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Environmental Impact Statement – Chapter 25: Visual amenity

Warragamba Dam Raising

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25 Visual amenity

This chapter provides an assessment of visual amenity during construction and operation of the Warragamba Dam Raising (the Project). The relevant Secretary's Environmental Assessment Requirements (SEARs) are shown in Table 25-1.

Table 25-1. Secretary's Environmental Assessment Requirements: Visual amenity

Desired performance outcomes	Secretary's Environmental Assessment Requirements[1]	Where addressed
18. Visual Amenity The Project minimises adverse impacts on the visual amenity of the built and natural environment (including public open space) and capitalises on opportunities to improve visual amenity.	1. The Proponent must assess the visual impact of the Project and any ancillary infrastructure on: (a) views and vistas	Section 25.5.
	(b) streetscapes, key sites and buildings	Section 25.5
	(c) heritage items including Aboriginal places and environmental heritage	Section 25.5.4 Chapter 17, Chapter 18
	(d) the local community.	Section 25.5
	2. The Proponent must assess the visual impact associated with the proposed maximum flood level both upstream and downstream within the catchment area.	Section 25.5
	3. The Proponent must provide artist impressions and perspective drawings of the Project to illustrate how the Project has responded to the visual impact through design and landscaping.	Section 25.5

1. This chapter specifically addresses SEAR 18 in addition to those general requirements of the SEARs applicable to all chapters and as identified as such in Chapter 1 (Section 1.5, Table 1-1).

The landscape character and visual impact assessment is supported by detailed investigations, which have been documented in the Landscape character and visual impact assessment report (Appendix P).

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

25.1 Project description and study area

25.1.1 Project description

Figure 25-1 shows the local and regional context of the Project. The Project site is in the Wollondilly Local Government Area (LGA), approximately 65 kilometres west of the Sydney Central Business District. 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.

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 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 Project construction area is shown on Figure 25-2. Plan and cross section details of the modified dam are shown on Figure 25-3 and Figure 25-4 respectively.

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 release 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, 2017 Metropolitan Water Plan. However, the actual environmental flow releases themselves do not form part of the Project and are subject to administration under the *Water Management Act 2000*.

Operational objectives 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.

Normal operations would occur when the dam storage level is at or lower than the full supply level. Normal operations mode for the modified dam would be essentially the same as current operations – apart from environmental flows releases. Inflows would be captured up until the full supply level, after which environmental flows releases would cease and flood operation procedures would be implemented. When water storage levels in the current Warragamba dam rise above FSL, the gates progressively open in accordance with the H14 operating rules. Under these rules the gates do not fully open until the upstream storage level is 1.83 metres above the full supply level, which corresponds to around a 1 in 20 year inflow event.

During large rainfall events when the storage level rises above full supply level, flood operations 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 to capture temporarily around 1,000 gigalitres of water during a flood event.

Water would be discharged in a controlled manner via the gated conduits or slots until the dam level returns to full supply level. FMZ operating protocols would guide this process and 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 25-1. Project study area

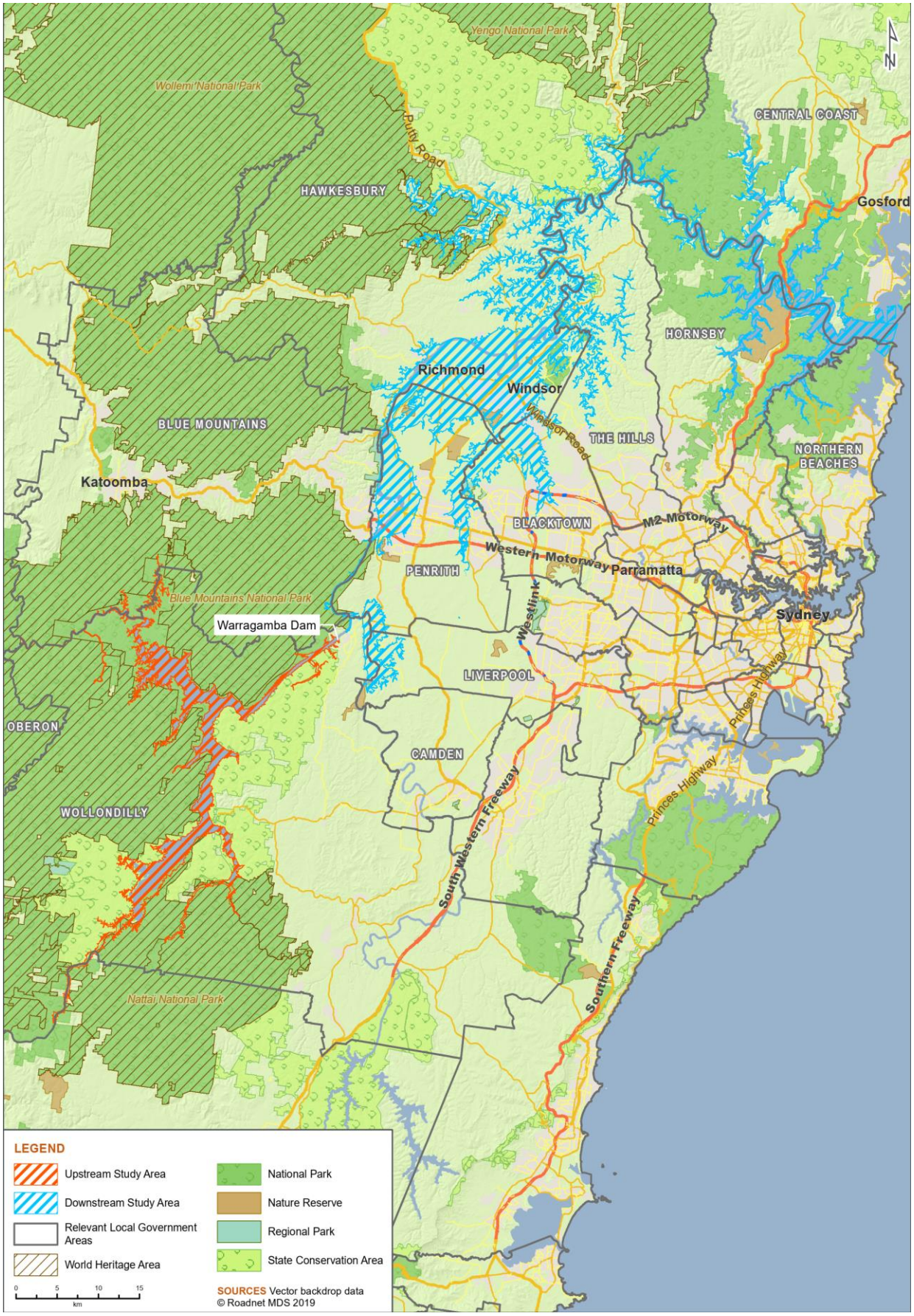


Figure 25-2. Warragamba Dam locality (including construction area)

Figure 25-3. Aerial view of modified dam

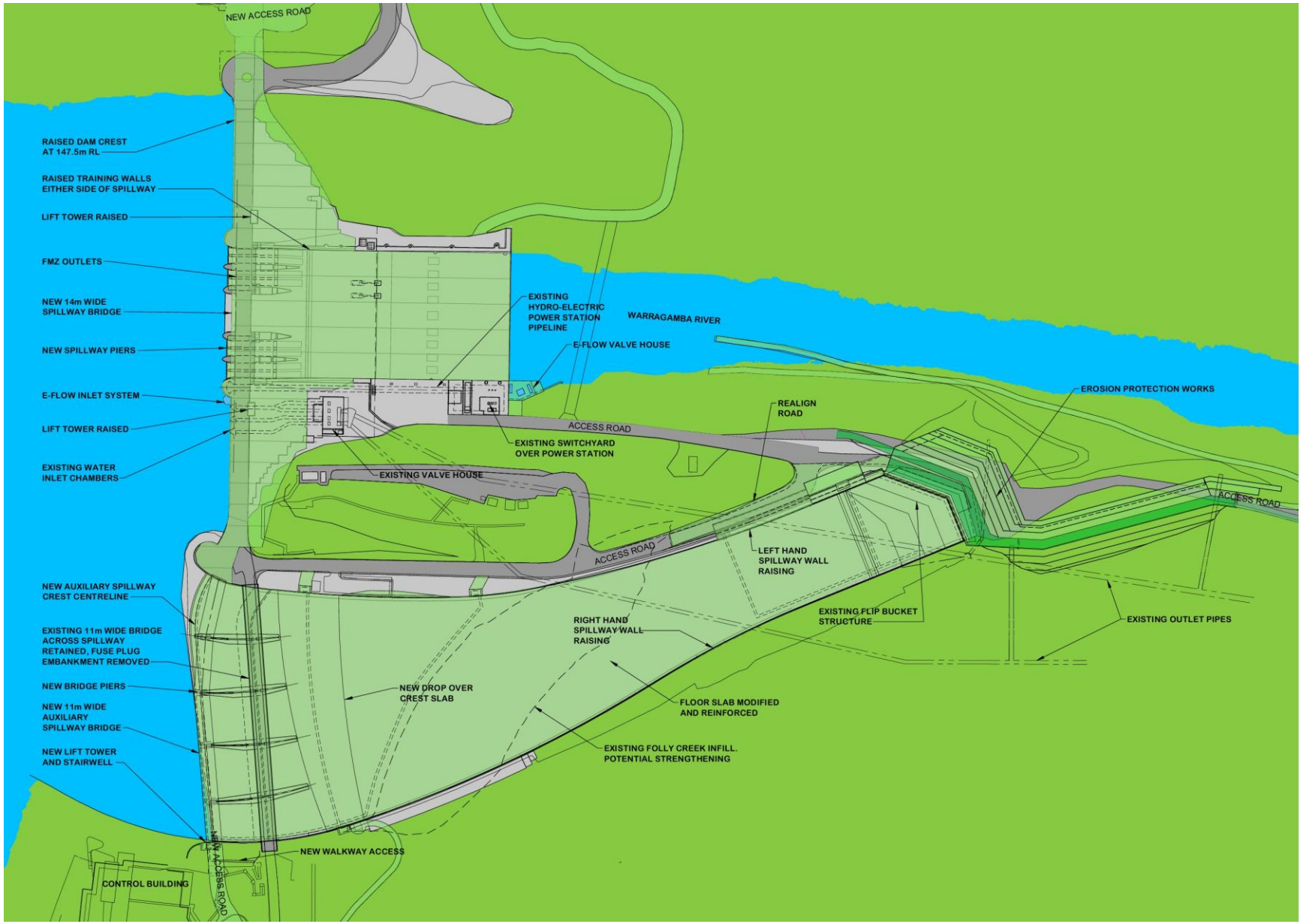
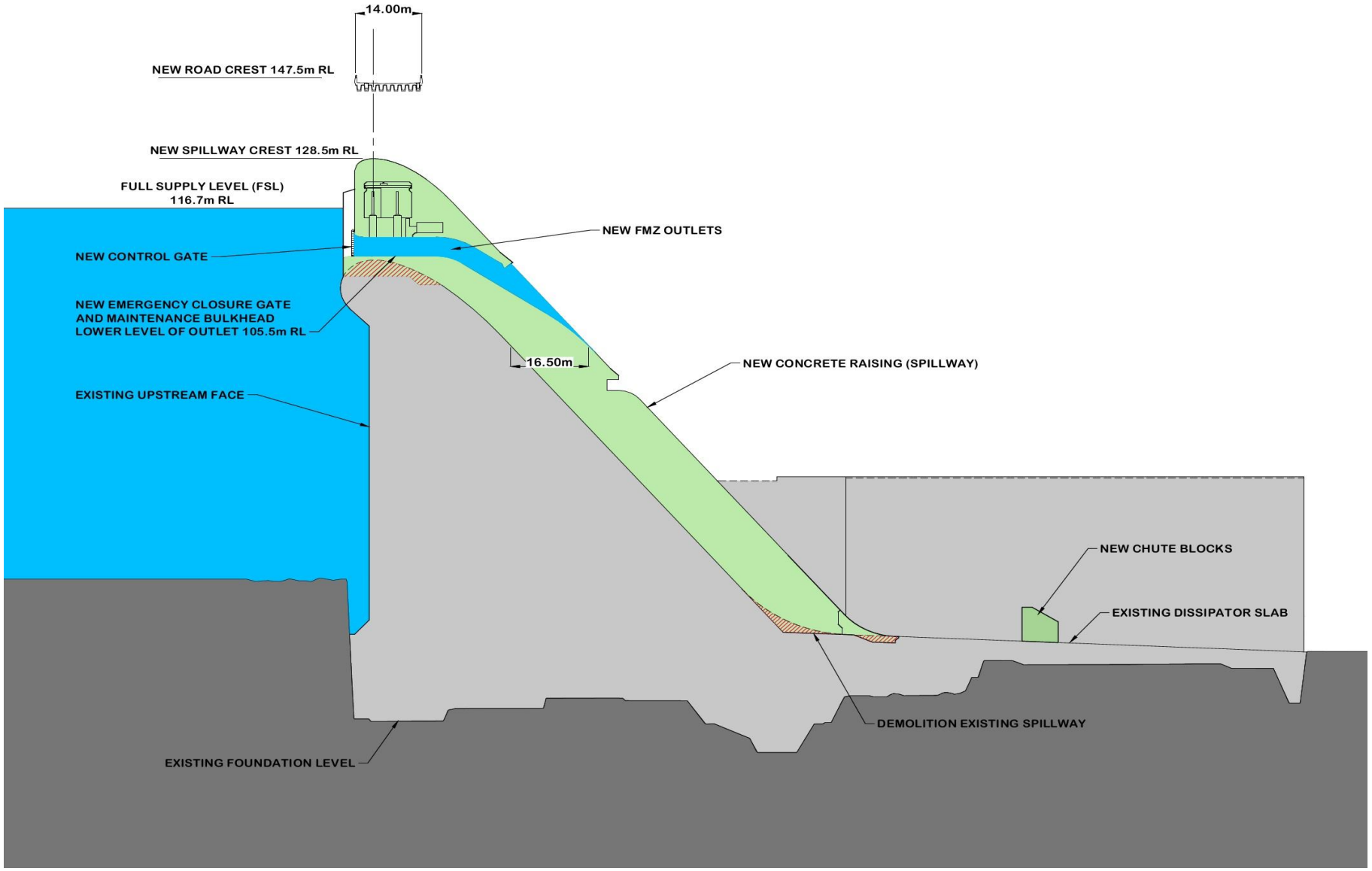


Figure 25-4. Cross section of central spillway works



25.1.2 Study area

The Project study area is divided into three locations, as shown on Figure 25-1 and Figure 25-2.

Upstream zone: Upstream of Warragamba Dam includes Lake Burragorang (i.e. the reservoir formed by Warragamba Dam) and its tributaries, which is surrounded by areas of the Blue Mountains National Park, Burragorang State Conservation Area, Nattai National Park, Nattai State Conservation Area and Yerranderie State Conservation Area. Most of the Blue Mountains National Park also forms part of the GBMWHA however, only a very small portion of the world heritage area would be impacted by an increase in water levels during temporary inundation. The extent of this zone has been determined using the Project PMF event level, which is the theoretical greatest extent of flooding that this zone would experience.

The visual assessment for the upstream zone has also considered potential impacts on the area most likely to be affected by temporary inundation from the Project. This area is referred to as the 'upstream impact area' and covers an area of about 1,400 hectares. A description of the derivation of the upstream area is provided in Appendix J (World Heritage assessment, Section 5).

The assessment relates to the operation phase.

Warragamba Dam zone (including the construction area): This comprises the immediate locality at Warragamba Dam. The construction area that would occur within about one kilometre of the dam wall. The main construction area includes features of the existing dam as well as ancillary facilities such as coffer dams, batch plants, material storage areas and worker facilities. The extent of this zone has been determined by the areas directly impacted by construction works and clearing of vegetation. Warragamba township is located nearby.

The assessment has considered the construction and operation phases.

The Project visual impact assessment considered:

- the PMF, a 1 in 5 chance in a year flood and a 1 in 20 chance in a year flood for the construction phase
- the area of the upstream impact area in proximity to the dam wall for the operation phase.

Downstream zone: This area is defined by the existing PMF, which is the greatest extent of flooding that this zone could potentially experience. This area includes the freshwater and estuarine reaches of the Hawkesbury-Nepean river system and its tributaries between Warragamba Dam where it joins the Nepean River near Wallacia and Wisemans Ferry, as well as the adjacent riparian zone, floodplain, and wetland/lagoon waterbodies. During flood events, there are backwater flooding impacts along South Creek, which flows into the Hawkesbury River downstream of Windsor. Consequently, South Creek has been included as part of this zone.

The Project visual impact assessment considered the PMF and a 1 in 20 chance in a year flood.

The assessment relates to the operation phase.

25.2 Project objectives

The overall objective for the Project is to reduce flood risk to life, property, and social amenity from regional floods in the Hawkesbury-Nepean Valley now and in the future. Large dams in NSW must be designed and managed to comply with the NSW Dam Safety guidelines. The guidelines align with the Australian National Committee on Large Dam guidelines which, in turn, are aligned with International Committee on Large Dam guidelines. These guidelines provide the overarching context for the assessment of urban design and visual amenity for the Project.

The over-arching aim of the urban design objectives is to ensure that the project is physically and visually integrated with its surrounding environment and where possible, maximises engagement of the potential viewers with local context, including infrastructural context, to provide the most enjoyable and interesting experience to those viewers.

To meet these aim, a set of urban design objectives have been developed, which are based on relevant assessment guidelines (see Section 25.3.1) and an understanding of the existing landscape and urban values of the Project study area and the landscape and urban design issues that affect, or are affected by, the Project.

Table 25-2 lists broad urban design objectives and principles for the Project and the existing features which could potentially be impacted by the Project.

Table 25-2. Summary of urban design objectives and principles across the study area

Zone	Objective	Principles
Upstream	Minimise visual impacts to the upstream zone, particularly from publicly accessible locations	The operation of the raised dam must minimise damage to existing vegetation through appropriate balancing of storage and release
Construction	Respect the existing historic, cultural and natural character of the area	As well as satisfying the hydraulic needs of the Project, the design of the dam wall must recognise the importance of the dam infrastructure for the community and tourism
Downstream	Minimise visual impacts to the downstream zone	The operation of the wall must minimise damage to existing vegetation and infrastructure through appropriate balancing of storage and release

25.3 Assessment methodology

25.3.1 Assessment guidelines

The visual assessment methodology was undertaken generally in accordance with *EIA N04 Practice Note: Guideline for Landscape Character and Visual Impact Assessment V2.0* (Roads and Maritime Services (RMS) 2018) (the Guidelines), which can be applied to various infrastructure developments.

The guidelines consider the site within its landscape setting and considers views from a variety of user groups and from a range of visually relevant locations. Key components of the visual assessment include:

- desktop studies and site analysis to understand the natural environment as well as human intervention and the shaping of that environment, including settlements and the interaction between place and community to understand the different landscape character units within the study area
- identifying and assessing the impacts of the Project to determine the impacts on landscape character. These impacts are based on the sensitivity of the landscape character to change and the magnitude of the Project within that landscape
- assessment of the visibility of the Project, which is based on desktop studies and site analysis, the extent of the Project, which is visible is captured in the viewshed mappings
- visual inspection of subject site and study area to identify, record and confirm key viewpoints, site character and the sensitivity of potential viewers. The final list of viewpoints does not represent the entire spectrum of viewers that could possibly be impacted by the Project, but rather focuses on views that would be experienced by the greatest number of viewers
- assessment of the unmitigated impact of the Project on each representative viewpoint based on a composite of the sensitivity of the view and magnitude of the Project in that view, before any mitigation strategy has been put in place. A landscape character and visual impact matrix is described in Section 25.3.4.
- development of a mitigation strategy, which includes principles and strategies to mitigate landscape character and visual impacts in the ongoing development of the design.

