similar matters. It further noted that the studies of Queensland dams did not suggest that temporary flood inundation would inevitably cause substantial environmental impact. The study did, however, note the limitations in extrapolating the findings of limited studies from one system to another, particularly

when there are regional differences in (for example) geographic setting, climate, geology, species mix and inundation characteristics. The study also noted the following relevant issues from published literature:

- the duration of inundation can have a significant effect on survival, with naturally riparian species generally able to tolerate longer inundation than naturally up-slope species
- the frequency of inundation can affect soil chemistry and waterlogging, leading to changes in the vegetation supported
- successional changes in vegetation on the margins of dams can take decades to complete.

Along the tributaries of Lake Burragorang there is a greater variety of plant species and communities including riparian plants and communities which are more tolerant to inundation. Further discussion is provided in Appendix F1 Biodiversity Assessment Report – Upstream.

6.1.9.2 Size and frequency of flood events

As discussed in Section 6.1.7, the extent, duration and frequency of temporary inundation would vary across the impacted area, and noting that the area is already subject to inundation from flood events. Depending upon the frequency, duration and extent of temporary inundation, the vegetation communities in certain areas may be able to regenerate and recover between events.

6.1.9.3 Duration and depth of temporary inundation

While related to the size and frequency of flood events, the depth and duration of temporary inundation is also a separate consideration especially near the fringes of inundation extents for larger events. The fringes of the inundation extents would only be inundated for relatively short periods of time (hours to up to two days) and to relatively low depths (generally less than half a metre; refer Section 4.2.3). Plants and vegetation communities that are relatively inundation intolerant may be able to withstand or recover from short shallow inundation.

As noted in Section 5, changes in depth and duration of temporary inundation with regard to the upstream impact area, these would be similar to that for Lake Burragorang, i.e. the additional depth of inundation would be up to about eight metres and the additional duration of temporary inundation would be up to eight and a half days.

Many of the soils of the Blue Mountains and especially around the tributaries are alluvial in nature and drain rapidly after flooding. This reduces any impacts associated with waterlogging of soils that may affect plants and vegetation communities.

6.1.9.4 Natural regeneration

There would be natural regeneration of some plants and vegetation communities after temporary inundation. For areas that receive infrequent, short and shallow inundation, the regeneration potential would be higher compared to other areas which are subject to more frequent deeper and longer temporary inundation. Many areas around Warragamba Dam and Lake Burragorang have experienced disturbance in the past from clearing for dam construction, agricultural, access and mining, and these areas have successfully naturally regenerated. Bushfire is another example of an episodic impact on vegetation which experiences natural regeneration.

In areas where more frequent, deeper and longer temporary inundation occurs, there would still be regeneration, however it is likely that more inundation tolerant species would either dominate or colonise these areas. There is some evidence of this already around Lake Burragorang where flood tolerant *Casuarina* species have colonised areas that are subject to more frequent inundation from the current operations of the dam.

6.1.9.5 Management actions

There are a number of management actions that would be undertaken to minimise any impacts on biodiversity and other environmental aspects from temporary inundation including:

- implementation of the Warragamba Offset Program (refer Section 13)
- development of a detailed flood mitigation operating procedure which would have as one of its objectives to minimise the extent and duration of upstream temporary inundation
- preparation of an environmental management plan (EMP) required under the *Water NSW 2014 Act* (refer Section 13).

It has been assumed that, for the purpose of offsetting potential impacts of the Project, there would be a total loss of biodiversity values within the upstream impact area. This has been used to inform calculation of the required type and number of biodiversity credits to be offset through the Warragamba Offset Program. Further details are provided in Section 13.2.

6.1.10 Threatened flora species

There are some threatened flora species that may be present in the GBMWHA that may be impacted by the Project. A conservative assessment was used in identifying potentially impacted threatened species by:

- Assuming the presence of many threatened species even though they were not found during the field survey. Detailed field survey to confirm presence of threatened species was not practicable due to the size of the area impacted by Project and the considerable survey requirements to determine presence/absence of a specific species. Threatened species that were not found during field surveys were identified through previous records, habitat association with plant community types and nominated in the SEARs. The identification of potential threatened species was undertaken in accordance with the Framework for Biodiversity Assessment (OEH 2014) and other relevant guidelines
- Assuming a conservative distribution of threatened species. Where possible the distribution (that is, the area that they occur in) of each individual threatened species was estimated. For many threatened species a conservative assumption of their distribution was estimated as field survey requirements to determine distribution in compliance with the Framework for Biodiversity Assessment (OEH 2014) was not undertaken.

The areas of threatened flora species habitat in the GBMWHA impacted by temporary inundation with the Project (304 hectares) for the upstream impact area (1,400 hectares) are presented in Table 6-3.

Table 6-3. Area of threatened flora species habitat in the GBMWHA within the upstream impact area

Threatened flora species	Area of habitat in the GBMWHA within upstream impact area (ha)	Area of habitat within upstream impact area (ha)
*Acacia clunies-rossiae**	18.19	770
Acacia flocktoniae	3.97	371
*Asterolasia buxifolia**	3.38	14
Baloskion longipes	4.06	31
Bossiaea oligosperma	213.69	483
*Callistemon linearifolious**	2.18	1,968 individuals
Eucalyptus benthamii	10.33	44
Eucalyptus glaucina	241.85	10,970 individuals
Genoplesium baueri	47.33	223
*Gyrostemon thesioides**	262.26	886
*Hygrocybe anomala var. iathinomarginata**	19.54	267
Leucopogon exolasius	6.67	50
Persicaria elatior	193.21	896
Persoonia bargoensis	6.67	22
Pomaderris brunnea	294.50	1,146
Pterostylis saxicola	1.75	111
*Rhodamnia rubescens**	6.64	78
*Solanum armourense**	213.66	305
*Tetratheca glandulosa**	54.00	305
Trachymene scapigera	0.68	19

* Not listed under the EPBC Act

The area of habitat for most threatened flora species within the GBMWHA within the upstream impact area is generally small with the exception of the following species:

- *Acacia clunies-rossiae* (Kanangra Wattle) is a bushy shrub or tree to eight metres tall. It is found in the Kowmung and Coxs River areas entirely within Kanangra-Boyd and Blue Mountains National Parks. It grows in dry sclerophyll forest on skeletal soils on rocky slopes, or on alluvium along creeks. Wattles such as this species are killed by fire but they regenerate well from seed; too frequent fire may threaten their survival. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was found during field surveys.
- *Bossiaea oligosperma* (Few seeded Bossiaea) is an erect shrub to two metres tall. It is found from two disjunct areas: the lower Blue Mountains in the Warragamba area (Wollondilly, Allum, Tonalli River catchments) and the Windellama area in Goulburn Mulwaree Council, where it is locally abundant. In the Warragamba area it occurs on stony slopes or ridges on sandstone. Key threats: Frequent fire may threaten the species' survival in the northern part of its range; clearing associated with rural residential developments in the southern part of its range; and habitat loss associated with roadworks. Inundation may kill affected individuals including soil-stored seed bank through flood stress. This plant was found during field surveys.
- *Eucalyptus glaucina* (Slaty Red Gum) is a medium-sized tree to 30 metres tall which before field work undertaken for the Project was only found on the North Coast and from Taree to Broke. Slaty Red Gum grows in a range of location including shallow soils or stony hillsides, grassy woodland on deep, moderately fertile and well-watered soil to gentle slopes near drainage lines in alluvial and clayey soils. Individuals and clusters of key threats in include clearing, timber harvesting, grazing, hybridisation, and insect attack. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. *Eucalyptus glaucina* was found both inside and outside the Project study area and some juvenile individuals were found below the FSL. Active recruitment of the species was observed in many other locations outside the Project study area.
- *Genoplesium bauera* (Bauer's Midge Orchid) is a terrestrial orchid 6–15 centimetres tall. It has been recorded from locations between Ulladulla and Port Stephens. Currently the species is known from just over 200 plants across 13 sites. The species has been recorded at locations be within the following conservation reserves: Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. It may occur in the Woronora, O'Hares, Metropolitan, and Warragamba Catchments. It grows in dry sclerophyll forest and moss gardens over sandstone. Key threats include: development, recreational users, maintenance of utilities such as powerline easements has the potential to damage some known sites, grazing by swamp wallabies/rabbits and weed invasions. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was not found during field surveys and its presence has been assumed.
- *Gyrostemon thesioides* is a multi-stemmed shrub to 70 centimetres tall. Within NSW, it has only ever been recorded at three sites to the west of Sydney, near the Colo, Georges and Nepean Rivers. The most recent sighting was of a single male plant near the Colo River within Wollemi National Park. The species has not been recorded from the Nepean and Georges Rivers for 90 and 30 years respectively, despite searches. It grows on hillsides and riverbanks and may be restricted to fine sandy soils. It is a fire-opportunist, with recruitment occurring from a soil stored seed bank following fire. Adult plants are killed by fire. The plant reaches maturity in less than a year and plants are presumably short-lived. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was not found during field surveys and its presence has been assumed.
- *Hygrocybe anomala* var. *iathinomarginata* is a small brightly coloured gilled fungus. In addition to being recorded in the Blue Mountains National Park, it has also been recorded in the Royal National Park, Lane Cove Bushland Park and the Lane Cove Local Government Area. The species occurs in gallery warm temperate forests dominated by Lilly Pilly (*Acmena smithii*), Grey Myrtle (*Backhousia myrtifolia*), Cheese Tree (*Glochidion ferdinandi*) and Sweet Pittosporum (*Pittosporum undulatum*). The species is associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. It occurs as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss. It does not produce above ground fruiting bodies (fungus) all year round. Fruiting bodies begin appearing mid May to mid July sometimes to August.
- *Persicaria elatior* (Tall Knotweed) is an erect herb to 90 centimetres tall and has been recorded in south-eastern NSW (Mt Dromedary (an old record), Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond

Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). The species also occurs in Queensland. This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance. This species has no known tolerance to waterlogging or submergence. This plant was found during field surveys.

- *Pomaderris brunnea* (Brown Pomaderris) is a shrub up to three metres tall that has distinctively hairy stems. Brown Pomaderris is found in a very limited area around the Colo, Nepean and Hawkesbury Rivers, near Walcha on the New England tablelands and in far eastern Gippsland in Victoria. Brown Pomaderris grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines. Key threats include: clearing, too frequent burning, forestry activities, trampling, weed invasion and grazing. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was found during field surveys.
- *Solanum armourense* is a recently described shrub 1–1.8 metres tall, with grey or brown densely haired branches that are sparsely armed with prickles. It is confined to a relatively small area south-west of Sydney, from Mt Armour within Blue Mountains National Park south to the Wombeyan area. Known from four locations, three of which occur within Blue Mountains National Park. Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was found during field surveys.
- *Tetratheca glandulosa* is a small, spreading shrub which grows 20–50 centimetres tall. It is restricted to the following LGAs: Baulkham Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah, and Wyong. There are approximately 150 populations of this plant ranging from Sampons Pass (Yengo NP) in the north to West Pymble (Lane Cove NP) in the south. The eastern limit is at Ingleside (Pittwater LGA) and the western limit is at East Kurrajong (Wollemi NP). Associated with shale-sandstone transition habitat where shale-cappings occur over sandstone, with associated soil landscapes such as Lucas Heights, Gymea, Lambert and Faulconbridge. Topographically, the plant occupies ridgetops, upper-slopes and to a lesser extent mid-slope sandstone benches Inundation may result in the death of affected individuals including soil-stored seed bank through flood stress. This plant was not found during field surveys and its presence has been assumed.

For the purpose of offsetting potential impacts, the Project has assumed there would be a total loss of biodiversity values within the upstream impact area, and this has been used to calculate species credits and ecosystem credits

6.1.11 Impacts to habitat of threatened fauna species

Presented in the following tables are the areas of habitat of threatened fauna species in the GBMWHA which are potentially impacted by the Project. The presence of some species has been assumed (rather than confirmed during field survey) and the distribution of all species has been assumed and estimated. A conservative assessment was used in identifying potentially impacted threatened species by:

- Assuming the presence of many threatened species even though they were not found during the field survey. Detailed field survey to confirm presence of threatened species was not practicable due to the size of the area impacted by the Project and the considerable survey requirements to determine presence/absence of a specific species. Threatened species that were not found during field surveys were identified through previous records, habitat association with plant community types and nominated in the SEARs. The identification of potential threatened species was undertaken in the compliance with the Framework for Biodiversity Assessment (OEH 2014) and other relevant guidelines.
- Assuming a conservative distribution of threatened species. Where possible the distribution (that is, the area in which they occur) of each individual threatened species was estimated. For many threatened species a conservative assumption of their distribution was estimated as field survey requirements to determine distribution in compliance with the Framework for Biodiversity Assessment (OEH 2014) was not undertaken.

Other factors to consider in assessing impacts on threatened fauna species are:

- Direct mortality of threatened fauna species due to the Project is likely to be negligible as all species are motile (that is, can move away from the flood edge) and the temporary inundation from the Project would be gradual rather rapid like a bush fire.
- There are large areas of other suitable habitat adjacent to the Project study area.

- The extent and impact on the habitat would vary depending on the location of habitat (that is, proximity to Lake Burragorang), the frequency of flood events and the flood tolerance of the habitat. The greatest potential impact to habitat would occur in areas which are affected more frequently, that is, adjacent to the lake's edge.

Areas of potential habitat of threatened fauna species in the upstream impact area within the GBMWHA are presented in Table 6-4. The woodland plant communities which dominate this area are generally potential habitat for most threatened fauna species.

Table 6-4. Area of threatened fauna species habitat in the GBMWHA in the upstream impact area

Threatened fauna species	EPBC Act status	BC Act status	Area of habitat in the GBMWHA in upstream impact area (ha)
Broad-Headed Snake	V	E	20.3
Brush-tailed Rock-wallaby	V	E	54.5
Eastern Pygmy-possum	—	V	291.0
Koala	V	V	303.3
Large-eared Pied Bat	V	V	269.6
Regent Honeyeater	CE	CE	260.8
Rosenberg's Goanna	—	V	283.8
Southern Brown Bandicoot (Eastern)	E	E	277.7
Southern Myotis	—	V	140.9
Squirrel Glider	—	V	284.4

6.1.12 Impacts on Eucalyptus species

The GBMWHA World Heritage listing includes recognition of the diversity of Eucalypt species within the World Heritage Area. Based on field survey, 22 different Eucalypt species were identified in the upstream study area. Not all of these species occur in the GBMWHA but do occur in adjacent areas that are not part of the GBMWHA. Extensive scientific literature reviews were also undertaken to identify information on the flood tolerance of each of the individual Eucalypt species (refer Table 6-5). Also, WaterNSW commissioned CSIRO to undertake a controlled field experiment (CSIRO 2019) to assess the impacts of extended temporary inundation on the Camden White Gum. The results of this field experiment are discussed in the following section.

For many species there was little or no information regarding their flood tolerance. The flood tolerance of species where information was available varied and was generally related to their typical occurrence in the landscape. Eucalypt species that were typically found in dry ridgetop areas were generally intolerant to flooding, whereas Eucalypts that were associated with riparian areas were flood tolerant.

A recent review of the environmental impacts of temporary inundation upstream of flood inundation dams in Queensland (Hydrobiology 2019) noted that temporary inundation may impact certain aspects of ecosystem health but that the extent to which this may occur is substantially dependent on a large range of independent variables such as geology, frequency and duration of flooding, geographic setting, ecosystem characteristics, land use, germination from flood-borne seeds, edge effects and similar matters. It further noted that the studies of Queensland dams did not suggest that temporary flood inundation would inevitably cause substantial environmental impact. Further detailed discussion is provided in Appendix F1 Biodiversity Assessment Report – Upstream.

Apart from two species, *Eucalyptus benthamii* (Camden White Gum) and *Eucalyptus glaucina* (Slaty Red Gum), none of the Eucalypt species were listed as threatened or endangered under NSW and/or Commonwealth biodiversity protection legislation. All other Eucalypt species were common and widely distributed in the Blue Mountains and other areas in NSW, and some species in other States.

As noted elsewhere in this report, for the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. Accordingly, there would be a diminution in this OUV component.

Table 6-5. Eucalypt species found in the upstream study area

Species	Tolerance to inundation
Eucalyptus albens	No information
Eucalyptus benthamii	Tolerant
Eucalyptus crebra	Intolerant
Eucalyptus cypellocarpa	Intolerant
Eucalyptus deanei	Possibly tolerant
Eucalyptus elata	Tolerant
Eucalyptus eugenioides	No information
Eucalyptus fibrosa	No information
Eucalyptus glaucina	Possibly tolerant
Eucalyptus globoidea	No information
Eucalyptus haemastoma	No information
Eucalyptus melliodora	No information
Eucalyptus moluccana	No information
Eucalyptus oblonga	Intolerant
Eucalyptus paniculata subsp. Paniculata	No information
Eucalyptus pilularis	Intolerant
Eucalyptus piperita	Intolerant
Eucalyptus punctata	No information
Eucalyptus racemosa	No information
Eucalyptus sclerophylla	Intolerant
Eucalyptus sieberi	No information
Eucalyptus tereticornis	Tolerant

6.1.12.1 *Eucalyptus benthamii* (Camden White Gum)

Eucalyptus benthamii (Camden White Gum) is a tall tree up to 40 metres high with smooth, white bark and numerous long, loose bark ribbons, and a persistent, flaky bark stocking at the base. It occurs on the alluvial flats of the Nepean River and its tributaries. The Camden White Gum Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Recruitment of juveniles appears to be most successful on bare silt deposits in rivers and streams. The recorded elevation range for the species is from 30 metres above sea level at Bents Basin to 750 metres above sea level in the Kedumba population. Most of the individuals have been recorded at between 60 and 300 metres above sea level[12].

The main identified threats to the Camden White Gum are land clearing, urban development, inappropriate fire regimes, changed hydrology, weed invasion, and inappropriate revegetation works (impacting genetic diversity) (OEH 2013). Populations are now isolated within fragmented habitat (NSW NPWS 2000) due to extensive pre-1840 land clearing (Benson *et al.* 1996, cited in Butcher *et al.* 2005). Regulation of flooding regimes, competition from weeds and inappropriate fire regimes limit natural regeneration (Butcher *et al.* 2005). The productive nature of alluvial flats make them particularly prone to weed invasion, and the following weeds threaten the Camden White Gum: honey locust (*Gleditsia triacanthos*), African olive (*Olea europaea subsp. cuspidata*), Privet (*Ligustrum vulgare*), Box Elder (*Acer negundo*), cactus (*Opuntia spp.*), Balloon Vine (*Cardiospermum grandiflorum*), Bridal Creeper (*Asparagus*

[12] Camden White Gum species profile: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10284

asparagoides), blackberry (*Rubus spp.*) and exotic grasses such as couch (*Cynodon spp.*) and *Paspalum* spp. (OEH 2013). Other threats to the Camden White Gum include habitat degradation caused by feral pigs (*Sus scrofa*) at Kedumba (OEH 2013) and hybridisation with Manna Gum (*Eucalyptus viminalis*) (Butcher *et al*. 2005).

The propagation and planting of Camden White Gums has been and is currently being undertaken. This include trial plantation planting of Camden White Gums in Deniliquin and overseas – and local habitat restoration programs such 20 Million Trees: Creating Habitat for Camden White Gum project by local government organisations in the region.

There are two major subpopulations: in the Kedumba Valley of the Blue Mountains National Park and at Bents Basin State Recreation Area. Several trees are scattered along the Nepean River around Camden and Cobbitty, with a further stand at Werriberri (Monkey) Creek in The Oaks. At least five trees occur on the Nattai River in Nattai National Park. Large areas of habitat were inundated by the formation of Warragamba Dam in 1960. Logging and clearing of other stands for agriculture and urban development along the Nepean River are also likely to have impacted its distribution.

The Kedumba Camden White Gum population is confined to the lower Kedumba River and Valley. Only a small part of the lower Kedumba River and Valley is contained within the GBMWHA, however there are some Camden White Gums in the area of the GBMWHA within the Kedumba Valley. Overall about 15 percent of the area of Camden White Gums potentially impacted by the Project is contained within the GBMWHA.

The population of the Camden White Gum in the Kedumba Valley consists of about 6500 to 7000 trees of varying maturity and at varying locations within the landscape. Some trees are located within the river and riparian zone of the Kedumba River, whereas others are located on dryer locations on rocky valley walls.

The Camden White Gum is flood tolerant and relies on flooding for germination and recruitment. To assess the ability of the Camden White Gum to withstand sustained flooding, WaterNSW commissioned CSIRO to undertake a controlled field experiment (CSIRO 2019). The study used stands of planted relatively mature Camden White Gums in Deniliquin and subjected them to various periods of shallow flooding (between one and six weeks). Parameters measured during the experiment include tree mortality, growth, stress responses and soil conditions. Overall the experiment found that the shallow flooding had no measurable impact on the Camden White Gums. In fact with longer flooding periods (that is, six weeks), the growth of the Camden White Gums was significantly higher compared to control plots and those had experienced shorter periods of flooding. The major limitations to the study were that it did not assess the impacts of deeper flooding or the impacts on flooding on juvenile individuals.

A CSIRO study to assess the impacts of partial and full inundation of juvenile Camden White Gums (CSIRO 1995) was undertaken for the 1995 EIS to raise Warragamba Dam by 23 metres (which did not proceed). The study included a range of different inundation regimes, water quality conditions and height of juvenile seedlings. The study found that there was little or no mortality of juvenile Camden White Gums with complete inundation for 15 days, providing that dissolved oxygen concentrations in the inundation water were moderate or high. With low dissolved oxygen concentrations in the inundation water 100 percent mortality was recorded. Flood waters generally have moderate or high dissolved oxygen concentrations. The major limitations to the study were that it did not assess the impacts of deeper flooding and it was undertaken in a laboratory/greenhouse which does not replicate natural conditions.

Based upon on the outcomes of the CSIRO studies, the infrequent nature of the operation of the FMZ, the distribution of the Kedumba Camden White Gum population across the landscape and the general tolerance and requirements of the Camden White Gums for flooding, the impacts on existing Camden White Gums within the GBMWHA may not be significant.

The Warragamba Offset Program and National Parks EMP may include specific measures to mitigate any additional threats to the Camden White Gum population (for example, pest control of pigs) and measures to encourage the health and recruitment of the existing population.

6.1.12.2 Eucalyptus glaucina (Slaty Red Gum)

Eucalyptus glaucina (Slaty Red Gum) is a medium-sized tree to 30 metres tall which before field work undertaken for the Project, was only found on the North Coast and from Taree to Broke. Slaty Red Gum grows in a range of situations, from shallow soils or stony hillsides, but not on poor sandstones, to grassy woodland on deep, moderately fertile and well-watered soil to gentle slopes near drainage lines in alluvial and clayey soils[13]. Individuals and clusters of

[13] Slaty Red Gum species profile: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10295

Eucalyptus glaucina were found both inside and outside the Project impact area and some juvenile individuals were found within the FSL. Active recruitment of the species was observed in many other locations outside the Project impact area. While there is no available information on its flood tolerance, its range of habitats and its association with the Forest Red Gum suggest some degree of flood tolerance. Given its widespread presence both inside and outside the Project area, its active recruitment and likely flood tolerance, this species is not considered at risk from the Project.

6.1.13 Impacts to scleromorphic species

The nomination for the World Heritage listing (Government of Australia 1998, p104) notes

> *Scleromorphic plants are those with a characteristic set of features: small, evergreen, tough leaves, thick cuticles, hairs, leaf rolling, succulent leaves and/or stems, sunken stomates and low transpiration rates. The leaves of scleromorphs are often stiff and pointed, containing a high proportion of sclerenchyma (increased fibre to protein ratio) and occasionally silica in the epidermal walls (Beadle 1981a, b). Soft-leaved xeromorphs frequently grow with the sclerophylls. Their leaves are less hard, but they usually possess thick cuticles, hairs and 'water storage' tissue.*

and (Government of Australia 1998, pp106 108)

> *The inherently infertile plateau soils of the Greater Blue Mountains have long been known to have a distinctive sclerophyllous vegetation (Hamilton 1912 1923 1932; Osborn 1930; Pidgeon 1937). The theory that xeromorphy and scleromorphy evolved primarily in response to poor soil fertility, particularly low phosphorus concentrations, within rainforests (rather than as an adaptation to an arid climate) is supported by the widespread occurrence of scleromorphs in wetter areas, for example in the Sydney district on low-fertility sands. Maximum sclerophyll development is attained in soils that are sandy, with minimal clay content and of acid reaction (pH 4.5-6.5). The nutrient status of such soil is very low, with phosphorus values of 30-70 ppm recorded for the types of soils that are most common in the Blue Mountains (Beadle 1981a). In comparison, phosphorus values for tall open-forest are 100-150 ppm and for rainforest 200-1000+ ppm.*
>
> *Scleromorphy occurs in about 20 plant families, notably Myrtaceae, Proteaceae and Epacridaceae (Beadle 1981b). Within the nominated area these families are all well represented, as well as the Fabaceae (including subfamilies Faboideae and Mimosoideae), Dilleniaceae (Hibbertia), Rutaceae (Boronia) and Euphorbiaceae (Tribe Stenolobeae).*
>
> *The family Myrtaceae, particularly the dry-fruited capsular genera, is prominent in Australian sclerophyll vegetation. Within the Greater Blue Mountains the Myrtaceae contain the second highest number of species within a plant family (156). These largely belong to dry-fruited groups, including Leptospermum, Baeckea, Darwinia and Eucalyptus.*

Vegetation potentially affected by the Project from temporary inundation occurs around the perimeter of Lake Burragorang and its associated tributaries. The upstream biodiversity assessment (Appendix F1 Biodiversity Assessment Report – Upstream) identified that about 51 percent of the upstream study area comprised dry sclerophyll forest and about 1.5 percent comprised wet sclerophyll forest.

Dry sclerophyll forest is the most common habitat within the study area, occurring throughout the study area, close to the lake edges and adjacent to areas of alluvial woodland along the major rivers. Dry sclerophyll forest 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.

Wet sclerophyll forest is a tall, open forest occurring in patches across the study area, particularly around Brereton Head. 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 shrubs and small trees including *Pittosporum, Acacia, Allocasuarina* and *Leucopogon* species. The understorey is formed by a diverse array of shrubs, grasses and graminoids.

As previously noted, the recent Queensland investigation of the effect of temporary inundation did not suggest that this would inevitably cause substantial environmental impact. In summary therefore, it is not possible to make a precise statement of the effect of the Project on scleromorphic species. For the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. Accordingly, there would be a diminution in this OUV component.

6.1.14 Impacts to ant-adapted plants

The nomination for the World Heritage listing (Government of Australia 1998, p108) notes

> *Nearly all genera of ant-dispersed plants are Australian endemics of dry sclerophyll eucalypt forest, woodland or heathland. While the seeds of eucalypts lack specialised structures for ant dispersal, ants transport and consume these in great numbers (O'Dowd & Gill 1984; Wellington & Noble 1985). The delayed release of eucalypt seeds undoubtedly contributes to a stable food supply for ants over many years.*
>
> *The seeds of other genera within the eucalypt forests and associated heathlands display a unique combination of characteristics that suggest a long history of co-evolution of ant-plant interactions in Australia.*

Ant-adapted plants likely comprise many of the plants potentially affected in the GBMWHA by the Project. However, the upstream impact area is a very small area compared to the broader GBMWHA (about 0.03 percent of the total area of the GBMWHA) and it is considered unlikely that the Project would have a significant impact on this aspect.

For the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. Accordingly, there would be a diminution in this OUV component.

6.1.15 Impacts to diversity and characteristics of the flora as a whole

The nomination for the World Heritage listing (Government of Australia 1998, pp108 110) notes

> *The flora of the nominated area is very diverse at all taxonomic levels with at least 152 families, 484 genera and some 1500 species.*
>
> *The plant families with the highest number of species recorded from the nominated area are Fabaceae (149), Myrtaceae (150), Orchidaceae (77), Poaceae (57), Asteraceae (69), Proteaceae (77) and Cyperaceae (43). The largest genera in the nominated area are Eucalyptus and related genera (90 species) and Acacia (64 species).*
>
> *The importance of the Greater Blue Mountains for the representation of eucalypts has been described above. They also have a high degree of significance for the representation of Australia's other typical woody genus, Acacia. Acacia is the largest genus of vascular plant species in Australia, with over 900 species that are mostly endemic to Australia, out of 1200 species world-wide. The majority of the species in Australia (c99%) belong to subgenus Phyllodineae (syn. Heterophyllum) which is largely endemic to Australia (Ross 1981, Maslin & Pedley 1988).*
>
> *The nominated area contains a total of 64 species, located within a centre of high Acacia species diversity. The two principal centres of species richness are south-west Western Australia and the Great Dividing Range south of the Tropic of Capricorn in eastern Australia (Maslin & Hnatiuk 1987; Hnatiuk & Maslin 1988). The node of highest diversity in eastern Australia (with over 50 species in a grid) encompasses the Greater Blue Mountains and adjacent sandstone plateaus.*

Discussion of potential impacts on eucalypt species is discussed in Section 6.1.12. The biodiversity assessment noted that *Acacia* species form part of the mid-storey of wet and dry sclerophyll forest, this collectively occurring across just over half of the upstream study area. Only one species, the Kanangra Wattle (*Acacia clunies-rossiae*), was recorded during field surveys, however, a further five species (*Acacia baueri* subsp. *aspera*; Bynoes Wattle, *Acacia bynoeana*; Flockton's Wattle, *Acacia flocktoniae*; Gordon's Wattle, *Acacia gordonii*, and Downy Wattle, *Acacia pubescens*) were considered to have a moderate likelihood of occurrence in the upstream study area. The biodiversity assessment noted that these species could have limited tolerance to flood stress such as through temporary inundation or waterlogging. Areas with the greatest potential for this would be around the perimeter of Lake Burragorang (including the upstream impact area), this reducing substantially moving up the tributaries.

