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Environmental Impact Statement – Appendix P: Landscape Character and Visual Impact Assessment Report

# Warragamba Dam Raising

Reference No. 30012078
Prepared for WaterNSW
10 September 2021

SMEC INTERNAL REF. 30012078

# WARRAGAMBA DAM RAISING

WARRAGAMBA, NSW

LANDSCAPE CHARACTER AND VISUAL IMPACT ASSESSMENT REPORT

PREPARED BY:

scape design

PREPARED FOR:

SMEC

WaterNSW

ISSUED DATE: 30/4/21

COVER PAGE: THE EXISTING DAM AS VIEWED FROM THE LOWER VIEWING TERRACE

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LAKE BURRAGORANG AS VIEWED FROM THE DAM WALL, LOOKING SOUTH

# 1. Introduction and requirements

## 1.1 Background

This Landscape Character and Visual Impact Assessment (LCVIA) Report has been prepared by SCAPE Design on behalf of SMEC Australia Pty Ltd (SMEC) and WaterNSW as part of the Environmental Impact Statement (EIS) for the proposed Warragamba Dam Raising.

Warragamba Dam Raising (the Project) is currently being planned to provide flood storage capacity in the Lake Burragorang catchment (Warragamba Catchment) to facilitate flood mitigation and to provide environmental flows downstream of Warragamba Dam.

This report assesses the landscape character and visual impacts to assist WaterNSW in understanding these potential impacts of the Project.

## 1.2 Planning framework

The Project requires approval from the NSW Minister for Planning under Division 5.2 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act).

Secretary's Environmental Assessment Requirements (SEARs) were issued by the Department of Planning, Industry and Environment (DPIE) on 30 June 2017 and revised SEARs were issued by DPIE on 13 March 2018, which included clarifications and additional assessment requirements.

SEARs requirements relevant to the visual assessment are provided in **Table 1-1**, which includes references to the relevant sections of this report where each requirement is addressed.

The SEARs also list current guidelines that generally pertain to visual assessments and a comprehensive understanding of the these has informed the professional judgement used to complete this assessment.

Table 1-1: Extract of SEARs for visual amenity

| SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS | WHERE ADDRESSED IN THIS REPORT |
|---|---|
| 18. Visual Amenity<br>The proposal 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 | |
| The Proponent must assess the visual impact of the proposal and any ancillary infrastructure on:<br>*(a) views and vistas;* | |
| Visual impacts on views and vistas are assessed | **Section 5 on page 23** |
| *(b) streetscapes, key sites and buildings;* | |
| Visual impacts on views and vistas are assessed | **Section 5 on page 23** |
| *(c) heritage items including Aboriginal places and environmental heritage;* | |
| The visual impact of non-Aboriginal heritage items, has been undertaken in the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)***. The results of the ***Aboriginal cultural heritage assessment (Appendix K to the EIS)*** found that no Aboriginal places had been declared within the study area | **Section 4 on page 18** |
| *(d) the local community.* | |
| Impacts on the local community are assessed | **Section 2.2 on page 7** |
| 2. The Proponent must assess the visual impact associated with the proposed maximum flood level both upstream and downstream within the catchment area | |
| PMF event levels in both the upstream and downstream catchment areas were assessed and was supplemented with additional hydraulic data that represented more frequent temporary inundation events | **Section 5 on page 23** |
| 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 | |
| A range of graphic representation methods was employed to demonstrate the likely appearance and scale of the project in its context from each viewpoint | **Section 5 on page 23** |

# 1. Introduction and requirements

## 1.3 Project overview

This LCVIA report has been prepared to assess the potential landscape and visual impacts of the Project, which is being planned to provide flood storage capacity in the Lake Burragorang catchment (Warragamba Catchment) to facilitate flood mitigation and to provide environmental flows downstream of Warragamba Dam.

WaterNSW is intending to undertake a dam raising project for the Warragamba Dam in the Hawkesbury-Nepean Valley. This would consist of adding around 12 metres to the height of the dam wall with no change to current full supply level. The additional 'air space' created by the raising would be used for flood controlled releases.

The proposed construction would be accompanied by changes in operational procedure associated with release of flood water stored within Lake Burragorang.

Refer to **Section 3 on page 14** of this report for a more detailed description of the Project.

## 1.4 Location

**Figure 1-1 on page 3** shows the local and regional context of the Project. The Project site is located in the Wollondilly Local Government Area (LGA), approximately 65 kilometres west of the Sydney Central Business District (CBD). 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 - which is the water storage formed by Warragamba Dam. To the east of the Project site is the Warragamba and Silverdale townships and surrounding rural residential areas.

## 1.5 The Project study area

For the purpose of this report, the Project study area has been split into three assessment zones:

1. Upstream zone - the operational area that could be affected by the future operation of the raised dam. It's geographic extent is defined by the Project Probable Maximum Flood (PMF)
2. Construction zone - the construction area surrounding the dam wall that would occur within about 1 km of the dam wall
3. Downstream zone - the operational area that could be affected by the future operation of the raised dam and environmental flow releases. It's geographic extent is defined by the existing PMF.

The PMF is the most extreme flood event that could conceivably be expected to occur at a particular location. Although such an event is considered to be extremely rare, it defines the maximum extent of land liable to flooding and has been used to determine the geographic extent of the upstream and downstream zones.

The extent of the study area is shown in **Figure 1-1 on page 3** and this map also defines the location and extent of the following three assessment zones:

### 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 greatest extent of flooding that this zone would experience.

### Construction zone

Shown in detail in **Figure 1-2 on page 4** the main construction zone 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 and areas that would be used for construction activities may require clearing of vegetation to allow for construction and access. Located close to this zone is the township of Warragamba.

### Downstream zone

Downstream of Warragamba Dam 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 (not including the reach of the Nepean River upstream of 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 extent of this zone has been determined using the existing PMF event level, which is the greatest extent of flooding that this zone would experience.

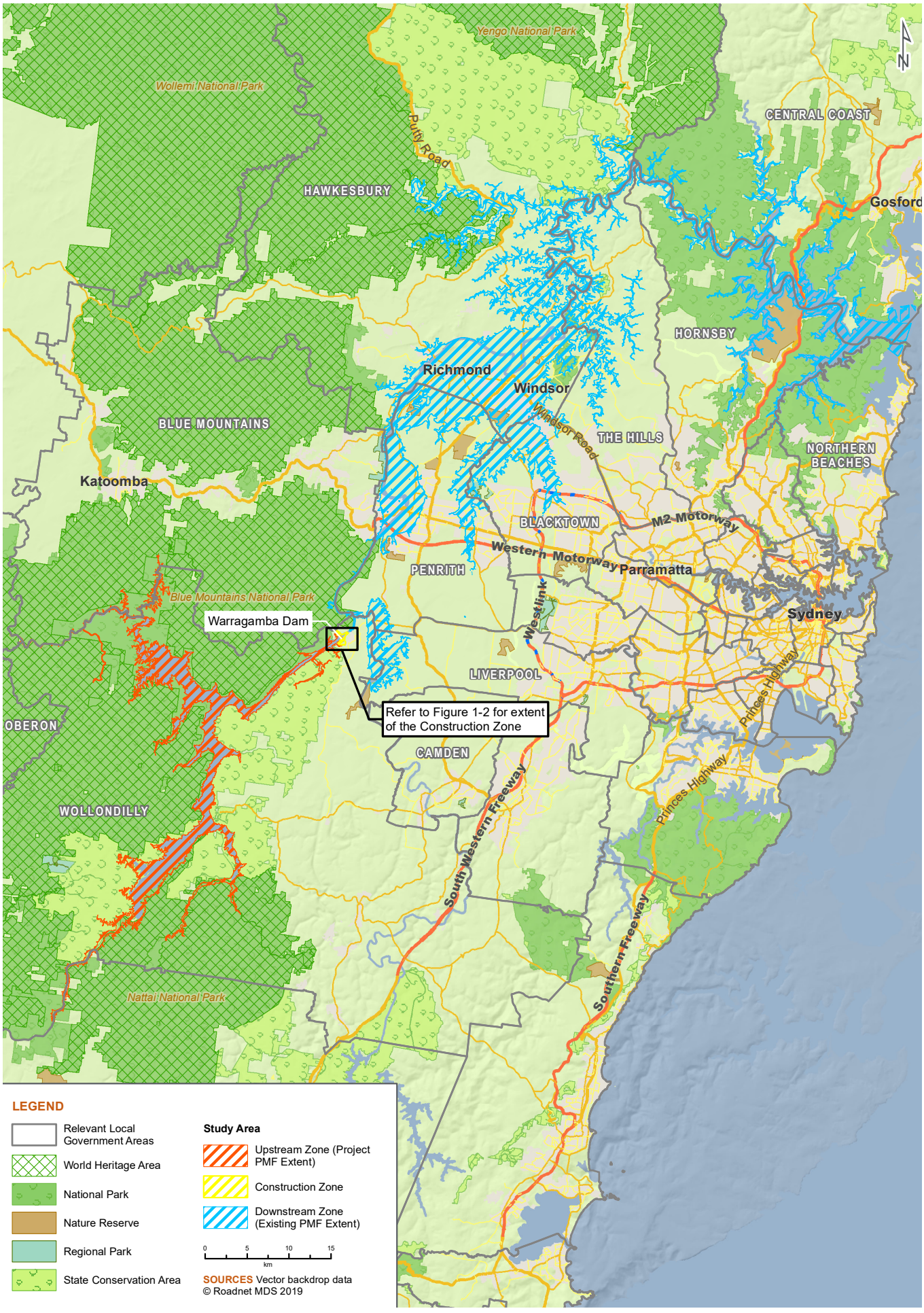


Figure 1-1: Location of the Project (SMEC)

# 1. Introduction and requirements

## 1.6 Report structure

The LCVIA report is structured into seven sections:

**1. Introduction and requirements**

Introductory section that describes the study area, the Project, the legislative context and the report structure

**2. Existing Environment**

An analysis of the existing environment according to the assessment zones based on topography, drainage and urban form etc.

**3. The Project**

A description of the project including both construction and operation phases of work

**4. Methodology**

Defines the criteria used to assess and rate impacts on landscape character and visual amenity that would potentially be caused by the project

**5. Impact Assessment**

An assessment of the likely landscape and visual impacts of the Project based on sensitivity and magnitude criteria

**6. Mitigation Measures**

A general description of a mitigation measures to be incorporated into the further planning and design of the Project. These mitigation measures would be discussed with the Project design team and integrated into future design stages

**7. Conclusion**

A summary of the landscape and visual impact assessment findings identified within the report.

## 1.7 Methodology

A number of methodologies can be utilised for assessing landscape character and visual impacts, most of which, are generally considered to be a qualitative and subjective appraisals rather than a measured science.

The SEARs do not set out a specific process or guideline that should be followed, therefore this assessment report has adopted a methodology based on the 'Environmental Impact Assessment (EIA) N04 Practice Note: Guidelines for Landscape Character and Visual Impact Assessment V2.0' (Roads and Maritime, 2018), which while often utilised for transport infrastructure projects, has been selected due to its adaptability to large scale project sites and its focus on landscape context and character.

The Roads and Maritime Practice note references a number of other publications and guidelines in setting out its Landscape and Visual Impact Assessment and is recognised by state authorities and industry professionals as a comprehensive reference publication for visual assessment. For these reasons, this Practice note has been used to inform the visual impact assessment of this Project.

Key components of this LCVIA methodology include:

- Contextual analysis
- Landscape character assessment
- Visual impact assessment - the visual impact of Non-Aboriginal heritage items has been undertaken and is included in the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)***
- Mitigation strategy and recommendations.

Refer to **Section 4.1.1 on page 18** of this report for a more detailed description of the methodology.

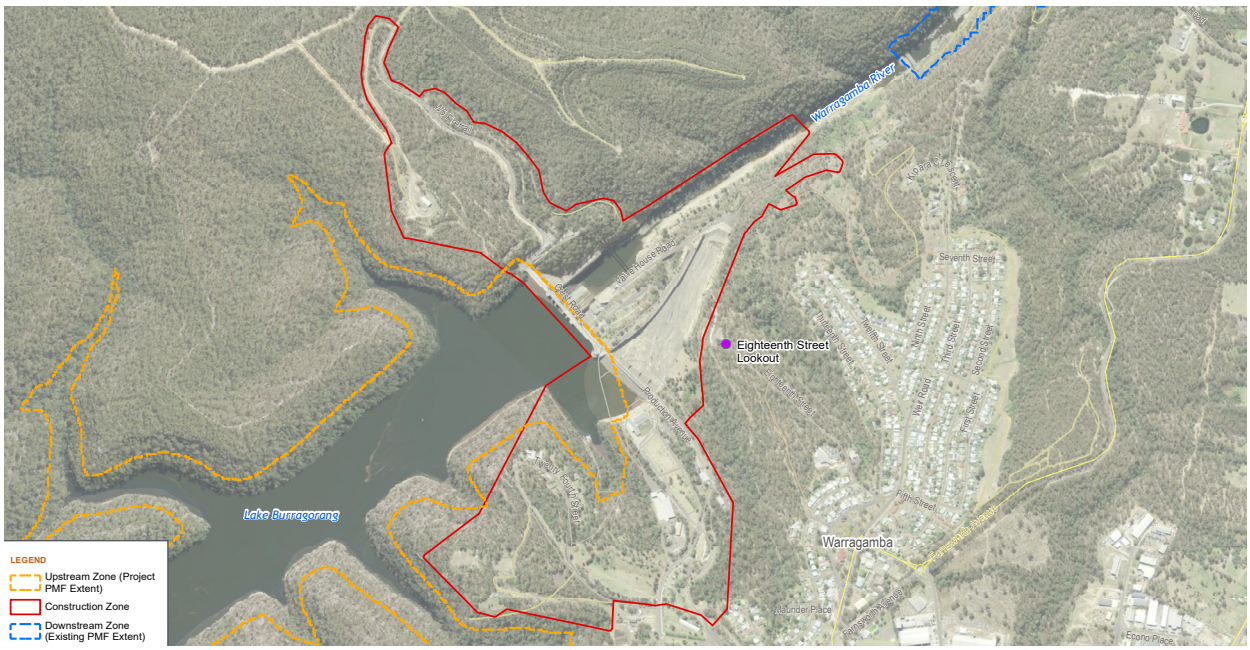


Figure 1-2: The construction zone (SMEC)

# 1. Introduction and requirements

## 1.8 Project objectives

The overall objective for the Project, as defined in the EIS 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 this Project.

## 1.9 Urban design objectives

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, in order to provide the most enjoyable and interesting experience to those viewers.

In order to meet these aims, a set of urban design objectives have been developed. These objectives reference Roads and Maritime's *Beyond the Pavement* and other current guidelines referenced in the SEARs and are based on 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 1-2 lists broad urban design objectives and principles for the Project and the existing features which could potentially be impacted by the Project.

## 1.10 Reference documents


1. Infrastructure NSW 2012, 'State Infrastructure Strategy 2012-2032', Infrastructure NSW
2. Graham Brooks and Associates Pty Ltd 2010, 'Conservation Management Plan, Draft version 7' Sydney Catchment Authority, Sydney
3. 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
4. Roads and Maritime Services 2018, '*Beyond the Pavement*'
5. Roads and Maritime Services December 2018, 'Guideline for landscape character and visual impact assessment, Environmental Impact Assessment Practice Note-N04, Version 2.1
6. 'The Sweat of Their Brows', M Beasley, Sydney, 1988
7. 'A Spirit of Progress: Art Deco Architecture in Australia', P Van Daele and R Lumby, Craftsman House, 1997
8. Various EIS appendices:
   - Appendix F1 - Biodiversity assessment report - upstream
   - Appendix F2 - Downstream biodiversity assessment report
   - Appendix F3 - Biodiversity assessment report - construction Area
   - Appendix H1 - Flooding and hydrology assessment report
   - Appendix I - Non-Aboriginal heritage assessment report
   - Appendix K - Aboriginal cultural heritage assessment report.


Table 1-2: 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 raised dam must minimise damage to existing vegetation and infrastructure through appropriate balancing of storage and release |

THE EXISTING DAM WALL AS VIEWED FROM THE CLIFF WALKWAY NEAR THE OPERATIONAL AND VISITOR INFORMATION CENTRE, LOOKING WEST

# 2. Existing environment

## 2.1 Overview

The following section of the report provides a summary of the existing landscape and cultural influences within the study area. The purpose of this background information is to inform the development of mitigation measures so that they respond appropriately to any impacts that may be identified.

Further detail can be obtained by reviewing the relevant specialist consultant's reports listed in **Section 1.10 on page 5**.

## 2.2 Site context

Warragamba Dam is located on the Warragamba River, which is a major tributary of the Hawkesbury-Nepean River system and stretches from the Great Dividing Range to the Pacific Ocean at Broken Bay.

Upstream of the dam wall, the environmental setting is spectacular with dense bushland draped over rugged mountainous terrain. The area includes sandstone plateaus and benched rock outcrops, which are distinct features of the area. These natural areas provide a significant recreation and tourism resource for Greater Sydney, and the world, as well as playing an important role in providing high quality drinking water to Sydney. About 28 per cent of the Warragamba catchment is classified as Special Area. In total, Special Areas cover about 3,640 square kilometres of land surrounding water storages and public access to large parts of the Special Areas is restricted to protect water quality. The residents of the Blue Mountains, especially those living the towns of Leura and Katoomba, are passionate about the conservation of surrounding areas and while tourists are numerous at scenic lookouts much of the area has limited public access.

Lake Burragorang is the storage reservoir formed by the construction of the Warragamba Dam. Before the dam was built the Warragamba River ran from the junction of the Wollondilly and Coxs Rivers down to the Nepean River below Wallacia. The dam is situated in a steep, narrow gorge and the land immediately surrounding the incised valley comprises densely forested National Park and conservation areas. Situated close to the dam wall is the township of Warragamba, which was originally constructed as a workers' settlement during the construction of the Dam in the 1940s and on completion many workers bought their homes from the Water Board and remained living in the township.

Downstream of the dam wall the Nepean River flows through a narrow gorge until it emerges into more open country just upstream of Penrith. Major urban population centres such as Penrith, Windsor and Richmond are typically surrounded by grazing lands, river and drainage systems, and areas of tree and shrub cover, which help define the character of this area.

Figure 2-1: Typical environment of the upstream zone

Figure 2-2: Typical environment of the construction zone


Figure 2-3: Typical environment of the downstream zone as seen from Yellow Rock Lookout

# 2. Existing environment

## 2.3 Character of the study area

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.

Typical of 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. Refer **Figure 2-1 on page 7**.

The construction zone is located 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. Refer **Figure 2-2 on page 7**.

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. Refer **Figure 2-3 on page 7**.

## 2.4 Regional geology

The upstream zone is comprised of the flooded base and sides of the Burragorang Valley, which are made up of the Berry Siltstone (Shoalhaven Group) comprising mid to dark grey siltstone to very-fine grained sandstone (NSW Seamless Geology Map Zone 56, 2015). The western extent of Burragorang valley is dominated by the Illawarra Coal Measures comprising shale, quartz-lithic sandstone, conglomerate, chert, sporadically carbonaceous mudstone, coal and torbanite seams. The topographically elevated escarpments and ridges above the Burragorang Valley generally comprise Triassic Sedimentary rocks including quartz-lithic to quartz-rich sandstone (including the Hawkesbury Sandstone) with conglomerate, mudstone and siltstone.

The base and sides of Burragorang Valley comprises Wentworth Clay Member, Burralow Formation and Banks Wall Sandstone (all components of the Narrabeen Group). The Narrabeen Group tapers approximately two kilometres upstream of the dam at which point Hawkesbury Sandstone dominates the landscape.

The construction zone is dominated by Hawkesbury Sandstone, which comprises horizontally-bedded medium to coarse grained quartz sandstone with minor shale and laminate lenses. The northwest and southwest extents of the study area are underlain by quartz rich sandstones and pebbly conglomerate units as well as sandstone, siltstone and mudstone.

The construction zone, has a dominant geological formation of the Wianamatta Group comprising the Ashfield and Bringelly Shales.

Immediately downstream of the construction zone Hawkesbury Sandstone dominates the geology while the dominant geological formation is the Wianamatta Group comprising the Ashfield and Bringelly Shales and. The remainder of the downstream zone from Maraylya east to the coast is underlain by the Hawkesbury Sandstone and the Burralow Formation. The floodplain suburbs of Emu Plains, Penrith, Castlereagh, Agnes Banks, Richmond, Lowlands and Cornwallis are underlain by quaternary sediments including channel and floodplain alluvium comprising gravel, sand, silt and clay. While the suburbs of Londonderry, Richmond, Clarendon, Bligh Park, Windsor Downs and Pitt Town are underlain by undifferentiated consolidated Cenozoic sedimentary rocks comprising sandstone, limestone, conglomerate, siltstone, duricrust; commonly ferruginised or silicified.

## 2.5 Topography and landforms

Most of the upstream zone sits within the steep slopes of the Burragorang Valley and is dominated by rugged topography where, over geological time scales, the highlands of a vast plateau have been incised by rivers to form steep valleys, rocky outcrops, sheer cliffs and escarpments. The ridges and peaks surrounding the western extent of the upstream zone, above the Burragorang Valley reach elevations of up to 640 metres Australian Height Datum (AHD), rapidly decreasing to around 117 metres AHD at Lake Burragorang.

The construction zone was built across the Warragamba Gorge, approximately 3.5 kilometres upstream of the confluence of the Warragamba River and Nepean River. The gorge is 160 metres deep, 30 metres wide at the base, and about 450 metres wide at the edge of the plateau.

The topography of the downstream zone, near the confluence of the Warragamba River and Nepean River, comprises densely forested undulating hills with a maximum elevation of 200 metres AHD. At Leonay/Regentville, the landscape flattens into a floodplain environment with a typical elevation of 20 to 40 metres AHD. Between Emu Plains and Castlereagh, the Nepean River is flanked to the west by the steep slopes of the eastern extent of the Blue Mountains National Park.

Further downstream, at Ebenezer/Cattai the topography starts to gently undulate as the Hawkesbury River flows north toward the Parr State Conservation Park. From the confluences of the Colo and Macdonald Rivers with the Hawkesbury River, at Lower Portland/Webbs Creek, to the Tasman Sea, the topography comprises narrow flat floodplain immediately adjacent to the river with undulating hills of the Dharug National Park, Marramarra National Park and Brisbane Water National Parks adjacent.

# 2. Existing environment

## 2.6 Soil landscape

The Soil Landscapes of Penrith 1:100,000 soil landscape sheet (Bannerman & Hazelton 1990) has mapped four soil landscapes within the study area. For the upstream and construction zones these are:

- Gymea - Limitations include steep slopes, water erosion hazard, rock outcrop, localised rockfall hazard, localised non-cohesive soils, shallow highly permeable soil, very low soil fertility
- Faulconbridge - Limitations include shallow, highly permeable soil, localised non-cohesive soils, very low soil fertility, localised water erosion hazard, localised rick outcrop
- Hawkesbury - Limitations include steep slopes, mass movement hazard, rockfall hazard, water erosion hazard, shallow soils, rock outcrop, non-cohesive soils (localised), stony, highly permeable soils of low fertility

For the downstream zone these are:

- Blacktown - Limitations include localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil, localised surface movement potential

## 2.7 Climate

The climate of the Blue Mountains is somewhat more temperate than the lower Sydney region. There is generally a 2°C drop in temperature every 300 metres increase in altitude. In Summer months the average temperature at Katoomba is 23°C while winters are cool to mild, with average maximum temperature of 9°C. Frosts and even occasional snow is common at higher altitudes.

Summers in the Hawkesbury-Nepean region are mild to hot, with average maximum January temperatures approaching 30°C at Richmond, although further south at Moss Vale, maximum summer temperatures average only 26°C.

The catchment receives approximately 800 –1,400 mm of rainfall each year. Peak precipitation occurs between November and March, and the variability in rainfall from one year to the next is high.

## 2.8 Bush fires

The NSW Rural Fire Service states that the 'Blue Mountains is a unique world heritage area and also one of the most bushfire prone areas in the World.'

The nature of bush fires in Australia is changing, with climate change driving an increase in extreme fire weather, and making fire seasons longer. Mitigating bushfire risk including fuel reduction is an important aspect of bushfire management and is usually undertaken outside of the bushfire season. To protect the community and the environment different types of hazard reduction activities are carried out across the study area throughout each year. These include controlled burning, mechanical clearing like slashing undergrowth, or even reducing the ground fuel by hand. As a result of these activities as well as bushfire events and subsequent regeneration the visual and physical composition of the study area is dynamic and variable.

## 2.9 Hydrology

In the upstream zone the catchment extends to the south, to the vicinity of Lake Bathurst. This area is drained by the Mulwaree Ponds, which joins the Wollondilly River, flowing from the west at Goulburn. The Wollondilly River then travels in a generally north-easterly direction to eventually enter Lake Burragorang. Of the many tributaries entering the Wollondilly, the most important is the Wingecarribee River, which rises in an area of high rainfall near Bowral to the east.

