Appendix I Hydrology assessment

Snowy 2.0 Transmission Connection Project

Environmental Impact Assessment

(February 2021)

Snowy 2.0 Transmission Connection Project

Hydrology assessment

Rev 4

December 2020

TransGrid

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Executive summary

TransGrid is seeking approval under Part 5 Division 5.2 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) for the construction and operation of a transmission line connection and substation to enable the grid connection of the Snowy 2.0 pumped hydro generation project.

The existing landscape character of much of the project area consists of undisturbed mountainous terrain and forested valleys, and is the only true alpine environment in NSW (NPWS 2003). This landscape contains signs of limited previous human disturbance. Previous disturbance within the project area consists of existing transmission line corridors, minor access tracks, and infrastructure associated with the Talbingo Reservoir.

The eastern extent of the project is defined by the location of the proposed Snowy 2.0 cable yard at Lobs Hole Ravine in Kosciuszko National Park (KNP). From the Snowy 2.0 cable yard, the transmission connection extends west through KNP, through a landscape characterised by steep, mountainous terrain before traversing Talbingo Reservoir. The transmission connection then continues west, passing Elliott Way at three locations before entering Bago State Forest to the proposed substation site and the connection with existing transmission lines.

The project lies within Murrumbidgee catchment within the Snowy Mountains alpine region.

The construction and the operation of the project has the potential to impact waterways near and within the project area, from the erosion of soils, the dispersal of residual ash from the bushfires, tannin leachate from vegetation clearing and accidental leaks or spills of chemical and fuels if not appropriately managed.

The project is unlikely to impact groundwater resources, including other groundwater users or groundwater dependent ecosystems, nor is it anticipated to have any significant take of surface or groundwater resulting from either construction or operation. In the event that groundwater is encountered during excavations, the potential inflows would be expected to be minimal and associated impacts to be negligible. Any dewatering would be managed in accordance with a Soil and Water Management Plan (SWMP) to be developed as part of an overarching Construction Environmental Management Plan (CEMP).

Most project components are located away from flood prone land and would be at low risk of flooding during construction. However, heavy rainfall during construction could result in local overland flows entering excavations or stockpiles of construction materials, and spoil being washed away into nearby waterways, unless appropriate management measures are implemented. Appropriate management measures will be documented and implemented under the project SWMP.

The first pair of transmission structures in the eastern extent of the project and the waterway crossing at Sheep Station Creek would be located on flood prone land. In addition, the new substation would potentially be subject to overland flooding. As such, these components would be designed accordingly during detailed design to ensure appropriate flood immunity.

During operation, the project is not be expected to cause any significant adverse impacts to flooding of any nearby properties or infrastructure (including Snowy 2.0) nor are there expected to cause any significant changes in existing flow patterns or flooding conditions.

With the implementation of the proposed mitigation measures and preparation of a SWMP, the project is expected to have minimal impacts on hydrology during the construction and operational phases.

1. Introduction

1.1 Overview

TransGrid is the manager and operator of the major high-voltage electricity transmission network in New South Wales (NSW) and the Australian Capital Territory (ACT).

TransGrid is seeking approval under Part 5 Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the construction and operation of an overhead transmission connection and substation to enable the grid connection of the Snowy 2.0 pumped hydro generation project (Snowy 2.0) (the project).

The Snowy 2.0 Transmission Connection Project (the project) has been declared critical State Significant Infrastructure (SSI) under the *State Environmental Planning Policy (State and Regional Development) 2011*, and is subject to assessment and determination by the Minister for Planning and Public Spaces. This hydrology assessment has been developed in support of the Environmental Impact Statement (EIS) for the project.

1.2 Purpose of this technical report

This technical report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued for the project on 1 November 2019 by the Planning Secretary of the NSW Department of Planning, Industry and Environment (DPIE).

The SEARs relevant to this hydrology assessment are presented in **Table 1-1**, along with a reference to where these requirements are addressed in this hydrology working paper.

Table 1-1 Secretary's environmental assessment requirements – Surface Water and Groundwater

SEARs	Section addressed
A site water balance for the project, including water supply and wastewater disposal arrangements	**Section 6.5**
An assessment of the impacts of the project on: ▪ The quantity of the region's surface and ground water resources, including Yarrangobilly River, Wallaces Creek, Talbingo Reservoir and the Tumut River; ▪ Hydrological flows on site, including any potential flooding impacts;	**Section 5.8.1, Section 6** **Section 6**

2. Description of the project

2.1 Project components

The project would involve the construction and operation of an overhead transmission connection and substation to connect the Snowy 2.0 project to the National Electricity Market.

The key elements of the project include:

- A new 500/330 kilovolt (kV) substation located within Bago State Forest and adjacent to TransGrid's existing Line 64, which forms a 330 kV connection between Upper Tumut and Lower Tumut switching stations. The substation would occupy a footprint of approximately 300 metres (m) wide and 600 m long inclusive of an approximate 25 m to 45 me wide cleared asset protection zone (APZ) surrounding the switchyard
- Upgrade and widening of an existing access road off Elliott Way to the new substation including the construction of new driveways into the 330 kV and 500 kV switchyards
- Two new 330 kV overhead double-circuit transmission lines from the Snowy 2.0 cable yard to the new substation:
  - Total length of each line is approximately nine kilometres (km)
  - Located in a transmission corridor ranging in width from approximately 120 m to 200 m
  - Each line would comprise approximately 21 steel lattice structures up to 75 m in height
- Short overhead 330 kV transmission line connection (approximately 300 m in length) comprising both steel lattice structures and pole structures as required between the substation and Line 64
- Construction of approximately 10 km of new access tracks (Option A) or 8 km (Option B) to the transmission structures and upgrade to existing access tracks where required. Option A minimises disturbance within a mapped high risk naturally occurring asbestos (NOA) zone. The access tracks would remain following the completion of construction to service ongoing maintenance activities along the transmission lines
- Establishment of a helipad (approximately 30 m wide by 30 m long) to support the transmission line construction activities carried out at higher elevations
- Ancillary activities, including the establishment of tensioning and pulling sites for conductor and earth wire stringing, crane pads, site compounds, and equipment laydown areas.

The project location and key components of the project are shown in **Figure 2-1** and **Figure 2-2** respectively.

A complete project description which includes a consolidated summary and discussion of the construction and operation of the project is provided in Chapter 5 of the EIS.

2.2 Project location

The eastern extent of the project is defined by the location of the Snowy 2.0 cable yard at Lobs Hole in Kosciuszko National Park (KNP). The cable yard serves as the transition point between the underground cables carrying electricity generated by Snowy 2.0 to the overhead transmission connection. The cable yard forms part of Snowy 2.0.

From the cable yard, the transmission connection extends west through KNP and up Sheep Station Ridge which is characterised by steep, mountainous terrain before traversing Talbingo Reservoir. The transmission connection then continues west, passing over Elliott Way at three locations before entering Bago State Forest to the proposed substation site. The location of the project is shown in **Figure 2-1**.

2.3 Project area

For the purposes of predicting environmental impacts of the project, a **disturbance area** has been defined. The disturbance area encompasses the extent of physical disturbance likely to be required to accommodate construction activities and infrastructure needed to build the overhead transmission line, the permanent substation and access roads and vegetation clearing along the transmission line corridor.

A broader **project area** has also been defined. The project area represents the limits of where disturbance may occur during construction to allow for flexibility for the final siting of project infrastructure. Final siting of the infrastructure (i.e. the disturbance area) can move within the assessed project area subject to recommended environmental management measures and provided it does not exceed the limits defined by the project area.

The project traverses Talbingo Reservoir, which naturally splits the project area into two. When defining the area of works, the terms 'project area east' and 'project area west' have been used where required for the purpose of the EIS. These are defined as follows:

- **Project area east:** includes the project area and existing surrounding access roads in the area east of Talbingo Reservoir
- **Project area west:** includes the project area and existing surrounding access roads in the area west of Talbingo Reservoir.

The existing landscape character of much of the project area consists of undisturbed and mountainous terrain, forested valleys, and is the only true alpine environment in NSW (NPWS 2003). This landscape contains limited human disturbance, however existing transmission line easements, minor access tracks, and infrastructure associated with the Talbingo Reservoir are located within and surrounding the project area.

The project area and the disturbance area are shown in **Figure 2-2**.