For the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. Accordingly, there would be a diminution in this OUV component.

6.1.16 Impacts to species diversity

The nomination for the World Heritage listing (Government of Australia 1998, pp110 112) notes

> *Some of the highest species-richness values in the world have been recorded from particular vegetation communities on sandstone country adjacent to the nominated area. (It is likely that similar values would exist within the area, but detailed research has not yet taken place.) In the upland swamps of the Woronora Plateau,*

species richness was compared within floristic groups at scales of 1m^2 10m^2 and 15m^2. High values of species richness were recorded for open-forest, woodland and heathland with mean values of 57-66 for an area 400m^2 (Keith 1994). A heath community occurring on relatively dry sites within the swamps recorded up to 70 vascular plant species in 15m^2, a significantly high value relative to other shrub and sedge communities in temperate latitudes, both within Australia and internationally (Keith & Myerscough 1993). Species-richness values at the 1-15m^2 scales were higher than any other published record, including data for Kwongan (in Western Australia) and Fynbos (in South Africa), which are renowned for their high species diversity (George et al. 1979; Cowling 1983). Such high species richness values can be related to the low nutrient soils, the open vegetation structure and disturbance by fire.

The upstream impact area within the GBMWHA potentially impacted by the Project is located along peripheral areas of the GBMWHA bordering Lake Burragorang and related tributaries, containing nine plant community types (refer Table 6-2). The percentage areas for six of the plant community types relative to the upstream study is less than five percent. The percentages for the three other plant community types is as follows:

- Mountain Blue Gum-Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion (HN553/PCT 941): 11.2 percent
- Narrow-leaved Ironbark-Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion (HN557/PCT 1401): 15.6 percent
- Water Gum-Coachwood riparian scrub along sandstone streams Sydney Basin Bioregion (HN607/PCT 1292): 18.2 percent.

These plant community types also occur in the broader Blue Mountains area outside of the upstream study area.

The Project would not affect any upland swamp areas.

Given the relatively small areas potentially affected relative to the broader upstream study area and the broader Blue Mountains area, the Project is considered unlikely to have a significant impact on species diversity relative to the overall GBMWHA. However, For the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. Accordingly, there would be a diminution in this OUV component.

6.1.17 Impacts to vertebrates

The nomination for the World Heritage listing (Government of Australia 1998, pp122 124) notes

The Greater Blue Mountains and surrounding plateaus provide habitat for a wide variety of mammals, birds, amphibians and reptiles. The faunal diversity strongly reflects the floristic and structural diversity of the sclerophyll vegetation. Approximately 400 vertebrate species have been recorded, including one reptile endemic to the area.

Fifty-two native and 13 introduced species of mammals have been recorded from the area. All native species are endemic to Australia, and include such Australian 'icons' as koalas, kangaroos and wombats.

Birds are the most prominent and diverse component of the vertebrate fauna of the Greater Blue Mountains. Some 265 native and 10 introduced species of birds have been recorded in the nominated area, comprising approximately one third of the total number of species found in Australia. Ford (1985) noted that the highest concentration of honeyeaters in Australia is found on the east coast and tablelands of New South Wales. Twenty-five species of honeyeaters have been recorded within the nominated area, approximately one third of the Australian total.

Although the Greater Blue Mountains do not possess the reptile diversity characteristic of arid regions of Australia, a wide variety of reptiles has been recorded, including two tortoises and more than 60 lizard and snake species. One species is endemic and two are largely restricted to the area.

More than 30 species of frogs are found in the Greater Blue Mountains area. Relatively few species are found on the upper plateaus (Smith & Smith 1990), with the majority occurring in the lower Blue Mountains. Frogs are predominantly found in the swamp communities. Litoria littlejohni and two other species have significant proportions of their known distributions occurring within the Greater Blue Mountains.

The following discussion provides comment with regard to the above nomination text for a number of vertebrate species, and reptiles and amphibians more generally.

6.1.17.1 Platypus

The Platypus (*Ornithorhynchus anatinus*) is not listed as threatened under any current NSW or Commonwealth legislation and is classified as 'Near Threatened' on the IUCN Red List of Threatened Species (Woinarski and Burbidge 2016). The Platypus has been provisionally included on the list of animals requiring urgent management intervention following the 2019-2020 bushfires, citing that further information on the species is required (DAWE 2020).

The Platypus is endemic to Australia, occurring along the east coast and Tasmania. It is mainly solitary and occupies permanent freshwater streams, but also occurs in lakes and wetlands. Steep, vegetated banks are preferred for burrowing (Menkhorst and Knight 2011). Local population declines and extinctions have been noted across its range as a result of threats including habitat disturbance for urbanisation, construction of dams and predation by feral carnivores (Bino *et al.* 2015).

The Platypus forages by repeatedly diving for aquatic invertebrates, which are stored in cheek pouches. Between dives, short periods are spent on the surface masticating food items. Platypus are crepuscular and nocturnal, travelling up to four kilometres to forage. When not foraging, platypus spend their time in burrows built into banks. Resting burrows are several metres in length while nesting burrows are up to 30 metres in length with side tunnels. In NSW, mating occurs in late winter or autumn and young emerge from burrows in January or February (Grant and Temple-Smith 1998). Juveniles disperse following each breeding season.

The Platypus was observed upstream of the study area in the Wollondilly River. There are additional records for the Kedumba, Kowmung and Coxs Rivers as well as within Lake Burragorang downstream of the Kowmung River confluence. The species has also been recorded in the Nepean River. Flooding can result in the drowning of nestlings if this occurs in the breeding season. Short term availability of macroinvertebrate prey can be reduced by flooding (Bino *et al*. 2015). Increased sedimentation and changes to macroinvertebrate assemblages associated with impacts to water quality due to the operation of the Project are potential threats to the Platypus in the lower reaches of the rivers flowing into Lake Burragorang (BMT 2020).

6.1.17.2 Short-beaked Echidna

The Short-beaked Echidna (*Tachyglossus aculeatus*) is not listed as threatened under any current NSW or Commonwealth legislation and is classified as 'Least Concern' on the IUCN Red List of Threatened Species (Aplin *et al*. 2016).

Short-beaked Echidnas are widely distributed throughout Australia and also occur in Papua New Guinea. Echidnas occupy almost all terrestrial habitat types, feeding on ants, termites and other soil invertebrates that are exposed by digging. They are active at varying times of day to avoid extreme temperatures, otherwise sheltering in burrows, logs and crevices (Menkhorst and Knight 2011). Studies have identified that echidna home ranges follow patterns seen in solitary eutherian mammals. Both sexes are promiscuous and large male home ranges overlap with several small female's home ranges, with individuals displaying a high fidelity to their home-range. As is expected with their very low metabolic rate, home-range sizes are smaller than similar sized carnivorous or omnivorous mammals (Nicol et al. 2011).

Animals are generally solitary except during the breeding season when females may be pursued by several males. The echidna breeds in spring, when an egg is laid and transferred to the pouch where it is incubated for approximately 10 days. Maternity burrows are built for nesting, with the young left in the burrow while the mother forages. Young are ejected from the pouch about the time they develop spines. Care of the young in the burrow continues for about three months with dispersal occurring in late summer to early autumn (Griffiths 1972).

The echidna was observed upstream during recent surveys and although other records are scarce, this is likely due to the lack of survey and access to record sightings. There are widespread records of the species in the downstream study area (NSW Bionet 2020). The echidna is expected to occur in all PCTs given their tendency to occupy a wide variety of habitats. The Project may result in temporary inundation of habitat and possible loss of individuals that occupy flooded areas as a result of increased competition due to their high fidelity with small home ranges.

A list of animals requiring urgent management intervention following the 2019-2020 bushfires, does not include the echidna (DAWE 2020). It has been shown to use torpor as a response to fire by sheltering and lowering their energy needs during and after the fire (Nowack *et al.* 2016). This behaviour means the echidna is more likely to be able to survive fires and re-occupy the same home-range once the fire has past. Their ability to persist in a burnt habitat is dependent on the presence of shelter, so where the fire is high intensity resulting in the complete loss of logs and leaf litter, individuals may be displaced.

6.1.17.3 Macquarie Perch/Blue Mountains Perch

The Macquarie Perch (*Macquaria australasica*), which is listed as endangered under both the EPBC Act and the NSW *Fisheries Management Act 1994* (FM Act), occurs within the upstream study area. The Blue Mountains Perch (*Macquaria sp. nov. 'Hawkesbury'*), which is likely related to the Macquarie Perch, is also likely present within the upstream study area. While not officially listed as threatened under the EPBC Act (or FM Act), the Blue Mountains Perch has been included on the provisional list of animals requiring urgent management attention in the Australian Government's bushfire recovery package for wildlife and their habitats.

The Macquarie Perch is known to prefer waterways with rocky substrate (Bruce *et al.* 2007) and has been recorded at several locations in the Hawkesbury-Nepean catchment. The distribution of this species within the study area is fragmented and they often occur in low numbers (Bruce *et al*. 2007, Knight 2010). Bruce *et al*. (2007) and Knight (2010) recorded this species in 20 of 48 water bodies sampled including the Colo River, lower Coxs River, Lake Burragorang and the Nepean River. This species was typically one of the most abundant species in locations where it was recorded (Bruce *et al*. 2007, Knight 2010). eDNA analysis undertaken to inform this assessment suggest this species also occurs in the Kedumba River within the upstream study area. Knight (2010) observed that all sites where Macquarie Perch occurred were in an undisturbed condition, suggesting that their distribution is limited by their sensitivity to in-stream habitat conditions.

The Blue Mountains Perch is thought to be restricted to the mid-reaches of small near-pristine streams, at elevations of 35-420 metres above sea level, mostly commonly at 100-175 metres above sea level. It occurs in complex boulder habitats near pristine, clear streams in rugged gorges, with minimal sediment and nutrient loads, and little or no instream vegetation. Historically the species was more widespread and has disappeared from areas such as the upper Kowmung River, Wollondilly River, and approximately 80 kilometres of the Nepean River between the Bargo River junction and Penrith weir (Bray 2020).

The aquatic ecology assessment (Appendix F4) noted that neither of these species would be likely to be impacted by construction activities due principally to their respective preferred habitats being upstream of the construction area. Potential impacts on habitat downstream is considered unlikely with the implementation of appropriate environmental management measures such as water quality controls (refer also Section 13.7). It was noted that there were likely to be areas within the FMZ that could potentially support preferred habitat of the Macquarie Perch but not for the Blue Mountains Perch.

Spawning of Macquarie Perch occurs above riffles (shallow running water), where adhesive eggs are deposited among small boulders, pebbles and gravel. It cannot be discounted that some of this type of habitat exists in the FMZ. The geomorphology assessment (Appendix N1) determined that changes in erosion and deposition in the upstream study area were unlikely to be significant, accordingly the risk of preferred habitat of the Macquarie Perch (rocky substrates) being altered through sediment deposition was low. Increases in turbidity would generally be temporary in nature and associated with flood events, and therefore unlikely to contribute to a permanent reduction in quality of habitat.

The rugged gorges that the Blue Mountains Perch prefers occur in the upper reaches of streams in the upstream catchment and below Yarramundi in the downstream catchment. As this species is thought to prefer streams with minimal sediment and nutrient loads, changes in sedimentation and turbidity could impact this species. However, such changes are not anticipated in areas where this species is likely to inhabit.

6.1.17.4 Regent Honeyeater

The Regent Honeyeater (*Anthochaera phrygia*) is listed as critically endangered under the EPBC Act and the NSW *Biodiversity Conservation Act 2016* (BC Act). Suitable habitat comprising dry and open forest habitat with a large number of mature trees occurs in the study area. The species has also recently been recorded on the western side of Lake Burragorang near Tonalli Point.

Impacts from temporary inundation of Regent Honeyeater habitat may include loss of structural components of the vegetation within areas of suitable breeding habitat, mortality of nestlings should a flood occur during a breeding event, and potential loss of suitable foraging habitat.

The upstream biodiversity assessment (Appendix F1) noted that the size of the local population potentially impacted was difficult to estimate due to the likely movement of individuals between the Burragorang Valley and other known breeding areas such as the Capertee Valley, Goulburn River and Lower Hunter Valley (R. Crates, unpublished data, Appendix K to Appendix F1). Due to limited monitoring of Regent Honeyeaters in the Burragorang Valley, the extent to which individuals move between the Burragorang Valley and other key breeding sites in the region is unknown. This

notwithstanding, the assessment concluded that there was potential for the Project to impact on the ecology of the local population.

The assessment concluded that it was unlikely that the Project would contribute to fragmentation and isolation of the local population or lead to increased threats and indirect impacts that could lead to a decrease in the viability of the local population.

6.1.17.5 Reptiles

Five reptile species were recorded in the study area during field surveys: Eastern Water Dragon (*Intellagama lesueurii*), Red-bellied Black Snake (*Pseudechis porphyriacus),* Eastern Brown Snake (*Pseudonaja textilis*), Rosenberg's Goanna (*Varanus rosenbergi*) and the Lace Monitor (*Varanus varius*). The biodiversity assessment identified potential impacts on these species may include loss of important habitat components such as exfoliated rocks and hollows, and potential mortality during flood events. The risk of loss of habitat components is considered low as water velocities associated with rise and fall of temporary inundation would be very low with low potential to mobilise and move habitat material. Velocities would be relatively higher in the upper reaches of tributaries associated with inflows, however, this would be no different to the existing situation. The rate of rise of floodwaters is unlikely to be such that most animals could not move ahead of the rising water.

6.1.17.6 Amphibians

The upstream biodiversity assessment identified the potential occurrence of two frog species in the study area: the Giant Burrowing Frog (*Heleioporus australiacus*), and Littlejohn's Tree Frog (*Litoria littlejohni*). The Red-crowned Toadlet (*Pseudophryne australis*) was also identified as potentially occurring. The biodiversity assessment identified the principal potential impacts on these species would be related to loss of structural components of vegetation within areas of suitable breeding habitat, potential mortality of individuals, and loss of suitable foraging habitat. As noted in the upstream biodiversity assessment the likelihood of a loss of habitat from a change in vegetation composition is considered low.

Consideration was also given to the Green and Golden Bell Frog (*Litoria aurea*), Booroolong Frog (*Litoria booroolongensis*), Stuttering Frog (*Mixophyes balbus*), and the Giant Barred Frog (*Mixophyes iteratus*). None of these were considered likely to be impacted by the Project; in the case of the latter two species this was due to their being unlikely to occur in the study area.

6.1.17.7 Effects of 2019-2020 bushfires

Scientific name	Common name
Anthochaera phrygia	Regent Honeyeater
Callocephalon fimbriatum	Gang-gang Cockatoo
Climacteris erythrops	Red-browed Treecreeper
Dasyurus maculatus	Spot-tailed Quoll
Eulamprus tympanum	Southern Water-skink
Heleioporus australiacus	Giant Burrowing Frog
Hoplocephalus bungaroides	Broad-headed Snake
Menura novaehollandiae	Superb Lyrebird
Monarcha melanopsis	Black-faced Monarch
Origma solitaria	Rockwarbler

Scientific name	Common name
Ornithorhynchus anatinus	Platypus
Petauroides volans	Greater Glider
Petaurus australis	Yellow-bellied Glider
Petrogale penicillate	Brush-tailed Rock-wallaby
Phascolarctos cinereus	Koala
Phoniscus papuensis	Golden-tipped Bat
Phyllurus platurus	Broad-tailed Gecko
Potorous tridactylus tridactylus	Long-nosed Potoroo
Pseudomys novaehollandiae	New Holland Mouse
Pteropus poliocephalus	Grey-headed Flying-fox
Pycnoptilus floccosus	Pilotbird

Species name	Common name	Threatened species polygon filters	Upstream impact area (ha)
Anthochaera phrygia	Regent Honeyeater	Associated PCTs: HN525; HN527; HN532; HN533; HN535; HN536; HN537; HN538; HN553; HN557; HN564; HN566; HN568; HN574; HN604; HN606; HN607; HN598 Associated IBRA subregions: Burragorang, Bungonia, Wollemi, Kanangra Onsite distribution: breeding population of minimum 21-25 individuals recorded around Tonalli Cove	1,264.55
Heleioporus australiacus	Giant Burrowing Frog	Associated PCTs: HN517; HN525; HN527; HN532; HN533; HN535; HN536; HN537; HN553; HN557; HN564; HN566; HN568; HN604; HN606; HN607; HN598 Associated IBRA subregions: Burragorang, Wollemi, Kanangra Habitat constraint: all areas of native vegetation within 300 metres 2nd and 3rd order streams on sandstone or upland swamps Onsite distribution: not observed within the survey area during current surveys. Assumed to be present	883.64

Species name	Common name	Threatened species polygon filters	Upstream impact area (ha)
Hoplocephalus bungaroides	Broad-headed Snake	Associated PCTs: HN517; HN525; HN527; HN532; HN533; HN535; HN536; HN537; HN553; HN564; HN566; HN568; HN574; HN604: HN606; HN607; HN598 Associated IBRA subregions: Burragorang, Wollemi, Kanangra Habitat constraint: land within 500 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping Onsite distribution: not observed within the survey area during current surveys. Assumed to be present	124.71
Petrogale penicillata	Brush-tailed Rock-wallaby	Associated PCTs: HN517; HN525; HN527; HN533; HN535; HN536; HN537; HN538; HN557; HN566; HN568; HN606; HN598 Associated IBRA subregions: Burragorang, Bungonia, Wollemi, Kanangra Habitat constraint: land within 1 km of rock outcrops or cliff lines Onsite distribution: not observed within the survey area during current surveys. Assumed to be present	411.70
Phascogale tapoatafa	Brush-tailed Phascogale	Associated PCTs: HN532; HN533; HN564; HN566; HN604; HN606 Associated IBRA subregion: Burragorang, Wollemi, Kanangra Onsite distribution: not observed within the survey area during current surveys. Assumed to be present	32.98
Phascolarctos cinereus	Koala	Associated PCTs: HN517; HN525; HN527; HN532; HN533; HN535; HN536; HN537; HN538; HN553; HN557; HN564; HN566; HN568; HN574; HN604; HN606; HN607; HN598 Associated IBRA subregion: Burragorang, Bungonia, Wollemi, Kanangra Onsite distribution: not observed within the survey area during current surveys. Assumed to be present	1,380.35

6.1.18 Impacts to invertebrates

The nomination for the World Heritage listing (Government of Australia 1998, pp124-126) notes

> *The taxonomy of invertebrates and knowledge of their distribution is limited and fragmentary within the Greater Blue Mountains area. Studies to date indicate that diversity is generally high in sclerophyll communities (Taylor et al. 1993; New 1988) and that the Blue Mountains contain a diverse and rich invertebrate fauna, much of which is undescribed. Surveys on the Boyd Plateau recorded a high diversity of invertebrates, including several new genera of slater and the Hairy Cicada (Tettigarcta crinita) (Mosley 1989).*
>
> *The butterflies and moths (Order Lepidoptera) are a particularly diverse group within the nominated area. It is estimated that 110-120 species of butterflies and 4,000 species of moths are found in the Greater Blue Mountains (Edwards pers. comm.).*
>
> *Rodd (1987a 1987b) provided the most detailed listing, recording 59 species of butterflies and 160 species of moths for the Mount Tomah area alone. There is also a diverse range of dragonflies and damselflies (Order Odonata) in the nominated area (Theischinger pers. comm.).*
>
> *Rainforest communities are rich in invertebrates, often including many 'primitive' forms representative of the Gondwanan fauna, and of considerable scientific interest. The Phylum Onychophora, for example, is particularly significant because it is believed to represent the 'missing link' between annelids (earthworms, etc.) and arthropods (insects, etc.) and bears striking similarities, in external features, to fossil specimens. Tait (pers. comm.) notes that there are at least five species within the Blue Mountains out of less than two hundred found in the world. Also of evolutionary significance are the glowworms, particularly the primitive genus Arachnocampa. A. richardsae is a predator species which traps its prey in hanging mucilaginous threads and the larvae is 'self-luminescent'. The type locality for this species is the Glowworm Tunnel, near Newnes (Harrison 1966) which has become a tourist attraction within Wollemi National Park.*
>
> *Also of significance within the area is the Family Gradunglidae (ground-dwelling spiders). A high proportion of this family is restricted to the east coast of Australia, and it is particularly well represented in the Greater Blue Mountains (Grey pers. comm.).*

The upstream biodiversity assessment identified that the Project could impact on important habitat features for fauna, including invertebrates, such as understorey vegetation, fallen logs, woody debris and leaf litter. While these features could be submerged due to temporary inundation, the Project is considered unlikely to result in the permanent loss of these habitat features given that the maximum duration of temporary inundation would be about two weeks. This is a worst case scenario and relates principally to Lake Burragorang and its immediate surrounds. The duration of temporary inundation decreases markedly moving upstream away from the lake. It is also noted that these habitat features are potentially affected by upstream flooding from operation of the existing dam.

The aquatic ecology assessment (Appendix F4) noted that changes to macroinvertebrate assemblages associated with impacts on water quality due to the operation of the Project could impact on species that rely on aquatic macroinvertebrates, such as fish. It also considered potential impacts on two invertebrate species listed under the NSW *Fisheries Management Act 1994*, the Adam's Emerald dragonfly (*Archaeophya adamsi*) and Sydney Hawk dragonfly (*Austrocordulia leonardi*). Threats to both species (DPI 2007, 2013) include:

- habitat degradation resulting from removal of riparian vegetation, drainage works, sedimentation from road crossings, and similar activities
- water pollution and sedimentation from land clearing, waste disposal and stormwater runoff from urban, industrial and agricultural development in catchments
- chance events such as natural disasters including bushfire and drought.

River regulation and alteration of flows resulting in the disappearance of natural deep pools has been identified as threat to the Sydney Hawk dragonfly (DPI 2007) while low population sizes and a long larval period (indicating an extremely low rate of natural recruitment and therefore slow recovery from any population decline) has been identified as threat to the Adam's Emerald dragonfly (DPI 2007).

The likelihood of habitat degradation is considered low; while habitat utilised by these species may be subject to temporary inundation (and which is also an existing risk), the limited duration (a maximum of about two weeks) would be unlikely to have a material affect on riparian habitat utilised by these species. There would be no change to the

operation of the Special Areas therefore there would be no change to the risk of water pollution and sedimentation. The Project would not have any effect on chance events that may affect these species. The Project would not result in the loss of natural deep pools. Accordingly, the assessment concluded that it was unlikely that the Project would have a significant impact on either of these two species.

A small area of Wollemi National Park (about one hectare) near the Colo River would fall inside the downstream Project PMF. As such the Project would not affect the Glowworm Tunnel within Wollemi National Park which occurs outside of the Project study area about 60 kilometres to the north on the Newnes Plateau.

6.1.19 Visual impacts

A visual impact assessment was undertaken for the Project which included assessing the potential visual impacts of the Project from the iconic Echo Point Lookout and from Burragorang Lookout at Nattai. Both viewpoints overlook some areas of the GBMWHA; see Appendix P to the EIS (Landscape character and visual impact assessment report).

6.1.19.1 Ground-based observers

Potential visual impacts associated with the Project would relate generally to the effects of temporary inundation upon vegetation that may result in the dieback of vegetation. It should be noted that there is still substantial uncertainty around the effects of temporary inundation on the mortality of plant species. A recent review of the environmental impacts of temporary inundation upstream of flood inundation dams in Queensland (Hydrobiology 2019) noted that temporary inundation may impact certain aspects of ecosystem health but that the extent to which this may occur is substantially dependent on a large range of independent variables such as geology, frequency and duration of flooding, geographic setting, ecosystem characteristics, land use, germination from flood-borne seeds, edge effects and similar matters. It further noted that the studies of Queensland dams did not suggest that temporary flood inundation would inevitably cause substantial environmental impact. Further discussion is provided in Appendix F1 Biodiversity Assessment Report – Upstream.

With regard to the GBMWHA, these potential impacts would be manifested largely along the Wollondilly River arm on the eastern shoreline of Lake Burragorang where there would be about an additional eight days of inundation associated with the Project with regard to the upstream impact area. This part of the shoreline of Lake Burragorang is visible from Burragorang Lookout with the nearest part being about five kilometres from the lookout. It should be noted that part of this vegetated area within the GBMWHA is already affected by flooding with an inundation period of about seven days (refer Table 4-3).

Figure 6-7 and Figure 6-8 show the viewsheds from Echo Point and Burragorang Lookout respectively. Figure 6-7 shows that Lake Burragorang and the upstream impact area are more than 10 kilometres distant. This distance, together with the characteristic blue haze of the Blue Mountains, suggests that any impacts on vegetation within the upstream impact area within the GBMWHA would not be visible from Echo Point.

Burragorang Lookout is closer to the upstream impact area and while areas of it within the GBMWHA may be visible from this location, the majority of it would be greater than five kilometres away (refer Figure 6-8). Any impacts on vegetation within the upstream impact area that may be visible and would have a low magnitude of change and an overall moderate visual impact. This is unchanged from the existing dam operations which have the same moderate visual impact due to the general absence of vegetation below the FSL and the fluctuating water levels.

Another location with views of Lake Burragorang is McMahons Point lookout which is accessible by foot about 800 metres from Kings Tableland Road. No areas of the GBMWHA, including the upstream impact area, visible from this lookout would be affected by the Project.

The majority of the GBMWHA that would potentially experience increased temporary inundation from the Project is also within the Schedule 1 Special Area of Lake Burragorang where public access is not permitted, and therefore only limited areas of potentially affected GBMWHA land would be visible to the public.

6.1.19.2 Aerial observers

The EIS prepared for Western Sydney Airport (DIRD 2016) included an assessment of potential impacts on the visual amenity of the GBMWHA, focussing on impacts on amenity of ground-based observers. It noted that almost all aircraft approaching or departing the airport would be at an altitude in excess of 1700 metres (5600 feet) above sea level when passing over the GBMWHA.

Aircraft travelling to and from Sydney Airport would be at similar or greater altitudes, however, in practice, the proportion of flights arriving at and departing from Sydney Airport that fly over the area potentially affected by the Project is very small (as determined by a review of flight paths for the period January 2016 to September 2019[14]). Given the altitude of aircraft, the relatively small proportion of flights overflying the area, the transit time, and the locations where vegetation dieback may occur, the potential impact of the Project on visual amenity for these receivers is considered to be very minor.

Various companies also operate sightseeing flights, both fixed wing and helicopter, over the GBMWHA and these typically fly at a lower altitude than commercial flights. Areas within the impact area within the GBMWHA where vegetation had been impacted by the Project through temporary inundation would therefore likely be more apparent. These areas are in immediate proximity to Lake Burragorang and the impacts would be mitigated to some extent by this.