Other reference documents include the following:

- Infrastructure NSW 2012, 'State Infrastructure Strategy 2012-2032', Infrastructure NSW
- Graham Brooks and Associates Pty Ltd 2010, 'Conservation Management Plan, Draft version 7' Sydney Catchment Authority, Sydney
- Blue Mountains Region of the National Parks and Wildlife Service 2001, 'Blue Mountains National Park - Plan of Management' NSW National Parks and Wildlife Service, Sydney
- Roads and Maritime Services December 2018, 'Guideline for landscape character and visual impact assessment, Environmental Impact Assessment Practice Note-N04, Version 2.1
- 'The Sweat of Their Brows', M Beasley, Sydney, 1988
- 'A Spirit of Progress: Art Deco Architecture in Australia', P Van Daele and R Lumby, Craftsman House, 1997

25.3.2 Selection of flood events

Hydrology and flooding characteristics are discussed in Chapter 15 (Flooding and hydrology). The SEARs require the Proponent to *'assess the visual impact associated with the proposed maximum flood level both upstream and downstream within the catchment area'*. The maximum flood level that can possibly occur is 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 (AR&R 2019). The PMF is used for dam safety and emergency planning purposes and has an extremely low probability of occurrence of happening. The PMF is theoretical, and for this reason the assessment of visual impacts of the dam raising under a PMF event is only indicative.

Upstream zone

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 areas with flatter terrain. The steep valley terrain surrounding Lake Burragorang, which extends from the dam wall upstream for at least 20 kilometres, results in the peak flood level inundation extent being contained to a small total land area. The terrain is notably flatter further upstream where the Wollondilly River and Coxs River enter Lake Burragorang. Therefore, the increase in peak flood level inundation extent from the existing to Project scenario encompasses a larger total area (as elevation increases more gradually). The Project would result in flood durations increasing from less than half a day for upstream areas, up to around two weeks near the dam wall.

The visual assessment for the upstream zone has also considered potential impacts on the area most likely to be affected by temporary inundation from the Project. This area is referred to as the 'upstream impact area' and is defined as the area between 2.78 metres above FSL (119.5 mAHD) and 10.25 metres above FSL (126.97 mAHD). A description of the derivation of this area is provided in Appendix J (World Heritage assessment, Section 5).

Warragamba Dam zone (including the construction area)

From an operational perspective, the upstream impact area is the principal area of interest for the visual assessment. As noted above, the upstream impact area is the area most likely to be affected by temporary inundation from the Project The assessment has also considered the 1 in 5 chance in a year event and the PMF event.

Downstream zone

The FMZ would delay and attenuate 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. The Project would result in a reduction in downstream flooding extents across all major flood events especially in the Penrith, Windsor, Richmond and South Creek areas.

The downstream visual assessment also considers the PMF flood, which for the downstream catchment would be reduced due to the Project. A 1 in 20 chance in a year flood was assessed as representing a large reduction in flooding extent due to the Project.

25.3.3 Vegetation and heritage considerations

Temporary inundation may trigger changes to vegetation resulting in changes in appearance of vegetated areas in the landscape. Potential impacts on vegetation are documented in the following biodiversity reports:

- Appendix F1 (Biodiversity assessment report – upstream)
- Appendix F2 (Downstream ecological assessment)
- Appendix F3 (Biodiversity assessment report - construction area).

The upstream assessment included consideration of the potential effects of temporary inundation, drawing in part on a recent study of Queensland dams (Hydrobiology 2019). The study concluded that temporary flood inundation would not inevitably cause substantial environmental impact.

Potential impacts on heritage values related to visual appearance are considered in:

- Appendix I (Non- Aboriginal heritage assessment report)
- Appendix K (Aboriginal cultural heritage assessment report)
- Appendix J (World Heritage Assessment).

25.3.4 Landscape character and impact ratings

The overall impact rating of the project on any given landscape character or viewer is based on a broad qualitative appraisal of magnitude and sensitivity and the combination of these assessments resulting in an overall impact rating (refer Section 25.3.1). The relevance of magnitude and sensitivity for each assessment type is described as follows.

The Roads and Maritime Services Guideline for landscape character and visual impact assessment, Environmental impact assessment practice note EIA-N04 (RMS EIA-N04) provides the following definition of landscape character:

> *Landscape character is the aggregate of built, natural and cultural aspects that make up an area and provide its unique sense of place. Landscape in this context is taken to include all aspects of a tract of land - the built, planted and natural topographical and ecological features.*

In applying this definition to the specific conditions within the study area and the features of the Project, the landscape character assessment also considers how the Project would be used and how it would function as a part of the region. The assessment has considered both existing landscape character and desired future character (where relevant).

Key landscape elements including landform, waterform, vegetation, land use and built form were identified during site visits, which informed the assessment of impacts on the landscape character of each assessment zone. Two primary factors are used to determine impacts:

- **Sensitivity** of the character within the zone: the degree to which a landscape type can absorb and accommodate change arising from a project. Sensitivity refers to how sensitive the character of the setting is to the proposed change. For example, a pristine natural environment would be more sensitive to change than an industrial area. It considers the perceived cultural, natural and heritage values of the visual environment and the elements within it.
- **Magnitude** of the Project in that zone: magnitude is a study of the scale or degree of change to the landscape resource, the nature of the effect and its duration including whether it is permanent or temporary. In the case where future development is already approved, this context is used in the assessment. Consideration is given to existing built form in the landscape and how closely the project matches this in bulk, scale and form.

A sensitivity and magnitude matrix is provided in Table 25-3. Impact categories are defined as follows:

- a **high** magnitude of change would result if the project is of a major scale and considered out of scale or uncharacteristic of the existing view, or if there is considerable modification to the existing built fabric or landscape
- a **moderate** magnitude of change would result if the project is prominent but not considered to be substantially different from the existing character
- a **low** magnitude of change would result if there is minimal alteration to the existing view and the project is of a scale and nature that is consistent with the existing landscape.

Table 25-3. Landscape character and visual impact matrix (RMS EIA-N04 Practice Note, V2.1, 14/12/2018)

		Magnitude			
		High	**Moderate**	**Low**	**Negligible**
Sensitivity	**High**	High	High–Moderate	Moderate	Negligible
	Moderate	High–Moderate	Moderate	Moderate–Low	Negligible
	Low	Moderate	Moderate–Low	Low	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

25.3.5 Visual impact assessment

The potential visual impact of the Project is assessed in relation to key viewpoints and/or group of viewpoints and assesses the unmitigated impact of the project on each representative viewpoint. Impacts are based on a composite of the sensitivity of the view and magnitude of the project in that view, before any mitigation strategy has been put in

place, and helps to determine mitigation measures. A sensitivity and magnitude matrix and impact categories are discussed above (Section 25.3.4).

Viewpoints

The selection of viewpoints was based on the requirement to assess potential visual impacts as follows:

- within each of the identified character zones
- from vantage points with higher numbers of viewers.

Visual impacts typically increase where views are experienced by many people. For this assessment, major publicly accessible viewing areas were selected rather than remote locations that only a small portion of the public would visit. Also considered in the viewpoint selection process were the limited number of campers, hikers and visitors during periods of heavy rainfall when the potential temporary impacts would be experienced.

The selection of viewpoints was based on factors related to:

- identified landscape character zones
- vantage points with a higher number ofviewers.

Visual impacts typically increase where views are experienced by many people. For this assessment, major publicly accessible viewing areas were selected rather than remote locations that only a small portion of the public would visit. Also considered are the limited number of campers, hikers and visitors during periods of heavy rainfall when the potential temporary impacts would be experienced.

Eight viewpoints were identified, including two in the upstream zone, three in the Warragamba Dam zone and three in the downstream zone. Viewpoints are outlined in Table 25-4 and shown on Figure 25-5 (upstream zone), Figure 25-6 (Warragamba Dam zone) and Figure 25-7 (downstream zone).

Viewsheds

Viewsheds define what will be visible from nominated viewpoints and are determined from:

- physical characteristics of surrounding landscape terrain
- extent of the existing development
- Project construction
- Project operation.

Viewshed figures for each viewpoint are provided in Appendix P (Landscape character and visual impact assessment report, Section 5). The upstream viewsheds for Echo Point Lookout and Burragorang Lookout are shown on Figure 25-8 and Figure 25-9.

Areas with views to the Project were modelled and validated in the field. Modelling is described in Appendix P (Landscape character and visual impact assessment report, Section 4.4.5) and included generating oblique figures using ArcGlobe (version 10.4) software and using landform data available from the Department of Lands (Land and Property Information Division). The viewing extent and looking angle were manually adjusted for each viewpoint.

Table 25-4. Viewpoints

Viewpoint (VP)	Location	Potential visibility of the Project
Upstream zone (Figure 25-5)		
1-1	Echo Point Lookout, Katoomba	▪ Long range views of existing and Project for upstream impact area
		▪ Long range views of existing and Project PMF events
1-2	Burragorang Lookout, Nattai	▪ Medium range views of existing and Project for upstream impact area
		▪ Medium range views of existing and Project PMF events
Warragamba Dam zone (Figure 25-6)		
2-1	Viewing platform, Warragamba visitor centre	▪ Close range views of construction activities ▪ Close range views of built infrastructure ▪ Close range views during all flood events
2-2	Valve House Road, Warragamba Dam	▪ Close range views of built infrastructure (assessment does not change across Existing and Project flood events)
2-3	18th Street Lookout, Warragamba	▪ Medium range views of existing and Project 1 in 5, 1 in 20 chance in a year level & PMF events (assessed impacts as per VP2-1)
Downstream zone (Figure 25-7)		
3-1	Penrith Weir, Penrith	▪ Close range views during existing and Project 1 in 20 chance in a year flood level
		▪ Close range views during existing and Project PMF events
3-2	Windsor Bridge, Windsor	▪ Close range views during 1 in 20 chance in a year flood level and PMF events
		▪ Close range views during existing and Project PMF events
3-3	Richmond Bridge, Richmond	▪ Close range views during existing and Project 1 in 20 chance in a year flood levels
		▪ Close range views during existing and Project PMF events