Lake Burragorang is the storage reservoir formed by Warragamba Dam and apart from the Wollondilly River, the main inflows to the lake are the Coxs and Kowmung Rivers in the west and the Nattai and Little Rivers in the east.

In the construction zone the Warragamba Dam is situated in a steep, narrow gorge. Before the dam was built the gorge carried the Warragamba River from the junction of the Wollondilly and Coxs Rivers down to the Nepean River below Wallacia. The total length of the Warragamba River was 22 kilometres, and all but the 3.5 kilometres downstream of the dam are now submerged below Lake Burragorang.

In the downstream zone, the Nepean River continues to flow through a narrow gorge until it emerges into more open country just upstream of Penrith. The elevation of the floodplain in the vicinity of Penrith, including Emu Plains and the Penrith Lakes Scheme, is surprisingly high and does not convey floodwaters until floods almost reach the magnitude of 1 in 100 chance in a year event. However, once water starts flowing over the flood plain they are partially restricted from flowing downstream by the Clarence Gorge, which is just upstream of the inflow of Grose River junction.

The Richmond/Windsor lowlands are encountered below the Grose River junction. These are extensive floodplains inundated by minor and moderate flooding. The main towns in the area, Richmond and Windsor, are in the most part elevated above smaller floods, but are seriously affected by medium sized floods.

### 2.9.1 Hydrogeology

A comprehensive assessment of hydrology and hydrogeology is provided in the ***Flooding and hydrology assessment (Appendix H1 to the EIS)*** and a brief summary of the aquifer types is provided below:

- fractured Rock aquifers – e.g. the Palaeozoic and Pre-Cambrian Fractured Rock that encompasses the

# 2. Existing environment

majority of the upstream zone (Groundwater in the Sydney Basin, Milne-Home, 2009)

- porous Rock aquifers – e.g. Hawkesbury Sandstone Formation and Narrabeen Group Sandstones
- unconsolidated sediment aquifers e.g. surficial sediment aquifers underlying the suburbs of Richmond and Penrith and proximal to Hawkesbury River throughout the downstream zone.

### 2.9.2 Wetlands

Lake Burragorang is the dominant hydrological feature of the upstream zone, which was created by damming the Warragamba River and flooding the Burragorang Valley. Water flows into the Warragamba River when the dam spills or is released (downstream of the Warragamba Weir) to provide a secure water supply to North Richmond.

Lake Burragorang is the only wetland located within the study area.

Downstream of the dam wall, there are some smaller dams to the east of the site, and the Nepean River and Penrith Lakes to the north.

No Ramsar Wetlands have been recorded within ten kilometres of the site.

## 2.10 Bioregions and subregions

Bioregions are large, distinct, geographically areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities.

The entire study area is located in the Interim Biogeographical Regionalisation of Australia (IBRA) Bioregion of the Sydney Basin and there are two subregions that are relevant to the Project:

1. The Wollemi subregion
   - Characterised by the highest part of the Blue Mountains and other sandstone plateaus with benched rock outcrops. Creek directions are generally controlled by jointing deep gorge of the Capertee and Wolgan Rivers
2. Burragorang subregion of the Sydney Basin Bioregion
   - Characterised by rolling hills on a sandstone plateau with deep gorges and sandstone cliffs in Burragorang valley.

## 2.11 Protected Areas

There are a number of protected areas, which cover parts of the study area as set out by the NSW National Parks and Wildlife Service www.nationalparks.nsw.gov.au. In the upstream zone these include:

- Blue Mountains National Park
- Kanangra-Boyd National Park
- Nattai National Park; and
- Nattai State Conservation Area
- Burragorang State Conservation Area
- Yerranderie State Conservation Area.

The downstream zone contains the following:

- Wollemi National Park
- Dharug National Park
- Marramarra National Park
- Cattai National Park
- Scheyville National Park.

## 2.12 Native vegetation

In the upstream zone both sides of Lake Burragorang is dominated by vegetation, which includes areas of ridgetop woodlands around the Sydney Basin, including *Angophora costata, Eucalyptus piperita, Eucalyptus eugenoides, Eucalyptus sieberi and Corymbia gummifera*.

To the north-east of Warragamba Dam there is an area of wet sclerophyll forest dominated by species of *Eucalyptus pilularis, Syncarpia glomulifera, Eucalyptus punctata and Angophora costata*.

Other flora species in the upstream zone include red bloodwood, Sydney blackbutt, red ironbark, scribbly gum, Sydney peppermint, and smooth-barked apple trees.

In the construction zone native vegetation covers approximately half of the proposed construction footprint and can be classified into three vegetation classes:

- Sydney Hinterland Dry Sclerophyll Forests
- Sydney Coastal Dry Sclerophyll Forests
- Northern Hinterland Wet Sclerophyll Forests.

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

In the downstream zone is a large geographic area, which supports a diversity of native vegetation including:

- Wollemi Pine, open eucalypt forest and woodlands including Hawkesbury and grey box, rainforests and perched swamps
- salt marsh and mangrove forests along the Hawkesbury River to tall open forest and ridge-top woodlands
- areas of paper bark, red gum, stringy bark, grey gum and cabbage gum
- a large area of the Cumberland Plain Woodland, a small area of Castlereagh Scribbly Gum Woodland and Shale Transition Forest.

# 2. Existing environment

## 2.13 Threatened flora and fauna

The study area is comprised of a diversity of landscapes, which provide habitat for a wide range of native plants including many rare or threatened species.

For a discussion on threatened flora, fauna and related to changes as a result of the Project, refer to the ***Biodiversity assessments (Appendix F1, F2 and F3 to the EIS)***.

## 2.14 Heritage

### 2.14.1 Aboriginal cultural heritage

As discussed in the ***Aboriginal cultural heritage assessment (Appendix K to the EIS)***, Aboriginal sites were identified across the three assessment zones within the Project study area.

The upstream and construction zones are part of the traditional lands of the *Gundungurra, Darkinjung*, *D'Harawal, Dharug* and *Wiradjuri* peoples, while the downstream zone is part of the traditional lands of *Wiradjuri*, *Dharug*, *Wanaruah* and *Darkinjung* Aboriginal peoples.

The visual impact assessment of Aboriginal cultural heritage items across the study area is documented in the ***Aboriginal cultural heritage assessment (Appendix K to the EIS)***.

### 2.14.2 Non-Aboriginal heritage

As outlined in the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)***, there are a number of historic sites across the study area.

The upstream zone includes the historical Yerranderie township, which retains much of the history of mining and settlement in the early 20th century.

The construction zone comprises the Warragamba Dam Supply Scheme (State Heritage Register), which includes the following elements:

- Main dam wall with a crest length of 351 metres (m) and height 142 (m). 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 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.

Within the downstream zone the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)*** outlines a number of historic sites, which are examples of early colonial activity and demonstrates the use of convict labour and engineering including:

- parcels of land that were granted to the First Fleet
- government cooperative farms and an agricultural training facilities
- 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.

The visual impact assessment for heritage items has been undertaken in the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)***.

## 2.15 Warragamba Special Areas and Controlled Areas

Special and Controlled areas have been declared under the Water NSW Act to protect major water storage areas. For Warragamba Dam this includes:

- Schedule 1 Special Areas - are the lands immediately around the Warragamba Dam. To protect water quality entry is not generally allowed to the Schedule 1 Special Areas, on foot or by vehicle, including cars, motorcycles, bicycles and horses. The majority of the upstream and construction zones are located within the Schedule 1 Special Areas.
- 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 is allowed.
- Controlled Areas – no entry; includes the land at Warragamba protecting the water supply infrastructure and the land along the Warragamba pipelines and upper canal.

# 2. Existing environment

## 2.16 Recreation and tourism

### 2.16.1 Blue Mountains

The intrinsic beauty, natural features and accessibility from the major population centres ensures that the Blue Mountains region, including it's National Parks (refer **Section 2.11 on page 10**), which are located within the GBMWHA, has high recreational values. The GBMWHA provides settings for recreation and tourism that are outstanding and increasingly rare by world standards, on the doorstep of Australia's major city.

Tourism includes popular lookouts such as the premier tourist attraction at Echo Point, which attracts the highest number of visitors each year *(Source: National Parks Wildlife Service statistics).*

Other tourist destinations and experiences within the region that have lower visitor statistics include:

- Prince Henry Cliff Walk
- Three Sisters Walking Track
- Great Blue Mountains Trail and bike route
- part of the route of the (future) Grand Cliff Top Walk
- historic walking tracks
- mountain biking trails
- adventure sports; and
- overnight hiking and camping.

As well as ground-based observers, aerial observers also view the region, including:

- Passengers on aircraft travelling to/from Sydney Kingsford Smith Airport (and in the future the Western Sydney International Nancy Bird Walton Airport)
- Passengers on privately operated sight-seeing aircraft including helicopters.

To a lessor extent, passengers in vehicles and on tourist coach and rail services also view and experience the region.


VIEW FROM VALVE HOUSE ACCESS ROAD PARKING AREA LOOKING ACROSS THE SPILLWAY BRIDGE TOWARDS THE CONTROL BUILDING

# 3. The project

## 3.1 Project description

Warragamba Dam Raising is a project to provide temporary storage capacity for large inflow events into Lake Burragorang (Warragamba Catchment) to facilitate downstream flood mitigation and includes infrastructure to enable environmental flows. The Project would:

- enable the dam to capture and temporarily hold back inflows from the Warragamba catchment behind the wall
- provide capacity to facilitate flood mitigation by increasing the central spillway by approximately 12 metres and increasing the dam abutments (including access road) by 17 metres, which includes approximately three metres to be resilient to the future impacts of climate change
- provide infrastructure to allow for environmental flows to be released from Warragamba Dam.

The Project would include the following main activities and elements:

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

### 3.1.1 Project infrastructure

In the following sections there are descriptions of the new and modified infrastructure that would be provided as part of the Project.

It should be noted that the detailed concept and detailed design of the Project is occurring concurrently with the preparation of the EIS and consequently there may be minor changes to the Project as described below.

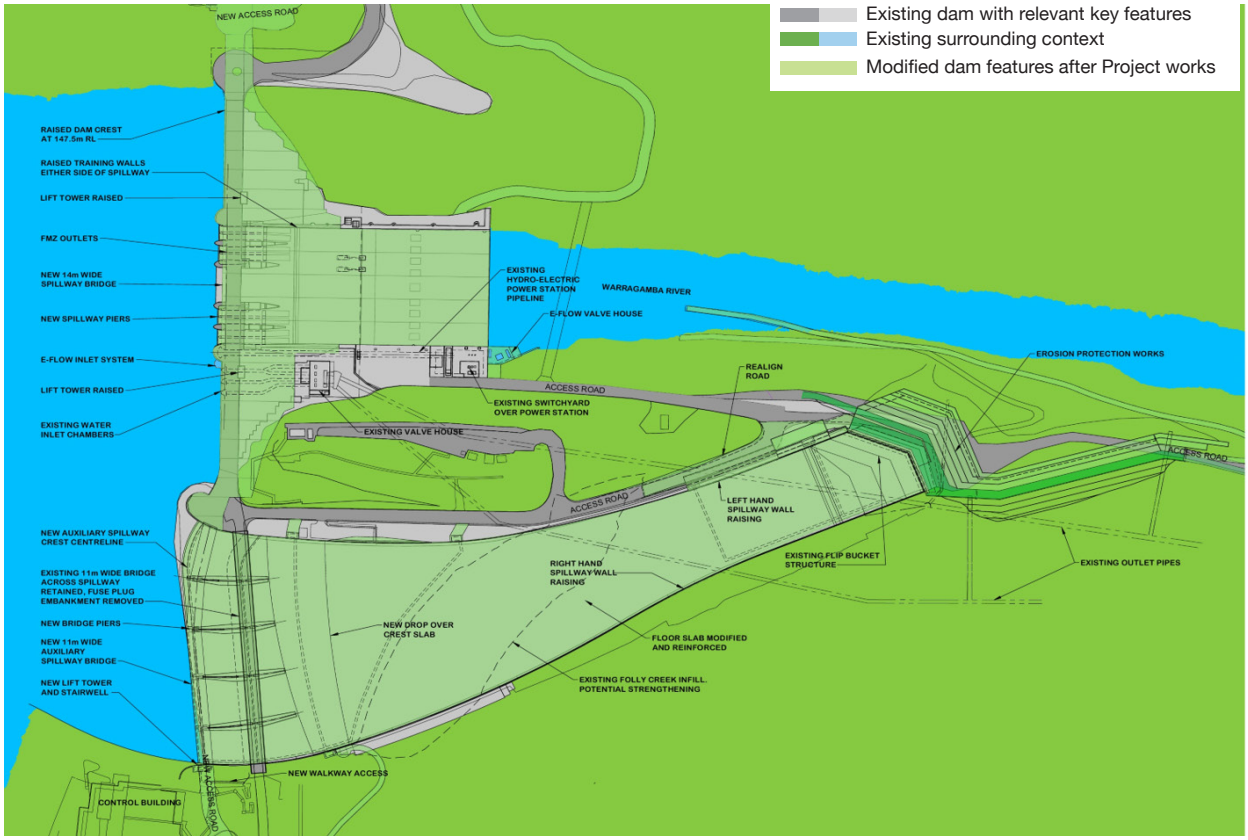


Figure 3-1: Aerial view of modified dam from the Project works (SMEC)

# 3. The project

### 3.1.2 Construction zone

The construction zone for the Project contains the following (refer to **Figure 5-42 on page 70** ):

- ancillary facilities such as coffer dams, batch plants, material storage areas and worker facilities
- areas which require clearing of vegetation to allow for construction and access
- areas directly impacted by construction
- areas that would be used for construction activities but would not be modified by the Project.

## 3.2 Main activities and elements

**Figure 3-1 on page 14** shows the Project works, which include:

- demolition
- thickening and raising of dam abutments
- thickening and raising of central spillway
- modifications to the auxiliary spillway
- other infrastructure and elements
- environmental flow infrastructure.

These are described in greater detail in the following sections.

### 3.2.1 Demolition

Elements of the existing Warragamba Dam would require demolition or removal to enable dam raising construction to proceed. These include:

- the existing road and main spillway bridge across the top of the dam
- the drum and radial gates, and associated mechanical and electrical infrastructure, and portions of the piers within the central spillway
- minor concrete structures to allow the tie-in of the new dam and spillway
- the valve house control room building located at the rear of the valve house
- areas of roads, operational lay-down areas, drainage systems and other infrastructure external to but associated with the dam
- the existing gantry crane and associated equipment
- the existing hydroelectric power station equipment to allow for new environmental flow infrastructure
- miscellaneous dam crest services and equipment.

### 3.2.2 Thickening and raising of the dam abutments

The dam abutments, located either side of the central spillway would be modified:

- the dam abutments would be thickened on the downstream side with additional concrete. The face of the abutments would be smooth as with the existing dam
- the abutment height would be increased by around 17 metres
- the left abutment would extend into the surrounding rock to suit the thickening and raising.

### 3.2.3 Thickening and raising of the central spillway

The existing central spillway would be modified as follows:

- the spillway would be thickened on the downstream face with concrete and it would have a smooth surface
- the spillway crest would be raised to create the 14m Flood Mitigation Zone, including the use of post tensioned anchors within the wall for stability
- gated conduits or slots would be constructed within the central spillway to allow for the controlled discharge of floodwaters. These openings would be located so the Flood Mitigation Zone could be drawn back down to the Full Supply Level.

### 3.2.4 Modifications to the auxiliary spillway

The following modifications would be undertaken on the auxiliary spillway:

- removal of the existing fuse plugs (earth/rock embankments designed to wash away in a major flood) and replacement with a concrete spillway crest
- the spillway floor slabs and walls would be modified and reinforced to suit discharging of flood water from the raised dam
- erosion protection would be provided downstream from the auxiliary spillway.

The existing bridge across the auxiliary spillway would be retained for access to the valve house and the base of the dam and spillway.

# 3. The project

### 3.2.5 Other infrastructure and elements

Other infrastructure and elements would include:

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

### 3.2.6 Environmental flows infrastructure

In 2017, the NSW Government released the 2017 Metropolitan Water Plan (www.planning.nsw.gov.au/about-us/Sydney-Metropolitan-Water),which included the introduction of new variable environmental flows from Warragamba Dam to improve the health of the Hawkesbury-Nepean River.

The Project would provide the infrastructure to enable environmental flows to be released from the Dam. Procedures would be developed as part of the implementation of the Metropolitan Water Plan.

Environmental flow releases would be designed to mimic the natural flow of the river if the dam did not exist.

The environmental flows infrastructure would include:

- a multi-level offtake concrete tower on the upstream face of the dam wall to draw water from Lake Burragorang
- the use of existing pipeline, formerly for the hydro-electric power station, to transfer the water to a valve house
- a new valve house, downstream of the existing hydro-electric power station, to discharge the water into the river.

VIEW ALONG SPILLWAY BRIDGE TOWARDS CREST GANTRY CRANE

# 4. Methodology

## 4.1 Overview

This chapter provides the methodology for conducting a qualitative assessment of the potential impacts on views and landscape character in and around the Project within the study area.

### Study Process

Key components of the LCVIA methodology 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 in order 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 was undertaken on 23rd May 2018 and the 4th December 2019 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 (Refer **Table 4-1** below)
- development of mitigation strategy, which includes principles and strategies to mitigate landscape character and visual impacts in the ongoing development of the design.

### 4.1.1 Hydraulic data selection

Following investigations of the hydrological systems, different hydraulic data (for both existing and Project flood events) was chosen in order to best examine the impacts that would likely occur as a result of the Warragamba Dam Raising.

A PMF is the largest hypothetical flood that could conceivably occur in a catchment such that there is negligible chance of it being exceeded. The PMF is principally an input to the design development process and in the case of the Project, is highly unlikely to ever occur in nature due to the size of the Warragamba catchment.

In view of this, the assessment for the upstream zone has considered more frequent events likely to occur over the life of the Project, these being the 1 in 5 chance in a year event and flooding likely to affect an area over a 20-year time period. This area is referred to as the 'upstream impact area' and a description of the derivation of this area is provided in ***Section 5 of the World Heritage Assessment Report (Appendix J to the EIS)***.

In the assessment of the construction zone, PMF levels were analysed as well as 1 in 20 and 1 in 5 chance in a year flood events. Consideration of this data provided a comprehensive understanding of the possible fluctuations in water levels within the steep, narrow gorge environment surrounding the dam wall.

In the assessment of the downstream zone, PMF levels were analysed as well as 1 in 20 chance in a year flood events, which were selected as they would have the largest reduction in flooding extent (i.e. area) due to the Project and are also likely to occur within an individual viewers lifetime.

Refer to the ***Flooding and hydrology assessment (Appendix H1 to the EIS)*** for further justification of the specific hydraulic data selection within each zone.

Table 4-1: Landscape character and visual impact rating matrix Source: 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 |

# 4. Methodology

### 4.1.2 Vegetation considerations

Potential impacts on vegetation are documented in ***Biodiversity Assessment Report - Upstream (Appendix F1 to the EIS)***, ***Downstream Ecological Assessment (Appendix F2 to the EIS)***, and ***Biodiversity Assessment Report - Construction Area (Appendix F3 to the EIS)***.

The upstream assessment included consideration of the potential effects of temporary inundation, drawing in part on a recent Queensland study which noted that the studies of Queensland dams reviewed did not suggest that temporary flood inundation would inevitably cause substantial environmental impact.

### 4.1.3 Heritage considerations

A visual impact assessment of Non-Aboriginal heritage items across the study area is documented in the ***Non-Aboriginal heritage assessment (Appendix I to the EIS)***.

The visual impact assessment of Aboriginal heritage items across the study area is documented in the ***Aboriginal cultural heritage assessment (Appendix K to the EIS)***.

## 4.2 Impact ratings

The overall impact rating of the project on any given landscape character or viewer are based on a broad qualitative appraisal of magnitude and sensitivity and the combination of these assessments resulting in an overall impact rating (Refer **Table 4-1 on page 18**). The relevance of magnitude and sensitivity for each assessment type is described below.

## 4.3 Landscape character

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).

### 4.3.1 Assessment zones

To enable the assessment of impacts on the landscape character of each assessment zone, key landscape elements including landform, waterform, vegetation, land use and built form were identified during site visits.

Two primary factors are used to determine impacts:

- sensitivity of the character within the zone
- magnitude of the project in that zone.

Refer to **Figure 1-1 on page 3** for landscape character zone identification.

# 4. Methodology

### 4.3.2 Sensitivity

The degree to which a particular 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.

### 4.3.3 Magnitude

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. This is categorised as follows:

- A high magnitude of change would result if the project becomes the dominant feature of the scene to which other elements become subordinate
- A moderate magnitude of change would result if the project forms a visible and recognisable new element within the overall landscape
- A low magnitude of change would result if the project constitutes only a minor new component within the landscape zone, which might be missed by the casual observer or receptor.

## 4.4 Visual impact

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.

### 4.4.1 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.

### 4.4.2 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.

### 4.4.3 Magnitude

The 'magnitude of visual change' describes the contrast or type of change resulting from the proposal or project, the extent of change and also 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.

# 4. Methodology

### 4.4.4 Assessment tools

In order 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 construction 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 (25m resolution) by Department of Lands (Land & Property Information Division) was used as surface raster, overlayed with 50m 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.

### 4.4.5 Viewshed figures

A viewshed is a theoretical assessment of visibility to, or from, a designated point in the landscape. The viewsheds from Echo Point Lookout and Burragorang Lookout were generated using the viewshed tool in ArcMap (version 10.4) with viewer height 1.77m and target height 0m. Surface raster used for the analysis was the New South Wales DTBT Landform Theme 50k x 50k Digital Elevation Model (25m resolution) by Department of Lands (Land & Property Information Division).

Viewshed mapping was used to help with the identification of areas that would be visible during times of impact and these areas were verified on site taking in to account such aspects as intervening vegetation and WaterNSW Special and Controlled Areas.

### 4.4.6 Photomontages

Three viewing locations were selected in consultation with SMEC for the production of 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 in a 35mm format (digital equivalent) camera at a camera height of 1.65m
- Viewpoint 2-3 was captured Sony DSLR-A350, focal length 27 in a 35mm format (digital equivalent) camera at a camera height of 1.65m

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.

THE EXISTING DAM AS VIEWED FROM THE LOWER VIEWING TERRACE

# 5. Impact assessment

## 5.1 Landscape character

### 5.1.1 Assessment zones

Across the study area a number of landscape character units were identified based on distinctions between different landscape elements including landform, waterform, vegetation and land use and built form. For the purpose of this broad scale character assessment, an aggregation of character units with similar landscape elements ultimately reflected the three hydraulic assessment zones used for the Project.

Each assessment zone was identified as having differing physical characteristics. These were:

- Upstream zone - which includes the Project PMF extent in Lake Burragorang and upstream tributaries and a variable portion of the lower slopes of the Burragorang Valley
- Construction zone - which includes the areas immediately adjacent 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 - which 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.

Across the upstream and downstream zones, rather than assessing character changes according to an individual flood event an assumption has been made that although several flood events may occur floods do not necessarily permanently alter the character of the landscape and that landscape does over time rehabilitate itself.

The elements of the Project likely to cause change are summarised in **Table 5-1** below and are described in the following pages in more detail.

Table 5-1: Summary of assessment zones

| Zones | List of physical attributes | Project elements causing change |
|---|---|---|
| Upstream | – Lake Burragorang (i.e. the reservoir formed by Warragamba Dam) and its tributaries<br>– 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.<br>– Burragorang State Conservation Area<br>– Nattai National Park<br>– Nattai State Conservation Area<br>– Yerranderie State Conservation Area. | – Includes the areas upstream of Warragamba Dam, that could be affected by the future operation of the Project |
| Construction | – The main dam wall and sub-components<br>– Haviland Park and picnic grounds<br>– Warragamba Emergency Scheme<br>– Warragamba Prospect Pipelines 1 and 2. | – New and modified infrastructure would be provided as part of the Project and include various modified and new structures<br>– The construction would result in a higher 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. |
| Downstream | – Freshwater and estuarine reaches of the river system and its tributaries between Warragamba Dam where it joins the Nepean River near Wallacia (not including the reach of the Nepean River upstream of Wallacia) and Wisemans Ferry<br>– abutting riparian zones<br>– abutting floodplain and wetland/lagoon waterbodies<br>– backwater flooding during flood events, which have impacts along South Creek, that flows into the Hawkesbury River downstream of Windsor and consequently South Creek. | – Includes the areas downstream of Warragamba Dam that could be affected by the future operation of the Project. |

# 5. Impact assessment

## Upstream zone

### *Location*

Upstream of the Warragamba Dam wall, the geographic extent of the upstream zone is defined by the Project PMF extent.

### *Existing landscape character*

The character of Blue Mountains National Park, which is within the upstream zone, is described in the NSW National Parks and Wildlife Service, 2001 'The Blue Mountains - Plan of Management' 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. A number of vegetation communities, such as the rainforests, tall open forests and heathland, have particular aesthetic appeal. The outstanding landforms and scenery of the park are a major draw card for international and domestic tourists and provide the focus for a broad range of recreation activities, which range from the passive enjoyment of the park's scenery from easily accessible cliff-top lookouts, to more active wilderness experiences in the park's many canyons and gorges. The large remote areas of the park are of special significance in offering opportunities for both the maintenance of natural processes and self-reliant recreation.

