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Environmental Impact Statement – Chapter 28: Cumulative impacts and interactions

Warragamba Dam Raising

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Prepared for WaterNSW
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28 Cumulative impacts

This chapter provides an assessment of cumulative impacts of the proposed Warragamba Dam Raising Project (the Project). The relevant Secretary's environmental assessment requirements (SEARs) are shown in Table 28-1.

Table 28-1. Secretary's Environmental Assessment Requirements: Cumulative impacts

Desired performance outcomes	Secretary's Environmental Assessment Requirements[1]	Where addressed
2. Environmental impact statement The project is described in sufficient detail to enable clear understanding that the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.	1. The EIS must include, but not necessarily be limited to, the following: (n) an assessment of cumulative impacts of the project taking into account other projects that have been approved but where construction has not commenced, projects that have commenced construction, and projects that have recently been completed.	This chapter

1. This chapter specifically addresses SEAR 2 in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1-1).

Potential environmental impacts of a project on a receptor or resource considered in isolation may not be deemed significant. However, the level of the impact may increase when individual project impacts are considered collectively, either for the same project or together with other projects.

The assessment of cumulative impacts included consideration of:

- the Project in conjunction with other major projects that have been approved by the NSW and/or Commonwealth Governments for which construction:
  - has not commenced
  - has commenced
  - has been recently completed.
- potential Project impacts identified for specific environmental or social aspects that may affect the same receptor(s).

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

28.1 Cumulative impact assessment scope

The cumulative impact assessment builds on the detailed assessment of impacts for environmental and social aspects presented in Chapters 7 to 27 of this EIS.

A review was undertaken to identify other major projects and developments with the potential to interact with the Warragamba Dam Raising Project.

The potential for a project to be considered for cumulative impacts was determined through consideration of:

- its location relevant to the Project study area
- timeframe – for example, project activity concurrent with Warragamba Dam Raising construction
- scale – size of project and potential impacts.

Through this review it was determined that the greatest potential for cumulative impacts would be projects within the upstream study area that may result in impacts to biodiversity; projects related to water infrastructure proposed along the Warragamba River or Nepean River; and State significant development or infrastructure projects proposed

in western Sydney. The assessment has also considered major long-term infrastructure development strategies and initiatives for the western Sydney region.

2019-2020 bushfires

New South Wales experienced severe bushfires starting in June 2019, continuing through to early 2020, and which affected part of the Project study area within the catchment of Lake Burragorang. The extent and severity of the bushfire event is shown in Figure 28-1. This mapping is based on the fire extent and severity map (FESM) developed by the Department of Planning, Infrastructure and Environment's (DPIE) Remote Sensing and Regulatory Mapping team in collaboration with the Rural Fire Service (RFS). 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 FESM classifies the fire severity into five burn severity classes. A description of each class, and the approximate extent of each burn severity classes within the upstream study area is provided in Table 28-2. This shows that only about 14 percent of the upstream study area experienced burning classed as 'High' or 'Extreme'.

Table 28-2. FESM burn severity classes and approximate burn extent within the upstream study area

Severity class	Description	Percent foliage fire affected	Approximate extent within the upstream study area (% of upstream study area)
Unburnt	Unburnt surface with unburnt canopy	0% canopy and understory burnt	26.9%
Low	Burnt understory with unburnt canopy	>10% burnt understory >90% green canopy	35.6%
Moderate	Partial canopy scorch	20-90% canopy scorch	27.7%
High	Full canopy scorch/partial consumption	>90% canopy scorched <50% canopy consumed	5.3%
Extreme	Full canopy consumption	>50% canopy biomass consumed	4.5%

From Figure 28-1 it can be seen that the more severely burnt areas occur largely away from the immediate Project study area. Within the upstream study area, the relatively greatest affected areas occur along the Wollondilly River, Kedumba River, Green Wattle Creek and Butchers Creek.

The effects of these bushfires on the environment are not yet fully understood. However, with regard to the Project, the bushfires have the potential to have a cumulative effect on the Project impacts, particularly in relation to biodiversity and Aboriginal heritage in the upstream study area.

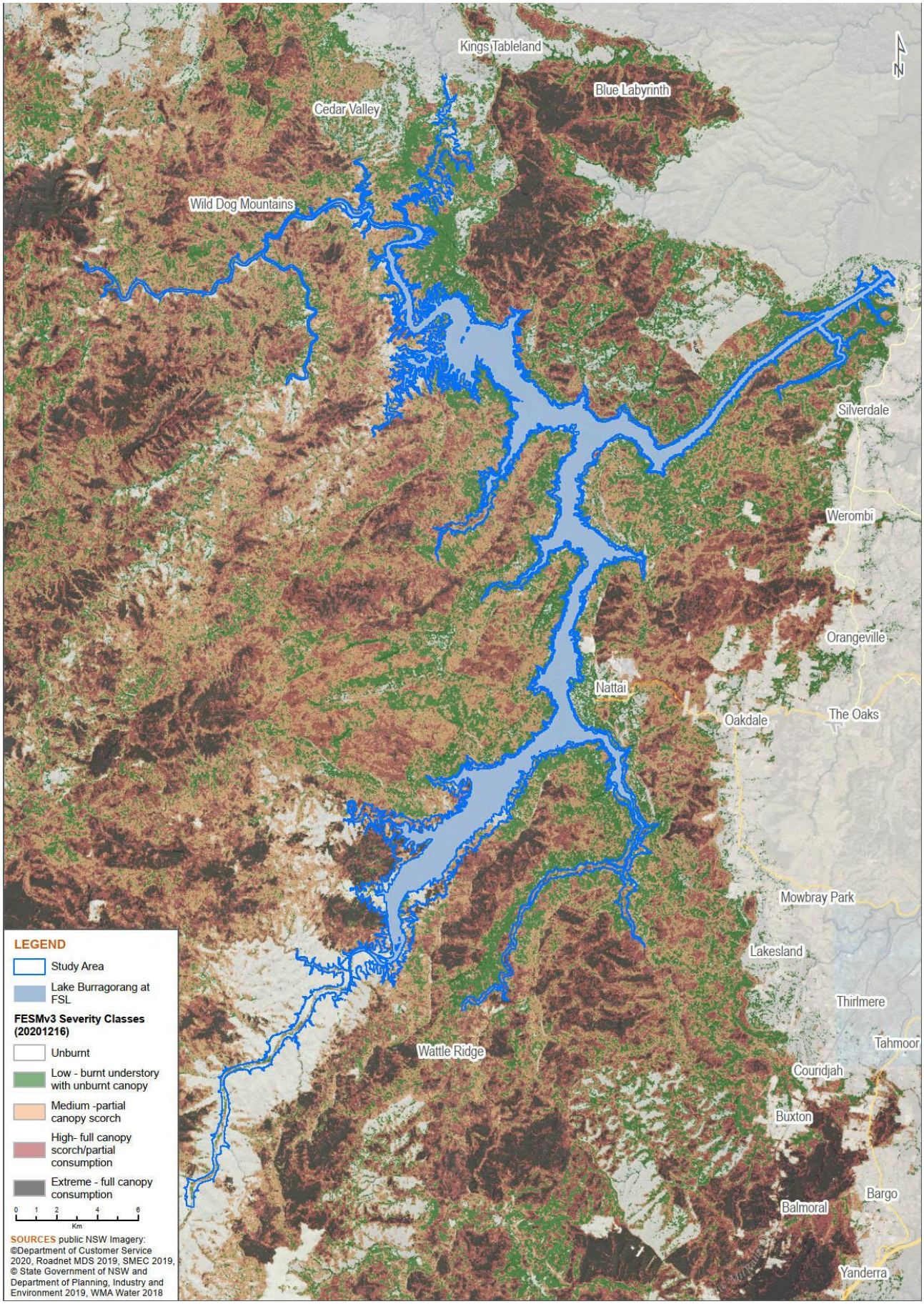
Both the Commonwealth and NSW governments are progressively providing advice in this regard. The Department of Agriculture, Water and the Environment (DAWE)[1] has released initial advice relating to threatened and migratory species which have more than 10 percent of their known or predicted distribution in areas affected by bushfires in southern and eastern Australia from 1 August 2019 to 13 January 2020. Regular updates are progressively being provided through the Department's website.