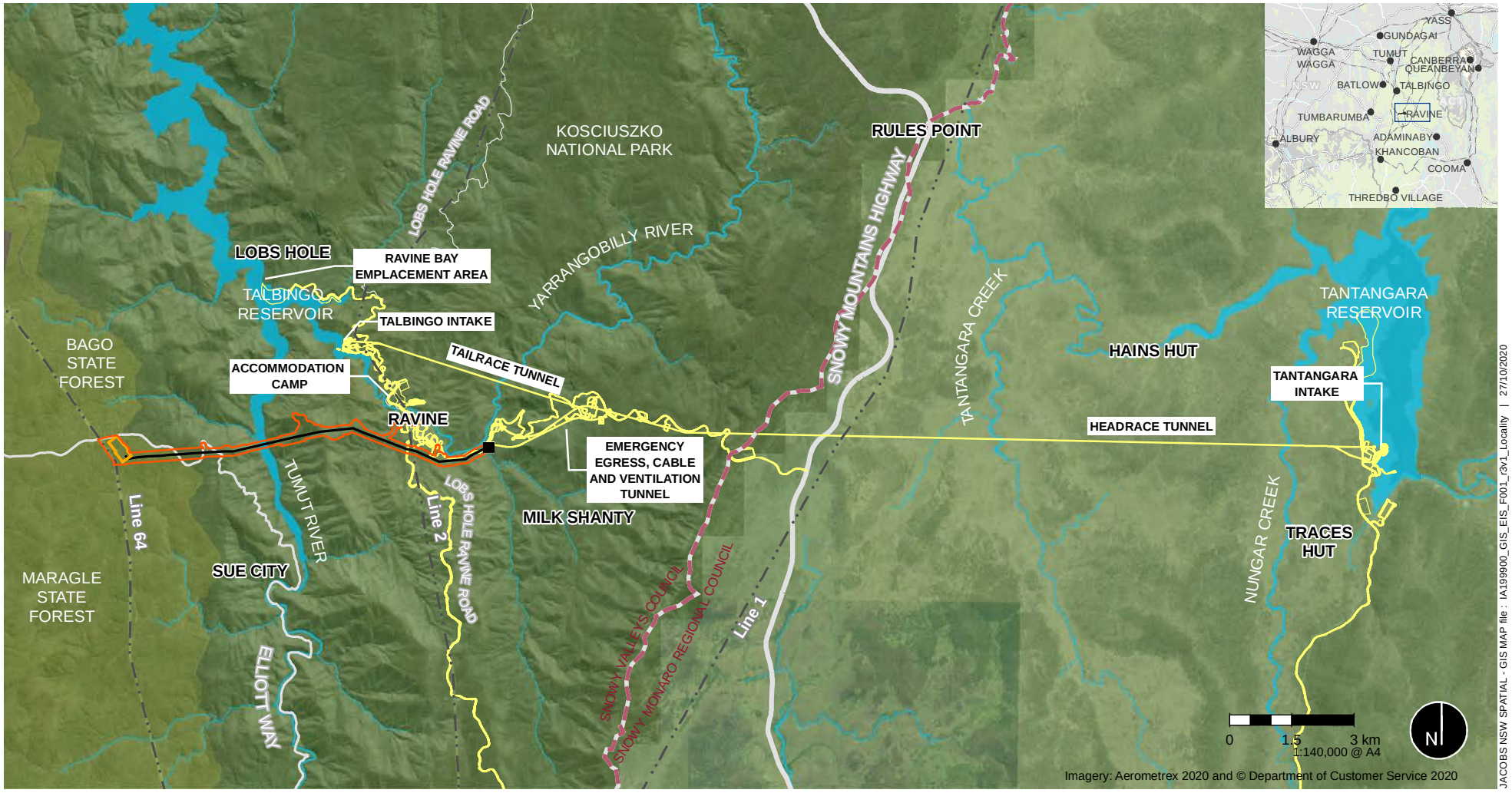
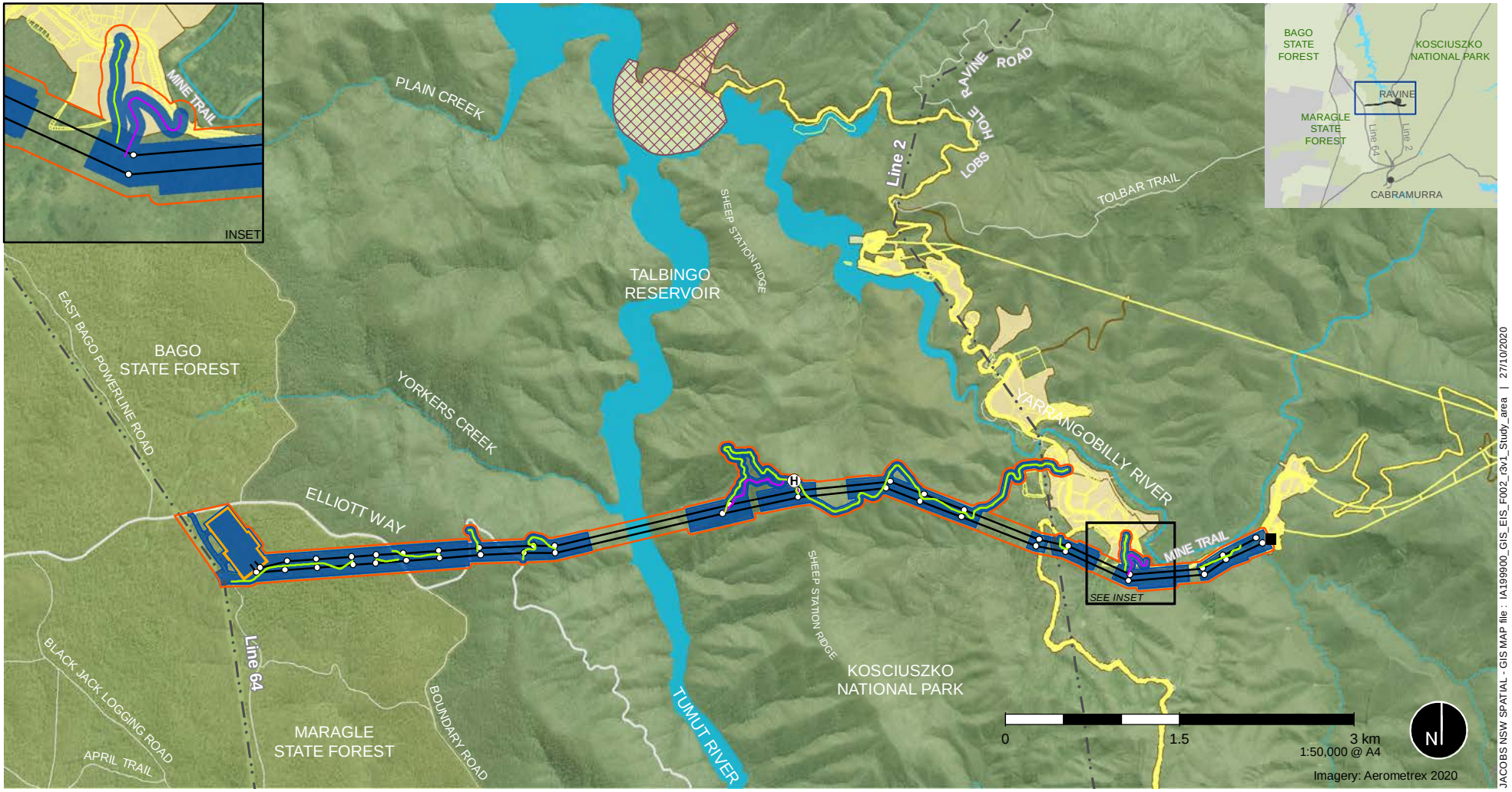


Figure 2-1 | Project location

Data source:
Jacobs 2020, TransGrid, EMM 2020
© Department Finance, Services and Innovation 2018



- Project area
- Disturbance area
- Proposed 500kV substation
- Potential helipad location
- Proposed structure
- Proposed transmission line
- Proposed access track - Option A
- Proposed access track - Option B
- Snowy 2.0 cable yard
- Snowy 2.0 element
- Ravine Bay Emplacement Area
- Snowy 2.0 Disturbance footprint
- Electricity transmission line
- Waterway
- Water body
- State forest
- NPWS estate

Figure 2-2 | Project overview

Data source:
Jacobs 2020, TransGrid, EMM 2020,

2.4 Construction activities

The construction works would commence with the construction of the access tracks to the substation and structure locations. Construction of the helipad is also expected to commence in the initial stages. Once suitable access has been established, construction of the substation and transmission connection would commence and occur concurrently.

A summary of the construction activities is provided in **Table 2-1**.

Table 2-1: Summary of construction activities

Construction activity	Description
Pre-construction, site establishment and vegetation clearance	▪ Site mobilisation once relevant approvals have been granted, property acquisitions have been finalised with Forestry Corporation of NSW (FCNSW) and National Parks and Wildlife Service (NPWS) and agreements with construction contractors has been achieved ▪ Surveying and marking out the approved disturbance area and any environmental avoidance areas ▪ Installation of appropriate stormwater and diversion drainage and erosion and sedimentation control works prior to ground disturbance and vegetation clearing ▪ Inform recreational users of KNP, Bago State Forest and Talbingo Reservoir of the construction activities, the extent of work areas and the locations of environmental exclusion areas with project notifications, including warning signs of construction activities and notifications of access restrictions ▪ Establishment of the construction compound and equipment laydown areas at the substation site and at Lobs Hole*.
Access tracks	▪ Vegetation clearing within the approved corridor. This is expected to be carried out both manually in the areas of steeper slopes and machine clearing where access can be safely achieved ▪ Grubbing and bulk earthworks (cut and fill) using an excavator ▪ Installation of suitable drainage structures and sediment retention basins where required ▪ Laying and compaction of a suitable rock aggregate/road base ▪ Grading and/or reshaping of existing tracks where required, within the existing access track width (no road widening) ▪ Minor excavations followed by laying and compaction of crushed rock or gravel, to improve the existing track surface and drainage.

Construction activity	Description
Substation	▪ Vegetation clearing across the substation site and surrounding APZ. This would involve the stripping and stockpiling of topsoil for later use. Vegetation clearing is expected to be carried out utilising a bulldozer equipment with a tree pusher, however would be confirmed in consultation with FCNSW ▪ Establishment of a site compound and laydown area within the cleared APZ. The site compound would be in place throughout the construction period and is expected to contain a demountable office, meal room, and toilet/shower facilities, equipment laydown areas, vehicle and equipment storage, maintenance sheds, chemical/fuel stores and stockpile areas ▪ Minor earthworks to establish the site amenities; which would include cut and fill to establish a level area for the site facilities and temporary storage areas and establishment of the permanent site access road ▪ Earthworks: ▪ Excavation works to remove excess material, provide a level surface, and create the required trenches for drainage, earthing, and electrical conduits. Some spoil from the excavation may be reused on site for filling and compaction (including benching areas of the site where required). Excavation works would be carried out using equipment such as excavators, dozers and crushing plant. Furthermore, depending on the underlying geology, blasting may be required to facilitate the break-up of rock, should it be present ▪ Bulk earthworks to establish the level surface for the substation bench ▪ Approximately 11,300 cubic metres of excess spoil would be generated from the levelling of the substation site and construction of the access road. Any soil which cannot be reused onsite as fill material, landscaping or other means would be disposed of off-site at a suitably licenced facility and/or at a location(s) as agreed with FCNSW ▪ Where excavated spoil is not appropriate for reuse on site, additional spoil would be imported to site. ▪ Civil and building works: ▪ Civil works involving the establishment of concrete footings for the high voltage equipment and buildings, construction of stormwater drainage and oil containment infrastructure and cable trenches and subsurface cables ▪ Construction of onsite buildings (e.g. control room) and services installed including general lighting, power and ventilation.
Transmission line	▪ Vegetation clearing within the approved transmission corridor where the overhead conductors would not meet safe clearance heights above the underlying vegetation ▪ Grading and/or reshaping of existing access tracks where required ▪ Vegetation clearing and bulk earthworks to establish the level helipad ▪ Establishment of the transmission structure work sites involving: ▪ Clearing of an approximate 40 m by 60 m area around each transmission structure location to allow for the laydown of materials and equipment and facilitate access for vehicles, plant and machinery during structure construction ▪ Bulk earthworks (cut and fill) to establish level construction benches within the worksite to allow for the safe operation of plant and equipment (namely elevated works platforms and cranes) during structure construction

Construction activity	Description
	▪ Geotechnical investigation works using a mobile drill rig at each structure location to determine the most appropriate footing design ▪ Bulk earthworks and excavations to establish the structure footings involving the installation of steel framework and backfilling with concrete or pile type footings involving boring four boreholes at each structure leg location and backfilling with concrete ▪ Steel lattice structures would be transported to each structure location via heavy vehicle in parts and assembled on site using mobile cranes ▪ Stringing of conductor and overhead earth wire which would involve: ▪ Establishment of level tensioning and pulling sites within the approximate 40 m by 60 m structure worksite or at suitable locations within the transmission line corridor ▪ Attachment of sheaves (or pulleys) to the top of the structures in readiness for stringing work using an elevated work platform ▪ Pulling out a light weight draw wire across the section of line being strung using a drone or, vehicle/machine (such as dozer), followed by the placement of the draw wire through the sheaves ▪ Attachment of the draw wire to the earth wire or conductor drum (depending on which is being strung) and pulling it through the sheaves under tension using specialised tensioning and pulling equipment ▪ Termination of the conductor/earth wire at each end clipping it into position followed by the removal of the sheaves.
Commissioning	▪ Testing of all high voltage equipment at the substation and ensuring all protection, control and metering equipment is operating correctly ▪ Completion of all necessary cut-in works to Line 64 and relevant testing undertaken ▪ Placement of the new transmission lines and substation into standby in readiness for Snowy 2.0 to be completed ▪ Once Snowy 2.0 becomes operational, energisation of the high voltage equipment and the project placed into service.