Most of the southern section of the GBMWHA, together with the Burragorang State Conservation Area (SCA) and areas of National Parks have an important function in contributing relatively unpolluted water to Lake Burragorang, Sydney's major potable water source.'

Refer to **Figure 5-1** to **Figure 5-3 on page 25** for existing character images.

### *The Project*

Defined by the upstream operational area that could be affected by the future operation of the raised dam and from 1 in 5 chance in a year events through to PMF events. Refer to **Section 3 on page 14** for a full Project description.

### *Landscape character assessment*

The large scale of the upstream zone, which has a diversity of natural features, including a rugged sandstone landscape, dominating cliff lines, narrow canyons and a maze of forested ridges and gorges ensure that areas potentially affected by changes as a result of increased temporary inundation are restricted to the immediate shoreline areas of the lake and its tributaries.

The impact on character is summarised in **Table 5-2** below. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-2: Upstream zone impact rating

| Upstream zone | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| Existing | High<br>– This zone is a natural area dominated by its rare diversity of natural features<br>– The large portion of this zone has limited/ no access for the public<br>– The area is highly valued by local population and tourists and includes sections of world heritage listed National Park. | Low<br>– 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.<br>– 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<br>– As above | Low<br>– Changes as a result 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 |

# 5. Impact assessment

Figure 5-1: Upstream zone: View from Echo Point Lookout

Figure 5-2: Upstream zone: View of the Three Sisters

Figure 5-3: Upstream zone: View across to Katoomba and Eagle Hawk Lookout

# 5. Impact assessment

## Construction zone

### *Location*

The area surrounding the dam wall that would occur within about 1 km of the dam wall.

### *Existing landscape character*

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 information 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. The design of the crest and associated dam wall features have been described as indicative of its 'post-war construction with simpler and cleaner utilitarian detailing' (Brooks, 2010), which contrasts with the naturally 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.

An extension of the dam wall 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. During it's four year construction period, the auxiliary spillway had a physical and visual impact on the immediate environment and resulted in the demolition and excavation of an area of Haviland Park. 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.

Refer to **Figure 5-4** to **Figure 5-6 on page 27** for existing character images.

### *The Project*

Defined by the construction footprint and includes new and modified infrastructure would be provided as part of the Project and would include 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. Refer to **Section 3 on page 14** for a full Project description.

### *Landscape character assessment*

The increase in the height and scale of the dam wall as a result of the raising is considered to be in keeping with the existing built infrastructure form and nature of the existing altered landscape. These new structural elements would essentially be a visual extension of the existing dam, albeit more 'contemporary' in appearance.

The wall is enveloped by the larger scale of the surrounding natural environment, which would continue to frame the substantially altered landscape of the dam wall surrounds.

During the spillway Project, much of the terrain to the west was artificially raised and revegetated, further contributing to the extensive and numerous Projects, which have altered the landscape at this location since the dam wall completion.

The impact on character is summarised in **Table 5-3**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-3: Construction zone impact rating

| Construction zone | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| Existing | Moderate<br>– 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<br>– There is a compelling juxtaposition between the natural landscape setting and the built dam wall infrastructure and other engineered elements | Moderate |
| Project | Moderate<br>– As above | Moderate<br>– 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 |

# 5. Impact assessment

Figure 5-4: Construction zone: View from existing clifftop walkway across the existing spillway bridge

Figure 5-5: Construction zone: View along the existing spillway bridge

Figure 5-6: Construction zone: View from the Eighteenth Street Lookout

# 5. Impact assessment

## Downstream zone

### *Location*

Downstream of the Warragamba Dam wall the geographic extent of the downstream zone is defined by the existing PMF extent.

### *Existing landscape character*

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 (not including the reach of the Nepean River upstream of 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, would experience backwater flooding impacts during flood events and has consequently also been included in the zone.

Refer to **Figure 5-7** to **Figure 5-9 on page 29** for existing character images.

### *The Project*

Defined by the downstream operational area that could be affected by the future operation of the raised dam and environmental flow releases from 1 in 5 chance in a year events through to PMF events. Refer to **Section 3 on page 14** for a full Project description.

### *Landscape character assessment*

The Hawkesbury-Nepean Valley river system and its tributaries generally comprises flat undulating floodplains that are subject to regular flooding.

While the dam wall raising has been determined by flood modelling as part of the Project to substantially reduce the flood risk, it can not eliminate it, regardless of the dam's height, however the main objective of the Project is to reduce risk to life, property and social amenity from floods in the Hawkesbury-Nepean Valley.

Post dam wall raising peak flood levels would reduce and flood risk to life and property would be reduced. The Project reduces downstream impacts, which could be interpreted as having positive visual impacts.

The impact on character is summarised in **Table 5-4**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-4: Downstream zone impact rating

| Zone 3 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| Existing | Moderate<br>– The overall sensitivity of this zone is considered to be 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<br>– Existing flood events within this zone are extensive and have substantial impacts both economically and socially | High-Moderate |
| Project | Moderate<br>– As above | Low<br>– Flooding within this zone would substantially reduce as a result of the Project (especially in the 1 in 20 year flood event) but not be eliminated altogether | Moderate-Low |

# 5. Impact assessment


Figure 5-7: Downstream zone: View looking upstream from the Penrith Weir (Victoria Bridge in background)


Image capture: Feb 2017 © 2020 Google

Figure 5-8: Downstream zone: View from Richmond Bridge looking upstream


Image capture: Feb 2017 © 2020 Google

Figure 5-9: Downstream zone: View from Windsor Bridge looking upstream

# 5. Impact assessment

### 5.1.2 Summary of impacts to assessment zones

For the purposes of this broad character assessment, areas of similar landscape character directly correlate to the three hydraulic assessment zones defined within the study area. The upstream and downstream zones have been assessed based on the impacts of Project flood levels compared with the existing equivalent floods on sensitivity and magnitude.

The nature of the Project being both partial demolition and raising of the Warragamba dam wall, as well as continuing operational zones upstream and downstream of the dam itself, has meant that there are identifiable impacts to each of the zones, which is summarised in **Table 5-5** below.

The impact in the upstream zone has the same overall rating as those experienced in the construction zone, however the sensitivity of the viewers is higher in the upstream zone. The high biodiversity value and spectacular scenery of the surrounding World Heritage and State Conservation areas means that there is a major focus for domestic and international tourism. Some recreational pursuits are undertaken within this unique natural upstream zone but from a limited number of locations.

A large part of the area falls within the WaterNSW Special and Controlled Areas, which prohibits public access to assist in protecting the drinking water catchment of Lake Burragorang. The extent of potential impacts in the upstream zone and to the surrounding lake shoreline, is dependant on future flood events and operation of the flood mitigation zone of the Warragamba Dam Raising. Changes as a result of increased temporary inundation, whether viewed from the identified viewpoints or by aerial observers, are unlikely to be perceptible within the scale and expanse of the zone or if visible will echo the current water levels fluctuations of the dam.

The construction zone is already a heavily modified environment. It is highly valued as a recreation resource and historical landmark, which is of regional significance that demonstrates a significant built/engineering achievement. The contrast between the built form and natural environment would become stronger as the new dam infrastructure would echo the existing infrastructural forms although increase the scale and bulk. The dam wall and immediate surrounds would continue to be a landmark tourist attraction and local recreational resource for western Sydney and consequently the sensitivity of viewers has been determined as moderate.

Across the downstream zone, impacts generally relate to changes in the landscape in the aftermath of a flood event. After the completion of the Project, flood events would be reduced in severity and consequently impacts are reduced, which for this Project is considered to be a positive impact.

Table 5-5: Impact rating summary

| Assessment zone | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| **Upstream zone** | | | |
| Existing flood events | High | Low | **Moderate** |
| Project flood events | High | Low | **Moderate** |
| **Construction zone** | | | |
| Existing built infrastructure | Moderate | Moderate | **Moderate** |
| Project built infrastructure | Moderate | Moderate | **Moderate** |
| **Downstream zone** | | | |
| Existing flood events | Moderate | High | High-**Moderate** |
| Project flood events | Moderate | Low | **Moderate-Low** |

# 5. Impact assessment

## 5.2 Visual assessment

### 5.2.1 Viewpoints

An initial desktop analysis was undertaken to determine the areas that both the construction and operational phases of the Project would likely be visible from. In each zone, different hydraulic data sets (refer **Section 4.1.1 on page 18**) are considered as part of this report and were evaluated according to the greatest measurable impacts that zone would potentially experience.

PMF events were assessed in the upstream zone however the long term impacts of vegetation during such events are unknown and infrequent and would be subject to further assessment when these events occur. *Hydraulic advice indicated that the* frequency of temporary inundation due to the operation of the Project during 1 in 5 and 1 in 20 chance in a year flood events *was more* likely to impact vegetation so this data was analysed.

Impacts in the construction zone are based on hydraulic advice, which suggested analysing three hydraulic data sets, which were 1 in 5 chance in a year flood levels, 1 in 20 chance in a year flood levels and PMF event levels to demonstrate a range of potential impacts within this zone.

In the downstream zone hydraulic advice indicated that the Project would reduce flooding in this zone. 1 in 20 chance in a year flood event levels were selected as they would have the largest reduction in flooding extent (i.e. area) as a result of the Project and are also likely to occur within an individual viewers lifetime. PMF events were also assessed in order to demonstrate any potential improvements.

After this analysis, eight viewpoints were identified as representative of more popular, publicly accessible locations, which were likely to be impacted by flood events. Following site inspections and further desktop analysis, these viewpoint locations were then assessed for potential visual impacts. These viewpoints are listed below in **Table 5-6** according to the assessment zones that they are located in and each viewpoint is assessed on the following pages.

Aerial observers, commuters and tourists on aircraft, were also considered, however only a high-level assessment of impacts were deemed necessary, with low to negligible impacts expected.

Table 5-6: Viewpoint summary

| VP | Location | Potential visibility of the Project |
|---|---|---|
| **Upstream zone (refer Figure 5-10 on page 32)** | | |
| 1-1 | Echo Point Lookout, Katoomba | – Long range views of existing and Project 1 in 5 chance in a year flood levels |
| | | – Long range views of existing and Project 1 in 20 chance in a year flood levels |
| | | – Long range views of existing and Project PMF events |
| 1-2 | Burragorang Lookout, Nattai | – Medium range views of existing and Project 1 in 5 chance in a year flood levels |
| | | – Medium range views of existing and Project 1 in 20 chance in a year flood levels |
| | | – Medium range views of existing and Project PMF events |
| **Construction zone (refer Figure 5-21 on page 47)** | | |
| 2-1 | Viewing Platform | – Close range views of existing and Project 1 in 5, 1 in 20 chance in a year level & PMF events |
| 2-2 | Valve House Road | – Close range views of built infrastructure (assessment does not change across existing and Project flood events) |
| 2-3 | 18th Street Lookout | – 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 (refer Figure 5-30 on page 56)** | | |
| 3-1 | Penrith Weir, Penrith | – 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 |
| 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 |

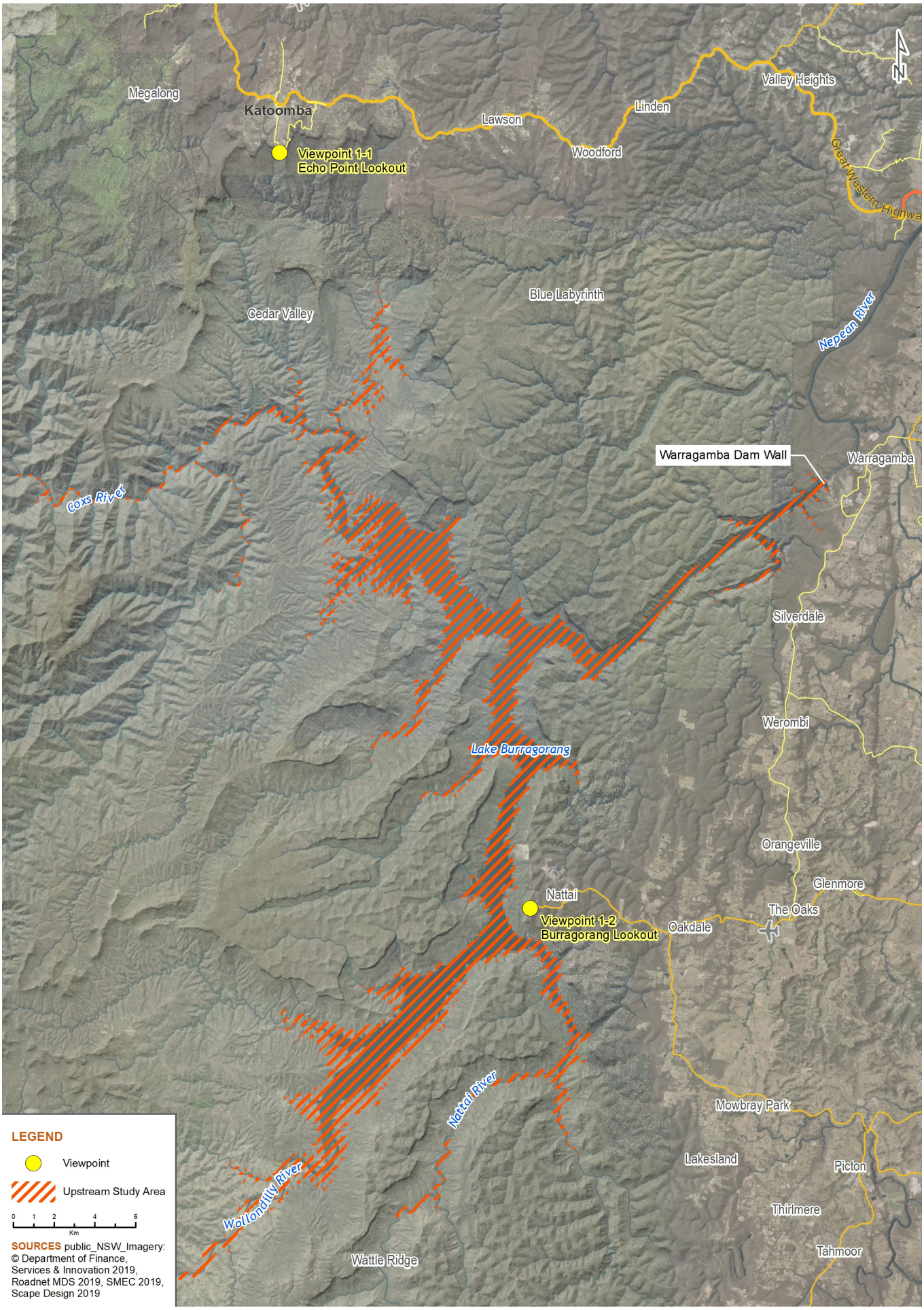


Figure 5-10: Upstream zone viewpoint locations (SMEC)

# 5. Impact assessment

## Viewpoint 1-1

### *Location and description*

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. Refer **Figure 5-11** below. The viewpoint has panoramic views south across the Blue Mountains National Park and the GBMWHA, which is highly valued for it's physical uniqueness and scenic qualities. The iconic Three Sisters rock formation is obvious in the 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 intervention in the form of camp grounds and fire trails.

### *Description of anticipated visible elements*

The Kedumba River is the closest waterway that could potentially be impacted by the Project and it is some 10 kilometres away from this viewpoint.

Operation of the flood mitigation zone of the raised dam, to temporarily capture flood waters, means that the lake and tributaries could potentially swell. Frequent temporary inundation as a result of 1 in 5 chance in a year flood events, due to the operation of the Project, are more likely to impact vegetation while PMF events are very rare and unlikely and if they occurred and would have the shortest duration of damaging flood waters. Any long term impacts of vegetation above the flood level are unknown and infrequent and would be subject to further assessment when these events occur.

Any changes as a result of increased inundation during 1 in 5 chance in a year and PMF floods are unlikely to be perceptible form this viewpoint given the intervening terrain and vegetation.

Refer **Figure 5-13 on page 35** and **Figure 5-15 on page 39** for oblique aerial views.

### *Affected viewers:*

- Tourists and locals visiting the scenic lookout
- Staff of Visitor information Centre (Blue Mountains City Council).

### *Description of potential impacts*

According to viewshed analysis of hydraulic data provided in **Figure 5-12 on page 34** and **Figure 5-14 on page 38**, flood events are unlikely to be visible from the Echo Point scenic lookout. While there is the potential for some low lying areas close to the existing watercourse to be impacted by increased temporary inundation, it is unlikely that such impacts, would be discernible at a distance of almost 10 kilometres.

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.

However, depending on the level and duration of inundation there is the potential to expose distant views of the flood waters and possibly vegetation loss itself could be a visual impact.

The visual impact on this viewpoint for 1 in 5 chance in a year flood is summarised in **Table 5-7 on page 35** and in **Table 5-9 on page 42**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.


Figure 5-11: Viewpoint 1-1 Looking south over the Jamison Valley from the Echo Point Lookout

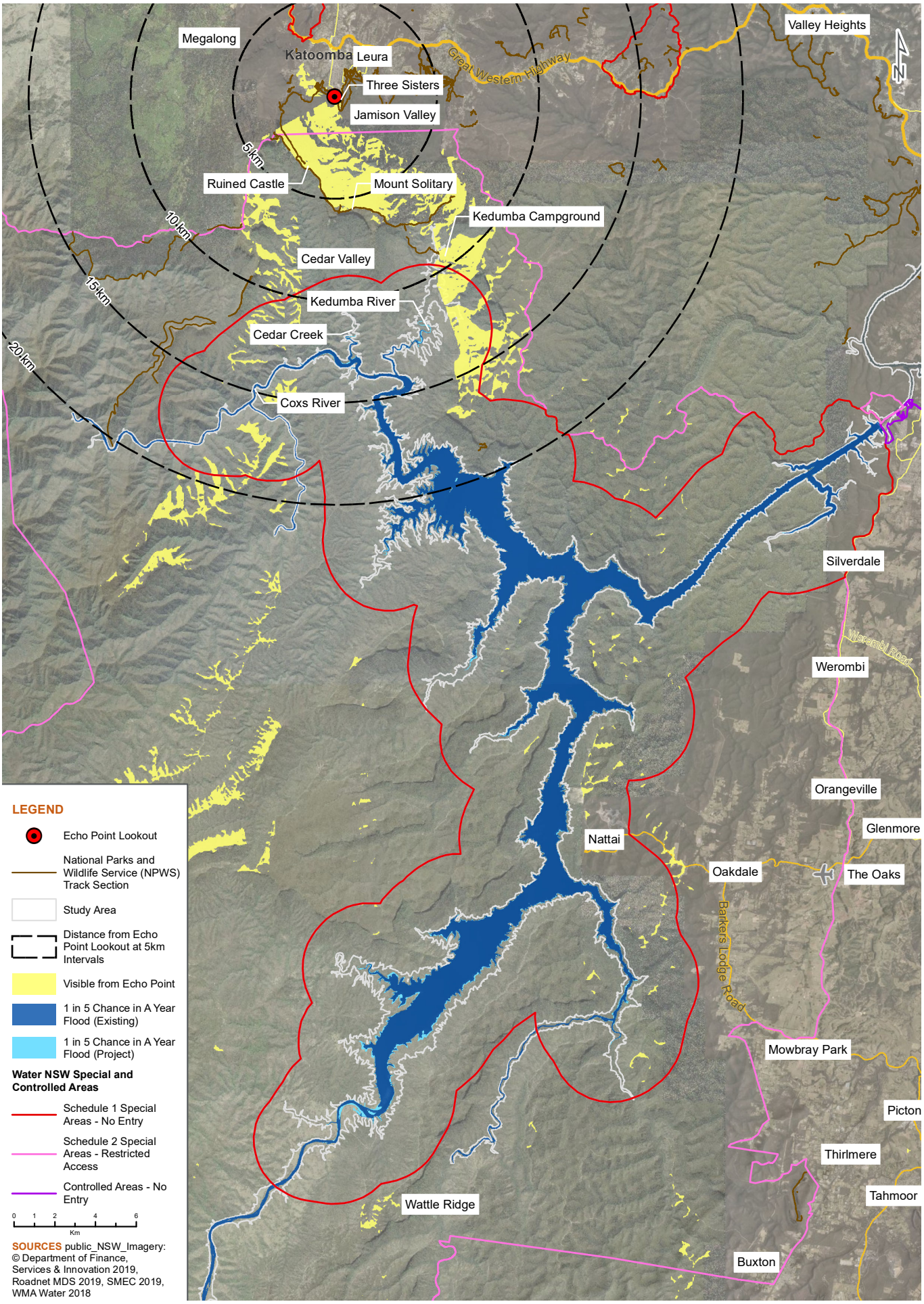


Figure 5-12: Viewshed from Echo Point Lookout showing 1 in 5 chance in a year flood levels (SMEC)

# 5. Impact assessment

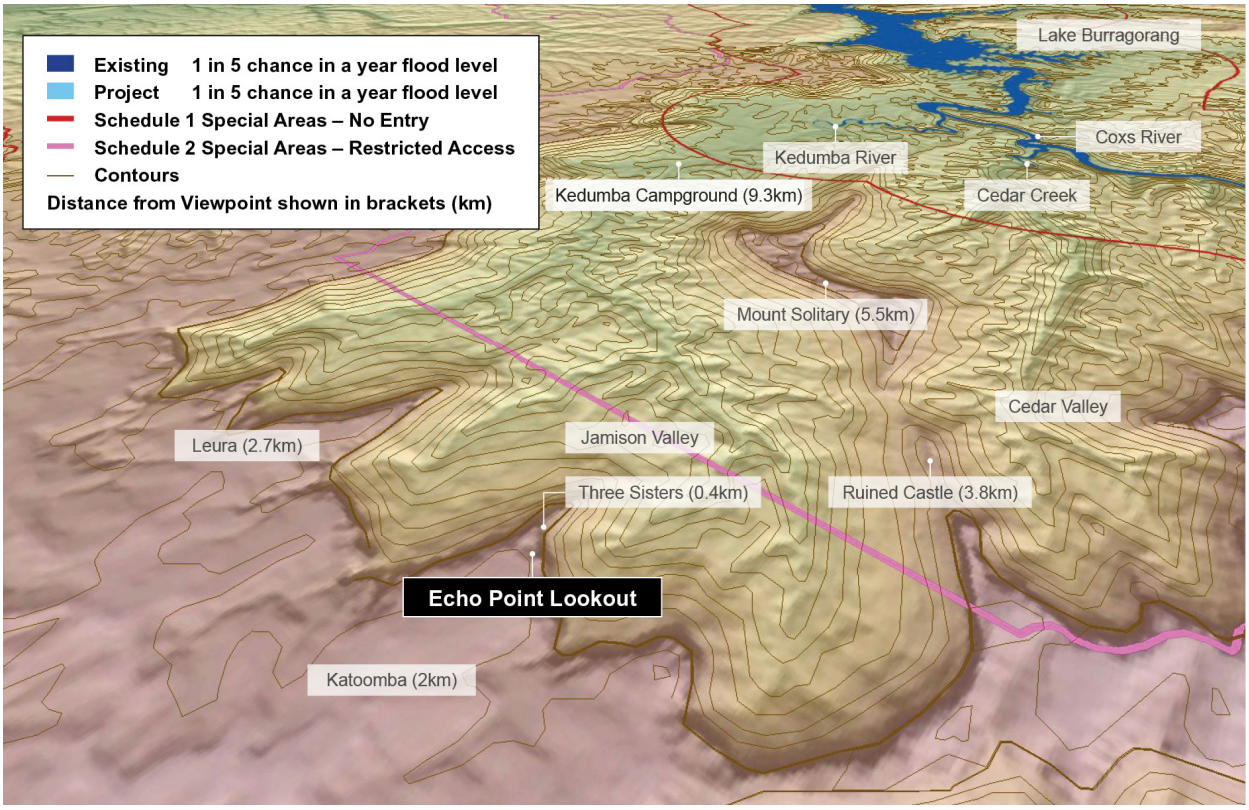


Figure 5-13: Oblique aerial view from Echo Point Lookout showing 1 in 5 chance in a year flood levels (SMEC)

Table 5-7: Visual impact summary of 1 in 5 chance in a year flood levels for VP 1-1

| VP 1-1 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 5 chance in a year flood level | | | |
| Existing | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | Low<br>– Small, if at all discernible, change to existing vegetation within the temporary inundation zones in the upstream environment, which is almost 10 kilometres away | Moderate |
| Project | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | Low<br>– Small, if at all discernible, change to existing vegetation within the temporary inundation zones in the upstream environment, which is almost 10 kilometres away | Moderate |