In February 2020, DPIE released a set of guidelines relating to carrying out biodiversity assessments under the Framework for Biodiversity Assessment at severely burnt sites. Further detail with regard to the Project is provided in the upstream biodiversity assessment (Appendix F1).

Consideration of the potential cumulative impacts of the Project with regard to the bushfire event is provided in Section 28.4.10.

[1] The Environment portfolio within the former Department of the Environment and Energy was transferred to the new Department of Agriculture, Water and the Environment (DAWE) which commenced operation on 1 February 2020.

Figure 28-1. Extent of 2019/2020 bushfires



28.2 Major projects and development initiatives considered

Major projects and development initiatives which may interact with the Warragamba Dam Raising Project resulting in cumulative impacts or benefits were assessed based on potential interactions during the construction and operation of the Project. Potential cumulative construction impacts would be primarily from other projects near Warragamba; however, cumulative impacts relating to traffic and transport and surface water quality may occur from projects farther afield.

Major projects and development initiatives which may interact with the Warragamba Dam Raising Project resulting in cumulative impacts or benefits were also assessed specific to individual environmental, cultural, or social aspects for which the assessments undertaken for this EIS suggest that there may be cumulative impacts or benefits. These relate to biodiversity, Aboriginal heritage, and surface water. Table 28-3 outlines the major projects and development initiatives that were considered in the cumulative impact assessment. These are also shown in Figure 28-2.

Table 28-3. Major projects and development initiatives considered for the cumulative impact assessment

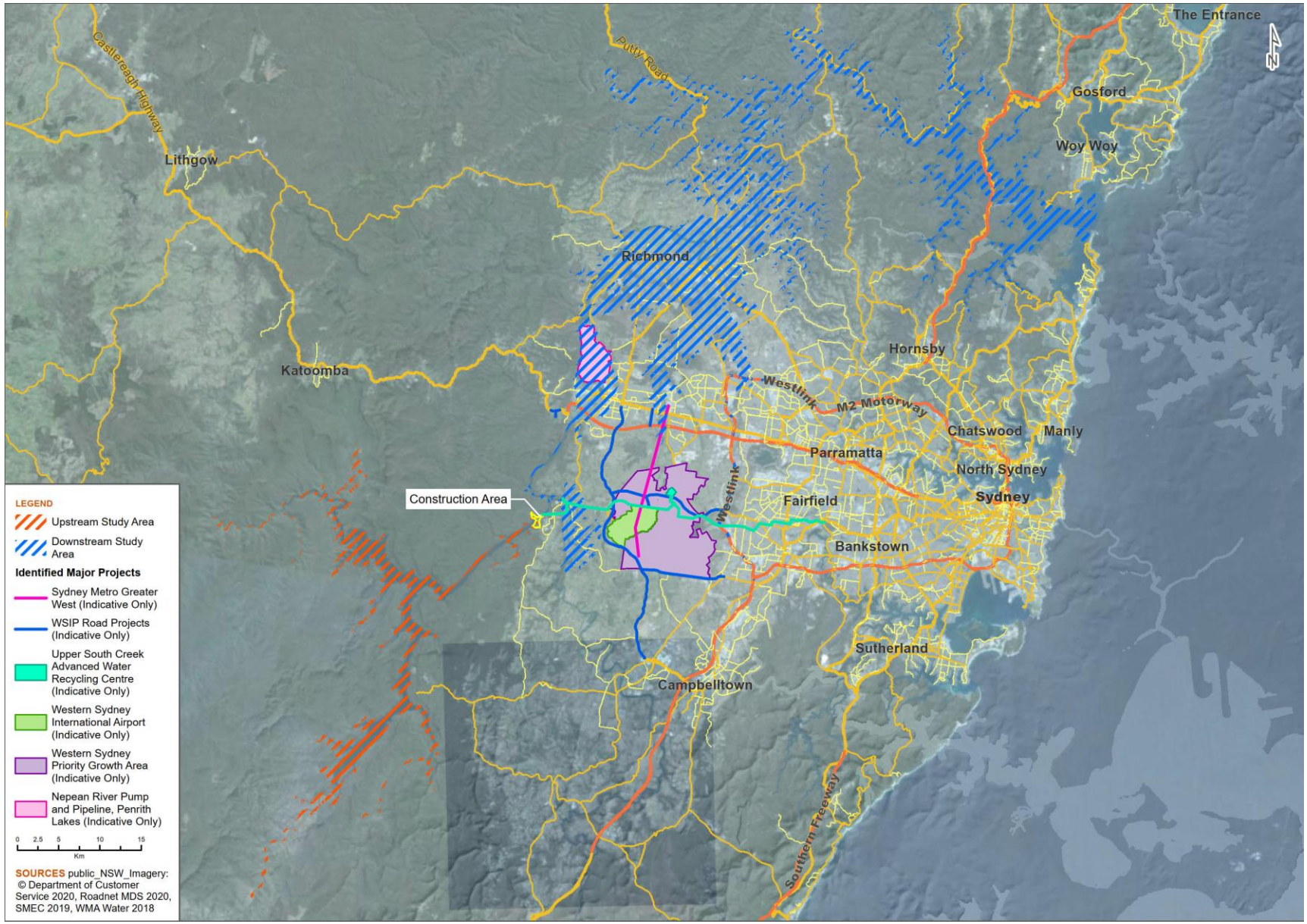
Major project or development initiative	Description	Potential interaction
Western Sydney International Airport High priority project (Cth)	Western Sydney International Airport will cover about 1,780 ha at Badgerys Creek in Western Sydney. The site is within the Liverpool Local Government Area (LGA). While 1,486 ha of the Liverpool LGA overlaps the downstream study area, the Western Sydney Airport site does not. Construction commenced in late 2018 with Stage 1 expected to be completed by 2026. Stage 1 would establish the airport facilities and provide an operational capacity for about 10 million domestic and international passenger movements per year, as well as freight traffic.	Yes. Western Sydney International Airport is located about 8.5 km east of Warragamba Dam, in the Hawkesbury-Nepean River catchment. The EIS for Western Sydney Airport identifies impacts including: ▪ 318.5 ha of native vegetation would be directly cleared, including 141.8 ha of fauna habitat ▪ direct and indirect impacts to threatened biota ▪ aircraft noise ▪ alterations to hydrology and groundwater dependent ecosystems ▪ traffic and transport, both construction and operational ▪ World Heritage.
Nepean River Pump and Pipeline State significant development (NSW)	The Nepean River Pump and Pipeline project is designated state significant development, assessed and determined under Division 4.1 of the *Environmental Planning and Assessment Act 1979*. The project comprises the construction and operation of a pump station and pipeline to take water from the Nepean River to the Penrith Lakes Scheme to enable filling of the lakes and securing a long-term water supply to maintain water levels in the lakes. Development consent was granted on 13 April 2015.	Yes. The Nepean River Pump and Pipeline EIS identifies impacts that may interact with the Warragamba Dam Raising Project relating to: ▪ water quality ▪ the hydrological regime of the Nepean River.
Northern Road upgrade Critical state significant infrastructure (NSW)	The Northern Road upgrade comprises four separate projects that will collectively upgrade about 34 km of the Northern Road between Narellan and Penrith. ▪ The Old Northern Road to Peter Brock Drive, Oran Park project was opened to traffic in April 2018 ▪ The Northern Road and Bringelly Road upgrades are currently under construction and is expected to be open to traffic in 2020 ▪ The Mersey Road to Glenmore Parkway project is currently under construction. It is expected that the Mersey Road to Eaton Road	Unlikely. The Northern Road upgrade project is located 10 km east of Warragamba Dam, in the Hawkesbury-Nepean River catchment. Construction of the Northern Road upgrade projects is likely to be completed by the time construction of the Warragamba Dam Raising Project commences. Operation of the Northern Road would provide benefit to road capacity in the region; however, as the Northern Road is not within the existing or Project PMF, interactions are considered with regard to