Figure 25-5. Upstream zone viewpoint assessment locations

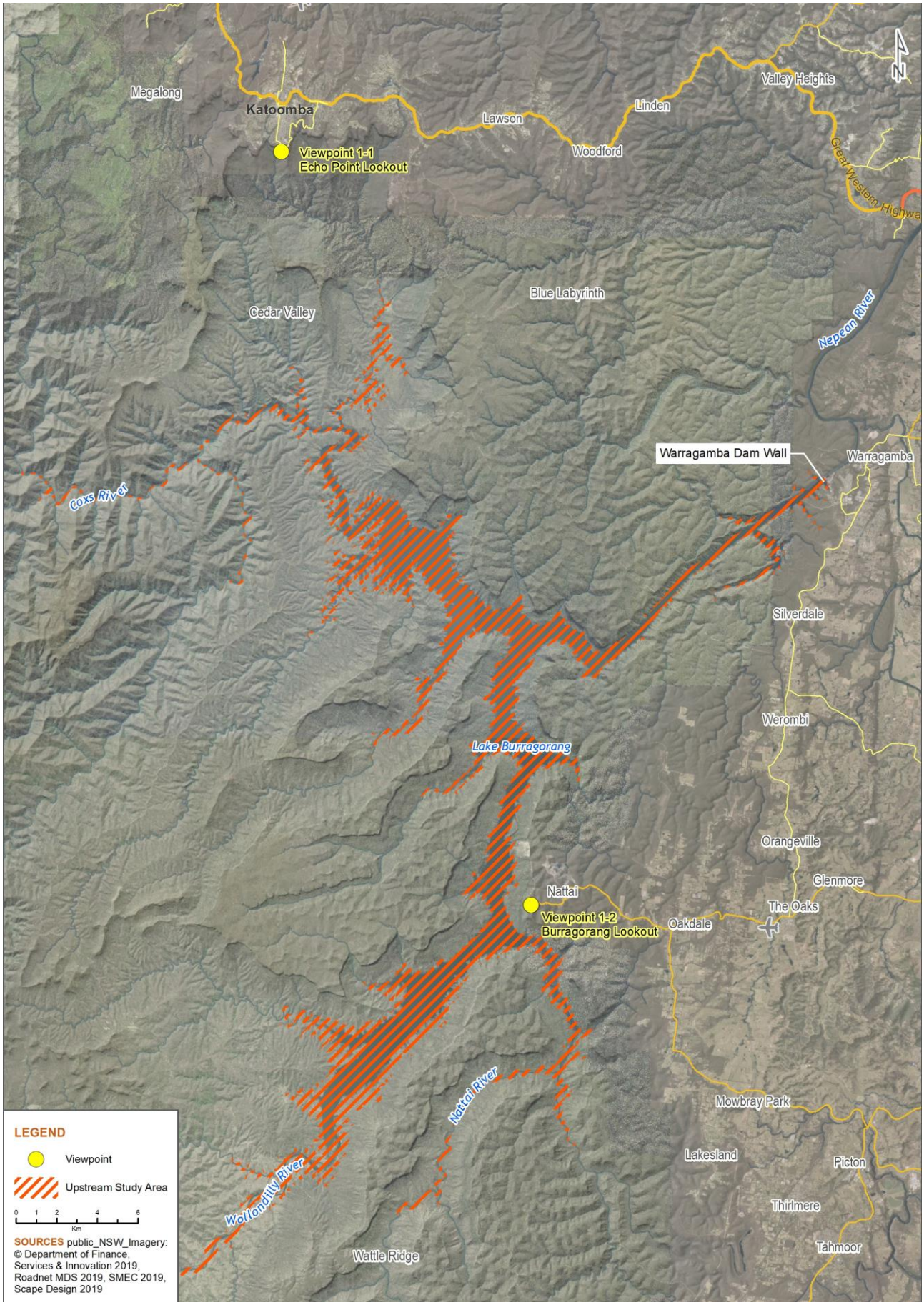


Figure 25-6. Warragamba Dam zone viewpoint assessment locations

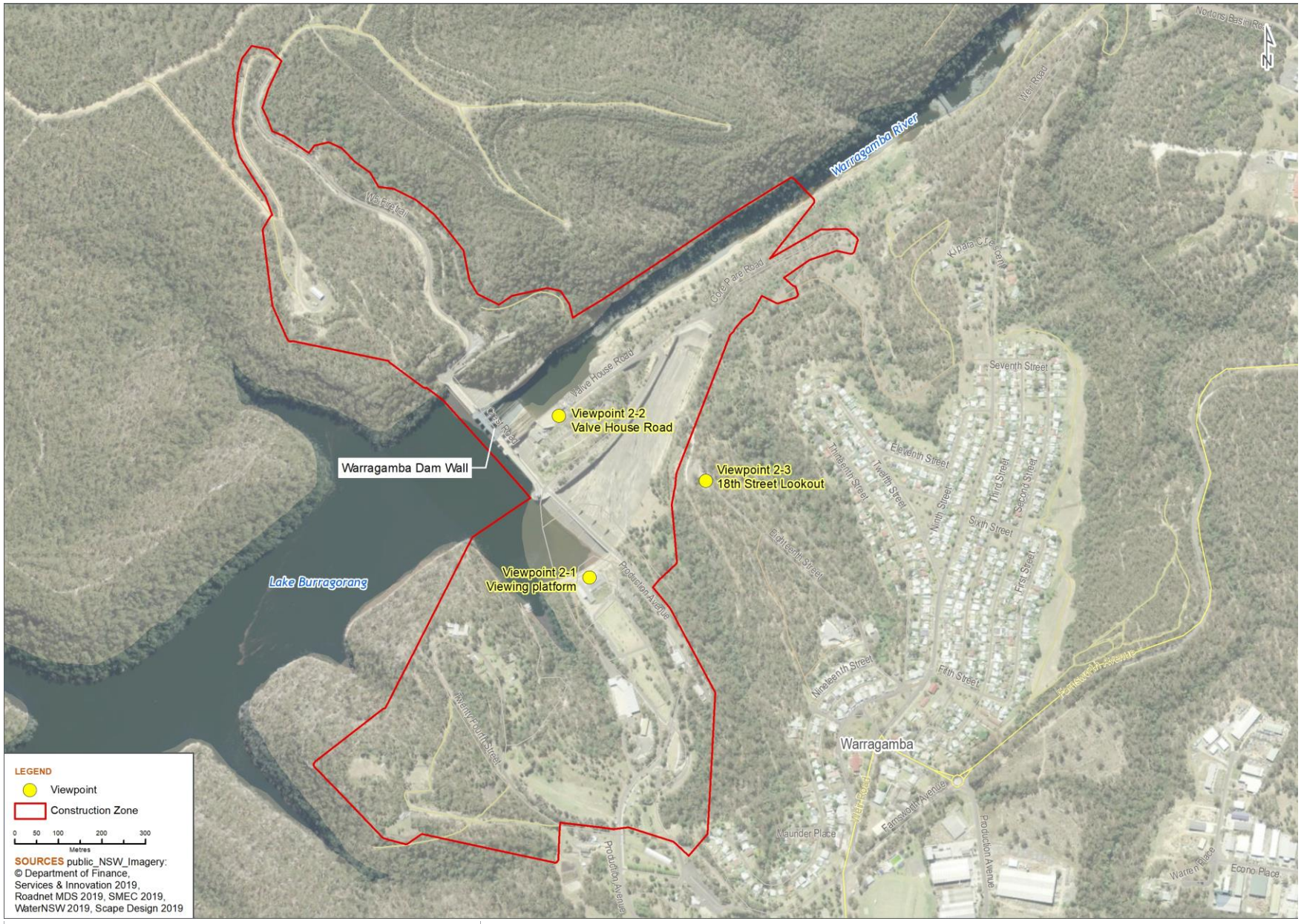


Figure 25-7. Downstream zone viewpoint assessment locations

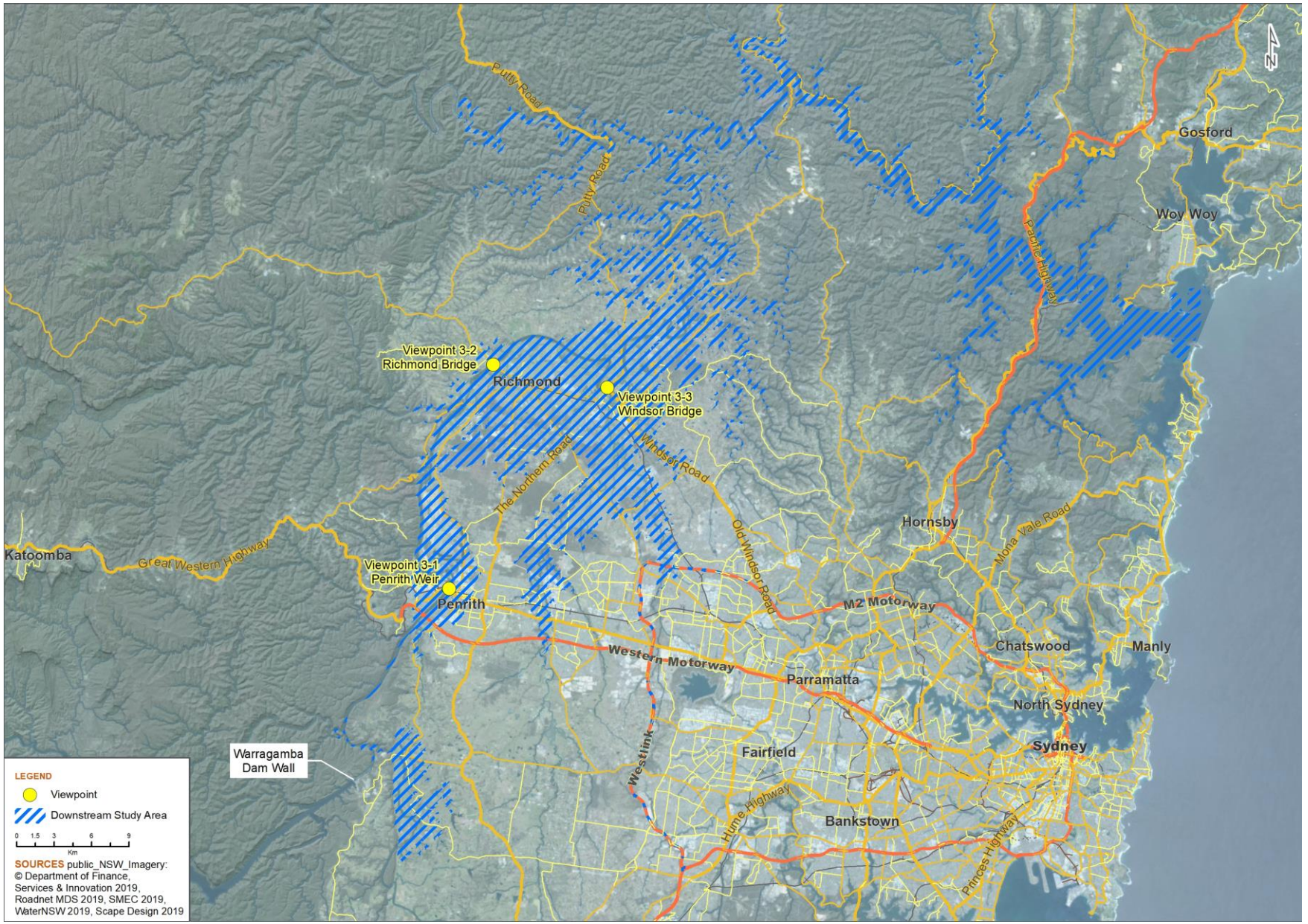


Figure 25-8. Viewshed for Echo Point Lookout

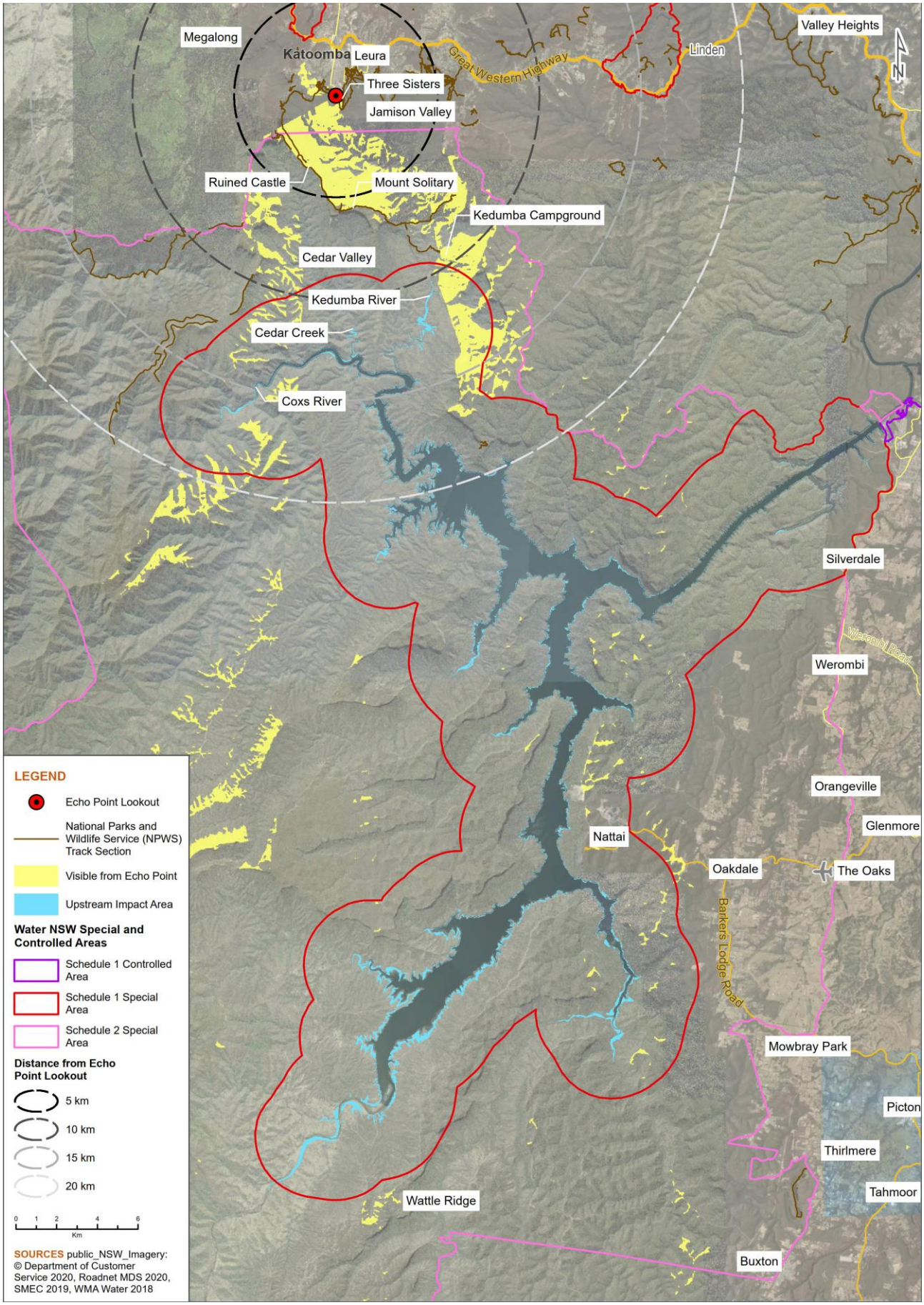
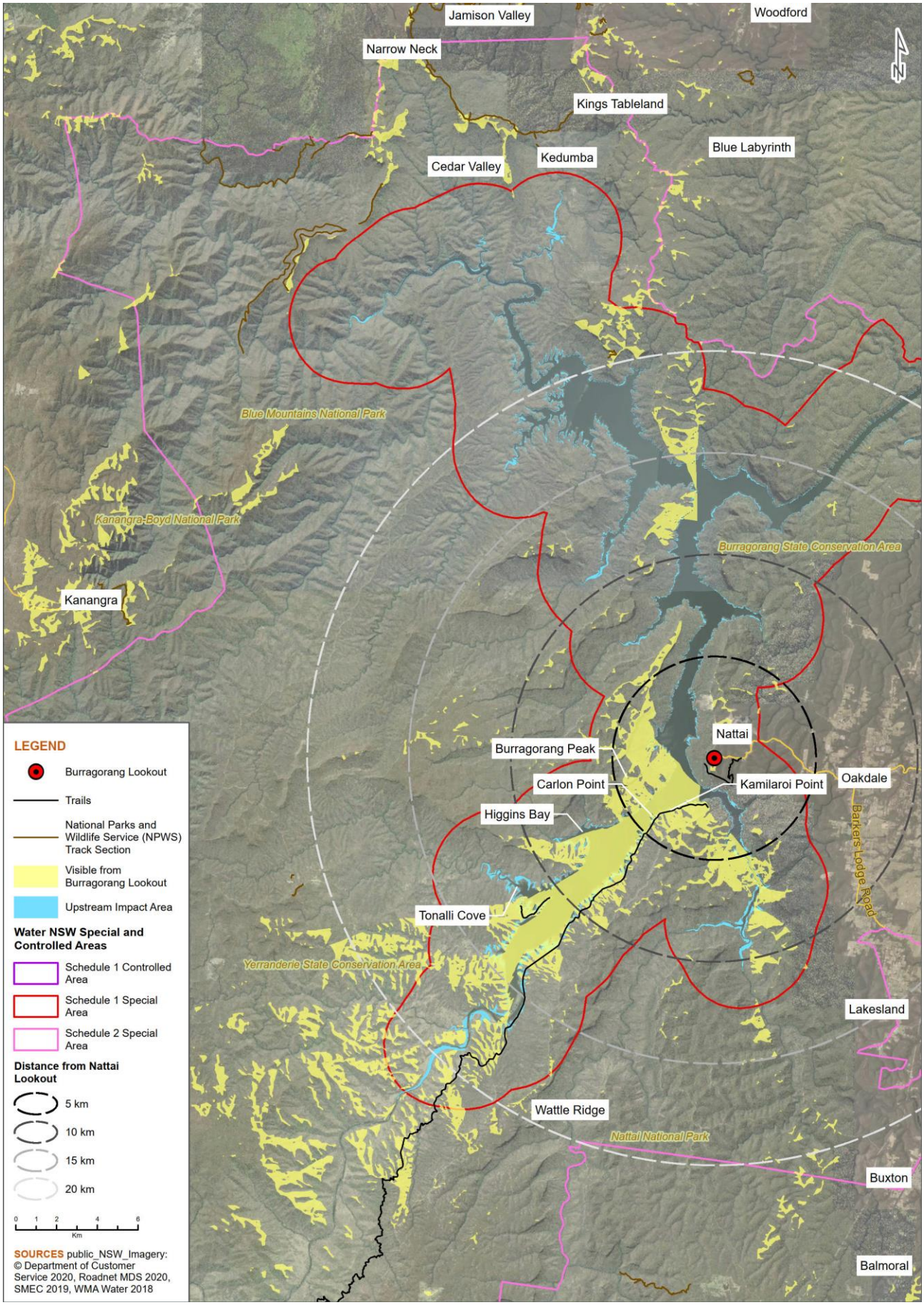


Figure 25-9. Viewshed for Burragorang Lookout



Sensitivity

Sensitivity is the measure of the visual importance of the view, the 'completeness' of the view and the perceived value of the existing landscape character. A judgment is made as to the quality of the landscape, its cultural and historical importance to the community, scenic value and overall composition of the place and its inhabitants. The following sensitivity parameters have been used as the basis for this assessment:

- the category of viewer such as resident, visitor or worker and the number and frequency of viewers or views
- the elements of the project that are visible
- importance of the view. Places with high social, recreational, and historical significance to local residents have higher sensitivity, as do areas of unique scenic quality
- generally, viewers with the highest sensitivity include:
  - residents who have existing views that would be affected by the Project and the context of this view i.e. kitchen window, balcony, bedroom, living room
  - users of public open space where their attention is focused on the visual landscape, for example, lookouts or other scenic natural areas
  - communities that place high cultural and historical significance on the visual landscape
- viewers with the lowest sensitivity are most likely to be:
  - employees working within an enclosed workplace and focused on their work (however interesting views should be provided for them within a short walk from their workplace)
  - motorists (apart from tourists) whose attention is focused on driving – however it is important to provide a stimulating motorist experience, particularly for tourists.

Magnitude

The 'magnitude of visual change' describes the contrast or type of change resulting from the proposal or project, the extent of change and the proximity of the viewer. Changes are categorised as follows:

- a high magnitude of change would result if the project is of a major scale and considered out of scale or uncharacteristic of the existing view, or if there is considerable modification to the existing built fabric or landscape
- a moderate magnitude of change would result if the project is prominent but not considered to be substantially different from the existing character
- a low magnitude of change would result if there is minimal alteration to the existing view and the project is of a scale and nature that is consistent with the existing landscape.

25.3.6 Assessment tools

To assess the potential impacts of the Project across the often vast and variable landscape features of the study area, it was necessary to investigate the specific visual impacts of both the upstream and downstream zones using different tools to those used for the assessment of the Warragamba Dam zone.

The oblique view figures were generated using the software ArcGlobe (version 10.4). The New South Wales DTBT Landform Theme 50k x 50k Digital Elevation Model (25 metre resolution) by Department of Lands (Land and Property Information Division) was used as surface raster, overlayed with 50 metre contours and various flood extents. The viewing extent and looking angle were manually adjusted for each viewpoint.

The application of the RMS EIA-N04 was used to assess the likely changes to landscape composition such as the dominance of form, lines, colours and textures. The sensitivity of potential viewers was combined with objective measurement to form assessment conclusions.

25.3.7 Photomontages

Three viewing locations were selected to produce photomontages to represent the views from locations with close range views of the Project. Photographic images used were captured using the following devices:

- viewpoints 2-1 and 2-2 were captured using an Apple iPhone 7 Plus, focal length 28 mm in a 35mm format (digital equivalent) camera at a camera height of 1.65 metres
- viewpoint 2-3 was captured Sony DSLR-A350, focal length 27 mm in a 35mm format (digital equivalent) camera at a camera height of 1.65 metres. The photomontages were prepared using specialized 3DStudio 2015

(created by Autodesk®) software, using the 'Camera Match utility' for creating the photomontages, with the following input information:

- digital photographs of the study area taken from each viewpoint
- architectural plans and elevations in DWG format
- certified survey plans.

25.4 Existing environment

25.4.1 Overview

Each of the three assessment zones within the study area were identified as having unique and varying landscape features, landform, water form, vegetation, built form and land use.

- The **upstream zone** is a diversity of spectacular natural features dominated by densely vegetated rugged topography with vast plateaus that have been incised by rivers, over time, forming steep valleys, rocky outcrops, sheer cliffs, and escarpments down to Lake Burragorang. The lake typically has a shoreline of bright exposed rock depending on water levels.
- The **Warragamba Dam zone** (including the construction area) is in a steep narrow, densely vegetated gorge, which contrasts with the scale and mass of the constructed dam wall, the auxiliary spillway, access roads, dam site buildings and parks and recreational areas adjacent to the dam.
- The **downstream zone** begins slightly upstream of the confluence of the Warragamba River and Nepean River. Densely forested undulating hills eventually lead through a steep narrow gorge and emerge into open, extensive floodplain country dotted with urban centres. During existing flood events, it is common for inundated river banks to experience some scaring and bank slumping.

The existing environment was described by determining landscape character zones within the Project catchment, which are outlined above. Landscape heritage values are summarised below, while additional baseline information is provided in Appendix P (Landscape character and visual impact assessment report, Section 2).

25.4.2 Cultural context

25.4.2.1 Aboriginal heritage

An assessment of aboriginal cultural heritage is provided in Appendix K (Aboriginal cultural heritage assessment report).

The **upstream zone** and **Warragamba Dam zone** are part of the traditional lands of the Gundungurra, Darkinjung, Tharawal, Dharug and Wiradjuri peoples. There are several Aboriginal sites in this upstream zone, which remain important to Aboriginal people today as they are physical evidence of a link to their ancestors. No sites were identified in the Warragamba Dam zone.

The **downstream zone** is part of the traditional lands of Wiradjuri, Dharug, Wanaruah and Darkinjung Aboriginal peoples. It was used as a source of food, medicines and shelter and has held significance dating back at least 12,000 years.

There are various Aboriginal sites across the study area which include:

- ceremonial grounds
- stone arrangements
- grinding grooves
- scarred trees
- rock engravings
- cave art
- middens
- other occupational deposits.

25.4.2.2 Non-Aboriginal heritage

An assessment of non-Aboriginal heritage is provided in Appendix I (Non-Aboriginal heritage assessment report). Some heritage sites registered by the State Heritage Register (SHR), National Heritage Listing (NHL) and World Heritage Listing (WHL) are found within the Project construction area and in the downstream flood plain. A summary of heritage sites is provided below.

The **upstream zone** includes the historical Yerranderie township (not on the SHR), which retains much of the history of mining and settlement in the early 20th century.

The **Warragamba Dam zone** contains the Warragamba Dam Supply Scheme (SHR No. 01376), which includes the following elements:

- Main dam wall with a crest length of 351 metres and height 142 metres). The dam is a straight gravity wall and contains the following sub-components:
  - crest gantry crane
  - crest gates
  - dam outlets
  - internal inspection galleries, lift shafts, and access tunnels
  - 18 tonne cableway (upper tail tower)
  - hydro-electric power station
  - suspension bridge
  - valve house
- Haviland Park (SHR No. 01375) and picnic grounds
  - production office and other buildings
  - dam models and former visitor centre
  - former construction township
- Warragamba Emergency Scheme
- Warragamba Prospect Pipelines 1 and 2.

The **downstream zone** includes examples of early colonial activity and demonstrates the use of convict labour and engineering and include:

- Australian Convict Sites (Old Great North Road) and buffer zone (WHL Place ID 106209)
- parcels of land that were granted to the First Fleet
- government cooperative farms and an agricultural training facility
- an internment camp during World War I
- a training base for the First Australian Parachute Battalion in World War II
- a migrant camp for new Australians
- an officer's training facility during the Vietnam War
- Arndell's 1821 homestead
- convict-built walls and roads, grain silos and ruins of a windmill believed to be Australia's oldest industrial building.

Also in the downstream zone are the Ku-ring-gai Chase National Park and Lion, Long & Spectacle Island Nature Reserves (NHL Place ID 105817).

25.4.3 Landscape character

Landscape character is defined in *EIA N04 Practice Note: Guidelines for Landscape Character and Visual Impact Assessment V2.0* (RMS 2018) as the aggregate of built, natural and cultural aspects that make up an area and provide its unique sense of place. Landscape in this context is taken to include all aspects of a tract of land – the built, planted, and natural topographical and ecological features.

In applying this definition to the specific conditions within the study area and the features of the Project, the boundaries of the landscape character zones (LCZs) were identified based on desktop studies and confirmed during site visits where they were recorded and photographed.

Based upon the assessment of the natural and cultural influences that shape the landscape and visual context of the Project study area, three LCZs have been identified. Each LCZ represents a relatively homogenous character based on the consideration of the following attributes:

- landscape value (for example, landscapes designated for their scenic or landscape importance or valued recreational function)
- landscape elements that contribute to defining character for example, pasture, crops, drainage channels, river/creek corridors, bushland, mature bushland corridors alongside roads, cultural plantings (for example, planting along property entrance drives)

- landscape character attributes (including scale, grain, and perceptual characteristics such as the sense of remoteness, tranquillity and/or its perceived rural character).

Three LCZs within the Project catchment have been defined for the purposes of this assessment as follows:

- **upstream zone** – upstream area including the PMF extent of Lake Burragorang and upstream tributaries.
- **Warragamba Dam zone** – dam wall and surrounding area, including the construction impact area.
- **downstream zone** – downstream area including the PMF extent of freshwater and estuarine reaches of the Warragamba River to where it joins the Nepean River near Wallacia.

Landscape character zones are summarised in Table 25-5, Table 25-6 and Table 25-7, and provide a framework for the visual impact assessment based on various viewpoints (see Section 25.3.5).