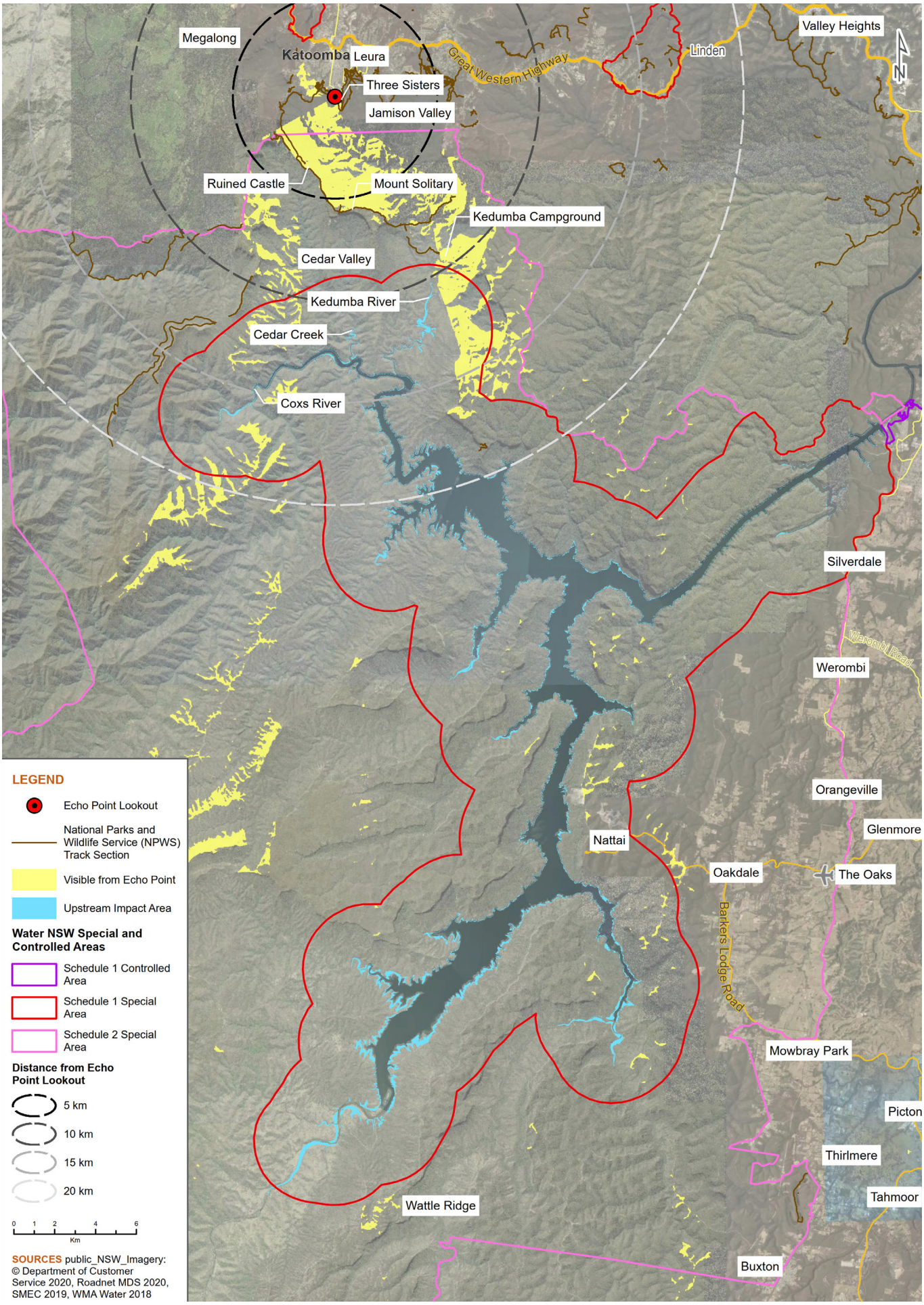


Figure 5-14: Viewshed from Echo Point Lookout showing upstream impact area (SMEC)

# 5. Impact assessment

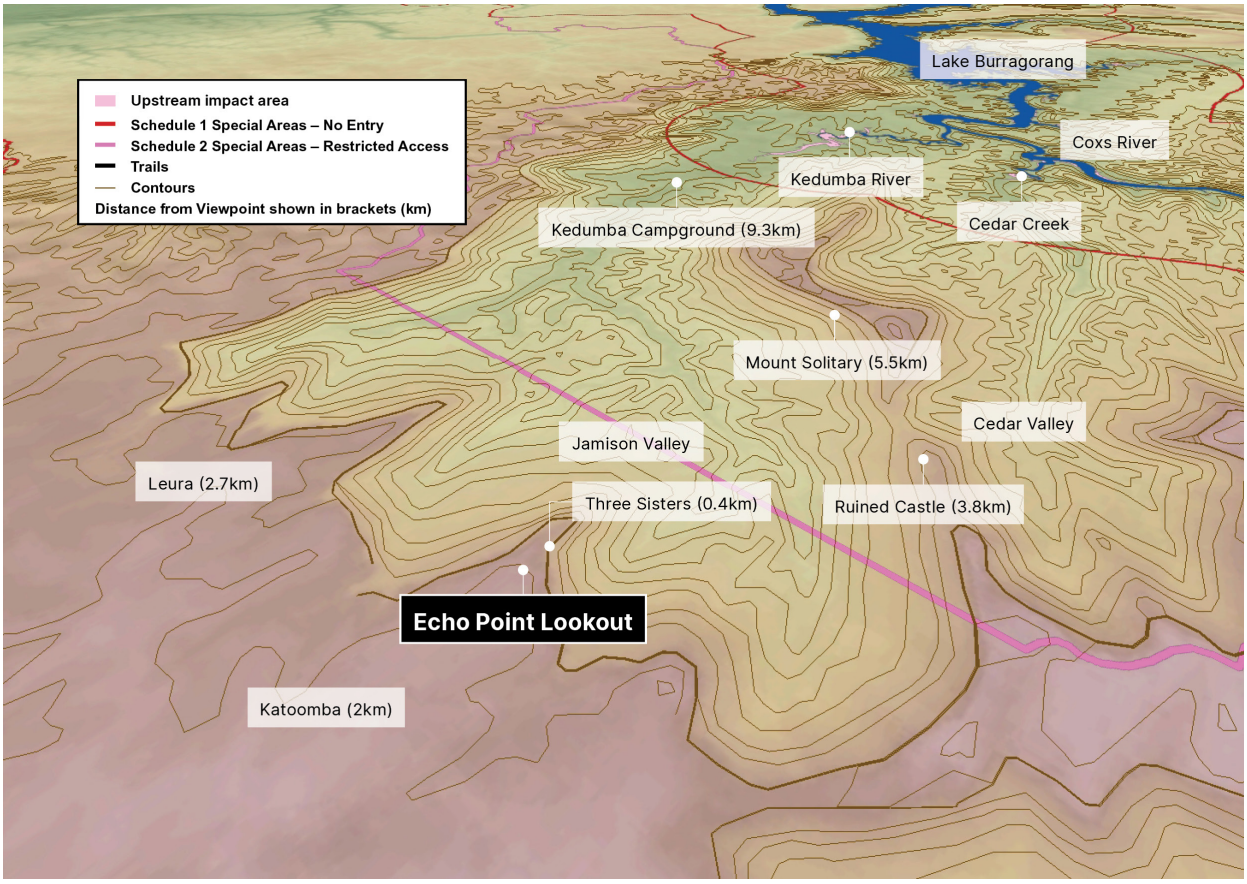


Figure 5-15: Oblique aerial view from Echo Point Lookout showing upstream impact area (SMEC)

Table 5-8: Visual impact summary of upstream impact area for VP 1-1

| VP 1-1 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| Upstream impact area | | | |
| Existing | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | Low<br>– Small, if at all discernible, change to existing vegetation within the temporary inundation zones in the upstream environment, which is almost 10 kilometres away | Moderate |
| Project | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | Low<br>– Small, if at all discernible, change to existing vegetation within the temporary inundation zones in the upstream environment, which is almost 10 kilometres away | Moderate |

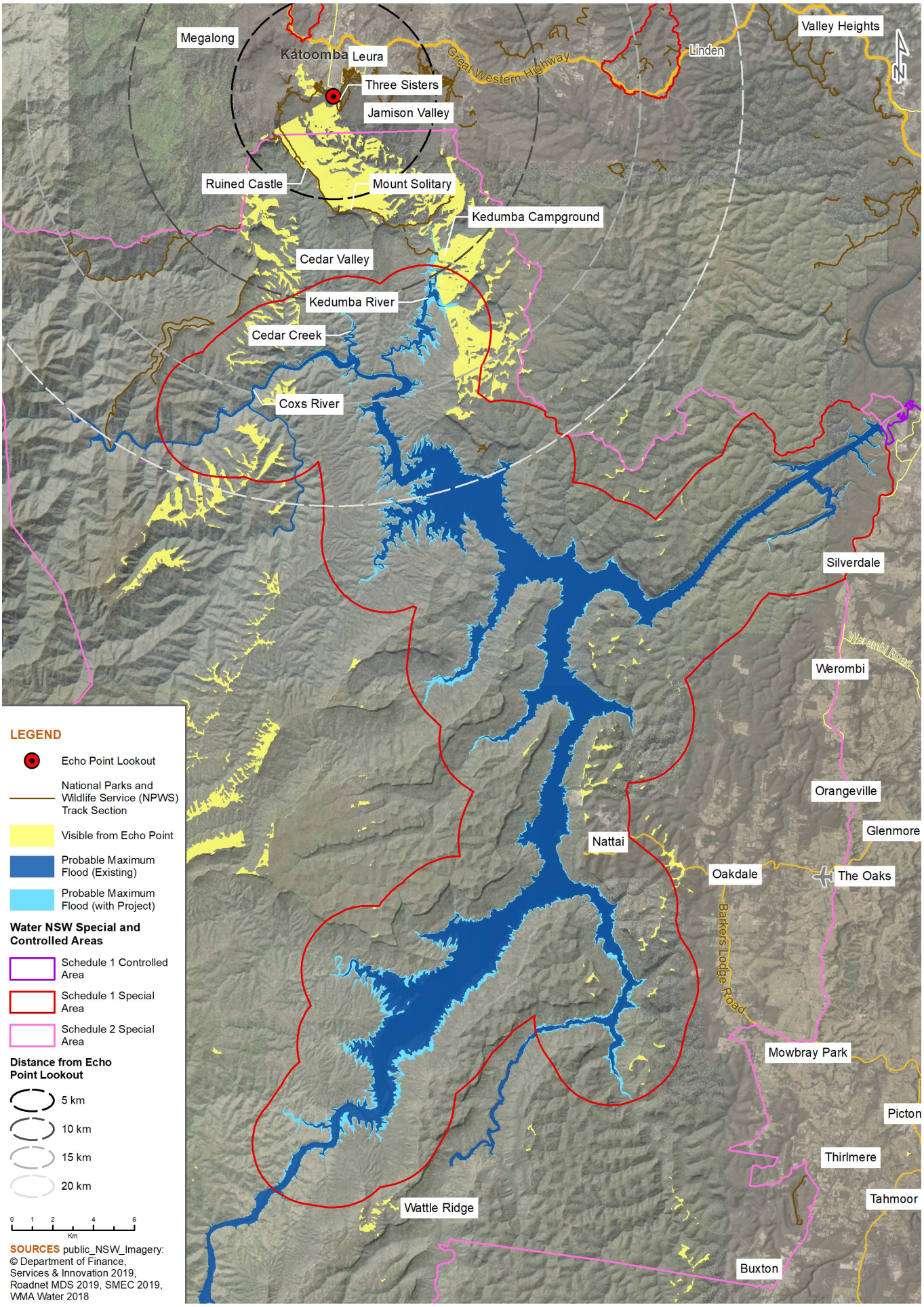


Figure 5-16: Viewshed from Echo Point Lookout showing PMF event levels (SMEC)

# 5. Impact assessment

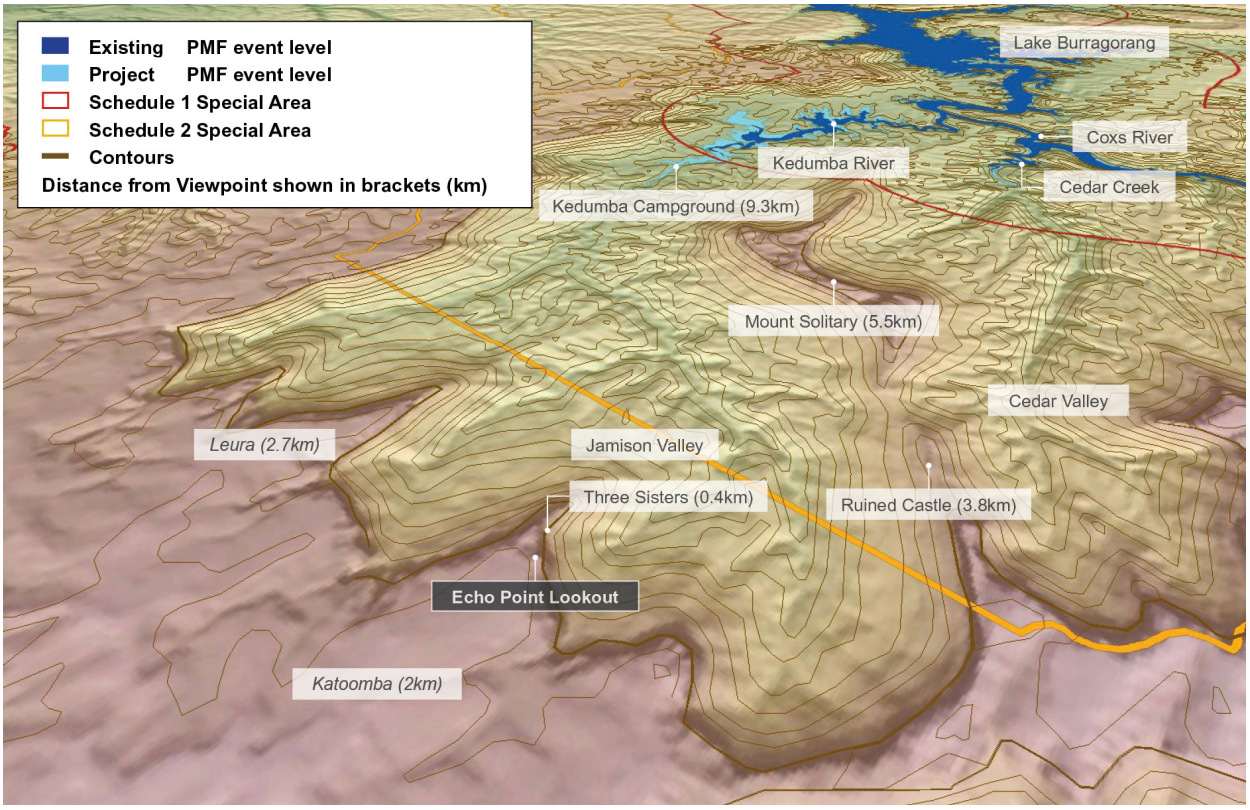


Figure 5-17: Oblique aerial view from Echo Point Lookout showing PMF event levels (SMEC)

Table 5-9: Visual impact summary of PMF event levels at VP 1-1

| VP 1-1 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| PMF event levels | | | |
| Existing | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | High<br>– PMF events are very rare and if they occurred they would have the shortest duration of damaging flood waters within the temporary inundation zones in the upstream environment<br>– Any long term impacts of vegetation above the flood mitigation zone of the upstream environment levels are unknown and would be subject to further assessment when these events occur. | High |
| Project | High<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the Greater Blue Mountains World Heritage Area<br>– Staff working at the Visitor Centre. | High<br>– PMF events are very rare and if they occurred they would have the shortest duration of damaging flood waters within the temporary inundation zones in the upstream environment<br>– Any long term impacts of vegetation above the flood mitigation zone of the upstream environment levels are unknown and would be subject to further assessment when these events occur. | High |

# 5. Impact assessment

## Viewpoint 1-2

### *Location and description*

This viewpoint is located at Burragorang Lookout, (refer **Figure 5-10 on page 32**) perched high above Lake Burragorang, 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.

Located at the end of a narrow sealed road, the lookout is just over an hours drive from the Sydney CBD and 40 kilometres south-west of the Warragamba Dam Visitor Centre. It is a popular place to visit and has an abundance of facilities including picnic tables, shelters, barbecues, toilets, a bush trail and children's playground and it is common for visitors to spend several hours there. Views from this elevated Blue Mountains escarpment look down a steep vegetated valley and reveal Lake Burragorang as a dominant feature in the visual catchment. The lake with a shoreline of bright exposed rock contributes to the high scenic amenity at this location.

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. Some of the properties are located within the Special Areas - Restricted Access the water supply protection zone surrounding Lake Burragorang. Refer **Figure 5-16 on page 40**.

### *Description of anticipated visible elements*

Located high above the upstream zone, this viewpoint may be impacted by operation of the flood mitigation zone to temporarily capture flood waters.

Operation of the flood mitigation zone of the raised dam, to temporarily capture flood waters, means that the lake could potentially swell. Frequent temporary inundation as a result of 1 in 5 chance in a year flood events, due to the operation of the Project, are more likely to impact vegetation while PMF are very rare and unlikely and if they occurred would have the shortest duration of damaging flood waters. Any long term impacts of vegetation above the flood level are unknown and infrequent and would be subject to further assessment when these events occur.

From this viewpoint some changes to the lake's shoreline may be apparent, however it should be noted that the lookout sits almost 300 m vertically above the surface elevation of the lake and is surrounded by dense bushland vegetation making changes difficult to discern.

Refer to **Figure 5-17 on page 41** for the viewshed map and **Figure 5-18 on page 42** for the oblique aerial view.

### *Affected viewers:*

- Tourists visiting the scenic lookout and picnic area
- Limited number of local residents located within the catchment area.

### *Description of potential impacts*

Sections of the exposed rock on the shoreline, which is comprised of the Nattai National Park and Yerranderie State Conservation Area, are visible could potentially be altered by infrequent inundation of the banks within the upstream zone.

At its closest point, the shoreline is still almost two kilometres from this viewpoint and stretches and far as 16 kilometres into the distance. Depending on the level and duration of inundation there is the 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 of this viewpoints is summarised in **Table 5-9**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

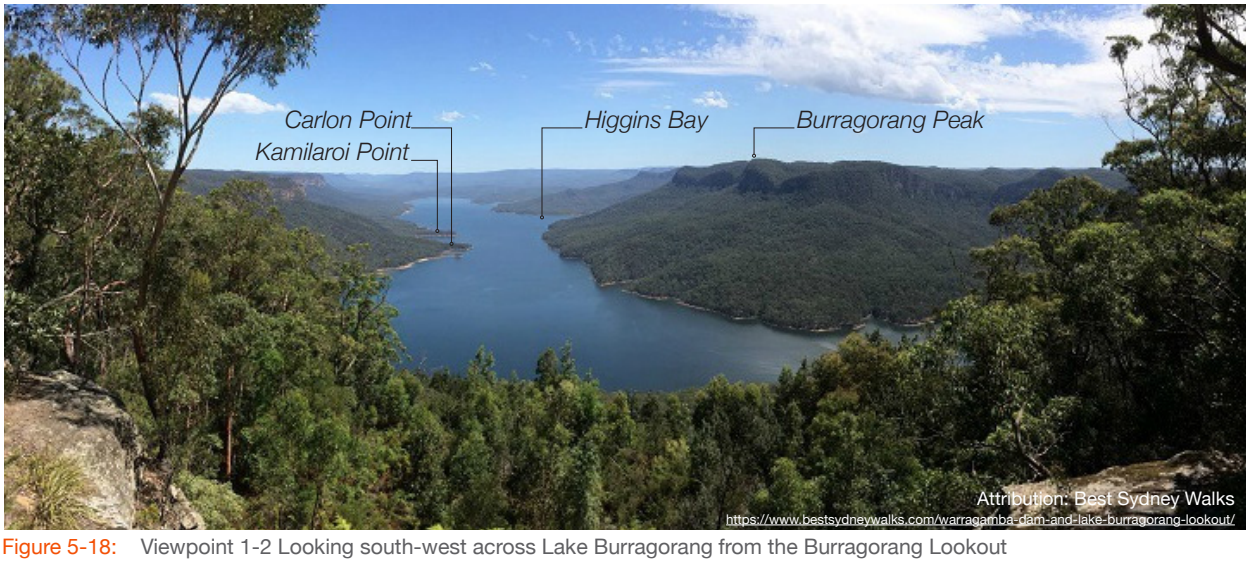


Figure 5-18: Viewpoint 1-2 Looking south-west across Lake Burragorang from the Burragorang Lookout

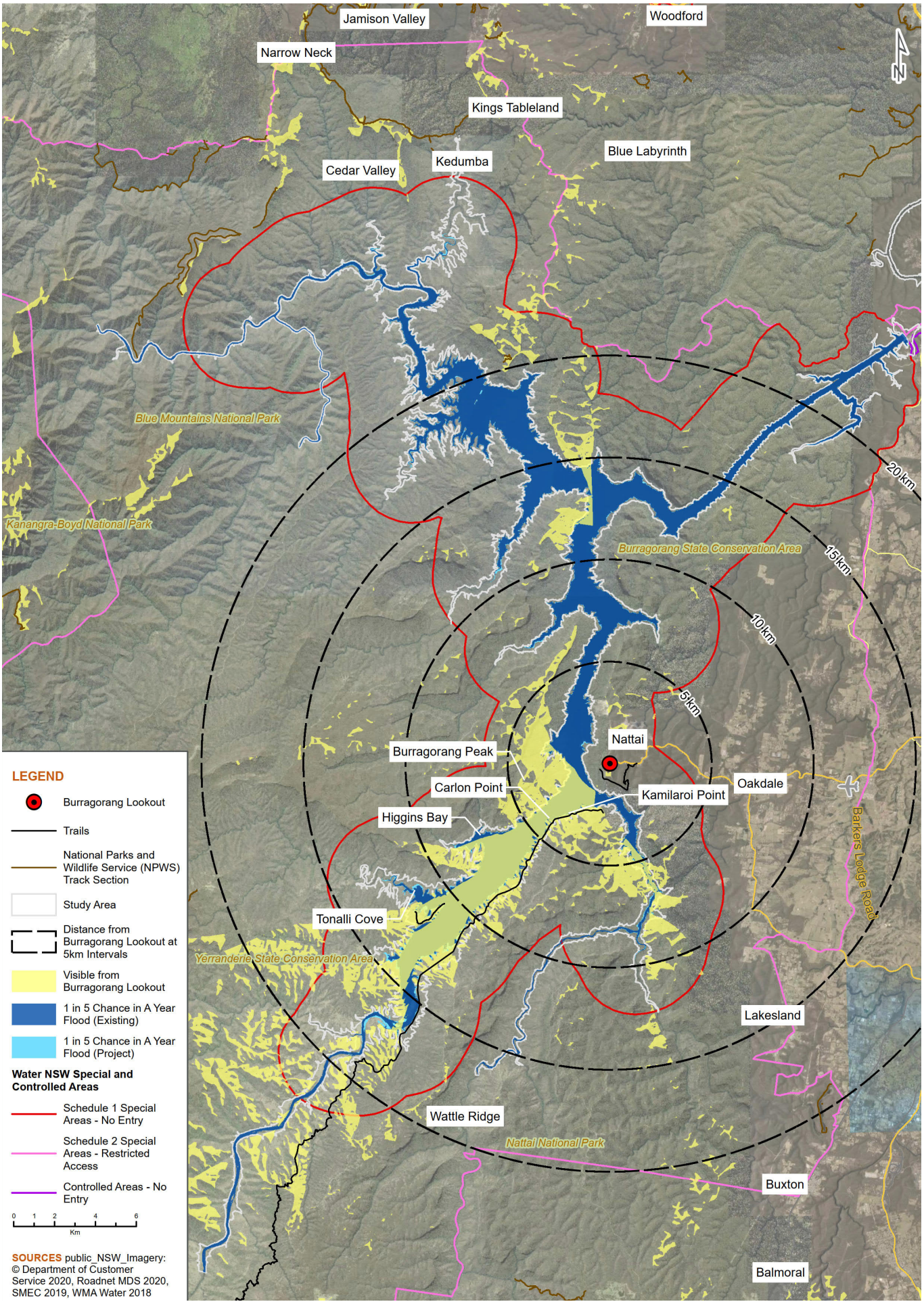


Figure 5-19: Viewshed from Burragorang Lookout showing 1 in 5 chance in a year flood levels (SMEC)