Major project or development initiative	Description	Potential interaction
	stage, around the Western Sydney Airport site, would be open in 2020. ▪ The Glenmore Parkway to Bringelly project was approved on 30 May 2018 and is expected to be open to traffic in 2020.	the broader Western Sydney Infrastructure Plan, of which the Northern Road Upgrade is a component (see below).
Sydney Metro Greater West State significant infrastructure (assumed)	New railway line which will service Greater Western Sydney and Western Sydney International Airport. The new line will have stations at Western Sydney Airport and the Western Sydney Aerotropolis, and a station at St Marys, interchanging with the existing station and connecting commuters with the rest of Sydney's rail system. The line is intended to be operational in 2026 coinciding with the opening of Western Sydney International Airport. At the time of preparation of this EIS, no SEARs had been formally issued for this project.	Yes. The area associated with the Sydney Metro Greater West is within the Hawkesbury-Nepean River catchment. Given the intended date for commencement of operation, construction of this project would likely overlap with construction of Stage 1 of the new airport. There is also potential for construction of the Warragamba Dam Raising Project to overlap with this project. Cumulative impacts may relate to: ▪ biodiversity values ▪ traffic and transport ▪ socio-economic and land use.
Upper South Creek Advanced Water Recycling Centre	New wastewater treatment plant to be located at Kemps Creek and will provide wastewater services to the South West Growth Area and Western Sydney Aerotropolis Growth Area. The plant would have capacity to treat up to 100 ML of wastewater per day. Infrastructure associated with the project includes a treated water pipeline running south for about one kilometre to Badgerys Creek and then turning west, running to Wallacia weir. The pipeline is to provide high quality water to the Warragamba River to replace environmental releases from Warragamba Dam and to conserve water in Lake Burragorang for drinking water supply. Construction for Stage 1 is anticipated to commence in mid 2022 and be completed by late 2024. Stage 1 is anticipated to commence operation in mid 2025. The SEARs for this project were issued on 18 January 2021. At the time of completion of the EIS for the Warragamba Dam Raising Project, the EIS for this project was still in preparation.	Yes. There is potential for construction of the Warragamba Dam Raising Project to overlap with this project, principally with regard to the treated water pipeline to Wallacia weir. Cumulative impacts may relate to: ▪ traffic and transport ▪ socio-economic and land use. Operation of the environmental flows infrastructure proposed as part of the Warragamba Dam Raising Project is separate to the Project and therefore no cumulative impacts are anticipated in this regard.

Major project or development initiative	Description	Potential interaction
Western Sydney Infrastructure Plan (WSIP)	Jointly funded by the Australian and NSW governments, the WSIP comprises a $4.1 billion road investment program for Western Sydney (Australian Government & NSW Government 2017). The objectives of the program are to support an integral transport solution for the region and capitalise on the economic benefits from developing the Western Sydney International Airport. The plan includes: ▪ Werrington Arterial Road – construction of a new arterial road to provide improved access to the M4 Motorway, increased road capacity, and more reliable travel times. Completed May 2017. ▪ Bringelly Road upgrade – upgrade of Bringelly Road from two lanes to a six-lane divided road between the eastern side of Upper Canal bridge and the western side of the Eastwood Road intersection, through the future Leppington Town Centre. The rest of Bringelly Road will be upgraded from two lanes to a four-lane divided road with a central median, which would allow for widening to six lanes when required. Currently under construction. ▪ Northern Road upgrade – upgrade of a 35 km section of The Northern Road between Old Northern Road, Narellan and Jamison Road, South Penrith, to meet future business and population growth in the local area and across broader western Sydney. Currently under construction. ▪ M12 Motorway – construction of a new motorway to provide direct access to Western Sydney International Airport at Badgerys Creek and connect to Sydney's motorway network. The corridor route spans 16 km east-west between the M7 Motorway, Cecil Hills and The Northern Road, Luddenham. The Project also aims to improve the movement of freight in and through western Sydney and is expected to serve the Western Sydney Aerotropolis and the South West Priority Growth Area. Project approved. EIS under preparation. ▪ Another $200 million local roads package.	Yes. The area associated with the WSIP is within the Hawkesbury-Nepean River catchment. Implementation of the WSIP concurrently with the Warragamba Dam Raising Project may lead to cumulative impacts associated with: ▪ biodiversity values ▪ traffic and transport ▪ socio-economic and land use.