Construction activity	Description
Rehabilitation and demobilisation	▪ Removal of all non-permanent infrastructure and equipment from the work sites and site compounds ▪ Decommissioning and dismantling of the site compounds at the substation and Lobs Hole ▪ Site stabilisation and landscaping involving: ▪ Stabilisation of exposed areas and slopes ▪ Installation and maintenance of erosion and sediment controls at the work sites to manage impacts post-construction ▪ Seeding soil slopes to assist stabilisation ▪ Planting vegetation on any higher risk slopes ▪ Mulching of stabilised and revegetated areas where required.

*The site compound at Lobs Hole would be located within the approved disturbance footprint of Snowy 2.0.

2.4.1 Construction staging and timing

Construction of the project is anticipated to commence in early 2022 and take approximately 39 months to complete. Estimated timing for the main construction activities is set out in **Figure 2-3**. Further details on the estimated timing and staging of the main project activities is described in Section 5.3 of the EIS.

Construction works	2022				2023				2024				2025
Quarter	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Access tracks, roads and helipad													
330 kV Switchyard													
500 kV Substation													
Transmission connection													

Figure 2-3: Indicative timing for the construction of key project components

2.4.2 Construction working hours

Given the isolated location and the Snowy 2.0 occurring in parallel, construction works are expected to be carried out 12 hours per day, seven days per week between the hours of 6 am and 6 pm.

2.5 Operation and maintenance

The substation and transmission connection would be inspected by field staff on a regular basis. Key activities undertaken during operation would include:

- Regular inspection and maintenance of electrical equipment at the substation including structural integrity of all footings and support structures
- General inspection and maintenance of other components within the substation including the stormwater management system, fire detection system, onsite buildings and drainage infrastructure
- Regular inspection and maintenance of the transmission structures, footings, fittings, conductors and overhead earth wires

- Vegetation removal and trimming along the transmission corridor and APZ surrounding the substation to maintain appropriate clearances between ground vegetation and the overhead transmission lines and around the substation to manage bushfire risk
- Removal of trees which have the potential to strike the overhead conductors if they were to fall (referred to as hazard trees) as required.

It is expected that only light vehicles and small to medium plant would need to access the substation site and the transmission corridor for these activities. The substation would not accommodate full-time staff or contractors, and the regular collection of waste would not be required. Any waste generated during operation of the substation would be minimal and disposed of on an 'as need' basis.

2.6 Other relevant technical information

2.6.1 Substation stormwater and drainage

An impervious surface and an oil containment system would be installed as part of the substation development. The on-site stormwater drainage system would allow stormwater flows from the site to be diverted appropriately away from the switchyard. The stormwater and drainage system would be developed during detailed design, however is expected to include a series of surface drains which would connect with a grid of stormwater pits within the substation site.

2.6.2 Access tracks and roads

New access roads and tracks would be required to allow for vehicles, plant, machinery and equipment to be transported to the work locations, including all transmission structures and the helipad during the construction phase. The access tracks would be approximately 5 m wide and would be retained to facilitate ongoing maintenance activities of the transmission lines and provide access during emergency events such as bushfire.

The new access tracks and roads would be of suitable grade to allow deliveries of large equipment and plant (such as transmission structures, concrete trucks, cranes, elevated work platforms etc) and allow for the turning radius of the vehicles. Where required, adequate sediment retention basins would be included in the access track design to manage erosion sedimentation and associated impacts on receiving waters.

Given the complex terrain and steep gradients, the establishment of linear access tracks was not feasible at some locations. Consequently, their design and location were primarily driven by the existing terrain. The final layout of access tracks would be established as part of the detailed design process.

A new waterway crossing would be required at Sheep Station Creek for the access track in this location. This crossing is expected to be either a small bridge or a large culvert and would be designed accordingly during detailed design.

3. Legislative and policy framework

Legislation applicable to surface water, groundwater, hydrology and flooding is outlined in this section.

3.1 NSW legislation and policies

3.1.1 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the *Water Act 1912* and the *Water Management Act 2000* (WM Act) by DPIE. The *Water Act 1912* is gradually being repealed and replaced by the WM Act. Some aspects are still operational across all of NSW, such as the requirement to hold a licence for all monitoring bores greater than 40 m in depth. This requirement would not be applicable to the project.

The aims of the WM Act are to provide for the sustainable and integrated management of the State's water sources for the benefit of both present and future generations. The WM Act implicitly recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The WM Act enables the State's water resources to be managed under water sharing plans, which establish the rules for the sharing of water in a particular water source between water users and the environment, and rules for the trading of water in a particular water source.

The WM Act establishes a system of licensing and approvals whereby access to water is generally regulated by way of water access licences (WALs). The majority of water access licences are issued under the WM Act, however where there is no water sharing plan, some access rights are still issued in the form of licences or permits under the *Water Act 1912* which are tied to the land.

The project is located within the Murrumbidgee water management area and is subject to the *Water Sharing Plan (WSP) for the Murrumbidgee Unregulated and Alluvial Water Sources* (2012). This plan applies to surface water sources and includes rules for protecting the environment, water extraction, managing licence holders' water accounts and water trading within the plan area.

The applicable groundwater source to the project area is the *Lachlan Fold Belt Murray Darling Basin Groundwater Source* of the *Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020*.

3.1.2 Protection of the Environment Operation Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the Environment Protection Authority (EPA). The POEO Act regulates air and water pollution, noise control and waste management. Under the POEO Act, there is a legal responsibility to ensure that runoff leaving a site meets an agreed water quality standard. There is a duty to notify relevant authorities of pollution incidents where material harm to the environment is caused or threatened.

3.1.3 NSW Aquifer Interference Policy (2012)

The *NSW Aquifer Interference Policy* (2012) outlines minimal impact considerations for water table and groundwater pressure drawdown for high priority Groundwater Dependent Ecosystems (GDEs) (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing groundwater supply bores. Water quality impact considerations are also outlined.

The project area has been interpreted as being within a 'less productive groundwater source' on the basis of low bore numbers, and expected low yields, for which the following impact considerations apply for fractured rock groundwater sources:

- Less than or equal to 10 per cent cumulative decline in the water table 40 m from any high priority groundwater dependant ecosystem or high priority, groundwater related, culturally significant site
- A maximum of 2 m cumulative decline in the water table or pressure head at any water supply work
- Any change in groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

If any of these conditions cannot be met, then appropriate studies would need to demonstrate to the Minister's satisfaction that the change in water level, pressure or groundwater quality would not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

Impact limits to high priority GDEs and culturally significant sites as outlined in the Aquifer Interference Policy (DPI NOW, 2012) are not applicable for project as high priority GDEs and culturally significant sites are not mapped within approximately 10 km of the site (refer **Section 5.7.5**).

3.1.4 Groundwater Dependent Ecosystems Policy

The NSW State Groundwater Dependent Ecosystems Policy (Department of Land and Water Conservation, 2002) implements the WM Act by providing guidance on the protection and management of GDEs. It sets out management objectives and principles to:

- Ensure that the most vulnerable and valuable ecosystems are protected
- Manage groundwater extraction within defined limits thereby providing flow sufficient to sustain ecological processes and maintain biodiversity
- Ensure that sufficient groundwater of suitable quality is available to ecosystems when needed
- Ensure that the precautionary principle is applied to protect groundwater dependent ecosystems, particularly the dynamics of flow and availability and the species reliant on these attributes
- Ensure that land use activities aim to minimise adverse impacts on groundwater dependent ecosystems.

3.2 Relevant guidelines

3.2.1 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS) is the adopted national approach to protecting and improving water quality in Australia. It consists of a number of guideline documents, of which certain documents relate to protection of surface water resources and others relate to the protection of groundwater resources.

The primary document relevant to the assessment of groundwater risks for the project is the *Guidelines for Groundwater Quality Protection in Australia* (Australian Government, 2013). This document sets out a high-level risk-based approach to protecting or improving groundwater quality for a range of groundwater beneficial uses (called 'environmental values'), including aquatic ecosystems, primary industries (including irrigation and general water users, stock drinking water, aquaculture and human consumption of aquatic foods), recreational and aesthetic values (e.g. swimming, boating and aesthetic appeal of water bodies), drinking water, industrial water and cultural values.

For the purpose of this groundwater assessment, all of the above 'environmental values' have been considered applicable, which is conservative.

3.2.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ 2000) has published the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* to provide benchmarks for assessment of the existing marine and fresh water quality for aquatic ecosystem protection and primary

industries and direction to guidelines for human health (drinking water, recreation and aesthetics). Further revisions to the Guideline were made in 2018 with the release of a web-based guideline (ANZG 2018). Together the Guideline and the updated ANZG (2018) guideline forms part of the *National Water Quality Management Strategy*.

The water quality guidelines and objectives to be applied in the assessment of surface water quality are presented in **Table 4-2.** These guidelines and objectives are dependent on nominated environmental values identified in **Section 4.1.2**. The objective adopted for the protection of aquatic ecosystems is "to maintain and enhance the ecological integrity of freshwater and estuarine ecosystems, including biological diversity, relative abundance and ecological processes". Aquatic ecosystems could be defined as ecosystems that depend on flows, or periodic or sustained inundation to preserve their ecological integrity (e.g. river, creeks, wetland and groundwater dependent ecosystems).