# 5. Impact assessment

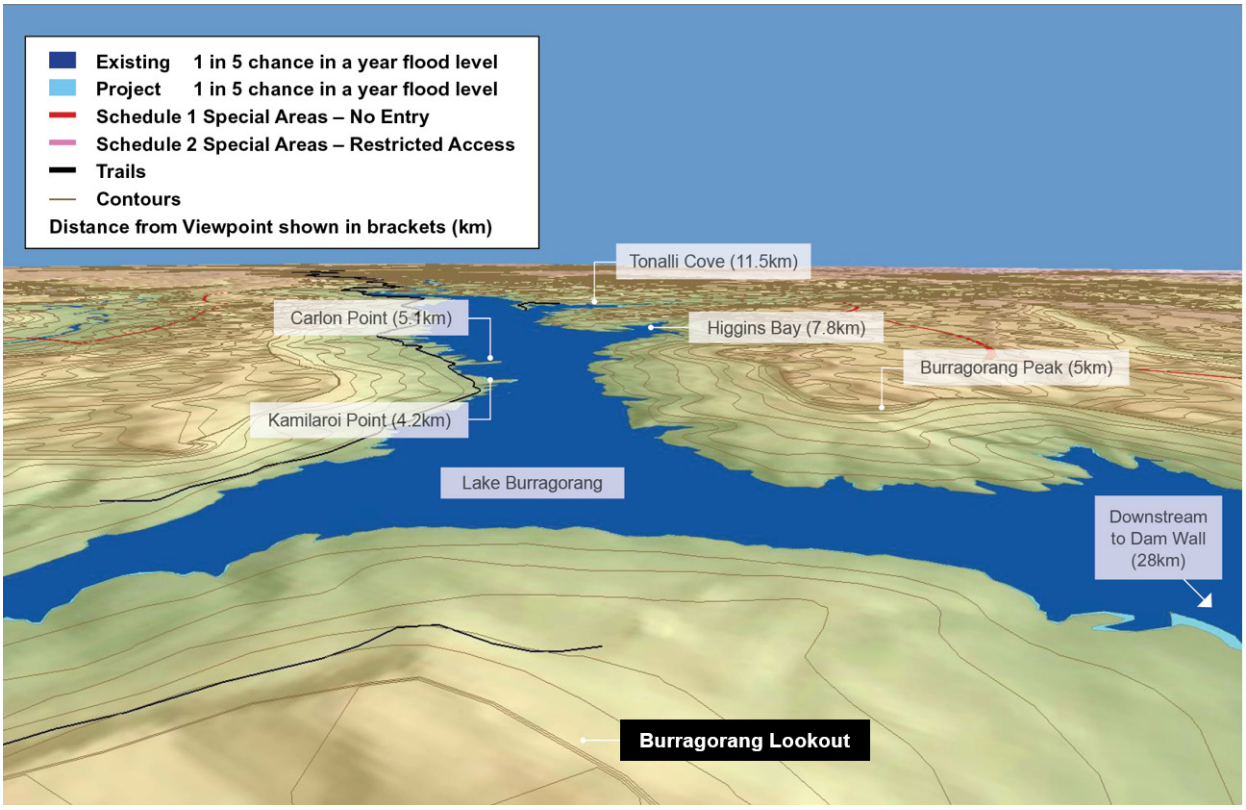


Figure 5-20: Oblique aerial from Burragorang Lookout showing 1 in 5 chance in a year flood levels (SMEC)

Table 5-10: Visual impact summary of 1 in 5 chance in a year flood levels at VP 1-2

| VP 1-2 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 5 chance in a year flood level | | | |
| Existing | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | Low<br>– Possible occasional increased inundation of existing banks of Lake Burragorang, within the flood mitigation zone of the upstream environment, are considered to have a low magnitude of change | Moderate |
| Project | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | Low<br>– Possible occasional increased inundation of existing banks of Lake Burragorang, within the flood mitigation zone of the upstream environment, are considered to have a low magnitude of change | Moderate |

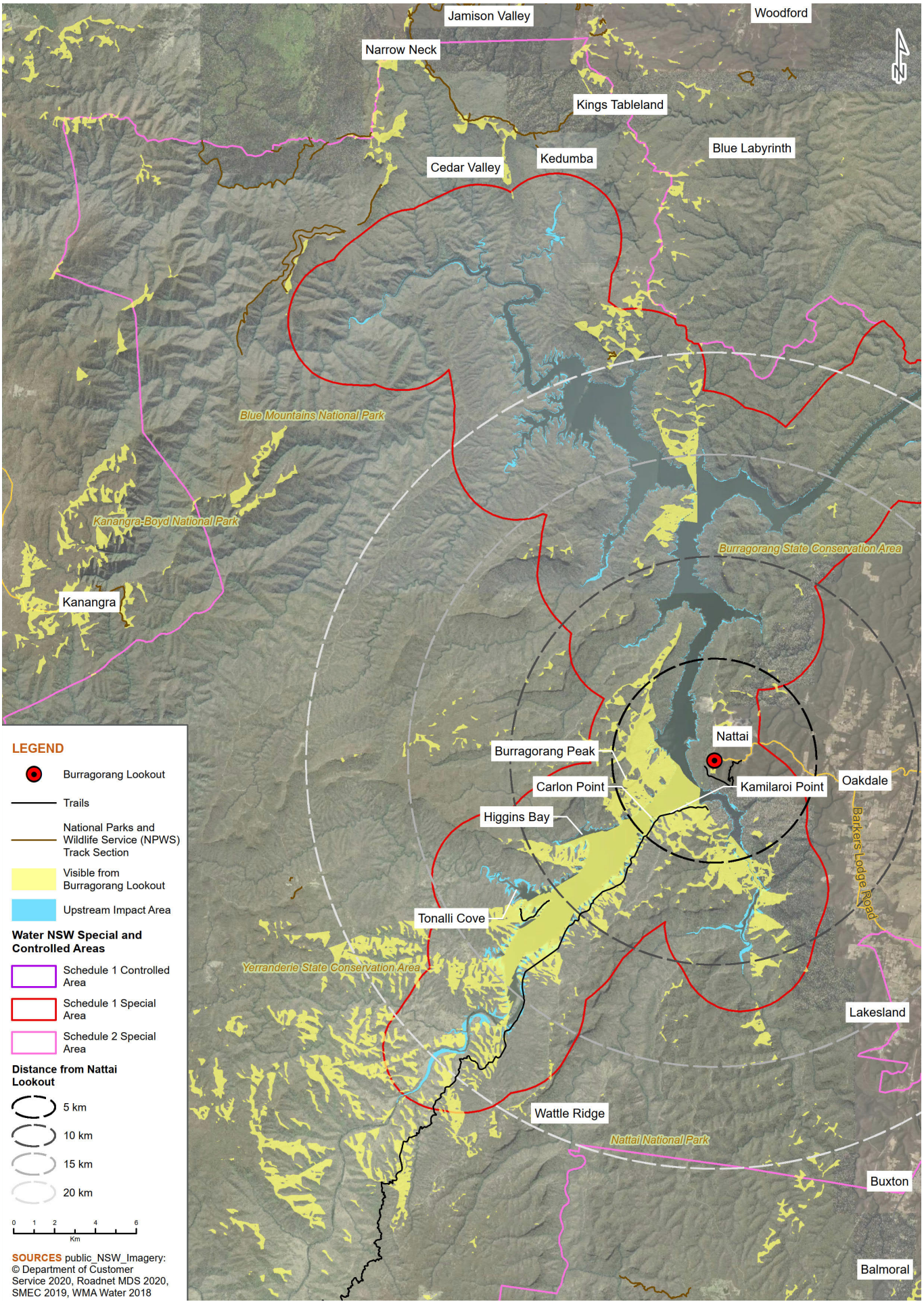


Figure 5-21: Viewshed from Burragorang Lookout showing upstream impact area (SMEC)

# 5. Impact assessment

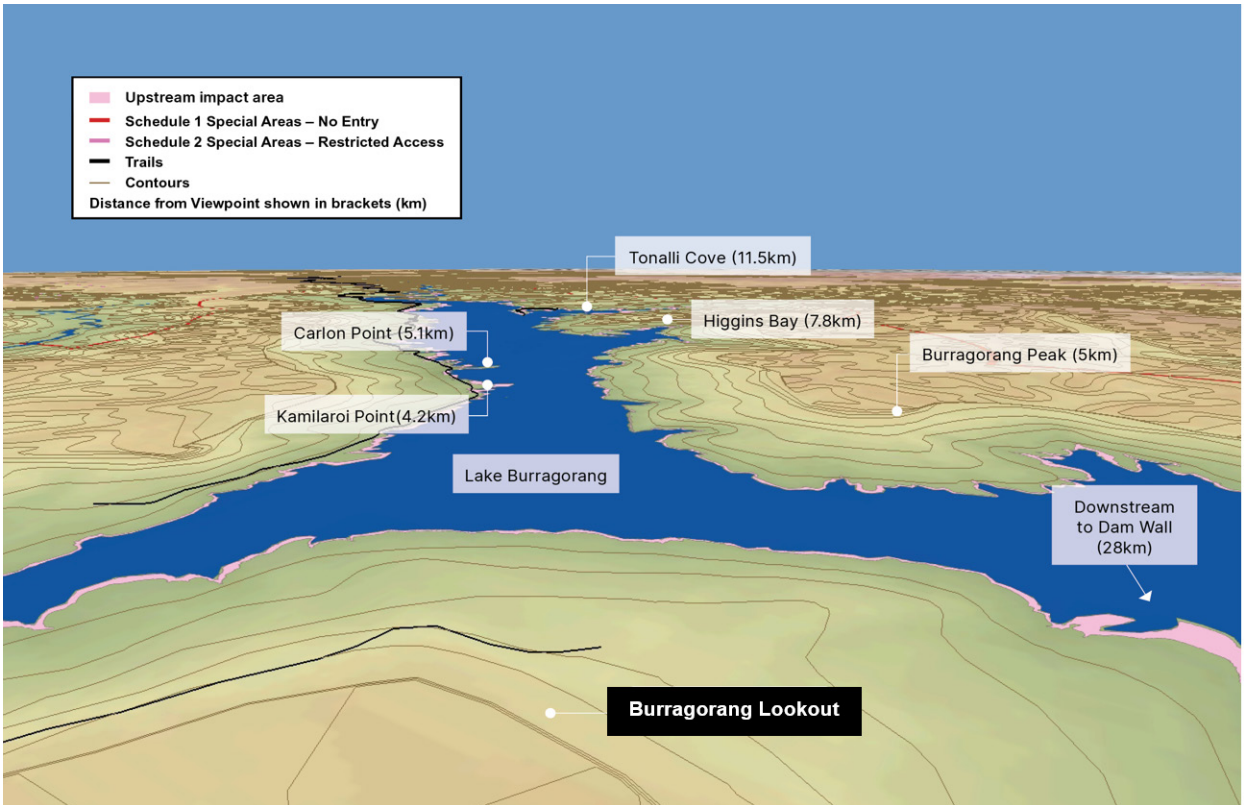


Figure 5-22: Oblique aerial from Burragorang Lookout showing upstream impact area (SMEC)

Table 5-11: Visual impact summary of upstream impact area at VP 1-2

| VP 1-2 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| Upstream impact area | | | |
| Existing | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | Low<br>– Possible occasional increased inundation of existing banks of Lake Burragorang, within the flood mitigation zone of the upstream environment, are considered to have a low magnitude of change | Moderate |
| Project | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | Low<br>– Possible occasional increased inundation of existing banks of Lake Burragorang, within the flood mitigation zone of the upstream environment, are considered to have a low magnitude of change | Moderate |

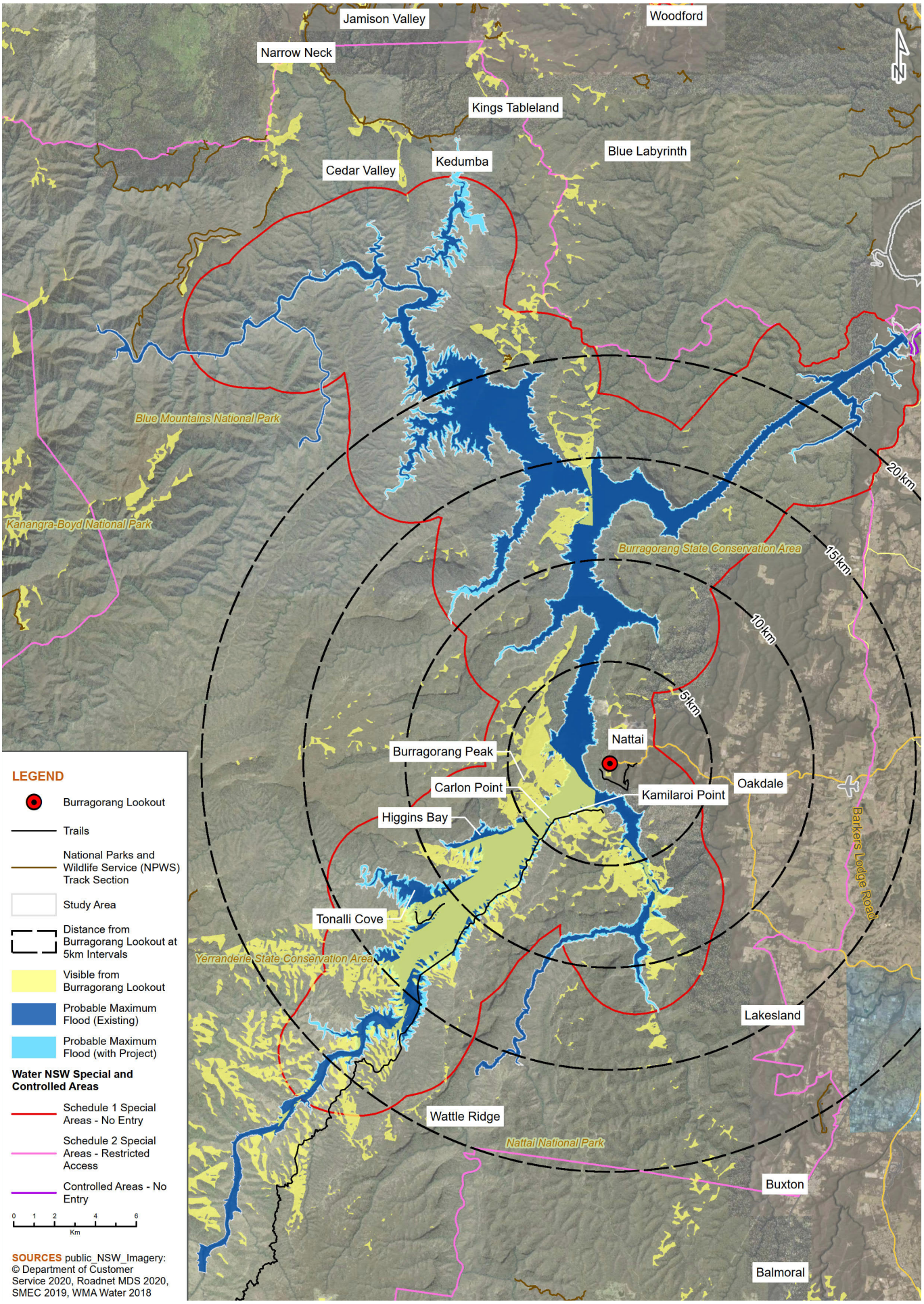


Figure 5-23: Viewshed from Burragorang Lookout showing PMF event levels (SMEC)

# 5. Impact assessment

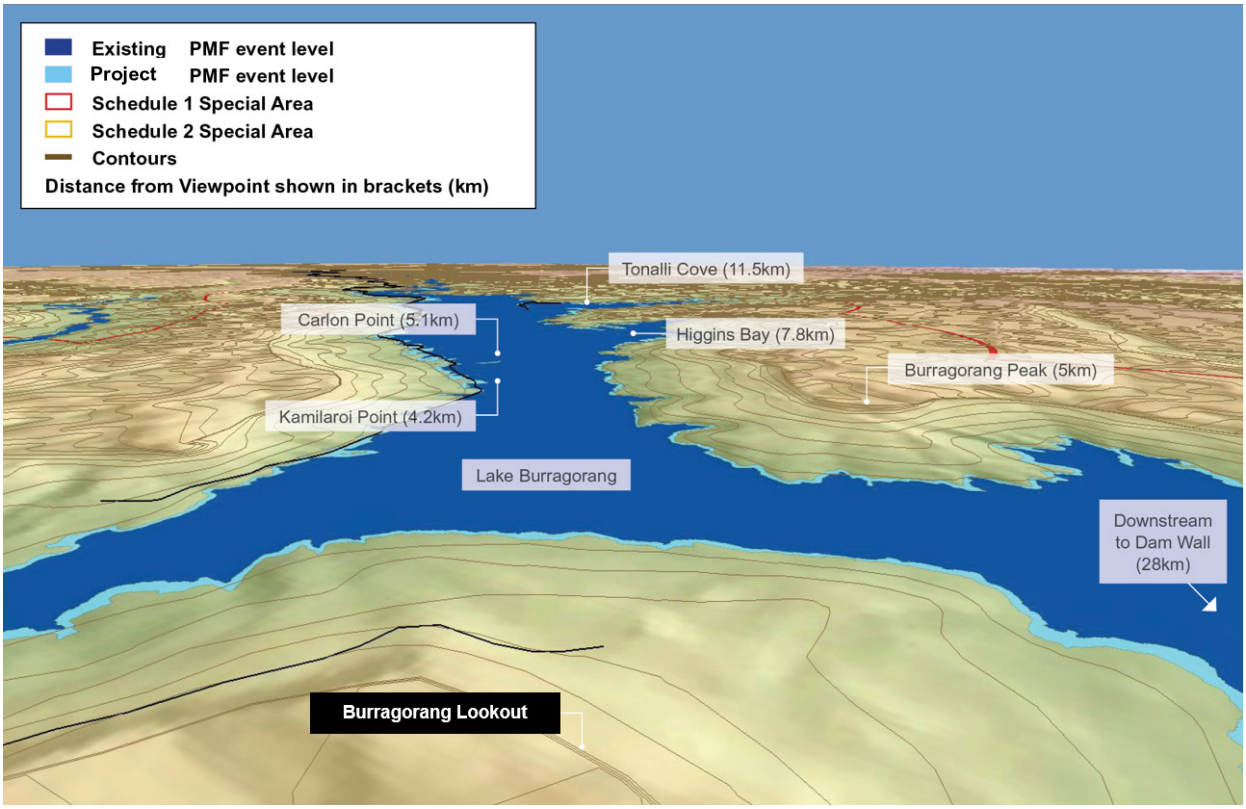


Figure 5-24: Oblique aerial from Burragorang Lookout showing PMF event levels (SMEC)

Table 5-12: Visual impact summary of PMF event levels at VP 1-2

| VP 1-2 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| PMF event levels | | | |
| Existing | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | High<br>– PMF events are very rare and if they occurred they would have the shortest duration of damaging flood waters within the temporary inundation zones in the upstream environment<br>– Any long term impacts of vegetation above the flood mitigation zone of the upstream environment levels are unknown and would be subject to further assessment when these events occur. | High |
| Project | High<br>– Local and regional tourists visiting the scenic lookout, which has panoramic views out across Lake Burragorang from high above | High<br>– PMF events are very rare and if they occurred they would have the shortest duration of damaging flood waters within the temporary inundation zones in the upstream environment<br>– Any long term impacts of vegetation above the flood mitigation zone of the upstream environment levels are unknown and would be subject to further assessment when these events occur. | High |

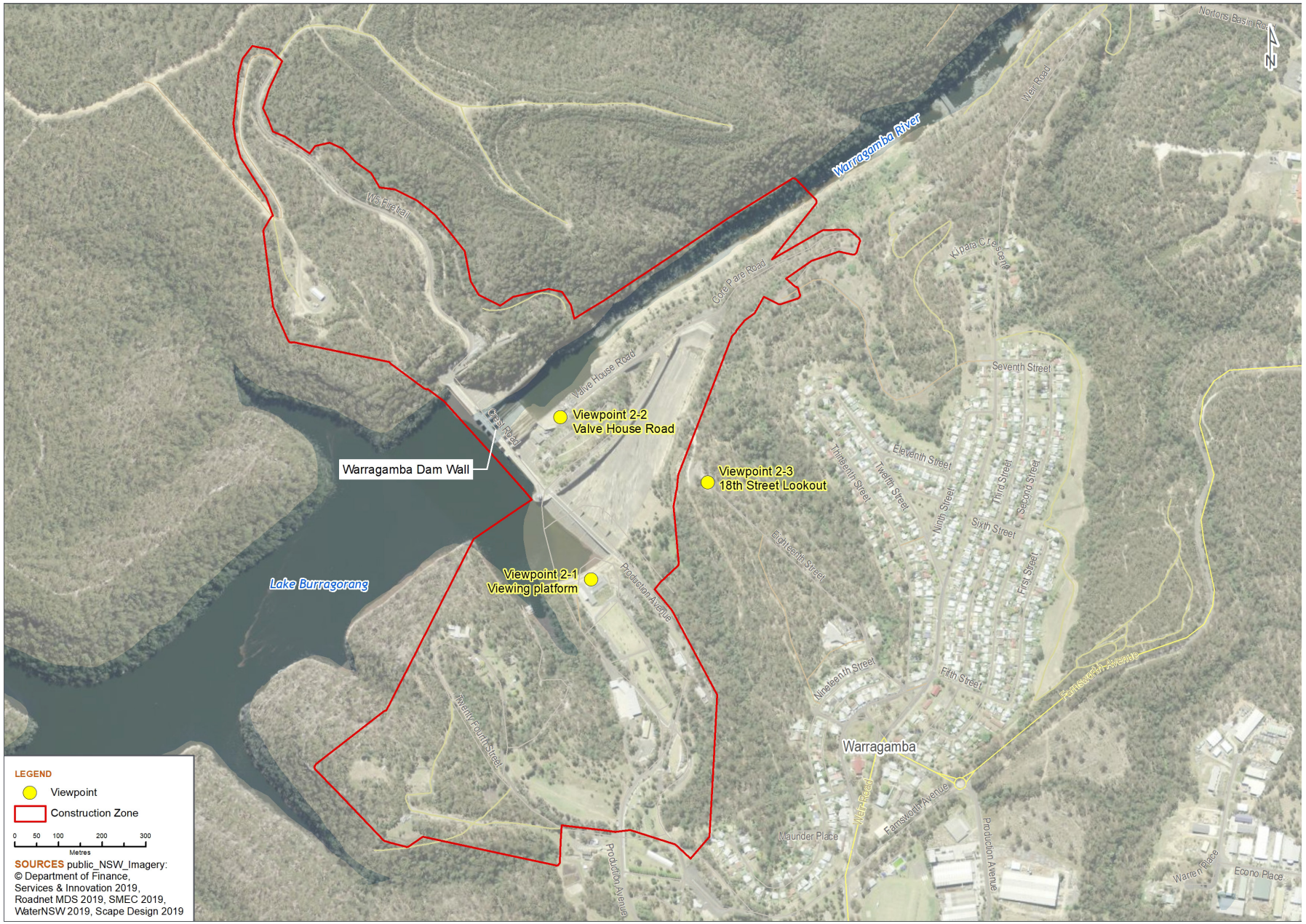


Figure 5-25: Construction zone viewpoint locations (SMEC)

# 5. Impact assessment

## Viewpoint 2-1

### *Location and description*

This viewpoint is located at the viewing platform on the cliff walkway, near the Warragamba Dam Visitors Centre (close to Production Avenue). The view comprises the 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, which links the Visitor centre with Production Avenue some 80 steps below.

### *Description of anticipated visible elements*

The 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, narrow gorge. Refer to **Figure 5-24 on page 51** for a view of the existing dam infrastructure.

### *Affected viewers:*

- Tourists in the Visitors Centre including the educational facilities and exhibition areas
- Dam operational staff working in offices located within the Operations and Visitor Information Centre.

### *Description of potential impacts*

The visual prominence of the new dam and auxiliary spillway infrastructure would substantially increase from this viewpoint as a result of 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. Refer to **Figure 5-25 on page 51** for a photomontage view of the raised dam wall.

The area of visible lake shoreline currently fluctuates depending on rainfall. Potential impacts as a result of 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, which reduces potential impacts. Refer to **Figure 5-22 on page 49** and **Figure 5-23 on page 50** for flood level mappings.

The impact of this viewpoint is summarised in **Table 5-11**. For mitigation measures relating to this view refer to **Section 6 on page 73** of this report.