[14] http://aircraftnoiseinfo.emsbk.com/sydney/flight-paths/

Figure 6-7. Viewshed from Echo Point

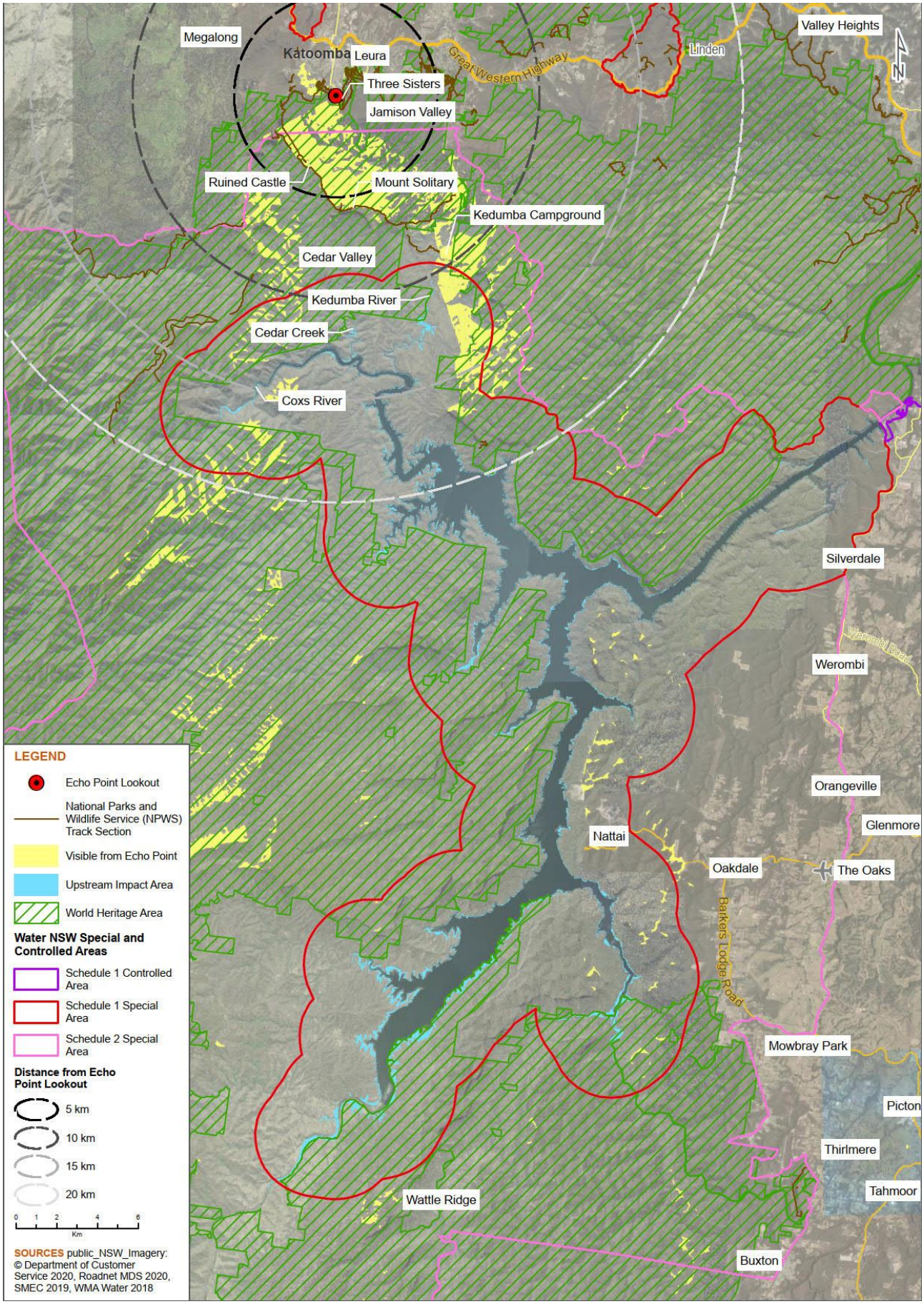
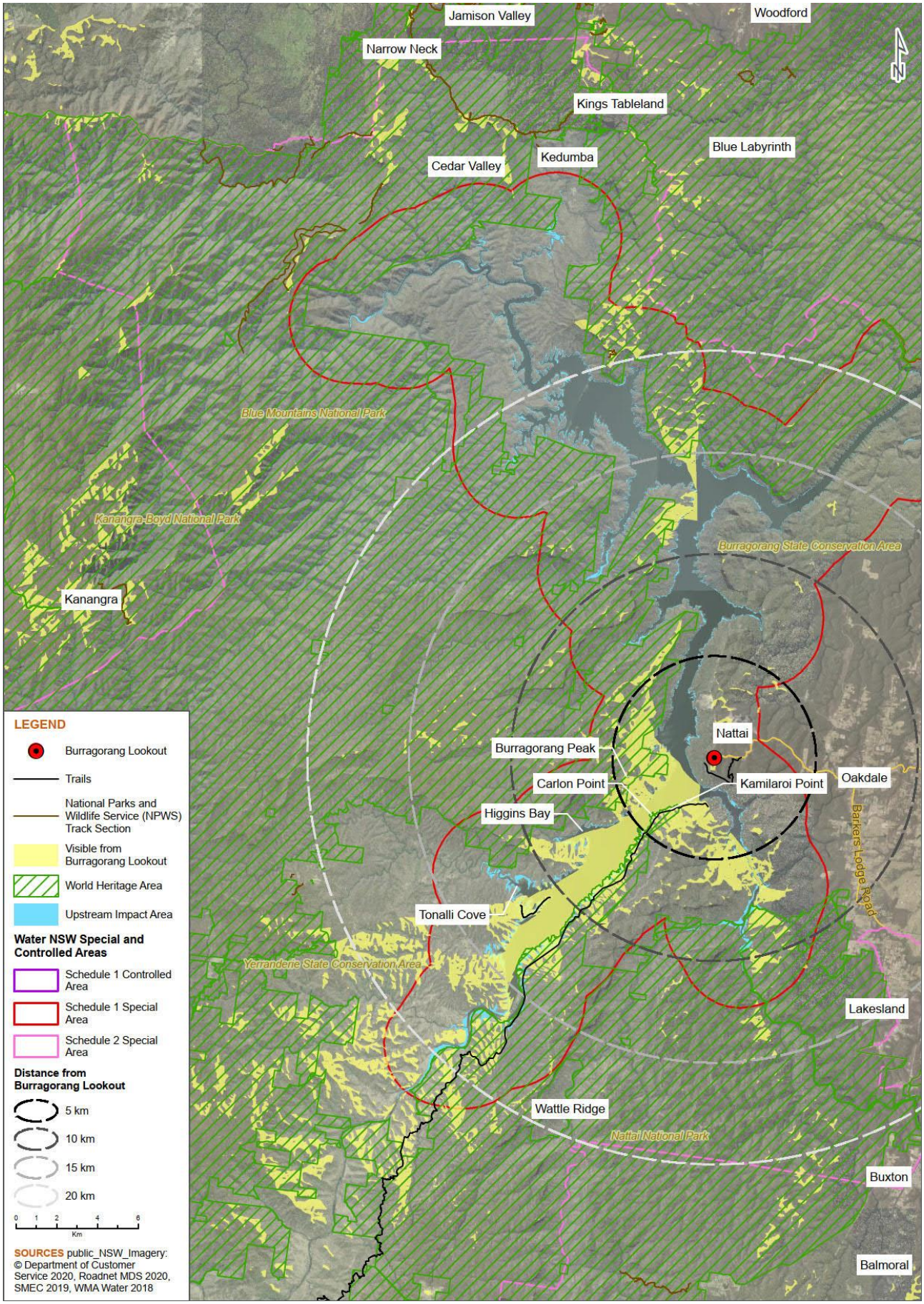


Figure 6-8. Viewshed from Burragorang Lookout



6.1.19.3 2019-2020 bushfires

Figure 2-1 shows the extent and severity of the 2019-2020 bushfire event. This shows there has been limited impact within the upstream study area relative to the wider upstream area. About 28 percent of the upstream study area has been mapped as moderately affected, and about 10 percent as 'High' and 'Extreme'. The extent of burn severity is very similar for the upstream impact area with nearly two thirds (65.8 percent) mapped as either 'Low' or 'Unburnt' (refer Table 2-1).

Areas of relative greatest impact within the upstream study area are generally located in the upper reaches of the various tributaries and unlikely to be visible to ground-based observers. The impacts of the bushfires would be more apparent to aerial-based observers, however, it would be highly unlikely that such observers would be able to accurately demarcate the boundary of the upstream study area.

The 2019-2020 bushfire event will be the predominant influence on changed visual amenity in the very limited area of the GBMWHA potentially affected by the Project compared to the broader GBMWHA for the immediate and near future and would be influenced by other factors affecting vegetation regrowth.

Impacts on visual amenity from the bushfire event with regard to the GBMWHA OUV within the upstream impact area are considered to be negligible compared to the wider GBMWHA.

6.1.20 Impacts on users

As noted in Sections 6.1.4.2 and 6.1.13, the upstream impact area within the GBMWHA that would potentially experience increased temporary inundation from the Project is within the Schedule 1 Special Area around Lake Burragorang to which public access is not permitted. In these areas there would be no direct impact from the Project on the public uses of the GBMWHA. Very small areas of the GBMWHA that would potentially experience increased temporary inundation from the Project (including the upstream impact area) are in Schedule 2 Special Areas to which the public is allowed to access on foot (bushwalkers). Consequently, the impact of the Project on public use of the GBMWHA would be minimal.

Other users of the area of the GBMWHA potentially impacted by the Project would be management staff (that is, NPWS and WaterNSW officers) and emergency services including the Rural Fire Service and potentially the State Emergency Service. The Project may result in the increased extent and duration of flooding of fire trails that are used to access areas in the GBMWHA, however this is likely to be minimal in relation to the upstream impact area within the GBMWHA. While bushfires are extremely unlikely to occur during and immediately after major flood events, if increased temporary inundation results in damage to trails, access may be affected for a longer period until the trails are repaired. The EMP would contain measures to monitor and repair damage to fire trails to ensure that any impacts to access are minimised. Further discussion and assessment of potential impacts to fire trails from increased temporary inundation is presented in Chapter 20 (Protected and sensitive lands) of the EIS.

6.1.21 Impacts to geological structure, geomorphology and water systems

The Statement of Integrity notes that 'the area's integrity depends upon the complexity of its geological structure, geomorphology and water systems, which have created the conditions for the evolution of its outstanding biodiversity and which require the same level of protection.'

Operation of the FMZ would not impact on the geological complexity or the water systems of the GBMWHA. The geomorphology assessment carried out for the Project (refer Appendix N2) identified the potential for some localised changes to geomorphological process in the upstream study area associated with watercourses and with the margins of Lake Burragorang. The area of the GBMWHA along the eastern side of the arm of Lake Burragorang running up to the Wollondilly River may be subject to these changed geomorphological process, however, given these would be localised and considering the small scale relative, any such changes are not regard as significant.

6.1.22 2019-2020 bushfires

Following the 2019-2020 bushfire event, DAWE released an initial provisional list of 113 fauna species as high priority for urgent management intervention on 11 February 2020. An updated list[15] was released on 20 March 2020. A similar list was released for plant species, the latest being released on 12 October 2020[16].

An assessment has been carried out with regard to the species on these lists that were identified in the upstream biodiversity assessment (Appendix F1 Biodiversity Assessment Report – Upstream) as having a moderate or greater likelihood of occurring in the upstream study area, or had been recorded in the upstream study area.

Estimates of areas of suitable habitat were derived based on associated PCTs occurring in the upstream study area (refer Table 2-3). This was carried out for:

- the total upstream study area (about 5,280 hectares)
- the upstream impact area (about 1,400 hectares)
- the area of the GBMWHA within the upstream impact area (about 304 hectares).

Estimates of suitable habitat affected by the bushfire event were then derived for the same areas. This was based on the fire extent and severity mapping developed by the DPIE Remote Sensing and Landscape Science team in collaboration with the RFS (refer Section 2.5) using the following three burn severity classes:

- Medium: Partial canopy scorch (20-90% canopy scorch)
- High: Full canopy scorch/partial consumption (>90% canopy scorched, <50% canopy consumed)
- Extreme: Full canopy consumption (>50% canopy biomass consumed).

Areas mapped as 'Unburnt' or 'Low' (>10% burnt understory, >90% green canopy) were excluded from the assessment as habitat in these areas was considered to be relatively unaffected in terms of utilisation by the species considered.

The approximate extents (in terms of percentage area) of each burn severity class within the upstream study area and upstream impact area are provided in Table 2-1. The area of each burn severity class within the World Heritage area for the upstream study area and upstream impact area is provided in Table 2-2.

The estimates of the areas of suitable habitat available in the above three areas and the estimated extents affected by the bushfire event in the same areas are presented in Table 6-6.The estimated burnt areas are also expressed as a percentage of the total estimated suitable habitat within the respective area.

The following is noted with regard to the priority fauna species considered:

- The proportion of burnt habitat relative to the total estimated suitable habitat is generally similar across the three areas, being in the range of 30-50 percent
- Almost all of the available suitable habitat for the Parma Wallaby (*Macropus parma*) has been burned, however, the total area of this habitat in the upstream study area is very small relative to the overall study area
- Habitat potentially utilised by the New Holland Mouse (*Pseudomys novaehollandiae*) appears to have been relatively less affected by the bushfire event, and no suitable habitat was identified in the area of the GBMWHA within the upstream impact area.

The following is noted with regard to the priority plant species considered:

- The extent of the burnt habitat areas in the upstream study area ranges from 23 percent (Scrub Turpentine, *Rhodamnia rubescens*) to 50 percent (Mountain Trachymene, *Trachymene scapigera*)
- A broadly similar pattern occurs for the upstream impact area with the exception of the Megalong Valley Bottlebrush (*Callistemon megalongensis*) where 71 percent of the estimated 11 hectares of suitable habitat for this species has been burnt. An estimated 84.6 hectares of suitable habitat for this species occurs in the upstream study area, of which an estimated 37 percent has been burnt. No suitable habitat for this species was identified in the area of the GBMWHA within the upstream impact area.

[15] https://www.environment.gov.au/system/files/pages/ef3f5ebd-faec-4c0c-9ea9-b7dfd9446cb1/files/provisional-list-animals-requiring-urgent-management-intervention-20032020.pdf

[16] https://www.environment.gov.au/system/files/pages/289205b6-83c5-480c-9a7d-3fdf3cde2f68/files/summary-final-list-plants-requiring-urgent-managment-intervention.pdf

Table 6-6. DAWE priority list species habitat affected by 2019-2020 bushfires

Scientific name	Common name	Upstream study area			Upstream impact area			GBMWHA in upstream impact area		
		Total area (ha)	Burnt area[1] (ha)	%	Total area (ha)	Burnt area[1] (ha)	%	Total area (ha)	Burnt area[1] (ha)	%
Fauna										
Heleioporus australiacus	Giant Burrowing Frog	3,270.5	1,217.2	37%	28.5	271.9	33%	69.4	32.6	47%
Anthochaera phrygia	Regent Honeyeater	5,203.6	2,115.4	41%	1,369.7	531.0	39%	295.9	144.4	49%
Callocephalon fimbriatum	Gang-gang Cockatoo	5,205.1	2,115.7	41%	1,370.2	531.0	39%	295.9	144.4	49%
Calyptorhynchus lathami	Glossy Black-cockatoo	4,973.9	2,063.6	41%	1,320.1	517.9	39%	295.8	144.3	49%
Monarcha melanopsis	Black-faced Monarch	5,205.1	2,115.7	41%	1,370.2	531.0	39%	295.9	144.4	49%
Dasyurus maculatus maculatus	Spotted-tailed Quoll	5,205.1	2,115.7	41%	1,370.2	531.0	39%	295.9	144.4	49%
Macropus parma	Parma Wallaby	36.6	30.4	83%	14.7	3.4	23%	8.8	8.4	95%
Petauroides volans	Greater Glider	5,203.6	2,115.4	41%	1,369.7	531.0	39%	295.9	144.4	49%
Petaurus australis	Yellow-bellied Glider	4,555.7	1,848.1	41%	1,221.2	494.8	41%	76.1	133.0	48%
Petrogale penicillata	Brush-tailed Rock-wallaby	4,415.0	1,693.8	38%	1,164.9	464.0	40%	224.7	96.0	43%
Phascolarctos cinereus	Koala	5,205.1	2,115.7	41%	1,370.2	531.0	39%	295.9	144.4	49%
Potorous tridactylus tridactylus	Long-nosed Potoroo	4,400.3	1,806.2	41%	1,186.9	484.9	41%	267.3	124.6	47%
Pseudomys novaehollandiae	New Holland Mouse	165.6	33.3	20%	43.9	6.5	15%	0	–	–
Pteropus poliocephalus	Grey-headed Flying-fox	5,205.1	2,115.7	41%	1,370.2	531.0	39%	295.9	144.4	49%
Hoplocephalus bungaroides	Broad-headed Snake	4,016.7	1,607.6	40%	1,017.3	335.5	33%	131.8	72.6	55%
Heleioporus australiacus	Giant Burrowing Frog	3,270.5	1,217.2	37%	828.5	271.9	33%	69.4	32.6	47%

Scientific name	Common name	Upstream study area			Upstream impact area			GBMWHA in upstream impact area		
		Total area (ha)	Burnt area[1] (ha)	%	Total area (ha)	Burnt area[1] (ha)	%	Total area (ha)	Burnt area[1] (ha)	%
Flora										
Acacia clunies-rossiae	Kanangra Wattle	4,496.4	1,806.8	40%	1,184.5	472.6	40%	244.4	107.3	44%
Acacia flocktoniae	Flockton's Wattle	2,152.1	756.8	35%	554.3	192.8	35%	64.1	13.9	22%
Baloskion longipes	Dense Cord-rush	368.2	193.9	53%	84.2	21.4	25%	19.7	11.3	57%
Callistemon megalongensis	Megalong Valley Bottlebrush	84.6	31.7	37%	11.0	7.8	71%	0	–	–
Epacris purpurascens var. purpurascens	–	69.1	16.6	24%	23.2	4.9	21%	0	–	–
Hakea dohertyi	Kowmung Hakea	1,452.6	561.5	39%	383.8	116.0	30%	28.5	13.2	46%
Isopogon fletcheri	Fletcher's Drumsticks	800.4	343.1	43%	212.9	64.2	30%	26.9	12.3	46%
Persoonia acerosa	Needle Geebung	125.2	32.2	26%	32.3	4.6	14%	0	–	–
Pomaderris brunnea	Brown Pomaderris	1,375.7	618.2	45%	326.9	98.4	30%	51.9	30.0	58%
Pultenaea glabra	Smooth Bush-pea	125.2	32.2	26%	32.3	4.6	14%	0	0	–
Rhodamnia rubescens	Scrub Turpentine	324.1	73.8	23%	77.1	13.7	18%	0.1	0.1	100%
Solanum armourense	–	4,179.1	1624.9	39%	1,110.7	452.2	41%	224.7	96.0	43%
Trachymene scapigera	Mountain Trachymene	1703.5	846.4	50%	491.6	246.0	50%	226.4	111.7	49%
Velleia perfoliata	–	1,829.7	752.5	41%	457.2	141.1	31%	50.3	22.6	45%
Zieria covenyi	Coveny's Zieria	58.2	15.5	27%	16.3	3.4	21%	0	0	–
Zieria murphyi	Velvet Zieria	58.2	15.5	27%	16.3	3.4	21%	0	0	–

1 Mapped as 'Medium', 'High', 'Extreme' as per DPIE FESM mapping (refer Table 2-1).

- The extent of the burnt habitat areas in the area of the GBMWHA within the upstream impact area ranges from 22 percent (Flockton's Wattle, *Acacia flocktoniae*) up to 100 percent (Scrub Turpentine, *Rhodamnia rubescens*). The next highest percentage burnt area is for Brown Pomaderris (*Pomaderris brunnea*) at 58 percent
- Suitable habitat for five priority plants species does not occur in the area of the GBMWHA within the upstream impact area.

As a general comment, based on this analysis, there are still substantial areas of unburnt habitat in the upstream impact area and upstream study area with regard to affected habitat areas within the area of the GBMWHA within the upstream impact area.

6.1.23 Summary

The following is a summary of the anticipated potential impacts of the Project upon the individual OUV components of the GBMWHA upstream of Warragamba Dam, principally in relation to the upstream impact area.

As noted previously, for the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. This may result in a diminution of the various OUV component values, however, it is considered that this would not necessarily lead to a material change in specific individual OUV components, particularly in view of the much larger area of the GBMWHA that would not be affected by the Project, and also with regard to the proposed mitigation measures and offsets identified in Section 13.

Wilderness

The area of declared wilderness areas in the GBMWHA within the upstream impact area that could be impacted by the Project is about 36 hectares (<0.01 % of the GBMWHA). The Project would not alter the values under which land is designated as wilderness under the NSW *Wilderness Act 1987* or wilderness values protected under the EPBC Act.

The Project is therefore not expected to result in a material change to this OUV component.

Aboriginal cultural heritage

The integrity statement for the Greater Blue Mountains World Heritage Area[17] includes the following text with regard to Aboriginal cultural heritage as part of the OUV for the GBMWHA:

> *An understanding of the cultural context of the GBMA is fundamental to the protection of its integrity. Aboriginal people from six language groups, through ongoing practices that reflect both traditional and contemporary presence, continue to have a custodial relationship with the area. Occupation sites and rock art provide physical evidence of the longevity of the strong Aboriginal cultural connections with the land. The conservation of these associations, together with the elements of the property's natural beauty, contributes to its integrity.*

This builds on the acknowledged Aboriginal cultural heritage values in the nomination which states (Government of Australia 1998; p44)

> *The rugged upland country of the Greater Blue Mountains is not only of exceptional natural diversity, and of spectacular and ephemeral beauty, but is also closely tied to the lives of people who have occupied, visited, thought about it and cared for it over thousands of years. The property represents, in fact, the combined works of nature and man.*
>
> *The direct and tangible cultural association with the million hectares of wild country is expressed in two physical forms. First are the widespread Aboriginal occupation sites, rock shelter paintings and rock platform engravings. Second is the narrower network of historic walking tracks, staircases and lookouts, festooned from the edges of the ridge crossing the Mountains and down to the valley floors.*
>
> *Both rock art and tracks are intact and authentic. The texts which follow, on Aboriginal rock art and on pioneering conservation movements in the area, explain the significance of these tangible links with events, traditions, ideas, beliefs, and artistic works of outstanding universal significance.*

The assessment has identified the potential total loss of value for 28 sites located between the FSL and the upper extent (RL 126.97 mAHD) of the upstream impact area. These sites comprise four occupation site types (Aboriginal

[17] https://whc.unesco.org/en/list/917/

Resource and Gathering, Open Camp Site, Axe Grinding Grooves, Isolated Artefact). All sites have been identified as being of high cultural significance with five sites identified as being of moderate or high scientific significance.

A further 15 sites were identified within the GBMWHA above (i.e at a higher elevation) the upstream impact area with one identified as containing art (Site type: Shelter with Deposit and Art). These sites are at a lesser risk of temporary inundation associated with the Project, and the Aboriginal cultural heritage assessment concluded that there would not be any loss of cultural heritage values for these sites.

The cultural values assessment noted that from the perspective of the Aboriginal cultural knowledge holders, it was understood that the potential impacts of the Project on identified cultural values would be harmful.

The Project has assumed a total loss of values within the upstream impact of which 304 hectares occurs within the GBMWHA. While this scale of impact may not be actually realised, on the assumption of total loss of values, this would result in a diminution of Aboriginal cultural heritage values (loss of 28 sites) and therefore the Project may result in a diminution of this OUV component.

Plant communities

The principal potential impact of the Project on plant communities relates to the tolerance of individual constituent species to temporary inundation when the FMZ is in use. Temporary inundation is an existing risk to plant communities in the upstream study area (including the upstream impact area) and the Project would result in an increase in the depth and duration of temporary inundation of up to an additional eight metres and up to an additional eight and half days respectively.

The inherent characteristics of individual plant species and some vegetation communities as a whole may allow them to tolerate temporary inundation. Generally riparian and wetland species and communities have a higher tolerance to inundation but other dryland species can also have specific tolerance characteristics. There is a lack of scientific information on the tolerance of many Blue Mountains plant and vegetation communities to temporary inundation. A recent investigation (Hydrobiology 2019) drawing on Queensland examples of the effects of temporary inundation on plant species concluded that based on the limited evidence of the studies of Queensland dams did not suggest that temporary inundation would inevitably cause substantial environmental impact.

In view of the above, it is difficult to make a definitive statement as to whether the Project would have a material effect on this OUV component. Based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is suggested the Project would not have a material effect on this OUV component.

Threatened flora species

As with plant communities, the principal potential impact of the Project on threatened flora species relates to their respective tolerance to temporary inundation when the FMZ is in use. The above summary for plant communities would also generally apply to threatened flora species. It should also be noted that for a number of species their presence was assumed notwithstanding they were not detected during field surveys.

In view of the above, it is difficult to make a definitive statement as to whether the Project would have a material effect on this OUV component. Based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is suggested the Project would not have a material effect on this OUV component.

Habitat of threatened fauna species

As with plant communities and threatened flora species, the principal potential impact of the Project on the habitat of threatened fauna species relates to its tolerance to temporary inundation when the FMZ is in use. The upstream biodiversity assessment noted that direct mortality of threatened fauna species due to the Project is likely to be negligible as all species are motile, there are large areas of other suitable habitat adjacent to the Project study area, and that the extent and impact on the habitat would vary depending on the location of habitat (that is, proximity to Lake Burragorang), the frequency of flood events and the flood tolerance of the habitat.

In view of the above, the Project is not expected to result in a material change to this OUV component.

Eucalyptus species

Apart from two species, *Eucalyptus benthamii* (Camden White Gum) and *Eucalyptus glaucina* (Slaty Red Gum), none of the Eucalypt species were listed as threatened or endangered under NSW and/or Commonwealth biodiversity

protection legislation. All other Eucalypt species were common and widely distributed in the Blue Mountains and other areas in NSW, and some species in other States

In view of the above, it is difficult to make a definitive statement as to whether the Project would have a material effect on this OUV component. Based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is suggested the Project would not have a material effect on this OUV component.

Other biodiversity-related matters

Comment on other biodiversity-related matters is provided in Table 6-7.

Table 6-7. Other biodiversity-related matters

Matter	Comment
Scleromorphic species	It is not possible to make a precise statement of the effect of the Project on scleromorphic species within the upstream impact area. However, based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is considered the Project would not have a material effect on this aspect of this OUV component.
Ant-adapted plants	Ant-adapted plants likely comprise many of the plants potentially affected in the GBMWHA by the Project. However, based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is considered the Project would not have a material effect on this aspect of this OUV component.
Diversity and characteristics of the flora as a whole	Based purely on the limited extent of the upstream area within the GBMWHA relative to the overall area of the GBMWHA, it is considered the Project would not have a material effect on this aspect of this OUV component.
Species diversity	The upstream impact area within the GBMWHA potentially impacted by the Project is located along peripheral areas of the GBMWHA bordering Lake Burragorang and related tributaries. The Project is considered unlikely to have a significant impact on species diversity within the part of the GBMWHA affected by the Project (including the upstream impact area), relative to the overall GBMWHA.
Vertebrates	Consideration has been given to potential impacts of the Project on unlisted species such as the Platypus and Short-beaked Echidna. The Platypus may be affected by flooding of burrows and drowning of nestlings. This is an existing risk that may increase with the Project. Operation of the FMZ may temporarily affect the preferred habitat of the Macquarie Perch, however, this was considered unlikely to contribute to a permanent reduction in quality of habitat. The Project is unlikely to affect areas of habitat preferred by the Blue Mountains Perch. The Project has potential to impact on the ecology of the local population of the Regent Honeyeater. While operation of the FMZ may temporarily affect areas of habitat utilised by reptiles and amphibians, it is considered unlikely that this would result in a permanent impact. The Project may diminish some aspects of this OUV component.
Invertebrates	While the Project could potentially impact on habitat features utilised by invertebrates through being submerged while the FMZ was in operation, the Project is considered unlikely to result in the permanent loss of these habitat features. The Project is not expected to result in a material change to this aspect of this OUV component.

Visual

Consideration has been given to potential impacts on visual amenity with regard to ground-based and aerial observers. Potential impacts relate principally to the possible dieback of vegetation as a result of temporary

inundation. As noted previously, the tolerance of individual plant species to temporary inundation is variable and subject to numerous influences, contributing to substantial uncertainty around whether dieback of vegetation would actually occur. A further consideration is the dynamic nature of the natural environment with regard to natural regeneration of areas of vegetation that may be affected by the Project.

The assessment considered potential impacts to ground-based observers at representative locations in the landscape. It concluded that impacts to vegetation within the upstream impact area that may be visible, would have a low magnitude of change and an overall moderate visual impact. Aerial observers, particularly sightseeing flights that operate at lower altitudes than commercial flights, would have greater visibility of areas within the impact area within the GBMWHA where vegetation may have affected by the Project through temporary inundation.

The Project is not expected to result in a material change to this OUV component.

Users

Impacts on users are anticipated to be minimal. The Project would not have a significant impact on public access and there would essentially be no change from existing arrangements. Similarly, the Project is not expected to have a material effect on access for management activities and by emergency services.

The Project is therefore not expected to result in a material change to this OUV component.

Geological structure, geomorphology and water systems

Operation of the FMZ would not impact on the geological complexity or the water systems of the GBMWHA.

The geomorphology assessment) identified the potential for some localised changes to geomorphological process in the upstream study area associated with watercourses and with the margins of Lake Burragorang. The area of the GBMWHA along the eastern side of the arm of Lake Burragorang running up to the Wollondilly River may be subject to these changed geomorphological process, however, given these would be localised and considering the small scale relative, any such changes are not regard as significant.

The Project is not expected to result in a material change to this OUV component.

Bushfire

The area of the GBMWHA within the upstream study area was relatively unaffected by the 2019-2020 bushfire event (refer Section 2.5). Less than 12 percent of the GBMWHA in the upstream study area experienced 'High' or 'Extreme' burning and almost 70 percent experienced 'Low' or no burning. The area of the GBMWHA within the upstream impact area was similarly relatively unaffected with only about 12 percent mapped as 'High' or 'Extreme' and about 70 percent mapped as 'Low' or 'Unburnt'.

Bushfires are natural events in the Australian landscape and, with regard to the GBMWHA, an existing risk that was present prior to its inscription on the World Heritage list. The Project will not change this risk as there would be no material change in operational activities from what presently occurs. However, the potential impacts of the Project may be influenced by bushfire events and the regeneration that would follow (reflecting the dynamic nature of the landscape).

As noted elsewhere in this report, for the purpose of offsetting potential impacts of the Project, it has been assumed that there would be a total loss of biodiversity values within the upstream impact area, including the 304 hectares of the GBMWHA within this area. In view of this, the issue of the combined impact of the bushfire event and the Project is considered a moot point.

6.2 Areas of GBMWHA downstream of the dam

There are two areas of the GBMWHA downstream of Warragamba Dam potentially affected by the Project:

- catchment areas adjacent to the Warragamba River and Nepean River which are in the Blue Mountains National Park; the GBMWHA area adjacent to the Nepean River extends from its confluence with Warragamba River to Lapstone
- catchment areas of some tributaries of the lower Colo River near its confluence with the Hawkesbury River which are in the Yengo National Park.

The Project would have the following potential impacts or benefits on these areas:

- reduced extent and duration of large floods
- increased low level flooding impacts due to the discharge of water from the FMZ.

These are discussed in more detail in the following sections.