3.2.3 NSW Water Quality Objectives

The *NSW Water Quality Objectives* (WQO) are the agreed environmental values and long-term goals for NSW's surface water (DECC 2006). They set out:

- The community's values and uses (i.e. healthy aquatic ecosystems, water suitable for recreation or drinking water etc) for our waterways (rivers, creeks, lakes and estuaries)
- A range of water quality indicators to assess whether the current condition of the waterway supports these values and uses.

The water quality objectives are consistent with the agreed national framework for assessing water quality set out in the ANZECC/ARMCANZ (2000) and ANZG (2018) Guidelines. These guidelines provide an agreed framework to assess water quality in terms of whether the water is suitable for a range of environmental values (including human uses). The WQO provide environmental values for NSW water and the ANZECC/ARMCANZ 2000 and ANZG (2018) Guidelines provide the technical guidance to assess the water quality needed to protect those values (DECCW 2006).

3.2.4 NSW Floodplain Development Manual

The NSW Floodplain Development Manual (2005) is a document that supports the development of sustainable strategies for managing human occupation and use of the floodplains considering risk management principles. The manual was prepared in accordance with the NSW Government's Flood Prone Land Policy, which has the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits flowing from the use, occupation and development on flood prone land.

3.2.5 Australian Rainfall and Runoff

Australian Rainfall and Runoff (Ball et al., 2019) is a national guideline for the estimation of design flood characteristics in Australia. The approaches presented in Australian Rainfall and Runoff (ARR) are essential for policy decisions and projects involving:

- Infrastructure such as roads, rail, bridges, dams and stormwater systems
- Floodplain risk management plans for urban and rural communities
- Flood warnings and flood emergency management
- Estimation of extreme flood levels.

4. Assessment methodology

4.1 Study methodology

The assessment of likely and potential impacts of the project on hydrology during construction and operation has included:

- Review of existing literature relating to the project, available hydrology data and existing conditions using available literature to obtain background information on catchment history and land use to aid in interpreting the existing conditions
- Assessment of the potential impact of construction activities on water quality with reference to the *NSW Water Quality Objectives* (DECCW 2006) and ANZECC/ARMCANZ (2000) and *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG) (2018) water quality guidelines for protection of the key environmental values. The water quality values are provided in **Section 4.1.2**
- Assessment of the potential impact of construction activities on groundwater with reference to the *NSW Aquifer Interference Policy* (DPI Water, 2012)
- Identification of appropriate measures to mitigate the potential impacts resulting from construction and operation of the project
- Review of water quality treatment measures that could be used to mitigate the impact of construction on water quality, following the principles of *Managing Urban Stormwater–Soils and Construction Volume 1* (Landcom, 2004) and Volume 2C (Unsealed Roads) (DECC, 2008).

4.1.1 Desktop assessment for hydrology and flooding

A desktop hydrology and flooding assessment has been undertaken for the project in order to:

- Define the existing flood behaviour though a review of the topographic data and available literature including the flooding assessment carried out for Snowy 2.0
- Undertake a qualitative assessment of potential impacts for the construction phase of the project and identify measures to address adverse impacts on flooding
- Identify potential impacts of the project on flooding for the operational phase and identify measures to mitigate adverse impacts on flooding
- Recommend safeguards and mitigation measures to manage potential impacts on flooding during construction and operation.

4.1.2 Water quality

4.1.2.1 Environmental values

Water quality and river flow objectives have been determined for the Murrumbidgee catchment based on the *NSW Water Quality Objectives* and *the Australian and New Zealand Environment and Conservation* Council (ANZECC/ARMCANZ 2000) and the ANZG (2018) guidelines for water quality. These objectives and guidelines provide benchmarks for assessment of the existing water quality of the river. The application of the criteria is dependent on the environmental values assigned to the waterway.

Areas within the catchment are categorised by the environmental values or uses of the environment that are important for a healthy ecosystem or for public benefit or health. They are values that require protection from the effects of pollution and waste discharges and provide goals that help in the selection of the most appropriate management options (ANZECC/ARMCANZ, 2000 and ANZG, 2018).

Waterways within the project area have been categorised as 'Streams affected by Snowy Scheme' and 'Mainly forested area' as they fall within the Kosciuszko National Park. Streams affected by the Snowy Scheme either contribute to or receive flow from the Snowy Mountains Hydro-electric Scheme and are therefore valued for resource uses. Mainly forested areas are streams in areas that are valued for conservation or recreation and generally drain catchments covered mainly by mature forest or woodland which are likely to have relatively natural flows and water quality.

The environmental values have been considered in the assessment of existing water quality and potential impacts as a result of the project. Key water quality indicators and related numerical criteria have been nominated for each environmental value using the DECCW (2006), ANZECC/ARMCANZ (2000) and ANZG (2018) water quality guidelines. The environmental values nominated for waterway categories are provided in **Table 4-1**. A summary of indicators and guideline values (ANZECC/ARMCANZ, 2000; ANZG, 2018) associated with each indicator, which were relevant to the assessment, based on available water quality data and potential construction and operational pollutants, is provided in **Table 4-2**.

Table 4-1: Environmental values for waterways in the project area

Category	Environmental values										
	Aquatic ecosystems	Visual amenity	Secondary contact recreation	Primary contact recreation	Livestock water supply	Irrigation water supply	Homestead water supply	Drinking water at point of supply – disinfection only	Drinking water at point of supply – clarification and	Drinking water at point of supply – groundwater	Aquatic foods (cooked)
Streams affected by Snowy Scheme	X	X	X	X		X	X	X	X	X	X
National Parks, Nature Reserves and State Forest (Mainly Forested Area Objective)	X	X	X	X				X	X	X	X

Table 4-2: Water quality indicators and guideline values

Environmental value/ Water quality objective	Indicator	Upland River	Lakes and Reservoirs
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	Total phosphorus	0.02 mg/L	0.01 mg/L
	Total nitrogen	0.25 mg/L	0.2 – 0.3 mg/L
	Turbidity	2-25 NTU	1-20 NTU
	Salinity (Electrical conductivity)	30-350 µS/cm	20-30 µS/cm
	Dissolved oxygen	90-120 % saturation	90-120 % saturation
	pH	6.5-8	6-8
	Toxicants	As per ANZG (2018) toxicant default guideline values	As per ANZG (2018) toxicant default guideline values
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter 0.25 mg/L	
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts	
Secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	Algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water. Secondary contact recreation – maintaining or improving water quality for activities such as boating and wading, where there is a low probability of water being swallowed	
	Nuisance organisms	As per the visual amenity guidelines Large numbers of midges and aquatic worms are undesirable.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation Toxic substances should not exceed values in table 9.3 of NHMRC (2008) guidelines	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Surface films	As per the visual amenity guidelines.	

Environmental value/ Water quality objective	Indicator	Upland River	Lakes and Reservoirs
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Algae and blue-green algae	As per the NHMRC 2008 Guidelines for managing risks in recreational water.	
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values in table 9.2 of NHMRC (2008) guidelines.	
	Visual clarity and colour	As per the visual amenity guidelines.	
	Temperature	15°-35°C for prolonged exposure.	
Irrigation water supply – protecting the quality of waters applied to crops and pasture	Algae and blue-green algae	Should not be visible. No more than low algal levels are desired to protect irrigation equipment.	
	Salinity (electrical conductivity)	To assess the salinity and sodicity of water for irrigation use, a number of interactive factors must be considered including irrigation water quality, soil properties, plant salt tolerance, climate, landscape and water and soil management. For more information, refer to Chapter 4.2.4 of ANZECC 2000 Guidelines.	
	Thermotolerant coliforms (faecal coliforms)	Trigger values for thermotolerant coliforms in irrigation water used for food and non-food crops are provided in table 4.2.2 of the ANZECC Guidelines	
	Heavy metals and metalloids	Long term trigger values (LTV) and short-term trigger values (STV) for heavy metals and metalloids in irrigation water are presented in table 4.2.10 of the ANZECC 2000 Guidelines.	
Homestead water supply – protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Blue-green algae	Recommend twice weekly inspections during danger period for storages with history of algal blooms. No guideline values are set for cyanobacteria in drinking water. In water storages, counts of < 1000 algal cells/mL are of no concern >500 algal cells/mL - increase monitoring >2000 algal cells/mL - immediate action indicated; seek expert advice >6500 algal cells/mL - seek advice from health authority	
	Turbidity	5 NTU; <1 NTU desirable for effective disinfection; >1 NTU may shield some micro-organisms from disinfection	
	Total dissolved solids	<500 mg/L is regarded as good quality drinking water based on taste 500-1000 mg/L is acceptable based on taste >1000 mg/L may be associated with excessive scaling, corrosion and unsatisfactory taste.	
	pH	6.5-8.5	
	Chemical contaminants	See Guidelines for Inorganic Chemicals in the *Australian Drinking Water Guidelines* (NHMRC & NRMMC 2004).	
Drinking water – disinfection only, clarification and disinfection, groundwater –	Blue-green algae	Recommend twice weekly inspections during danger period for storages with history of algal blooms >500 algal cells/mL - increase monitoring	

Environmental value/ Water quality objective	Indicator	Upland River	Lakes and Reservoirs
refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment		<2000 algal cells/mL - water may be used for potable supply >2000 algal cells/mL - immediate action indicated; seek expert advice >6500 algal cells/mL - seek advice from health authority >15 000 algal cells/mL - may not be used for potable supply except with full water treatment, which incorporates filtration and activated carbon.	
	Turbidity	Site specific determinant	
	Salinity (electrical conductivity)	<1500 µS/cm > 800 µS/cm causes a deterioration in taste	
	Dissolved oxygen	>80% saturation	
	pH	6.5-8.5	
	Chemical contaminants	See ANZECC 2000 guidelines, section 6.2.2.	
Aquatic foods (cooked) – refers to protecting water quality so that it is suitable for production of aquatic foods for human consumption and aquaculture activities	Algae and blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.	
	Toxicants (as applied to aquaculture activities)	Metals: Copper: less than 5 µgm/L Mercury: less than 1 µgm/L Zinc: less than 5 µgm/L. Organochlorines: Chlordane: less than 0.004 µgm/L (saltwater production) PCB's: less than 2 µgm/L.	
	Physico-chemical indicators (as applied to aquaculture activities)	Temperature: less than 2 degrees Celsius change over one hour. Suspended solids: less than 40 micrograms per litre (freshwater)	

4.1.2.2 Data analysis

Water quality data used in this report is sourced from a variety of recent assessments undertaken as part of the Snowy Exploratory and Main Works assessments. Available data was largely sourced from waterways east of the Talbingo Reservoir. Whilst it is expected that water quality to the west would be similar to the east given there is little variation in surrounding landuse, this does present a data gap. However, given purpose of water quality data at this stage of the assessment is to determine if the WQO are currently being met it does not impact on the findings in this report.