Table 25-5. Upstream zone: landscape character zone

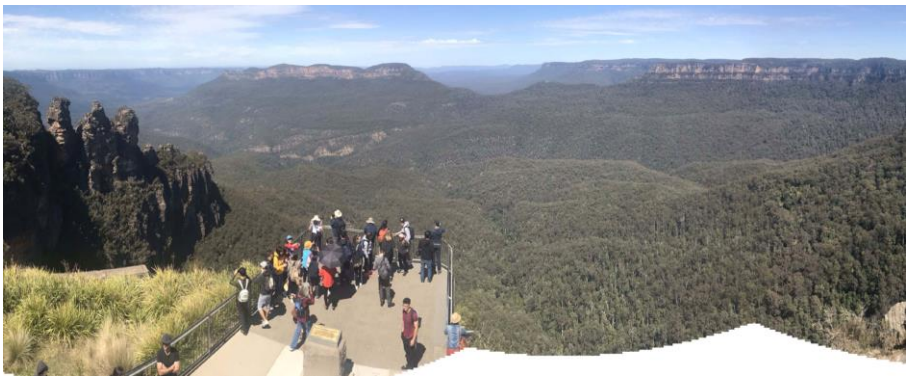
Upstream zone: landscape character zone	
Consists of upstream of Warragamba Dam including Lake Burragorang and tributaries, areas of the Blue Mountains National Park, Burragorang State Conservation Area, Nattai National Park, Nattai State Conservation Area and Yerranderie State Conservation Area. Most of the Blue Mountains National Park is within the GBMWHA.	
The character of Blue Mountains National Park, which is within the upstream zone, is described in 'The Blue Mountains National Park Plan of Management' (NPWS, 2001) as having a diversity of 'natural features characteristic of much of the region's sandstone landscape. These include dominating cliff lines, narrow incised river canyons and a maze of forested ridges and gorges. Vegetation communities include rainforests, tall open forest and heathland have aesthetic appeal. The Blue Mountains National Park is a major international and domestic tourist attraction due to its outstanding landforms and scenery. Visitors can enjoy a broad range of recreational facilities including passive enjoyment of the scenery from the lookouts to more active wilderness experiences in the canyons and gorges. There are also large areas that are remote that offer opportunities for protection of the biodiversity and self-reliant recreation. A large part of the upstream zone falls within the WaterNSW Special and Controlled Areas, which prohibits public access to assist in protecting the drinking water catchment of Lake Burragorang (Schedule 1 Special Areas includes the lands immediately around the Warragamba Dam. Entry is not generally allowed to the Schedule 1 Special Areas, on foot or by vehicle, including cars, motorcycles, bicycles, and horses. Schedule 2 Special Areas form a second-tier buffer zone around Lake Burragorang in the Warragamba catchment. No vehicles, including cars, motorcycles, bicycles, and horses, are permitted in Schedule 2 lands. Bushwalking and camping are allowed.	
View from Echo Point, looking towards the Three Sisters	
Jamison Valley	

Table 25-6. Warragamba Dam zone: landscape character zone

Warragamba Dam zone: Landscape character zone	
Comprises the dam wall and immediately surrounding areas including access roads, spillway, infrastructure, and site buildings (operations and visitor centre). The dam wall intersects the steep, densely forested river valley. The crest of the dam wall and associated features have been described as indicative of 'post-war construction with simpler and cleaner utilitarian detailing' (Brooks 2010). This contrasts with the vegetated slopes and helps to highlight the form, scale, and mass of the dam wall. The scale of the landform is co-dominant with the dam wall and associated infrastructure. The auxiliary spillway and bridge were extended in 2002 and contributes to the enormity of the dam infrastructure in the immediate downstream area. This extension resulted in the loss of part of Haviland Park.	
View from existing cliff top walkway across the existing spillway bridge	
View from the Eighteenth Street Dam Lookout	

Table 25-7. Downstream zone: landscape character zone

Downstream zone: Landscape character zone	
Consists of the freshwater and estuarine reaches of the Hawkesbury-Nepean river system and its tributaries between Warragamba Dam, where it joins the Nepean River near Wallacia and Wisemans Ferry, as well as the abutting riparian zone, floodplain and wetland / lagoon waterbodies. Downstream of Windsor, South Creek which flows into the Hawkesbury River, will experience backwater flooding impacts during flood events and has consequently also been included in the downstream zone.	
View looking upstream from the Penrith Weir1 (Victoria Bridge is in the background)	
View looking downstream from the Windsor Bridge	

[1] Penrith Weir - Nepean River - Penrith NSW by sv1ambo available at https://www.flickr.com/photos/50415738@N04/5554094989/ under a Creative Commons Attribution 2.0. Full terms at http://creativecommons.org/licenses/by/2.0.

25.5 Impact assessment

25.5.1 Landscape character

Landscape character is discussed in Section 25.3.4. A landscape character zone (LCZ) is an aggregation of character units with similar landscape elements including landform, water-form, vegetation, land use and built form. Three Project LCZs were identified, which are discussed in Section 25.1.2 (Study area) and Section 25.4.1 (Existing environment), and summarised below:

- **Upstream zone**- includes the Project PMF extent in Lake Burragorang and upstream tributaries, and a variable portion of the lower slopes of the Burragorang Valley
- **Warragamba Dam zone** - includes the areas immediately adjacent to the dam wall and some local surrounding areas; the architectural character of the dam wall is not necessarily typical of other built items within the zone
- **Downstream zone**- includes the existing PMF extent in the freshwater and estuarine reaches of the river system and its tributaries between Warragamba Dam where it joins the Nepean River near Wallacia.

Project elements with potential to cause changes to LCZs, together with potential impact ratings are presented in Table 25-8, Table 25-9 and Table 25-10 (see Section 25.3.4 for impact rating definitions).

Table 25-8. Upstream zone: Project changes and landscape character zone impact ratings

Upstream zone			
Existing / Project	**Sensitivity**	**Magnitude**	**Impact rating**
This character zone is a natural area in a landscape dominated by its rare diversity of natural features with limited public use. It is characterised by a rugged sandstone landscape, dominating cliff lines, narrow canyons and a maze of forested ridges. The area is highly valued by local population and tourists and includes sections of world heritage listed National Park. ▪ *Physical attributes* - Lake Burragorang (the reservoir formed by Warragamba Dam) and its tributaries - areas of the Blue Mountains National Park - most of the Blue Mountains National Park is also in the GBMWHA, however only a very small portion of the GBMWHA would be impacted by an increase in water levels during temporary inundation. The likely area of change would be in the order of 0.03% based on current hydraulic modelling for a 1 in 20 chance in a year flood event - Burragorang State Conservation Area - Nattai National Park - Nattai State Conservation Area - Yerranderie State Conservation Area. ▪ *Project elements causing change* Includes areas upstream of Warragamba Dam that would be affected by operation of the FMZ. Operation of the FMZ is described in Chapter 5 (Project description) and includes capturing and temporarily storing flood inflows, thereby increasing levels in Lake Burragorang and upstream tributaries. Water would be discharged in a controlled manner, resulting in temporary upstream inundation. For a large storm event, the Project would result in flood durations increasing from less than half a day for upstream areas, up to around two weeks near the dam wall (see Section 25.3.2).			
Existing	**High** - This zone is a natural area dominated by its rare diversity of natural features - The large portion of this zone has limited/ no access for the public - The area is highly valued by local population and tourists and includes sections of world heritage listed National Park.	**Low** - Lake Burragorang is bordered by a visible shoreline. This shoreline is defined by a dynamic water level, which results in inundation at various levels and frequencies. - The water level in the lake and tributaries varies depending on a combination of rainfall within the catchment and operational needs of Sydney's water supply.	Moderate
Project	**High** As above	**Low** Changes because of increased temporary inundation are unlikely to be perceptible within the scale and expanse of the zone, which is already impacted by dynamic water levels.	Moderate

Table 25-9. Warragamba Dam zone: Project changes and landscape character zone (LCZ) impact ratings

Warragamba Dam zone			
Existing / Project	**Sensitivity**	**Magnitude**	**Impact rating**
This zone includes the dam wall and areas immediately surrounding it, including auxiliary access roads, spillway, infrastructure and site buildings, including the operations and visitor centre. The surrounding natural area is defined by steep, densely forested river valley slopes, which are intersected by the considerable built structure of the existing dam wall. An extension of the dam wall zone and the auxiliary spillway and bridge, completed in 2002, links across to the dam wall and contributes to the enormity of the dam infrastructure in the immediate downstream area. That project, along with the original dam construction completed in 1960 and subsequent ad-hoc projects, are indicative of the scale of intervention required for a major water supply site ▪ *Physical attributes* - the main dam wall and sub-components - Haviland Park and picnic grounds - Warragamba Emergency Scheme - Warragamba Prospect Pipelines 1 and 2. ▪ *Project elements causing change* New and modified infrastructure would be provided as part of the Project and include various modified and new structures. The works would result in a higher and more visually prominent structure of the dam wall and more extensive downstream infrastructure especially in relation to the auxiliary spillway, however the dam elements would essentially be the same style and be similar in visual appearance to the existing dam albeit more 'contemporary' in appearance			
Existing	**Moderate** The sensitivity of the zone reflects the highly modified landscape of the dam wall and the vistas to the wider natural landscape. Thus, the sensitivity of this zone is primarily a reflection of the built form, but is influenced by the sensitivity of the natural environment in which it sits	**Moderate** There is a compelling juxtaposition between the natural landscape setting and the built dam wall infrastructure and other engineered elements	Moderate
Project	**Moderate** Construction of the Project would result in a more visually prominent structure due to the raising of the dam wall and construction of more extensive downstream infrastructure, especially within and downstream of the auxiliary spillway.	**Moderate** The size and scale of the built infrastructure would increase however; these new structural elements would essentially be a visual extension of the existing dam.	Moderate

Table 25-10. Downstream zone: Project changes and landscape character zone impact ratings

Downstream– zone 3			
Existing / Project	**Sensitivity**	**Magnitude**	**Impact rating**
This zone includes the areas downstream of the Warragamba Dam wall, which include the freshwater and estuarine reaches of the Hawkesbury-Nepean Valley river system and its tributaries between Warragamba Dam, where it joins the Nepean River near Wallacia and Wisemans Ferry as well as the abutting riparian zone, floodplain and wetland/lagoon waterbodies. South Creek, which flows into the Hawkesbury River, downstream of Windsor, will experience backwater flooding impacts during flood events and has consequently also been included in the zone. ▪ *Physical attributes* - freshwater and estuarine reaches of the river system and its tributaries between Warragamba Dam where it joins the Nepean River near Wallacia and Wisemans Ferry - abutting riparian zones - abutting floodplain and wetland/lagoon waterbodies - backwater flooding during flood events which have impacts along South Creek, that flows into the Hawkesbury River downstream of Windsor and consequently South Creek. ▪ *Project elements causing change* The FMZ would delay and attenuate the progression of floodwaters coming from the upstream Warragamba catchment, which in turn reduces the severity of regional flood events impacting on the downstream Hawkesbury-Nepean Valley. The Project would reduce the flooding extents for all modelled floods.			
Existing	**Moderate** The existence of the expansive river system, tributaries and extensive flood plains means that it is considered to have a reasonable capacity to accommodate changes which result from flooding.	**High** Existing flood events within this zone are extensive and have substantial impacts both economically and socially.	High–Moderate
Project	**Moderate** As above	**Low** Flooding within this zone would substantially reduce because of the Project (especially in the 1 in 20 chance in a year flood event) but not be eliminated altogether	Moderate–Low

25.5.2 Visual assessment - operations

25.5.2.1 Upstream zone

Viewpoint 1-1: Echo Point Lookout, Katoomba

Viewpoint 1-1 - Upstream viewpoint: Echo Point Lookout, Katoomba

Affected viewers

- tourists and locals visiting the scenic lookout.
- staff of visitor centre (Blue Mountains City Council).

Existing environment

This viewpoint is located at the Echo Point scenic lookout on the edge of an escarpment approximately 2.2 kilometres south of the township of Katoomba (Figure 25-10). This viewpoint has panoramic views south across the Blue Mountains National Park and the GBMWHA, which is highly valued for its physical uniqueness and scenic qualities. The iconic Three Sisters rock formation is prominent in the left foreground with Mount Solitary and Ruined Castle rock formation in the middle distance, and the Narrow Neck Plateau in the background. These landmarks sit within a densely vegetated natural bushland area, which within this view has experienced only minimal human disturbance.

Figure 25-10. Viewpoint 1-1 looking south over the Jamison Valley from the Echo Point Lookout

Potential impacts

Operation of the FMZ of the raised dam to temporarily capture flood waters means that the lake and tributaries could potentially swell.

The Kedumba River is approximately 10 kilometres away from this viewpoint and would potentially be impacted by the Project. The Kedumba River is surrounded by densely vegetated valleys and together with steep topography, much of the river from this viewpoint is screened and any further inundation is unlikely to be discernible. Any visual changes due to increased inundation would be imperceptible from this viewpoint given the long distance for the viewpoint and intervening terrain and vegetation.

The visual impact assessment provided in Appendix P (Landscape character and visual impact assessment, Section 5) concluded that potential existing and Project visual impacts are **Moderate** for the upstream impact area, and **High** for the PMF. Therefore, the net change in impact is **negligible**. Oblique views for the upstream impact area and Project PMF are shown on Figure 25-11 and Figure 25-12 respectively.

Viewpoint 1-1 - Upstream viewpoint: Echo Point Lookout, Katoomba

Figure 25-11. Viewpoint 1-1: Echo Point Lookout showing Project upstream impact area

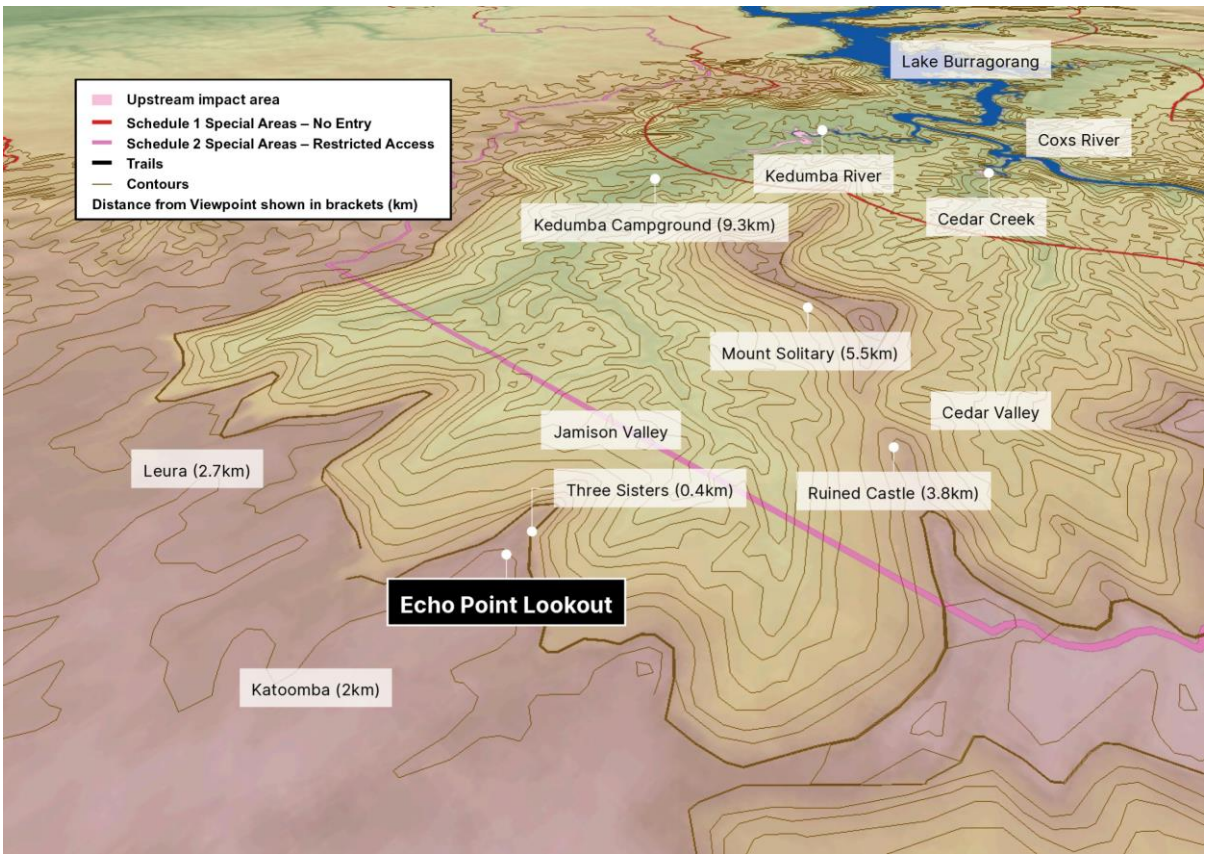
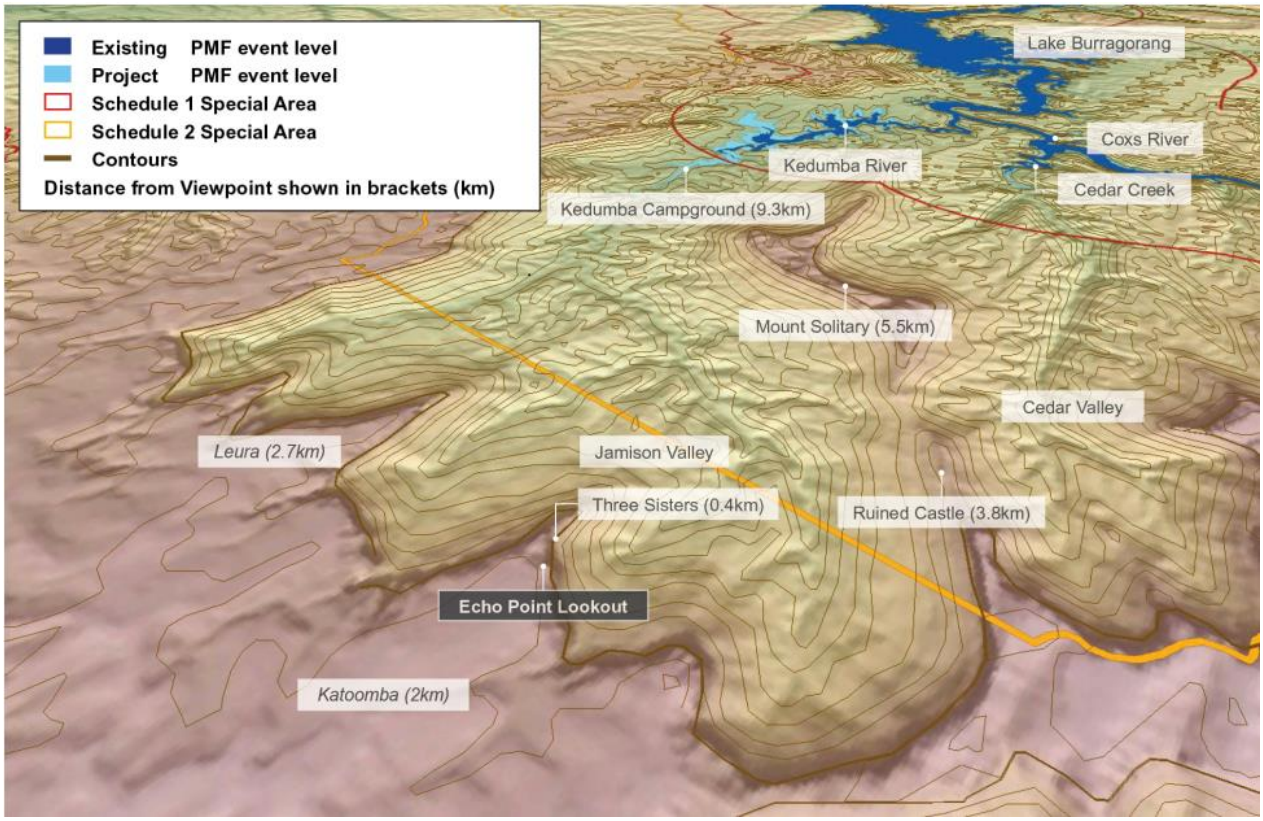


