Chapter 14
Surface water and flooding

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14 Surface water and flooding

This chapter summarises the surface water and flooding assessment carried out for the upgrade of the Great Western Highway between Blackheath and Little Hartley (the project). The full surface water and flooding assessment is provided in Appendix J (Technical report – Surface water and flooding).

14.1 Assessment approach

14.1.1 Surface water and hydrology

The approach to the surface water and hydrology assessment included:

- review of previous water quality reports to understand the existing environment and water quality conditions within the study area (see Figure 14-1)
- identification of project-specific environmental values and assessment criteria including the neutral or beneficial effect (NorBE) criteria (required for projects within Sydney's Drinking Water Catchments)
- qualitative assessment of potential water quality impacts during construction
- quantitative modelling of potential operational impacts using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC)
- consideration of whether the project has a NorBE on water quality (i.e., a 10 per cent reduction in total suspended solids, total phosphorus and total nitrogen, and gross pollutant loads equal to or less than the existing loads)
- development of a surface water balance for construction and operation of the project (see Sections 14.3 and 14.4)
- identification of mitigation measures to avoid or minimise potential impacts.

The surface water quality objectives for the project are outlined in Section 2.2.4 of Appendix J (Technical report – Surface water and flooding).

14.1.2 Flooding

The approach to the flooding assessment included:

- review of historic flooding information and flood assessments
- identification of project-specific criteria for operational impacts
- flood modelling of existing and proposed flooding conditions including for the five per cent annual exceedance probability (AEP), two per cent AEP, one per cent AEP, 0.2 per cent AEP (climate change) and probable maximum flood (PMF) events[1]
- qualitative assessment of potential temporary construction flooding impacts
- quantitative assessment of potential operation flooding impacts based on flood modelling
- identification of mitigation measures to avoid or minimise potential impacts.

The flood management objectives for the project are outlined in Section 2.2.3 of Appendix J (Technical report – Surface water and flooding).

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[1] The full range of listed flooding events was considered at Little Hartley. Only the PMF event was considered at Blackheath due to the low flood risk identified at this location. Soldiers Pinch is unlikely to be affected by flooding given the high elevation of the site, upstream catchments and localised flow paths directing water toward the Grose River.

14.2 Existing environment

14.2.1 Sensitivity of the receiving environment

The project is located adjacent to the Blue Mountains National Park and the Greater Blue Mountains World Heritage Area. This sensitive and unique environment comprises important views, rugged tablelands, sheer cliffs, deep, inaccessible valleys and swamps supporting a diverse ecosystem. There are a number of sensitive ecological receptors and water bodies near the project, including threatened species and groundwater dependent ecosystems (GDEs) as well as water bodies supporting Sydney's drinking water catchment. The area is largely undeveloped and remains largely in its natural form. The integrity of the Greater Blue Mountains World Heritage Area depends upon the complexity of its geological structure, geomorphology and water systems, which have created the conditions for the evolution of its outstanding biodiversity.

14.2.2 Catchments and waterways

Catchments

The project is located within the Hawkesbury-Nepean River catchment, which has an area of around 22,000 square kilometres. Runoff from the project would ultimately drain to the Hawkesbury River via:

- Grose River– proposed work at Blackheath and Soldiers Pinch, given the natural ridgeline and modelling which suggests runoff would drain to the east, would be located within the Grose River sub-catchment and would drain to Grose River via a series of tributaries located immediately downstream of the existing Great Western Highway
- Coxs River– proposed work at Little Hartley and the majority of the tunnels would be located within and beneath the Coxs River sub-catchment and would drain to Coxs River via Butlers Creek and River Lett.

The indicative locations of these sub-catchments are shown on Figure 14-1 which lie within the larger Hawkesbury-Nepean River catchment.

The majority of the project would be located within or beneath the mid-Coxs River catchment, which forms part of the Sydney Drinking Water Catchment eventually draining to the Warragamba Dam. This would include most of the project tunnels and the surface works at Little Hartley.

The project east of the existing Great Western Highway, including the Soldiers Pinch construction site, is within the Grose River sub-catchment and is not associated with a drinking water catchment.

The project at Blackheath would be located within the Blue Mountains Special Area, listed under Schedule 1 of the *Water NSW Regulation 2020*. The Blue Mountains Special Area forms the surface water catchment for Lake Medlow and Lake Greaves, which supply water (along with supply from the Cascade dams) to the Cascade water filtration plant for subsequent supply to the populations of Medlow Bath, Blackheath and Mount Victoria. Public access to this area is restricted to protect water quality and create a buffer of land around essential water storage.

Land within drinking water catchments, as shown in Figure 14-2 to Figure 14-4, plays an important role in capturing drinking water. Further detail on relevant legislation pertaining to the drinking water catchments is provided in Section 2.1 of Appendix J (Technical report – Surface water and flooding).

The project is also located within two water sources which form part of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011:

- Upper Nepean and Upstream Warragamba Water Source
- Hawkesbury and Lower Nepean Rivers Water Source.

These water sources include all water naturally occurring on the surface of the ground, and in rivers, lakes estuaries and wetlands.

Watercourses

There are 21 waterways within proximity to the project as listed in Section 3.5 of Appendix J (Technical report – Surface water and flooding). Of these, 17 are ephemeral streams (i.e., only flow after rainfall) and four streams are intermittent (i.e., stop flowing when groundwater levels are low).

Rosedale Creek and an unnamed creek at Little Hartley are third and first order streams (as defined by Strahler) respectively and the only watercourses characterised as key fish habitats. All other waterways within the study area are first order streams and do not comprise key fish habitat.

Waterways in proximity to the construction footprint are shown in Figure 14-2 to Figure 14-4.

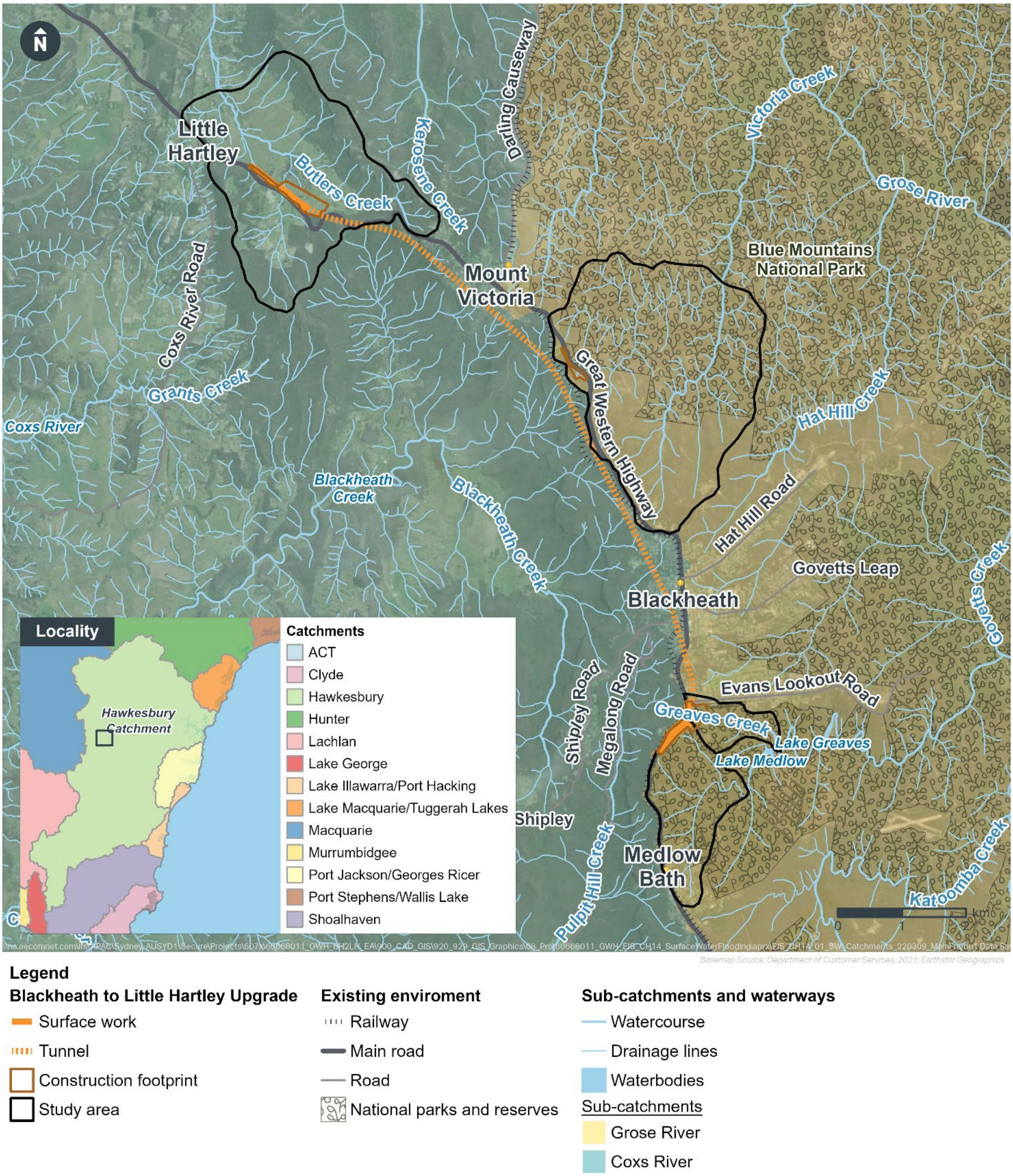


Figure 14-1 Overview of the surface water study area, sub-catchments and waterways[2]

[2]Data for the boundaries of sub-catchments was not available. Indicative boundaries shown have been adapted from Figure 1 of the 'Hawkesbury-Nepean Valley Flood Management Review Stage One' (Department of Primary Industries, 2014)