4.1.2.3 Sensitive receiving environments

Sensitive receiving environments (SREs) are environments that have a high conservation value or support ecosystems/human uses of water that are particularly sensitive to pollution or degradation of water quality. It is important to identify SREs that are directly impacted by the project or are located downstream of project activities so that these values may be adequately protected.

For the purposes of this assessment, SREs have been determined using aquatic habitat as an indicator. The level of sensitivity of an aquatic environment was determined through classification of key fish habitat (KFH) "Type" and waterway "Class" in accordance with criteria outlined in the Department of Primary Industries (DPI*) Policy and Guidelines for Fish Habitat Conservation and Management* (2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge, 2003), respectively. The assessment of KFH "Type" is based on the presence of habitat structures such as woody debris, macrophytes and substrate characteristics, as well as on the predicted presence of threatened aquatic species (DPI, 2013). Assessment of waterway "Class" is determined by physical characteristics of the waterway (Fairfull & Witheridge, 2003).

SREs within the project study area have been identified and described in Section 5.9.

5. Existing environment

5.1 Catchment overview

The project is located at the headwaters of the Murrumbidgee catchment within the Snowy Mountains alpine region. The catchment is characterised by 5100 square km of national parks and reserves including the KNP. Significant water diversions occur for irrigated agriculture and private land holders (DPI Water 2017). As such, environmental flows and a cap on diversion of water were introduced to improve river health, as part of the Murrumbidgee Water Resource Plan (DPI Water 2017). Snowy Hydro Limited (Snowy Hydro) is required to release to the Murrumbidgee 1,026,000 megalitres (ML) of water year per year, which may vary from year to year depending upon climatic conditions under the Water Licence 2010 (DPI Water 2017).

5.2 Climate

Average rainfall in the Murrumbidgee catchment is approximately 1000 millimetres (mm) per annum in the headwaters. Within the upper catchment, rain falls year-round, however the highest rainfall occurs in winter and spring. The lower catchment relies on summer thunderstorms which are less predictable, and the areas can be susceptible to prolonged periods of drought (DPI Water 2017).

5.3 Bushfires

Bushfires are known to occur in Australia, and while having a devastating impact on communities, the environment and economy, they also affect the quality and quantity of water in streams, rivers and dams. In early 2020, areas of the Murrumbidgee catchment were affected by bushfires.

The 2019/2020 bushfires have affected the project area and beyond extensively. Affected areas have received varying degrees of damage or destruction to vegetation, as well as damage to slopes and roads including Elliott Way. The impact of the bushfires are discussed further in Bushfire Assessment (Jacobs, 2020).

A Google Earth Engine Burnt Area Map (GEEBAM) was produced to visually represent where bushfires in NSW have affected vegetation (NSW Government 2020). These areas were assigned a Burnt Area Class ranging between 0 to 6 and described below, noting there is no class 1 (NSW Government 2020).

- Class 0 – No data
- Class 2 – Low (burnt understory with unburnt canopy)
- Class 3 – Medium (canopy partially burnt, understory may be burnt)
- Class 4 – High (canopy and understory are likely to be completely burnt)
- Class 5 – Very high (the canopy or highest stratum have been completely consumed)
- Class 6 – Not native vegetation.

The GEEBAM mapping tool indicates that the project is located within an area that has largely been classified as Class 4 or 5 and therefore has been significantly impacted by bushfires. This presents a high risk of contamination to water quality, as rainfall could result in ash and sediment being transported to downstream waterways. At present, there is a high potential for downstream water quality impacts to waterways within the project area from bushfire contamination and high turbidity (MDBA 2020), however there has not be a significant rain event (to date) in the Upper Murrumbidgee that could cause mobilisation of poor-quality runoff to downstream receiving environments. On-going surface water monitoring has been carried out for Snowy 2.0, extending on the program that was implemented for Snowy 2.0 Exploratory Works as well as ongoing baseline monitoring.

5.4 Topography

Topography is highly variable within the project area, ranging from elevated plateaus in project area west, to steeply incised valleys and ridges surrounding Talbingo Reservoir and Yarrangobilly River, and narrow alluvial terraces in the base of the Yarrangobilly River valley in project area east.

5.5 Waterways

Waterways within the project area have been classified according to the Strahler stream classification system where waterways are given an order according to the number of additional tributaries associated with each waterway (Strahler, 1952). A first order stream, otherwise known as headwater streams begin at the top of a catchment. They are generally the smaller tributaries that carry water from the upper reaches of the catchment to the main channel of the river and are rarely named. Where two first order streams join, the section downstream of the junction is referred to as a second order stream. Additionally, where two second order streams join, the waterway downstream is classified third order and so on. Where a lower order stream (e.g. first) joins a higher order stream (e.g. third) the area downstream of the junction retains the higher order. The waterways within the project area are shown on **Figure 5-1**.

5.5.1 Major river and basin systems

The Tumut River crosses beneath the proposed transmission connection, travelling for 182 km before entering the lower Murray Darling Basin. The waterway is the largest tributary of the Murrumbidgee River and contains several water storage dams along its length including; Talbingo and Blowering Dam Reservoir. Talbingo Reservoir is a major rock fill dam forming part of the Snowy Hydro Scheme and is crossed by the Project area near the confluence of the Tumut River and Yarrangobilly River. Blowering Dam is an additional 22 km downstream and is one of the largest dams in NSW (DPI Water 2017).

5.5.2 Waterways crossed by the project

A total of 29 waterways traverse the project area, including several named waterways and unnamed drainage lines (refer to **Table 5-1**). The main alignment would traverse 11 waterways and drainage channels including minor tributaries of Yorkers Creek and Tumut River, Tumut River (and Talbingo Reservoir), Sheep Station Creek, Lick Hole Gully, Cave Gully, Wallaces Creek, and minor tributaries of Yarrangobilly River. Other key project elements including the proposed access tracks and substation would also traverse existing waterways as listed below:

- Proposed access tracks – Option A will cross five waterways and drainage lines – two minor tributaries of Tumut River (and Talbingo Reservoir), Sheep Station Creek an unnamed drainage line and a minor tributary to Yarrangobilly River.
- Substation would cross two waterways – New Zealand Gully and a minor tributary of Yorkers Creek
- Proposed access track – Option B would not traverse any waterways.

Six waterways within the project area are stream order three or greater and have also been mapped as KFH (DPI 2013) as shown on **Figure 5-1** and detailed in **Table 5-1**. The waterways include Wallaces Creek (**Photo 5-1**), Tumut River (and Talbingo Reservoir) (**Photo 5-2**) and Yarrangobilly River (**Photo 5-3**) which are major waterways greater than sixth order, and Sheep Station Creek, (**Photo 5-4**) Lick Hole Gully and Cave Gully (**Photo 5-5**) which are third order streams. A tributary of Lick Hole Gully, which is second order and has been mapped as KFH

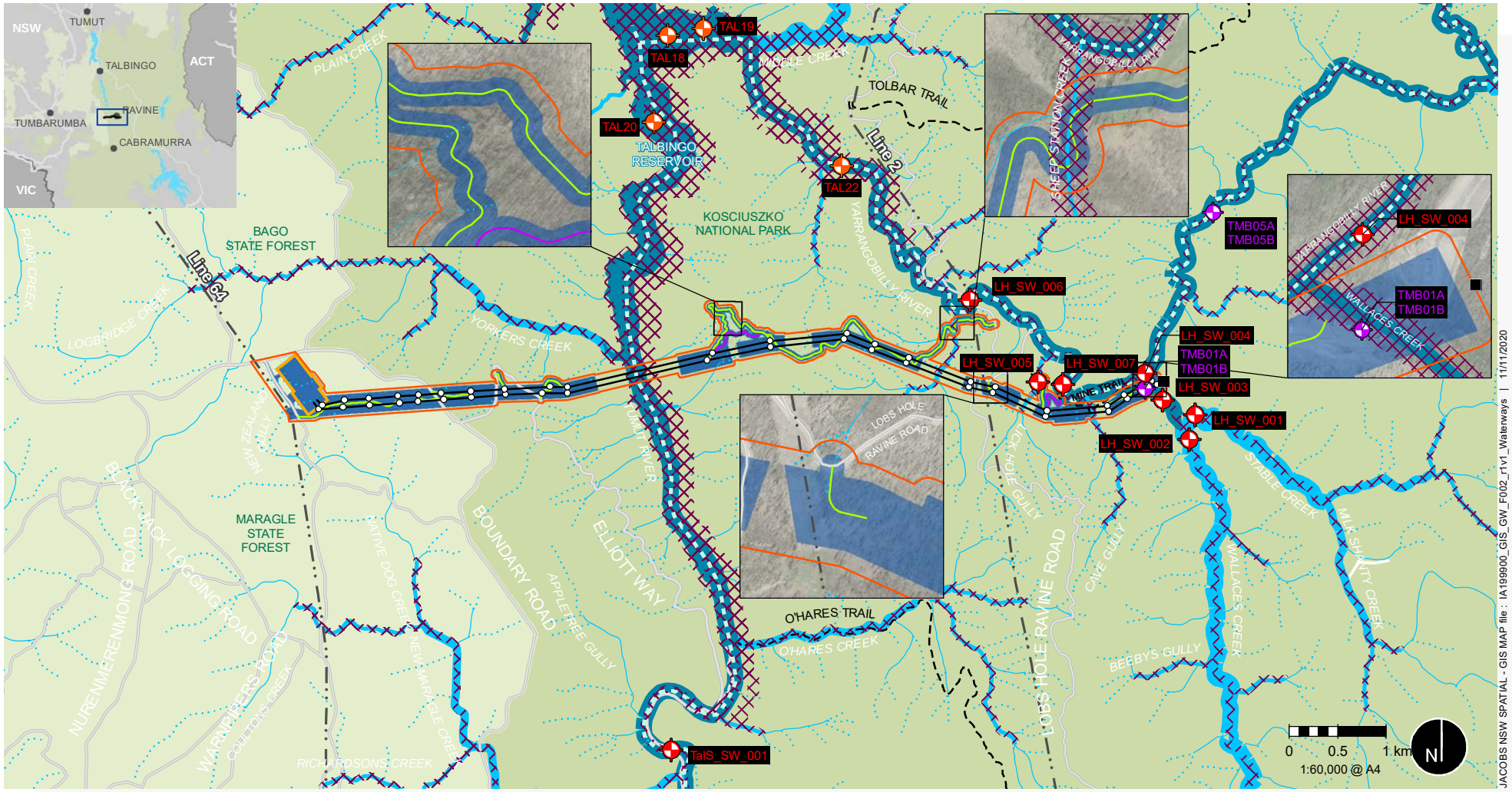
Twenty-one generally unnamed gullies/drainage lines also occur within the project area. These gullies are first order, ephemeral and have little to no channel definition. Most of these first order streams are not considered KFH and are only likely to contain water for brief periods of time following high rainfall. The Yarrangobilly River

is included in this assessment as it occurs approximately 35 m from the project area, at the eastern edge of the project and several tributaries drain to it. Of the first order streams, only unnamed tributary of Yorkers Creek was visited.