Figure 25-12. Viewpoint 1-1: Echo Point Lookout showing Project PMF



Viewpoint 1-2: Burragorang Lookout, Nattai

Viewpoint 1-2 - Upstream viewpoint: Burragorang Lookout, Nattai

Affected viewers

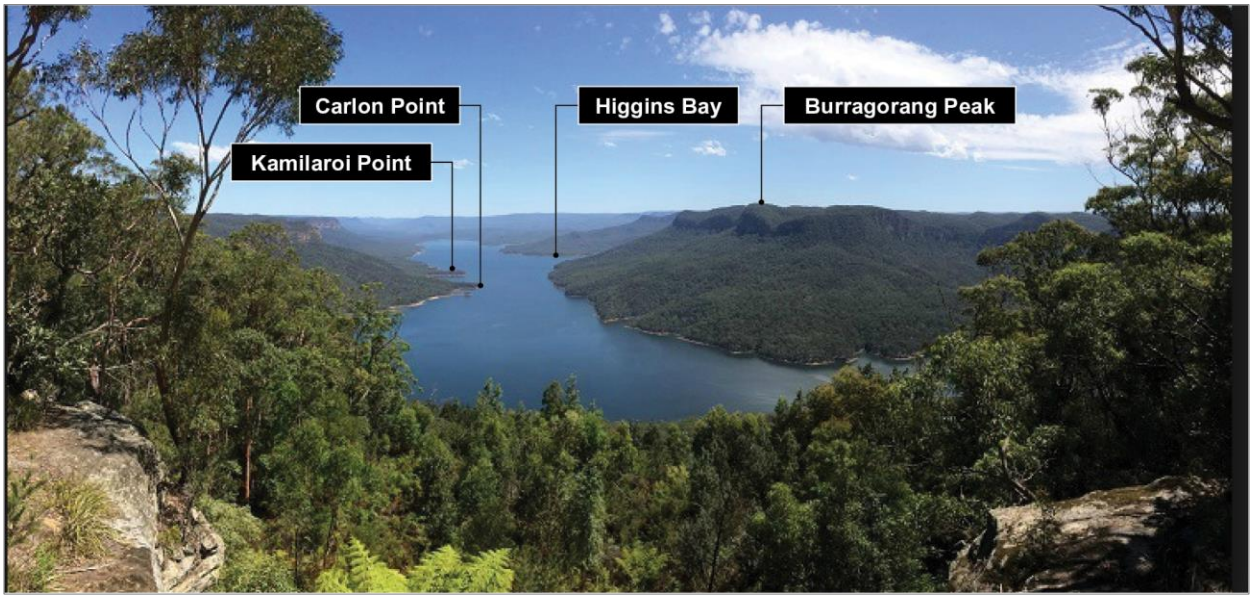
- tourists visiting the scenic lookout and picnic area.
- residents located within the catchment.

Existing environment

This viewpoint is located at Burragorang Lookout (Figure 25-13) and is perched high above Warragamba Dam, on an escarpment in the Blue Mountains. The viewpoint has spectacular panoramic views across Lake Burragorang, the Nattai National Park and Yerranderie State Conservation Area.

Burragorang Lookout is just over an hour's drive from the Sydney CBD and 40 kilometres south-west of the Warragamba Dam visitor centre, and is located at the end of a narrow, sealed road. The lookout area includes facilities such as picnic tables, shelters, barbecues, toilets, a walking track and children's playground. The small village of Nattai, with less than 60 residential blocks, is located approximately 1.5 kilometres east of the lookout and is situated at the entrance to the Burragorang State Forest and Conservation Area.

Figure 25-13. Viewpoint 1-2 looking south-west across Lake Burragorang from Burragorang Lookout



Potential impacts

Operation of the FMZ of the raised dam to temporarily capture flood waters means that the lake and tributaries could potentially swell. Some changes to the lake's shoreline may be apparent, however it should be noted that the lookout is situated almost 300 metres vertically above the surface elevation of the lake and is surrounded by dense bushland vegetation making changes difficult to discern. Any long-term vegetation impacts are unknown and infrequent and would be subject to further assessment when these events occur.

Sections of exposed rock on the shoreline, which is within the Nattai National Park and Yerranderie State Conservation Area, are visible and could potentially be altered by infrequent inundation of the banks. At its closest point, the shoreline is still almost two kilometres from this viewpoint and stretches as far as 16 kilometres into the distance. Depending on the level and duration of inundation there is potential for some loss or change in vegetation species, which itself could be a visual impact. However, impacts are unlikely to be discernible as distinct from the existing exposed shoreline, which fluctuates in scale depending on rainfall and drought conditions.

The visual impact assessment provided in Appendix P (Landscape character and visual impact assessment, Section 5) concluded that potential existing and Project visual impacts are **moderate** for the upstream impact area, and **High** for the PMF. Therefore, the net change in impact is **negligible**. Oblique views for the upstream impact area and Project PMF are shown on Figure 25-14 and Figure 25-15 respectively.

Viewpoint 1-2 - Upstream viewpoint: Burragorang Lookout, Nattai

Figure 25-14. Viewpoint 1-2: Burragorang Lookout showing Project upstream impact area

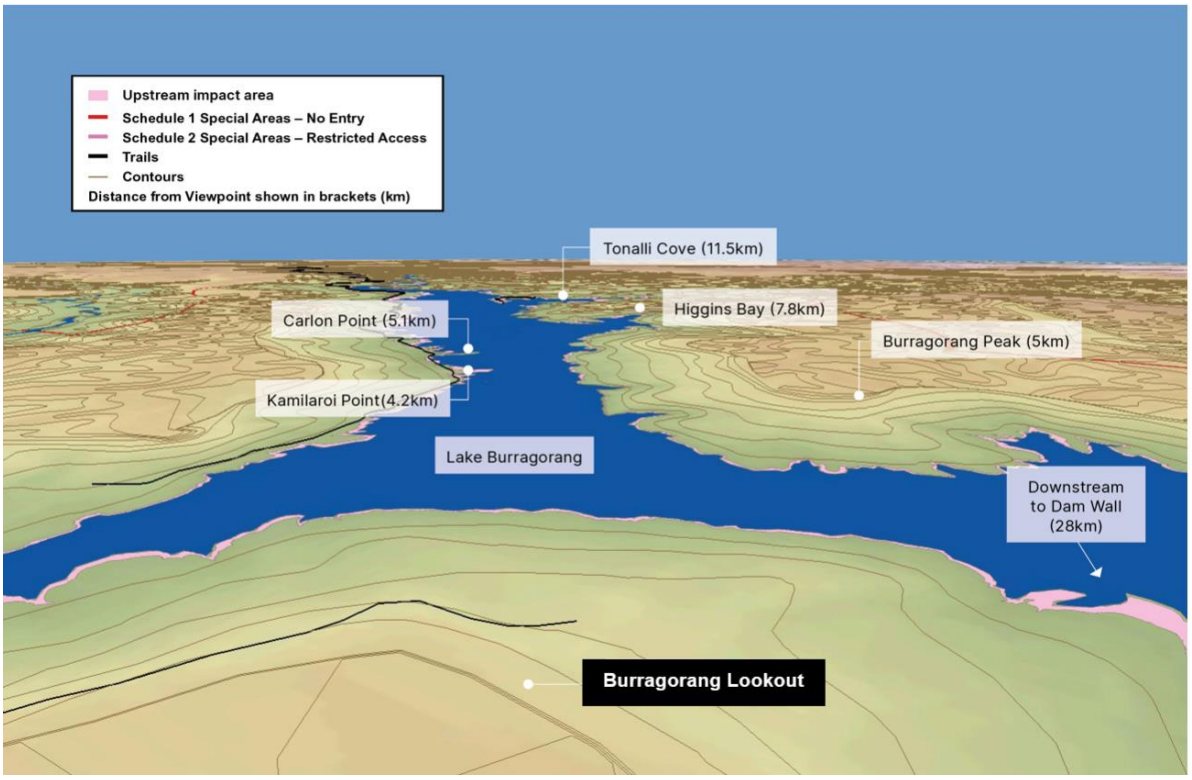
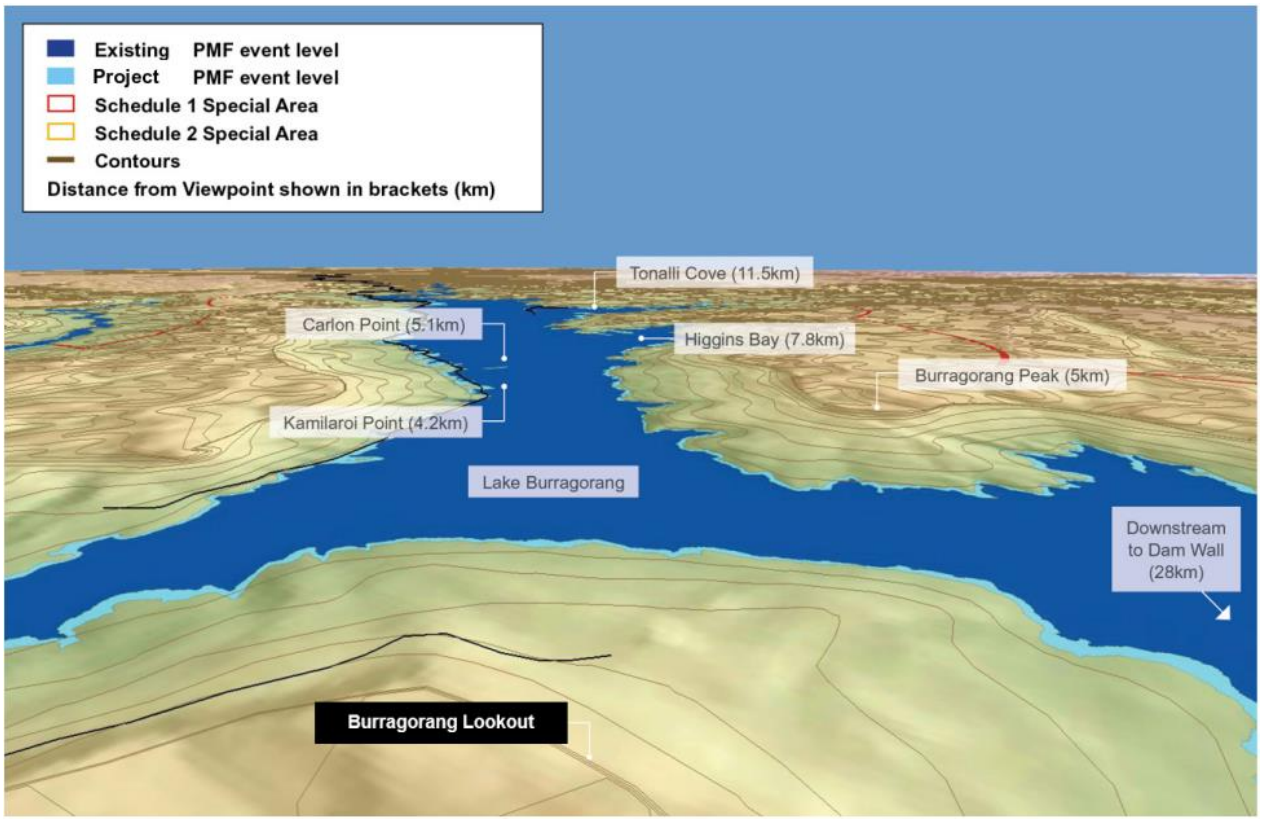


Figure 25-15. Viewpoint 1-2: Burragorang Lookout showing Project PMF

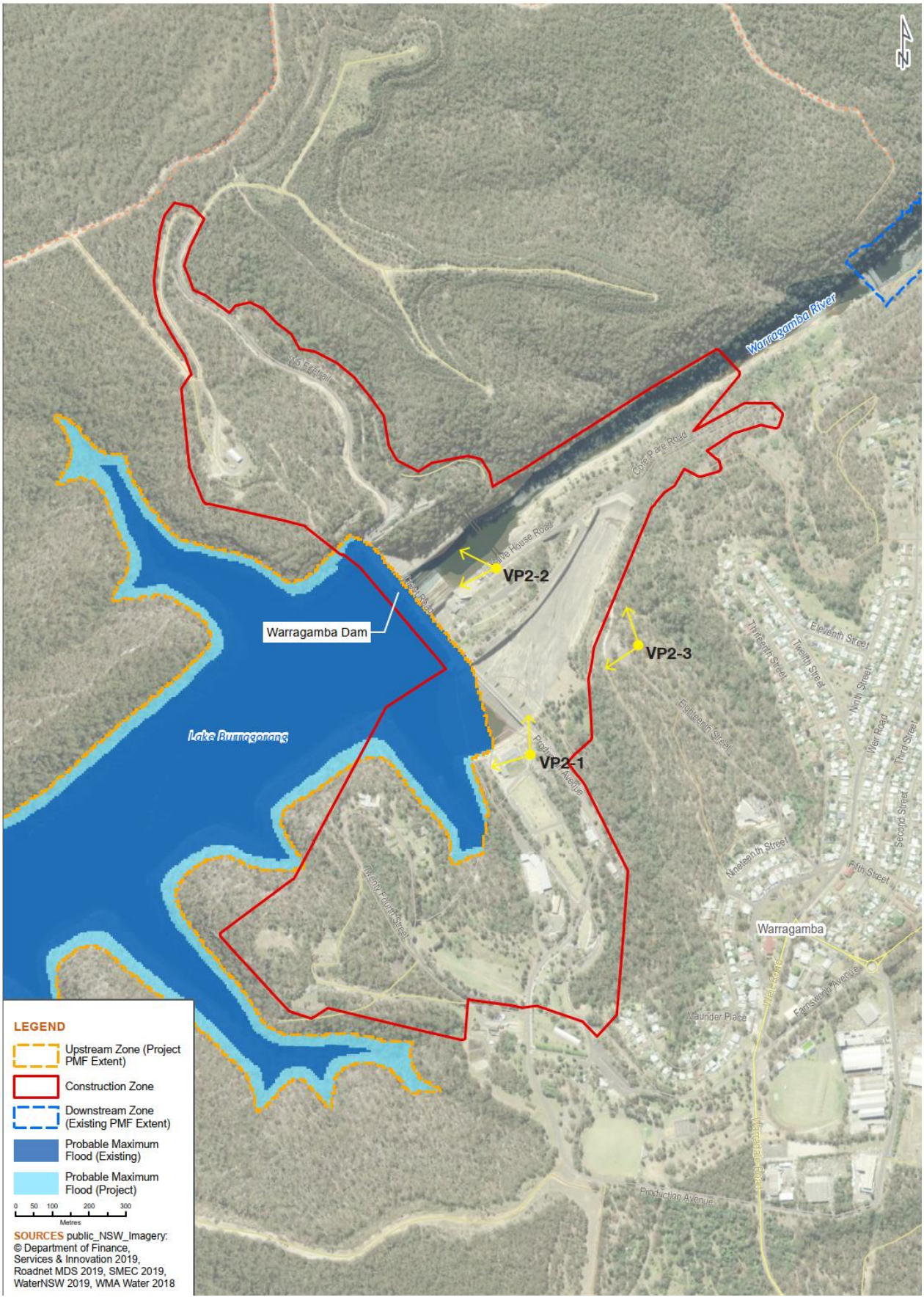


25.5.2.2 Warragamba Dam zone

Viewpoint 2-1: Viewing platform, Warragamba visitor centre

Viewpoint 2-1 - Construction viewpoint: viewing platform, Warragamba visitor centre
Affected viewers ▪ tourists in the visitor centre including the educational facilities and exhibition areas. ▪ dam operational staff working in offices located within the Operations and visitor centre.
Existing environment This viewpoint is located at the viewing platform on the cliff walkway, near the Warragamba Dam visitor centre (close to Production Avenue) (Figure 25-17). The view comprises the immediate upstream area of Lake Burragorang, the dam spillway bridge and associated infrastructure, the auxiliary spillway bridge and the spillway itself. The viewing platform is part of an existing clifftop walkway that links the visitor centre with Production Avenue some 80 steps below.
Potential impacts Views from this location would be dominated by the new bridge access road and raised auxiliary spillway bridge, which would run directly through the location of the existing viewing platform. Foreground views are also dominated by the natural features of the upstream dam environment including the lake water surface and exposed rocky shoreline, while prominent longer-range views include distinguishable dam infrastructure elements surrounded by the densely vegetated steep and narrow gorge. The visual prominence of the new dam and auxiliary spillway infrastructure would substantially increase from this viewpoint due to the Warragamba Dam raising. The dam wall and associated infrastructure demonstrate a significant built/engineering achievement and it is the contrast between the scale and massing of the dam infrastructure with the surrounding natural features (the lake water surface, exposed rocky shoreline and bushland) that heightens the value of each element within this view and contributes to the visual amenity. New infrastructure elements would be sympathetic to the design of the existing built form so that although the magnitude of change would be appreciable at this location, it is predicted that the contrast between infrastructure and natural features would be heightened in a positive manner. The area of visible lake shoreline currently fluctuates depending on rainfall and the water level in the lake. Potential impacts as a result of the Project may be discernible when compared to the existing conditions, however future fluctuations of the lake water levels would be of a similar visual nature to current operations, which reduces potential impacts. The Project PMF near the dam wall is shown on Figure 25-16. The potential visual impact on this viewpoint, compared with the current situation, is shown on Figure 25-17. The latter figure also shows the location of the upstream impact area near the dam wall. The area of visible lake shoreline currently fluctuates depending on rainfall. Potential impacts due to the Project may be discernible when compared to the existing conditions, however future fluctuations of the dam water levels would be of a similar visual nature to current operations. The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The sensitivity was assessed as moderate due to local and international tourists visiting the scenic lookout and the staff working at the visitor centre. The magnitude of visual impact was assessed as high due to the visual prominence of the Warragamba Dam Raising and infrequent raising of the water level in the upstream environment, including the upstream impact area. The overall visual impact was assessed as **High–Moderate.**

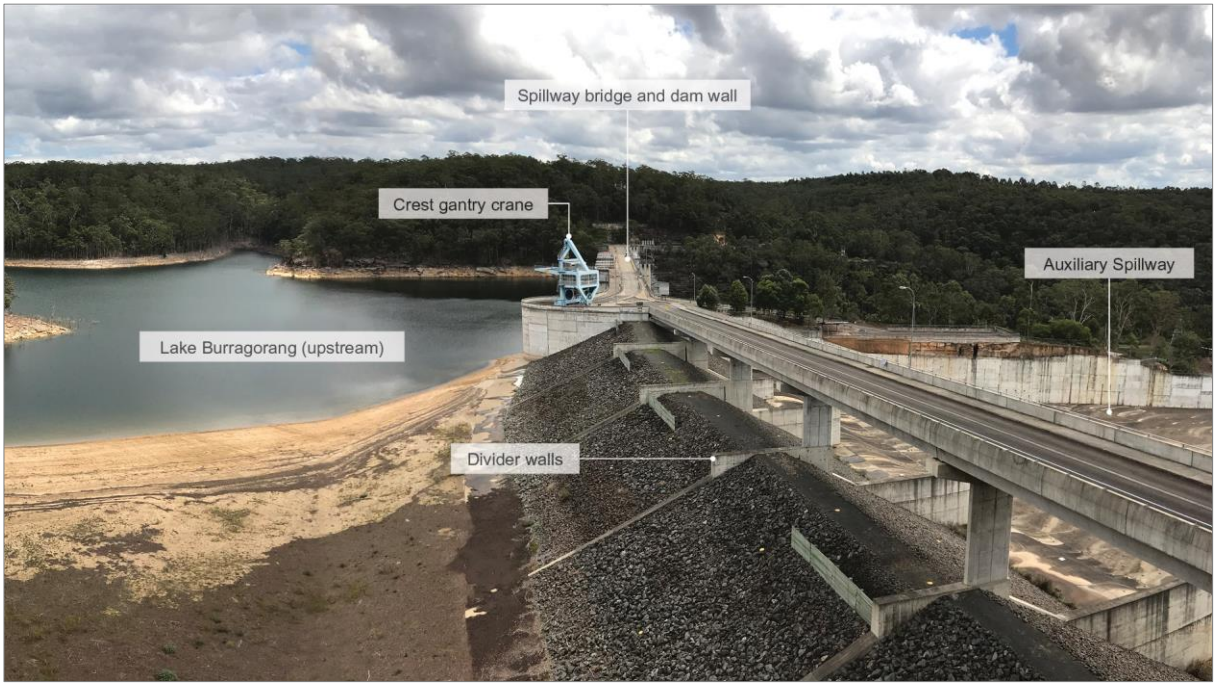
Figure 25-16. Project PMF near dam wall



Viewpoint 2-1 - Construction viewpoint: viewing platform, Warragamba visitor centre

Figure 25-17. Viewpoint 2-1: Project visual impact (Warragamba Dam zone)

Existing view looking northwest over auxiliary spillway and bridge towards the dam wall



Project photomontage view looking northwest over the upgraded auxiliary spillway / bridge towards the dam wall

Date of photo	08th March 2018
FSL	116.72 m
Dam storage level on this date	110.78 m

Event (1 in x chance in a year)	Existing	Project
	Maximum upstream level	*Increase in maximum level*
1 in 5	117.4 m	120.3 m
Upstream impact area	119.5 m	126.97 m
PMF (3 day)	129.8 m	142.5 m

Viewpoint 2-2: Valve House Road, Warragamba Dam

Viewpoint 2-2 - Construction area viewpoint: Valve House Road, Warragamba Dam

Affected viewers

- staff guided tourists visiting the dam site.
- dam operational staff working on site.