Table 5-13: Visual impact summary VP2-1

| VP 2-1 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 5 chance in a year flood level | | | |
| Project | Moderate<br>– Local and international tourists visiting the scenic lookout, which has panoramic views out across the dam infrastructure, upstream environment and natural bushland<br>– A substantial number of dam operational staff working at the visitors centre. | High<br>– Visual prominence of the raised dam wall and associated infrastructure would increase as a result of the Project<br>– Possible discernible impacts may be observed by the infrequent raising of the water levels in the upstream environment. | High-Moderate |

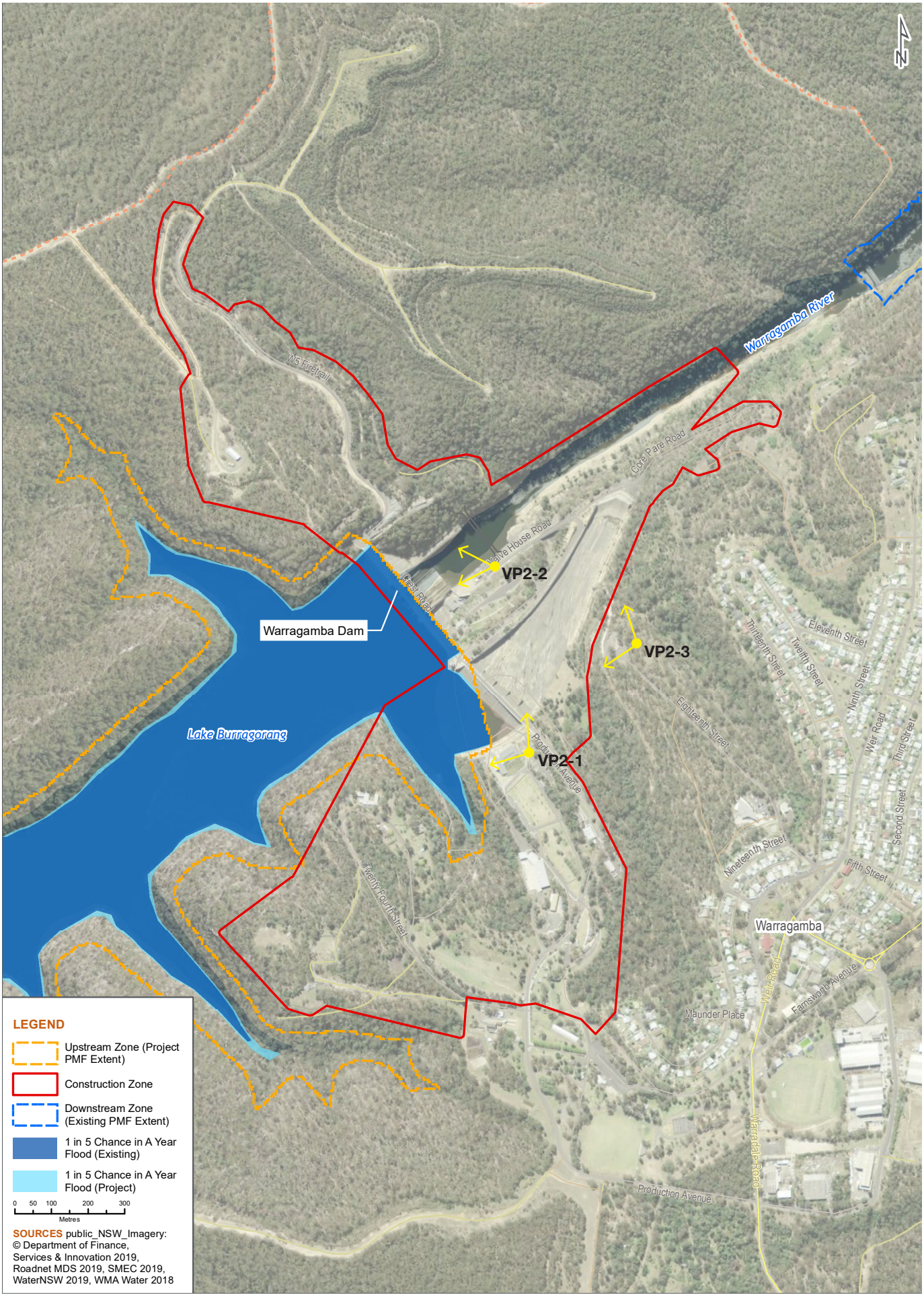


Figure 5-26: Construction zone showing 1 in 5 chance in a year flood levels (SMEC)

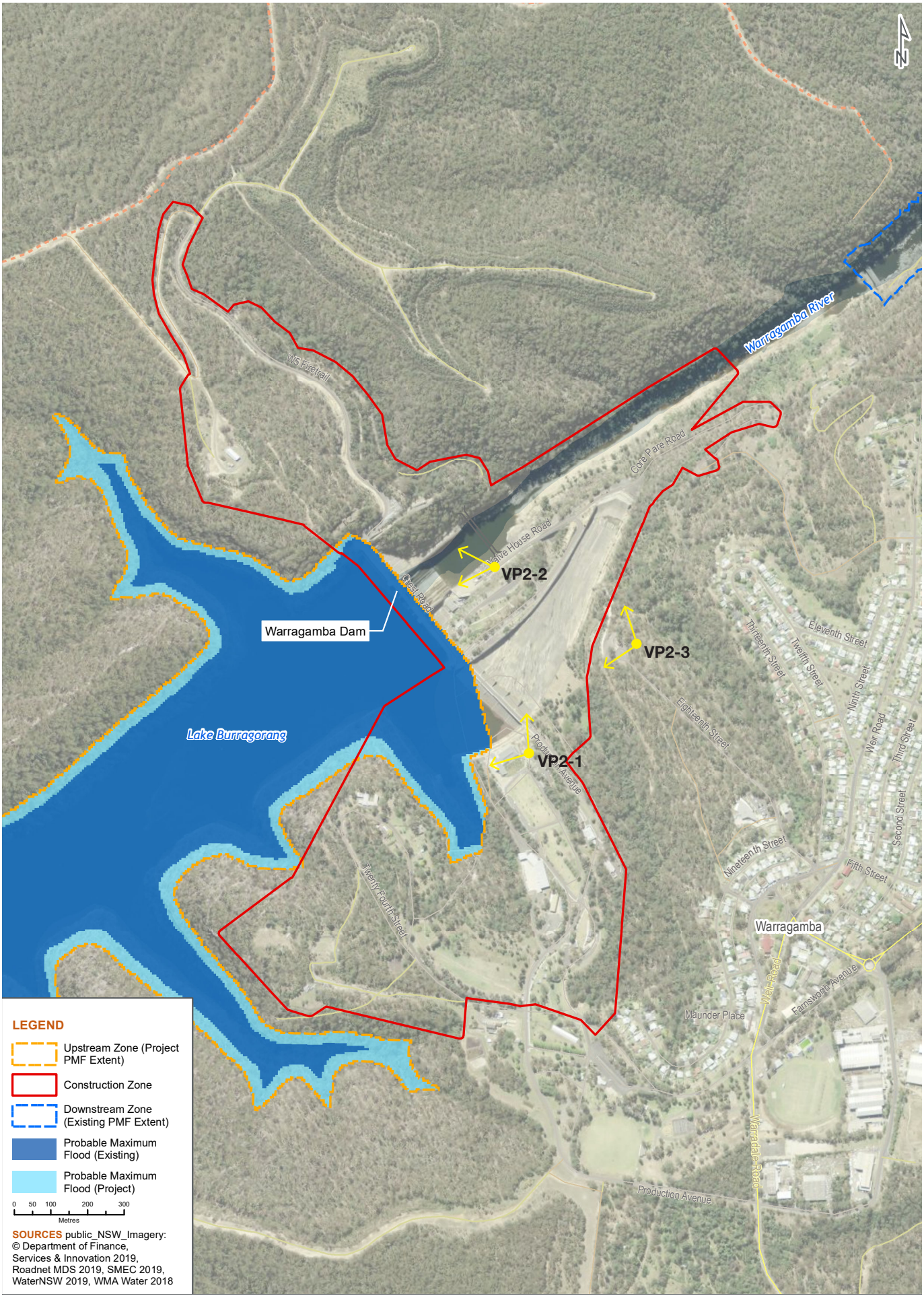


Figure 5-27: Construction zone showing PMF event levels (SMEC)


Figure 5-28: Viewpoint 2-1 - Existing view looking northwest over auxiliary spillway and bridge towards the dam wall


Figure 5-29: Viewpoint 2-1 - Photomontage view looking northwest over the upgraded auxiliary spillway and bridge towards the dam

| | |
|---|---|
| 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 |
| 1 in 20 | 118.6 m | 126.8 m |
| PMF (3 day) | 129.8 m | 142.5 m |

Table 5-14: Changes to temporary inundation levels at dam wall (SMEC)

# 5. Impact assessment

## Viewpoint 2-2

### *Location and description*

This viewpoint is situated on the lower terrace, located on Valve House Road approximately 150 metres downstream of the wall. The dam wall and associated infrastructure are the distinct features at this location and their massive scale dominates the view. Several individual trees are also visible in the foreground and obscure some features of the dam wall. Secondary to the built form in this view is an expanse of sky and a smaller portion of dense bushland vegetation in the middle distance.

The downstream face of the wall, which is symmetrical about the central drum gate also features two simply detailed lift towers (with one blocked by foreground tree), which are original and were retained as existing during the previous 1980s raising of the crest. The visible concrete tower is simply finished and features rectangular windows at the top and are surmounted by typical stepped fascia detail and flat roof. 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).

Refer to **Figure 5-26 on page 53** for view of the existing dam wall.

### *Description of anticipated visible elements*

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 as result of 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. Refer to **Figure 5-27 on page 53** for a photomontage view of the raised dam wall.

### *Affected viewers:*

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

### *Description of potential impacts*

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 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 visual impact of this viewpoints is summarised in **Table 5-13**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-15: Visual impact summary VP2-2

| VP 2-2 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 5 and 1 in 20 chance in a year event levels | | | |
| Project | Moderate<br>– Local and international tourists visiting the scenic lookout, which has immediate views of the dam wall and associated infrastructure<br>– Dam operational staff working on site. | High<br>– The scale and size of the raised dam wall and associated infrastructure would substantially increase and the proportion of visible sky and existing bushland would decrease | High-Moderate |


Figure 5-30: Viewpoint 2-2 - Existing view looking north-west to the dam wall


Figure 5-31: Viewpoint 2-2 - Photomontage view of the raised dam wall from the lower terrace

# 5. Impact assessment

## Viewpoint 2-3

### *Location and description*

This viewpoint is located approximately 300 metres north-east of the Warragamba Dam Visitors Centre at the Eighteenth Street Lookout and provides a panoramic view across the auxiliary spillway and a longer range view of the Warragamba Dam wall.

The lookout was built during the closure of Haviland Park, so that public could still view the dam and auxiliary spillway construction. 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.

The viewing platform was closed in late 2016 to allow for the removal of the hazardous materials and the remediation of the surrounding site and was re-opened in early 2018. During this period the viewing platform was also refurbished in recognition of the popularity of this community asset. Refer to **Figure 5-28 on page 55** for view of the existing dam wall.

### *Description of anticipated visible elements*

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 located 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. Refer to **Figure 5-29 on page 55** for a photomontage view of the raised dam wall.

### *Affected viewers:*

- Tourists and local residents visiting the viewing platform.

### *Description of potential impacts*

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 visual impact of this viewpoints is summarised in **Table 5-14**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-16: Visual impact summary VP2-3

| VP 2-3 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 5 and 1 in 20 chance in a year event levels | | | |
| Project | Moderate<br>– Local and international tourists are typically considered as having high sensitivity, however this scenic lookout is visited specifically to view the dam and associated infrastructure so the sensitivity is considered moderate | High<br>– 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 | High-Moderate |

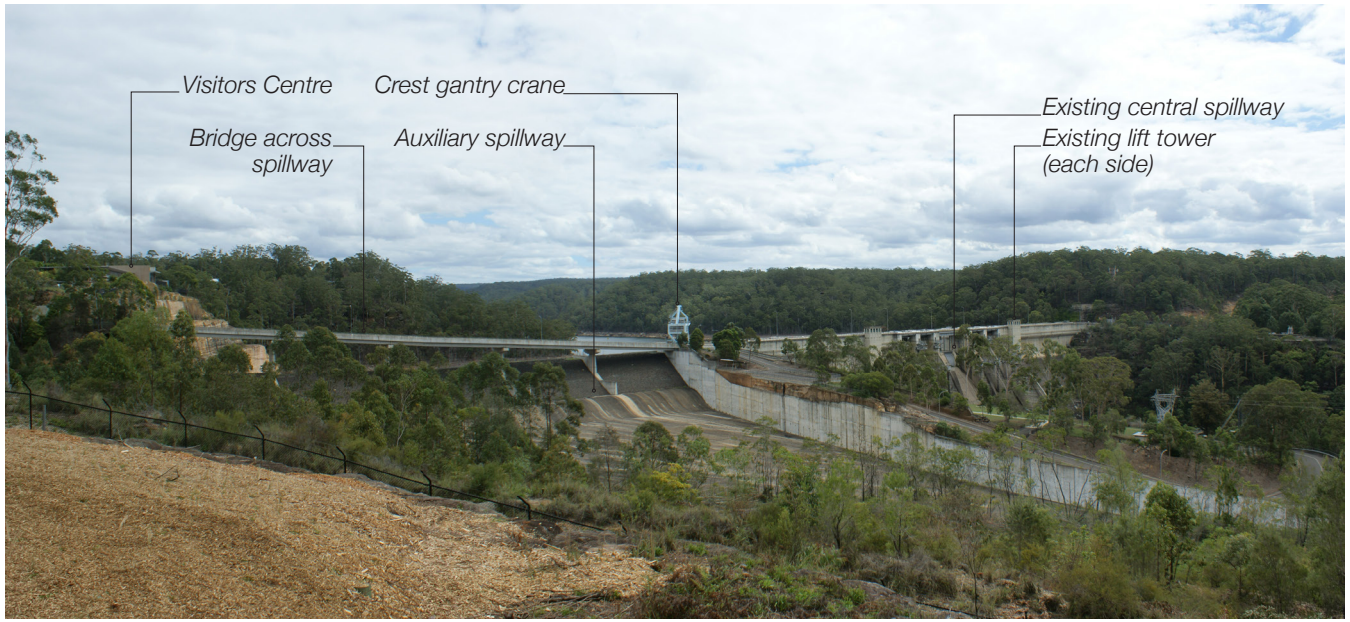


Figure 5-32: Viewpoint 2-3 - Existing north-west view from the 18th Street Lookout


Figure 5-33: Viewpoint 2-3 - Photomontage 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 |
| 1 in 20 | 118.6 m | 126.8 m |
| PMF (3 day) | 129.8 m | 142.5 m |

Table 5-17: Changes to temporary inundation levels at dam wall (SMEC)

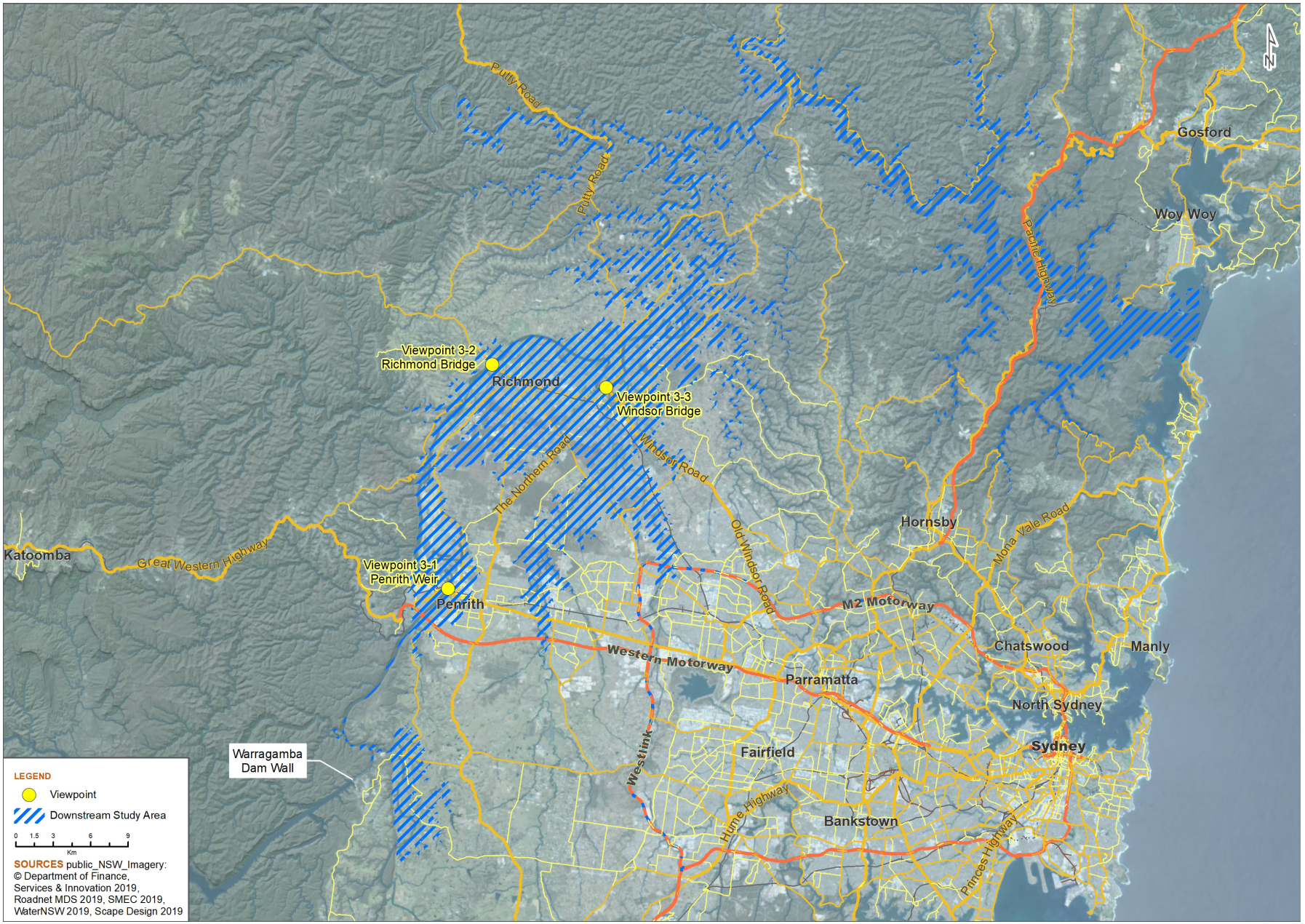


Figure 5-34: Downstream zone viewpoint locations (SMEC)

# 5. Impact assessment

## Viewpoint 3-1

### *Location and description*

This viewpoint is located approximately 22 kilometres downstream of Warragamba Dam on the banks of the Nepean River at the Penrith Weir.

Built in 1908, the weir is historically significant and representative of a concrete buttressed cantilever wall. It raises the water level of the river 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 viewpoint enhancing the tree lined river edge and is locally valued as a scenic and recreational asset.

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 features picnic tables, barbecues, sporting field, toilets, Gazebo and Japanese Pavilion available for birthday and wedding functions, which expands it's local visitation and broadens the viewer types. As well, The Great River Walk passes through the Reserve and is a picturesque section of the larger walk, which would cover 570 kilometres, linking the river's mouth at Broken Bay to its headwaters at Lake Bathurst, south of Goulburn bringing a range of regional viewer types to this vicinity.

Less than five kilometres downstream from the Weir is Penrith Lakes, 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. Refer **Figure 5-35 on page 61**.

### *Description of anticipated visible elements*

Although the downstream zone would experience reductions in the extent of flooding during an event, it is unlikely that the changes would be perceptible to viewers due to the infrequency of flood events 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.

Refer **Figure 5-31 on page 58** and **Figure 5-32 on page 59** for downstream flooding extent maps and **Figure 5-33** and **Figure 5-34 on page 60** for oblique aerial views.

### *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.

### *Description of potential 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 of this viewpoints is summarised in **Table 5-16 on page 61**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

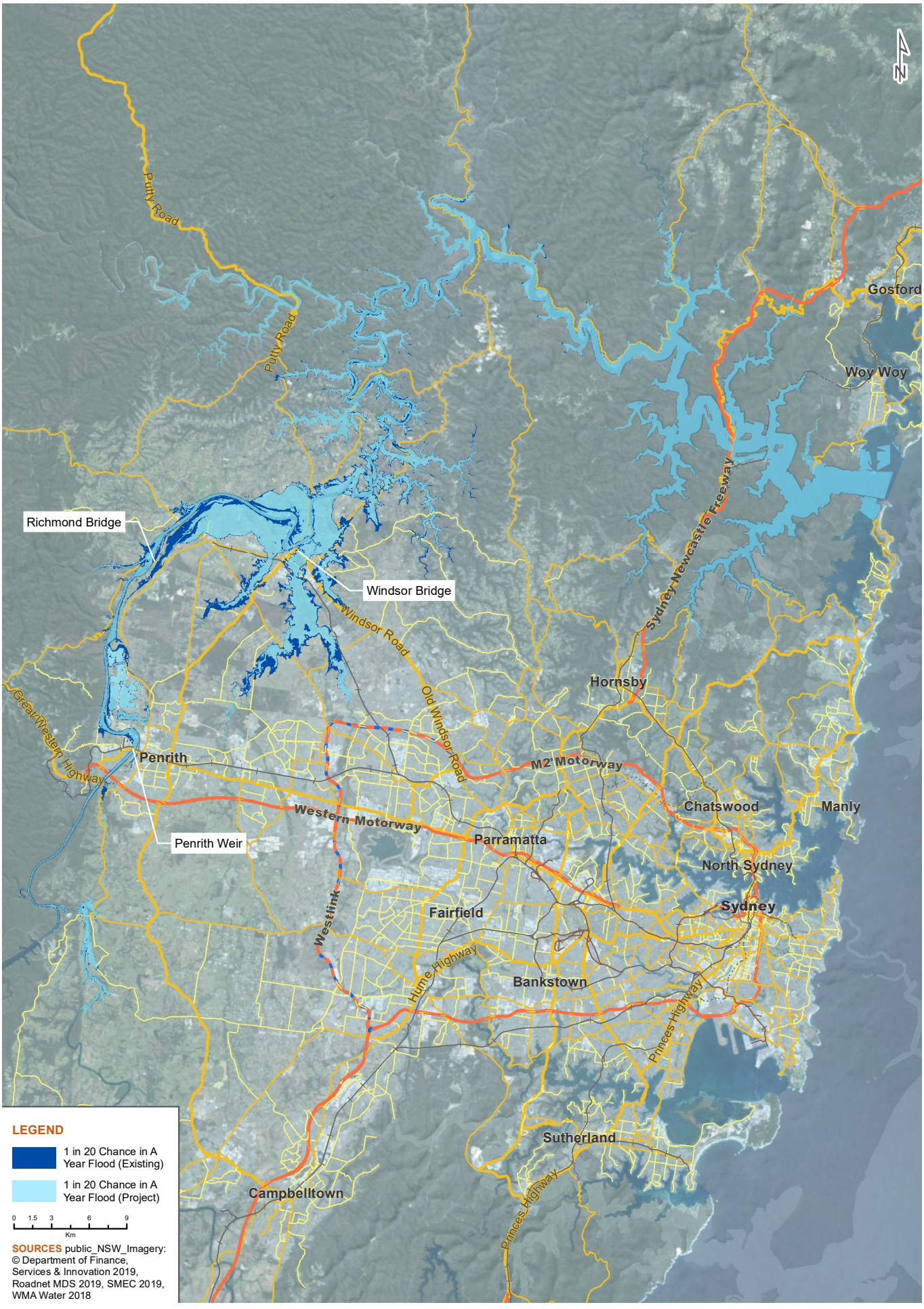


Figure 5-35: Downstream zone 1 in 20 chance in a year flood levels (SMEC)

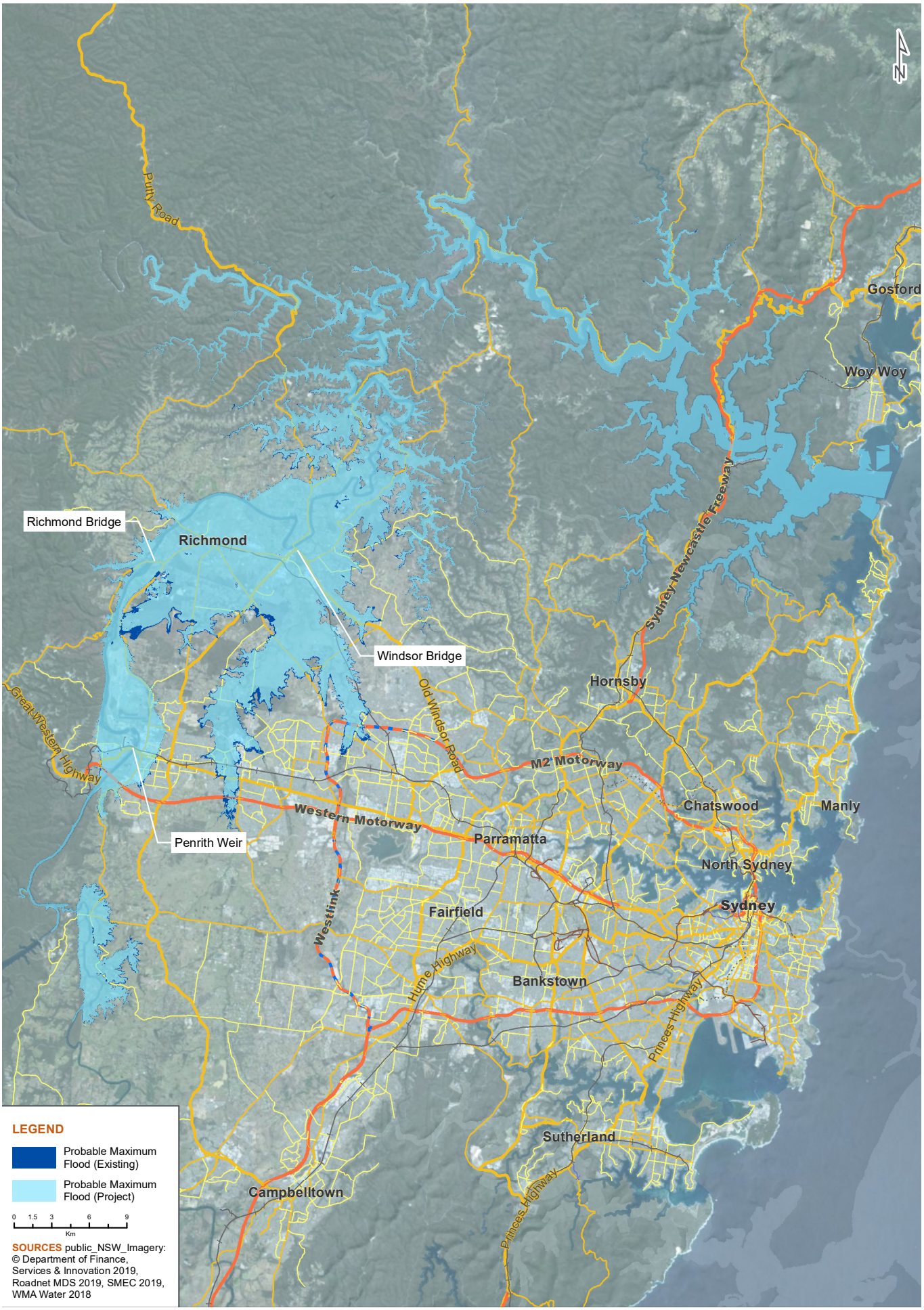


Figure 5-36: Downstream zone PMF event levels (SMEC)