Table 5-1: Waterways within the project area

Waterway name	Easting (mga55)	Northing (mga55)	Strahler	KFH	Project element
Unnamed tributary of Yorkers Creek (at Substation)*	618917.7147	6038111.002	1		Substation switchbays
New Zealand Gully (at Substation)	619064.7075	6037957.417	1		Substation APZ
Unnamed tributary of Yorkers Creek	620946.6718	6038030.785	1		Transmission line
Tumut River (and Talbingo Reservoir)*	622416.4189	6038224.169	6	KFH	Transmission line
Unnamed tributary of Tumut River	623366.904	6038439.545	1		Transmission line
Unnamed tributary of Tumut River	623559.6819	6038453.458	1		Transmission line
Unnamed tributary of Tumut River	623318.476	6038825.667	1		Access track (option A)
Unnamed tributary of Tumut River	623351.0582	6038693.355	1		Access track (option A)
Unnamed tributary of Yarrangobilly River	624186.8837	6038574.486	1		Transmission line
Sheep Station Creek	625697.376	6038664.255	3	KFH	Access track (option A)
Unnamed drainage line	626043.7484	6038732.757	1		Access track (option A)
Sheep Station Creek*	625547.5592	6038237.374	3	KFH	Transmission line
Unnamed tributary of Yarrangobilly River	626056.6822	6038139.087	1		Access track (option A)
Lick Hole Gully*	626437.0078	6037913.864	3	KFH	Transmission line
Unnamed tributary of Yarrangobilly River	626717.4617	6037819.638	1		Transmission line
Unnamed tributary of Yarrangobilly River	626966.3605	6037840.518	1		Transmission line
Cave Gully*	627124.4018	6037853.73	3	KFH	Transmission line
Wallaces Creek*	627689.2029	6038093.12	6	KFH	Transmission line
Unnamed tributary of Native Dog Creek	619302.8638	6037804.487	1		Project area
Unnamed tributary of Yorkers Creek	620502.0268	6038092.707	1		Project area
Unnamed tributary of Yorkers Creek	621427.9342	6038114.343	1		Project area
Unnamed tributary of Yorkers Creek	621958.6485	6038188.599	1		Project area
Unnamed tributary of Sheep Station Creek	624800.3803	6038456.574	1		Project area
Unnamed tributary of Sheep Station Creek	625515.5601	6038308.858	1		Project area
Unnamed tributary of Sheep Station Creek	625835.2004	6038219.707	1		Project area
Unnamed tributary of Yarrangobilly River	626006.6552	6038164.332	1		Project area
Unnamed tributary of Sheep Station Creek	625562.3342	6038651.338	2		Project area
Unnamed tributary of Sheep Station Creek	625570.8871	6038709.147	1		Project area
Unnamed tributary of Lick Hole Gully	626403.162	6037842.925	2	KFH	Project area
Yarrangobilly River*	627486.80	627486.80	6	KFH	35 m from project area

* field assessment (aquatic habitat) undertaken



Project area
Disturbance area
Proposed structure
Proposed transmission line
Proposed access track - Option A
Proposed access track - Option B
Proposed 500kV substation
Snowy 2.0 cable yard
Water bore
Water quality monitoring location
Macquarie Perch (Tumut River and Yarrangobilly River)
Key Fish Habitat

Strahler order
1
2
3
4
5
≥6

Major road
Road
State forest
NPWS estate

Figure 5-1 | Waterways and monitoring locations

Data source:
Jacobs 2020, TransGrid, EMM 2019,
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Photo 5-1: Wallaces Creek

Photo 5-2: Tumut River and Talbingo Reservoir

Photo 5-3: Yarrangobilly River

Photo 5-4: Sheep Station Creek

Photo 5-5: Cave Gully Creek

5.6 Geology

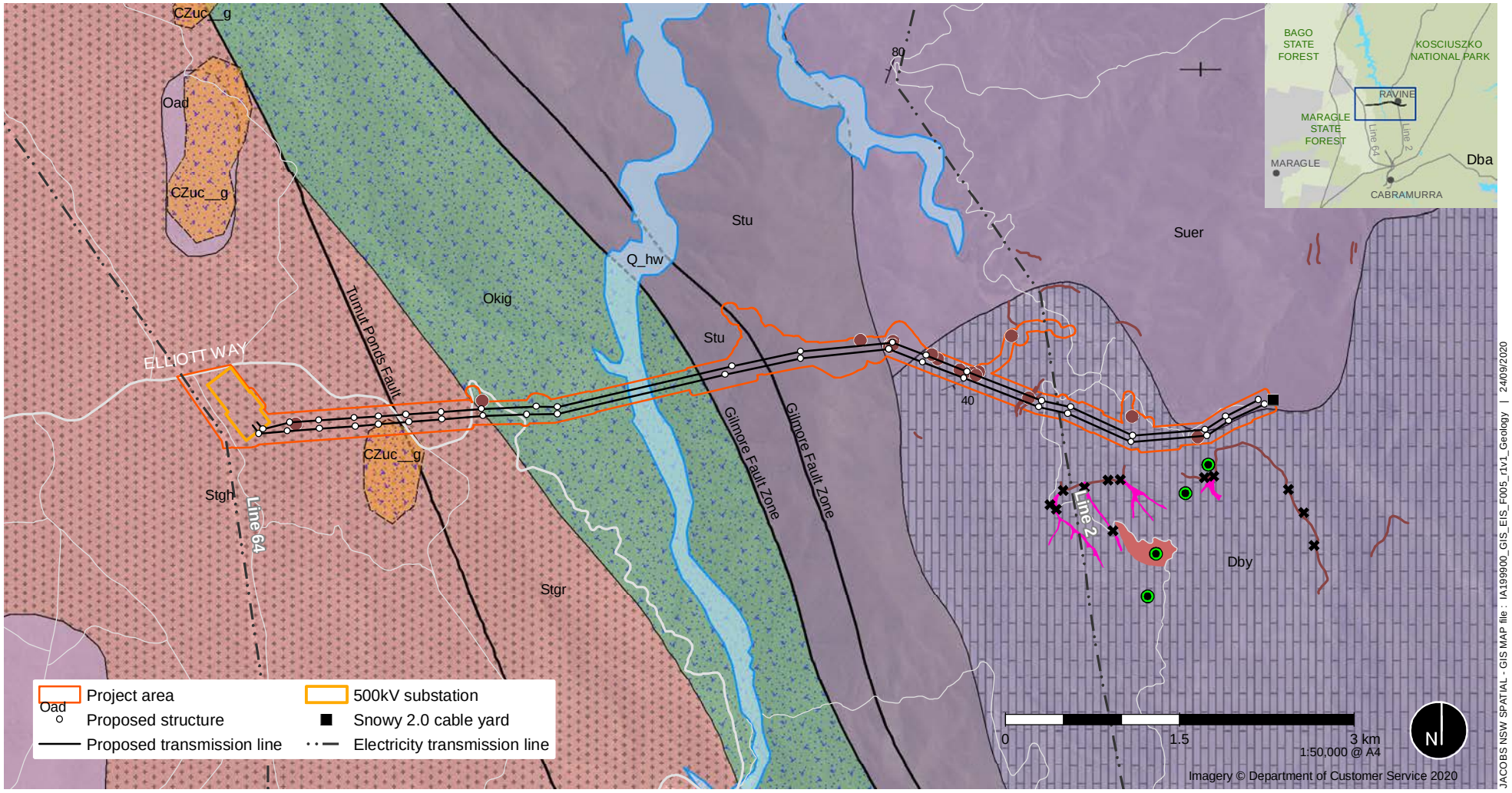
Geology of the project area is described by Colquhoun et al (2018) as dominated by Lithologies of the East Lachlan Orogen. In the project area west these include upper Silurian age plutonic intrusives, including the Greenhills Granodiorite and Rough Creek Tonalite. These lithologies are capped in places by Tertiary olivine basalts, however, the occurrence of tertiary basalt is limited within the project area about 1 km to the east of the proposed substation. The plutonic lithologies are intruded against the meta-sediments and meta-volcanics of the East Lachlan Orogen. Locally this includes the Ordovician Gooandra Volcanics to the east and west of Talbingo Reservoir and in project area west, lower Silurian Tumut Pond Group, Ravine Beds, and the lower Devonian Byron Range Group. Significant faulting, along the Tumut Ponds Fault and the Gilmore Fault Zone, occurs roughly perpendicular to the project through the steeply incised valley that holds the Talbingo Reservoir. Typical stratigraphy, including dominant lithologies are provided in **Table 5-2** and surface geology is shown on **Figure 5-2.**

Table 5-2: Stratigraphic summary

Age	Unit	Dominant lithology	Secondary lithologies
Tertiary	Underground igneous units	Basalt	Alkali olivine basalt
Devonian	Byron Range Group	Limestone	siltstone, quartzite, shale, sandstone, conglomerate
Silurian	Ravine Beds	Shale	slate, siltstone, conglomerate.
	Tumut Pond Group	Sandstone	Quartzite, slate, phyllite, serpentinite
	Rough Creek Tonalite	Tonalite	Biotite granodiorite and tonalite commonly containing cordierite, common metasedimentary xenoliths
	Greenhills Granodiorite	Granodiorite	Medium to coarse-grained biotite granodiorite, fine to medium-grained biotite-muscovite granodiorite/granite; biotite granodiorite and tonalite commonly containing cordierite, common metasedimentary xenoliths.
Ordovician	Gooandra Volcanics	Basalt	Metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists, feldspathic sandstone; aphyric and feldspar phyric basalt, lava breccia, pillow lava, rhyolite, shale; fine feldspathic siltstone and shale

Geology encountered along the project area from west to east and the relevant project components within the units is shown on **Figure 5-2** and as follows:

- Greenhills Granodiorite and Rough Creek Tonalite (substation, substation access road and 15 structure locations
- Gooandra Volcanics (basalt) (Access track and five structure locations)
- Tumut Pond Group (sandstone) (two access tracks, helipad and four structure locations)
- Ravine Beds (shale) (Access track and seven structure locations)
- Byron Range Group (Limestone) (Access track and 11 structure locations).