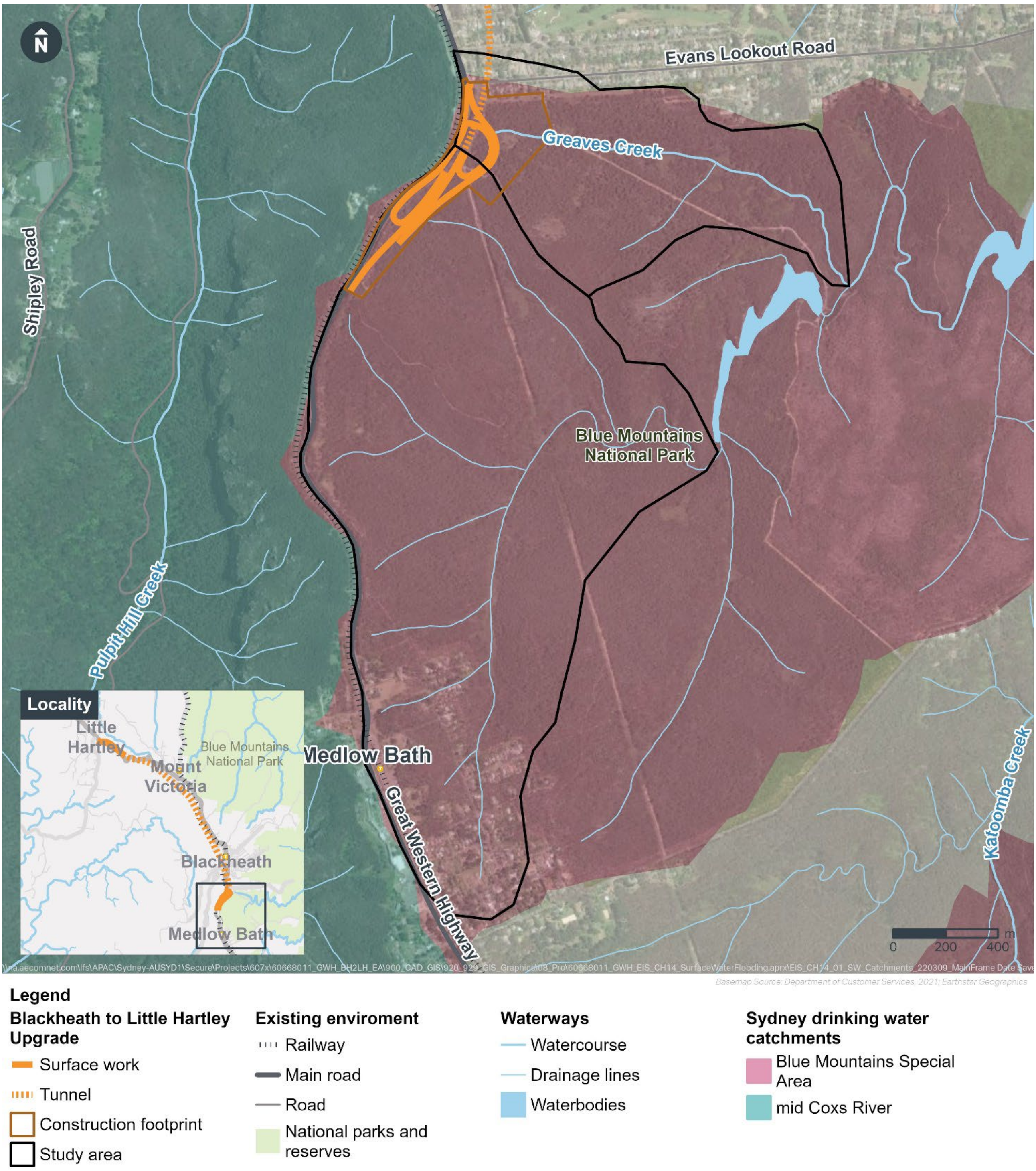
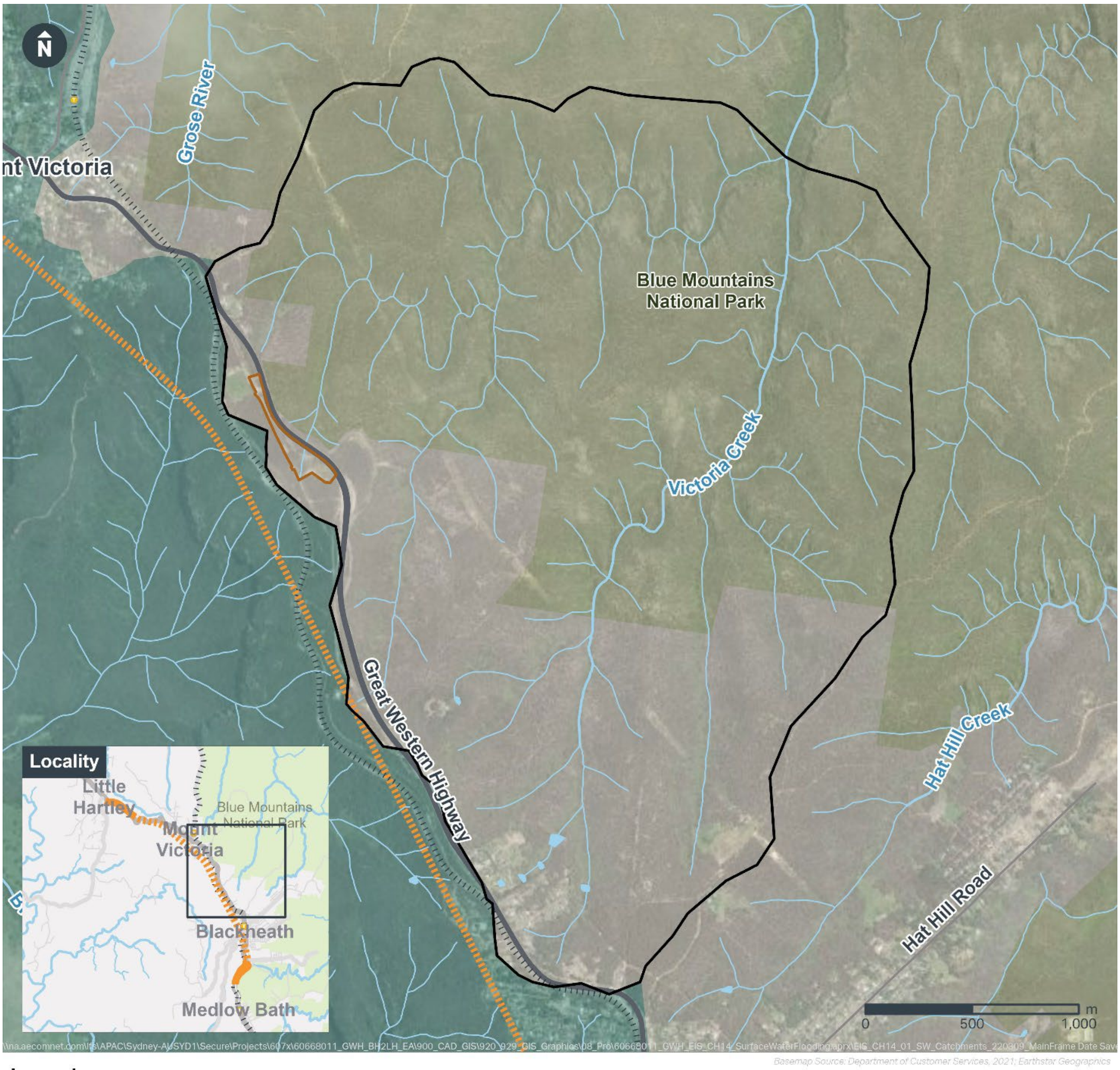


Figure 14-2 Sydney Drinking Water Catchments and waterways near the Blackheath study area



Legend

Blackheath to Little Hartley Upgrade
- Surface work
- Tunnel
- Construction footprint
- Study area

Existing enviroment
- Railway
- Main road
- Road
- National parks and reserves

Waterways
- Watercourse
- Drainage lines
- Waterbodies

Sydney drinking water catchments
- mid Coxs River

Figure 14-3 Sydney Drinking Water Catchments and waterways near the Soldiers Pinch study area

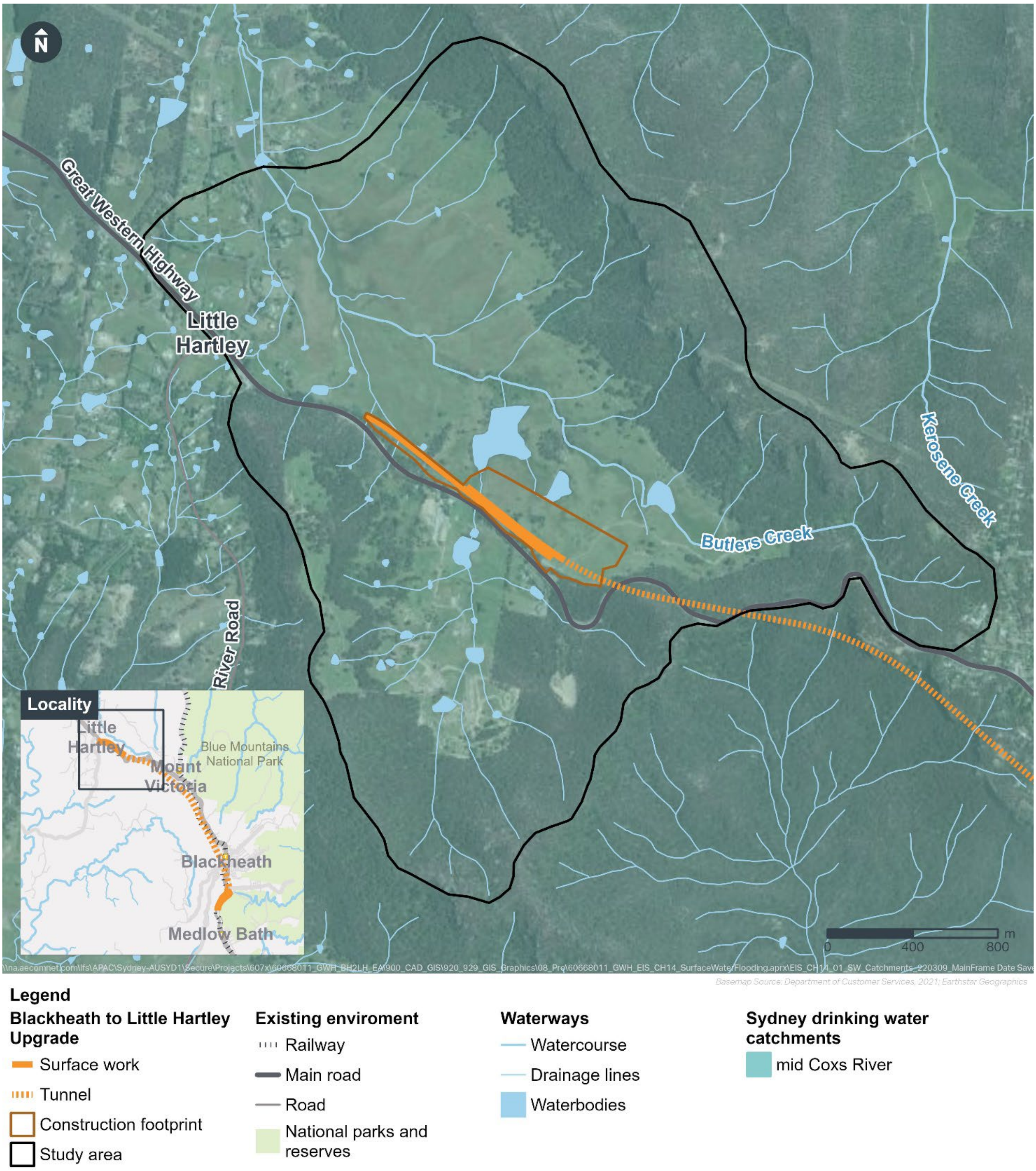


Figure 14-4 Sydney Drinking Water Catchments and waterways near the Little Hartley study area

14.2.3 Surface water and water quality

Available water quality reporting suggests that the water quality of the surrounding watercourses and broader catchments relevant to the project vary from good to poor (see Table 14-1). The water quality in mid Coxs River was found to be mostly compliant with Australian and New Zealand Environment and Conservation Council (ANZECC) Water Quality Guideline values. Greaves Creek sub-catchment (which sits within the Blue Mountains Special Area) was mainly found to be non-compliant with guideline values. Previous reports used to characterise the existing water quality environment are summarised in Section 2.2 of Appendix J (Technical report – Surface water and flooding).