# 5. Impact assessment

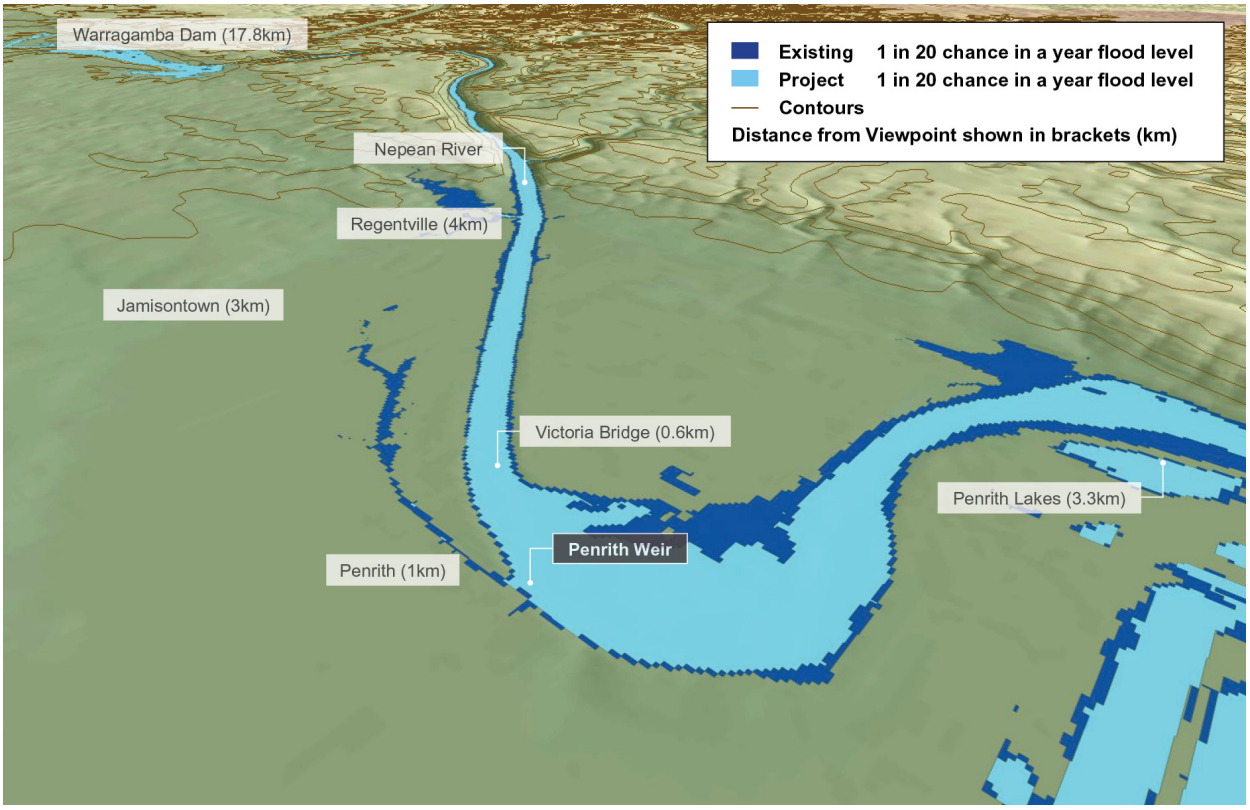


Figure 5-37: Oblique aerial view at Penrith Weir showing 1 in 20 chance in a year flood levels (SMEC)

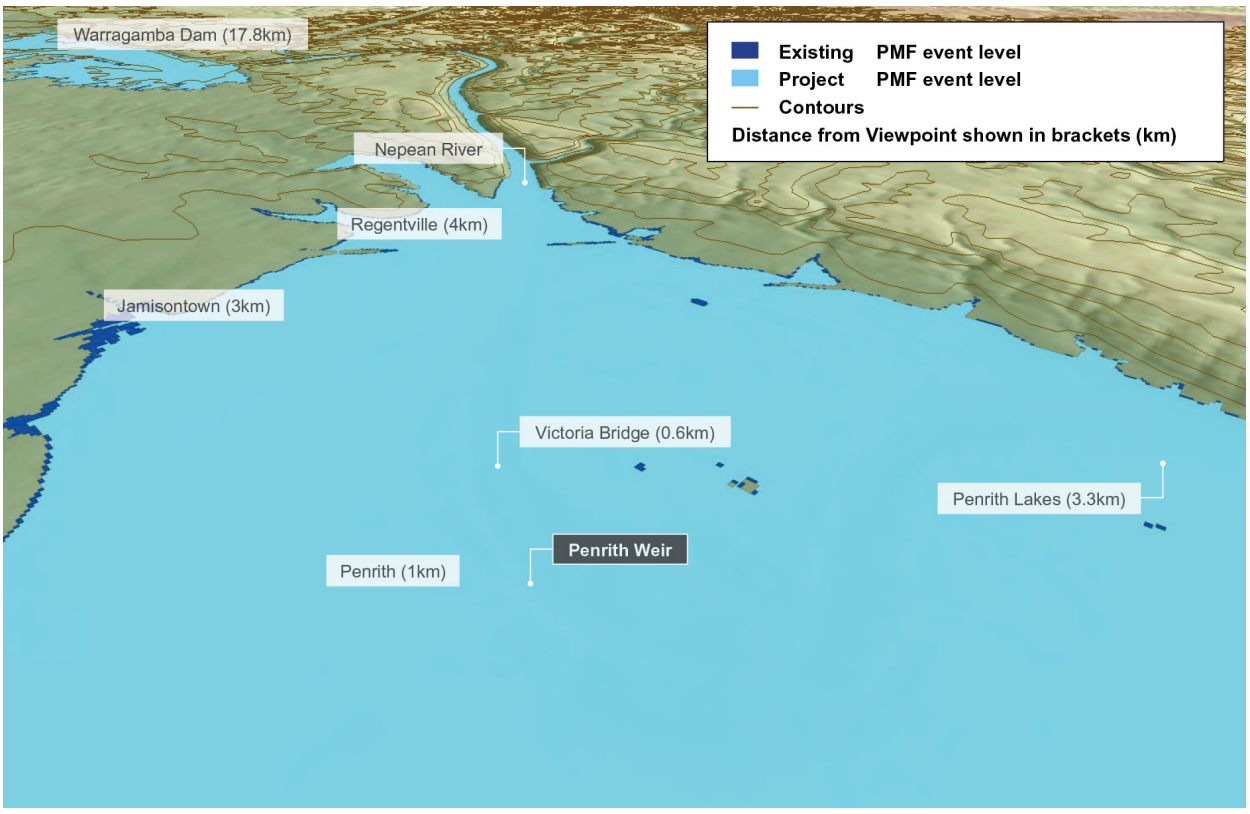


Figure 5-38: Oblique aerial view at Penrith Weir showing PMF event levels (SMEC)

# 5. Impact assessment

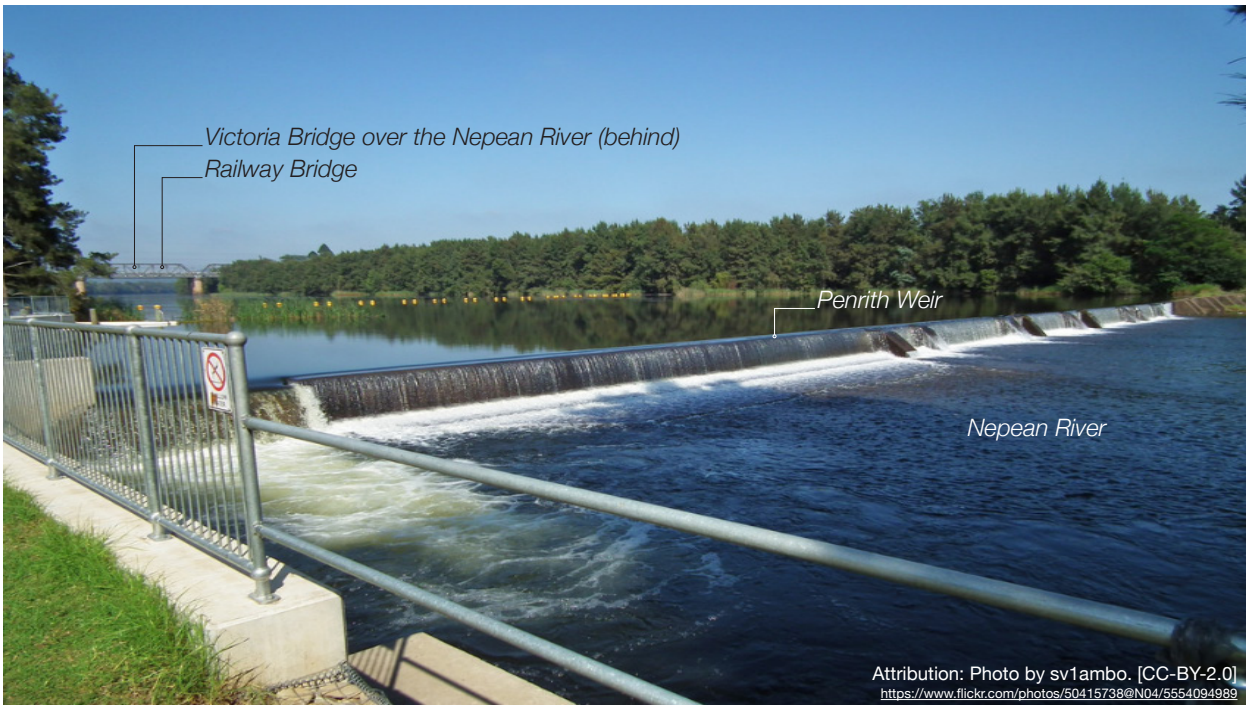


Figure 5-39: Viewpoint 3-1 Looking upstream along the Nepean River north towards the railway bridge

Table 5-18: Visual impact summary VP3-1

| VP 3-1 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 20 chance in a year event levels | | | |
| Existing | High<br>– Local and tourists visiting the scenic river, park reserve historic weir and bridges | High<br>– Increased water levels as a result of a 1 in 20 year flood event have a substantial impact | High |
| Project | High<br>– As above | Low<br>– Post Project a major rainfall event would still result in flooding downstream albeit to a lesser extent than the existing situation | Moderate |
| PMF event level | | | |
| Existing | High<br>– As above | High<br>– Water levels and flows at this location increase substantially during PMF event, which typically result in extensive flooding and property damage | High |
| Project | High<br>– As above | Moderate<br>– Although unlikely to be perceivable during a PMF event, post Project peak flood levels would reduce leading to a reduction in the visual impact of flood levels | High-Moderate |

# 5. Impact assessment

## Viewpoint 3-2

### *Location and description*

This viewpoint is located approximately 44 kilometres downstream from the Warragamba Dam Visitor Centre on the Richmond Bridge.

The bridge was built in 1905 to cross the Hawkesbury River. It was widened on the downstream side for a railway track in 1927 and this was converted to road deck in 1966. The carriageway between kerbs is 8.53 metres wide and carries two traffic lanes. There is a footway on the upstream side and an 800 millimetre water main attached to the downstream side.

The viewpoint has expansive views through simple pedestrian safety fences out across the Hawkesbury River to the densely vegetated woodland and forested banks. Nestled behind the western bank is Hanna Park and the North Richmond Playground, which are popular riverside locations to enjoy walks, fish or canoe and kayak. Hanna Park is regularly used for picnics as it has shelters, electric barbecues and public toilets and is in demand for events such as cricket and football games, Christmas Carols and weddings. Refer **Figure 5-36**.

### *Description of anticipated visible elements*

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 (i.e. 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.

Refer **Figure 5-31 on page 58** and **Figure 5-32 on page 59** for downstream flooding extent maps and **Figure 5-37** and **Figure 5-38 on page 63** for oblique aerial views.

### *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.

### *Description of potential 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.

Hydraulic modelling has indicated that should the dam wall be raised, flood levels would be reduced. Consequently, this would reduce the visual impacts.

The visual impact of this viewpoints is summarised in **Table 5-17 on page 64**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.


Figure 5-40: Viewpoint 3-2 Looking upstream from the Richmond Bridge Image capture: May 2017 © 2020 Google

# 5. Impact assessment

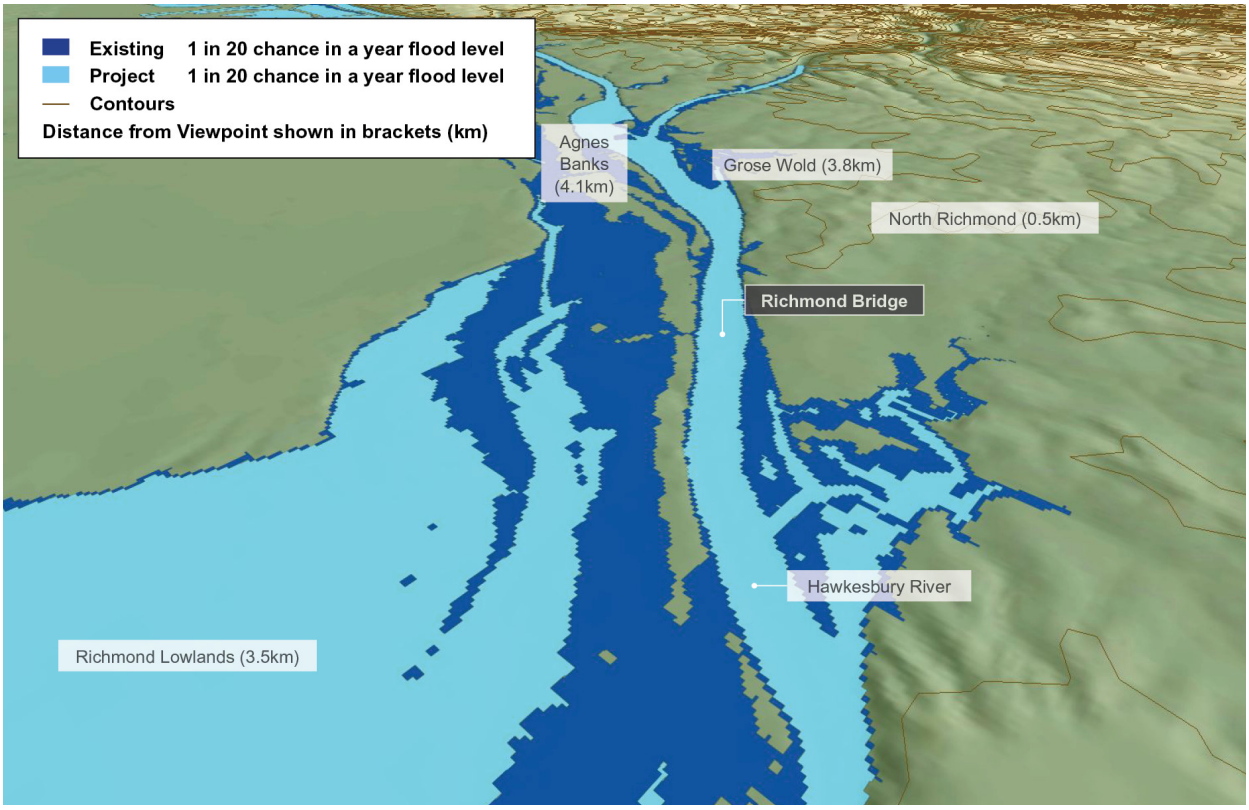


Figure 5-41: Oblique aerial view at Richmond Bridge showing 1 in 20 chance in a year flood levels (SMEC)

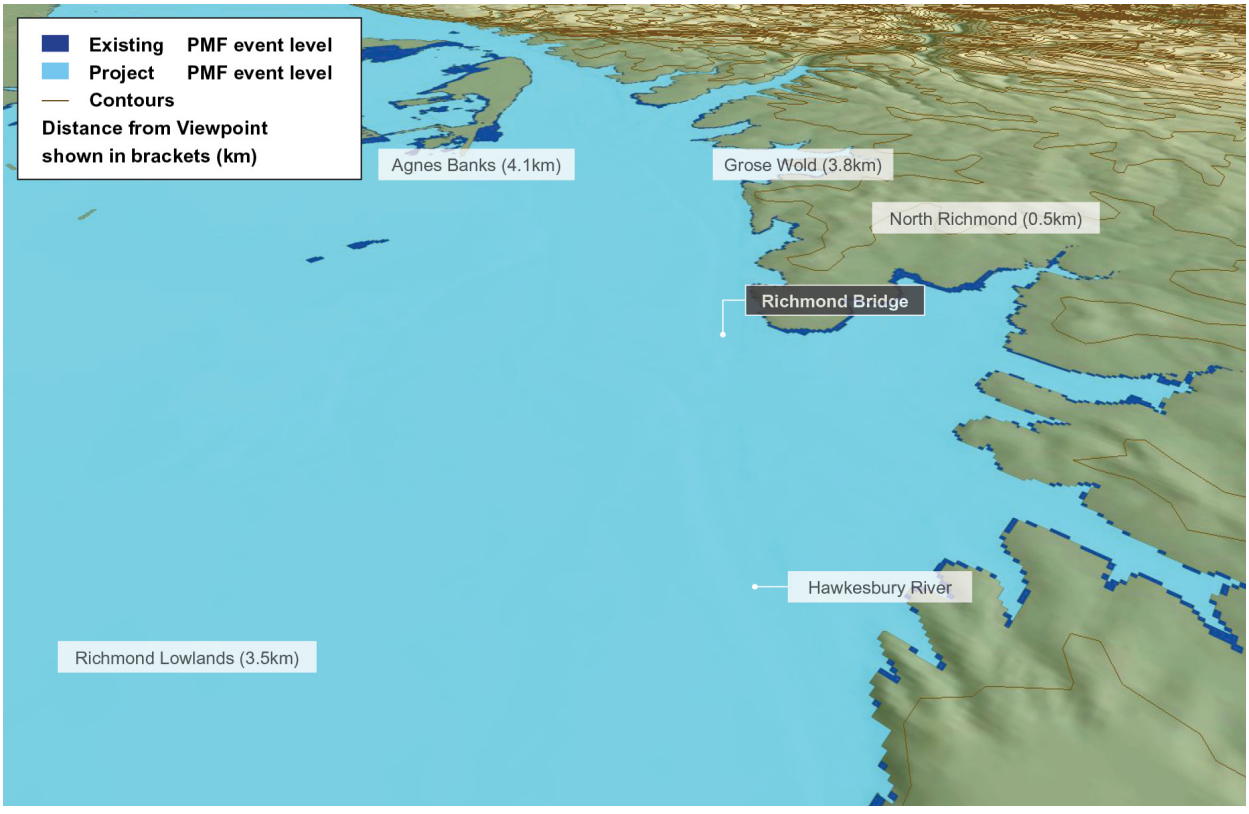


Figure 5-42: Oblique aerial view at Richmond Bridge showing PMF event levels (SMEC)

# 5. Impact assessment

Table 5-19: Visual impact summary VP3-2

| VP3-2 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 20 chance in a year flood event levels | | | |
| Existing | High<br>– Motorists, cyclists and pedestrians are transitory and would only experience changes in the water levels of the river for brief periods<br>– Recreational river based activities are unlikely to occur during even minor flood events<br>– Locals and tourists using the park facilities would have intermittent views of the river through existing forested river banks. | High<br>– Increased water levels as a result of a 1 in 20 year flood event have a substantial impact | High |
| Project | High<br>– As above | Low<br>– A flood event would likely still result in flooding downstream, however, hydraulic modelling has indicated this would be to a lesser extent than the existing situation | Moderate |
| PMF event levels | | | |
| Existing | High<br>– As above | High<br>– Water levels and flows at this location increase substantially during PMF event, which typically result in extensive flooding and property damage | High |
| Project | High<br>– As above | Moderate<br>– Although unlikely to be perceivable during a PMF event, post Project peak flood levels would reduce, leading to a reduction in the visual impact of flood levels | High-Moderate |

# 5. Impact assessment

## Viewpoint 3-3

### *Location and description*

This viewpoint is located approximately 60 kilometres downstream of the Warragamba Dam Visitor Centre on the Windsor Bridge.

Windsor Bridge is the oldest surviving crossing still in use over the Hawkesbury River. It was opened in 1874 and consists of a timber deck and cast iron piers. The bridge is 143 metres long and 6.1 metres wide. A pedestrian footway was constructed in 1968 is made of removable concrete slabs and steel bracing with ducting for utilities (telephone cables, a water main and an electrical conduit) fixed to the underside of the footpath.

The viewpoint comprises views across simple pedestrian safety fences (with mesh infill) out towards steep river banks. Although the area is characterised by a wide flat floodplains of mostly pasture grasses, at this location the township of Windsor sits above a ridge on the southern river bank. Trees associated with parks and open spaces mostly screen views of the town.

Recreational river based activities including water skiing, wake boarding, river cruises, house boats, 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. Refer **Figure 5-39**.

### *Description of anticipated visible elements*

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 (i.e. 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.

Refer to **Figure 5-31 on page 58** and **Figure 5-32 on page 59** for downstream flooding extent maps and **Figure 5-40** and **Figure 5-41 on page 66** for oblique aerial views.

### *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.

### *Description of potential impacts*

At this location minor flood events (1 in 20 flood) would have an impact on the recreational areas directly abutting the waterway, however during major flood events (PMF) there would be a substantially higher degree of flooding out across the floodplain and even into the township of Windsor, inundating large floodplains between the eastern bank of the Hawkesbury River at Windsor Bridge and the township of Windsor.

Hydraulic modelling has indicated that should the dam wall be raised, flood levels would be reduced. Consequently, this would reduce the visual impacts.

The visual impact of this viewpoints is summarised in **Table 5-18 on page 67**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.