Cenozoic Sedimentary Province
- Lake edge
- Anthropogenic stored water, pondage, reservoirs, canals (Q_hw)

Cenozoic Igneous Province
- Geological boundary, position approximate
- Basalt
- Ungrouped Cenozoic igneous units - olivine basalt (CZuc_g)
- Rock outcrop
- Cliff

Geodiversity
- Tufa deposit
- Geodiversity site
- Tufa extent
- Fossil area

Lachlan Orogen
- Strike of strata, dip not determine
- Strike and dip of bedding
- Vertical bedding (strata)
- Geological boundary, position accurate
- Geological boundary, concealed
- Fault, position accurate
- Fault, concealed
- Basalt
- Granodiorite
- Limestone
- Quartzite
- Sandstone
- Tonalite
- Boraig Group (Dba)
- Byron Range Group (Dby)
- Tumut Pond Group (Stu)
- Ravine beds (Suer)
- Green Hills Granodiorite (Stgh)
- Rough Creek Tonalite (Stgr)
- Gooandra Volcanics (Okig)
- Adaminaby Group (Oad)

Figure 5-2 | Surface geology

Data source:
Jacobs 2020, DIRE 2014, NPWS 2019,
© Department Finance, Services and Innovation Feb 2018

5.7 Hydrogeology

There is very little information available regarding groundwater conditions in the vicinity of the project, with no registered bores (other than those installed for Snowy 2.0) within 5 km of the project. Groundwater investigations have been undertaken as part of Snowy 2.0 (EMM, 2018 and EMM, 2019a). The groundwater investigations for Snowy 2.0, typically undertaken to the east of the substation and transmission corridor, provide useful information on groundwater occurrence that can be applied to the project. Geotechnical investigations have also been undertaken at the substation site (SMEC, 2019), including the drilling of 17 boreholes and seven test pits.

Groundwater occurrence is anticipated to be associated with fractured or weathered basement lithologies. Some thin veneers of colluvium or residual soils are likely, however these are not expected to be saturated and would generally sit above the regional water table. Some alluvial deposits may be associated with the major drainages, such as Yarrangobilly River within project area east, however, these would be within the narrow valley floors and typically away from the project. EMM (2018) note that alluvial deposits associated with Yarrangobilly River are estimated to be of the order of 3 to 4 m thick.

In project area east, there is potential for development of karst features within the limestones of the Byron Range Group, refer to **Figure 5-2**. The presence of any karst aquifers is not expected to impact on the project from a groundwater perspective but may be of consideration from a geotechnical perspective.

5.7.1 Depth to water

At the substation site, groundwater was encountered in 13 of the 17 geotechnical boreholes (SMEC, 2019). Depths to water ranged from 6.1 m to 11.0 meters below ground level (mbgl) with water being encountered in the extremely weathered and decomposed granites.

For project area east, water level data is available for 20 monitoring bores installed as part of the Snowy 2.0 Exploratory Works (EMM, 2018), as summarised in **Table 5-3** and shown on **Figure 5-1.** However, only two of the Snowy 2.0 monitoring bores are near the project, the nearest location (TMB01A/B) is within the disturbance area in project area east. The remainder of the monitoring bores are generally located east of project area east. Indicative depths to groundwater with the project area can be inferred from the general topographic and geomorphological environments as discussed below.

The conceptual hydrogeology for the Snowy 2.0 Exploratory Works is presented on **Figure 5-3**. The cross section provided in **Figure 5-3**, generally overlaps with project area east, encompassing the area from Talbingo Reservoir to Yarrangobilly River.

Indicative depths to water for the three main topographic/geomorphological environments, derived from the Snowy 2.0 Exploratory Works, and as indicated on **Figure 5-3** are as follows:

- Elevated plateau areas: 4.6 to 48.8 mbgl (average 16.4 mbgl)
- Steeply incised valleys and ridges: 3.5 to 21.9 mbgl (average 11.21 mbgl)
- Valley floor/alluvial: 3.1 to 6.1 mbgl (average 4.4 mbgl).

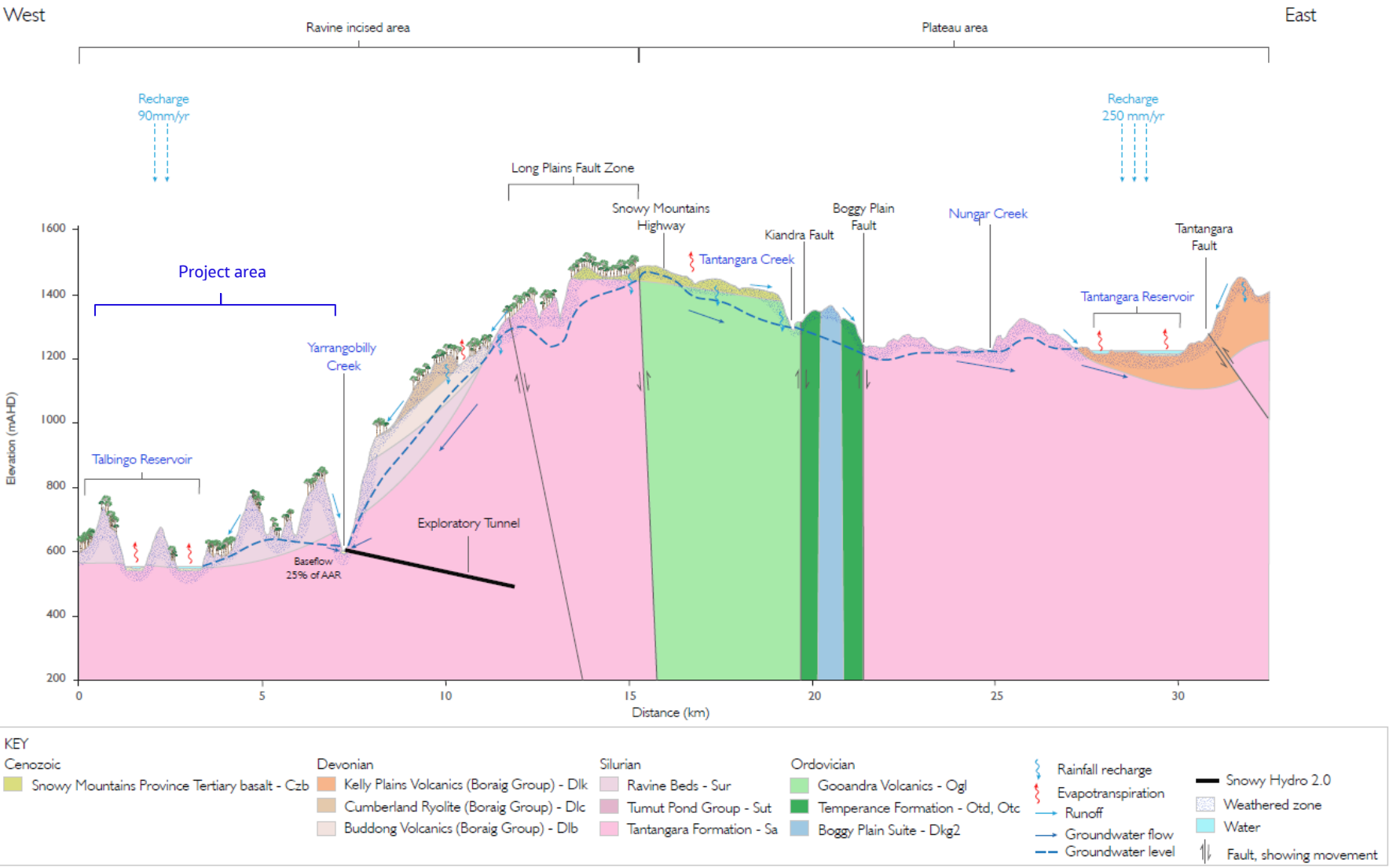


Figure 5-3: Snowy 2.0 Exploratory Works Conceptual Hydrogeological Model (EMM, 2018)

Table 5-3: Snowy 2.0 Exploratory Works monitoring bores (EMM, 2018)

Bore ID	Easting	Northing	Elevation (mAHD)	Screen Depth (mbgl)	Surface water level (mbgl)	Indicative Topographic Position
MB01B	637059.5	6040238	1464.4	6.8	3.5	Incised Valley / Ridge
MB01C	637065.7	6040245.3	1464.0	51	21.5	Incised Valley / Ridge
MB02	634310.5	6033304.1	1386.7	147	6.05	Incised Valley / Ridge
MB03	637491	6043212.7	1373.0	98	5.7	Incised Valley / Ridge
MB04A	640023.4	6047809.3	1330.0	29	21.87	Elevated Plateau
MB04B	640023.7	6047817.4	1330.0	99.5	48.81	Elevated Plateau
MB06A	628723.4	6048391.5	1145.4	12	4.57	Elevated Plateau
MB06B	628719.8	6048397	1145.4	70	4.51	Elevated Plateau
MB07A	641051	6042294.1	1265.0	13	8.85	Elevated Plateau
MB07B	641042.9	6042294	1265.0	57	9.09	Elevated Plateau
TMB01A	627670.5	6038074.1	581.2	14	5.1	Valley Floor
TMB01B	627677.7	6038070	581.8	69	6.1	Valley Floor
TMB02A	634554	6038586.4	1469.6	14	5.6	Incised Valley / Ridge
TMB02B	63458.5	6038606.6	1472.3	197	7.13	Incised Valley / Ridge
TMB03A	636224.2	6038504.3	1477.7	32.5	11.87	Incised Valley / Ridge
TMB03B	636215.2	6038505.1	1477.6	147	17.68	Incised Valley / Ridge
TMB03C	636220.7	6038495.1	1478.0	249	21.94	Incised Valley / Ridge
TMB04	639018.2	6038261.2	1345.8	197	17.02	Elevated Plateau
TMB05A	628370.9	6039896	601.7	18	3.1	Valley Floor
TMB05B	628370.7	6039896	601.7	74	3.2	Valley Floor

5.7.2 Groundwater flow

Groundwater flow is driven by areas of groundwater recharge and groundwater discharge. Groundwater recharge would occur from infiltration of rainfall and runoff over areas of outcropping and shallow sub-cropping formations, and groundwater flow in the vicinity of the project would be from topographically elevated areas towards the Talbingo Reservoir and Yarrangobilly River. This pattern of groundwater flow in project area east is confirmed by groundwater modelling completed for the Snowy 2.0 Main Works EIS Water Assessment (EMM, 2019) but is also applicable to project area west.