Existing environment

This viewpoint is located approximately 150 metres below the dam wall on the lower terrace, on Valve House Road (Figure 25-18). The dam wall and associated infrastructure are the distinct features at this location, completely dominating the view by their massive size. The downstream face of the wall, which is symmetrical about the central drum gate features the two simply detailed original lift towers. The wall has been described as 'Stripped Classical' (Beasley 1988) and was featured in 'The Spirit of Progress Art Deco Architecture in Australia' publication (Van Daele and R Lumby 1997).

Potential impacts

The view from this location is dominated by the dam wall and a bitumen access road, park seating and pedestrian fences, and some native trees in the immediate foreground. From this location colour striation of the dam wall face is obvious due to both discolouration and previous raising. Parts of the dam wall including the spillway bridge, spillway piers, dam crest and lift towers would all be raised as part of the Project but would aim to mimic the style and materials of the existing wall albeit with simpler smoother forms.

The visual prominence of the raised dam wall and associated infrastructure would increase at this location. It should be noted that while the dam and associated infrastructure contrasts strongly with the natural bushland surroundings of the locality, it is viewed as a historical landmark of regional significance and demonstrates a significant engineering achievement. As a result of the raising, it is likely that the engineering significance of the wall would continue. The small valve house control building at the rear of the existing valve house would also need to be demolished to create an access between the raised dam buttress and the remaining valve house building.

The potential visual impact on this viewpoint, compared with the current situation, is shown on Figure 25-18.

The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The sensitivity was assessed as moderate due to local and international tourists visiting the scenic lookout and the staff working at the visitor centre. The magnitude of visual impact was assessed as a high as the scale and size of the raised dam wall and associated infrastructure would substantially increase. The overall visual impact was assessed as **High–Moderate.**

Viewpoint 2-2 - Construction area viewpoint: Valve House Road, Warragamba Dam

Figure 25-18. Viewpoint 2-2: Potential visual impact (Warragamba Dam zone)

Existing view looking northwest to the dam wall

Photomontage of view of the raised dam wall from the lower terrace viewing area

Viewpoint 2-3: Eighteenth Street Lookout, Warragamba

Viewpoint 2-3 - Construction area viewpoint: Eighteenth Street Lookout, Warragamba

Affected viewers

- tourists and residents visiting the viewing platform.

Existing environment

This viewpoint is located approximately 300 metres north-east of the Warragamba Dam visitor centre and provides a panoramic view across the auxiliary spillway and a longer-range view of the Warragamba Dam wall (Figure 25-19). Accessed via the township, it is located at the end of Eighteenth Street and is a popular tourist vehicle and coach stop. The lookout is a contemporary steel framed structure that arcs around the end of the car parking area and provides access to the car park via concrete paths and stairs. The lookout also features five free-standing interpretive signs on the dam, spillway and left bank spoil emplacement.

Potential impacts

The view from this location is dominated by the large extent of the existing auxiliary spillway, auxiliary spillway bridge with views of the Warragamba Dam wall and associated infrastructure partly filtered by existing vegetation. Vegetation dominates the background view and a cleared and mulched area is in the immediate foreground. From this location, the colour variation of the auxiliary spillway and spillway walls is obvious as result of both discolouration and previous modifications. Parts of the dam wall including the spillway bridge, spillway piers, dam crest and lift towers would all be raised as part of the Project but would aim to mimic the style and materials of the existing wall and associated infrastructure.

The visual prominence of the raised dam wall and associated infrastructure would increase at this location. It should be noted that while the dam and associated infrastructure contrasts strongly with the natural bushland surroundings of the locality, it is viewed as a historical landmark of regional significance and demonstrates a significant built/engineering achievement. As a result of the raising, it is likely that the engineering significance of the wall would continue.

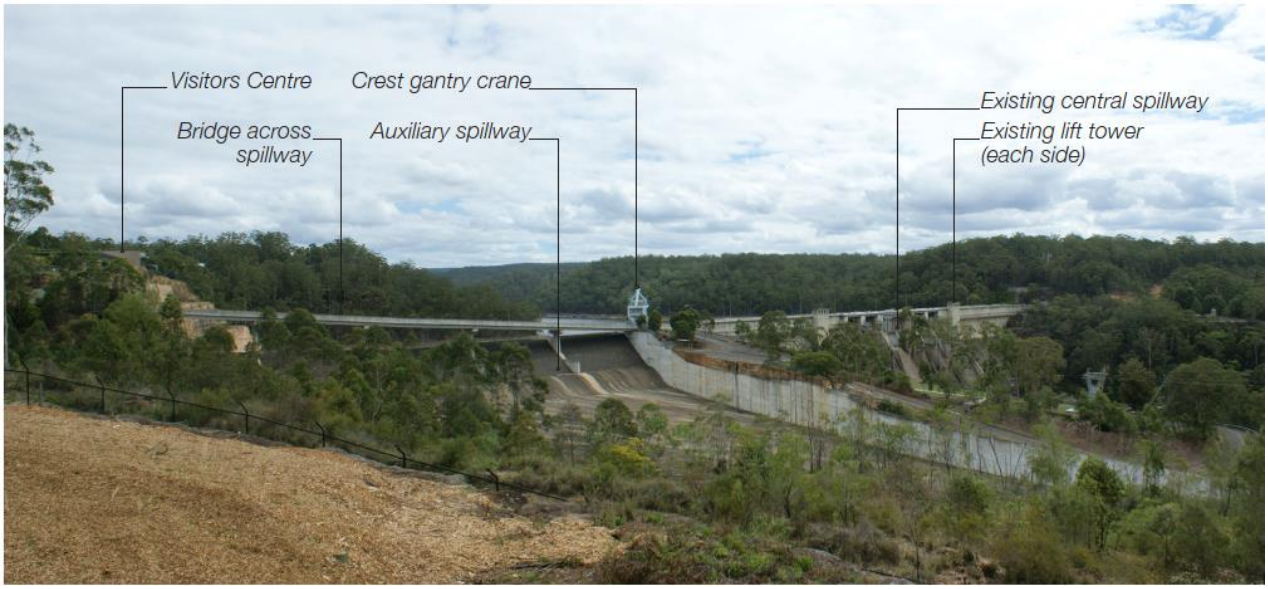
The potential visual impact on this viewpoint, compared with the current situation, is shown on Figure 25-19.

The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The sensitivity was assessed as moderate as this scenic lookout is visited specifically to view the dam and associated infrastructure. The magnitude of visual impact was assessed as high as the scale and size of the dam wall and associated infrastructure would increase however, the changes could also be considered as having a positive impact depending on the viewer type. The overall visual impact was assessed as **High–Moderate.**

Viewpoint 2-3 - Construction area viewpoint: Eighteenth Street Lookout, Warragamba

Figure 25-19. Viewpoint 2-3: Potential visual impact (Warragamba Dam zone)

Existing view looking north-west from the Eighteenth Street lookout



Photomontage of view showing raised dam wall and bridge over spillway

Date of photo	08th March 2018
FSL	116.72 m
Dam storage level on this date	110.78 m

Event (1 in x chance in a year)	Existing	Project
	Maximum upstream level	*Increase in maximum level*
1 in 5	117.4 m	120.3 m
Upstream impact area	119.5 m	126.97 m
PMF (3 day)	129.8 m	142.5 m

25.5.2.3 Downstream zone

Viewpoint 3-1: Penrith Weir, Penrith

Viewpoint 3-1 - Downstream viewpoint: Penrith Weir, Penrith

Affected viewers

- locals and tourists using the reserve, hiring the gazebo and pavilion.
- pedestrians and cyclists using the Great River Walk and the river.
- canoeists using both the recreational and natural waterways.
- motorists and railway passengers crossing the Victoria Bridge.

Existing environment

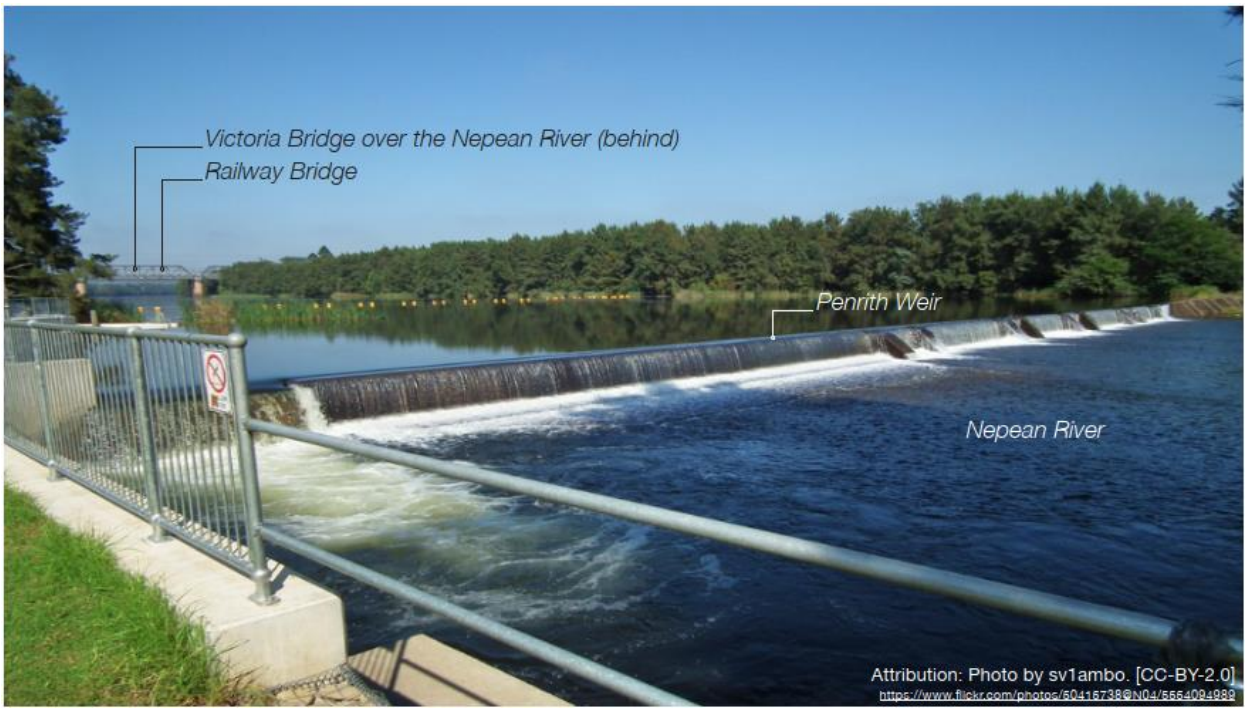
This viewpoint is located approximately 22 kilometres downstream of Warragamba Dam on the banks of the Nepean River at the Penrith Weir (Figure 25-20). Built in 1908, the weir is historically significant and representative of a concrete buttressed cantilever wall. It raises the water level of the river by about 1.5 metres above the natural flow level and creates pondage of water 18 kilometres upstream. This pondage contributes to the aesthetic appeal of the viewpoint.

The viewpoint has expansive views dominated by the pooled water of the Nepean River and the weir structure in the foreground with an impressive metal bridge, one of the earliest bridges constructed in NSW, located in the background.

The Weir Reserve attracts a variety of users to the facilities including picnic tables, barbecues, sporting field, toilets, Gazebo and Japanese Pavilion. In addition, The Great River Walk passes through the Reserve, bringing a range of regional viewer types to this vicinity.

Penrith Lakes is located less than five kilometres downstream of the Weir, which along with recreational waterways, walking tracks and wildlife havens includes flood mitigation infrastructure that would provide an additional five hours of notice time in the local region before flooding occurs, and up to an additional three hours for downstream catchments in Western Sydney.

Figure 25-20. Viewpoint 3-1 looking upstream along the Nepean River towards the railway bridge, to the north of Victoria Bridge



Viewpoint 3-1 - Downstream viewpoint: Penrith Weir, Penrith

Potential impacts

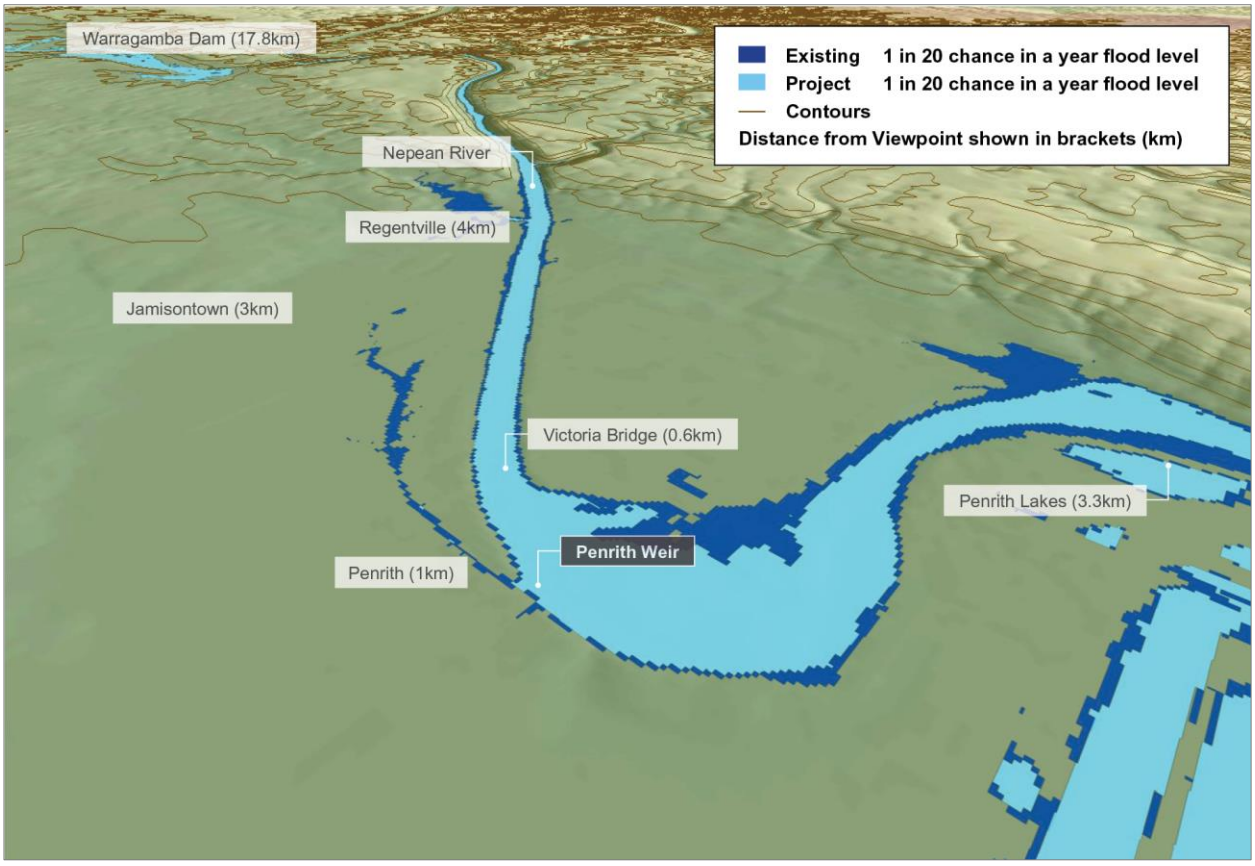
Although the downstream zone would experience reductions in the extent of flooding during an event, it is unlikely that changes would be perceptible to viewers due to the infrequency of flood events and since this viewpoint is not likely to be accessible during flood events. The aftermath of the flood event however, would have visual impacts with potential damage to infrastructure, loss of vegetation, debris and other matter along riparian zones and deposited sediment. By reducing flood extents (and flows), flood damage would be reduced and consequently the Project would have reduced impacts.

At this location, it is expected that during a flood event the extent of inundation would be reduced but it is still likely that recreational areas and the floodplains of Penrith, Emu Plains, Richmond and Windsor would continue to see some inundation. After the dam wall raising, there would be a reduction in the possible visual impact of flood levels.