Major project or development initiative	Description	Potential interaction
Western Sydney Priority Growth Area	The Western Sydney Priority Growth Area strategic planning initiative aims to provide jobs, housing and services on the land surrounding the Western Sydney International Airport. The Western Sydney Priority Growth Area extends from Blacktown, through Leppington toward Campbelltown-Macarthur, and across toward Penrith and the western extent of the airport. The initiative aims to connect Western Sydney International Airport with regional centres of Penrith and Liverpool.	Yes. The area subject to the initiative has been identified as a priority area for urban, commercial, industrial and infrastructure development. Development associated with the Area would interact with the Warragamba Dam Raising Project relevant to: ▪ traffic and transport ▪ socio-economic and land use. The Western Sydney Priority Growth Area is within the Hawkesbury-Nepean River catchment; however, does not overlap either the existing or Project PMF.
Greater Sydney Regional Plan: A Metropolis of Three Cities	The *Greater Sydney Region Plan: A Metropolis of Three Cities* is built on a vision of three cities where most residents live within 30 minutes of their jobs, education and health facilities, services and great places (Greater Sydney Commission (GSC) 2018a).	Yes. One of the 'cities' in the vision is Western Parkland City, encompassing Blue Mountains, Camden, Campbelltown, Fairfield, Hawkesbury, Liverpool, Penrith and Wollondilly. Potential cumulative impacts relate to: ▪ biodiversity ▪ traffic and transport ▪ socio-economic and land use.
Greater Macarthur Plan 2040	The *Greater Macarthur Plan 2040* is an urban renewal initiative to the south of Campbelltown. It would include urban renewal precincts, urban land releases, road upgrades, public transport corridors, active transport, and social infrastructure.	Yes. The area of the *Greater Macarthur Plan 2040* is within the Hawkesbury-Nepean River catchment. Potential cumulative impacts relate to: ▪ biodiversity ▪ traffic and transport ▪ socio-economic and land use.

Figure 28-2. Major projects and initiatives considered in the cumulative impact assessment



28.3 Summary of EIS findings

Table 28-4 provides a brief summary of the findings of this EIS for each specific environmental, cultural, or social aspect. Where a potential cumulative impact has been identified further discussion and assessment is presented in Section 28.4.

Table 28-4. Summary of EIS findings relevant to cumulative impact assessment

Environment, cultural or social aspect	Summary of findings	Potential cumulative impact
Air quality	Potential construction impacts relating to: ▪ minor increases in 24-hour and annual particle (TSP, dust, PM_{10} and $PM_{2.5}$) ▪ magnitude of increase is low and unlikely to result in measurable difference in air quality or exceedance of air quality criteria. No potential operation impacts predicted.	Unlikely. The area over which minor increases in some air pollutants are predicted is small and centred on the construction area. The projects identified in Table 28-3 are unlikely to contribute to a cumulative impact on air quality.
Biodiversity	Potential construction impacts relating to: ▪ a total of 22.4 ha of native vegetation would be directly cleared, also representing loss of habitat for numerous threatened species ▪ indirect impacts may result in further loss of native vegetation ▪ combined direct and indirect impacts would lead to fragmentation of vegetation communities ▪ direct loss of 1.6 ha of the critically endangered ecological community (NSW and Cth) Shale Sandstone Transition Forest ▪ direct loss of 7.0 ha of riparian vegetation. Potential operation impacts relating to: ▪ potential loss of biodiversity values in upstream study area due to temporary inundation from operation of the flood mitigation zone ▪ indirect impacts due to changes in flood inundation extents and durations downstream.	Yes. Several other identified projects may impact many of the same biodiversity values as the Warragamba Dam Raising Project. This is discussed further in Section 28.4.1.
Aquatic ecology	Potential construction impacts relating to: ▪ installation of temporary in-stream structures obstructing fish passage ▪ potential localised (that is, adjacent construction site) sedimentation and turbidity impacts Potential operation impacts or benefits relating to: ▪ vegetation decay (when vegetation in flood mitigation zone is inundated) leading to water quality impacts ▪ promotion of weeds and nuisance species ▪ improvements in water quality due to implementation of new environmental flow regime.	Unlikely. None of the identified projects had documented potential impacts to aquatic habitats of the Hawkesbury-Nepean catchment.
Climate change	Potential construction impacts relating to: ▪ increase in extreme rainfall leading to flooding impacts affecting construction site, activities ▪ increase in extreme heat affecting construction workforce, construction activities.	Unlikely. Climate risk assessment uses projections that consider modelled scenarios of emissions and related climate impacts irrespective of specific projects.

Environment, cultural or social aspect	Summary of findings	Potential cumulative impact
	Potential operation impacts relating to: ▪ increase in extreme rainfall reducing benefits of flood mitigation zone ▪ increase in extreme rainfall and potential frequent inundation of flood mitigation zone exacerbating environmental impacts.	
Flooding and hydrology	Potential construction impacts relating to: ▪ increased flooding impacts ▪ reduced downstream flows ▪ increased stormwater runoff and water demand. Potential operation impacts and benefits relating to: ▪ a reduction in flood extents across all flood events, especially in the Penrith, Windsor, Richmond and South Creek areas, resulting in lower flood damages and social impacts associated with flooding ▪ more predictable rise in flood waters and evacuation routes would remain open for longer, reducing the risk of loss of human life during floods ▪ reduction in downstream peak flood flows and flooding extents ▪ longer periods when water levels and velocities downstream of the dam would be higher than the current situation ▪ increased area and duration of temporary inundation of Lake Burragorang catchment.	Yes. The Nepean River Pump and Pipeline Project plans to extract water from the Nepean River. Cumulative impacts may result related to flow regimes in the Nepean River. This is discussed further in Section 28.4.2.
Health and safety	Potential construction impacts relating to: ▪ localised and short-term noise, vibration, and air quality impacts ▪ storage, handling, and disposal of hazardous materials. Potential operation impacts and benefits relating to: ▪ positive changes to the community through reduction of flood risk ▪ reduction in flood liability in the floodplain.	Unlikely. No significant interaction identified for health and safety impacts between the Warragamba Dam Raising Project and other projects.
Non-Aboriginal heritage	Potential construction impacts relating to: ▪ physical and visual impacts to State heritage and section 170 heritage-listed items at Warragamba Dam. Potential operation impacts or benefits relating to: ▪ direct impacts to national heritage listed items ▪ reduction in the number of Commonwealth, State and local heritage items that would experience flooding with the Project for all flood events.	Unlikely. Heritage items potentially impacted by construction activities are restricted to items near the construction area, and would not be impacted by the other identified projects/developments.
Aboriginal heritage	Potential operation impacts relating to: ▪ increased temporary inundation of numerous sites or artefacts within the flood mitigation zone.	Yes. Other developments considered in this cumulative impact assessment have highlighted potential impacts to Aboriginal heritage.
Noise and vibration	Potential construction impacts relating to: ▪ noise levels would exceed construction noise criteria during each construction stage	Unlikely. The spatial scale over which minor increases in noise and vibration are