6.2.1 Reduced extent and duration of large floods

The Project would result in the reduced extent and duration of large floods in both the Warragamba/Nepean River area and the Lower Colo area. There would be a small decrease in flooding extents in both areas for the assessed flood events (refer Table 4-9).

In the Nepean/Warragamba area, the rivers are contained within a gorge so any changes in spatial flood extents would be minimal unlike the downstream floodplain areas around the Penrith and Richmond/Windsor area. The Lower Colo River's confluence with the Hawkesbury River is about 75 kilometres downstream of Warragamba Dam. At this distance from the dam any changes in flooding extents due to the Project would be negligible (about 0.7 hectares). Overall while there is likely to be some reduction in flood extents and durations in these areas of the GBMWHA, any benefits or impacts would be minimal.

6.2.2 Impacts from the operation of the FMZ

While peak flood levels and velocities would be lower due to the Project, there would be sustained lower level discharges from the FMZ which could potentially impact downstream areas, principally the Nepean/Warragamba River area of the GBMWHA. Once flood levels downstream of the dam had peaked, flood waters temporarily stored in the FMZ would be discharged. Generally, controlled discharges from the FMZ could range up to 200 gigalitres per day also depending on the size of the flood event and could occur for up to around two weeks, also depending on the size of the flood event.

The Nepean/Warragamba River area of the GBMWHA downstream of Warragamba Dam is located within a gorge which greatly constrains the lateral spread of floodwaters into the GBMWHA downstream of the confluence with the Nepean River. This area is already subject to flooding associated with releases from the dam and from contributions from the Nepean catchment.

The geomorphology assessment for the Project identified that the sandstone gorge areas in the Warragamba River and Nepean River within the GBMWHA are very stable and would not be impacted by operation of the FMZ.

6.2.3 Summary

The two areas of the GBMWHA downstream of Warragamba Dam would likely experience limited impacts from the Project and it is not expected that there would be any significant impact s on World Heritage values.

6.3 Old Great North Road

The Old Great North Road is one of 11 places that make up the Australian Convict Sites World Heritage property. The 11 sites were given World Heritage listing in 2010. The Devines Hill and Finchs Line sections of the Old Great North Road, which lie in Dharug National Park, are included in this listing.

The cultural significance of the road is reflected through its inscription on the Australian National Heritage List (gazetted on 1 August 2007) as a nationally significant example of major public infrastructure developed using convict labour, and on the UNESCO World Heritage list as one of the Australian Convict Sites on 31 July 2010. The Old Great North Road was built between 1826 and 1836 to link Sydney with the Hunter Valley, running for some 250 kilometres and constructed using convict road gang labour.

The National Heritage List inscription notes:

> *The Old Great North Road is the best surviving example of an intact convict built road with massive structural works which remain undisturbed by later development on or around the road.*

and

> *Old Great North Road provides evidence of the transition of New South Wales from a penal colony to a permanent settlement and is an excellent representation of the extensive road building undertaken by Governor Ralph Darling to expand the colony, provide transportation and communication links with dispersed settlements, and provide harsh punishment for convicts.*

The Old Great North Road World Heritage Area is currently unaffected by all SEARs events up to the 1 in 100 chance in a year event and this would not change with the Project. About 1.1 hectares is affected by the existing PMF and this would reduce to about 0.6 hectares with the Project. As has been noted elsewhere in this report, the PMF is event is used principally as an input to design and, given the scale of the catchment of Lake Burragorang, is highly unlikely to occur in nature.

Management of the Old Great North Road World Heritage Area is carried out through the following plans:

- *Old Great North Road Dharug National Park Conservation Management Plan* (Griffin NRM 2005)
- *The Old Great North Road CMP Dharug National Park Addendum* (Department of Environment and Climate Change 2007).

Section 8 of the Conservation Management Plan identifies a range of policies to guide implementation of the Plan. These are listed in Table 6-8 together with comment on the consistency or otherwise of the Project for each policy.

Table 6-8. Policies for Old Great North Road Conservation Management Plan

Policy	Consistency of Project with policy
Policy 1 Significance the basis for planning and work The statement of cultural significance set out in Section 5 of the CMP should be the principal basis for future planning and work.	The Project would not be inconsistent with this policy.
Policy 2 Adopt and endorse this CMP This CMP will be submitted for endorsement by the NPWS executive and the NSW Heritage Office.	This policy is not relevant to or affected by the Project.
Policy 3 Standards of practice The outstanding significance of the OGNR and its cultural landscape requires best practice standards of heritage management.	The Project would not be inconsistent with this policy.
Policy 4 Expert advice The management and conservation of the OGNR and its cultural landscape will draw on appropriate expert advice to ensure high standards of conservation practice.	The Project would not be inconsistent with this policy. The environmental assessment prepared for the Project may assist in informing future management decision-making with regard to consideration of flooding matters.
Policy 5 Knowledge and skills All those involved in the care and management of the OGNR and its cultural landscape will have an appropriate level of knowledge and skills.	This policy is not relevant to or affected by the Project.
Policy 6 Conservation of the fabric The fabric of the OGNR and its associated features within Dharug National Park will be conserved in accordance with the policies, strategies and actions set out in this Conservation Management Plan.	The Project would not be inconsistent with this policy.
Policy 7 Community management partnerships The community will be involved in, and consulted about, the management of the OGNR cultural landscape.	The Project would not be inconsistent with this policy.
Policy 8 Dharug National Park POM The POM will be reviewed and amended as required following the adoption and endorsement of the CMP.	This policy is not relevant to or affected by the Project.
Policy 9 Compliance with environmental legislation This CMP provides a context for the NPWS's determination of whether proposed works will have a significant effect on the environment (under the EP&A Act 1979). The analysis of both cultural and natural heritage values which it contains provides a basis for the determination, and recommendations for the need for a Review of Environmental Effects (REF) for required works along the road identified in this CMP are included in the precinct management strategies.	The Project would not be inconsistent with this policy. The environmental assessment prepared for the Project may assist in informing future assessments with regard to changes in flooding.

Policy	Consistency of Project with policy
Policy 10 Funding, sponsorship The maintenance and management requirements of the OGNR cultural landscape, as set out in this CMP and further refined in the maintenance plan, should be recognised in a regular, annual budgetary allocation by the NPWS, as well as through the investigation of alternative funding sources including sponsorship, National List funding and World Heritage funding.	This policy is not relevant to or affected by the Project.
Policy 11 Archiving and documentation The documents and archives associated with the history and management of the OGNR landscape will be stored and curated to ensure their long-term conservation and accessibility as a record of the management of the OGNR cultural landscape.	This policy is not relevant to or affected by the Project.
Policy 12 Access and use The terms and conditions of access to, and use of, the OGNR cultural landscape will be based on a policy which is developed with expert heritage advice and community consultation, and which: ▪ is publicly available; ▪ governs NPWS and community alike; ▪ is based on sound data; ▪ is regularly revised, responding to the results of monitoring of condition and impacts carried out as a part of the Strategic Management Approach outlined above.	The Project would not be inconsistent with this policy. The Project would reduce the extent of the PMF event, supporting this policy. However, this reduction in flood extent would not have a material effect with regard to access and use.
Policy 13 Natural heritage The natural heritage values of the Old Great North Road cultural landscape will be conserved and interpreted. Natural heritage values will be managed through vegetation (including weed) control (guided by the Vegetation Management Procedure, Appendix 3), fire management, roadside vista management, and runoff control.	The Project would not be inconsistent with this policy.
Policy 14 New works The aim of this CMP is to minimise the loss of significant cultural fabric. New works will be undertaken in accordance with the specifications prepared by an appropriately qualified heritage specialist where it has been demonstrated (in a structural engineer's report) that the long-term conservation of original fabric depends upon new works. Examples of new work include new culverts, new road surface, run-off control works and so on.	The Project would reduce the extent of the PMF event, supporting this policy. However, this reduction in flood extent would not have a material effect on this World Heritage area.
Policy 15 Design, appearance and installation of new elements The installation of new elements (such as fences, signs, gates, toilets, etc as indicated in the Conservation Policies) within the OGNR cultural landscape will not impact upon significant fabric. The design and appearance of new elements will clearly distinguish them from original fabric, and will contribute to the aesthetic experience of the OGNR cultural landscape.	This policy is not relevant to or affected by the Project.
Policy 16 The Telegraph Line Remains of the Telegraph Line found in many of the precincts will be left in situ and not actively conserved.	The Project would reduce the extent of the PMF event, supporting this policy. However, this reduction in flood extent would not have a material effect with regard to this heritage item. The Project would not be inconsistent with this policy.

Policy	Consistency of Project with policy
Policy 17 Moveable artefacts Moveable artefacts associated with the OGNR will be retained in situ unless a heritage impact assessment or an archaeological assessment determines that their significance is such that they must be removed in order to ensure their long-term conservation. Archaeological relics must only be removed in accordance with the statutory provisions of Section 139 of the Heritage Act, 1977. Removed artefacts must have their significance and conservation needs assessed, and must be stored and curated in order to ensure their long-term conservation and association with the OGNR cultural landscape.	The Project would not be inconsistent with this policy. The Project would reduce the extent of the PMF event, supporting this policy. However, this reduction in flood extent would not have a material effect with regard to moveable artefacts.
Policy 18 Precinct-based management Manage each road precinct in accordance with the strategic management approach, including baseline management, and establish a precinct management cycle in the maintenance plan in accordance with the individual needs of the precinct.	This policy is not relevant to or affected by the Project.
Policy 19 Interpretation The integrated heritage values of the OGNR cultural landscape will be interpreted through creative and innovative methods which provide: ▪ enhanced understanding of the integrated heritage values of the OGNR cultural landscape; ▪ opportunities for access, involvement and educational/cultural experiences for local and regional communities, and national and international visitors; and ▪ for the promotion of cultural tourism experiences for the broader community.	This policy is not relevant to or affected by the Project.
Policy 20 Research, listing and recording Ongoing research into the cultural and natural significance of the OGNR cultural landscape should be supported and promoted.	This policy is not relevant to or affected by the Project.
Policy 21 Plan implementation This CMP will be implemented in accordance with Section 9 Implementation Strategies and Action.	This policy is not relevant to or affected by the Project.
Policy 22 Plan review A public and professional review of the CMP should be undertaken in five years time, ie, in 2010.	This policy is not relevant to or affected by the Project.

Section 1.1 of the Addendum identifies specific policies to support the implementation of the Conservation Management Plan. These are listed in Table 6-9 together with comment on the consistency or otherwise of the Project for each policy.

Table 6-9. Policies for Old Great North Road Conservation Management Plan Addendum

Policy	Consistency of Project with policy
A1 The following maps become the basis for identifying features of the Old Great North Road; these maps should become the basis for all future descriptions of the 'roads' along with the recorded GPS coordinates included in HIMMS. ▪ Devine's Hill to Ten Mile Hollow - 'The Great North Road' Heather Burke 1988 ▪ Devine's Hill – Historical Archaeological Survey of Devine's Hill, The Old Great North Road Wiseman's Ferry, Jillian Comber,1990. ▪ Shepherds Gully Road including Sternbecks Gully Road – Historical Archaeological Survey of Shepherds Gully, The Old Great North Road Wiseman's Ferry, Jillian Comber,1991	This policy is not relevant to or affected by the Project.

Policy		Consistency of Project with policy
	▪ Finch's Line – Archaeological Survey of Finch's Line, The Old Great North Road Wiseman's Ferry, Jillian Comber,1991. ▪ Simpson's Track – Simpson's Track, An Archaeological Assessment and Management Plan, Stedinger Associates 2006 ▪ An Archaeological and Conservation Assessment of the Convict Graffiti and Timber Guardrails, The Old Great North Road, Dharug National Park. Austral Archaeology Pty Ltd - May 2000 ▪ Old Great North Road, Dharug National Park Maintenance Plan, David Young · Neil Urwin · Dr Tracy Ireland March 2007	
A2	All information included on the survey maps will be entered into the DECC Historic Heritage Information Management System and kept up to date as information becomes available or changes.	This policy is not relevant to or affected by the Project.
A3	Develop, report and work with committees established by Commonwealth agencies required under the EP&BC Act for sites of World Heritage value.	This policy is not relevant to or affected by the Project.
A4	Produce a Master Plan, which will identify acceptable activities within the OGNR World heritage area consistent with World Heritage principles and guidelines and which will be consistent with the proposals of the Strategic Management approach identified in the CMP.	This policy is not relevant to or affected by the Project.
A5	A Statement of Heritage Impact for any proposed works or changes will be undertaken by a heritage professional with recognised skills in this area.	This policy is not relevant to or affected by the Project.
A6	In conjunction with any Commonwealth initiative, carry out a study to ascertain the best options for interpretation of the Old Great North Road. The study should include off and on site strategies. Physical on-site strategies should include a Statement of Heritage Impact of the development/signage, defined positions and set design guidelines.	This policy is not relevant to or affected by the Project.
A7	All conservation works will be undertaken in accordance with the CMP and Maintenance Plan developed for this site.	This policy is not relevant to or affected by the Project.
A8	Resources must be provided to enable conservation maintenance to be carried out to protect the OGNR and its World Heritage values.	This policy is not relevant to or affected by the Project.
A9	Upgrading of any of the roads within the curtilage to provide increased access should be assessed prior to any work being carried out to protect the identified values of the site, meet World Heritage obligations and Management Guidelines included in 3.2.1, the EP&BC Act, the CMP (including the Addendum), State and local heritage provisions.	This policy is not relevant to or affected by the Project.
A10	Create and maintain sufficient staff positions for the OGNR so that it can be managed at a level that will ensure that World Heritage values are protected.	This policy is not relevant to or affected by the Project.
A11	Provide training to all staff involved in the management of Old Great North Road in the requirements for managing the site as a World Heritage property.	This policy is not relevant to or affected by the Project.
A12	Maintain records dealing with all actions carried out at Old Great North Road in a central location, to enable annual reporting to researchers, committees and Government agencies as required.	This policy is not relevant to or affected by the Project.
A13	An annual or 6 yearly report is to be produced that meets the EP&BC Act requirements.	This policy is not relevant to or affected by the Project.
A14	Review and where necessary further develop key indicators for protection and management of all aspects of the OGNR in consultation with any existing committees and those established by the Commonwealth under the EP&BC Act.	This policy is not relevant to or affected by the Project.
A15	Use indicators to monitor the values of the OGNR to meet reporting requirements.	This policy is not relevant to or affected by the Project.

Policy	Consistency of Project with policy
A16 Fulfill the Strategic Management Approach included in the CMP within the first reporting period (5 years) allowing for a level of reporting that will enable key indicators to be further developed and used.	This policy is not relevant to or affected by the Project.

Assessment of the Project against section 137 of the EPBC Act with regard to the Old Great North Road is provided in Table 11-1.

7 Assessment of the Project against the 43rd session of the World Heritage Committee

7.1 Decision 43 COM 7B.2

Decision 43 COM 7B.2 adopted by the World Heritage Committee at its 43rd Ordinary Session in 2019 states in full:

The World Heritage Committee,

1. *Having examined Document WHC/19/43.COM/7B.Add,*
2. *Recalling Decision 28 COM 15B.15, adopted at its 28th session (Suzhou 2004),*
3. *Notes with concern that the State Party recognizes that the proposed raising of the Warragamba Dam wall is expected to increase the frequency and extent of temporary inundation of the property upstream of the dam;*
4. *Considers that the inundation of areas within the property resulting from the raising of the dam wall are likely to have an impact on the Outstanding Universal Value (OUV) of the property, recalls Decision **40 COM 7**, in which it considered that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urged States Parties to "ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the OUV", and requests the State Party to ensure, in line with its commitment, that the current process to prepare an Environmental Impact Statement (EIS) for the proposal fully assesses all potential impacts on the OUV of the property and its other values, including Aboriginal cultural heritage, and to submit a copy of the EIS to the World Heritage Centre for review by IUCN, prior to taking any final decisions regarding the project;*
5. *Also notes with concern that several mining projects exist in the vicinity of or adjacent to the property, and that some mining activities have resulted in impacts on the property, as evidenced by the incident at the Clarence Colliery, and also requests the State Party to undertake an assessment of potential cumulative impacts of all existing and planned mining projects in the vicinity of the property through a Strategic Environmental Assessment (SEA) or a similar mechanism;*
6. *Reiterates its position that mineral exploration or exploitation is incompatible with World Heritage status, which is supported by the International Council of Mining and Metals (ICMM) Position Statement to not undertake such activities within World Heritage properties;*
7. *Notes the information provided by the State Party regarding the Western Sydney Airport proposal and further requests the State Party to submit to the World Heritage Centre a copy of the EIS for the anticipated airspace and flight path operations, once available, for review by IUCN;*
8. *Welcomes the development of a Strategic Management Framework for the property as a new integrated management instrument and requests furthermore the State Party to ensure that potential threats to the property from activities outside its boundaries, particularly mining, are fully considered in the development of this management framework and that the EIS required are carried out in conformity with IUCN's World Heritage Advice Note on Environmental Assessment, with a specific section focusing on the potential impact of the project(s) on the property's OUV;*
9. *Finally requests the State Party to submit to the World Heritage Centre, by **1 December 2020**, an updated report on the state of conservation of the property and the implementation of the above, for examination by the World Heritage Committee at its 45th session in 2021.*

7.2 Discussion

Comments with regard to Items 2 to 9 inclusive are provided as follows.

7.2.1 Item 2

Decision 28 COM 15B.15 states:

1. *Acknowledges receipt of the State Party's report with clarifications on the status of the proposed sand and clay mine adjacent to the World Heritage property of the Greater Blue Mountains Area;*
2. *Encourages the State Party to prevent any developments that could have adverse effects on the World Heritage property;*

3. *Requests that the State Party keep the World Heritage Centre and IUCN informed on the status of the proposed sand and clay mine adjacent to the Greater Blue Mountains Area and the proposed measures to avoid any potential impact it may have on the World Heritage property.*

Items 1 and 3 are considered a separate matter to the Project.

With regard to Item 2, a comprehensive environmental assessment has been carried out with regard to the potential impacts of the Project on the OUV of the GBMWHA, and which is documented through this report. The assessment has had regard to the IUCN's *World Heritage Advice Note on Environmental Assessment* (refer Section 8).

7.2.2 Item 3

The analysis of potential changes to flooding and hydrology upstream of Warragamba Dam identified that the creation and operation of the FMZ would result in additional temporary inundation and an increase in the duration of inundation.

With regard to the upstream study area (including the upstream impact area):

- Increases in the depth of temporary inundation with the Project would be half a metre or less up the tributaries and up to about eight metres in locations around the perimeter of Lake Burragorang
- The increase in the duration of temporary inundation for the Wollondilly River ranges from less than half a day to 3.2 days within the channelised section of the river and then up to about eight days where it meets Lake Burragorang; this would affect a small area of the GBMWHA along the eastern bank of the Wollondilly River
- The increase in the duration of temporary inundation for the Nattai River is about eight days at the confluence with the Little River and then drops off rapidly moving upstream to less than half a day; this would affect a small area of the GBMWHA adjacent to the Nattai River
- The increase in the duration of temporary inundation for the Kowmung River would be less than half a day up to the 1 in 20 chance in a year event and about 1-2 days for larger events (≥1 in 100 chance in a year)
- The increase in the duration of temporary inundation for the Coxs River would be less than half a day; this would not would affect the GBMWHA.

There is an increasing influence of the Project moving downstream with the increase in temporary depth and duration of temporary inundation with locations within Lake Burragorang generally reflecting the pattern of changes in depth and duration of temporary inundation for the same flood events at the dam wall (refer Section 4.2.2 for specific details).

7.2.3 Item 4

Item 17 under Decision 40 COM 7 states:

17. *Notes with significant concern that an increasing number of properties are facing potential threats from major dam projects, considers that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urges States Parties to ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the Outstanding Universal Value (OUV)*

A comprehensive assessment of the potential impacts of the Project has been carried out through preparation of the EIS for the Project. The assessment documented in this report draws extensively upon the various technical investigations carried out for the EIS.

It should be noted that a key distinction between the Project and the type of dam projects noted in Item 17 is that the Project is solely for the temporary storage of floodwaters and would not involve any permanent change to the FSL of Lake Burragorang.

There is already an existing risk of temporary inundation within the upstream impact area within the GBMWHA, and which pre-dates the inscription of the GBMWHA on to the World Heritage List.

7.2.4 Item 5

This is considered a separate matter to the Project, however, a cumulative impact assessment has been carried out for the Project (refer Chapter 29 of the EIS).

7.2.5 Item 6

This is considered a separate matter to the Project.

7.2.6 Item 7

This is considered a separate matter to the Project.

7.2.7 Item 8

Development of a Strategic Management Framework for the GBMWHA is considered a separate matter to the Project, however, it is recognised that the mitigation and management measures developed for the Project with respect to potential impacts on World Heritage values would need to align with the Strategic Management Framework.

Consideration of the potential impacts of the Project with regard to the IUCN's *World Heritage Advice Note on Environmental Assessment* is provided in Section 8.

7.2.8 Item 9

The final EIS including this report will be provided to DAWE to assist the Australian Government in responding to this request.

8 Assessment of the Project against IUCN Advice Note: Environmental Assessment

The following table provides comment on how the assessment has been carried out with regard to the eight World Heritage impact assessment principles in the IUCN Advice Note: Environmental Assessment.

Table 8-1. Assessment against World Heritage impact assessment principles

Principle	Response
1. All proposals that may adversely affect a natural World Heritage Site must undergo a rigorous Environmental Assessment early on in the decision-making process, whether they are located within or outside its boundaries.	The Project was identified as potentially impacting two World Heritage Areas and is subject to assessment under the NSW EP&A Act and the Commonwealth EPBC Act which require a comprehensive assessment to be carried out. The assessment has considered sources of potential impacts both within and outside of the affected World Heritage areas.
2. Experts with World Heritage, protected area and biodiversity knowledge must be closely involved in the assessment process in order to identify the issues that will need to be assessed.	The assessment has been carried out by an experienced multi-disciplinary team comprising specialists in ecology, heritage, and various other technical areas.
3. The likely environmental and social impacts of the development proposal on the site's Outstanding Universal Value must be assessed, including direct, indirect and cumulative effects.	Potential impacts, both direct and indirect, have been assessed against the Outstanding Universal Value for the GBMWHA and this is documented in Sections 6-11 inclusive. Cumulative impacts are assessed in Section 13.5 of this report.
4. Reasonable alternatives to the proposal must be identified and assessed with the aim of recommending the most sustainable option to decision-makers.	Chapter 4 of the EIS (Project Development and Alternatives) provides a comprehensive and detailed discussion of the development of options for the Project, the evaluation criteria and methodology, and the selection of the preferred option.
5. Mitigation measures should be identified in line with the mitigation hierarchy, which requires first avoiding potential negative impacts and secondly reducing unavoidable residual impacts through mitigation measures.	Mitigation measures are listed in Section 13 of this report. Potential impacts have been avoided as far as practicable, and where this has been unavoidable, mitigation measures have been identified to manage residual impacts.
6. A separate chapter on World Heritage must be included in the Environmental Assessment.	This report is intended to satisfy this requirement and forms an appendix to the EIS.
7. The assessment must be publicly disclosed and subject to thorough public consultation at different stages.	The full EIS including this report will be placed on public display in accordance with the requirements of the NSW EP&A Act. This will provide further opportunity for comment on the assessment. A detailed summary regarding consultation for the Project is provided in Chapter 6 of the EIS (Consultation).
8. An Environmental Management Plan must be proposed, implemented and independently audited.	An EMP would be prepared and implemented for the construction phase. While the construction area is outside the GBMWHA, the EMP would be required to address impacts that could potentially impact upon the GBMWHA.

Principle	Response
	Operational activities potentially affecting the GBMWHA would be mitigated and managed through an offset strategy as outlined Section 13.2. Under section 64C(1) of the *Water NSW Act 2014*, WaterNSW is requited to prepare an environmental management plan for temporary inundation of national park land resulting from the Warragamba Dam project (refer Section 13.3). This would complement and support management of potential operational impacts.

9 Assessment of the Project against the Strategic Plan

With World Heritage listing, the Australian Government is required to ensure the identification, protection, conservation, rehabilitation, and presentation of the GBMWHA and its preservation for future generations. However, day-to-day management of the GBMWHA is the responsibility of the Environment, Energy and Science Group (EES, which is part of DPIE) and the NPWS. In early 2001 a committee of senior agency officials (the GBMWHA Establishment Project Steering Committee) was established to develop strategic policy directions for the GBMWHA including preparing a Strategic Plan for the GBMWHA. The Strategic Plan was released in 2009 and updated in 2016 with an addendum.

There are a number of sections in the Strategic Plan which are relevant to the Project including:

- World Heritage management obligations – these are the management requirements the Australian Government must achieve to maintain World Heritage listing. There are six obligations some of which are relevant to the Project.
- World Heritage values – The GBMWHA was listed based upon on two key values, namely unique and natural eucalypt dominated ecosystems, and the significant of biodiversity exhibited within the World Heritage area. The integrity statement accompanying the World Heritage listing also identifies Aboriginal cultural heritage as a key value
- Other values – The Strategic Plan also identifies other values of the World Heritage area which contribute to its overall value and could potentially be additional values for listing considered by the World Heritage Committee in the future. There are 10 additional values, with many of these having a subset of specific values.
- Threats – The Strategic Plan nominates six key threats to the World Heritage area, of which some of are relevant to the Project
- Management responses – The Strategic Plan contains 59 management responses across 10 aspects. Many of these manage objectives have relevance to the Project.

The potential impacts of the Project have been assessed against the all of the relevant sections of the Strategic Plan.

9.1 World Heritage management obligations

Under Article 5 of the World Heritage Convention, signatories are required to meet six management obligations to protect designated world heritage areas including the GBMWHA. While the Project and WaterNSW are not directly responsible for meeting the management obligations as they are not signatories, their actions and impacts may affect the ability of the signatories to meet the management obligations. An assessment of the Project against the six management objectives is presented in Table 9-1.

Table 9-1. Assessment of project against World Heritage Convention management objectives

Management objective	Response
Ensure that effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage situated on its territory, each signatory to this Convention should endeavour insofar as possible and as appropriate for each country.	Mitigation measures for biodiversity, heritage and other environmental aspects are proposed for the protection, conservation and presentation of the cultural and natural heritage of the GBMWHA. These include: ▪ Warragamba Offset Program ▪ National Parks EMP ▪ Other mitigation measures as detailed in the EIS. The Minister (or their delegate) would have approval and input into all mitigation measures to ensure that any risks from the Project to the GBMWHA are appropriately addressed and are consistent with this management obligation.
Adopt a general policy which aims to give the cultural and natural heritage a function in the life of the community and to integrate the protection of the heritage into comprehensive planning programs.	Mitigation measures for biodiversity, heritage and other environmental aspects would be integrated into or complement any relevant comprehensive planning programs for the GBMWHA and other MNES. This would also include consultation with relevant stakeholders with a responsibility for any planning programs to ensure that mitigation measures are consistent with World Heritage management obligations.

Management objective	Response
Set up within its territories, where such services do not exist, one or more services for the protection, conservation and presentation of the cultural and natural heritage with an appropriate staff and possessing the means to discharge their functions.	The GBMWHA Advisory and Management Committees and Government departments and agencies such as DAWE, DPIE, EES and NPWS provide services for the protection, conservation, and presentation of the cultural and natural heritage. The GBMWHA Advisory and Management Committees, DAWE, DPIE, EES and NPWS have been consulted and informed during the preparation of the EIS and would be able to provide formal comments during the exhibition of the EIS. Approval under the EP&A Act and EPBC Act would be required for the Project to proceed. The GBMWHA Advisory and Management Committees, NPWS, EES, DAWE and DPIE would be consulted in the development and implementation of mitigation measures in relation to values of the GBMWHA. The interaction of the Project with these services in the development and assessment phases and potentially the development and implementation of mitigation measures, if the Project is approved, is consistent with this management obligation.
Develop scientific and technical studies and research and to work out such operating methods as will make the signatory capable of counteracting the dangers that threaten its cultural or natural heritage.	The scientific and technical studies and research undertaken for the Project contribute significantly to the knowledge of the GBMWHA and would be provided to Advisory Committee and NPWS to assist in the management of the GBMWHA. The EIS provides a comprehensive assessment of the potential dangers of the project and details mitigation measures that counteract threats to cultural and natural heritage of the GBMWHA. The scientific and technical studies undertaken to support the EIS and the proposed additional studies are consistent with this management obligation.
Take appropriate legal, scientific, technical, administrative and financial measures to ensure the identification, protection, conservation, presentation and rehabilitation of this heritage.	The studies undertaken for the Project contribute to the identification of the heritage and other values of the GBHWHA. Mitigation measures for biodiversity, heritage and other environmental aspects have been developed to ensure the protection, conservation, presentation and rehabilitation of the heritage of the GBMWHA. This includes: ▪ Warragamba Offset Program ▪ National Parks EMP ▪ Other mitigation measures as detailed in the EIS. DAWE (and other NSW government agencies with responsibility for regulation and management of matters concerning the GBMWHA) have been consulted during the preparation of the EIS. The Project and EIS have been developed in compliance with relevant Australian and NSW guidelines, policies and legislation. The requirement for the Project to obtain approval from both the NSW Minister for Planning and Australian Government Minister for the Environment provides the opportunity for both levels of Government to impose approval conditions which detail appropriate legal, scientific, technical, administrative and financial measures to ensure the identification, protection, conservation, presentation and rehabilitation of GBMWHA
Foster the establishment or development of national and regional centres for training in the protection, conservation and presentation of the cultural and natural heritage and to encourage scientific research in this field.	This obligation is beyond the scope of the Project and is a NSW and Australian Government responsibility. The Project would not affect either level of Government's ability to implement this management obligation.