The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The potential visual impacts on this viewpoint for the 1 in 20 chance in a year flood and PMF, compared with the current situation, are shown on Figure 25-21 and Figure 25-22. Visual impacts for the 1 in 20 chance in a year flood and PMF are:

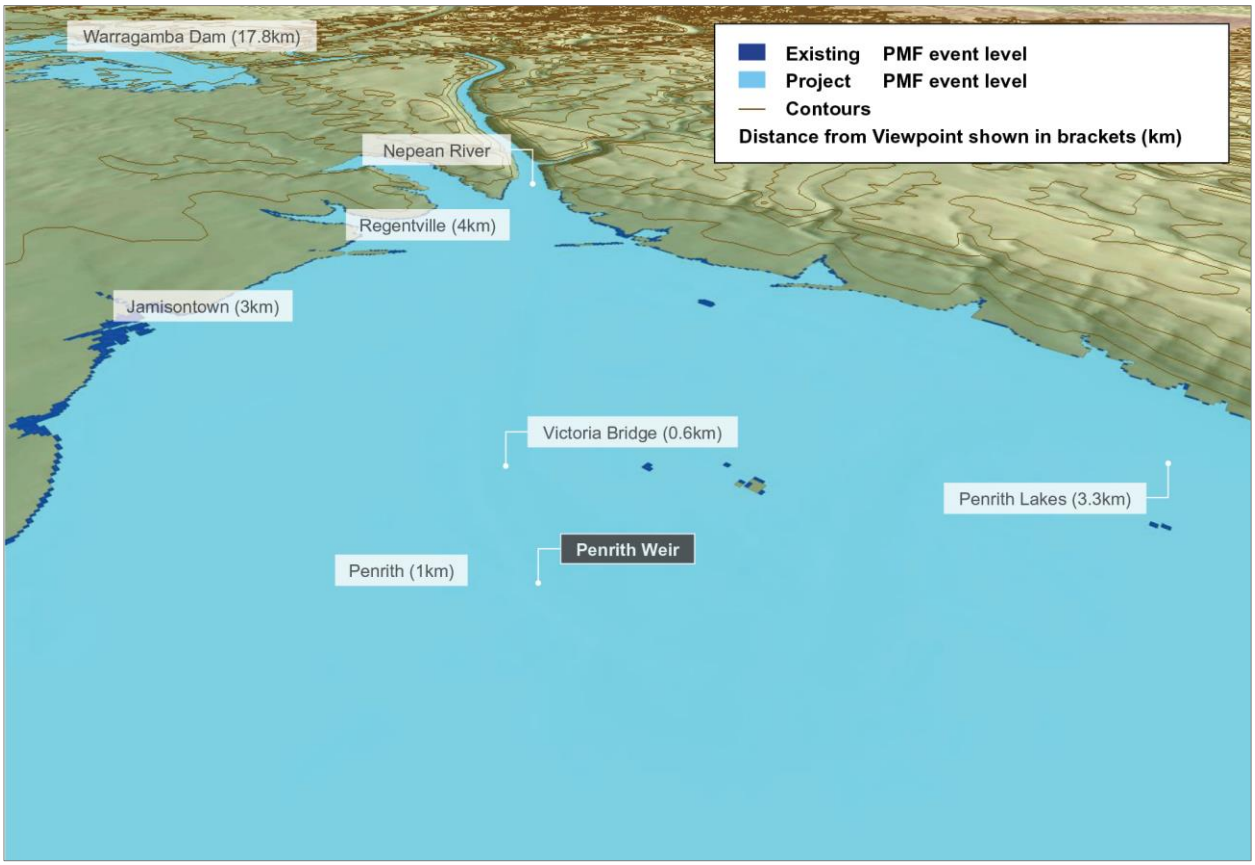
- 1 in 20 chance in a year flood: **beneficial impact** with assessed impact ratings reducing from High to Moderate after the Project.
- PMF: **beneficial impact** with assessed impact ratings reducing from High to High–Moderate after the Project.

Figure 25-21. Viewpoint 3-1: Oblique view showing current and Project 1 in 20 chance in a year flood



Viewpoint 3-1 - Downstream viewpoint: Penrith Weir, Penrith

Figure 25-22. Viewpoint 3-1: Oblique view showing existing and Project PMF



Viewpoint 3-2: Richmond Bridge, Richmond

Viewpoint 3-2 - Downstream viewpoints: Richmond Bridge, Richmond

Affected viewers

- motorists, pedestrians, and cyclists crossing the Richmond Bridge.
- locals and tourists using the many park facilities.
- pedestrians and cyclists using the parks internal paths.
- people participating in various recreational and professional river- based activities.

Existing environment

Viewpoint 3-2 is located on the Richmond Bridge, approximately 44 kilometres downstream of the Warragamba Dam visitor centre. Richmond Bridge was built across the Hawkesbury River in 1905 and in 1927 was widened on the downstream side for a railway track, which was converted to road deck in 1966. The bridge carries two traffic lanes, a footpath on the upstream side and an 800-millimetre water main attached to the downstream side.

This viewpoint has expansive views through pedestrian safety fences out across the Hawkesbury River to the densely vegetated woodland and forested banks.

Hanna Park and the North Richmond Playground are located on the western bank and are popular riverside locations to enjoy walks, fish or canoeing and kayaking. Hanna Park is regularly used for picnics as it has shelters, electric barbecues and public toilets and is used for events such as cricket and football games, Christmas Carols and weddings.

Viewpoint 3-2 - Downstream viewpoints: Richmond Bridge, Richmond

Figure 25-23. Viewpoint 3-2 looking upstream from the Richmond Bridge

Potential impacts

Although the downstream zone, which includes the Hawkesbury River, would experience reductions in the extent of flooding during an event, it is unlikely that the changes would be perceptible to viewers as they would have no context to compare (that is a similar flood event) and this viewpoint is not likely to be accessible during flood events. The aftermath of the flood event, however, would have visual impacts with damage to infrastructure, loss of vegetation, debris and other matter along riparian zones and deposited sediment. By reducing flood extents (and flows), flood damage would be reduced and consequently the Project would have reduced impacts.

At this location, it is expected that during a flood event the extent of inundation would be reduced but it is still likely that recreational areas and the floodplains between the eastern bank of the Hawkesbury River at Richmond Bridge and the township of Richmond would continue to see some inundation. The Project would reduce flood levels and visual impacts.

The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The potential visual impacts on these viewpoints for the 1 in 20 chance in a year flood and PMF, compared with the current situation is shown on Figure 25-24 and Figure 25-25. Visual impacts for the 1 in 20 chance in a year flood and PMF are:

- 1 in 20 chance in a year flood: **beneficial impact** with assessed impact ratings reducing from High to Moderate after the Project.
- PMF: **beneficial impact** with assessed impact ratings reducing from High to High–Moderate after the Project.

Viewpoint 3-2 - Downstream viewpoints: Richmond Bridge, Richmond

Figure 25-24. Viewpoint 3-2: Oblique view showing current and Project 1 in 20 chance in a year flood

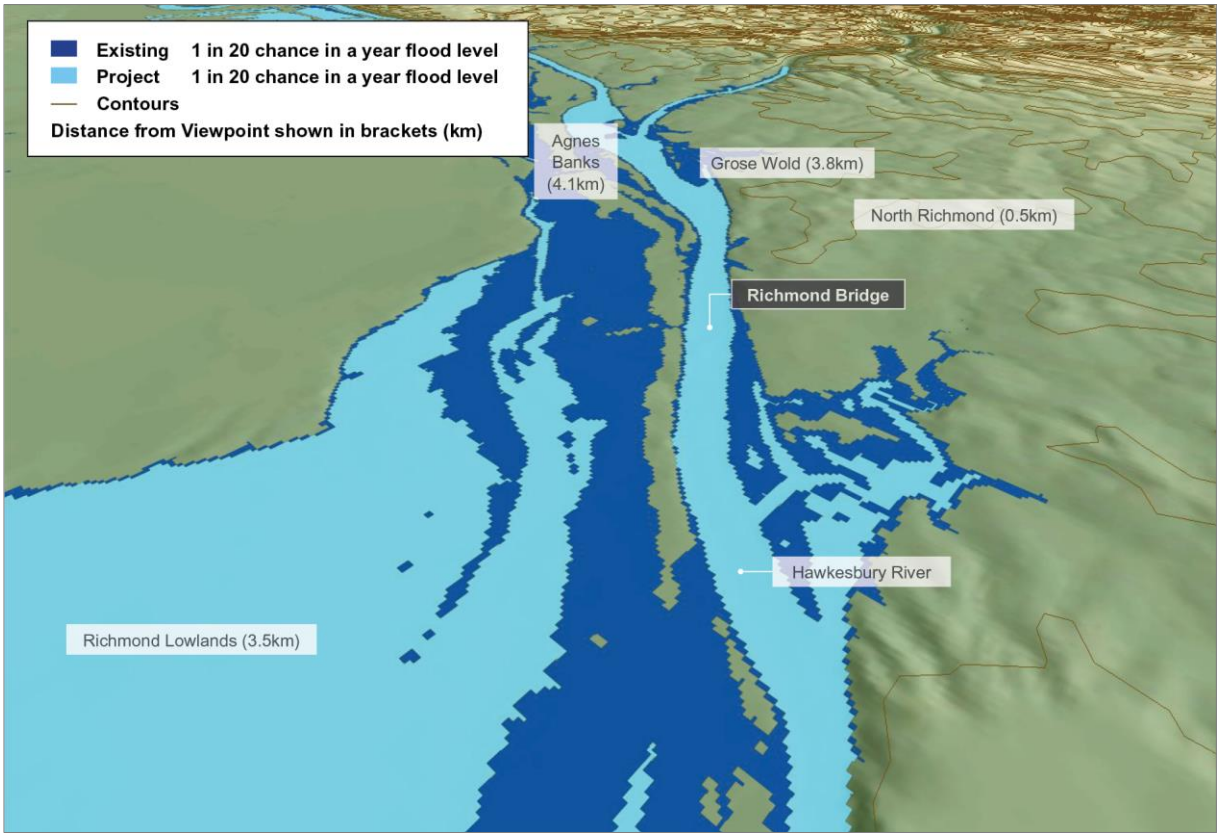
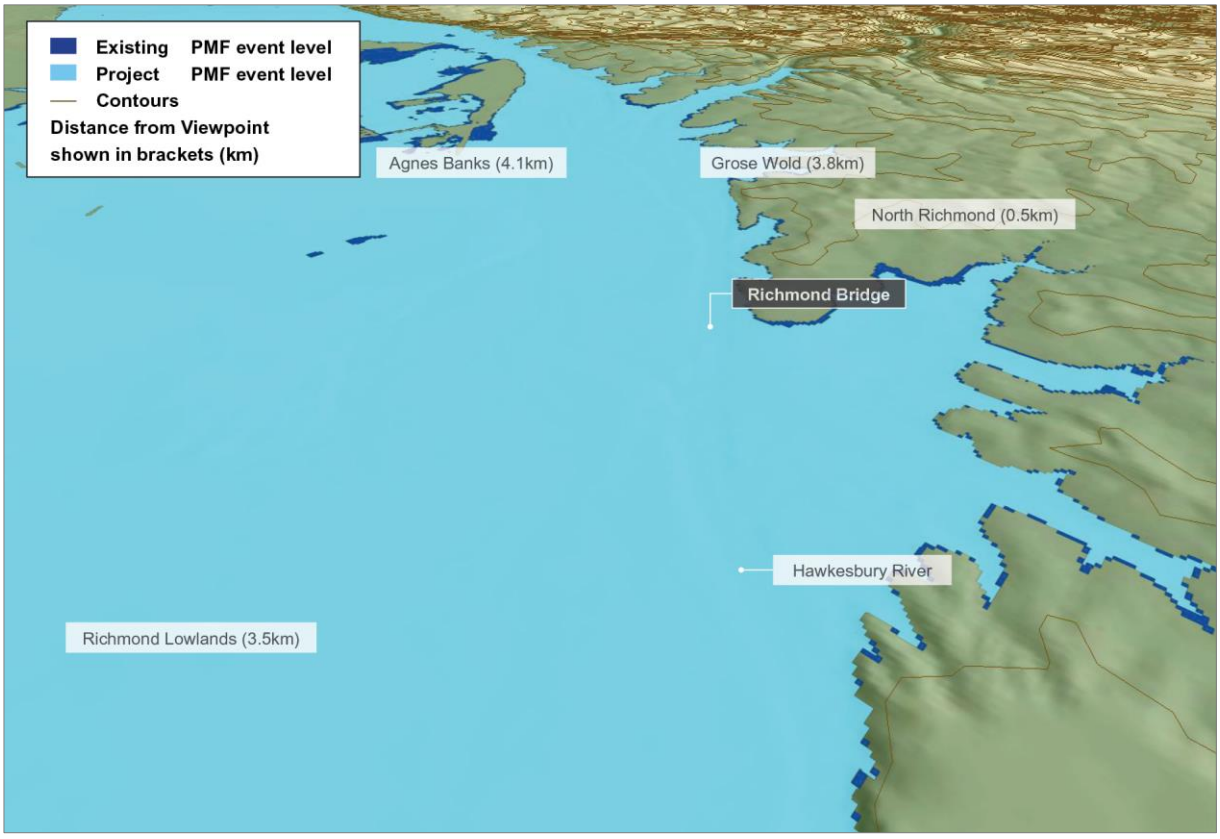


Figure 25-25. Viewpoint 3-2: Oblique view showing existing and Project PMF



Viewpoint 3-3: Windsor Bridge, Windsor

Viewpoint 3-3 - Downstream viewpoint: Windsor Bridge, Windsor

Affected viewers

- motorists, pedestrians and cyclists crossing the Windsor Bridge.
- locals and tourists using the many park facilities.
- pedestrians and cyclists using the parks and open spaces near the river.
- people participating in various recreational and professional river-based activities.

Existing environment

Viewpoint 3-3 is located on the Windsor Bridge, approximately 60 kilometres downstream of the Warragamba Dam visitor centre. Windsor Bridge opened in 1874 and is the oldest surviving crossing still in use over the Hawkesbury River. Consisting of a timber deck and cast-iron piers, Windsor Bridge is 143 metres long and 6.1 metres wide. In 1968, a pedestrian footway was constructed using removable concrete slabs and steel bracing with ducting for utilities fixed to the underside.

The viewpoint comprises views across pedestrian safety fences (with mesh infill) out towards steep river banks. The town of Windsor sits above a ridge on the southern river bank although trees located in the parks and open spaces mostly screen views of the town. Recreational river-based activities that occur include water skiing, wake boarding, river cruises, house boating, fishing, kayaking and canoeing while professional water-based events include the Power Boat Race, Bridge to Bridge Water Ski Classic and the Hawkesbury Canoe Classic.

Figure 25-26. Viewpoint 3-2 looking downstream from the Windsor Bridge

Potential impacts

At Viewpoint 3-3, the 1 in 20 chance in a year flood would have an impact on the recreational areas directly abutting the waterway. During a PMF, flooding would occur out across the floodplain, inundating large floodplains between the eastern bank of the Hawkesbury River at Windsor Bridge and the town of Windsor.

Although the downstream zone of the Hawkesbury River would experience reductions in the extent of flooding during an event, it is unlikely that the changes would be perceptible to viewers as they would have no context to compare (that is, a similar flood event) and this viewpoint is not likely to be accessible during flood events. It is expected that flood damage would be reduced, leading to a reduction in the visual impact of flood levels.

The visual impact assessment is provided in Appendix P (Landscape character and visual impact assessment, Section 5). The potential visual impacts on these viewpoints for the 1 in 20 chance in a year flood and PMF, compared with the current situation is shown on Figure 25-27 and Figure 25-28.

Visual impacts for the 1 in 20 chance in a year flood and PMF are:

- 1 in 20 chance in a year flood: **beneficial impact** with assessed impact ratings reducing from High–Moderate to Moderate after the Project.
- PMF: **beneficial impact** with assessed impact ratings reducing from High to High–Moderate after the Project.

Viewpoint 3-3 - Downstream viewpoint: Windsor Bridge, Windsor

Figure 25-27. Viewpoint 3-3: Oblique view showing current and Project 1 in 20 chance in a year flood

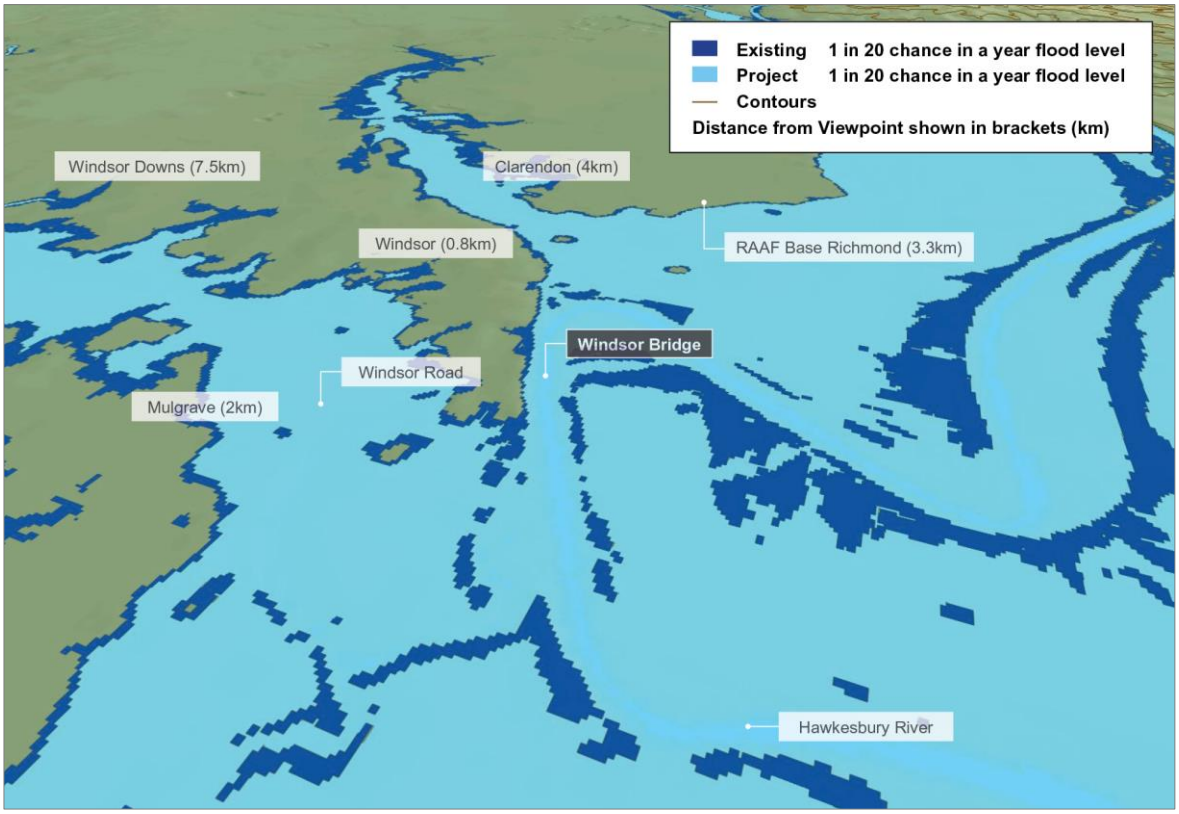
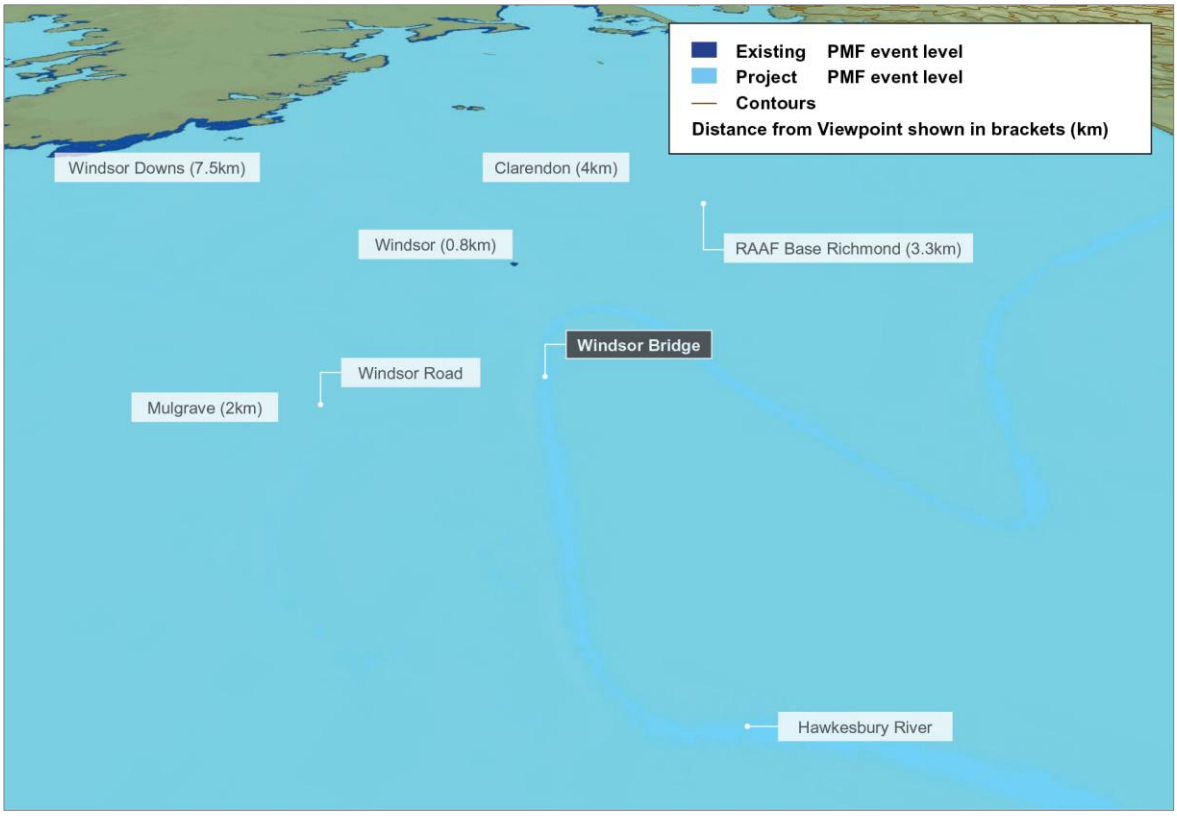


Figure 25-28. Viewpoint 3-3: Oblique view showing existing and Project PMF



25.5.2.4 Summary of operational visual impacts

A summary of visual impacts for each viewpoint is presented in Table 25-11 as follows.