To understand the existing water quality conditions, 22 in situ-sites nearby the project were sampled, with a summary of the results provided in Table 14-2. Further information on water quality sampling is provided in Section 3.6 of Appendix J (Technical report – Surface water and flooding).

Table 14-1 Existing water quality relevant to the project

Report or Study	Relevant catchment/waterway	Overall assessment of water quality in relation to the project
Sydney Drinking Water Catchment Audit 2019 (Eco Logical Australia, 2020)	Little Hartley (mid Coxs River catchment)	Water quality found to be mostly compliant, with the following parameters outside the recommended range: • pH • electrical conductivity • total aluminium. These results are similar to previous audit findings.
Annual Water Quality Monitoring Report 2020-21 (WaterNSW, 2021)	Blackheath (Lake Greaves – Greaves Creek sub-catchment)	Parameters outside the recommended range included: • pH • total aluminium. The Greaves Creek sub-catchment was found to be prone to increases in metals, nitrogen and phosphorus post-rainfall which can cause sustained algal growth.
Waterways Health Report 2017 (Blue Mountains City Council, 2017)	Blackheath (Adams Creek, Govetts Leap Brook, and Pulpit Hill Creek) and Soldiers Pinch (Grose River tributary)	The following health ratings were given to the waterways close to the study area: • Pulpit Hill Creek (Coxs River Catchment) – excellent/good health • Grose River Tributary – good health • Adams Creek – good health • Govetts Leap Brook – good health. A rating of good health suggests that data collected was mostly in compliance with guidelines and reference data.

Table 14-2 Summary of in-situ water quality sampling results

Sample	ANZECC Water Quality Guidelines Range	Percentage of sites within ANZECC Water Quality Guidelines Range	Notes
Dissolved oxygen (% saturation)	90-110	36%	Considerably low oxygen readings at the upper Relton Creek and upper Greaves Creek sites are likely due to sites being at the headwaters of the creeks with very little flow, resulting in only small, oxygen poor pools of water present.

Sample	ANZECC Water Quality Guidelines Range	Percentage of sites within ANZECC Water Quality Guidelines Range	Notes
Electrical conductivity (mS/cm)	30-350	72%	All of the sites not within the range were below the lower limit. It is noted that the ANZECC guidelines do not accurately reflect the true geochemical nature of Blue Mountains streams which are typically dilute.
pH	6.5-8	9%	The lowest pH was recorded at the middle Greaves Creek site which had a pH of 4.74. As with electrical conductivity, the ANZECC guidelines do not reflect the naturally acidic nature of Blue Mountains streams and results such as this are typical of Blue Mountains creeks with minimally disturbed catchments.
Turbidity (NTU)	2-25	81%	The sites that were not within the guideline range were below the lower limit, which reflects the relatively clear and dilute sandstone derived waters.
Total suspended solids (TSS) (mg/L)	No range stated. The Blue Book (Landcom, 2004) states < 50 mg/L	Results between <5 to 538 mg/L	The upstream of most watercourses showed an increase in TSS compared to most downstream watercourses. Butlers Creek (at Little Hartley) is an exception to this, likely resulting from the transition from minimally disturbed upper reach to an agricultural land use.

14.2.4 Drainage infrastructure

The existing drainage environment surrounding the project is described in Table 14-3.

Table 14-3 Existing drainage infrastructure

Location	Description
Blackheath	• limited underground drainage with a one-way crossfall, directing stormwater runoff towards the low side of the Great Western Highway • roadside swales.
Soldiers Pinch	• no existing formal drainage at Solders Pinch • surface water appears to sheet off the existing road into the surrounding environment • surface water paths appear to have formed within some of the road corridors due to erosion of the existing unsealed road.

Location	Description
Little Hartley	• piped drainage along kerbed sections of the Great Western Highway • inlet pits which transfer surface flows into the existing underground drainage network, which then discharge to an existing channel, watercourse and/or transverse culvert • surface road runoff sheets directly off the road at un-kerbed sections of the Great Western Highway.

For the purposes of the environmental impact statement, it has been assumed that the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade and associated drainage, flooding and water quality infrastructure have been assessed, approved and are operational prior to construction of the project. This infrastructure would be used to manage surface water related impacts from the construction and operational phases of the project. The baseline scenario represents an environment where:

- downstream drainage infrastructure has been sized and constructed so that it can accommodate discharges from the project without affecting the drainage performance of adjacent projects that are part of the Upgrade Program. This includes designing the sizing of pipes and attenuation basins in the adjacent projects to accommodate the predicted flows from all Upgrade Program projects. The Little Hartley to Lithgow Upgrade will construct a section of the Rosedale Creek culvert crossing to accommodate the project, as well as upgrading and realigning the culvert on the existing Great Western Highway at Rosedale Creek
- treatment devices to manage the quality of stormwater runoff include flow diversions, treatment systems, flow spreaders and infiltration areas. These have all been designed to accommodate runoff from the adjacent east and west projects where necessary in addition to runoff from this project. These treatment devices would be in place when this project is constructed. Treatment targets for water quality for this project would be met by integrating design of this project with treatment systems provided by the adjacent projects.

The water quality controls for the project are described in Chapter 4 (Project description). Figure 4-15 and 4-19 in Chapter 4 (Project description) show water quality control infrastructure to be delivered by the project and adjacent projects as part of the Upgrade Program.

14.2.5 Sensitive receiving environments

Vegetation communities

Aquatic ecosystems within stream environments may be sensitive to changes in surface runoff. Temperate Highland Peat Swamps on Sandstone community (THPSS) is listed as an endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and listed as endangered under the *Biodiversity Conservation Act 2016* (NSW) (BC Act). The project is in close proximity to THPSS, and surface runoff from the project would be discharged to waterways that contain THPSS.

Several swamp communities listed under the BC Act make up the THPSS community including:

- Blue Mountains Swamps in the Sydney Basin Bioregion (Vulnerable, BC Act and Endangered, EPBC Act)
- Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion (Endangered, BC Act)
- Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions (Endangered, BC Act).

Further discussion of potential impacts to swamp communities, including THPSS, is provided in Chapter 12 (Biodiversity).

14.2.6 Flooding

Flood modelling for the project and previous flooding studies for the Great Western Highway Upgrade Program – Katoomba to Lithgow have determined the existing flood behaviour for the study area.

Blackheath

Based on the existing PMF depth, major flooding is considered unlikely to occur at the Blackheath portal. This area is located on a natural ridgeline and therefore the majority of water would flow away from the Great Western Highway to the east or west. Existing PMF depths at Blackheath show three overland flow paths within the construction footprint where flood depth is up to 0.75 metres (locations 1, 2 and 3 in Figure 14-5), and one location where localised ponding occurs above 1.2 metres, however this does not overtop the railway line (location 4 in Figure 14-5). In other locations flood depths are generally below 0.2 metres.

Based on PMF modelling results, areas of higher velocity are associated with existing flow paths (identified above) downstream of the existing Great Western Highway including Relton Creek, an unnamed tributary of Adams Creek and Greaves Creek downstream of the existing Great Western Highway. Peak flood velocities in these flow paths range from 1.5 to 2.5 metres per second. Peak velocity levels are shown in Figure 3-15 of Appendix J (Technical report – Surface water and flooding).

The Katoomba to Blackheath Upgrade would be under construction when construction of the project commences. There is expected to be some flood risk due to temporary blockage or diversion of waterways and drainage lines due to construction activities. These temporary impacts are expected to be minor and would be managed through the implementation of standard construction techniques.

Soldiers Pinch

Solders Pinch is located at a high point in the landscape and is unlikely to experience major flooding given the elevation profile. While Soldiers Pinch is located around eight metres below the existing Great Western Highway, water passes under the highway downstream west to east. A natural drainage channel runs through the construction footprint and towards the Grose River. There may be some localised ponding at depressions along and around the natural drainage channel, however, modelling suggests that the channel conveys flows downstream towards Grose River before any major ponding occurs.

Little Hartley

Under baseline conditions for all modelled scenarios, deep water ponding above two metres occurs at the Rosedale Creek crossing (location 3 in Figure 14-8) for the one per cent AEP. Across different flood events, there are five other locations where the existing Great Western Highway overtops. The existing one per cent AEP flood depth and flood hazard maps are shown in Figure 3-17 and Figure 3-18 in Appendix J (Technical report – Surface water and flooding).

The existing one per cent AEP peak flood velocities for Little Hartley identify areas of higher velocity associated with Rosedale Creek and unnamed tributaries of Butlers Creek. Flood velocities in these flow paths generally peak at between 2.0 and 2.5 metres per second but are generally less than 1.5 metres per second. Within the construction footprint, the highest velocities are experienced downstream of the existing Rosedale Creek culvert crossing, which reaches 2.1 metres per second for the one per cent AEP event. Peak flood velocities in these flow paths range from 1.5 to 2.5 metres per second.

During the one per cent AEP, the flood hazard for the upstream and downstream ends of the culvert crossing at Rosedale Creek has a flood hazard rating of H5 (unsafe for people or vehicles with all buildings vulnerable to structural damage).

The Little Hartley to Lithgow Upgrade would be under construction at the time of project construction. The Little Hartley to Lithgow Upgrade will construct a section of the Rosedale Creek culvert crossing to tie into the project and assist in managing existing the flood hazard at this location.

Emergency management

No formal emergency management, evacuation and access and contingency measures were identified for Little Hartley. Existing emergency evacuation routes are assumed to be eastbound and westbound via the Great Western Highway.