9.2 World Heritage values of the GBMWHA

World Heritage values are those values directly related to the criteria for which an area is included on the World Heritage List. The GBMWHA was inscribed on the World Heritage List in 2000 because it satisfies two of the criteria for natural values of outstanding universal significance. The values related to the within the GBMWHA. The Outstanding

Universal Values integrity statement also nominates a third value, being Aboriginal cultural heritage. The impacts of the Project are assessed against these three values in Section 7.

9.3 Other values of the GBMWHA

Apart from those particular features which have been recognised by the World Heritage Committee as having World Heritage value, the GBMWHA has numerous other important values which complement and interact with its World Heritage values. Some of these may have the potential to be nominated for World Heritage listing following further research and documentation. Protection of these values is an integral component of managing individual reserves as well as the GBMWHA as a whole. These other values are:

- geodiversity and biodiversity
- water catchment
- indigenous values
- historic values
- recreations and tourism
- wilderness
- social and economic
- research and education
- scenic and aesthetic
- bequest, inspiration, spirituality and existence.

Table 9-2. Assessment of the potential impact of the Project on other unlisted values of the GBMWHA identified in the Strategic Plan

Other values identified	Potential impact of the Project
Geodiversity and biodiversity A number of important natural values were documented during the process of preparing plans of management for individual reserves and during the preparation of background reports for the World Heritage nomination. In particular, the GBMWHA incorporates the largest integrated system of protected areas in NSW, representing outstanding opportunities for the conservation of natural communities and processes.	
Extensive dissected sandstone plateaux representing ongoing geological processes.	The Project would not have any impacts on the geology of the dissected sandstone plateaux.
The most extensive sandstone canyon system in eastern Australia.	The Project may result in the temporary inundation of increased areas of sandstone canyons along waterways. However, this would not affect significant areas of sandstone canyons and any impacts would be temporary and negligible.
A significant geological boundary between the Lachlan Fold Belt and the Sydney Basin as evidenced by the diversity of geology and topography in Kanangra-Boyd National Park and the Jenolan Karst Conservation Reserve.	The Project would not impact on the significant geological boundary between the Lachlan Fold Belt and the Sydney Basin.
Karst landscapes with several cave systems of importance for their antiquity, scientific, and recreational values (for example, Jenolan Caves being the world's oldest open cave system).	The Project would not impact on karst landscapes or known caves. The Jenolan Karst Conservation Reserve is located about 18 kilometres to the west of the upstream study area.
A number of palaeontological (for example, fossil) sites including evidence of the once widespread Gondwanan flora.	No known palaeontological sites would be impacted by Project.
Prominent basalt-capped peaks and other significant features associated with periods of volcanic activity.	The Project would not impact on basalt-capped peaks and other significant features associated with volcanic activity
Quaternary alluvial deposits which support significant heath and woodland vegetation with an unusual mix of species and plant communities.	The Project would result in the temporary inundation of increased areas of Quaternary deposits which support significant woodland vegetation with an unusual mix of species and plant communities. Some of the areas are within the GBMWHA.
A series of 'perched' perennial freshwater lakes (in Thirlmere Lakes National Park) of considerable geomorphological and	Thirlmere Lakes National Park is located to the east of Nattai National Park about 8 kilometres south-east of the study area.

Other values identified	Potential impact of the Project
biological significance because of their great age and geomorphic stability.	The Project would not impact upon 'perched' perennial freshwater lakes in Thirlmere Lakes National Park.
Water catchment As most of the GBMWHA lies in the steep and rugged landscape behind the coastal plains, it experiences relatively high rainfall and is the source of several major river systems. The area includes a number of wild rivers which have been identified within plans of management for further investigation and declaration under the *National Parks and Wildlife Act 1974*. While the Kowmung River within Kanangra-Boyd National Park was declared a wild river in July 2005, parts of the Colo River in Wollemi National Park and the Grose River in Blue Mountains National Park, are also likely to be declared as wild rivers during the term of this Plan.	
The GBMWHA protects a large number of pristine and relatively undisturbed catchment areas, some of which make a substantial contribution to maintaining high water quality in a series of water storage reservoirs supplying Sydney and adjacent rural areas. They also make an important contribution to the maintenance of water quality and natural flow regimes in the Hawkesbury-Nepean and Goulburn Hunter river systems. The GBMWHA also forms part of the upper catchment of the Lachlan and Macquarie Rivers.	The Project would not have a significant impact on water quality in Warragamba Dam or other parts of the Hawkesbury-Nepean River. Mitigation measures such as the Warragamba Offset Program and EMP would also ensure that any impacts from the Project on the water catchment would be mitigated.
Indigenous values The GBMWHA encompasses the traditional Country of at least six different Aboriginal language groups including several associated with the earliest contact with European settlers in Australia. Although no comprehensive surveys have been undertaken, a widespread and diverse sample of Aboriginal sites has been recorded, preserving a vital record of the social interactions and artistic activities within as well as between these different language groups.	
Known sites provide evidence of at least 14,000 (and possibly 22,000) years of Aboriginal occupation of the area, but traditional beliefs connect Aboriginal people with the landscape back as far as the creation stories. Several prominent landscape features with spiritual significance are linked with creation stories, for example Mt Yengo in Yengo National Park and the Coxs and Wollondilly River valleys (Blue Mountains National Park). Recorded sites of archaeological significance include a widespread sample of the Sydney Region's distinctive Aboriginal rock art, which incorporates two synchronous forms (that is, pigment and engraved forms) on a scale unique in Australia. A number of scientifically important rock art sites with an unusually large number of individual motifs have been recorded within the GBMWHA and continue to be revealed, such as the Eagles Reach site. Given the wilderness nature of the area and the limited archaeological surveys to date, there is enormous potential for uncovering further significant sites which will contribute to a better understanding of Aboriginal use of the area over many millennia. The area is important to contemporary Aboriginal groups. Formal co-management arrangements with those groups is underway (see sections Native Title, p.19 and Key Issue – Cultural heritage values, p.32).	Impacts on Aboriginal cultural and archaeological heritage sites are discussed in Section 6.1.8. An Aboriginal Cultural Heritage Assessment (ACHA) report (Appendix K to the EIS) has been prepared in consultation with Aboriginal organisations and individuals with a cultural connection to the impacted areas. The Project may result in impacts to Aboriginal cultural and archaeological heritage sites from temporary inundation. The Project could potentially affect up to 43 sites in the upstream impact area within the GBMWHA, noting that the majority of these sites are already subject to inundation from the existing dam. Of these 43 sites, 28 have been identified as potentially experiencing a total loss of value. These sites are located between the FSL and the upper extent (RL 126.97 mAHD) of the upstream impact area. The ACHA report has also recommended mitigation measures to minimise impacts to Aboriginal cultural heritage from the Project.
Historic values The GBMWHA includes numerous places of historic significance, some dating back to the earliest years of European settlement and exploration in Australia. Many locations within the GBMWHA are recorded in the journals of the earliest explorers and surveyors. Recorded sites demonstrating post-1788 human use are associated with:	
Rural settlement, pastoral use and timber getting, for example Euroka and Burralow Creek (Blue Mountains NP), a number of small graziers' huts in Wollemi National Park and cedar logging roads and stock routes in Kanangra-Boyd National Park.	The specific heritage items identified are not within the area impacted by the Project. No listed heritage items in the GBMWHA would be impacted by Project. Some areas which have a history of rural use and contain ruins of rural properties are situated along the Wollondilly River and may be temporarily inundated in extreme flood events. However, these areas would generally

Other values identified	Potential impact of the Project
	be temporary inundated with the existing dam and are unlikely to experience significant impacts given the low frequency and duration of flooding.
Mining, for example the ruins of oil shale mines at Newnes and Baerami (Wollemi NP), lead/silver/gold mines at Yerranderie (Blue Mountains NP) and coal/shale mines in the Jamison and Grose Valleys (Blue Mountains NP).	The specific heritage items identified are not within the area impacted by the Project. No listed heritage items in the GBMWHA would be impacted by project.
Road and rail transport routes, for example parts of the Old Great North Road and the Putty Road/Old Bulga Road (Yengo NP) which linked Sydney with the earliest settlements in the Hunter Valley and remnants of a mid-19th century pumping station (Thirlmere Lakes NP) which supplied water for steam engines on the main southern railway line.	The specific heritage items identified are not within the area impacted by the Project. No listed heritage items in the GBMWHA would be impacted by Project.
Tourism and recreation; for example Jenolan Caves was one of the first tourist attractions in Australia, with visitation dating back to the early 1800s, and the Reserve contains numerous historic relics related to tourism and the village's infrastructure; many lookouts and walking tracks on the central Blue Mountains ridgeline (including Blue Mountains NP) have been in continuous use since the late 19th century.	The specific heritage items identified are not within the area impacted by the project. No listed heritage items in the GBMWHA would be impacted by Project. While some walking tracks may be impacted, historic walking tracks along ridgelines would not be impacted by the Project.
Recreation and tourism Most of the reserves in the GBMWHA are located along the Great Escarpment behind the coastal plains. Because of their intrinsic beauty, natural features and accessibility from the major population centres, the GBMWHA has high recreational values. The GBMWHA provides settings for recreation and tourism that are outstanding and increasingly rare by world standards, on the doorstep of Australia's major city.	
All areas of the GBMWHA potentially impacted by the Project are also within the Schedule 1 Special Areas of the Warragamba Dam catchment. Access to Schedule 1 Special Areas of the Warragamba Dam catchment for recreation and other activities is not permitted. This is to protect the catchment and water quality of Lake Burragorang. The section of the Nattai River outside the Schedule 1 Special Areas of the Warragamba Dam catchment in GBMWHA which is also potentially impacted by the Project contains a NWPS/fire trial which could potentially be used by bush walkers. About 450 metres of this trail would be impacted by the Project during a PMF event but would not be impacted by smaller flood events. Given the low probability of this section of fire trail to be impacted and that it would be unlikely that bush walkers would be using the track during and after a PMF event, the impacts of the Project on recreational use and assets of the GBMWHA would be negligible.	
Wilderness The GBMWHA contains some of the largest forested wilderness areas in eastern mainland Australia, including the largest declared wilderness (Wollemi Wilderness at 361,113 hectares). Extensive natural areas have the capacity to protect and conserve a greater diversity of habitats in better health than smaller or more modified areas. Wilderness often represents the only opportunity to maintain the integrity, gradients and mosaics of ecological processes that constitute native biodiversity at the genetic, species, community and landscape levels. Wilderness also has many cultural values, providing not only opportunities for solitude and self-reliant recreation, but also aesthetic, spiritual and intrinsic value. With no roads, except for management trails and largely free of exotic species, they are rare examples of the indigenous Australian landscape. Protection of wilderness was one of the main reasons for the establishment of many of the national parks within the GBMWHA.	
Formal recognition of wilderness through the provisions of the NSW *Wilderness Act 1987* has been given to over 551,000 hectares of wilderness areas in the GBMWHA, in the Blue Mountains, Kanangra-Boyd, Nattai and Wollemi National Parks. Another area of 139,900 hectares in the Yengo National Park has been identified as wilderness and a proposed wilderness declaration of 120,300 hectares has been exhibited for community input. Management of these areas aims to preserve their capacity to evolve in the absence of significant human interference. It is therefore linked closely to the World Heritage natural criterion (ii). The wilderness condition and integrity of many of the key areas in the GBMWHA were greatly influential in the success of its nomination for World Heritage listing.	The Project would potentially result in increased temporary inundation of declared wilderness areas in the part of the upstream impact area within GBMWHA. The potential impacts of the Project on declared wilderness areas in the GBMWHA are assessed in Section 6.1.7.

Other values identified	Potential impact of the Project
Social and economic The regional economy surrounding the GBMWHA is increasingly supported by specialist tourism. The reserves within the GBMWHA have considerable social and economic value and contribute directly and indirectly to the employment, income, and output of the regional economy. Although visitation to specific locations may be static or declining, overall visitation to the GBMWHA is increasing, reflecting the region's increasing importance as a tourist destination for day trips and longer stays.	
Because most of the reserves only offer basic camping facilities, many visitors stay at nearby towns or guesthouses. It has been estimated that, for every 10,000 visitors to regional national parks, between four and six jobs are created in the local area. The Jenolan Karst Conservation Reserve generated $6.5 million in tourism revenue in 2006 and Jenolan Caves House provide an important source of additional employment in the otherwise rural local area.	The Project would not have an impact on tourism in the GBMWHA as only a small area of the GBMWHA would be impacted. The areas that would be subject to increased temporary inundation due to the Project are within the Special Areas of the Lake Burragorang, and recreational and public access to these areas is very limited.
Research and education The variety of ecological communities and landscapes and associated cultural sites makes the GBMWHA ideal for research and educational visits.	
Information arising from the scientific research conducted to date in the GBMWHA supported the World Heritage nomination. In fact, the current state of knowledge about the GBMWHA's World Heritage values is directly related to the levels of research undertaken. This information however is far from comprehensive, highlighting the need for further research in the GBMWHA. The high scientific value of the GBMWHA therefore reflects not only what has been discovered, but also what remains to be discovered. Large gaps in knowledge remain, especially regarding Aboriginal use and occupation of the area and the ecological needs of threatened species and communities. As some communities and species are found only in the GBMWHA, it is inevitable that there will be ongoing scientific interest in the GBMWHA. As effective management will rely increasingly on future research work to understand the GBMWHA's complex natural systems and their significance, this interest should be fostered. Facilitating increased levels of scientific research is directly related to the obligations under the World Heritage Convention to encourage scientific research into the identification, conservation, and rehabilitation of the GBMWHA's World Heritage values, as well as fostering best management practice and abatement of threatening processes.	The technical studies undertaken for the project would contribute to the scientific knowledge of the GBMWHA – especially in relation to biodiversity and cultural heritage.

Other values identified	Potential impact of the Project
Scenic and aesthetic The GBMWHA includes some of the most dramatic scenery in Australia, with its best-known landscapes dominated by striking vertical cliffs and waterfalls. With many vantage points on ridges and escarpments, the GBMWHA offers outstanding vistas, from uninterrupted views of forested wilderness covered by natural vegetation to the contrasts of steep forested slopes surrounding cleared valleys. The Jenolan Karst Conservation Reserve provides a different but still dramatic scenic landscape, and the outstanding aesthetic values associated with its extensive caves have attracted a large number of visitors since the early days of tourist activity. In more recent times, the spectacular complex of narrow sandstone canyons and pagoda rock formations found largely in Wollemi and Gardens of Stone National Parks have become more widely known and appreciated. The area's scenic and aesthetic values are demonstrated in a variety of ways, for example:	
By the large body of contemporary art (visual, performance and written) and photography inspired by the landscape.	The possible loss or change in vegetation would result in moderate visual impacts around the fringe of the existing reservoir and to a lesser extent in the tributaries. However, it would be similar to the existing visual impacts caused by the impacts of the operation of the dam and its FSL. Visual impacts would not be visible from key lookouts such as Echo Point.
The significant levels of visitation to scenic vantage points within the GBMWHA and its increasing popularity as a scenic backdrop for weddings (including those of international tourists).	
The diverse scenic landscapes and natural features of the GMBWHA have been the subject of photographers for a period of more than a century and they feature prominently in Australian wilderness, wildlife, and natural history books.	
The increasing visitation to a number of well-known and publicly accessible indigenous rock art sites.	The area potentially affected by the Project is located entirely with the Schedule 1 Warragamba Special Area (refer Section 6.1.4.2). Public access is not permitted to this area. As such, no publicly accessible indigenous rock art sites would be impacted by the Project.
Bequest, inspiration, spirituality, and existence One of the goals of world heritage management is to ensure that future generations can experience and appreciate the uniqueness of these areas. This goal explicitly recognises an area's bequest values and the importance of Aboriginal cultural continuity.	
The wild and rugged landscapes, diverse flora and fauna, and opportunities for solitude and quiet reflection are attributes that promote inspiration, serenity and rejuvenation of the human mind and spirit. Such feelings are valued by individuals and society, and lead to contributions in the fields of philosophy, painting, literature, music, and photography. The GBMWHA has inspired such contributions and these have promoted a sense of place for all Australians who then want such places protected. Existence values derive from the community's pleasure from simply knowing that places such as the GBMWHA exist and are protected, even though they may never visit them.	The Warragamba Offset Program provides for the identification of suitable offsets that would ensure that the GBMWHA would continue to provide inspiration and rejuvenation as well as preserving the area for future generations.

9.4 Threats

The Strategic Plan (DECC 2009) notes the GBMWHA faces a range of threats to its immediate and long-term integrity. with these varying greatly in scale from localised incompatible land use on adjoining land (for example, agriculture and mining) through to much larger scale disturbances such as global climate change. The management measures from the Strategic Plan primarily address those threats that are of strategic importance to the overall integrity of the GBMWHA's World Heritage values.

The operation and impacts of the Project have been assessed against potential threats in Table 9-3 to identify if the Project increases the risks or impacts of identified threats.

Table 9-3. Threats identified in the GBMWHA Strategic Plan and potential impacts of the Project

Threat	Response
Uncontrolled or inappropriate use of fire.	The Project would not result in any increased threat of uncontrolled or inappropriate use of fire.
Inappropriate recreation and tourism activities, including the development of tourism infrastructure, under the increasing visitor pressure from Australian, overseas, and commercial ventures.	The Project would not result in any inappropriate recreation and tourism activities.
Invasion by pest species including weeds and feral animals.	The Project may result in increased invasion of weeds and feral species due to loss or change in soil and vegetation in the areas experiencing increased extent, frequency, and duration of temporary inundation. Specific mitigation measures have been proposed to mitigate any weed and feral animal impacts including the EMP.
Loss of biodiversity and geodiversity at all levels.	The Project would not impact upon geodiversity (refer Table 9-2), however, it may have impacts on flora and fauna within the World Heritage area. This would be offset where possible and other mitigation measures are proposed to minimise impacts with the Warragamba Offset Program. While there may be loss of some biodiversity, this would not significantly impact the GBMWHA as a whole.
Impacts of human enhanced climate change.	The Project would not result in increased impacts of human enhanced climate change.
Lack of understanding of heritage values.	The Project would result in increased understanding of heritage values through the studies undertaken for the EIS. An assessment of the Project's impact on Aboriginal heritage values is presented in Section ? and in the Aboriginal and Non-Aboriginal Heritage reports

9.5 Key management issues and desired outcomes

The Strategic Plan identifies the following 10 key management issues for the GBMWHA as follows:

- integrity
- major impacts
- biodiversity
- geodiversity
- water catchment protection
- cultural heritage
- landscape, natural beauty and aesthetic values
- recreation and visitor use
- social and economic issues
- education, community participation, and consultation.

For each of these key management issues there is an associated primary objective and detailed desired outcomes, accompanied by a suite of management measures to achieve the primary objective and desired outcomes.

The primary objectives and desired outcomes are described in the following sections with individual management measures considered in the context of the Project.

9.5.1 Integrity

The primary objective and desired outcomes for this key management issue are presented as follows. The context of the Project in relation to management measures for this issue is assessed in Table 9-4. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To maintain, and wherever possible, improve the current and future integrity of the GBMWHA.

Desired outcomes

- Areas of potential outstanding universal value or that improve the integrity of the GBMWHA are evaluated as additions to the GBMWHA
- The location and extent of World Heritage values within the GBMWHA is comprehensively documented.
- Knowledge of World Heritage and other values of the GBMWHA is improved through research
- Biodiversity policies and programs including on-the-ground conservation activities are consistent with the strategies and actions outlined in the National Biodiversity and Climate Change Action Plan 2004 – 2007
- Local communities support any proposed additions to the GBMWHA
- Policy formulation and planning for the GBMWHA is undertaken strategically, considering the implications for the entire GBMWHA
- All the GBMWHA reserves are covered by World Heritage-relevant statutory plans of management and, where necessary, operational plans such as fire, introduced species, catchment action and visitation management plans
- Effective inter-governmental and inter-agency administrative arrangements are in place to ensure the cooperative, coordinated and consistent management of the GBMWHA
- Adjoining land uses are compatible with the conservation and presentation of World Heritage values
- Wilderness and wild rivers are formally identified, declared and protected.

Summary

The majority of the desired outcomes with regard to integrity are considered to be of limited direct relevance to the Project, however, it is also considered that the Project would not be inconsistent with any of these, and would directly support achievement of a number of them such as facilitating effective inter-governmental and inter-agency coordination of management of the GBMWHA.

Table 9-4. Assessment of Project against management measures for integrity

Management measure	Response
1.1 Ensure that statutory plans of management of all GBMWHA reserves are reviewed and amended to specifically address World Heritage objectives and meet the requirements of the Australian World Heritage management principles and this Strategic Plan and that they contain provisions for evaluating and monitoring their effectiveness.	This management measure is not directly relevant or affected by the Project. However, an EMP is required under the *Water NSW Act 2014* for the temporary inundation of National Parks and State Conservation Areas, which include areas of the GBMWHA. This would include addressing World Heritage objectives and meeting the requirements of the Australian World Heritage management principles and the Strategic Plan and would contain provisions for evaluating and monitoring the EMPs effectiveness.
1.2 Assess existing reserved areas not within the GBMWHA for potential addition to the GBMWHA and seek the addition of suitable qualifying areas to the GBMWHA.	The Warragamba Offset Program would include the potential purchase of land which may be suitable for inclusion in National Parks, and subsequently the GBMWHA.
1.3 Acquire high conservation value and/or strategically located freehold land within or adjacent to the GBMWHA, on a voluntary acquisition basis.	The Warragamba Offset Program would include the potential purchase of high conservation value and/or strategically located freehold land within or adjacent to the GBMWHA which may be suitable for inclusion in National Parks, and subsequently the GBMWHA.
1.4 Support and encourage appropriate “off-park” conservation programs and, where appropriate, negotiate Voluntary Conservation Agreements with adjacent landholders.	The Warragamba Offset Program may include ‘off-park’ conservation programs which are supplementary measures allowed under NSW and Commonwealth offsetting policies.
1.5 Investigate and pursue the establishment of a Greater Blue Mountains Biosphere Reserve which encourages the compatible management of lands adjoining the World Heritage Area.	The Project would not be inconsistent with this management measure, however, responsibility for this management measure does not rest with WaterNSW.

Management measure	Response
1.6 Provide ongoing and proactive input to the establishment and implementation of effective local government planning and land management controls for land adjacent to the GBMWHA.	The National Parks EMP required under the *Water NSW Act 2014* would support this management measure with regard to land covered by the EMP outside of the GBMWHA.
1.7 Establish a system for formal auditing and reporting on the state of the GBMWHA's World Heritage values based on systematic monitoring of the impact of threatening processes (including environmental changes partly or largely attributable to global climate change).	Responsibility for this management measure does not sit with WaterNSW. However, the Warragamba Offset Program would support existing NPWS management activities relating to the GBMWHA, and associated monitoring and reporting activities carried out by NPWS.
1.8 Maintain and enhance the wilderness and wild river quality and values of the GBMWHA through formal declaration and appropriate management programs (see also Key Issues — Biodiversity).	This management measure would not be materially affected by the Project. GIS analysis using spatial data sourced from NSW Spatial Services identified a small section of the Kowmung River (about 1,250 metres) within the Project study area but above the upstream impact area (refer Figure 6-6). An analysis of depth-duration curves for the closest cross section downstream of the declared wild river catchment showed no material difference between the existing situation and with the Project for all flood events up to the 1 in 100 chance in a year event and a very small difference (less than 0.3 metres) up to the 1 in 1,000 chance in a year event. In real world terms, the Project would not impact on the declared wild river section of the Kowmung River. There are no other designated wild rivers in the part of the GBMWHA potentially affected by the Project. The National Parks EMP would also support this management measure.
1.9 Collaborate with the Blue Mountains World Heritage Institute and the GBMWHA Advisory Committee to identify gaps in existing databases of both indigenous and scientific "provide strategic directions for both proactive management and rehabilitation of threatening processes" knowledge, and develop and implement appropriate research programs which will assist in management of the GBMWHA, maintenance of its integrity and in identifying National and additional World Heritage values (see also Key Issues — Major Impacts, Biodiversity, Geodiversity, Water catchment protection and Cultural heritage).	The Warragamba Offset Program, National Parks EMP and other relevant monitoring and management programs would be developed and implemented in consultation with Blue Mountains World Heritage Institute and the GBMWHA Advisory Committee, where appropriate.

9.5.2 Major impacts

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9-5. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To reduce the potential for major impacts to adversely affect the integrity of the GBMWHA.

Desired outcomes

- Local, regional, and state-wide planning instruments and catchment blueprints for areas adjacent to the GBMWHA adequately address the need for protection of the GBMWHA's World Heritage values
- Effective inter-governmental and interagency administrative arrangements are in place to ensure the cooperative, coordinated, and consistent processing of development proposals which may adversely impact the GBMWHA

- Developments and activities with an unknown but potentially significant impact on the World Heritage and other values of the GBMWHA are either modified to minimise the risk of impact on those values or do not proceed
- The impacts of surrounding land use on World Heritage values are better understood and monitored.

Summary

In terms of the desired outcomes regarding major impacts, the Project represents a potential impact on parts of the GBMWHA associated with temporary inundation of areas, principally around the perimeter of Lake Burragorang. It should be noted that these areas are already at risk of potential inundation associated with the original construction of Warragamba Dam in 1960.

As previously noted, a recent review of the environmental impacts of temporary inundation upstream of flood inundation dams in Queensland (Hydrobiology 2019) noted that temporary inundation may impact certain aspects of ecosystem health but that the extent to which this may occur is substantially dependent on a large range of independent variables such as geology, frequency and duration of flooding, geographic setting, ecosystem characteristics, land use, germination from flood-borne seeds, edge effects and similar matters. It further noted that the studies of Queensland dams did not suggest that temporary flood inundation would inevitably cause substantial environmental impact.

Table 9-5. Assessment of Project against management measures for major impacts

Management measure	Response
2.1 Ensure that environmental impact assessments for proposals that may affect the GBMWHA (whether or not on the reserves themselves) adequately address potential and existing impacts on World Heritage values and are carried out in accordance with the principles of the EPBC Act and, where required, referred to the Australian Government Minister for the Environment.	The EIS and this WHA assessment report assess the impact of the Project on World Heritage values and the principles of the EPBC Act. The Project has been referred to the Australian Government Minister for the Environment for a decision in relation to approval under the EPBC Act.
2.2 Provide information to local and state government authorities and other relevant organisations (for example, those responsible for infrastructure) about the GBMWHA's World Heritage values and ensure they are aware of legal provisions to protect these values.	This management measure is not relevant to or affected by the Project
2.3 Work with local councils to develop suitable local and regional planning instruments (for example, Local and Regional Environment Plans) for areas adjacent to the GBMWHA.	This management measure is not relevant to or affected by the Project

9.5.3 Biodiversity

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9-6.A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To conserve the GBMWHA's biodiversity and ensure the ecological viability and capacity for ongoing evolution of its World Heritage and other natural values is maintained.

Desired outcomes

- Terrestrial and aquatic ecosystems and their associated ecological processes, species, populations, and genetic diversity are all protected and conserved in-situ
- Conservation of the reserves' World Heritage values is the primary consideration in their management
- Management objectives, policies and activities are coordinated between agencies, consistent with World Heritage objectives and improved in line with best practice
- Research results are widely promulgated and a comprehensive biological and visitor use data set is available to managers in all agencies
- An appropriate regime of monitoring is in place to enable assessment of the state of the World Heritage values of the GBMWHA

- Management decisions are guided by independent scientific and technical advice
- Promote connectivity of the GBMWHA with adjacent natural areas.

Summary

The Project is not considered to be inconsistent with the desired outcomes relating to biodiversity of the GBMWHA. The environmental assessment has included a comprehensive investigation of the potential impacts of temporary inundation of the upstream study area including parts of the GBMWHA. Management of potential impacts would be supported through the National Parks EMP outlined in Section 13.3.

The focus of the Warragamba Offset Program will be the purchase of land suitable for inclusion in the National Park and protected areas system potentially included within the World Heritage area. This is consistent with the potential impacts of the project occurring within the National Park system. WaterNSW would work with NPWS to ensure that the land is suitable for inclusion and that costs of management of the lands to ensure the offset is delivered is appropriately considered in the Warragamba Offset Program.