- **Upstream zone** - Viewpoints 1-1 and 1-2: there would be **negligible** impact resulting from the Project due to long distances from viewpoints and intervening terrain and vegetation
- **Warragamba Dam zone** - Viewpoints 2-1, 2-2 and 2-3: there would be a **High – Moderate** impact resulting from the Project. The dam is a regionally significant landmark and demonstrates a nationally important engineering achievement. The magnitude of visual impact was assessed as high due to the visual prominence of the Warragamba Dam Raising and infrequent raising of the water level in the upstream environment.
- **Downstream zone** - Viewpoints 3-1, 3-2 and 3-3: there would be a **positive** impact resulting from the Project as the extent of flooding would be reduced.

Table 25-11. Summary of potential visual impacts of each viewpoint

Viewpoint (VP)	Flood event	Sensitivity	Magnitude	Impact rating	Project impact
Key: Blue = existing conditions; Red = Project					
Upstream zone					
1-1: Echo Point Lookout, Katoomba	Impact area	High High	Low Low	Moderate Moderate	Negligible
	PMF	High High	High High	High High	Negligible
1-2: Burragorang Lookout, Nattai	Impact area	High High	Low Low	Moderate Moderate	Negligible
	PMF	High High	High High	High High	Negligible
Warragamba Dam zone					
2-1: Viewing Platform, Warragamba Visitors Centre		Moderate	High	High–Moderate	High–Moderate
2-2: Valve House Road, Warragamba Dam		Moderate	High	High–Moderate	High–Moderate
2-3: 18th Street Lookout, Warragamba		Moderate	High	High–Moderate	High–Moderate
Downstream zone					
3-1: Penrith Weir, Penrith	1 in 20	High High	High Low	High Moderate	Beneficial
	PMF	High High	High Moderate	High High–Moderate	Beneficial
3-2: Richmond Bridge, Richmond	1 in 20	High High	High Low	High Moderate	Beneficial
	PMF	High High	High Moderate	High High–Moderate	Beneficial

Viewpoint (VP)	Flood event	Sensitivity	Magnitude	Impact rating	Project impact
3-3: Windsor Bridge, Windsor	1 in 20	High High	Moderate Low	High–Moderate Moderate	Beneficial
	PMF	High High	High Moderate	High High–Moderate	Beneficial

25.5.3 Visual assessment - construction

A preliminary construction program is shown in Table 25-12. The Project is estimated to be completed four to five years from commencement and would create short-term impacts. These impacts would primarily relate to the visual appearance of the construction work that would be phased, temporary, restricted to the construction period and would be either direct or indirect with some areas being required on a temporary basis for compounds and storage areas to support the construction. Construction activities would initially impact the locality near the dam wall area.

Table 25-12. Preliminary construction program

Activity	Start month	Finish month
Early works	1	12
Enabling works and demolition	5	33
Construction of concrete elements for thickening and widening the dam abutments, central spillway and modifications to the auxiliary spillway	5	55
Other infrastructure elements	5	39
Environmental flows infrastructure	5	23
Demobilisation and site rehabilitation	48	55

The operation of the visitor and education centre may be impacted by construction activities. Options to continue operating the visitor and education centre within the existing site during construction or at alternative locations are being considered. Factors to be considered include safety, impacts to construction, and the visitor and educational experience. There would be no public access to Haviland Park during construction. Access to the Warragamba Dam WaterNSW offices would be maintained for WaterNSW staff and other authorised personnel. For the purpose of the visual assessment, a general assumption has been made that viewpoints located within the construction area would be closed from the early works phase through to site restoration.

Viewpoints 2-1, 2-2 and 2-3 would potentially be affected by construction phase works, as shown in Figure 25-6. These are:

- VP2-1: Viewing Platform, Warragamba Visitors Centre
- VP2-2: Valve House Road, Warragamba Dam
- VP2-3: 18th Street Lookout, Warragamba

Two of the three viewpoints (2-1, 2-2) would not be accessible during construction and one viewpoint (2-3) would be impacted by visibility of the construction works. WaterNSW would implement a media campaign to promote public awareness that viewpoints 2-1 and 2-1, and surrounding areas would be closed from the early works phase throughout construction.

Once the Project is fully operational, the visual impact for these potential viewers would reduce as construction plant is removed from site. The construction visual impact assessment is summarised in Table 25-13.

Table 25-13. Warragamba Dam zone visual impacts

Viewpoint	Phase	Sensitivity	Magnitude	Impact rating
2-1 Viewing Platform, Warragamba Visitors Centre	Early works	Low – Some early works activities in and around the construction area may be obvious from this location before it closes but these activities would be short term and intermittent.	Low – Once the security fencing is installed, public access to Haviland Park, the dam viewing platforms and walkways and visitor centre would be closed, if not considered safe to remain open, with road and pedestrian access terminated at the intersection of Production Avenue and Twenty Third Street.	Low
	Construction	Low – This viewpoint will be inaccessible during construction so the sensitivity will be low.	High – The construction phase of the Project will see the viewing platform closed to visitors and create adverse amenity impacts.	Moderate
2-2 Valve House Road, Warragamba Dam	Early works	Low – Some early works activities in and around the construction area may be obvious from this location before it closes but these activities would be short term and intermittent.	Low – Once the security fencing is installed, public access to this viewpoint would be closed	Low
	Construction	Low – This viewpoint will be inaccessible during construction so the sensitivity will be low.	High – The construction phase of the Project will significantly disrupt the operation of the road for visitors and create adverse amenity impacts.	Moderate
2-3 18th Street Lookout, Warragamba	Early works	Moderate – Some early works activities are likely to be visible although these will be at 300 metres or more. Other activities that may be more obvious in the foreground are: ▪ installation of security fencing and site environmental controls ▪ procuring of concrete batching facilities, cranes, conveyors and other infrastructure ▪ clearing of vegetation ▪ adjustment and provision of utilities for construction facilities.	Moderate – This viewpoint will remain open and activities will be visible, creating adverse amenity impacts.	Moderate
	Enabling works and demolition	Moderate – the following activities involved in this phase are likely to be visible: ▪ an existing access road from the bottom of the auxiliary spillway to base of the dam wall would be upgraded	High – This viewpoint will remain open and activities will be visible, creating adverse amenity impacts.	High–Moderate

Viewpoint	Phase	Sensitivity	Magnitude	Impact rating
		▪ establishment of batching plants ▪ clearing and pruning of vegetation ▪ construction of coffer dams at multiple locations around the dam wall ▪ demolition of several existing structures and removal of machinery, pipes, and operational equipment ▪ possibly some controlled blasting for excavations.		
	Construction	Moderate – Local and international tourists would usually result in high sensitivity however, this scenic lookout is visited specifically to view the dam and associated infrastructure, so the sensitivity is considered moderate.	High – The Project is anticipated to result in discernible changes to the character of this location due to its exposure (elevation, unscreened). Mass concrete would enable the dam height to be increased with reinforced concrete used to construct elements such as bridges, walls, piers, conduits, chambers, etc. Throughout this phase of works different construction machinery and building processes will be employed typical of the construction of a large infrastructure Project.	High–Moderate

25.5.4 Visual assessment - Greater Blue Mountains World Heritage Area

Consideration of potential impacts on visual amenity formed part of the assessment of potential impacts on the Outstanding Universal Value of the GBMWHA, which is documented in Appendix J (World Heritage Assessment). This considered both ground-based observers and aerial observers as follows.

25.5.4.1 Ground-based observers

Assessment included assessing the potential visual impacts of the Project from the iconic Echo Point Lookout and from Burragorang Lookout at Nattai (see Section 25.5.2.1). Both viewpoints overlook some areas of the GBMWHA.

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. Figure 25-8 and Figure 25-9 (see Section 25.3.5) show respective viewsheds from Echo Point and Burragorang Lookouts.

The Echo Point Lookout viewshed 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, most it would be greater than five kilometres away. 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.

Most 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.

25.5.4.2 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 more than 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[2]). Given

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

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 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 any impacts would be mitigated to some extent.

25.5.5 Visual assessment - cultural heritage

Aboriginal heritage

The SEARs (S 18) require that *'the Proponent must assess the visual impact of the Project and any ancillary infrastructure on: (c) heritage items including Aboriginal places and environmental heritage'.* Results presented in Appendix K (Aboriginal cultural heritage assessment report) found that no Aboriginal places had been declared within the study area or listed within the Aboriginal Heritage Information Management System (AHIMS).

Non-Aboriginal heritage

The SEARs (S 18) requires that *'the Proponent must assess the visual impact of the Project and any ancillary infrastructure on: (c) heritage items including Aboriginal places and environmental heritage'.* Visual assessment of environmental heritage is addressed in Appendix I (Non-Aboriginal heritage impact assessment report) and summarised in Table 25-14.

Table 25-14. Environmental heritage visual assessment summary

Environmental heritage item	Summary assessment	Appendix I reference
1. Haviland Park (SHR No. 01375)	Visual impact during construction due to establishment of a batching plant and introduction of large machinery in Haviland Park, which would also obscure significant views from the approaches towards the dam along Farnsworth Avenue. The Project would result in an overall temporary **moderate** indirect (visual) impact	Section 7.2.1
2. Warragamba Emergency Scheme (SHR No. 01376)	Visual impact during construction due to vegetation clearing and a proposed laydown area near the heritage curtilage of the Warragamba Emergency Scheme. This would result in minor alteration to the current landscape setting of the item. The Project would result in an overall **low** indirect (visual) impact.	Section 7.2.2
3. Warragamba Supply Scheme (WaterNSW Section 170 Heritage and Conservation Register No. 4580161)	Project would involve clearing of bushland and vegetation adjacent to the dam and its surrounds, increasing the height and width of the dam wall, modifications to ancillary machinery and equipment, and demolition of the original crest crane. This would result in visual changes to the dam's profile and modifications to aspects and machinery and equipment that are evocative of the original design of the dam wall. The Project would result in an overall **moderate** indirect (visual) impact.	Section 7.2.3
4. Australian Convict Sites (Old Great North Road) and buffer zone (WHL Place ID 106209)	The Project is not anticipated to result in visual changes to the portions of the Australian Convict Sites (Old Great North Road) heritage curtilage and Buffer Zone that are within the study area. No permanent changes are proposed within the World (and National) heritage property. It is considered potential indirect (visual) impact associated with flooding and the localised effect of retention of low level flood waters for an extended period would not result in additional adverse impact to the heritage item. The localised affected areas of the item's heritage curtilage currently experience flood events. The project would result in a **neutral** indirect (visual) impact Significant Impact Criteria outlined in the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (2013:* No -The proposed action would not visually alter the heritage item.	Section 7.4.4.4

Environmental heritage item	Summary assessment	Appendix I reference
5. Ku-ring-gai Chase National Park and Lion, Long & Spectacle Island Nature Reserves (NHL Place ID 105817)	The Project would not result in any visual changes to portions of the Ku-ring-gai Chase National Park and Lion, Long and Spectacle Island Nature Reserves. The Project would result in a neutral (visual) impact Significant Impact Criteria outlined in the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (2013:* No- the construction study area would not be visible from the heritage item and would **not impact** on significant sight lines or its setting.	Section 7.4.4.6

25.5.6 Summary of visual impacts

A summary of assessed visual impacts is provided as follows.

Operations

- *Upstream zone*: negligible visual impact with assessed impact ratings remaining as Moderate before and after the Project
- *Warragamba Dam zone*: **High–Moderate** due to visual prominence of the raised dam wall and associated infrastructure
- *Downstream zone*: beneficial impact with assessed impact ratings reducing from High–Moderate to **Moderate–Low** after the Project.
- GBMWHA: Potential impacts would mostly occur along the Wollondilly River arm on the eastern shoreline of Lake Burragorang. This area is visible from Burragorang Lookout with the nearest part being about five kilometres from the lookout. However, it was assessed that the incremental change from the current situation is Low. Most 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.
- Aboriginal heritage: no Aboriginal places have been declared within the study area or listed in the Aboriginal Heritage Information Management System (AHIMS)
- Non-Aboriginal heritage: **Moderate** visual impact on Haviland Park (SHR No. 01375)

Construction

- *VP2.1 - Viewing Platform, Warragamba Visitors Centre*: **Moderate** visual impact during construction
- *VP2.1 - Valve House Road, Warragamba Dam*: **Moderate** visual impact during construction
- *V2.3 - 18th Street Lookout, Warragamba:* **High–Moderate** visual impacts during enabling/demolition and construction works. **Moderate** visual impact during early works
- *Non-Aboriginal heritage:* **Moderate** visual impact on Warragamba Supply Scheme (WaterNSW Section 170 Heritage and Conservation Register No. 4580161).

25.6 Environmental management measures

Management measures have been developed to avoid, minimise or manage potential impacts identified in Section 25.5. Relevant management and mitigation measures have been detailed in Table 25-15. These mitigation and management measures have been incorporated in the environmental management measures in Chapter 29.

Table 25-15. Management measures

Impact	ID	Environmental management measure	Timing	Responsible
Construction impacts on visual amenity	VA1	Promote public awareness that the site would be closed and provide signs to direct people to Eighteenth Street Lookout.	Construction	WaterNSW Construction Contractor
Construction impacts on visual amenity	VA2	The clifftop walkway and dam wall pedestrian access will be reinstated to provide an enhanced visitor/ tourist experience and to continue to provide access to the raised dam crest.	Construction	WaterNSW Construction Contractor
Construction impacts on visual amenity	VA3	Ensure that a similar level of pedestrian amenity is reinstated after construction of ancillary facilities	Construction Design	WaterNSW Construction Contractor Design Contractor
Construction impacts on visual amenity	VA4	Enhance the quality of all public domain areas that were closed for the duration of construction	Construction Design	WaterNSW Construction Contractor Design Contractor
Construction impacts on visual amenity	VA5	Provide signage/ interpretation panels referencing the construction scope and construction program.	Construction	WaterNSW Construction Contractor
Upstream impacts on visual amenity from potential vegetation loss	VA6	Vegetation management – see Chapter 29, Section 29.7.2 (BC1 – BC9)	Operation	WaterNSW
Downstream impacts on visual amenity from potential vegetation loss	VA7	Vegetation management – see Chapter 29, Section 29.7.2 (BDS1)	Operation	WaterNSW
Downstream impacts on visual amenity from potential vegetation loss	VA8	Vegetation management – see Chapter 29, Section 29.7.2 (BC1, BC2)	Operation	WaterNSW

25.7 Risk assessment

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

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

The likelihood and consequence matrix is shown on Figure 25-29.

Once the consequence and likelihood of an impact are assessed, the risk matrix provides an associated ranking of risk significance: **Low**; **Medium**; **High** or **Extreme,** as shown in Table 25-16**.** The residual risk was determined after the application of proposed mitigation measures.

The risk analysis for potential landscape and visual impacts is provided in Table 25-17. This includes the residual risk of the potential impact after the implementation of mitigation measures.

Table 25-16. Risk ranking definitions

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

Figure 25-29. Risk matrix

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

Risk Definition (see Table 25-16)	**Low**	**Medium**	**High**	**Extreme**

Table 25-17. Landscape and visual risk analysis

Visual amenity								
Key impacts	**Risk before mitigation**			**Mitigation and management**	**Risk after mitigation**			**Residual risk**
	L	**C**	**R**		**L**	**C**	**R**	
Construction								
Visual impacts due to construction activities. Warragamba visitor centre & dam wall viewpoints: negligible/moderate sensitivity and moderate/high magnitude of change, resulting in a **Negligible** to **Moderate impact**	b	C	19	VA1, V25, VA3, VA4, VA5	b	B	12	The Project would result in a High impact from viewpoints around the dam wall, resulting in a temporary degradation of scenic qualities. Mitigation will include protection of heritage values and rehabilitation of disturbed areas, which will result in a Medium residual impact during and immediately following the construction period. This is expected to reduce to a low risk as rehabilitation becomes established.
Operation								
Upstream zone Potential impacts resulting from a frequent 1 in 20 chance in a year flood and PMF at viewpoints at: ▪ Echo Point (VP 1-1) ▪ Burragorang Lookout (VP1-2)	a	B	14	VA6	a	A	13	There would be negligible impact resulting from the Project due to long distances from viewpoints and intervening terrain and vegetation. However, a Medium residual risk remains due to the high sensitivity of the viewing points.
Warragamba Dam zone Potential impacts resulting from viewpoints at: ▪ Warragamba visitor centre (VP2-1) ▪ Valve House Road, Warragamba Dam (VP 2-2)	a	C	20	VA7, VA8	a	B	14	The visual prominence of the Warragamba Dam Raising and associated infrastructure would increase however, as the dam is a regionally significant landmark and demonstrates a nationally important engineering achievement the

Visual amenity								
▪ Eighteenth Street Lookout, Warragamba (VP2-3)								magnitude is not considered to be negative.
Downstream zone Potential Impacts Resulting from a 1 In 20 chance in a year flood and PMF at viewpoints at: ▪ Penrith (VP3-1) ▪ Richmond (VP3-2) ▪ Windsor (VP3-3)	a	C	20	VA7, VA8	a	B	14	There would be a positive impact resulting from the Project as the extent of flooding would be reduced. This results in a low residual impact.

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