Environment, cultural or social aspect	Summary of findings	Potential cumulative impact
	▪ noise levels are expected to range from noticeable to clearly audible across each of the catchment areas assessed in Warragamba.	predicted is small. No other projects with significant noise and vibration impacts, and therefore likely to result in cumulative impacts, were identified during this assessment.
Protected lands	Potential operation impacts relating to: ▪ increased temporary inundation of protected and sensitive lands.	Yes. The Western Sydney International Airport EIS stated potential *indirect* impacts to the Greater Blue Mountains World Heritage Area associated with noise, air quality, and visual amenity.
Socio-economic	Potential construction impacts and benefits relating to: ▪ temporary disruption of tourist and recreational uses of Warragamba Dam Visitor Centre and Haviland Park ▪ delayed travel time in accessing properties in some areas due to increased construction traffic ▪ localised and short-term noise, vibration, air quality and visual amenity impacts ▪ generating employment opportunities. Potential operation impacts or benefits relating to: ▪ positive landscape character ▪ increase in visitation numbers to the dam ▪ community concern relating to impacts to world heritage listed areas ▪ direct effects on private properties (upstream) ▪ reduced impact of flooding.	Yes. Construction of the Project is anticipated to deliver positive socio-economic outcomes both locally and more widely, and these could be augmented where construction of other identified projects overlaps. Conversely, there could be negative impacts on amenity such as journey travel times on routes used by construction traffic. Again, such impacts could be magnified if specific routes (such as major arterials) are used by construction vehicles for multiple projects concurrently.
Soils	Potential construction impacts relating to: ▪ disturbance of contaminated land ▪ soil erosion and sediment transport. Potential operation impacts relating to: ▪ soil erosion and sediment transport.	Unlikely. Disturbance of contaminated lands would be localised. Potential areas of impacts associated with soil erosion and sediment transport do not interact with any projects identified in this assessment.
Transport and traffic	Potential construction impacts relating to: ▪ roads and intersection capacity, pavement conditions, average travel speeds, property access, pedestrian and cyclist, public transport and local parking.	Yes. Many of the projects assessed for cumulative impacts involve increased construction traffic. Some of the projects assessed for cumulative impacts involved road upgrades.
Visual amenity	Potential construction impacts relating to: ▪ construction activities. Potential operation impacts or benefits relating to: ▪ moderate to high/moderate visual impacts anticipated at all viewpoint locations ▪ sensitivity of tourists and recreational users ▪ positive association of the dam as a regionally significant landmark.	Unlikely. No projects that would add to visual impacts were identified in proximity to the construction site during this assessment.
Water quality	Potential construction impacts relating to: ▪ erosion and sedimentation	Yes. Several projects in the downstream catchment area could impact surface

Environment, cultural or social aspect	Summary of findings	Potential cumulative impact
	▪ inadvertent runoff or release of wastewater from construction areas/processes (for example, concrete batch plant) ▪ inadvertent release of hazardous materials.	water quality (together with numerous other downstream land use activities).
Waste	Potential construction impacts relating to: ▪ generation of significant quantities of material from earthworks, demolition works, vegetation waste and general construction wastes ▪ use of significant quantities of raw materials to produce concrete.	Yes. Significant waste quantities may be generated by the Project and other projects.
Commonwealth matters	Potential construction impacts relating to: ▪ direct loss of 1.6 ha of the critically endangered ecological community (Cth) Shale Sandstone Transition Forest ▪ fragmentation of threatened vegetation communities and threatened fauna habitat. Potential operation impacts relating to: ▪ temporary inundation within the flood mitigation zone ▪ changes in flood inundation extents and durations downstream.	Yes. Several other projects identified may impact similar biodiversity-related protected matters as the Warragamba Dam Raising Project. These are considered further in Section 28.4.1.

28.4 Cumulative impact assessment

Cumulative impacts that may arise during construction and operation of the Warragamba Dam Raising Project are outlined as follows. The impact assessment has been differentiated by environmental, cultural, or social aspect, rather than study area or project phase.

28.4.1 Biodiversity

The upstream study area largely comprises protected lands with limited access. Therefore, pressures on biodiversity values of the area are largely from broader, regional threats notably bushfire and climate change, legacy impacts from historical land use, and encroaching urban development at the fringes.

Potential Project impacts on upstream biodiversity values relate to increased temporary inundation of the catchment of Lake Burragorang. This area contains vegetation which could change in condition and composition due to the impacts of increased temporary inundation. Repeat occurrences of temporary inundation may permanently alter the vegetation, potentially leading to indirect impacts such as increased risk of erosion.

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.

Downstream of Warragamba Dam, progressive urbanisation and development has placed increasing pressure on biodiversity values of the floodplain. This relates to potential cumulative impacts to threatened species and their habitats, and ecological communities including the endangered Cumberland Plain Woodland community. The Warragamba Dam Raising Project would reduce peak flood velocities and flood extents in the downstream study area; however, some areas that are still inundated may experience longer duration of flooding, particularly during larger flood events. Potential Project impacts to biodiversity values downstream of Warragamba Dam relate to these changes in flood inundation extents and durations. These impacts may result in the loss and fragmentation of habitat, and potential impacts to flood dependent threatened species and vegetation communities.

Construction of the Project may result in the loss of 1.6 hectares of Shale Sandstone Transition Forest which is listed as critically endangered under the EPBC Act. The Project could potentially impact up to a further 684.8 hectares downstream. None of the other projects listed in Table 28-3 identified this as a specific impact.

Environmental assessments for the other projects discuss potential impacts to biodiversity values of the downstream study area, notably the Western Sydney International Airport and the collective projects of the WSIP (Table 28-3). Many of these projects would result in the direct loss of biodiversity. Quantifying direct loss of biodiversity in the downstream study area as a result of the Warragamba Dam Raising Project is difficult as the frequency of flooding remains uncertain, and impacts would also likely be dependent on other factors such as the duration of flooding. Regardless, cumulative impact of the Project and other developments may result in further loss and fragmentation of habitat, and potential impacts to threatened species.

Chapter 13 (Biodiversity offset strategy) and Appendix F6 of this EIS outline the proposed biodiversity offset strategy for the Project. Both the Western Sydney International Airport and WSIP also have biodiversity offset strategies to compensate for potential losses in biodiversity. The implementation of these offset strategies would help address unavoidable impacts to threatened species and communities.