Table 9-6. Assessment of Project against management measures for biodiversity

Management measure	Response
3.1 Support and undertake relevant co-ordinated research programs, in conjunction with the Blue Mountains World Heritage Institute and other organisations, which will assist managers, particularly in relation to threatened species, monitoring, fire management, pest species control and impacts of visitor use.	The biodiversity assessments undertaken for the EIS provide a greater understanding of the location, extent, and type of threatened species in the GBMWHA, and have been informed by field survey and assessment in accordance with the NSW Framework for Biodiversity Assessment.
3.2 Develop an integrated data storage and retrieval system accessible to managers in all relevant agencies to provide information relevant to improved management of World Heritage and other values.	Information from the EIS would be publicly available and would be provided to relevant Government agencies and groups involved in the management of the GBMWHA.
3.3 Review current pest species management and fire management priorities and programs to ensure they are adequate for conservation of biodiversity and maintenance of World Heritage values.	Specific matters to be addressed in the development of the National Parks EMP are still subject to negotiation (refer Section 13.3). However, it is anticipated that the EMP would include pest and weed management as key components of mitigating any impacts from the Project on upstream catchment areas including areas of the GBMWHA affected by the Project. Existing pest and weed management programs and priorities would be reviewed as part of this process and any additional resources would complement existing programs or prioritise new threats. The Project would not have an impact on fire management.
3.4 Strengthen and expand existing cooperative pest species management programs, with particular emphasis on programs which encourage ongoing community and neighbour involvement.	Specific matters to be addressed in the development of the National Parks EMP are still subject to negotiation (refer Section 13.3). However, it is anticipated that the EMP would include pest and weed management as key components of mitigating any impacts from the Project on upstream catchment areas including areas of the GBMWHA affected by the Project. Existing pest and weed management programs and priorities would be reviewed as part of this process and any additional resources would complement existing programs or prioritise new threats.
3.5 Encourage and assist local councils to develop suitable statutory controls (for example, vegetation management orders or animal management orders) in areas which may impact on the GBMWHA to prevent the spread of weeds and introduced animals into the GBMWHA.	This management measure is not relevant to or affected by the Project.

Management measure	Response
3.6 Give priority to the implementation of threat abatement plans and the preparation and implementation of recovery plans for all endangered ecological communities, endangered populations, and threatened species within the GBMWHA.	Existing threat abatement plans and recovery plans for threatened species and communities have been considered in the biodiversity assessments. The Warragamba Offset Program would include specific actions from relevant threat abatement plans and recovery plans.

9.5.4 Geodiversity

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 7. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To protect the GBMWHA's geodiversity.

Desired outcomes

- Geodiversity is conserved, managed, presented and interpreted.
- Sound understanding of geodiversity throughout the GBMWHA, and informed decision-making, particularly of karst environments and processes, through targeted research and capacity building in staff.
- The geodiversity values of the GBMWHA are better understood and their significance is formally recognised at State, National and World Heritage level as appropriate.

Summary

The geomorphological assessment carried out for the Project identified the potential for an increase in out of bank erosion in the upstream study area to be generally low. Similarly, it identified that there would be a limited increase in the extent and lateral width of deposition in the upstream rivers. The assessment was carried out prior to the 2019-2020 bushfire event and the potential for erosion risk may have increased. However, only about 14 percent of the upstream study area was classified as being of high or extreme burn severity through the FESM (refer Table 2-1). The Project would not affect any karst environments within the GBMWHA.

The Project is not considered to be inconsistent with the desired outcomes relating to geodiversity.

Table 9-7. Assessment of Project against management measures for geodiversity

Management measure	Response
4.1 Support and undertake geodiversity research and education programs, in conjunction with the Blue Mountains World Heritage Institute, the Australian Speleological Federation and other relevant research organisations to better understand the relationship with World Heritage values.	This management measure is not relevant to or affected by the Project.
4.2 Research, record and assess the significance of the geodiversity values of the GBMWHA against State, National and World Heritage listing criteria and seek formal recognition as appropriate.	This management measure is not relevant to or affected by the Project.
4.3 Support and undertake geodiversity research and education programs to inform and support a program of better protection of geodiversity.	This management measure is not relevant to or affected by the Project.
4.4 Prevent or minimise unnatural chemical and mechanical weathering and other damage to geological features/diversity through intervention, monitoring and stabilisation.	This management measure is not relevant to or affected by the Project.

Management measure	Response
4.5 Develop infrastructure and maintenance regimes developed at Jenolan Caves to protect the karst environment there, while still meeting visitor needs, as appropriate.	This management measure is not relevant to or affected by the Project.
4.6 Finalise and implement the Jenolan Karst Conservation Reserve Plan of Management.	This management measure is not relevant to or affected by the Project.

9.5.5 Water catchment protection

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 8. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To maintain and improve the water quality and water catchment values of the GBMWHA.

Desired outcomes

- Any adverse impacts on water quality and quantity within the GBMWHA arising from park management activities, upstream land uses or visitor use are eliminated or, at least, minimised.
- Improved understanding of visitors, neighbours and nearby communities of their potential impact on the GBMWHA's World Heritage value and their role in minimising adverse impacts on water quality.

Summary

The Project is not considered to be inconsistent with the desired outcomes related to water catchment protection. The National Parks EMP would facilitate coordinated management of the upstream area including affected parts of the GBMWHA.

Table 9-8. Assessment of Project against management measures for water catchment protection

Management measure	Response
5.1 Review current catchment protection priorities and programs and co-operative management arrangements to ensure they are adequate for the maintenance and improvement of World Heritage and other values of the GBMWHA.	The National Parks EMP would involve a review and enhancement of existing catchment protection priorities and programs and co-operative management arrangements to ensure they are adequate for the maintenance and improvement of potentially impacted lands including the impacted world heritage land and other values of the GBMWHA. This would be undertaken in consultation with the NPWS which is responsible for the day-to-day management of the catchment in conjunction with WaterNSW.
5.2 Support and encourage catchment education and research programs in conjunction with the Sydney Catchment Authority, catchment management authorities and the Blue Mountains World Heritage Institute.	The Project would require additional monitoring and research to assess the impact of temporary inundation on biodiversity and other aspects of areas of GBMWHA potentially impacted by the Project. This information would be provided to relevant external parties and therefore demonstrates support and encouragement of catchment education and research.

9.5.6 Cultural heritage

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 9. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

- To identify, formally recognise and protect the cultural heritage values of the GBMWHA.
- To manage the GBMWHA jointly with local Indigenous people.

Desired outcomes

- The cultural heritage values of the GBMWHA are retained and better understood, and their significance is formally recognised at State, National and World Heritage level as appropriate.
- Management of the GBMWHA is undertaken co-operatively with the Aboriginal people who have traditional connections to the Countries that comprise the GBMWHA.
- The cultural, traditional and social significance of the landscapes within the GBMWHA to Aboriginal people is widely acknowledged and respected.
- The social and historical significance of the landscapes within the GBMWHA to non–Aboriginal people is acknowledged and respected.

Summary

The Aboriginal cultural heritage assessment and non-Aboriginal heritage assessment both acknowledge the diverse heritage and landscape values within the Project study area, and including those areas within the World Heritage areas. These values have formed an integral baseline for the assessments. The assessments have identified mitigation and management measures which would contribute to the ongoing management of the GBMWHA facilitating the co-operative participation of Aboriginal peoples with connection to the land.

Table 9-9. Assessment of Project against management measures for cultural heritage

Management measure	Response
6.1 Continue and further develop close consultation with local Aboriginal peoples through the Living Country Aboriginal Co-management Project and the Central Coast/Hunter Range Region Co-Management Committee.	This management measure is not relevant to or affected by the Project. However, local Aboriginal individuals and groups have been extensively consulted regarding the Project and involved in the preparation of the ACHA report (Appendix K to the EIS). This included: ▪ consultation and endorsement of the assessment methodology ▪ participation in all field surveys (70+ days) and the recording of Aboriginal heritage ▪ opportunity to review, comment and provide additional comment on the ACHA report before finalisation. All consultation with the Aboriginal people has been undertaken in compliance with relevant NSW guidelines for Aboriginal consultation. The Lake Burragorang catchment, including some areas of the GBMWHA, are part of the ILUA with the Gundungurra people. The ILUA acknowledges the Gundungurra people's custodianship, use and management of their traditional land and waters. The ILUA would not be affected by the Project.
6.2 Through the Mapping Country Project and in partnership with local Aboriginal communities, appropriately document the Indigenous cultural values of the GBMWHA.	The ACHA report, associated field surveys and consultation with local Aboriginal communities has significantly increased the knowledge of the cultural values of the upstream area including areas of the GBMWHA. These have been documented in the ACHA report and would be further recorded in the NSW Aboriginal Heritage Information Management System.
6.3 Ensure valid native title is recognised and Indigenous Land Use Agreements negotiated, consistent with Australia's obligations under the World Heritage Convention and the restrictions on land use imposed by law.	There is an existing ILUA for the Warragamba Dam catchment and it is presumed this would continue into the future. The IULA is a separate matter to the Project.

Management measure	Response
6.4 Through the Living Country Co-management Project, prepare and implement agreed GBMWHA Indigenous heritage strategies, consistent with government and agency cultural heritage policies (for example, Cultural Heritage Conservation and Cultural Heritage Community Consultation Policies).	There is an existing ILUA for the Warragamba Dam catchment and it is presumed this would continue into the future. The IULA is a separate matter to the Project. The ACHA report has proposed a number of heritage management strategies including further survey, enhanced recording of high value sites, interpretive strategies and other measures that would be developed and implemented with local Aboriginal communities. These would comply with NSW and Commonwealth cultural heritage policies.
6.5 Investigate the feasibility of establishing an Aboriginal employment/capacity-building program and develop strategies for working towards Aboriginal co-management of the GBMWHA reserves.	The Aboriginal Participation in Construction (APIC) policy would apply for construction of the Project. The APIC aims to increase the number of Aboriginal people employed and the number of Aboriginal owned businesses. Under the APIC policy a minimum of 1.5 percent of project spend must be dedicated to Aboriginal participation. The ACHA report recommended a number of measures to enhance the co-management of Aboriginal cultural heritage in Lake Burragorang catchment including the areas of the GBMWHA potentially impacted by the Project.
6.6 Research, record and assess the significance of the cultural heritage values of the GBMWHA against State, National and World Heritage listing criteria and seek formal recognition as appropriate.	The ACHA report and Non-Aboriginal Heritage Assessment has included field surveys, research, recording and assessing the significance of Aboriginal and Non-Aboriginal Heritage cultural values in the GBMWHA and other areas. The assessment of significance has been undertaken in consideration of NSW and Commonwealth listing criteria.
6.7 Encourage cultural heritage research projects which assist with the protection and management of the GBMWHA's cultural heritage values.	The ACHA report has proposed a number of additional heritage research projects including further survey, enhanced recording of high value sites and interpretive strategies that would be undertaken with local Aboriginal communities.
6.8 Emphasise the importance of Indigenous culture and history, by identifying suitable Aboriginal words for naming/co-naming the GBMWHA and its reserves.	This management measure is not relevant to or affected by the Project.
6.9 Ensure recognition of non-Aboriginal heritage values, including art inspired by the landscape, relationships between people and the environment, early conservation campaigns, built heritage, and recreational activities and infrastructure.	The Non-Aboriginal Heritage Assessment has included research, recording and assessing the significance of Non-Aboriginal Heritage cultural values in the GBMWHA and other areas. Warragamba Dam and its catchment areas (of which are in the GBMWHA) is a key component of the built heritage and infrastructure which contributes to the overall values of the GBMWHA. The protection of the Warragamba Dam catchment from development and clearing has resulted in the conservation of substantial areas of high quality intact native vegetation that were eventually included in the GBMWHA.

9.5.7 Landscape, natural beauty, and aesthetic values

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 10. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objectives

- To protect the landscape, natural beauty, and aesthetic values of the GBMWHA.

Desired outcomes

- The natural beauty and aesthetic values of the GBMWHA are identified, better understood and their significance is formally recognised at State, National and World Heritage level as appropriate

- Any adverse impacts on the natural beauty and aesthetic values are prevented, eliminated, or at least minimised
- Recreational and tourist overflights do not interfere with the natural quiet, biodiversity and GBMWHA aesthetic values
- Adjacent lands are managed so as to retain the landscape values of the GBMWHA.

Summary

The Project may impact on amenity values of parts of the GBMWHA associated with potential inundation of areas of vegetation, potentially resulting in a change in vegetation composition including dieback of vegetation above FSL. As noted previously, there is uncertainty over whether vegetation that is temporarily inundated would be detrimentally impacted to the extent that its viability would be materially affected. Historically this has not occurred, and indeed vegetation has established below FSL during prolonged drier periods when Lake Burragorang has been below FSL.

Table 9-10. Assessment of Project against management measures for landscape, natural beauty and aesthetic values

Management measure	Response
7.1 Research, record and assess the significance of the natural beauty and aesthetic values of the GBMWHA against State, National and World Heritage listing criteria and seek formal recognition as appropriate.	The visual significance of the upstream catchment impacted by the Project including areas of the GBMWHA has been assessed in the visual impact assessment.
7.2 Ensure that management activities and visitor use within and adjacent to the GBMWHA have minimal impacts on the area's scenic and aesthetic values.	The visual impact of the Project on the upstream catchment area including areas of the GBMWHA within the upstream impact area has been assessed. Visual impacts on upstream areas would occur due to either a change in vegetation communities or loss of vegetation in areas fringing Lake Burragorang or its tributaries. The visual impact assessment concluded that any visual changes due to the Project would not be visible from key viewing locations such as Echo Point, and at other locations would be moderate but unlikely to be easily distinguished from the existing impacts of vegetation loss from the current operations of the dam. Subject to agreement with NPWS, the EMP would include measures to control weeds and revegetate land affected by the flood mitigation operations of the Project.
7.3 Improve visitor identification of the GBMWHA as a region, develop a sense of arrival at entry points, and ensure development of visitor facilities/interpretation of appropriate character, design and construction.	This management measure is not relevant to or affected by the Project.
7.4 Ensure that the impact of new developments within and adjacent to the GBMWHA on the area's scenic and aesthetic values are considered, including any adverse impacts associated with lighting.	The visual impact of the Project on the upstream catchment area including areas of the GBMWHA has been assessed. Visual impacts on upstream areas would occur due to either a change in vegetation communities or loss of vegetation in areas fringing Lake Burragorang or its tributaries. The visual impact assessment concluded that any visual changes due to the Project would not be visible from key tourist locations such as Echo Point, and at other locations would be moderate but unlikely to be easily distinguished from the existing impacts of vegetation loss from the current operations of the dam. Subject to agreement with NPWS, the EMP would include measures to control weeds and rehabilitate land affected by the flood mitigation operations of the Project.
7.5 Continue to work with the relevant agencies, aviation industry and military to implement and monitor the existing Fly Neighbourly program to ensure that any impact of aircraft on the GBMWHA (especially wilderness areas), park visitors and neighbouring communities is minimised.	This management measure is not relevant to or affected by the Project.

Management measure	Response
7.6 Seek the establishment of a Restricted Area under the Air Services Regulations to provide statutory restrictions on tourist flights over the GBMWHA.	This management measure is not relevant to or affected by the Project.
7.7 Work with local government authorities to introduce appropriate development controls for lands adjoining and within, scenery catchments of the GBMWHA.	This management measure is not relevant to or affected by the Project.
7.8 Assess scenery catchments, particularly at approaches, access points and visitor facilities to identify negative features and develop short and long-term amelioration measures.	The visual impact of the Project on the upstream catchment area including areas of the GBMWHA has been assessed. Visual impacts on upstream areas would occur due to either a change in vegetation communities or loss of vegetation in areas fringing Lake Burragorang or its tributaries. The visual impact assessment concluded that any visual changes due to the Project would not be visible from key tourist locations such as Echo Point, and at other locations would be moderate but unlikely to be easily distinguished from the existing impacts of vegetation loss from the current operations of the dam. Subject to agreement with NPWS, the EMP would include measures to control weeds and revegetate land affected by the flood mitigation operations of the Project.

9.5.8 Recreation and visitor use

The primary objective and desired outcomes for this key management issue are presented as follows. The context of the Project in relation to management measures for this issue is assessed in Table 9 11. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To provide for an appropriate range of recreation and visitor use, consistent with the protection of World Heritage and related values.

Desired outcomes

- Appropriate use of the GBMWHA is catered for with minimal impact on its World Heritage and other values.
- The role of the GBMWHA in providing a particular type of nature-based visitor experience, compatible with protection of World Heritage values, is widely recognised, and supported.

Summary

The Project would not be inconsistent with the desired outcomes relating to protection of the landscape, natural beauty, and aesthetic values of the GBMWHA.

Table 9-11. Assessment of Project against management measures for recreation and visitor use

Management measure	Response
8.1 Ensure that the prime consideration in the face of increasing pressures for recreation and access is the conservation and protection of the values of the GBMWHA.	This management measure is not relevant to or affected by the Project.
8.2 Facilitate and contribute to the development of regional cross-tenure recreation and visitor management strategies across the GBMWHA.	This management measure is not relevant to or affected by the Project.
8.3 In consultation with other relevant agencies and tourism bodies, develop and implement a co-ordinated system for visitor use monitoring across the GBMWHA to assist in the development of visitor management strategies.	This management measure is not relevant to or affected by the Project.

Management measure	Response
8.4 Continue to work co-operatively with user groups to develop and implement specific recreation management strategies aimed at protecting World Heritage and related values while providing for appropriate use conditional upon consistency with the Plans of Management of the individual reserves.	This management measure is not relevant to or affected by the Project.
8.5 Provide opportunities for ongoing community consultation regarding decisions on visitor use and management within the GBMWHA through the existing National Parks Regional Advisory Committees, the Trust, the GBMWHA Advisory Committee and additional consultation forums on specific issues as they arise.	This management measure is not directly relevant to or affected by the Project. However, there would be ongoing consultation and engagement with the GBMWHA Advisory Committee and the National Parks Regional Advisory Committees in the development and implementation of The EMP and the proposed Warragamba Offset Program.
8.6 Progressively implement the Interpretation & Visitor Orientation Plan for the GBMWHA, in co-operation with other relevant agencies and tourism bodies.	This management measure is not relevant to or affected by the Project.

9.5.9 Social and economic issues

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 12. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

Consistent with the protection of World Heritage and other values, optimise the potential and existing social and economic benefits derived from visitation to the GBMWHA.

Desired outcomes

- Potential and existing social and economic benefits of the GBMWHA are widely recognised and broadly distributed without adverse impact on World Heritage and related values.
- A proportion of the economic benefits arising from the GBMWHA is applied towards improved management of the GBMWHA.

Summary

The Project is not considered to be inconsistent with the desired outcomes relating to social and economic issues.

Table 9-12. Assessment of Project against management measures for social and economic issues

Management measure	Response
9.1 Collaborate with local councils, tourism agencies, Aboriginal groups, industry bodies and local operators and businesses to ensure that economic benefits are realised without compromising World Heritage and other values or adversely impacting on local communities.	This management measure is not relevant to or affected by the Project.
9.2 Formally adopt and implement the Interpretation and Visitor Orientation Plan for the GBMWHA.	This management measure is not relevant to or affected by the Project.
9.3 Investigate the possibility of establishing gateway facilities near major entrance points to the GBMWHA in conjunction with local government, tourism organisations, Aboriginal groups, businesses and communities. In consultation with other relevant agencies, Aboriginal groups and tourism bodies, investigate options for some return of economic benefits to contribute to management of the GBMWHA.	This management measure is not relevant to or affected by the Project.

9.5.10 Education, community participation, and consultation

The primary objective and desired outcomes for this key management issue are presented below. The context of the Project in relation to management measures for this issue is assessed in Table 9 13. A summary statement on the consistency of the Project with regard to the desired outcomes is provided following the list of desired outcomes.

Objective

To encourage community stewardship of the GBMWHA through education, consultation, and the provision of opportunities for community participation in its protection.

Desired outcomes

- Visitors to the GBMWHA and the broader community understand the area's World Heritage and related values and the potential impacts of their own actions on those values.
- Reserve neighbours, local communities and visitors to the GBMWHA are recognised as valuable conservation partners and are involved in community partnerships with management agencies to protect its World Heritage and other values.
- The World Heritage and other values of the GBMWHA are a focus for environmental education in the surrounding regions.

Summary

The Project is not considered to be inconsistent with the desired outcomes relating to education, community participation, and consultation. As noted in the above table, it would support various aspects of consultation related to the GBMWHA.

Table 9-13. Assessment of Project against management measures for education, community participation, and consultation

Management measure	Response
10.1 Work with reserve neighbours and local communities to develop and implement new partnership programs, for example World Heritage Neighbourhood Watch and GBMWHA "Ambassadors".	This management measure is not relevant to or affected by the Project.
10.2 Establish a forum for information exchange and neighbour input into the management of the GBMWHA.	This management measure is not relevant to or affected by the Project.
10.3 In partnership with local agencies, support and expand community-based volunteer rehabilitation programs to maximise the effectiveness of pest species control programs and rehabilitation of degraded areas.	This management measure is not relevant to or affected by the Project.
10.4 Support and expand education programs for tourism operators (as per the GBMWHA Interpretation and Visitor Orientation Plan).	This management measure is not relevant to or affected by the Project.
10.5 Support and expand education programs regarding the GBMWHA such as DECC Discovery and seek interagency support and external funding for improved education packages, particularly for use in schools and other environmentally based community activities, such as the Earth Journeys Schools program.	This management measure is not relevant to or affected by the Project.
10.6 Support the GBMWHA Advisory Committee and effectively engage the community and the National Parks Regional Advisory Committees in the implementation of this Strategic Plan. (See also Key Issue — Cultural Heritage partnerships with Aboriginal groups).	There would be ongoing consultation and engagement with the GBMWHA Advisory Committee and the National Parks Regional Advisory Committees in the development and implementation of the National Parks EMP and the proposed Warragamba Offset Program.

Management measure	Response
10.7 Support and assist local Aboriginal people to develop further educational cultural heritage programs and activities for schools, visitors, and local communities regarding the GBMWHA.	One of the mitigation measures proposed in the ACHA report is the development and delivery of an Aboriginal education program for local schools by local Aboriginal people. This would include Aboriginal cultural heritage values of the areas of the GBMWHA.

10 Assessment of the Project against national park plans of management

As noted in Section 6.1.3, parts of Blue Mountains National Park, Nattai National Park and Yengo National Park are within the GBMWHA and are potentially impacted by the Project. Management of these protected areas is carried out under the following plans of management:

- Blue Mountains National Park Plan of Management
- Nattai Reserves Plan of Management
- Yengo National Park Plan of Management.

Under the NPW Act, national parks are managed to:

- conserve biodiversity, maintain ecosystem functions, protect geological and geomorphological features and natural phenomena and maintain natural landscapes
- conserve places, objects, features and landscapes of cultural value
- protect the ecological integrity of one or more ecosystems for present and future generations
- promote public appreciation and understanding of the park's natural and cultural values
- provide for sustainable visitor use and enjoyment that is compatible with conservation of natural and cultural values
- provide for sustainable use (including adaptive reuse) of any buildings or structures or modified natural areas having regard to conservation of natural and cultural values
- provide for appropriate research and monitoring.

In addition to specific management objectives for individual national parks, there are also general objectives, derived from the NPW Act, that apply to the management of national parks in New South Wales. These are listed in Table 10-1 together with an assessment of the consistency of the Project with these general objectives.

Table 10-1. General management objectives for national parks

Management objective	Consistency of Project with management objective
Protection and preservation of scenic and natural features	The Project is considered unlikely to have a significant impact on the scenic values and natural features of the three national parks. The National Parks EMP would support this management objective.
Conservation of wildlife and natural biodiversity	The Project may potentially impact biodiversity but the affected areas are limited and relatively minor in extent compared to the total areas in the three national parks. The upstream area will be managed in accordance with the National Parks EMP, with development of the EMP including consultation with relevant stakeholders to ensure management activities are consistent with and supportive of the management plans for the three affected national parks.
Maintenance of natural processes as far as is possible	The Project would potentially affect erosion risk in areas in the upstream, however, the assessment carried out for the Project identified this as being limited.
Preservation of Aboriginal and historic sites, features and places	The Project would potentially affect a number of Aboriginal sites and places.
Provision of appropriate recreation opportunities	The Project would not impact on this management objective.
Encouragement of scientific and educational inquiry into environmental features and processes, prehistoric and historic features and park use patterns.	Information generated from monitoring activities and further investigations would be shared with relevant land managers to support this management objective.

10.1 Blue Mountains National Park

The Blue Mountains National Park Plan of Management commenced operation in May 2001. Table 10-2 assesses the consistency of the Project with the specific management objectives for the Blue Mountains National Park.

Table 10-2. Management objectives for Blue Mountains National Park

Management objective	Consistency of Project with management objective
Protection of the park as part of the system of protected lands of the Sydney Basin bioregion and the Great Escarpment, with emphasis on maintenance of the ecological relationships between the park and adjoining protected areas	The Project would potentially impact areas of the park adjoining Lake Burragorang and its associated tributaries. The National Parks EMP would support this management objective.
Protection of catchments and water quality in the park, with priority to protection of Sydney's water supply and protection of wilderness catchments	The Project would not affect the protection of Sydney's water supply. Operation of the FMZ could temporarily affect water quality, however, this would not be dissimilar to the situation at present with major inflow events into Lake Burragorang. The National Parks EMP would support this management objective.
Identification, protection, conservation, presentation and transmission to future generations of the values of the Greater Blue Mountains World Heritage Area	This management objective is not relevant to or affected by the Project.
Protection and promotion of the outstanding scenic values of the park including protection of viewscapes from within and from outside the park	Potential changes to scenic values would principally be associated with potential changes in vegetation extent around the perimeter of Lake Burragorang. The Project would have limited impact on viewscapes within the park for ground-based observers, however, changes may be more apparent to aerial observers. The National Parks EMP would support this management objective.
Protection of the diverse range of plant and animal communities within the park, with particular attention to threatened species, endangered populations and endangered ecological communities and their habitats	The Project may potentially impact areas of habitat occupied by endangered ecological communities and utilised by threatened species, principally through temporary inundation associated with operation of the FMZ. The National Parks EMP would support this management objective.
Provision of a range of high quality visitor facilities and information to encourage awareness and appreciation of the park and maintain the regional significance of the park in providing nature-based recreation and tourism opportunities	The Project would not affect access to the park, nor impact the regional significance of the park in providing nature-based recreation and tourism opportunities.
Management of wilderness areas in conjunction with the adjoining national parks and reserves to maintain and enhance opportunities for solitude and self-reliant recreation, while ensuring the maintenance of natural processes	The Project would potentially affect designated wilderness generally around the perimeter of Lake Burragorang and along the Coxs River, Kedumba River and other tributaries, associated with temporary inundation. The National Parks EMP would support this management objective.
Management of recreation and tourism within the park to ensure sustainable use, to minimise the impacts on the park's natural and cultural features and to maintain opportunities for a diverse range of recreational experiences	The Project would not affect the management of recreation and tourism within the park. The National Parks EMP would be prepared in consultation with NPWS and other relevant stakeholders and would support this objective where relevant.
Encouragement of public awareness and appreciation of the park's outstanding natural and cultural features through a variety of improved information, interpretation and education programs, with particular emphasis on: ▪ the park's outstanding biodiversity and wilderness values and its ecological links with the adjoining conservation reserves;	This management objective is considered separate to the Project, however, the Project would broadly support this objective, and is therefore not considered inconsistent with it.

Management objective	Consistency of Project with management objective
▪ the park's Aboriginal heritage ▪ the park's historical features associated with its unique place in the history of settlement of New South Wales and the development of the bushwalking and conservation movement in Australia, as well as its long history of tourism use ▪ the importance of water quality protection and catchment management ▪ appropriate recreational use of the park and minimal impact use	

10.2 Nattai National Park

The Nattai Reserves Plan of Management, which includes Nattai National Park, was adopted on 17 April 2001. Table 10-3 assesses the consistency of the Project with the specific management objectives for Nattai National Park.

Table 10-3. Management objectives for Nattai National Park

Management objective	Consistency of Project with management objective
To manage the Nattai Reserves System as a part of the system of protected lands of the Sydney Basin, with emphasis on maintenance of the ecological relationships between these reserves and adjacent protected areas	The Project would not impact on this management objective. The National Parks EMP would support this management objective.
To protect the Warragamba Catchment. The protection of water quality will take precedence over the provision of recreational opportunities in the reserves	The Project would not impact on this management objective. The National Parks EMP would support this management objective.
To protect the rainforest communities	The Project may potentially impact a small area of Nattai National Park in the upper reaches of the Nattai River, however, the vegetation in this area does not comprise species considered to form a rainforest community.
To protect, and where necessary restore wilderness areas	The Project may potentially impact small area of declared wilderness in Nattai National Park in the upper reaches of the Nattai River. Incremental inundation associated with the project would be in the order of an additional half a day and half a metre; accordingly significant impacts are considered unlikely.
To protect all Aboriginal sites and places in the Nattai Reserves System in partnership with the local Aboriginal community	The Project may potentially impact a small number of sites/locations adjacent to the Nattai River. The National Parks EMP would support this management objective.
To promote the appreciation, protection and appropriate use of wilderness amongst visitors to the reserve system	This management objective is not relevant to or affected by the Project. However, the Project is not considered to be inconsistent with this management objective.
Subject to the protection of catchment values, to maintain existing recreation opportunities for visitors to experience the outstanding scenic, natural and wilderness qualities of the park	The Project would not existing recreation opportunities for visitors and would therefore not impact on this management objective.
To promote public awareness of the Nattai Reserves System with emphasis on natural qualities of continental and regional significance	This management objective is not relevant to or affected by the Project. However, the Project is not considered to be inconsistent with this management objective.
Promotion within the local community, particularly neighbours of the reserves of the importance and purpose of management programs necessary for the protection of natural features and the control of fire and pest species	This management objective is not relevant to or affected by the Project. However, the Project is not considered to be inconsistent with this management objective.

10.3 Yengo National Park

The Yengo National Park Plan of Management was adopted on 12 January 2009. Table 10-4 assesses the consistency of the Project with the specific management objectives for Yengo National Park.