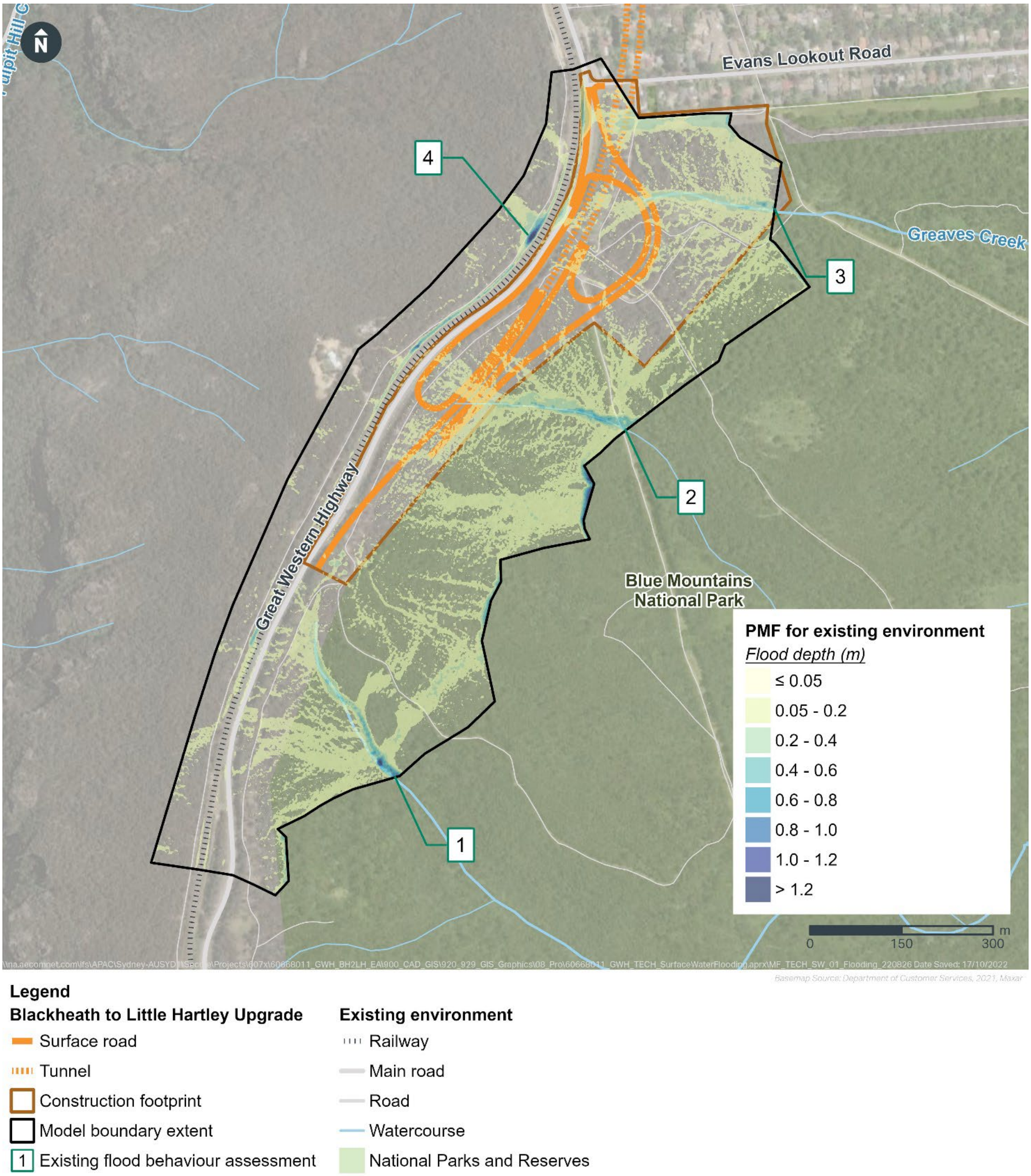


Figure 14-5 Baseline modelled flood depth for the PMF at Blackheath

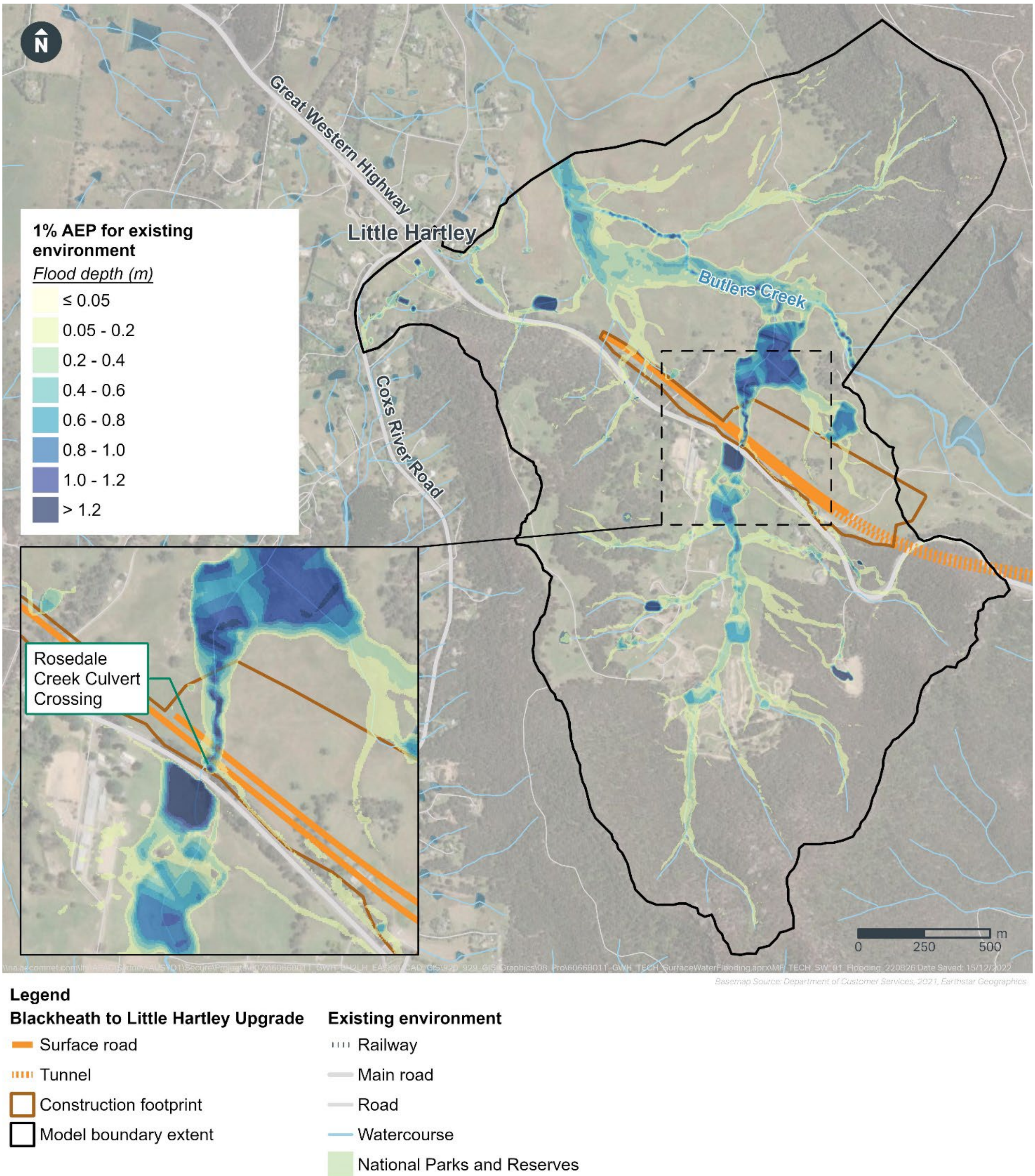


Figure 14-6 Baseline modelled flood depth for a one per cent AEP event at Little Hartley

14.3 Potential impacts – construction

14.3.1 Surface water and hydrology

Surface activities

The construction of the project has the potential to temporarily impact the water quality of waterways within the study area and areas downstream of the project as outlined in Table 14-4, if not properly managed.

Table 14-4 Potential water quality impacts during construction (before mitigation measures)

Construction activity	Potential impact
• clearing of vegetation and exposure of soils could result in mobilisation and release of sediment laden runoff from construction areas or stockpiles of soil • direct disturbance of waterway bed and/or banks as a result of earthworks could result in soil and bank erosion and mobilisation of sediments into receiving waterways, particularly at Rosedale Creek (a key fish habitat) • loading and transporting of building materials, stockpiling, earthworks, and demolition of structures could result in dust, litter and other pollutants being mobilised by wind and stormwater runoff into waterways • vehicle movement across construction footprints may loosen soils and transport sediment onto public roads and into the waterways either by runoff carrying sediment from loosened soils or through sediments attached to the vehicles traversing drainage lines.	• sediments could smother receiving waterways impacting aquatic ecosystems • increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems • nutrients associated with sediments could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods • reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
• leakage or spills of oils, fuel and/or chemicals from machinery or equipment, during refuelling or accidental spill could potentially result in pollutants being conveyed to downstream waterways.	• oil sheen on water surface could impact amenity or recreation • increased toxicant concentration could lead to fish kills and other aquatic ecosystem impacts, livestock and aquatic foods impacts, including impacts to peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Concreting could result in: • accidental runoff of concrete washout water into waterways • chemicals used in treatment and curing of concrete and mobilisation of concrete dust through wind and runoff could impact waterways • spills of excess or waste concrete could be discharged into stormwater systems.	• increased alkalinity and toxicant concentration could lead to impacts to aquatic ecosystems such as fish kills and undesirable impacts to livestock • increased turbidity could impact aquatic ecosystems, amenity and recreation • changes in alkalinity and toxicity also have the potential to impact peat swamps identified at Blackheath and Little Hartley • pollution of surface water within the Blue Mountains Special Area at Blackheath.

Construction activity	Potential impact
Earthworks and changes to the site resulting in concentrated flows that have potential to disrupt existing surface water flow paths, scour the earth and increase sediment loads carried by surface waters.	• increased turbidity, lower dissolved oxygen levels and increased nutrients could lead to algal blooms and aquatic weed growth which could impact aquatic ecosystems • increased toxicant concentration • reduced visual amenity (turbidity) • localised ponding could occur creating drainage/flooding issues within nearby properties and surrounding downstream environment • erosion affecting channel geomorphology and bank stability • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Activities related to discharges from the project include: • dewatering open excavations following periods of rainfall, which may contain sediments and other pollutants mobilised by the rainfall • increased baseflow rate to receiving waterways due to continuous discharge from construction water treatment plants, causing a potential for increased erosion and scouring of waterways due to increased discharged volumes • impacts to ambient water quality as a result of poorly treated discharges from the construction water treatment plants.	• increased alkalinity and toxicant concentration could lead to fish kills and other undesirable impacts to aquatic ecosystems, livestock, and aquatic foods • increased turbidity, lower dissolved oxygen levels and nutrients could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, amenity, recreation, irrigation, livestock, and aquatic foods • potential for pollution and impacts described above to impact peat swamps identified at Blackheath and Little Hartley, as well as the Blue Mountains Special Area at Blackheath.
Oxidation and/or runoff stockpiles comprising acid sulfate rock (ASR) at Little Hartley during construction excavation, earthworks and tunnelling.	• sulfuric acid production resulting in more aggressive conditions and increased acidity of surface water impacting water quality • reduction in pH of downstream receivers can stress aquatic fauna and flora • reduction in pH can increase solubility of metal pollutants which can negatively impact aquatic organisms.