28.4.2 Flooding and hydrology

The Warragamba Dam Raising Project is being considered to reduce flood risk to communities in the Hawkesbury-Nepean Valley. The Project would result in a reduction in peak flood flow and velocities, and flooding extents downstream of Warragamba Dam; however, some areas would experience increased durations of flood inundation.

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.

The potential impacts of these changes in flooding and hydrology, particularly downstream, are seen mainly as positive. The Project would provide additional warning time for major flood events, allowing more time for flood evacuation. The Project would also reduce flood levels, reducing flood damages and liability. These Project impacts would benefit other developments in the downstream study area. Similarly, some of the major projects or initiatives considered in this cumulative impact assessment, as well as others that are planned would benefit communities in the downstream study area during floods. For example, new roads and road upgrades approved under the Western Sydney Infrastructure Plan would be designed and built based on modelling underpinned by the latest Australian rainfall and runoff data (Ball *et al*. 2019). This data considers the latest rainfall patterns and predictions, including the potential influence of climate change. This should allow for these roads to perform at a higher capacity during flood events that older roads, providing a benefit to flood evacuation.

The specialist hydrology report for Western Sydney Airport (GHD 2016) carried out to support the EIS for the Western Sydney Airport includes discussion regarding the hydrological impacts of the airport development for both Stage 1 and the longer term. The report notes the potential for significant hydrological changes associated with the substantial increase in impervious areas associated with the airport development but that these could be adequately managed through provision of on-site detention. The cumulative effect of the hydrology and flooding impacts of the airport development with those of the Project is considered to be low.

The Nepean River Pump and Pipeline Project would extract water from the Nepean River; however, environmental assessment documents for this project state that this would be done under existing water access licence conditions. This project is related to water supply whereas the Warragamba Dam Raising Project is related to flood mitigation. Accordingly, there is not expected to be any material cumulative impact on water resources from these two projects.

28.4.3 Aboriginal heritage

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. Downstream of Warragamba Dam, progressive urbanisation and development has placed increasing pressure on Aboriginal heritage values.

Potential Project impacts on upstream Aboriginal heritage values relate to increased temporary inundation of the catchment of Lake Burragorang It is in this area that a large number of Aboriginal sites have been identified. Downstream of Warragamba Dam, some previously identified sites would benefit from the Project, due to a reduction in flood extent.

Chapter 18 (Aboriginal cultural heritage) and Appendix K (Aboriginal cultural heritage assessment) of this EIS provide management and mitigation measures to minimise impacts to Aboriginal heritage values as a result of the Project. These include the preparation of a dedicated Aboriginal cultural heritage management plan for the Project. The plan would detail protocols for involvement of Registered Aboriginal Parties (RAPs) in cultural heritage works, and procedures for management and reporting of previously unknown Aboriginal heritage sites.

Environmental assessments for other projects discuss potential impacts to Aboriginal heritage in the downstream study area. For example, numerous artefacts were identified at the Western Sydney International Airport site. Under an agreement reached between the proponent for Western Sydney International Airport and the Department of Infrastructure and Regional Development, an Aboriginal cultural heritage 'keeping place' would be established for archival storage of some artefacts salvaged from the airport site. If established, this facility could also be used as a repository for Aboriginal cultural heritage artefacts salvaged from other developments in the region.

The specialist Aboriginal heritage investigation (Navin Officer 2016) carried out to support the EIS for the Western Sydney Airport includes discussion regarding the potential impacts on the Greater Blue Mountains World Heritage Area (GBMWHA). It notes that there is very little potential for the proposed airport to directly impact the Aboriginal cultural heritage values of the GBMWHA but does identify several potential impacts as follows:

- jettisoning of fuel, however, it notes that this is an extremely rare event and conducted at an altitude which makes it very unlikely for any significant quantities of fuel, if any, to reach the ground
- temporary loss of contextual value from the intrusion of aircraft noise associated with aircraft take offs and landings, which could potentially affect sites such as rock shelters and open sites where there may be an expectation or requirement for a quiet and natural surrounding environment.

The specialist Aboriginal heritage investigation for Western Sydney Airport (Navin Officer 2016) concluded that any potential impacts that may affect Aboriginal cultural heritage values would be indirect in nature and relate to aircraft noise and visual intrusion from aircraft. The cumulative effect of these indirect impacts with those of the Project is considered to be low.

While the EIS for the Warragamba Dam Raising Project and other projects considered for the cumulative impact assessment, provide mitigation measures for Aboriginal heritage values, these and other developments would still place increasing pressure on Aboriginal values of the region, particularly the retention of sites or artefacts in their original location and landscape setting.

28.4.4 Protected lands

The Warragamba Dam Raising Project may impact protected lands including the GBMWHA. Potential impacts to the GBMWHA relate principally to an increase in the occurrence of temporary inundation, and the consequent impacts on environmental values that form the basis for the World Heritage listing. The Project would affect about 304 hectares of the GBMWHA within the upstream impact area, which represents about 0.03 percent of the total area of the GBMWHA. Assessment of potential impacts on the GBMWHA and its World Heritage values is provided in Chapter 20 (Protected and sensitive lands) and Appendix J (World Heritage assessment report). This assessment concluded that potential impacts would be minor.

Other developments in the region have noted potential indirect impacts to the GBMWHA, notably the Western Sydney International Airport which identified potential indirect impacts relating to noise, air quality, Aboriginal heritage and visual amenity.

In view of the above, the likelihood of material cumulative impacts on protected lands from direct and indirect impacts is considered low.

28.4.5 Socio-economic

Upstream of Warragamba Dam, potential socio-economic impacts resulting from the Project largely relate to increased stress associated with potential loss of biodiversity, potential impacts to world heritage properties and national park estates, and visual amenity. Downstream of Warragamba Dam, impacts are mainly beneficial relating to a reduction in flood risk, longer evacuation time, and potential employment opportunities during construction.

No major projects or other projects were identified that would result in cumulative 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.

The communities around the construction site would experience impacts related to socio-economic amenity during the construction period. These would relate to noise and vibration, air quality, construction traffic, and visual amenity.

The cumulative effect of the other projects identified in Table 28-3 would likely be minimal even where construction periods coincide, due largely to geographic separation.

Downstream of Warragamba Dam, western Sydney is undergoing major urbanisation, facilitated and accelerated by various government initiatives and strategies and major infrastructure works. Some of these are detailed Table 28-3. Several other infrastructure projects in the greater Sydney region are aimed at facilitating the realisation of *The Greater Sydney Regional Plan: A Metropolis of Three Cities* (GSC 2018a). One of the 'cities' in this plan is 'Western Parkland City, encompassing greater Penrith, north to Marsden Park, east to Liverpool and south to Greater Macarthur'. The Project, with its stated intent of mitigating downstream flooding risk, would be a positive cumulative effect.