It should be noted that Yengo National Park lies downstream of Warragamba Dam with only a very small portion (less than five hectares) occurring within the downstream study area to the north of Wisemans Ferry. There would be no material change to the flooding regime in this area due to the Project.

Table 10-4. Management objectives for Yengo National Park

Management objective	Consistency of Project with management objective
Promotion of wildlife corridors that link the parks to other protected lands and enhance their conservation value	The Project would not impact any wildlife corridors associated with Yengo National Park.
Limiting the impact of fire in the parks and on adjoining properties	This management objective is not relevant to or affected by the Project.
Protection of the warm temperate and dry rainforest communities	This management objective is not relevant to or affected by the Project.
Protection, and where necessary restoration, of wilderness values	This management objective is not relevant to or affected by the Project.
Consultation with the Central Coast Hunter Range Region Aboriginal Heritage Advisory Committee in relation to management of the parks	This management objective is not relevant to or affected by the Project.
Provision of opportunities for the Aboriginal community to continue their traditional practices and maintain sites	This management objective is not relevant to or affected by the Project.
Maintenance of dispersed, low-impact recreation opportunities, including vehicle-based and self-reliant activities, so that visitors may experience the heritage, scenic, natural and wilderness values of the parks	This management objective is not relevant to or affected by the Project.
Management of Big Yango homestead and associated areas to conserve and interpret the cultural heritage values	This management objective is not relevant to or affected by the Project.
Promotion of public awareness and appreciation of the parks, with emphasis on: ▪ their importance as part of the system of conservation areas in the Sydney Basin ▪ wilderness values ▪ adoption of minimal impact recreation practices by park visitors	This management objective is not relevant to or affected by the Project.
Promotion within the local community of the importance and purpose of management programs necessary for the protection of natural features and the control of fire, weeds and feral animals.	This management objective is not relevant to or affected by the Project.

11 Assessment of the Project against matters relevant to World Heritage in the EPBC Act and Regulation

This section considers impacts on World Heritage with regard to specific matters under the EPBC Act, EPBC Regulation, and the EPBC Act Environmental Offsets Policy.

11.1 EPBC Act

Section 137 identifies three matters to be considered with regard to decision-making for proposals affecting World Heritage. The following table provides an assessment for each of these three matters.

Table 11-1. Assessment of the Project against section 137 of the EPBC Act

Matter	Assessment
In deciding whether or not to approve, for the purposes of section 12 or 15A, the taking of an action and what conditions to attach to such an approval, the Minister must not act inconsistently with:	
a) Australia's obligations under the World Heritage Convention	The Project has been assessed against these obligations in Section 6.1. The assessment did not identify any material inconsistencies with regard to the Project and the Australian Government's obligations related to World Heritage.
b) The Australian World Heritage management principles	Assessed in Table 11-2. The Project is not considered to be inconsistent with these principles.
c) A plan that has been prepared for the management of a declared World Heritage property under section 316 or as described in section 321.	Section 321 provides for cooperation between the Australian Government and State/Territory governments in the preparation and implementation of plans to manage World Heritage properties. **GBMWHA:** The GBMWHA Strategic Plan (and the 2016 Addendum) is the overarching plan for the management of the GBMWHA and provides the framework for its integrated management, protection, interpretation, and monitoring. Implementation of the plan is achieved through the constituent NSW plans of management for the individual national parks that fall within the GBMWHA. Each plan of management has been prepared in accordance with the Convention Concerning the Protection of the World Cultural and Natural Heritage. The GBMWHA Strategic Plan has not been prepared under section 316 of the EPBC Act but is considered to be consistent with the relevant matters for such a plan as provided for in section 321. **Old Great North Road:** The Conservation Management Plan for the Old Great North Road was completed in 2005 with an addendum prepared in 2008 to support the nomination for World Heritage listing. In 2010, part of the Old Great North Road was World Heritage listed as part of the Australian Convict Sites World Heritage Property. The Australian Government has prepared a strategic management framework for the Australian Convict Sites (Commonwealth of Australia 2018), and the NSW Government is a signatory to this. Responsibility for implementing the management plans for the individual places rests with the relevant State and Australian Government agencies and the established governing bodies. In August 2018, the NSW Government advertised a tender for the updating of the current Conservation Management Plan. The current status of this update is not known. The Conservation Management Plan for the Old Great North Road has not been prepared under section 316 of the EPBC Act but is considered to be consistent with the relevant matters for such a plan as provided for in section 321.

11.2 EPBC Regulation

As required under Schedules 5 and 5B of the EPBC Regulation, the impacts of the Project have been assessed against the General Principles of World Heritage property management in Table 11-2 and the Management Principles of listed National Heritage places in Table 11-2.

Table 11-2. Assessment of the Project against the General Principles of World Heritage property management – Schedule 5 of the EPBC Regulation

General principles	Assessment of the Project
1.01 The primary purpose of management of natural heritage and cultural heritage of a declared World Heritage property must be, in accordance with Australia's obligations under the World Heritage Convention, to identify, protect, conserve, present, transmit to future generations and, if appropriate, rehabilitate the World Heritage values of the property.	The Project has been developed to minimise its impacts on the GBMWHA, wherever possible. Mitigation measures have been developed for biodiversity, Aboriginal heritage and other relevant environmental aspects, see Chapter 29 of the EIS (EIS synthesis, Project justification and conclusion). The EMP would include all areas in the GBMWHA potentially impacted by the Project and would contain additional mitigation measures developed in conjunction with DAWE, DPIE, NPWS and other relevant stakeholders (for example, GBMWHA Advisory and Management Committees). Where impacts cannot be avoided, the Warragamba Offset Program would ensure that appropriate offsets are provided to rehabilitate any loss or degradation of the World Heritage values of the GBMWHA. The combination of mitigation measures and offsets associated with the Project would ensure that Australia's obligations under the World Heritage Convention to identify, protect, conserve, present, transmit to future generations the values of the GBMWHA are achieved.
1.02 The management should provide for public consultation on decisions and actions that may have a significant impact on the property.	In the development of the Project and the preparation of the EIS there has been public and stakeholder consultation, see Chapter 6 of the EIS (Consultation). The EIS for the Project would also have a public exhibition period where stakeholders and the public would have the opportunity to make formal submissions on the Project.
1.03 The management should make special provision, if appropriate, for the involvement in managing the property of people who: (a) have a particular interest in the property; and	The overall management of the GBMWHA is the direct responsibility of the GBMWHA Management Committee- and while WaterNSW is a stakeholder it is not directly responsible. However Aboriginal stakeholders, other relevant stakeholders (for example, GBMWHA Advisory and Management Committees) and the NPWS which have a particular interest in the GBMWHA would be involved in the development of the National Parks EMP, the Warragamba Offset Program and other mitigation measures relating to Aboriginal cultural heritage. The existing ILUA would provide for ongoing involvement of Aboriginal stakeholders in the management of the GBMWHA but is a separate matter to the Project..
(b) may be affected by the management of the property.	The overall management of the GBMWHA is the direct responsibility of the GBMWHA Management Committee- and while WaterNSW is a stakeholder it is not directly responsible. However Aboriginal stakeholders, other relevant stakeholders (for example, GBMWHA Advisory and Management Committees) and the NPWS which have a particular interest in the GBMWHA would be involved in the development of the National Parks EMP, the Warragamba Offset Program and

General principles	Assessment of the Project
	other mitigation measures relating to Aboriginal cultural heritage. The existing ILUA would provide for ongoing involvement of Aboriginal stakeholders in the management of the GBMWHA but is a separate matter to the Project..
1.04 The management should provide for continuing community and technical input in managing the property.	Technical information from the EIS, monitoring required under other mitigation measures and supplementary offsetting measures would contribute significantly to the management of GBMWHA.
2 Management planning 2.01 At least one management plan should be prepared for each declared World Heritage property.	The GBMWHA Strategic Plan (and the 2016 Addendum) is the overarching plan for the management of the GBMWHA. The EMP would include all areas in the GBMWHA potentially impacted by the Project and would contain additional mitigation measures developed in conjunction with NPWS and other relevant stakeholders (for example, GBMWHA Advisory and Management Committees).
2.02 A management plan for a declared World Heritage property should:	The GBMWHA Strategic Plan (and the 2016 Addendum) is the overarching plan for the management of the GBMWHA. The EMP would include all areas in the GBMWHA potentially impacted by the Project and would comply with requirements of 2.02 a-h.
(a) state the World Heritage values of the property for which it is prepared; and	
(b) include adequate processes for public consultation on proposed elements of the plan; and	
(c) state what must be done to ensure that the World Heritage values of the property are identified, conserved, protected, presented, transmitted to future generations and, if appropriate, rehabilitated; and	
(d) state mechanisms to deal with the impacts of actions that individually or cumulatively degrade, or threaten to degrade, the World Heritage values of the property; and	
(e) provide that management actions for values, that are not World Heritage values, are consistent with the management of the World Heritage values of the property; and	
(f) promote the integration of Commonwealth, State or Territory and local government responsibilities for the property; and	
(g) provide for continuing monitoring and reporting on the state of the World Heritage values of the property; and	
(h) be reviewed at intervals of not more than 7 years.	
3 Environmental impact assessment and approval 3.01 This principle applies to the assessment of an action that is likely to have a significant impact on the World Heritage values of a property (whether the action is to occur inside the property or not).	Noted
3.02 Before the action is taken, the likely impact of the action on the World Heritage values of the property should be assessed under a statutory environmental impact assessment and approval process.	This report and the Project EIS are being prepared to meet the statutory environmental impact assessment and approval processes under the EP&A Act and the EPBC Act.

General principles	Assessment of the Project
	These would be considered by the relevant approval authorities in both jurisdictions and a decision would be made whether to approve the Project or not.
3.03 The assessment process should: (a) identify the World Heritage values of the property that are likely to be affected by the action; and	This report and the Project EIS identify the World Heritage values of the property that are likely to be affected by the action (that is, the Project).
(b) examine how the World Heritage values of the property might be affected; and	This report and the Project examine how the World Heritage values of the property might be affected.
(c) provide for adequate opportunity for public consultation.	In the development of the Project and the preparation of the EIS there has been public and stakeholder consultation, refer to Chapter 6 of the EIS (Consultation)). The EIS for the Project would also have a public exhibition period where stakeholders and the public would have the opportunity to make formal submissions on the Project.
3.04 An action should not be approved if it would be inconsistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property.	Based on the impact assessment and the proposed mitigation measures, the Project is considered consistent with the protection, conservation, presentation, or transmission to future generations of the World Heritage values of the property. The Warragamba Offset Program would ensure that the biodiversity values of the GBMWHA are maintained. The Biodiversity Offset Strategy, that forms part of the Warragamba Offset Program provides for, amongst other mitigation measures, identification and establishment of offset sites including those suitable for inclusion into national parks estate and the GBMWHA to add to the integrity of the World Heritage area or protected land estates. Other mitigation measures such as those developed for Aboriginal cultural heritage are consistent with the requirements for protection, conservation, presentation, or transmission to future generations for World Heritage values.
3.05 Approval of the action should be subject to conditions that are necessary to ensure protection, conservation, presentation or transmission to future generations of the World Heritage values of the property.	If the Project is approved, it is likely that both the Australian and State Governments would impose conditions of approval that are necessary to ensure protection, conservation, presentation, or transmission to future generations of the World Heritage values of the property.
3.06 The action should be monitored by the authority responsible for giving the approval (or another appropriate authority) and, if necessary, enforcement action should be taken to ensure compliance with the conditions of the approval.	The Warragamba Offset Program provides for the auditing of compliance with enhancing World Heritage values and the integrity of the GBMWHA. The responsibility for monitoring will sit with the relevant regulatory authorities.

Table 11-3. Assessment of the Project against the Management Principles of listed National Heritage places – Schedule 5B of the EPBC Regulation

Management principles	Assessment of the Project
1 The objective in managing National Heritage places is to identify, protect, conserve, present and transmit, to all generations, their National Heritage values	The Project has been developed to minimise its impacts on the GBMWHA, wherever possible. Mitigation measures have been developed for biodiversity, Aboriginal heritage, and other relevant environmental aspects. The National Parks EMP would include all areas in the GBMWHA potentially impacted by the Project and would contain additional mitigation measures developed in conjunction with NPWS and other relevant stakeholders (for example, GBMWHA Advisory and Management Committees).
2 The management of National Heritage places should use the best available knowledge, skills and standards for those places, and include ongoing technical and community input to decisions and actions that may have a significant impact on their National Heritage values.	The National Parks EMP would include all areas in the GBMWHA potentially impacted by the Project and would contain additional mitigation measures developed in conjunction with NPWS, other relevant stakeholders (for example, GBMWHA Advisory and Management Committees) and other relevant technical experts.
3 The management of National Heritage places should respect all heritage values of the place and seek to integrate, where appropriate, any Commonwealth, State, Territory and local government responsibilities for those places.	All management measures developed would respect the heritage values of the GBMWHA and would integrate with existing State and Commonwealth responsibilities.
4i The management of National Heritage places should ensure that their use and presentation is consistent with the conservation of their National Heritage values.	All management measures developed would aim to ensure that their use and presentation is consistent with the conservation of their National Heritage values.
5 The management of National Heritage places should make timely and appropriate provision for community involvement, especially by people who: (a) have a particular interest in, or association with, the place; and (b) may be affected by the management of the place.	This is beyond the scope of the Project. However, the National Parks EMP would include all areas in the GBMWHA potentially impacted by the Project and would contain additional mitigation measures developed in conjunction with NPWS, other relevant stakeholders (for example, GBMWHA Advisory and Management Committees) and other relevant technical experts.
6 Indigenous people are the primary source of information on the value of their heritage and the active participation of indigenous people in identification, assessment and management is integral to the effective protection of indigenous heritage values.	Local Aboriginal representatives have been involved in heritage surveys and have provided input in to the ACHA report for the Project. The Gundungurra people and organisations have also been consulted.
7 The management of National Heritage places should provide for regular monitoring, review and reporting on the conservation of National Heritage values.	Responsibility for monitoring of National Heritage places does not sit with WaterNSW. However, the Warragamba Offset Program would support monitoring related to management of the GBMWHA.

11.3 EPBC Act Environmental Offsets Policy

DAWE has advised that as the Department has endorsed the NSW Biodiversity Offsets Scheme, provided WaterNSW complies with the scheme, it is not required to simultaneously comply with the EPBC Environmental Offsets Policy. Section 13.2 provides further details regarding the proposed offset strategy and how it accords with the NSW Biodiversity Offsets Scheme.

12 Summary of potential impacts

12.1 Impacts on World Heritage values

As previously noted, the GBMWHA was inscribed onto the World Heritage list against the following two outstanding universal criteria:

- Outstanding examples of ongoing ecological and biological processes
- Significant natural habitats for the in situ conservation of biological diversity.

The following discussion provides an assessment of the potential impacts of the Project against the Outstanding Universal Values of the GBMWHA.

12.1.1 Criterion (ix): outstanding examples of ongoing ecological and biological processes

The first criterion that the GBMWHA was listed for is:

> ***Criterion (ix):*** *The Greater Blue Mountains include outstanding and representative examples in a relatively small area of the evolution and adaptation of the genus Eucalyptus and eucalypt-dominated vegetation on the Australian continent. The site contains a wide and balanced representation of eucalypt habitats including wet and dry sclerophyll forests and mallee heathlands, as well as localised swamps, wetlands, and grassland. It is a centre of diversification for the Australian scleromorphic flora, including significant aspects of eucalypt evolution and radiation. Representative examples of the dynamic processes in its eucalypt-dominated ecosystems cover the full range of interactions between eucalypts, understorey, fauna, environment, and fire. The site includes primitive species of outstanding significance to the evolution of the earth's plant life, such as the highly restricted Wollemi pine (Wollemia nobilis) and the Blue Mountains pine (Pherosphaera fitzgeraldii). These are examples of ancient, relict species with Gondwanan affinities that have survived past climatic changes and demonstrate the highly unusual juxtaposition of Gondwanan taxa with the diverse scleromorphic flora.*

The Project would not impact any primitive species of outstanding significance such as the Wollemi pine and the Blue Mountains pine. A small area of Wollemi National Park (about one hectare) near the Colo River is inside the downstream Project PMF, this being the only part of Wollemi National Park potentially affected by the Project. Knowledge of the specific location(s) of the individual Wollemi pines is restricted by NPWS, however, it is quite likely that these are well outside the Project study area.

All known populations of the Blue Mountains pine occur between Katoomba and Wentworth Falls, and are found within the spray zones and drip lines associated with seepage areas of waterfalls. Small areas of suitable habitat occur within the upstream study area. The upstream biodiversity assessment identified the likelihood of occurrence of this species as moderate and noted that waterfall spray-zone habitat is marginal in study area. As a precautionary position, the Project has assumed one hectare of suitable habitat would be removed (and has been accounted for in the species credit calculation in Appendix F1 Biodiversity assessment – Upstream).

The Project would likely impact on 16 plant community types (PCTs) in the GBMWHA, 13 of which contain Eucalypt species. Most of these PCTs are common and well represented within the GBMWHA and/or the region and therefore the Project would not result in any significant impact to the distribution or survival of these PCTs. There are five PCTs associated with ecological communities listed as endangered under the *Biodiversity Conservation Act 2016* (BC Act) and/or the EPBC Act, and which are present within the GBMWHA and are potentially impacted by the Project.

The five PCTs that would be potentially impacted by the Project are:

- Narrow-leaved Ironbark–Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion.
- Forest Red Gum–Yellow Box woodland of dry gorge slopes southern Sydney Basin Bioregion and South Eastern Highlands Bioregion.
- Mountain Blue Gum–Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion.
- Turpentine–smooth-barked Apple moist shrubby forest of the lower Blue Mountains Sydney Basin Bioregion.
- Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East corner Bioregion.

Narrow-leaved Ironbark–Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion: this PCT is endemic to Burragorang Valley and is predominately found in Wollondilly and Tonalli River catchments. The majority of the area of this PCT is within the GBMWHA. The PCT has some species that are flood tolerant (for example, Forest Red Gum), however many of the mid-storey and groundcover plants are potentially flood intolerant; see Appendix F1 to the EIS (Biodiversity assessment report - upstream). The total extent of this PCT in the Lake Burragorang catchment is estimated to be about 4,740 hectares based upon previous mapping undertaken by ESS with about 150 hectares occurring in the upstream impact area. While the Project may have some impacts on this PCT, large areas of this PCT would not be affected by the Project.

Forest Red Gum–Yellow Box woodland of dry gorge slopes southern Sydney Basin Bioregion and South Eastern Highlands Bioregion: this PCT is known from the Wollondilly, Shoalhaven, Coxs and Jenolan Gorges and also occurs in Bathurst, Bungonia, Burragorang, Ettrema and Kanangra regions. This PCT contains both flood tolerant and intolerant species – however for many of the species within the PCT there is no information on flood tolerance; see Appendix F1 to the EIS (Biodiversity assessment report - upstream). Given their habitat preferences near waterways, much of the upper storey is likely to be somewhat flood tolerant. About 23 hectares of this PCT occurs in the upstream impact area. As this PCT is relatively well represented in other areas in the GBMWHA (and also outside the GBMWHA) and has some flood tolerance, it is considered unlikely that the Project would result in a significant loss of Eucalypt biodiversity in relation to this PCT.

Mountain Blue Gum–Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion: this PCT occurs predominantly along the sandy riverbanks of the Georges River and its tributaries, and on gentle, narrowly incised valleys that drain the north-west Woronora Plateau west from the Woronora River. It also occurs in the Lake Burragorang catchment and contains the Camden White Gum (which is flood tolerant). Most of the other individual species within the PCT are also flood tolerant, see Appendix F1 to the EIS (Biodiversity assessment report-upstream)). About 43 hectares of this PCT occurs in the upstream impact area. As the PCT is relatively flood tolerant and only a small area relative to its extent would be potentially impacted, it is considered unlikely that the impacts on this PCT would be significant.

Two threatened Eucalypt species are known to occur in the GBMWHA and are potentially impacted by the Project, namely:

- *Eucalyptus benthamii* (Camden White Gum): the largest natural stand of Camden white gum occurs in Kedumba Valley with about 10.3 hectares occurring in the upstream impact area. The species is flood tolerant and based on studies undertaken by the CSIRO, existing mature and juvenile individuals are likely to survive shallow and/or temporary inundation. However, the impact of complete submergence of mature individuals is unknown.
- *Eucalyptus glaucina* (Slaty Red Gum): this species is widely distributed through the Burragorang Valley, both inside and outside the Project impact areas. It is likely to be flood tolerant and there is ample evidence of active recruitment. Therefore, the Project is not likely to significantly impact the viability and population of this species.

Summary

Overall, the two potential risks of the Project to the first World Heritage criterion and its component values of the GBMWHA are to the Narrow-leaved *Ironbark - Forest Red Gum on rocky slopes of the lower Burragorang Gorge Sydney Basin Bioregion* and *Eucalyptus benthamii.* Three key mitigation measures are proposed to minimise impacts of the Project on biodiversity (refer Section 13). These would reduce or offset the impacts of the Project on biodiversity.

12.1.2 Criterion (x): significant natural habitats for the in-situ conservation of biological diversity

The second criterion that the GBMWHA was listed for is:

> ***Criterion (x):*** *The site includes an outstanding diversity of habitats and plant communities that support its globally significant species and ecosystem diversity (152 plant families, 484 genera and c. 1,500 species). A significant proportion of the Australian continent's biodiversity, especially its scleromorphic flora, occur in the area. Plant families represented by exceptionally high levels of species diversity here include Myrtaceae (150 species), Fabaceae (149 species), and Proteaeceae (77 species). Eucalypts (Eucalyptus, Angophora and Corymbia, all in the family Myrtaceae) which dominate the Australian continent are well represented by more than 90 species (13% of the global total). The genus Acacia (in the family Fabaceae) is represented by 64species. The site includes primitive and relictual species with Gondwanan affinities (Wollemia, Pherosphaera, Lomatia,*

Dracophyllum, Acrophyllum, Podocarpus and Atkinsonia) and supports many plants of conservation significance including 114 endemic species and 177 threatened species

The diverse plant communities and habitats support more than 400 vertebrate taxa (of which 40 are threatened), comprising some 52 mammal, 63 reptile, over 30 frog and about one third (265 species) of Australia's bird species. Charismatic vertebrates such as the platypus and echidna occur in the area. Although invertebrates are still poorly known, the area supports an estimated 120 butterfly and 4,000 moth species, and a rich cave invertebrate fauna (67 taxa).

The Project would result in the temporary inundation of 16 PCTs. This would have varying impacts depending upon the location of the PCTs in the landscape (which determines the depth and duration of temporary flooding), the frequency of events and the flood tolerance of individual species within each PCT. As well as the PCTs forming individual ecosystems, they also provide habitat for threatened and other flora and fauna species. The presence of many threatened species has been assumed as the survey requirements to conclusively determine whether a threatened species is present and its distribution within the study area were considerable. None of the threatened species are found only in the area of the GBMWHA potentially affected by the Project, and would be assumed to occur in adjacent areas or other areas in the region. Fauna species are generally motile, while there would be some impacts on their habitat, there would generally not be significant direct mortality from the operation of Project. Flora species however would experience relatively greater impacts from the Project.

Within the upstream impact area in the GBMWHA, potential habitat for 20 threatened flora species has been identified, however, for 12 of these species the actual potential habitat area is small (less than 25 hectares). For the remaining threatened flora species, the area of potential habitat in this area is greater than 25 hectares. However, these species are typically found in woodland habitats of which significant intact areas would remain unaffected by the Project in adjacent areas.

Within the upstream impact area in the GBMWHA, potential habitat for 10 threatened fauna species has been identified. Most of these species are found in woodland habitats of which significant intact areas would remain unaffected by the Project in adjacent areas.

12.1.3 Integrity values

The Statement of Integrity identifies a number of values that individually and holistically contribute to the overall World Heritage value of the GBMWHA. Comment with regard to these individual values is provided as follows.

Size and extent of the GBMWHA

The Statement of Integrity notes that

The seven adjacent national parks and single karst conservation reserve that comprise the GBMA are of sufficient size to protect the biota and ecosystem processes…

The Project would potentially affect an area of 304 hectares of the GBMWHA upstream of Warragamba Dam within the upstream impact area, or about 0.03 percent of the total area of the GBMWHA.

Downstream of Warragamba Dam, there would be a reduction in the area of the GBMWHA affected compared to the current situation, equating to about 18 hectares for the PMF event. For the 1 in 100 chance in a year event, the reduction in the affected area would be about 29.5 hectares.

While temporary inundation upstream associated with operation of the FMZ would affect the GBMWHA (part of which is already affected by the existing dam), this would not affect the size or extent of the GBMWHA.

Wilderness quality

The Statement of Integrity notes that

Most of the natural bushland of the GBMA is of high wilderness quality and remains close to pristine. The plant communities and habitats occur almost entirely as an extensive, largely undisturbed matrix almost entirely free of structures, earthworks and other human intervention. Because of its size and connectivity with other protected areas, the area will continue to play a vital role in providing opportunities for adaptation and shifts in range for all native plant and animal species within it, allowing essential ecological processes to continue.

The areas of the GBMWHA potentially affected by the Project are associated mostly with Nattai National Park adjacent to the Wollondilly River and Nattai River. Other small areas potentially affected occur up the Kedumba River,

Butchers Creek, Green Wattle Creek and Lacys Creek. All of these areas occur at the fringes of the GBMWHA which are already subject to influences from adjoining land uses and would likely not be regarded as areas of significant wilderness value, particularly with reference to the values applying to areas designated as wilderness under the *Wilderness Act 1987* (refer Section 6.1.7).

Geological structure, geomorphology and water systems

The Statement of Integrity notes that

> *The area's integrity depends upon the complexity of its geological structure, geomorphology and water systems, which have created the conditions for the evolution of its outstanding biodiversity and which require the same level of protection.*

The World Heritage nomination (Government of Australia 1998) identifies geo-diversity as contributing significantly to the unique character of the area, and provides a number of examples of this geo-diversity including:

- extensive dissected sandstone plateaux representing ongoing geological processes
- bottleneck valleys resulting from the downfolding of the resistant Hawkesbury Sandstone at the Lapstone Monocline
- palaeontological sites including evidence of the once widespread Gondwanan flora
- prominent basalt-capped peaks and other significant features associated with periods of volcanic activity
- Quaternary alluvial deposits which support significant heath and woodland vegetation with an unusual mix of species and plant communities
- hanging swamps reflecting the relatively low permeability of the Hawkesbury Sandstone and sandstones of the Narrabeen Group.

The additional temporary inundation associated with the Project would occur immediately adjacent to Lake Burragorang and would not affect these areas, and accordingly would not affect geological processes that could change the geological structure of the GBMWHA.

The geomorphology assessment carried out for the Project (Appendix N2 Geomorphology Technical Assessment) included consideration of potential erosion risks in the catchment upstream of Warragamba Dam. This identified that the potential for an increase in erosion risk was low and was associated with relatively more frequent flood events such as the 1 in 5 chance in a year and 1 in 10 chance in a year events which for the latter, would affect only about an additional 166 hectares or about 0.02 percent of the total area of the GBMWHA upstream of Warragamba Dam. The geomorphology assessment also identified that the section of the Warragamba River downstream of the dam to the confluence with the Nepean River had a low fragility and moderate recovery potential; about two kilometres metres of this reach borders part of the GBMWHA. Overall, the Project is considered unlikely to have a material effect on geomorphological processes that could affect the geomorphology of the GBMWHA.

The GBMWHA protects a large number of pristine and relatively undisturbed catchment areas, some of which make a substantial contribution to maintaining high water quality in a series of water storage reservoirs supplying Sydney and adjacent rural areas. They also make an important contribution to the maintenance of water quality and natural flow regimes in the Hawkesbury-Nepean and Goulburn-Hunter river systems. The Project would not have a significant impact on water quality in Warragamba Dam or other parts of the Hawkesbury-Nepean River.

Aboriginal cultural heritage

The Statement of Integrity notes that

> *An understanding of the cultural context of the GBMA is fundamental to the protection of its integrity. Aboriginal people from six language groups, through ongoing practices that reflect both traditional and contemporary presence, continue to have a custodial relationship with the area. Occupation sites and rock art provide physical evidence of the longevity of the strong Aboriginal cultural connections with the land. The conservation of these associations, together with the elements of the property's natural beauty, contributes to its integrity*.

About 40 percent of the GBMWHA potentially impacted by the Project was surveyed. A synopsis of the findings of the assessment relevant to Aboriginal cultural heritage (Appendix K – Aboriginal Cultural Heritage Assessment (ACHA)) is presented as follows.

- Forty-three (43) archaeological sites were identified in the GBMWHA within the upstream study area (i.e. between FSL and the Project PMF); all sites were identified as being of high cultural significance through consultation with Aboriginal stakeholders
- Twenty (20) sites were identified between FSL and the upstream impact area; three were identified as being of high scientific significance, one as moderate scientific significance, and the remainder as low scientific significance
- Eight (8) sites were identified in the upstream impact area; one was identified as being of high scientific significance and the remainder as low scientific significance
- Fifteen (15) were identified between the upstream impact area and the upstream study area boundary; one was identified as being of high scientific significance and the remainder as low scientific significance
- Thirty-three (33) of the potentially affected sites are open camp sites with 19 of these being located below the upstream impact area, and four of these being of 'High' or 'Moderate' scientific significance; other types of sites are resource gathering, isolated artefacts, axe grinding grooves, shelters with artefacts/deposits and shelters with art
- Art sites are generally the most vulnerable to temporary inundation impacts as the water may degrade the drawing materials; there is only one identified art site in the GBMWHA, this being located above the upstream impact area with the archaeological assessment identifying that there would be no loss of value to this site
- The materials at the other sites are generally rock (that is, artefacts, axe grinding grooves) and would not be directly affected by temporary inundation, however indirect impacts such as changes in erosion and deposition of sediments may affect the integrity and access to the sites
- The assessment has identified a potential total loss of value for sites between FSL and the upper extent of the upstream impact area
- There is potential for other sites to occur within areas that have not been surveyed.