Erosion and sedimentation management measures and water treatment plant maintenance procedures would be detailed in the Construction Environment Management Plan (CEMP) for the project. These measures would be implemented in accordance with Managing Urban Stormwater – Soils and Construction, Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008), commonly referred to as the ‘Blue Book’. Compliance with the Blue Book requirements would meet NorBE requirements for the construction phase of the project.

No public access to the Blackheath Special Area would be permitted as the construction site would be appropriately secured.

With the implementation of these controls, potential construction related erosion and sedimentation impacts would be appropriately managed and would be negligible.

Water treatment

As described in Section 14.2.4, the water quality controls and drainage infrastructure such as sediment basins at the Blackheath and Little Hartley construction sites would have been previously established by the Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade project respectively.

These basins and drainage infrastructure would be appropriately sized to manage and mitigate the pollutants generated and convey flow volumes during construction, meeting the required criteria for the projects.

Water use requirements during construction of the project, including measures to avoid and minimise water consumption, particularly of potable water are outlined in Chapter 21 (Resource use and waste management). An indicative total for water required during construction is estimated at around 758,000 kilolitres. An indicative construction water balance for the project is outlined in Figure 14-7.

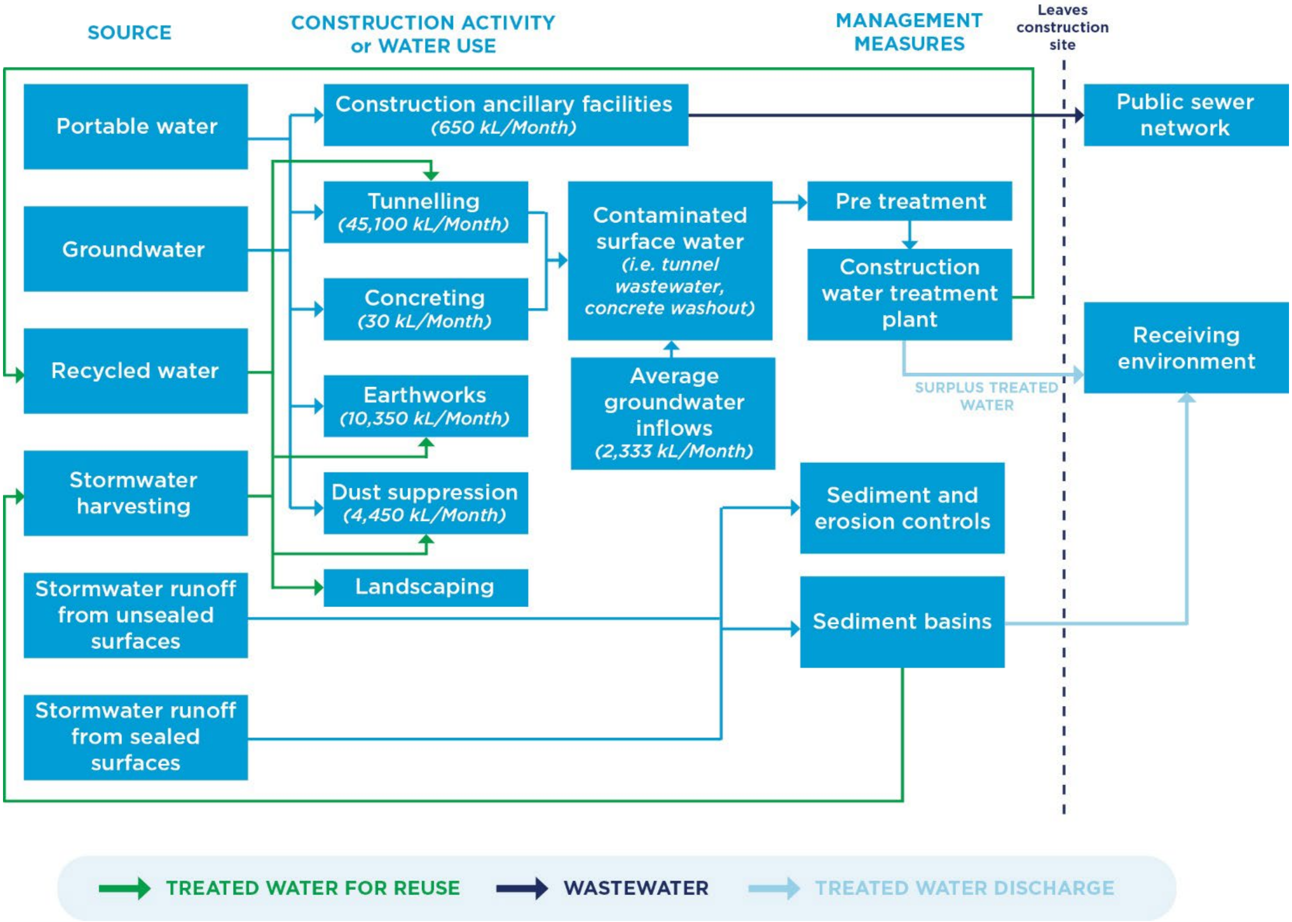


Figure 14-7 Indicative construction water balance[3]

[3] Recycled water and stormwater harvesting would make up at least 33 per cent of construction water demand

Water generated during construction would vary depending on the types of construction activities being carried out and the stage of construction. The majority of water generated during construction would be through tunnelling followed by earthworks. The new water supply pipeline at Little Hartley, described in Chapter 4 (Project description), would supply water to the Little Hartley construction site to support construction activities including the tunnel boring machines (TBMs).

A description of how construction water would be managed is provided in Chapter 5 (Construction).

As outlined in Section 13.3.1, predicted tunnel groundwater inflow volumes are predicted to:

- peak during construction of the tunnel (between the mid-tunnel cavern and Blackheath when the TBM switches to earth pressure balance mode), and during construction of the tunnel cross-passages
- decrease around 2029 once construction of these elements is complete, with the cross-passages and twin tunnels being tanked (i.e. structures which prevent groundwater from entering the structure as opposed to a drained structure which captures, diverts and treats groundwater ingress)
- stabilise after construction given most infrastructure would be tanked.

Water generated during construction including groundwater encountered during tunnelling would be captured and treated and either reused or discharged. The anticipated generation of water during construction would be greater than the potential for reuse. Therefore, treatment of surplus construction water and off-site discharge would be required. The water generated from tunnel construction would be tested and treated at construction water treatment plants at each construction site prior to reuse or discharge. Where surplus treated groundwater needs to be discharged, it may be discharged to the local stormwater system or to a surrounding local watercourse.

Treatment and discharge of water that cannot be reused would be carried out in accordance with the Environment Protection Licence for the project. Construction water would be treated so it meets the requirements for discharge to the Sydney Drinking Water Catchment in accordance with Part 6.61 of the State Environmental Planning Policy (Biodiversity and Conservation) 2021 which requires that developments have a NorBE on water quality.

Baseflow changes

Aquatic ecosystems may be sensitive to changes in groundwater quantity and quality. Some surface water features that are partially or wholly reliant on expressed groundwater to sustain baseflow can be affected by changes to groundwater. The surface water/groundwater relationship, including analysis of potential changes in baseflow to surface water environments as a result of the project are discussed in Chapter 13 (Groundwater and geology).

Tunnelling activities as part of the project would result in groundwater inflows and drawdown of groundwater which in turn has potential to reduce baseflows to surface watercourses. Groundwater modelling undertaken for the project indicates minor losses in baseflow along the tunnel alignment as a result of tunnelling activities. The most notable predicted reduction is at Greaves Creek, which is located immediately east of the proposed unlined (drained) Blackheath portal. This would be in the order of one per cent baseflow loss. Predicted impacts as a result of baseflow reduction at Greaves Creek and associated GDEs including THPSS are further discussed in Chapter 12 (Biodiversity).

Reductions in baseflow during construction are expected to be of short duration (less than six months) given majority of the project tunnel would be progressively lined during construction. This would be unlikely to impact the survival of plant communities as the small amount of baseflow reduction would be within the plant tolerance limits for seasonal variability. The risk to the swamp communities identified around Greaves Creek would continue to be assessed and refined as part of further design development (further discussed in Section 14.4.1).

14.3.2 Flooding

Potential flooding impacts identified during construction that could occur without the implementation of appropriate management measures may include:

- inundation and damage to construction sites, machinery, equipment and stockpiles and delays to construction programming
- safety risk to construction workers
- blockage of existing drainage infrastructure due to mobilisation of sediment
- increased flow rates in receiving drainage lines downstream of the construction footprint due to vegetation clearing and increased impervious areas
- increased velocity and ponding potentially restricting access to construction sites
- obstruction of floodwaters and overland flow paths due to temporary works, such as site sheds and stockpiles, leading to exacerbated flooding conditions in and outside the construction footprint.

Blackheath

As discussed in Section 14.2.6, Blackheath is unlikely to be affected by flooding. There is expected to be some overland flows during construction due to temporary blockage or diversion of waterways and drainage lines due to construction activities. Flood modelling has identified three overland flow paths, and these convey flows from west to east during the PMF event. It can be expected that smaller flow depths may be experienced through these locations during smaller events such as the five per cent AEP and one per cent AEP events. The following maximum flow depths were modelled for a the PMF event:

- 0.46 metres for overland flow
- 0.65 metres for localised ponding
- 0.75 metres within the existing channel within the project area to Greaves Creek.

Potential flooding impacts during construction would be considered during design development and detailed construction planning. This would include consideration of the Blackheath construction site layout (especially stockpile locations) so flows are effectively diverted or unimpeded. With the implementation of standard mitigation measures (in accordance with the Blue Book) and other controls, the potential impacts to surrounding properties, for flood hazard, hydraulic functions, downstream velocity and scour potential would be expected to be temporary and minor.

Without appropriate management of stormwater, there is potential for overland flow to impact the tunnel portals during construction. Construction sequencing should be considered in the CEMP to manage and direct flow paths away from both tunnel portals. Where this is not possible, bunding (or similar) would be used to divert flow paths. However, the overland flow would likely have a minimal impact on the tunnel entries during the construction phase since they are located at the ridge line with no upstream catchment and there is no flooding present in the existing PMF.

Additionally, the topography (and the project design) generally slopes downhill away from the tunnel portal. Hence, overland flow would not be directed toward the tunnel at any stage of the construction phase.