The cumulative impacts of the Warragamba Dam Raising Project and those detailed in Table 28-3 would have both impacts and benefits to the socio-economic welfare of communities in the study area. These are likely to be widespread with the magnitude subject to construction timing. Overall, these projects and initiatives are aimed at improving the quality of life for residents of western Sydney through the development of integrated land use planning, and state-of-the-art infrastructure to facilitate employment and recreational opportunities to promote a better quality of life. The population of western Sydney is forecast to increase at one of the fastest rates in NSW. Business and household incomes are projected to rise significantly, both of which would stimulate further development and better social infrastructure such as health and education services, shops and recreational services. However, with the number of projects underway, approved, and being considered, and construction timeframes stretching into the mid- to late-2020s, western Sydney residents may also experience 'construction fatigue'. Urbanisation and increasing populations also lead to greater demand for social infrastructure, more congested roads and transport services.

28.4.6 Traffic and transport

The Warragamba Dam Raising Project would result in increased construction traffic over the Project construction timeframe, which is about four to five years. Increased traffic volumes would be associated with construction workforce, the transport of construction materials to the site, and the transport of construction waste materials from the site. This would potentially result in an increase in road and intersection congestion, deterioration of road pavement conditions, reduction in average travel speeds, restricted property access, and impacts to pedestrian and cyclist facilities, public transport and local parking.

Of the projects identified in Table 28-3, only the Western Sydney International Airport construction period may overlap with that of the Project. The construction traffic assessment for the airport identifies that construction activities would generate an additional 1,254 vehicle movements per day on the surrounding road network but would generally not be expected to impact significantly on the surrounding transport system (GHD 2016). It also identifies several anticipated construction routes and notes that the M7 and Elizabeth Drive are expected to be the most likely access routes for heavy vehicles. Given the geographic separation of the Project from the Western Sydney International Airport project site, the likelihood of cumulative construction traffic and transport impacts is considered to be very low.

28.4.7 Water quality

Construction of the Warragamba Dam Raising Project may result in impacts to surface water quality relating to erosion and sedimentation, and inadvertent runoff from the construction site or from construction processes. This would be managed though the development of management plans to avoid or minimise erosion and runoff from the site.

Downstream of Warragamba Dam, progressive urbanisation and development has placed increasing pressure on surface and groundwater quality. Existing water quality in some areas of the catchment, including the floodplain is already degraded. Other development projects and initiatives identified in Table 28-3 would place additional pressures on surface and groundwater resources. These would largely be during construction of these projects, during which appropriately scoped management and mitigation measures would need to be implemented to avoid or minimise impacts. Provided these projects implement erosion and sediment control measures in accordance with best practice, risks to surface water quality are anticipated to be low.

A detailed discussion around the downstream water quality impacts of the Project is provided in Chapter 27, Section 27.7.4 of the EIS. The assessment examined changes in total nitrogen, total phosphorus, chlorophyll-a, and total suspended solids. This identified that water quality in the flood mitigation zone was generally better than the downstream receiving environment. Accordingly, the cumulative impact of the Project on downstream water quality is expected to be positive.

28.4.8 Waste

Generation of waste during construction of Warragamba Dam would be reduced through the implementation of a waste management plan that would be prepared as part of the construction environmental management plan. The waste management plan would detail measures to avoid, reduce, reuse, and recycle materials and waste. Waste generated during construction of the Project that requires disposal would be transported and disposed of at an appropriately licenced facility, by means appropriate to the type of waste.

Other projects identified in Table 28-3 would also generate significant quantities of construction waste, some of which would require disposal at appropriately licenced facilities. Sydney's waste and resource recovery sector is mature and currently handles significant volumes of waste from domestic, commercial and industrial sources across Sydney. Many more waste and resource recovery facilities are proposed for western Sydney, including facilities at Wallacia and Penrith. It is anticipated that waste facilities in western Sydney would be able to handle the volumes of construction waste generated by this and other projects.

28.4.9 Commonwealth matters

Commonwealth matters, or protected matters, relate to World Heritage, national heritage, and to biodiversity. Cumulative impacts with regard to these have been considered in discussion in Sections 28.4.1, 28.4.3 and 28.4.4.

28.4.10 2019-2020 bushfires

Consideration of the potential interaction of the Project with the 2019-2020 bushfire event is provided as follows. For some environmental aspects such as noise and vibration, and traffic and transport, no material cumulative effects would be anticipated and therefore have been excluded from the discussion. It should also be noted that the cumulative effects would vary over time and that new post-event baselines for some aspects, notably biodiversity, have yet to be established.

Flooding and hydrology

Vegetation within a catchment plays a role in intercepting rainfall and delaying and reducing runoff. The bushfire event has affected the upstream vegetation cover to varying degrees across the catchment but as noted, the severity of this has been limited within the upstream study area, with only 10 percent of vegetation burnt classed as 'High' or 'Extreme'. It is noted, however, that there are more extensive areas of severe burning further upstream in the catchment which would also influence the volume of runoff resulting from a major rainfall event.

The potential cumulative effect of the bushfire event would be larger runoff volumes from a specific rainfall event than might have been expected prior to the bushfire event. This risk would be ameliorated over time as the vegetation canopy recovers. However, this is now an existing risk and is considered separate to the Project. Accordingly, it is expected that there would be no material cumulative effect on hydrology.

Water quality

The water quality assessment (refer Chapter 27) identified the following potential operational impacts:

- increased natural organic matter which could result in disinfection by-products
- increased turbidity from erosion
- increased nutrient concentrations
- increased pathogen concentrations
- changes in pollutant loads.

The assessment concluded that it was unlikely that any of these would result in significant material impacts on water quality.

Water quality can be affected by changes in land use, and for the bushfire event, the principal change is the reduced vegetation cover (which is variable across the catchment) contributing to increased runoff and the entrainment of material and subsequent transport into waterways that could affect water quality. This is now an existing risk and is considered separate to the Project. Accordingly, it is expected that there would be no material cumulative effect on water quality.

Biodiversity

As previously noted, only about 10 percent of the upstream study area experienced burning classed as 'High' or 'Extreme' (this relating principally to the effect of the bushfire on the vegetation canopy). This would be expected to moderate the cumulative effect of the Project with regard to the bushfire event in the upstream study area.

The magnitude of the cumulative effect will be influenced by factors such as the extent to which the vegetation has recovered at the time of the flood event, the magnitude of the flood event and related factors such as flood extent, and depth and duration of temporary inundation. Impacts may range from negligible through to possible permanent loss of existing vegetation in specific locations. Areas of vegetation that had experienced 'Moderate' or less severe burning would be expected to be more resilient than areas that had experienced 'High' or 'Extreme' burning.