As noted, the survey effort for the Project included about 40 percent of the GBMWHA within the upstream study area. The ACHA report contains an assessment of the number of potential Aboriginal heritage sites based upon the representative survey undertaken (which was 27 percent of the upstream study area) and included land outside the GBMWHA (see Section 11.2 of Appendix K to the EIS). As the majority of the GBMWHA potentially impacted by the Project is adjacent to the Wollondilly and Nattai Rivers, and the soil landscapes are consistent within the PMF event extents in these locations, the number and type of sites in the area not surveyed would be consistent with areas surveyed. Therefore, there could be potentially another nine sites in the GBMWHA that may experience temporary inundation due to Project. However, based on the survey results, these would generally be of low scientific significance and likely to be open camp sites.

Section 6.4 of the World Heritage nomination report (Government of Australia 1998) identifies a total of 691 known Aboriginal heritage sites in the national parks within the Greater Blue Mountains Area, and provides a breakdown by site type and national park. This was the known number of sites around 1988 and this would have increased since then as a result of other investigations, including the Project which identified 303 new sites within the Project study area. Of the 691 known sites, 421 sites are in areas of national parks outside of the Project study area.

The Project has assumed a total loss of values within the upstream impact of which 304 hectares occurs within the GBMWHA. While this scale of impact may not be actually realised, on the assumption of total loss of values, this would result in a diminution of Aboriginal cultural heritage values (loss of 43 sites) and therefore a potential impact of the Project on the integrity value of the Outstanding Universal Value of the GBMWHA with regard to Aboriginal cultural heritage.

12.2 Assessment against matters of national environmental significance

The EPBC Act contains impact assessment guidelines specifically for potential impacts on World Heritage areas. There are three criteria relating to World Heritage and these are assessed against the potential impacts of the Project in Table 12-1.

Table 12-1. Assessment of the potential impacts of the Project against World Heritage significant impact criteria

Criterion	Assessment
An action is likely to have a significant impact on the World Heritage values of a declared World Heritage property if there is a real chance or possibility that it will cause:	
One or more of the World Heritage values to be lost.	The Project would not result in the loss of one or more World Heritage values. The Project only impacts a small area of the GBMWHA and the considerable diversity of Eucalypts, flora and fauna would remain in other areas not impacted by the Project. While there is potential for an incremental impact on Aboriginal cultural heritage in the GBMWHA, this would be a diminution rather than a loss of value.
One or more of the World Heritage values to be degraded or damaged.	The Project may result in one or more of the World Heritage values being degraded or damaged, namely Criterion x. The biodiversity assessment identified the potential for the loss of biodiversity values but noted uncertainty around the specific nature and degree of impacts. Mitigation measures such the Warragamba Offset Program and the other mitigation measures detailed in EIS Chapter 29 (EIS synthesis, Project justification and conclusion), and including the National Parks EMP required under the *Water NSW Act 2014*, would ensure that any degradation or damage to World Heritage values is rehabilitated, and the overall values of the GBMWHA are maintained in the longer term.
One or more of the World Heritage values to be notably altered, modified, obscured or diminished.	The Project would not notably alter, modify, obscure or diminish the World Heritage values. The Project would potentially impact only a very small area of the GBMWHA (304 hectares in the upstream impact area) and the considerable diversity of Eucalypts, flora and fauna would remain.

DAWE has already determined that the Project would have a potential significant impact on the GBMWHA and has determined the Project to be a controlled action under the EPBC Act. The SEARs (which contain the Australian Government assessment requirements) state that:

Where a significant residual adverse impact to a World Heritage property and/or a National Heritage place is considered likely the EIS must provide information on the proposed offset strategy. The offset strategy must:

i. include a discussion and supporting evidence of the conservation benefit associated with the proposed offset strategy. The conservation benefit must demonstrate, at a minimum, how the proposed offset will improve the integrity and resilience of the heritage values of the impacted heritage place or property; and

ii. be consistent with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offset Policy (2012)

While some impacts of the Project on the GBMWHA would be able to be mitigated or minimised, some impacts would not able to mitigated or minimised and consequently offsets are required. Mitigation measures and offsets are further discussed in Section 13.

13 Mitigation measures and offsets

Presented in the following sections are relevant mitigation measures and offsets to the GBMWHA. This comprises:

- the offset strategy for protected lands values comprising principally the BOS and the Warragamba Offset Program
- the National Parks Environmental Management Plan
- further research and monitoring
- Aboriginal cultural heritage mitigation measures
- other mitigation measures.

13.1 Overview

The proposed Warragamba Offset Program (described in Appendix F6 and Chapter 13) is the vehicle for offsetting the potential impacts of the Project in the upstream study area. The cornerstone of the Program is the Biodiversity Offset Strategy (BOS) required to be prepared under the NSW Framework for Biodiversity Assessment (FBA). The objective of the BOS is to provide a framework for the delivery of offsets for the potential impacts of the Project related to the upstream study area and the construction study area which were assessed in accordance with the FBA.

The BOS would also facilitate achievement of a long-term conservation gains for the threatened species, populations and communities, and biodiversity-related matters with regard to national parks and World Heritage values impacted by the Project. The BOS includes the biodiversity offsets required under the FBA and set out in the SEARs, and offsets addressing potential loss of biodiversity-related World Heritage and national park values.

The Warragamba Offset Program also encompasses non-biodiversity matters such as:

- geodiversity
- water catchment protection
- cultural heritage
- landscape, natural beauty and aesthetic values
- recreation and visitor use
- social and economic benefits derived from visitation to these areas.

13.2 Biodiversity Offset Strategy and Warragamba Offset Program

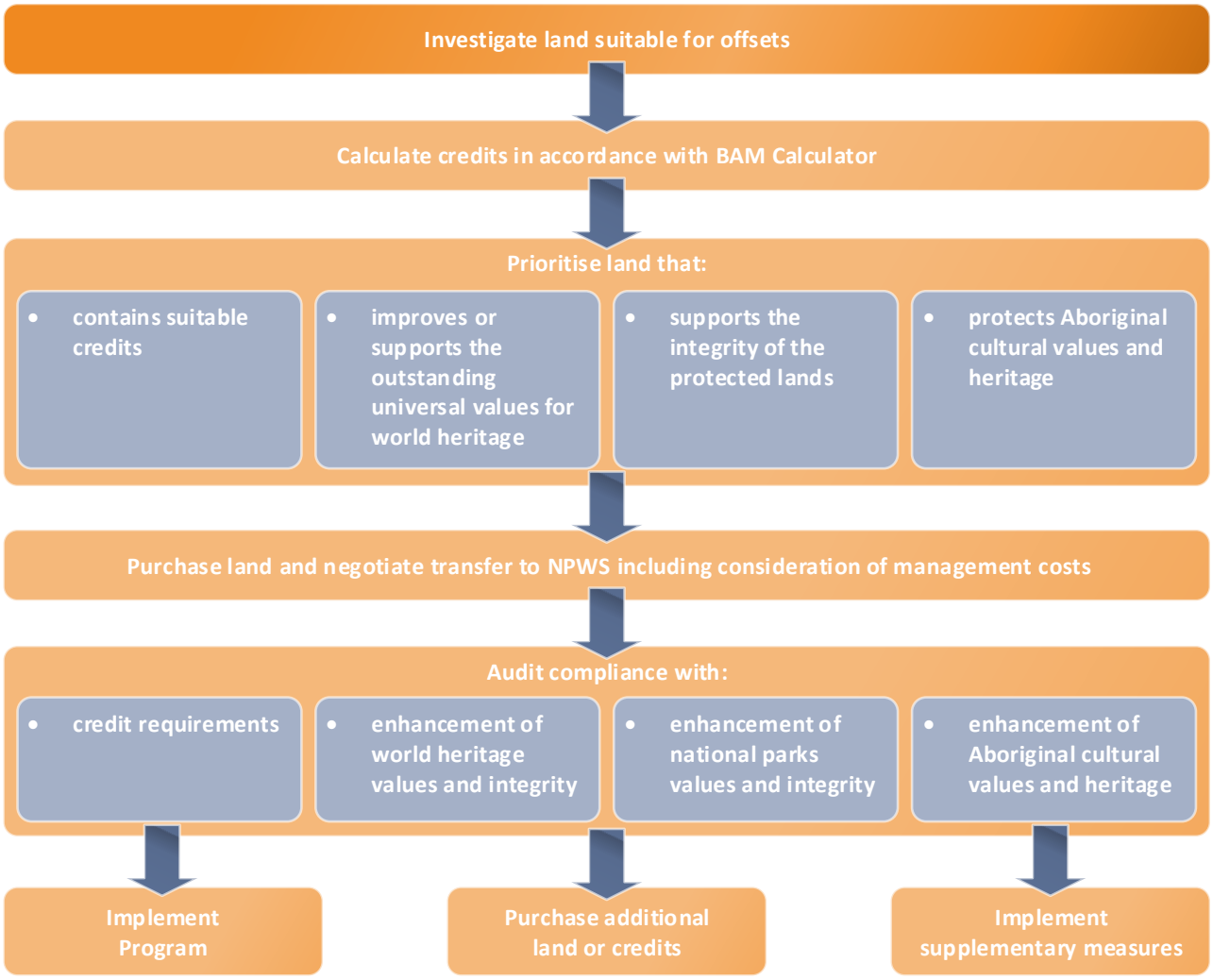
Mitigation and management of potential impacts of the Project on biodiversity values of the GBMWHA would be addressed through the BOS. As noted above, the BOS is the key component of the Warragamba Offset Program which is focussed principally on the upstream area and has the following objectives:

- to identify, purchase and manage additional appropriate land to offset any impacts on biodiversity
- undertake additional supplementary management actions which may contribute to the protection and enhanced survival of threatened species. These actions would comply with National and State threatened species recovery plans and could include breeding programs, seeding and propagation programs, disease management and research
- where possible, ensure that any land purchased would be suitable for inclusion in National Parks and the GBMWHA.

The Warragamba Offset Program would include specific actions which, when implemented, would offset for the potential impacts of the Project within the upstream study area. The proposed approach to implementing the Warragamba Offset Program is shown in Figure 13-1.

It should be noted that while the Warragamba Offset Program will prioritise land suitable for inclusion in the National Park estate additional offsets may be needed through purchase and retirement of biodiversity credits in order to meet the credit requirements for the project. Any land containing suitable offsets must also be appropriate for the National Park estate and supported by NPWS for this purpose. It is intended that as a minimum the quantum of land required to compensate for impact on National Parks (including the affected part of the GBMWHA) will be equivalent to or greater than the area impacted (1,400 hectares) and that this would incorporate a minimum area of 304 hectares containing OUV values to offset potential impacts to the GBMWHA.

Figure 13-1. Summary of the proposed approach to implementing the Warragamba Offset Program



13.2.1 Timing of offset program implementation

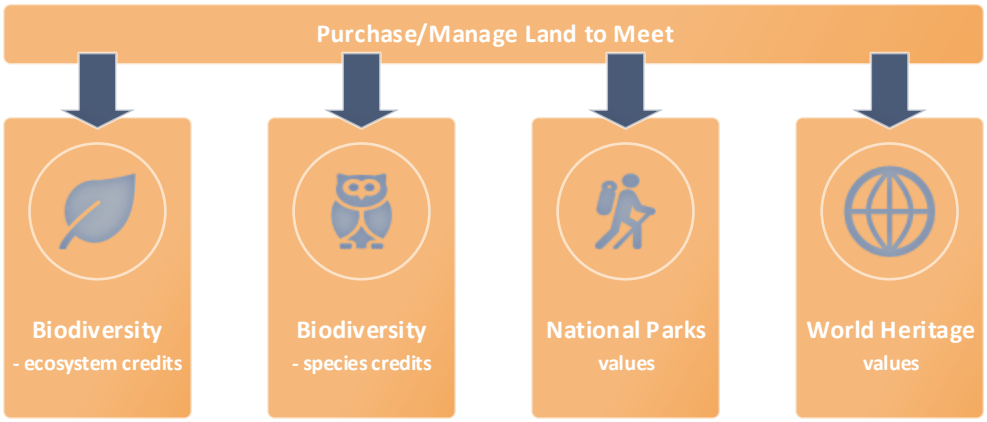
The Warragamba Offset Program for upstream impacts will be implemented prior to Project operation.

13.2.2 Assessment of offset site options

The Warragamba Offset Program would investigate the suitability of potential offset sites. This process would involve:

- Initial desktop assessment to identify land which potentially contains plant community types, and species credit species habitat which meet the requirements of like-for-like, or allowable under the variation rules, in order to identify potential offset sites
- Ground truth the identified potential offset sites for suitable PCTs and species credit species habitat. Targeted surveys may be required to determine presence of species credit species within the potential offset sites
- Determine if areas of selected land are suitable for inclusion into national parks and World Heritage estate and add to the integrity of the world heritage area or protected land estate. Suitable lands may include freehold lands and properties within or immediately adjacent to the national parks and world heritage areas. Figure 13-2 illustrates the goal of the Warragamba Offset Program to target offset sites that meet both biodiversity and protected lands goals.
- Select offset sites and carry out necessary assessment and reporting consistent with establishing a Biodiversity Stewardship Agreement.
- Assessment will be carried out by an accredited person under the BC Act.

Figure 13-2. Targeting of offsets



13.2.3 Establishment of offsets

It is proposed that the priority for the Warragamba Offset Program will be purchase of land suitable for inclusion in the National Park and protected areas system potentially included within the World Heritage area. This is consistent with the potential impacts of the project occurring within the National Park system. WaterNSW would work with NPWS to ensure that the land is suitable for inclusion and that costs of management of the lands to ensure the offset is delivered is appropriately considered in the Warragamba Offset Program.

The implementation of the Warragamba Offset Program will be audited to measure progress towards providing the required biodiversity credits and improvements to the protected lands system and world heritage values. Should additional offsets be required the following actions would be considered:

- purchase of additional land
- purchase and retirement of credits from the credit market
- implementation of supplementary measures that achieve benefits for species and communities potentially impacted by the project or benefit the management of the protected lands system or the integrity of world heritage values. The final suite of supplementary measures would meet the 18 rules governing the use of supplementary measures under the NSW Biodiversity Offsets Policy for Major Projects.

Potential supplementary measures may include species specific actions recommended within the NSW Saving our Species program and commonwealth recovery plans; actions that contribute to threat abatement programs; biodiversity research and survey programs; actions that promote protection of world heritage values within the regional community.

The Warragamba Offset Program would materially contribute to the maintenance and enhancement of the biodiversity values that form part of the Outstanding Universal Value of the GBMWHA.

13.3 National Parks Environmental Management Plan

The *Water NSW Act 2014* establishes the powers and functions of WaterNSW and allows areas associated with water supply to be declared as special or controlled areas. These areas may include the catchment of water storages or other land used for water supply purposes (for example, pipeline and dam sites).

In 2018, an amendment to the *Water NSW Act 2014* was enacted which related specifically to the Project and the potential impacts of temporary inundation on national parks estate in the Warragamba Dam catchment. The amendment provided a special provision to allow the temporary inundation of national park land in the Warragamba Dam catchment.

Under section 64C of the *Water NSW Act 2014*, WaterNSW is required to develop and implement an EMP for the upstream operational area related to the temporary inundation of national park land resulting from the Warragamba Dam Project. The EMP will be separate to the proposed Warragamba Offset Program but will complement and support the Program.

To ensure the mitigation of any impacts from temporary inundation, the special provisions also require:

- WaterNSW to prepare an EMP in consultation with the Chief Executive of OEH 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 to implement and monitor the EMP.
- Water NSW to notify the Chief Executive of 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.

The scope and content of the National Parks EMP have yet to be defined but would be consistent with the existing management plans for the national parks and the GBMWHA. The National Parks EMP would contribute to the maintenance and strengthening of protected lands values.

The National Parks EMP would be prepared in consultation with the NPWS (and require approval from the Minister administering the *National Parks and Wildlife Act 1974*). Other stakeholders such as the GBMWHA Management Committee and GBMWHA Advisory Committee would also be consulted. Funding for the EMP would be additional to the current funds used for management activities and would be agreed once the scope and requirements of the EMP are determined.

13.4 Further biodiversity research and monitoring

As noted in previous sections, there is a lack of knowledge about the impacts to Blue Mountains plant species and vegetation communities from temporary inundation, and also the presence of threatened species in the potentially impacted area. This has resulted in a very conservative assessment of potential impacts to biodiversity in the upstream area. To refine and improve the understanding of potential impacts from the Project further monitoring, survey and research could be undertaken including:

- work to improve the mapping of plant communities, particularly threatened or endangered plant communities
- work to determine the presence or absence of threatened or endangered flora and fauna species, and their location and use of the landscape
- field monitoring of plant communities and species (and other environmental variables) to assess their responses to temporary inundation
- further research into the impact of temporary inundation on biodiversity.

It is envisaged that these activities would remove some of the conservative assumptions used in the current biodiversity and World Heritage assessment and improve the effectiveness of any management action in the EMP.

13.5 Cumulative impacts

Chapter 28 of the EIS assesses potential cumulative impacts of the Project in relation to other major projects or projects in close proximity. These have been considered for both construction and operation phases. It is considered highly unlikely that there would be any material cumulative impacts of the Project on the GBMWHA related to the construction phase.

With regard to the operational phase of the Project:

- No known projects of significant scale or degree of impact to biodiversity values that warranted cumulative impact assessment were identified for the upstream study area
- Upstream of Warragamba Dam, flooding and hydrological changes resulting from the Project include a temporary increase in flood inundation extent and longer duration of flooding, notably in the flood mitigation zone. There are no other known projects likely to contribute to these potential impacts

- The upstream study area largely comprises protected lands with limited access. Therefore, pressures on Aboriginal heritage sites of the area are largely from broader, regional threats, notably bushfire and encroaching urban development at the fringes
- Other developments in the region have noted potential indirect impacts to protected lands including the GBMWHA, notably the Western Sydney International Airport which identified potential indirect impacts relating to noise, air quality, Aboriginal heritage and visual amenity
- No major projects or other projects were identified that would result in cumulative social impacts in the upstream study area. However, the Project itself could contribute to cumulative social impacts relating to:
  - potential loss or changes to biodiversity values and associated amenity
  - potential impacts to the Greater Blue Mountains World Heritage area and associated amenity
  - potential impacts to national park estates and state conservation areas and associated amenity
  - visual amenity.

In view of the above, there is considered to be some potential for cumulative impacts on the GBMWHA, however it is considered unlikely that these would be significant.

13.6 Aboriginal cultural heritage

The ACHA report (Appendix K to the EIS) proposed the following recommendations which would also apply to Aboriginal cultural heritage sites in the GBMWHA:

- WaterNSW should continue consultation and engagement with the Registered Aboriginal Parties for the duration of the Project
- An Aboriginal Cultural Heritage Management Plan (ACHMP) should be developed for the Project. The ACHMP should be developed and managed in consultation with the RAPs and relevant regulatory authorities. The ACHMP should include, but not be limited to the following:
  - Protocols for the involvement of the RAPs in cultural heritage investigations conducted under the ACHMP.
  - A communications protocol that describes clear methods of communication and expectations between the Parties to the plan.
  - Procedures for the management and reporting of previously unknown Aboriginal heritage sites that may be identified during the life of the Project.
  - A regular review process for the ACHMP.
  - The inclusion of site Warragamba-288 (AHIMS ID #pending) in the ACHMP
- The ACHMP should be written so as to manage the recommendations below.
- The unsurveyed portion of the PUIA should be surveyed well prior to construction should the Project be approved
- The unsurveyed portion of the area above the PUIA should be sample surveyed to identify sites and places of high significance prior to construction should the Project be approved
  - For recommendations 4 and 5 survey should include provision for detailed recording of all shelter sites, including 3D photogrammetry, planning, detailed photography and scale drawing of any art or other features present
- Further detailed impact assessment of all Aboriginal cultural heritage sites and places that are located within the Project PUIA, and sites of high significance in the area above the PUIA should be completed. The detailed assessment should include, but not be limited to:
  - Further detailed assessment of potential impacts through detailed recording of site or place elevation
  - Site or place-specific hydrological modelling (expected frequency and duration of inundation at the specific site or place location)
  - An informed impact assessment to guide further management strategies (assessing risks of erosion, for example).
  - Depending on the outcomes of site-specific assessment
    - Test excavation be completed at those rockshelter sites and open sites with sufficient soil profiles to understand the potential of archaeological deposit
    - Appropriately detailed analysis of any artefacts or samples recovered during test excavations
    - Appropriate recording of axe grinding grooves, engraving sites or other open sites

- Prior to the operation of the Project, WaterNSW will review its assessment processes for works within the upstream catchment to include awareness to personnel undertaking an activity on its behalf of any potential Aboriginal cultural heritage values and objects in the area.
- Protocols for heritage awareness training to be incorporated into the site inductions for both employees and sub-contractors involved in the construction of the Project, operation of the dam and activities in the catchment of Lake Burragorang. Registered Aboriginal Parties should be involved in the development and presentation of the cultural awareness training.

Additional recommendations made in the cultural values assessment (Appendix 11 to the ACHA report) are as follows:

- Recommendation 1: Develop a cultural heritage awareness and cultural competency training package to be delivered to all WaterNSW staff. The training package should include a site-specific module developed in consultation with the relevant Aboriginal communities and RAPs.
- Recommendation 2: Develop a formal agency-specific process and policy for undertaking cultural heritage assessments and engaging with the Aboriginal community in line with those developed by other state government agencies. This process aims to:
  - embed early and ongoing engagement with the Aboriginal community in relation to the development and ongoing management of WaterNSW projects
  - provide clear trigger points for differing levels of engagement and assessment in response to Aboriginal community concerns and expressions of cultural value.
- Recommendation 3: Consider engaging an in-house archaeological specialist support in line with other state government agencies
- Recommendation 4: An Aboriginal Heritage Management Plan (AHMP) should be prepared and implemented as part of the Construction Environmental Management Plan (CEMP). The AHMP should provide specific guidance on measures and controls to be undertaken to avoid and mitigate impacts on Aboriginal cultural heritage during construction. This should include protection measures to be applied during construction, including but not limited to the recommendations set out in this table, as well as contractor training in general Aboriginal cultural heritage awareness and management of Aboriginal heritage values
- Recommendation 5: The site-specific Aboriginal cultural heritage awareness training package to be delivered as part of the site induction for all contractor(s) and maintenance personnel involved in the construction works and ongoing site management. The training package should at a minimum ensure awareness of the cultural significance of the Study area, the requirements of the AHMP and relevant statutory responsibilities, and the identification of unexpected heritage items and appropriate management procedures.
- Recommendation 6: Detailed archaeological recording (including photographic record) of all known archaeological sites within the PUIA [upstream impact area] and of all art sites within the PMF. Photographic recording should include the landscape context of sites and sites complexes, not just Aboriginal objects in isolation, to order to capture the combined cultural and archaeological values.
- Recommendation 7: An independent facilitator to work with the RAPs and the wider Aboriginal community to develop an Aboriginal advisory group to guide the implementation of Recommendations 8 to 11.
- Recommendation 8: WaterNSW to facilitate bi-annual on-country visits open to Aboriginal community members with cultural connections to the area.
- Recommendation 9: In consultation with the RAPs and the Aboriginal community, develop interpretative materials on the Aboriginal cultural values and history of the cultural landscape of the Project area including:
  - a permanent exhibition at the Warragamba Dam Visitor Centre
  - interpretative signage and audio posts within the Warragamba Dam grounds
  - facilitating the provision of Aboriginal-led cultural events (i.e. tours and talks) through the Warragamba Dam Visitor Centre.
- Recommendation 10: In consultation with the RAPs and the Aboriginal community, develop a cultural values project to record the Gurrangatch-Mirrigan Dreaming Story route through the photographic recording of specific cultural locations within the Study area (prior to any further impacts), oral history recordings with Aboriginal community members, and documentary research.
  The project outcomes to be developed in consultation with the proposed Aboriginal advisory group but could include:
  - published booklets

  - website content
  - interpretative signage
  - audio post content
  - educational packages
  - public art installations.
- Recommendation 11: In consultation with the RAPs and the Aboriginal community, undertake a heritage study of the Aboriginal traditional and historical occupation of the Study area through photographic recording of specific sites (prior to any further impacts), historical documentary research, and oral history interviews. The project outcomes to be developed in consultation with the proposed Aboriginal advisory group but could include:
  - published booklets
  - website content
  - interpretative signage
  - audio post content
  - educational packages.

The Integrity statement for the inscription of the GBMWHA on the World Heritage list includes the following statement:

> *An understanding of the cultural context of the GBMA is fundamental to the protection of its integrity. Aboriginal people from six language groups, through ongoing practices that reflect both traditional and contemporary presence, continue to have a custodial relationship with the area.*

The above recommendations specifically target intergenerational equity matters for the Aboriginal community and would support the ongoing protection of the integrity of the cultural matters that form part of the values of the GBMWHA.

13.7 Other mitigation measures

A range of other mitigation measures relating to soils, water quality, visual impacts and access would be implemented in the upstream areas including in the GBMWHA. The relevant assessment reports and EIS chapters contain other mitigation measures. The full list of mitigation measures is provided in Chapter 29 of the EIS (EIS synthesis, Project justification and conclusion).

13.8 Overall summary

While the Project could potentially impact the GBMWHA, these impacts would not be significant and would not result in a material loss or degradation of the Outstanding Universal Value of the GBMWHA as:

- the upstream impact area comprises 0.03 percent of the total area of the GBMWHA; the remaining 99.97 percent would not be affected by the Project
- comprehensive mitigation, monitoring and offsetting measures have been identified which would ensure that any impacts on the GBMWHA are minimised, detected and rehabilitated, and which would contribute to the maintenance and enhancement of the Outstanding Universal Value of the GBMWHA.

Overall the Project is not considered to be inconsistent with the management obligations and principles for World Heritage properties specified in the World Heritage Convention and the EPBC Act.

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Appendix A Environment Protection and Biodiversity Conservation Regulations 2000 - Schedule 4

Matters to be addressed by draft public environment report and environmental impact statement

1 General information

1.01 The background of the action including:

(a) the title of the action;

(b) the full name and postal address of the designated proponent;

(c) a clear outline of the objective of the action;

(d) the location of the action;

(e) the background to the development of the action;

(f) how the action relates to any other actions (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action;

(g) the current status of the action;

(h) the consequences of not proceeding with the action.

2 Description

2.01 A description of the action, including:

(a) all the components of the action;

(b) the precise location of any works to be undertaken, structures to be built or elements of the action that may have relevant impacts;

(c) how the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts;

(d) relevant impacts of the action;

(e) proposed safeguards and mitigation measures to deal with relevant impacts of the action;

(f) any other requirements for approval or conditions that apply, or that the proponent reasonably believes are likely to apply, to the proposed action;

(g) to the extent reasonably practicable, any feasible alternatives to the action, including:

(i) if relevant, the alternative of taking no action;

(ii) a comparative description of the impacts of each alternative on the matters protected by the controlling provisions for the action;

(iii) sufficient detail to make clear why any alternative is preferred to another;

(h) any consultation about the action, including:

(i) any consultation that has already taken place;

(ii) proposed consultation about relevant impacts of the action;

(iii) if there has been consultation about the proposed action--any documented response to, or result of, the consultation;

(i) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views.

3 Relevant impacts

3.01 Information given under paragraph 2.01(d) must include:

(a) a description of the relevant impacts of the action;

(b) a detailed assessment of the nature and extent of the likely short term and long term relevant impacts;

(c) a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;

(d) analysis of the significance of the relevant impacts;

(e) any technical data and other information used or needed to make a detailed assessment of the relevant impacts.

4 Proposed safeguards and mitigation measures

4.01 Information given under paragraph 2.01(e) must include:

(a) a description, and an assessment of the expected or predicted effectiveness of, the mitigation measures;

(b) any statutory or policy basis for the mitigation measures;

(c) the cost of the mitigation measures;

(d) an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing;

(e) the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program;

(f) a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including mitigation measures proposed to be taken by State governments, local governments or the proponent.

5 Other approvals and conditions

5.01 Information given under paragraph 2.01(f) must include:

(a) details of any local or State government planning scheme, or plan or policy under any local or State government planning system that deals with the proposed action, including:

(i) what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy;

(ii) how the scheme provides for the prevention, minimisation and management of any relevant impacts;

(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action;

(c) a statement identifying any additional approval that is required;

(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.

6 Environmental record of person proposing to take the action

6.01 Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against:

(a) the person proposing to take the action; and

(b) for an action for which a person has applied for a permit, the person making the application.

6.02 If the person proposing to take the action is a corporation--details of the corporation's environmental policy and planning framework.

7 Information sources

7.01 For information given in a draft public environment report or environmental impact statement, the draft must state:

(a) the source of the information; and

(b) how recent the information is; and

(c) how the reliability of the information was tested; and

(d) what uncertainties (if any) are in the information.

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