Soldiers Pinch

As discussed in Section 14.2.6 Soldiers Pinch is unlikely to be affected by flooding. Localised ponding may occur at lower elevations within this site and therefore stockpiles located in low points of the site have the potential to obstruct floodwater and alter flow paths. The layout of the Soldiers Pinch construction site, including the placement of construction plant and equipment, site offices and stockpiles relative to overland flow paths would be considered during design development and detailed construction planning.

The flood results for the five per cent AEP event have been used to guide the construction impact assessment and for the selection and layout of construction sites including areas of stockpiling and chemical storage. High level calculations estimate that the flow rate through the existing channel during the five per cent AEP event would be around 0.3 cubic metres per second. If the five per cent AEP peak flow can be conveyed within the channel, then stockpiles would be located at least above the identifiable banks of the channel. During design development and construction planning it would be determined if catch drains or bunding at locations upstream of stockpiles would be necessary to prevent water ponding from minor overland flow paths.

The proposed sediment basin would be located in the path of the channel and adequately sized to minimise downstream impacts of potential scour and erosion due to changes in surface water behaviour as a result of construction.

Little Hartley

An assessment of potential flood impacts during construction at Little Hartley has considered the full range of flood events (refer to Annexure A of Appendix J (Technical report – Surface water and flooding). The existing five per cent AEP flood results have been used to guide the construction impact assessment and for the selection and layout of construction sites including stockpiling and chemical storage. The existing five per cent AEP extent with observations in relation to flow conveyance, storage areas and flood hazard summarised in is summarised in Table 14-5 and presented in Figure 14-8. The Little Hartley construction site would be largely located outside the five per cent AEP flood extents.

Flood management measures and site planning as part of the CEMP would manage conveyance of overland flow to minimise potential flooding and scour impacts during construction. This would minimise the potential for impacts to surrounding properties including localised flooding, flood hazard, hydraulic function, downstream velocity and scour potential. These impacts are expected to be temporary and minor.

In the five per cent AEP event, overland flow was not observed near the Little Hartley portal. The topography in this area generally slopes downhill, away from the portal. However construction sequencing would be considered to manage and direct flow paths away from the tunnel entries.

Existing emergency evacuation routes are assumed to be eastbound and westbound via the Great Western Highway, and these would be retained throughout the construction phase.

Table 14-5 Construction flood impact assessment for Little Hartley – five per cent AEP event

Location (Figure 14-8)	Impact assessment	Mitigation
1 – eastern extent at tunnel portals	During the 5% AEP event the flood depth reaches up to 0.8 metres. A small area is classified with a flood hazard rating of H3 (unsafe for vehicles, children and the elderly).	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event.
2 – immediately west of tunnel portals	Based on the 5% AEP flood hazard there are no restrictions at this location. There are some flow paths and flood extents during the 5% AEP event.	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event.

Location (Figure 14-8)	Impact assessment	Mitigation
3 – Rosedale Creek	During the 5% AEP event the flood depth is modelled to exceed 1.2 metres. The flood hazard rating is H5 (unsafe for people and vehicles). The concentrated flow contributes to the high flood hazard risk (a safety threat to construction workers).	A dedicated floodway zone (avoid placement of construction plant and equipment, site offices and material stockpiles) would be established using the 1% AEP flood mapping during construction planning.
4 – western extent	Based on the 5% AEP flood hazard there are no restrictions. There are some flow paths and flood extents during the 5% AEP event.	Detailed construction planning would develop site layouts that avoid placement of construction plant and equipment, site offices and material stockpiles within the modelled extent of the 5% AEP event

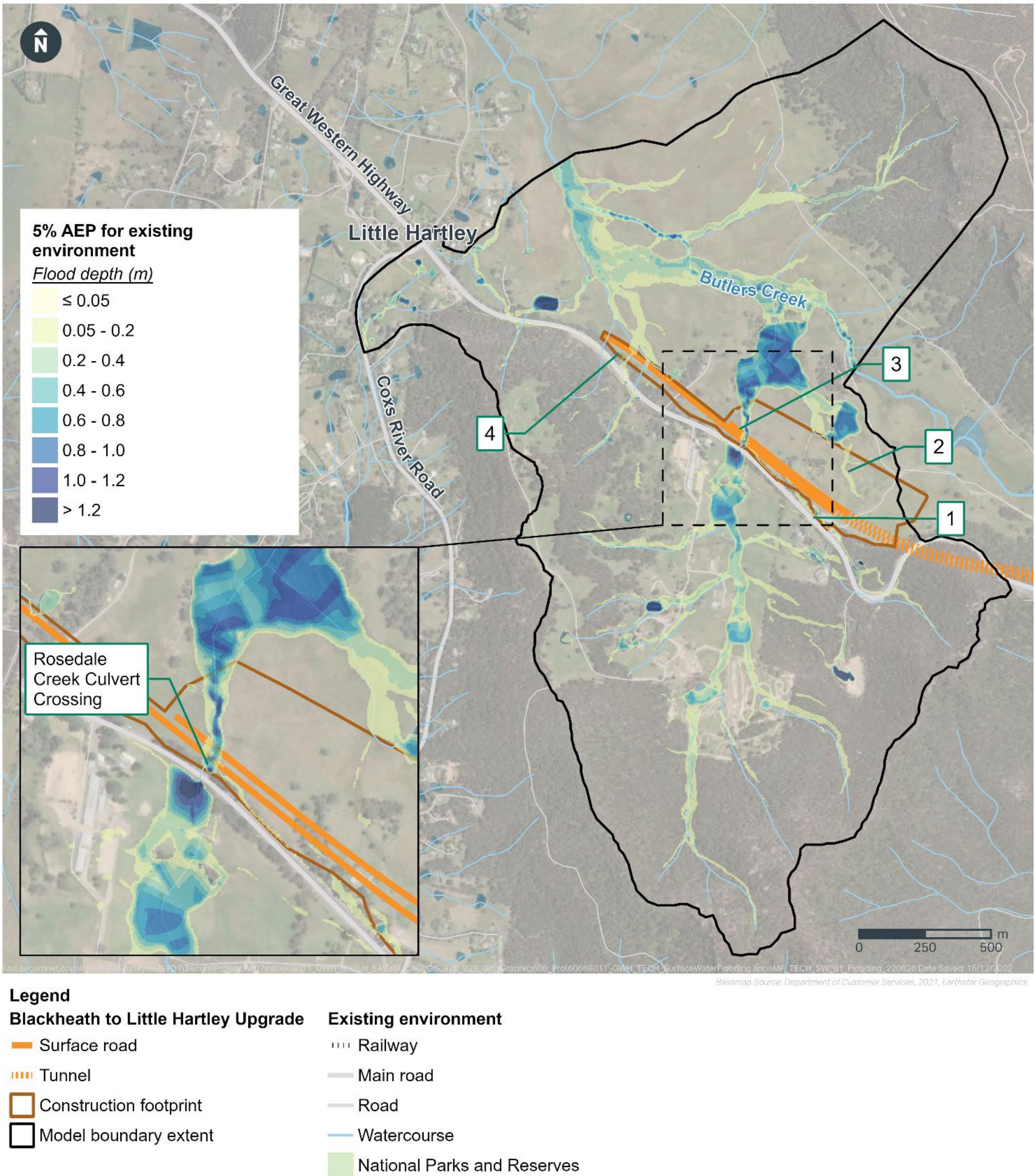


Figure 14-8 Modelled flood depth under a five per cent AEP event at Rosedale Creek (near Little Hartley construction site)

14.4 Potential impacts – operation

14.4.1 Surface water and hydrology

Surface water runoff

During operation of the project, there is potential for the following impacts if not managed appropriately:

- increased sedimentation which could affect receiving waterways impacting aquatic ecosystems
- increased turbidity, lower dissolved oxygen levels, and increases in toxicant concentrations could impact aquatic ecosystems and livestock
- nutrients in runoff could lead to algal blooms and aquatic weed growth, which could impact aquatic ecosystems, recreation, irrigation, livestock, and aquatic foods
- reduced visual amenity could result from turbid water and visible gross pollutants, impacting recreation and visual amenity
- potential for pollution and impacts described above to adversely affect peat swamps identified at Blackheath, Soldiers Pinch and Little Hartley, as well as the Blue Mountains Special Area at Blackheath
- increase in scour and erosion potential due to increase in impervious surface, mitigated by the proposed stormwater treatment devices
- increased acidity of surface water impacting quality from potential changes to pH levels from untreated ASR which could impact aquatic ecosystems
- alkalisation of surface water from runoff during rainfall periods, which could impact aquatic ecosystems.

To mitigate potential surface water quality impacts, stormwater treatment opportunities would be considered, including:

- flow splitters (a device designed to divert the flow of water into two or more directions)
- gross pollutant traps
- bioretention basins or filtration devices
- vegetated buffers and swales
- detention basins
- scour protection, energy dissipation devices and/or flow spreaders (structures that disperse the energy of concentrated flows).

The potential surface water runoff impacts would be largely mitigated by the proposed stormwater treatment devices and procedures for spills management. Therefore, the project would not be expected to impact the environmental values and water quality objectives of the receiving environment.

NorBE assessment

The annual pollutant loads of TSS, total phosphorus, total nitrogen and gross pollutants leaving the study area under both existing environment and project operation conditions are summarised for Blackheath and Little Hartley in Table 14-6. A NorBE assessment is not required for the Soldiers Pinch construction site as this temporary site would be used during construction only.

Stormwater treatment measures that would be located at each discharge location would include a range of onsite detention basins, sediment basins, water quality basins and flow spreaders. The indicative locations of these treatment measures are shown in Section 5.3 of Appendix J (Technical report – Surface water and flooding). The results of the NorBE assessment indicate that with the implementation of these treatment measures, the project would successfully achieve the

NorBE criteria in relation to annual pollutant loads by demonstrating pollutant load reductions of at least 10 per cent. Future design development could identify alternative treatment options that could be implemented to achieve the same outcomes.

Table 14-6 Operational NorBE assessment

Location	Criteria	Annual pollutant load (kg/year)			
		TSS	Total phosphorus	Total nitrogen	Gross pollutants
Blackheath (Sydney Drinking Water Catchment, Greaves Creek sub-catchment, tributary of the Grose River)	Existing environment	38,400	29	145	1,440
	Unmitigated	26,000[1]	44	220	2,460
	Mitigated	3,250	21	125	0
	Improvement compared to existing environment	92%	29%	14%	100%
	NorBE target met?	**Yes**	**Yes**	**Yes**	**Yes**
Little Hartley (Sydney Drinking Water Catchment, Butlers Creek sub-catchment, tributary of the Coxs River)	Existing environment	14,000	25	140	824
	Unmitigated	285,000	47	235	2,660
	Mitigated	1,330	15	106	0
	Improvement compared to existing environment	91%	42%	24%	100%
	NorBE target met?	**Yes**	**Yes**	**Yes**	**Yes**

Table notes:

1. TSS is greater for the pre-development case compared to the post-development (unmitigated) case at Blackheath as there is a greater percentage of unsealed roads in the pre-development case compared to the post-development case. An unsealed road produces approximately four times as much TSS as sealed road.