Similarly, potential cumulative impacts on upstream fauna habitat and associated fauna species would also be influenced by the factors noted above.

The cumulative effect of the Project and the bushfire event on terrestrial biodiversity values in the downstream study area is anticipated to be minimal.

Aquatic ecology

The potential impact of the Project on aquatic habitats in the upstream study area relates principally to operation of the flood mitigation zone, and also noting that the extent of upstream inundation would be influenced by the level of Lake Burragorang at the time of the inflow event.

The assessment of potential impacts on aquatic ecology (refer Chapter 11) in the upstream area identified that these would relate principally to short term changes to water quality such as increased nutrient loads and organic matter concentrations, and increased sedimentation and turbidity. Other potential impacts would relate to temporary increase in water depths, temporary inundation of riparian habitats, and potential changes in the distribution of pest or nuisance aquatic species.

From a review of the bushfire mapping (refer Figure 28-1), aquatic habitats in the upstream study area may have experienced a lesser direct impact from the bushfire event compared to terrestrial habitats. However, aquatic habitats may have also been indirectly impacted through changes in water quality from runoff from affected areas both within and outside of the upstream study area, compounded by potentially larger volumes of runoff that otherwise may have been intercepted by vegetation.

The nature and magnitude of the potential cumulative effects of the bushfire event and the Project would be largely influenced by the degree of recovery of vegetation in the catchment (both within and outside of the upstream study area) and the consequent effect on runoff volumes, and on the potential for material to be entrained and transported into waterways.

Non-Aboriginal heritage

The assessment identified one unlisted potential heritage item in the upstream study area located within the existing PMF area, this being the Jooriland Homestead, a former substantial sheep and grazing station located in the upper Wollondilly. The effect of the bushfire event on this potential heritage item was not known at the time of finalisation of the EIS. Irrespective of this, the cumulative effect of the bushfire event and the Project is considered to be negligible.

The other non-Aboriginal heritage item in the upstream study area is a small area of the GBMWHA (refer Chapter 20). The assessment of potential impacts on the GBMWHA and its World Heritage values concluded that potential impacts would be minor. The assessment identified that up to 415 hectares of the GBMWHA (about 0.03 percent of the total area of the GBMWHA) could be affected by temporary inundation in a 1 in 100 chance in a year event. This area is likely to have been subject to varying degrees of burning from the bushfire but as has been noted elsewhere in this chapter, about 90 percent of the upstream study area experienced only 'Moderate' or less severe burning. In view of this, the cumulative effect of the Project and the bushfire event is considered to be minimal.

Aboriginal cultural heritage

The Aboriginal cultural heritage assessment (refer Chapter 18) identified two broad types of potential impacts of the Project on Aboriginal cultural heritage: physical impacts on heritage sites such as rock art, stone artefact sites, sandstone shelter sites, etc, and impacts on the cultural values both on individual sites and the landscape more broadly. The potential upstream impacts of the Project relate principally to temporary inundation associated with significant inflow events and operation of the flood mitigation zone, and the consequent effects of temporary

inundation. Resilience to the effects of inundation would vary across site types with sites such as axe grinding grooves and engravings being relatively more resilient than rock art sites.

The vegetation canopy may have afforded a level of protection to individual sites. The bushfire event has altered the level of vegetation cover reflected in the post-event mapping and classification of areas in terms of severity of burning. It is expected that the vegetation canopy will recover over time, however, if an inflow event occurs once the Project is operational, and the vegetation canopy has not recovered to the pre-bushfire condition, then conceivably some sites may experience increased exposure than otherwise might have occurred in the absence of the bushfire event.

Visual amenity

The visual impact assessment (refer Chapter 25) identified that there would be a negligible impact from the project in the upstream area due to the substantial distances between viewpoints and the intervening terrain and vegetation. Potential impacts would relate principally to the consequential impacts of temporary inundation on areas of vegetation and the resilience of constituent flora species to inundation. The resilience of vegetation may be influenced by the effects of the bushfire and the extent to which vegetation has recovered by the time of a flood event. Noting that only about 10 percent of vegetation experienced burning classed as 'High' or 'Extreme' in the upstream study area, the cumulative effect of the Project with regard to bushfire-affected areas is anticipated to be minimal.

Socioeconomic

As previously noted, upstream of Warragamba Dam, potential socio-economic impacts resulting from the Project largely relate to increased stress associated with potential loss of biodiversity, potential impacts to world heritage properties and national park estates, and visual amenity. The bushfire event has potential to have a cumulative effect on these possible impacts. However, and noting discussion on other individual aspects elsewhere in this section, for the most part, these are anticipated to be minimal.

Air quality

The assessment of the potential impacts of the project on air quality (refer Chapter 7) identified that these largely related to construction activities and there would be negligible impacts associated with operational activities.

The bushfire event has affected vegetation to varying degrees potentially resulting in reduced vegetation cover and potential exposure of unvegetated areas presenting sources of material that could be entrained through wind erosion. The risk of this would be mitigated as the vegetation recovers over time. It is anticipated that there would be a negligible cumulative effect of the Project and the bushfire event on air quality.

28.5 Environmental management measures

Environmental management measures have been proposed for each of the aspects discussed above. These are detailed in:

- Chapter 8 (Biodiversity upstream)
- Chapter 9 (Downstream ecological assessment)
- Chapter 10 (Biodiversity construction area)
- Chapter 13 (Biodiversity offset strategy)
- Chapter 15 (Flooding and hydrology)
- Chapter 18 (Aboriginal cultural heritage)
- Chapter 21 (Socio-economic, land use and property)
- Chapter 24 (Traffic and transport)
- Chapter 26 (Waste)
- Chapter 27 (Water quality).

Environmental management measures related to the Commonwealth matters noted in Section 28.4.9 are captured through the above chapters.

All management measures have been summarised in Chapter 29 (EIS Synthesis, Project justification, and conclusion), and risk assessed in individual chapters, as summarised in Table 28-5.

Table 28-5. Risk assessments

EIS Chapters – Risk assessment	
Chapter 7	Air quality
Chapter 8	Biodiversity – upstream
Chapter 9	Downstream ecological assessment
Chapter 10	Biodiversity – construction area
Chapter 11	Aquatic ecology
Chapter 14	Climate change risk
Chapter 15	Flooding and hydrology
Chapter 17	Heritage (non-Aboriginal)
Chapter 18	Aboriginal cultural heritage
Chapter 19	Noise and vibration
Chapter 20	Protected and sensitive land
Chapter 21	Socio-economic, land use, and property
Chapter 22	Soils
Chapter 23	Sustainability
Chapter 24	Traffic and transport
Chapter 25	Visual amenity
Chapter 26	Waste
Chapter 27	Water quality

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