Figure 5-43: Viewpoint 3-3 Looking downstream from the Windsor Bridge Image capture: Feb 2017 © 2020 Google

# 5. Impact assessment

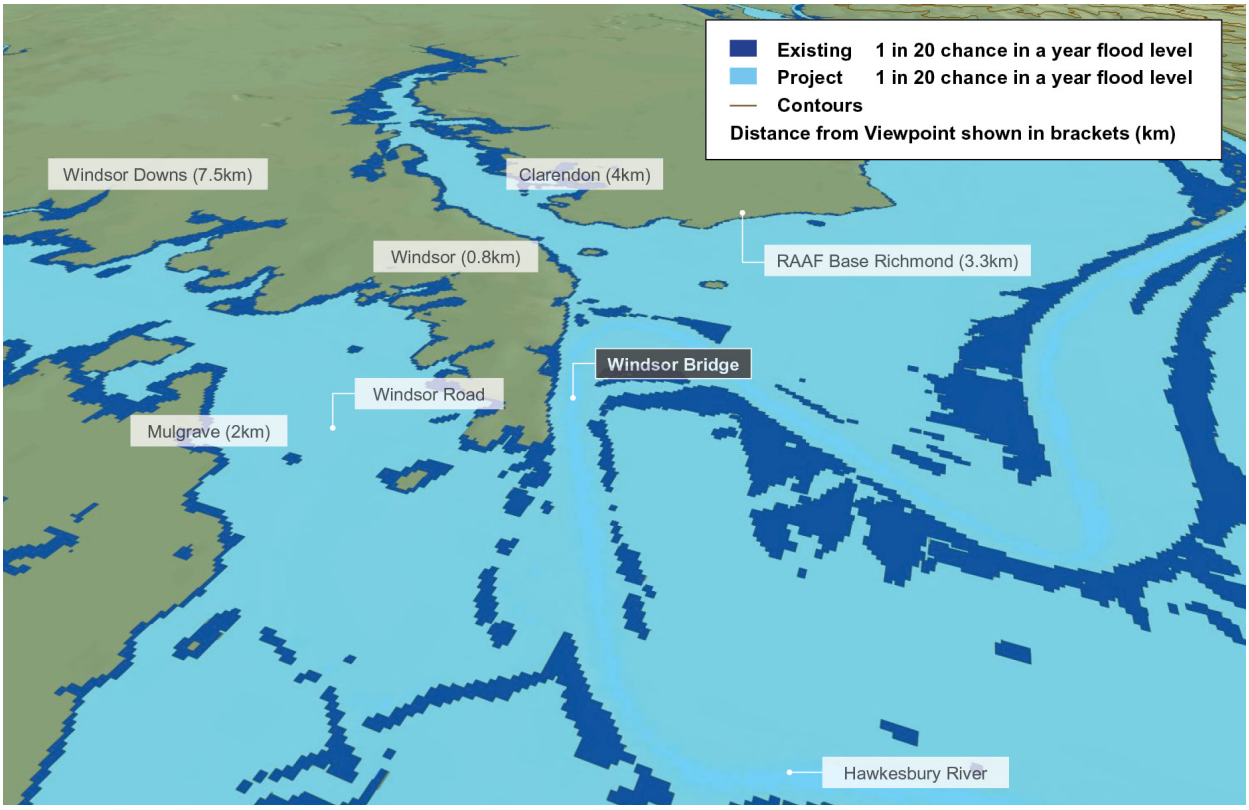


Figure 5-44: Oblique aerial view at Windsor Bridge showing 1 in 20 chance in a year flood levels (SMEC)

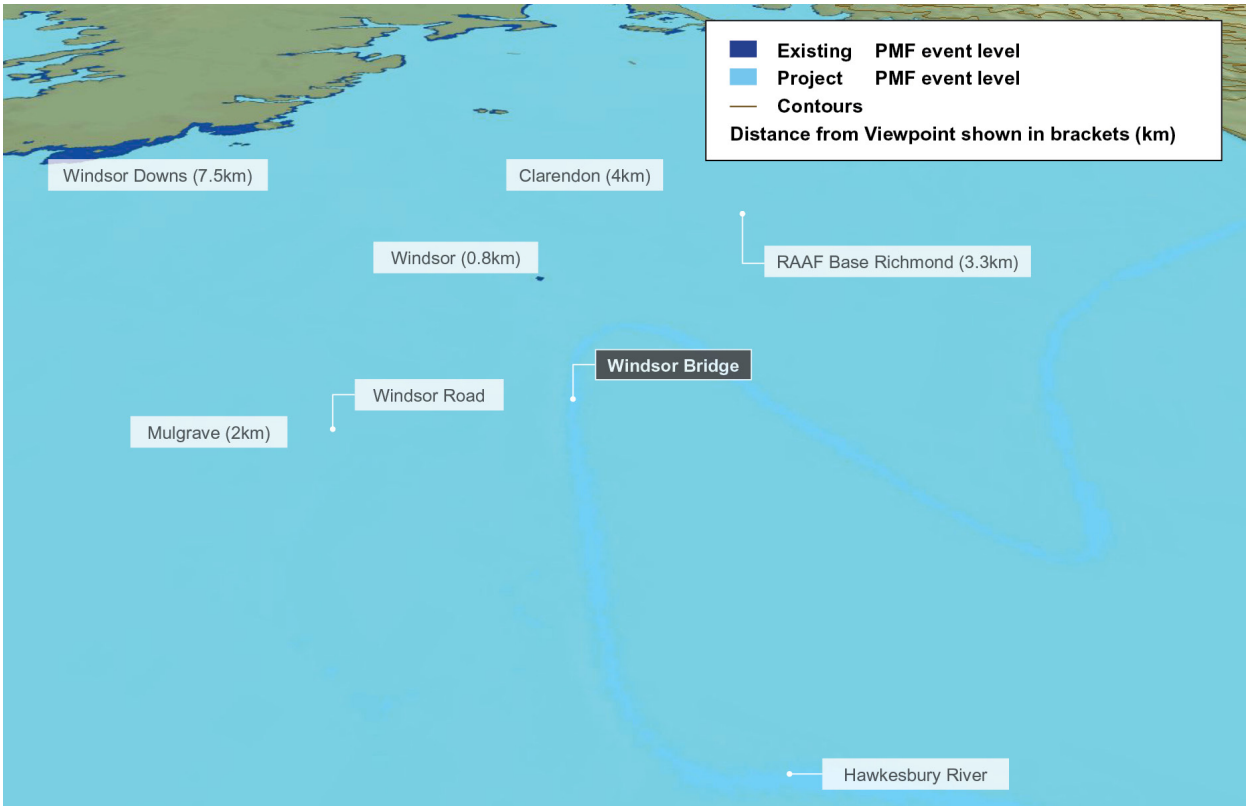


Figure 5-45: Oblique aerial view at Windsor Bridge showing PMF event levels (SMEC)

# 5. Impact assessment

Table 5-20: Visual impact summary VP3-3

| VP3-3 | Sensitivity | Magnitude | Impact |
|---|---|---|---|
| 1 in 20 chance in a year event levels | | | |
| Existing | High<br>– Motorists, cyclists and pedestrians are transitory and would generally only experience changes in the water levels of the river for brief periods<br>– Recreational river based activities are unlikely to occur during even minor flood events<br>– Local and tourists using the park and open space facilities would have clear views of the river. | Moderate<br>– Increased water levels as a result of a 1 in 20 chance in a year flood event have a substantial impact | High-Moderate |
| Project | High<br>– As above | Low<br>– Post Project a 1 in 20 chance in a year flood event would still result in flooding downstream albeit to a lesser extent than the existing situation | Moderate |
| PMF event levels | | | |
| Existing | High<br>– As above | High<br>– Water levels and flows at this location increase substantially during PMF event, which typically result in extensive flooding and property damage | High |
| Project | High<br>– As above | Moderate<br>– Although unlikely to be perceivable during a PMF event, post Project peak flood levels would reduce, leading to a reduction in the visual impact of flood levels | High-Moderate |

# 5. Impact assessment

## 5.2.2 Visual assessment summary

Of the eight viewpoints assessed for the Project, the visual analysis identified that impacts could be demonstrated at all viewpoint locations. The impacts range from high-moderate to moderate largely due to the sensitivity of the viewers to reduced flood impacts due to improvements to flood management.

The high sensitivity of tourists and recreational visitors in the upstream zone is offset by the distance of these viewers from future impact areas. The steep, densely vegetated intervening terrain results in a moderate level of impact for 1 in 5 and 1 in 20 chance in a year events. In terms of PMF events, these are considered to be very rare and unlikely and if they occurred would have the shortest duration of damaging flood waters. Long term impacts of vegetation above the flood mitigation zone are unknown and would be subject to further assessment when these events occur. For the purpose of this assessment however, the total area of flood water during PMF events was assessed for the period of time that viewers are likely to be visiting the popular vantage points and was given a High-Moderate rating.

The visual prominence of the raised dam wall and associated infrastructure from viewpoints located close to it, would increase, however, the dam is considered to be a regionally significant landmark and demonstrates a nationally important built/engineering achievement. As a result of the raising, it is likely that the engineering significance of the wall would continue and/ or be increased so although the magnitude of change is almost always high it is not considered to be a negative when viewers arrive at the site to look an important piece of dam infrastructure.

During a flood event, viewpoints located in the downstream zone are still expected to be impacted after the dam wall raising. However, after the raising of the dam wall flood extents (and flows) as well as flood damage would be reduced and consequently the impacts would reduce at each of these viewpoints.

The visual impact of the Project across the viewpoints in the study area is summarised in **Table 5-19**. For mitigation measures relating to these views refer to **Section 6 on page 73** of this report.

Table 5-21: Viewpoint assessment summary

| VP | Location | | Sensitivity | Magnitude | Impact |
|---|---|---|---|---|---|
| **Upstream zone with Project** | | | | | |
| 1-1 | Echo Point Lookout, Katoomba | 1 in 5 chance in a year event | High | Low | **Moderate** |
| | | Upstream impact area | High | Low | **Moderate** |
| | | PMF event | High | High | **High** |
| 1-2 | Burragorang Lookout, Nattai | 1 in 5 chance in a year event | High | Low | **Moderate** |
| | | **Upstream** impact area | High | Low | **Moderate** |
| | | PMF event | High | High | **High** |
| **Construction zone with Project** | | | | | |
| 2-1 | Viewing Platform, Warragamba Visitors Centre | | Moderate | High | **High-Moderate** |
| 2-2 | Valve House Road, Warragamba Dam | | Moderate | High | **High-Moderate** |
| 2-3 | 18th Street Lookout, Warragamba | | Moderate | High | **High-Moderate** |
| **Downstream zone with Project** | | | | | |
| 3-1 | Penrith Weir, Penrith | 1 in 20 chance in a year event | High | Low | **Moderate** |
| | | PMF event | High | Moderate | **High-Moderate** |
| 3-2 | Windsor Bridge, Windsor | 1 in 20 chance in a year event | High | Low | **Moderate** |
| | | PMF event | High | Moderate | **High-Moderate** |
| 3-3 | Richmond Bridge, Richmond | 1 in 20 chance in a year event | High | Low | **Moderate** |
| | | PMF event | High | Moderate | **High-Moderate** |

# 5. Impact assessment

## 5.3 Impacts during construction

A preliminary construction program is presented in **Table 5-20 on page 70**. The Project is likely 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.

At the time of writing this report, it has not been possible to determine the exact method of construction and range of equipment that the contractor would use so general assumptions have been made.

Initially, the construction activities would impact the construction zone in the vicinity of the dam wall area then after construction the operational phase of the Project would likely impact the upstream and downstream zones.

This section describes the proposed general approach to construction. If the Project is approved, further detailed construction planning would take place prior to commencement to inform a Construction Environmental Management Plan (CEMP). This plan would consider methods and the scheduling of activities to minimise impacts on the community and the environment such as noise, access and amenity, and would detail mitigation and management measures.

### 5.3.1 Access to Warragamba Dam during construction

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 this report, a general assumption has been made that viewpoints located within the construction zone would be closed from the early works phase through to site restoration.

### 5.3.2 Construction impact footprint

The proposed construction zone is shown in **Figure 5-42 on page 70**. This area may be refined as part of detailed design and construction planning. This includes:

- areas directly impacted by construction
- areas where access for construction is required
- concrete batch plants and material storage and handling areas
- offices and worker amenities
- visitors and education centre
- other ancillary sites.

Refer to **Section 3 on page 14 for** details regarding construction areas and methods.

### 5.3.3 Construction methodology

The Project has been divided into main stages and elements in the following sections to describe the construction methodology. The stages and elements described below include:

- Early works
- Enabling works and demolition
- Construction of concrete elements for thickening and widening the dam abutments, central spillway and modifications to the auxiliary spillway
- Thickening and raising dam abutments
- Thickening and raising of the central spillway
- Auxiliary spillway modifications
- Other Infrastructure and elements
- Environmental flows infrastructure
- Demobilisation and site restoration.

### 5.3.4 Potential impacts to viewpoints

All viewpoints were considered in terms of the possible impacts that could be experienced during the construction phases:

- Viewpoint 1-1 - No views of construction phase
- Viewpoint 1-2 - No views of construction phase
- Viewpoint 2-1 - Viewpoint inaccessible during construction
- Viewpoint 2-2 - Viewpoint inaccessible during construction
- Viewpoint 2-3 - Possible views of construction phase work from this viewpoint
- Viewpoint 3-1 - No views of construction phase
- Viewpoint 3-2 - No views of construction phase
- Viewpoint 3-3 - No views of construction phase

Of the eight viewpoints only three would potentially be affected by construction phase work and only one of these would remain open during construction. All three viewpoints have been assessed in order to demonstrate if the closure of a viewpoint itself could be an impact.

**Table 5-21 on page 71** summarises the assessment of these.

# 5. Impact assessment

Table 5-22: Preliminary construction program (SMEC)

| Activity (Project likely to be completed between four to five years from commencement) | Start month | Finish month |
|---|---|---|
| Early works | 01 | 12 |
| Enabling works and demolition | 05 | 33 |
| Construction of concrete elements for thickening and widening the dam abutments, central spillway and modifications to the auxiliary spillway | 05 | 55 |
| Other infrastructure elements | 05 | 39 |
| Environmental flows infrastructure | 05 | 23 |
| Demobilisation and site rehabilitation | 48 | 55 |

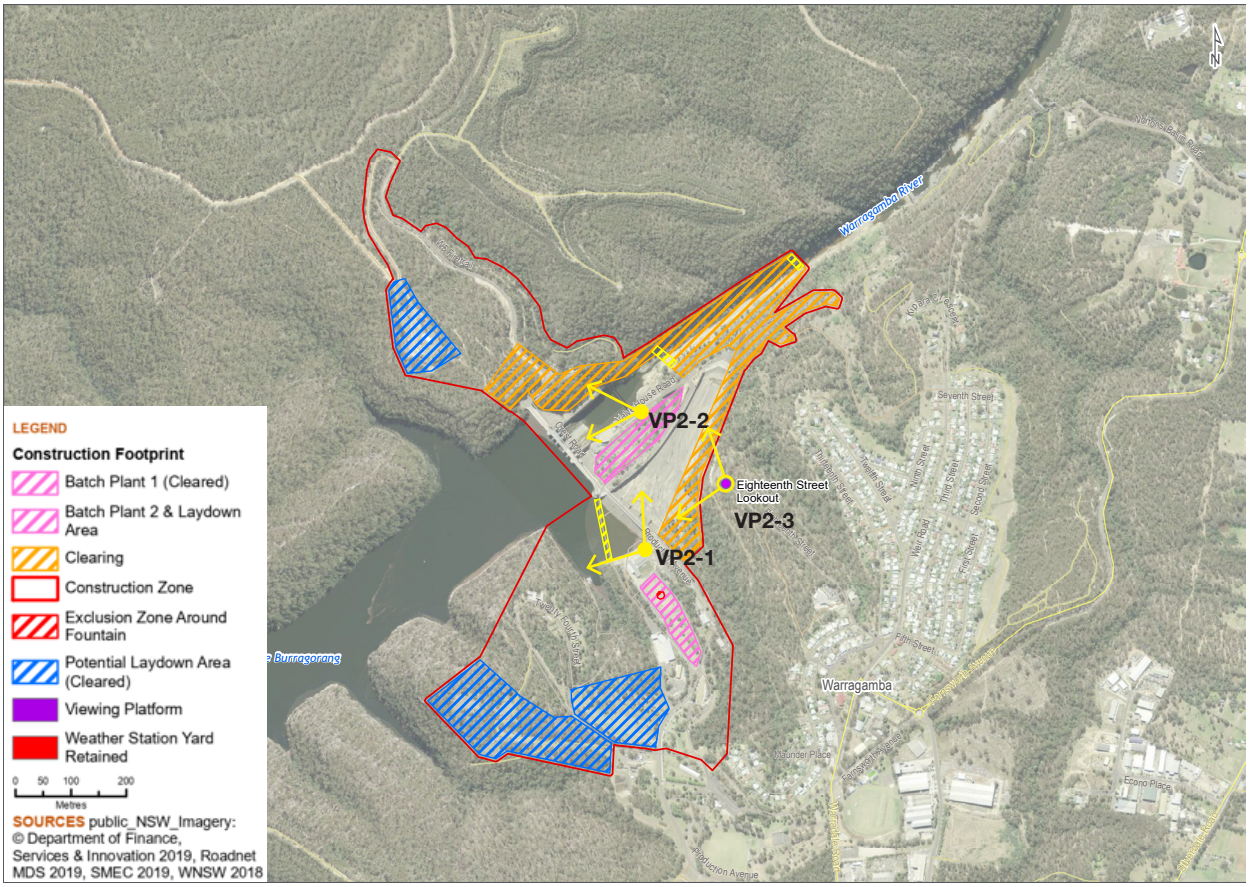


Figure 5-46: Construction zone impact footprint (SMEC)

# 5. Impact assessment

### 5.3.5 Visual impact summary

As seen in **Table 5-21**, the early works would have some impact on visual amenity. Of the eight viewpoints assessed, it is anticipated that three viewpoints located within the construction zone would be impacted either by the construction work or because the viewpoints would be inaccessible.

Upon the completion of the Project, it is assumed that contractors would be required to 'make good' all work areas prior to or at the end of the construction phase and the impact ratings are expected to reduce once construction machinery is removed from site and the area is restored.

Changes at the viewpoints after the construction phase would be seen within the context of an existing landscape, which is largely modified.

Table 5-23: Visual Impacts on viewpoints during construction

| Viewpoint 2-1 | | | |
|---|---|---|---|
| Phase | Sensitivity | Magnitude | Impact Rating |
| Early works | Low<br>– Some early works activities in and around the construction zone may be obvious from this location before it closes but these activities would be short term and intermittent | Low<br>– Once the security fencing is installed, public access to Haviland Park, the dam viewing platforms and walkways and visitor's centre would be closed, with road and pedestrian access terminated at the intersection of Production Avenue and Twenty Third Street | Low |
| Construction | Low<br>– This viewpoint would be inaccessible during construction so the sensitivity would be low | High<br>– The construction phase of the Project would see the viewing platform closed to visitors and create adverse amenity impacts | Moderate |

| Viewpoint 2-2 | Valve House Road, Warragamba Dam | | |
|---|---|---|---|
| Phase | Sensitivity | Magnitude | Impact Rating |
| Early Works | Low<br>– Some early works activities in and around the construction zone may be obvious from this location before it closes but these activities would be short term and intermittent | Low<br>– Once the security fencing is installed, public access to this viewpoint would be closed | Low |
| Construction | Low<br>– This viewpoint would be inaccessible during construction so the sensitivity would be low | High<br>– The construction phase of the Project would disrupt the operation of the road for visitors and create adverse amenity impacts | Moderate |

| Viewpoint 2-3 | 18th Street Lookout, Warragamba | | |
|---|---|---|---|
| Phase | Sensitivity | Magnitude | Impact Rating |
| Early Works | Moderate<br>– Some early works activities are likely to be visible although these would be at a distance of 300 metres or more. Other activities that may be more obvious in the foreground are:<br>• installation of security fencing and site environmental controls<br>• procuring of concrete batching facilities, cranes, conveyors and other infrastructure<br>• clearing of vegetation<br>• adjustment and provision of utilities for construction facilities. | Moderate<br>– This viewpoint would remain open and activities would be visible, creating adverse amenity impacts or interest to those that are interested in construction | Moderate |

# 5. Impact assessment

| Viewpoint 2-3 | 18th Street Lookout, Warragamba (cont.) | | |
|---|---|---|---|
| Phase | Sensitivity | Magnitude | Impact Rating |
| Enabling works and demolition | Moderate<br>– The following activities involved in this phase are likely to be visible:<br>• an existing access road from the bottom of the auxiliary spillway to base of the dam wall would be upgraded<br>• establishment of batching plants<br>• clearing and pruning of vegetation<br>• construction of coffer dams at multiple locations around the dam wall<br>• demolition of a number of existing structures and removal of machinery, pipes and operational equipment<br>• possibly some controlled blasting for excavations. | High<br>– This viewpoint would remain open and activities would be visible, creating adverse amenity impacts | High / Moderate |
| Construction | Moderate<br>– 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<br>– 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.<br>– Throughout this phase different construction machinery and building processes would be employed typical of the construction of a large infrastructure Project. | High / Moderate |

# 6. Mitigation measures

## 6.1 Overview

The management of the adverse landscape and visual impacts is usually addressed according to the hierarchy of avoidance, reduction and remedy throughout an iterative design process through the construction phases of the Project.

Further work is required to develop the detailed design into a final scheme and more opportunities to mitigate adverse impacts are likely to arise during this process and should be considered as they emerge. A summary of key mitigation measures that should be considered further in design development are discussed in **Table 6-1** below.

Table 6-1: Possible mitigation measures

| Zone | VP# | Impact rating pre-mitigation | Description of mitigation | Reason | Impact rating post mitigation |
|---|---|---|---|---|---|
| Upstream | VP1-1 | Moderate | – Areas of vegetation, which experience a loss or change in species composition would be assessed for rehabilitation in accordance with Environmental Management Plan required under section 64C of the Water NSW Act 2014 | – Restoring vegetation, which supports endangered species and stabilises soil would help mitigate upstream visual and character impacts depending on the extent of change and location of the viewer | Low |
| | VP1-2 | Moderate | | | Low |
| Upstream & Construction | VP2-1 | High / Moderate | – Promote public awareness that the site would be closed and provide signs to direct people to Eighteenth Street Lookout<br>– The clifftop walkway and dam wall pedestrian access would be reinstated to provide an enhanced visitor/ tourist experience and to continue to provide access to the raised dam crest. | – Maintaining and enhancing (where possible) the pedestrian experience of the dam wall area is important for the community and tourism at the site | Low |
| | VP2-2 | High / Moderate | – Promote public awareness that the site would be closed and provide signs to direct people to Eighteenth Street Lookout<br>– Ensure that a similar level of pedestrian amenity is reinstated after construction<br>– Enhance the quality of all public domain areas, which were closed for the duration of construction. | – The dam wall and immediate surrounds have education, recreation, tourism and historic values and minimising impacts ensures that the dam continues to be considered a landmark of regional significance, which demonstrates a significant built/ engineering achievement and continues to be used as an important public space | Moderate |
| | VP2-3 | Moderate | – The Project would not restrict public access to the Eighteenth Street Lookout<br>– Provide signage/ interpretation panels referencing the construction scope and construction program. | – The dam wall and immediate surrounds have tourism and historic values and ensuring that visitors in the area have a continued point of visual contact to the historic landmark during it's construction is important for the region | Low |
| Upstream & Downstream | VP3-1 (1 in 20 event) | Moderate | – Areas impacted by vegetation loss and surface scouring from the Project would be assessed for rehabilitation in accordance with Environmental Management Plan required under section 64C of the Water NSW Act 2014 | – Although downstream impacts as a result of the Project would be reduced, some areas would continue to be impacted during a flood event. The treatment of these areas should be considered in order to mitigate visual impacts | Low |
| | VP3-2 (1 in 20 event) | Moderate | | | Low |
| | VP3-3 (1 in 20 event) | Moderate | | | Low |

# 7. Conclusion

## Overview

The purpose of this report is to provide a landscape character and visual impact assessment to inform the preparation of the EIS.

The report provides an assessment of landscape and visual impacts associated with the Warragamba Dam Raising, which is a significant infrastructure Project about 65km west of the Sydney CBD. The Project has the potential to generate landscape character and visual impacts across each of the assessment zones within the study area.

This report represents a qualitative assessment of impacts based on the three assessment zones and selected representative viewpoints, which were determined from desktop studies and on-site investigations in conjunction with professional judgement.

The key landscape values and visual features identified in each zone that could potentially be affected by the Project, are summarised below.

## Existing Conditions

Specialist consultants reports have informed our understanding of potential impacts of the Project, in particular hydrology and biodiversity. In addition, the project heritage consultants undertook visual impact assessment from heritage items so this was not undertaken as part of this report.

Review of background information informed the designation of three distinct assessment zones within the study area, namely:

- Upstream
- Construction
- Downstream.

These zones are as described in detail in **Section 2 on page 7** of this report.

## Landscape character impacts

The Project is likely to impact all three zones but impacts would be slightly higher for the work proposed in the upstream and construction zones.

The high biodiversity value and spectacular scenery of the upstream zone means that there is a major focus for tourism and, while public access to much of this zone is restricted in order to protect water quality, there are a limited number of locations open to the public for recreational activities and sight seeing where impacts may be experienced and these have been assessed as moderate.

The construction zone is already a heavily modified environment that is highly valued as a recreation resource and historic landmark of regional significance. It demonstrates a significant built/engineering achievement that after the construction of the Project would continue to be an important engineering achievement, a landmark tourist attraction and a local recreational resource for western Sydney.

Finally, the downstream zone is likely to experience a reduction in flood extents during flood events. A reduction in flood extents (and flows) would reduce the flood damage and consequently the Project could be interpreted as having positive visual impacts. There are still some unavoidable impacts that would be experienced and these impacts have been assessed as moderate-low.

## Visual Impacts

The Project is a significant piece of infrastructure and as a result of both construction and operation stages, visual impacts were demonstrated at all viewpoints.

In the upstream zone the sensitivity of viewers is offset by the large distance between them and the potential impacts as well as the steep, densely vegetated terrain of the existing environment.

In the construction zone, the demolition of existing features and construction of new dam infrastructure would increase the scale and bulk of the built form, however it is likely that the engineering significance of the wall would continue and/ or even be further heightened. So then, although the magnitude of change is almost always high it is not considered to be a negative when viewers often arrive at the site to look specifically at a significant piece of dam infrastructure at close range.

Viewpoints located in the downstream zone during a flood event are still expected to be impacted after the dam wall raising, however overall flood extents and flood management practices would reduce the impacts at each of these viewpoints, which has been interpreted as a positive impact.