Water treatment

Water use requirements during operation of the project, including measures to avoid and minimise water consumption, particularly of potable water are outlined in Chapter 21 (Resource use and waste management). During operation, impacts to surface water availability and flows are expected to be minimal and would be minimised through the variety of treatment measures including those mentioned above and described further below.

An indicative operational water balance for the project is provided in Figure 14-9. Connection to and supply of mains water would be confirmed during design development. A new water supply pipeline between Lithgow and Little Hartley would provide operational water supply for the project at Little Hartley (noting that use of recycled water sourced from the project would be prioritised).

The tunnels would include drainage infrastructure to capture groundwater and stormwater, spills, maintenance water, fire deluge and other potential water sources. The tunnel drainage may contain a variety of pollutants (such as fuel, oil grease, and fire suppressants) requiring different treatment before discharge. Due to the potentially saline nature of the groundwater that may be encountered within the project locality (particularly from within coal seams), groundwater would also be treated prior to reuse/ discharge to minimise water quality impacts to the receiving environments. A permanent water treatment plant at Little Hartley would treat water to an adequate quality prior to reuse or discharge. All deluge flows, including those from the tunnel, would be stored and pumped to the water treatment plant with no untreated flows directly discharged into the receiving environment.

Surplus treated water would be directed to the environment. Indicative water quality treatment measure locations to meet NorBE requirements and discharge locations for Blackheath and Little Hartley are shown in Figure 5-4 and 5-5 of Appendix J (Technical report – Surface water and flooding), respectively. Engineered treatment measures would be located at each discharge location to treat stormwater runoff from the project. Several of these treatment measures would be constructed by the adjacent projects (Katoomba to Blackheath Upgrade and Little Hartley to Lithgow Upgrade), and therefore are considered in the baseline environment for the project's surface water and flooding assessment.

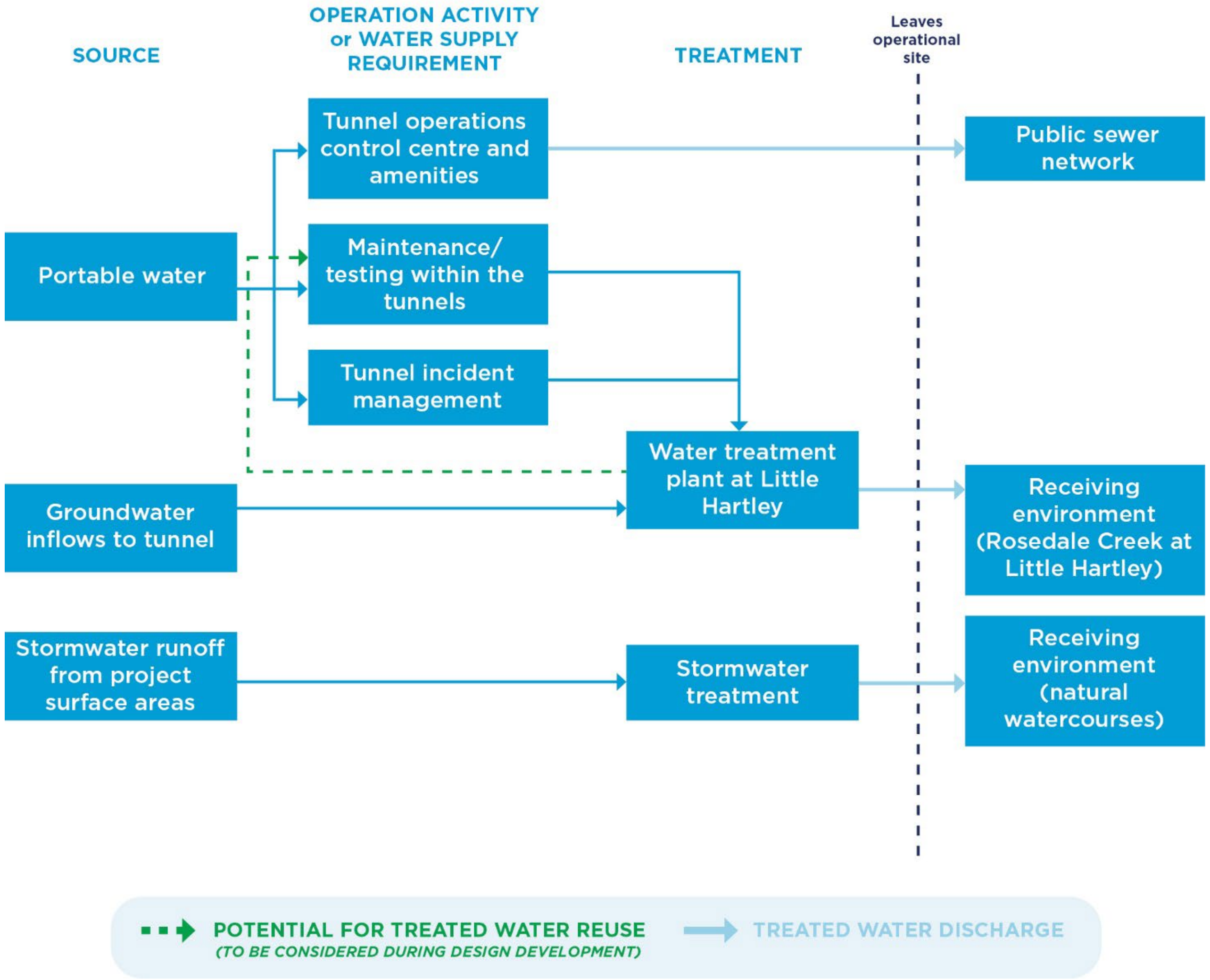


Figure 14-9 Indicative operation water balance

Baseflow changes

Changes in water quality and flows can be detrimental to the natural environment as they can:

- reduce the area of available habitat for sensitive fauna (such as native frog species)
- cause structural changes in creek lines, swamps and wetland ecosystems due to flow induced changes in geomorphology, or hydrological changes to the wetting and drying regimes of peat, which can affect the integrity of the peat
- cause alterations in the floristic diversity e.g. change in species density and vegetation community structural composition, increases in exotic species due to water quality changes.

Surface water features may be impacted during operation as a result of continued potential reduction in stream baseflow. Reductions in stream baseflows can negatively impact the valley floor infill swamps by reducing the water supply that these plant communities rely upon. Potential changes to stream baseflows are discussed in Chapter 13 (Groundwater and geology).

Reductions in baseflow of around 15 to 17 per cent (for a 95th percentile year (dry year)) are predicted at Greaves Creek near the Blackheath portal. In drier years there may be impacts to peat swamps. Potential impacts related to a reduction in baseflows and management measures are further discussed in Chapter 12 (Biodiversity).

Further investigation into the impacts of baseflow reductions on watercourses and swamps will be undertaken during design development. Future investigations would include field hydrogeological investigations to provide more accurate, site-specific parameters that can be used in predictive groundwater modelling. Modelling would then be revised for this catchment to enable more accurate predictions of the likely impact of the Blackheath portal on baseflow reductions.

If revised modelling determines that a reduction in baseflow to the valley floor infill swamps of Greaves Creek is likely and that there is a risk of detrimental impacts to these ecosystems as a result, then further mitigation measures would be investigated. Performance outcomes for the mitigation measures would be developed and agreed upon by subject matter experts, and mitigation actions including design responses such as lining the Blackheath tunnel portal would be assessed for their effectiveness in addressing the risk.

In the instance that residual risk is predicted, monitoring would continue during construction for the hydrogeology, geomorphology and vegetation community likely to be impacted. Observations would be assessed against set triggers, trigger thresholds, and responses for observed impacts. Monitoring methods would be developed with reference to supporting justification where appropriate.

14.4.2 Flooding

The operational flooding assessment considered proposed surface components of the project at Blackheath and Little Hartley as these have the potential to obstruct or alter the path of surface water flows. As no operational ancillary facilities would be located at Soldiers Pinch, this site has not been considered in the operational assessment.

Potential flooding impacts during operation, if not adequately managed may include:

- changes in peak flood level within the study area
- increases in velocity and scour potential
- increase in flood hazard
- impacts to adjacent property and infrastructure due to changes in flood behaviour.

Generally operational flooding impacts are expected to be minimal with the implementation of appropriate mitigation measures. Drainage infrastructure delivered as part of the Little Hartley to Lithgow Upgrade would also result in increased flood immunity through the addition of drainage infrastructure described in Section 14.2.4, therefore improving the existing and baseline flooding environment at Little Hartley.

Blackheath

As discussed in Section 14.2.6 Blackheath is unlikely to be affected by flooding. Flood modelling for the existing environment PMF event, as shown in Figure 14-5, indicates that the overland flow is expected to have minimal impact on the proposed tunnel portal locations. Water currently flows east away from the Blackheath portal due to the project's location on a natural ridgeline.

Flood immunity of the tunnel portals at Blackheath would also be achieved. The surface drainage infrastructure would direct all surface road runoff around or away from the Blackheath tunnel portal towards the nearest drainage outlet and after treatment, be reused or discharged to the closest waterway. Surface drainage infrastructure (including pits, pipes, detention basins and on-site detention tanks) at Blackheath have been designed to capture and convey all flows up to and including the 0.05 per cent AEP event (1 in 2000 year flood event). Therefore this design provides flood immunity for the highway and tunnel portals at Blackheath.

Based on the surface drainage system design, the project is not expected to adversely impact existing flood characteristics (including flood hazard, hydraulic functions, downstream velocity and scour potential) or surrounding properties and infrastructure. The drainage design would effectively convey stormwater flows, not increase scour and erosion potential in receiving waterways and manage localised flooding. As the project would not impact any residential, commercial or industrial dwellings, or result in an increase in peak flood velocity, the flooding criteria would be met (described in Section 2 of Appendix J (Technical report – Surface water and flooding)).

Little Hartley

Flood modelling for one per cent AEP event at Little Hartley is shown in Figure 14-6. The remaining flood scenarios are shown in Annexure A of Appendix J (Technical report – Surface water and flooding).

Various flood events were modelled for Little Hartley including the five per cent AEP, two per cent AEP, one per cent AEP, 0.2 per cent AEP[4] (climate change) and PMF events. The following potential operational flooding potential impacts were observed based on modelling results:

- during the one per cent AEP event:
  - with the introduction of the proposed realigned culvert at Rosedale Creek as part of the Little Hartley to Lithgow Upgrade, no overtopping of the upgraded Great Western Highway is observed at this location (see Figure 14-6)
  - overtopping of the upgraded Great Western Highway occurs at location one, resulting in a six metre flow width and high flood velocity (around 2.5 metres per second) which is not compliant with the flood immunity criteria. Drainage design, such as lowering and refining the design of the swale, would be investigated during design development to mitigate overtopping of the existing highway
  - immediately downstream of the Rosedale Creek culvert, a localised high flow velocity of around eight metres per second for the one per cent AEP is estimated due to a change in elevation at this location. The high velocity may lead to increased scour potential at this location, therefore scour protection would be included at this location. Design refinement would include using energy dissipation, erosion and sediment control measures at all drainage outlets to minimise these impacts
  - due to the proposed drainage design for the project, conveyance of surface water under the Great Western Highway, particularly at Rosedale Creek, is improved. Upstream of the culvert would generally experience a reduction in flood level, since the proposed culvert would convey more water downstream. Immediately downstream of the culvert, a flood level increase of up to 700 millimetres is predicted. At the existing dam downstream of the Rosedale Creek culvert there would be an increase in influx of 10 to 15 millimetres.

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[4] In accordance with ARR 2019 guidelines and "Technical Guide Climate Change Adaptation for the Road Network" provided by Transport, the 0.2 per cent AEP was adopted to represent the climate change scenario of the one per cent AEP flood event

Downstream of the project, modelled flood level increases are less than 100 millimetres with no adverse flood impact or flood damage to surrounding residential areas, commercial areas or agricultural land expected, thereby complying with the flooding criteria used for this project (further described in Section 2 of Appendix J (Technical report – Surface water and flooding))

  - locations which exceed a flood hazard rating of H2 (unsafe for small vehicles) are confined to existing concentrated flow paths and water bodies, with no detrimental changes to flood hazard predicted during operation

- during the 0.2 per cent AEP event (climate change):
  - the only change to flood behaviour would be a localised flood level increase upstream of the Rosedale Creek culvert crossing. The flood depth would increase from around 2.8 to 3.2 metres for the 0.2 per cent AEP compared to the one per cent AEP. Downstream of the Rosedale Creek culvert crossing, the flood depth would increase from around 1.5 to 1.8 metres for the 0.2 per cent AEP compared to the one per cent AEP. Therefore the predicted effects of climate change are not expected to materially change the flood risk of the project
- during the PMF event:
  - both tunnel portal entries would achieve the flood immunity criteria as there is no overland floodwater flowing from the floodplain that reaches the portals. Based on the localised topography, any floodwater conveyance flows away from the tunnel portals.

The proposed surface road drainage is designed to convey up to the 10 per cent AEP event for the underground drainage system and flood immunity is designed up to the one per cent AEP for overland flow. The drainage design would effectively manage localised flooding based on criteria.

Flood modelling indicated an increase in velocity in a number of locations. Increases in velocity greater than one metre per second at locations downstream of the project are associated with transverse drainage structures and upstream of the project are associated with a proposed swale (described above). These exceedances would be managed as part of further design development and residual increases would be managed with measures detailed in Section 14.5 such as energy dissipation and flow control measures to minimise impacts of erosion and scour.

The potential flooding impacts above are not expected to impact transport corridors or nearby properties during operation. The Great Western Highway, as the primary road network and emergency evacuation route, would benefit from project related flood immunity improvements at Little Hartley improving community emergency management arrangements. The project would also provide an additional emergency access capacity in the event of flooding events which may affect the Great Western Highway.

Consultation with Lithgow City Council and the State Emergency Services was undertaken to review the flood behaviour and the evacuation management route for the project, which also concluded that with appropriate stormwater management measures, no impacts would be expected. Consultation with Blue Mountains City Council was not undertaken as no flood impacts are anticipated within the Blue Mountains local government area.

14.5 Environmental mitigation measures

14.5.1 Performance outcomes

Performance outcomes for the project in relation to surface water and flooding are listed in Table 14-7 and identify measurable performance-based standards for environmental management.

Table 14-7 Surface water and flooding performance outcomes

SEARs desired performance outcome	Project performance outcome	Timing
Flooding The project minimises adverse impacts on existing flooding characteristics.	Design and construct the project to minimise adverse effects on existing flooding characteristics, to meet relevant standards, guidelines and policies and meet the flood design criteria developed for the project.	Design and construction
Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	Design and construct the project to achieve flood immunity consistent with design standards, guidelines and policies for road and tunnel infrastructure and meet the flood design criteria developed for the project.	Design and construction
Water – Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved).	Design and operate the project to minimise adverse long term impacts on surface water and groundwater, and related environmental values, including: • minimising the volume and rate of groundwater inflow to the project during operation • minimising the magnitude and extent of groundwater drawdown around the project during operation • minimising the reduction in baseflow volumes in watercourses affected by groundwater drawdown around the project during operation • discharging surface water from the project, including site runoff and water treatment plant discharges, to achieve a neutral or beneficial effect on the receiving watercourse and catchment, taking into account relevant Water Quality Objectives.	Design, construction and operation
Sustainable use of water resources.	Design, construct and operate the project to minimise the volume of water and rate of water consumption required during construction and operation. Subject to quality and volume requirements, maximise the reuse and recycling of water within the project.	Design, construction and operation

SEARs desired performance outcome	Project performance outcome	Timing
Water – Quality The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	Manage surface water discharges from the project during construction and operation, including collection and treatment where necessary, to achieve a neutral or beneficial effect on receiving watercourses and catchments, taking into account relevant Water Quality Objectives.	Design, construction and operation

14.5.2 Mitigation measures

Mitigation measures that would be implemented to manage potential surface water and flooding impacts of the project are listed in Table 14-8. A full list of environmental mitigation measures for the project is provided in Appendix R (Compilation of environmental mitigation measures).

Table 14-8 Environmental mitigation measures – surface water and flooding

ID	Mitigation measure	Timing
SW1	A Construction Soil and Water Management Plan (CSWMP) will be prepared as part of the Construction Environmental Management Plan (CEMP) in consultation with relevant government agencies and local councils. The CSWMP will be prepared and implemented to detail measures to minimise erosion and sedimentation, manage surface water and flooding, and protect local water quality during construction, including the potential impacts of high risk construction activities to the Sydney Drinking Water Catchment and the Blue Mountains Special Area. The CSWMP will include: • erosion and sediment control measures prepared by or in consultation with a soil conservationist to be applied to each construction site, consistent with the guidance in *Managing Urban Stormwater – Soils and Construction (4th Edition)* (Landcom, 2004). Specific control measures may include: - diversion of runoff from undisturbed areas of the catchment around project disturbance areas - diversion of existing drainage lines disturbed by construction, or establishment of an alternative drainage line - construction and commissioning of sediment and water quality basins before major earthworks. Where projects overlap, the sizing of basins would account for the concurrent construction catchments and common discharge locations shared between the east, central and west projects, and sizing would be modified as required to accommodate the construction catchments. - use of sediment management devices such as fencing, sandbags, coir logs and graded or lined earth or sandbag diversion bunds and banks	Construction

ID	Mitigation measure	Timing
	- measures to divert or capture and filter water prior to discharge, such as drainage diversion channels to flush and sediment sumps or traps - scour protection and energy dissipaters at locations of high erosion risk - location and storage of construction materials, fuels, and chemicals, including controls where possible to minimise the risk of leaks, spills and other unintended releases - storage of materials clear of frequently flooded low-lying areas - stabilisation of the surface of batters and drains, including temporary works and diversions - regular inspections and responsive adaptive management to improve erosion and sedimentation control practices as required to achieve the outcomes of the Blue Book. This will include inspections at regular intervals and after large rainfall events. • planning and management of stockpile areas in accordance with *Stockpile Site Management Guideline* (RMS, 2011a) • progressive and timely stabilisation and rehabilitation of disturbed areas, taking into account the ultimate requirements of the Place Design and Landscape Plan (PDLP) for the project (refer to environmental mitigation measure LV1) • a spill management procedure to minimise the risk of release of construction materials, fuels, and chemicals from construction sites. The procedure will include: - management of chemicals, fuels and potentially polluting materials - any specialised containment, security and bunding requirements (refer to environmental mitigation measure HR02) - maintenance of plant and equipment - emergency management, including notification, response, and clean-up procedures • measures to manage construction activities in areas prone to flooding or inundation, particularly around Rosedale Creek, including: - daily monitoring of weather conditions, including rainfall forecasts, to provide advance warning of potential flooding or inundation - cessation of relevant works and site security and stabilisation requirements in the event of a severe weather warning - site clean-up and recovery measures in the event of flooding or inundation • measures to manage acid sulfate rock, consistent with the Acid Sulfate Rock Management Plan (ASRMP) for the project (refer to environmental mitigation measure SC3).	

ID	Mitigation measure	Timing
SW2	A surface water monitoring network will be maintained for the project to: • continue to gather baseline surface water monitoring data to inform ongoing design development, and the updated numerical groundwater model for the project • characterise the hydrological environment along and around Greaves Creek and associated groundwater dependent ecosystems • monitor surface water, including surface water quality, prior to, during and for two years after completion of construction of the project • complement the groundwater monitoring network for the project (refer to environmental mitigation measure GW3). The surface monitoring network will be developed in consultation with relevant government agencies, and monitoring data will be made available to those agencies upon request. A qualified hydrologist or environmental scientist or equivalently experienced professional will be engaged to periodically review surface water monitoring data, and to advise on potential surface water impacts and appropriate mitigation and management measures prior to, during and after construction of the project.	Design, construction and operation
SW3	Batters constructed as part of the project will be designed and implemented to minimise risk of exposure, instability, and erosion, and to support long-term, on-going best practice management, in accordance with *Guideline for Batter Surface Stabilisation using Vegetation* (RMS, 2015).	Design and construction
SW4	Construction wastewater, including water from each construction site and groundwater ingress collected during tunnel works, will be treated to a suitable standard prior to reuse and/ or discharge to the environment. Water quality criteria for discharges to the environment will be developed in consultation with relevant government agencies, and will be based on the need to achieve a neutral or beneficial effect on sensitive receiving waters and drinking water catchments.	Construction
SW5	Operational wastewater will be treated via a mix of water quality control basins and a wastewater treatment plant at Little Hartley to a suitable standard prior to reuse and/ or discharge to the environment as part of routine operations. Water quality criteria for discharges to the environment will be developed in consultation with relevant government agencies, and will be based on the need to achieve a neutral or beneficial effect on sensitive receiving waters and drinking water catchments.	Operation
SW6	Further design development will be carried out to minimise flooding impacts and to meet flood criteria identified for the project.	Design