The regolith profile has potential to result in a perched upper aquifer that is hydraulically disconnected from the regional water table. This is evident from paired Snowy 2.0 Exploratory Works monitoring bores such as MB01B and MB01C, MB04A and MB04B, and TMB03A and TMB03B (**Table 5-3**), and also from the substation geotechnical investigations where groundwater was encountered within the weathered granite (regolith). Perched aquifers were not evident at all monitoring locations, and the effect is likely to be accentuated in elevated areas and diminished in the valley floor areas. The deeper groundwater systems would be reliant on vertical infiltration from overlying perched aquifers for recharge.

5.7.3 Groundwater quality

Groundwater quality would be significantly controlled by the formation lithology and groundwater age, with shallow perched aquifers typically being of better water quality than deeper regional aquifers.

Average water quality data from the Snowy 2.0 Exploratory Works EIS are summarised in **Table 5-4**. It is noted that TMB01A/B and TMB05A/B are located close the project area east in the vicinity of Yarrangobilly River as shown in **Figure 5-1**.

Table 5-4: Snowy 2.0 Exploratory Works mean water quality (Feb 2018 to June 2018) (EMM 2018)

Bore ID	pH	EC (µS/cm)	TDS (mg/L)	Sum of major ions (mg/L)
TMB01A	7.62	470	1530[1]	413
TMB01B	7.37	1050	765	933
TMB05A	8.18	948	627	677
TMB05B	9.18	613	484	519

1 The reported value for TDS at TMB01A is considered erroneous, the sum of major ions is presented for comparison.

From **Table 5-4**, water quality in the valley areas is typically of neutral to alkaline pH and relatively fresh. Water quality within perched aquifers in the vicinity of the project can be expected to be of similar quality.

5.7.4 Groundwater users

Review of the Australian Groundwater Explorer (BoM, 2020) indicates that there are no registered groundwater works within 5 km of the project.

5.7.5 Groundwater dependent ecosystems

The mapped aquatic groundwater dependant ecosystems (GDEs) are generally situated along the larger named waterways. Within and near the project area, the mapped aquatic GDEs include vegetation along Yorkers Creek, Native Dog Gully, New Zealand Gully and Appletree Gully to the west of the Talbingo Reservoir and vegetation along the Tumut River, Sheep Station Creek, Lick Hole Gully, Cave Gully, Wallaces Creek, Stable Creek and the Yarrangobilly River to the east. None of the plant community types (PCTs) within the project area are likely to have a total reliance on groundwater. Four PCTs (PCT 285, PCT 296, PCT 300 and PCT 302) are likely to be facultative GDEs, that is they are partial dependent on groundwater. The type and locality of GDEs are discussed further in the Snowy 2.0 Transmission Connection Project - Biodiversity Development Assessment Report (Jacobs, 2020) (BDAR).

5.8 Surface water quality

5.8.1 Existing water quality

Surface water monitoring has been carried out at several monitoring sites on waterways within the project area (including Talbingo Reservoir and waterways to the east) for Snowy 2.0 (EMM, 2018a, EMM, 2018b, Cardno, 2018 EMM, 2019). No water quality data was available for review for any major or minor waterways within the project area west (ie Yorkers Creek or New Zealand Gully), however given the land use in the surrounding area, it is expected that waterways would exhibit similar water quality as those waterways within the project area east. Water quality data available for review was sourced from a number of recent assessments as summarised in **Table 5-5**. It is important to note, however, this data may not accurately represent current water quality in waterways which have been monitored as the recent bushfires may have affected surface water quality.

Table 5-5: Summary of available water quality data for waterways within the project area

Project	Author and year	Waterways monitored	Monitoring type	Sampling information
Snowy 2.0 Exploratory Works – Groundwater Assessment	EMM (2018a)	▪ Tumut River ▪ Yarrangobilly River ▪ Talbingo Reservoir	Monitoring bores[1]	Samples were collected from monitoring bores between February and June of 2018.
Snowy 2.0 Exploratory Works – Surface Water Assessment	EMM (2018b)	▪ Yarrangobilly River ▪ Wallaces Creek ▪ Stable Creek ▪ Tumut River ▪ Lick Hole Gully ▪ Talbingo Reservoir	In-situ surface water monitoring	Samples collected from river locations in February, March and April of 2018. A single round of samples were collected for Talbingo Reservoir sites in March 2018.
Snowy 2.0 Main Works	EMM (2019)	▪ Yarrangobilly River ▪ Wallaces Creek ▪ Stable Creek ▪ Tumut River ▪ Lick Hole Gully ▪ Talbingo Reservoir	In-situ surface water monitoring	Samples collected from locations between March 2018 and February 2019.

1 – For the purposes of this surface water quality assessment, only data collected for up to 1 m below the surface has been interpreted.

The locations of these monitoring sites are shown on **Figure 5-1**. Available water quality information is summarised below.

5.8.1.1 Talbingo Reservoir

Data collected for the Snowy 2.0 (EMM, 2018b and EMM, 2019) investigations were recorded at several monitoring locations including Lobs Hole (TAL22) and other sites further downstream (TAL18, TAL19 and TAL21).

Lobs Hole

Water quality monitored at Lobs Hole was generally good, although dissolved oxygen concentrations did fall slightly below the lower recommended limit of 90 per cent saturation. Nutrient levels, including total nitrogen and total phosphorus were low and therefore complied with recommended limits for protection of environmental values. Similarly, metal concentrations (total and filtered) were low for most indicators and complied with relevant guidelines. The exceptions were total chromium and total zinc which had median concentrations above the guideline for 99 per cent level of aquatic species protection. Median chromium concentrations ranged between 0.00075 mg/L and 0.0001 mg/L which exceeded the recommended limit of 0.00001 mg/L and median zinc concentrations of 0.0025 mg/L marginally exceeded the recommended limit of 0.0024 mg/L.

Downstream of Lobs Hole

Talbingo Reservoir, downstream of the Lobs Hole collects major inflows from Tumut River and Yarrangobilly River, and less significant inflows from Middle Creek, Plain Creek and other unnamed drainage lines. The most recent water quality data available (EMM, 2019) revealed that the reservoir was frequently above the upper limit of 30 µS/cm for electrical conductivity and exceeded the guideline limit for lakes and reservoirs for total phosphorus, copper and zinc during the summer and autumn months. During the winter and spring period, electrical conductivity and pH were frequently outside their respective guideline ranges of 20 – 30 µS/cm and 6.5 – 8.0, and ammonia was often above the recommended guideline limits for 99 per cent species protection. NO_x concentration was frequently above the recommended guideline limit of 0.01 mg/L. Chromium and zinc were also occasionally above the guideline limits but all other nutrient and heavy metal parameters were generally below recommended ANZG (2018) guideline limits. During winter and spring, electrical conductivity and pH were frequently outside their recommended guideline ranges, and ammonia, NO_x, and total phosphorus were generally above their recommended guideline limits on most occasions. There were also occasional exceedances of recommended guideline values for total nitrogen, reactive phosphorus, copper and zinc. All other parameters were either below the detection limit or recommended ANZG (2018) guideline value.

5.8.1.2 Wallaces Creek and Stable Yards Creek

Wallaces Creek is upstream of Yarrangobilly River and was monitored at two sites, one located upstream (LH_SW_002) and the other downstream (LH_SW_003) of its main tributary, Stable Yards Creek (EMM, 2018a) (EMM,2018a). Stable Yards Creek was also monitored at one site (LH_SW_001) and is included in this summary. Water quality for both waterways was generally good, with median concentrations for physiochemical parameters of electrical conductivity, pH and turbidity remaining within the guideline limits for upland rivers at all times. Median dissolved oxygen concentrations however were below the lower guideline limit of 90 per cent saturation at most sites. Nutrient concentrations were generally below guideline limits except for oxidised nitrogen (NO_x) which was above the guideline limit of 0.030 mg/L. All heavy metals (dissolved) remained below the guideline limits except for barium which exceeded the guideline limit of 0.097 mg/L for 99 percent species level of protection.

More recent data for Wallaces creek revealed that water quality was frequently below the lower guideline limit of 90 per cent saturation for dissolved oxygen, outside the guideline range for pH (6.5 – 8.0), and above the guideline limit for NO_x (0.03 mg/L), copper (0.0014 mg/L) and zinc (0.008 mg/L) during summer and autumn months (EMM, 2019). In winter and spring, dissolved oxygen, NO_x, reactive phosphorus (0.005 mg/L) and copper (0.001 mg/L) frequently exceeded guideline concentration limits, while pH, turbidity, ammonia, total nitrogen and zinc were occasionally above guideline limits (EMM, 2019).

5.8.1.3 Yarrangobilly River

The Yarrangobilly River was monitored at several sites including upstream of Wallaces Creek confluence (LH_SW_004) and at its downstream end where it flows into Talbingo Reservoir (LH_SW_006) (EMM, 2018a). At the upstream extent, water quality was generally good with low turbidity, and electrical conductivity and pH remaining within the recommended guideline ranges of 30 – 350 µS/cm and 6.5 – 8.5, respectively (ANZG, 2018). Although dissolved oxygen was below the guideline limit of 85% saturation on most occasions and total nitrogen concentration was above the recommended guideline value of 0.03 mg/L on one occasion in February 2018. All other heavy metals were either not monitored or below the detection limit. Physicochemical water quality at the downstream extent was also generally good with neutral pH, low turbidity and low nutrient concentrations. Dissolved oxygen levels were occasionally recorded below the recommended limit of 90% saturation. Metal concentrations for zinc, silver, lead and copper were detected in concentrations greater than the recommended limits for 99 per cent species protection. All other heavy metals were either not detected or in low concentrations that complied with relevant guidelines.

More recent data (EMM, 2019) collected from four sites along the Yarrangobilly River (LH_SW_001, LH_SW_004, LH_SW_006 and LH_SW_007) demonstrated generally good water quality in summer and autumn however was frequently below the lower guideline limit of 90% saturation for dissolved oxygen and above the upper limit of 8.0 for pH, frequently above the guideline limits for NO_x (0.0015 mg/L) and aluminium (0.027 mg/L), but generally complied with guideline concentrations for total nitrogen, total phosphorus and total chromium for protection of upland river aquatic ecosystems. During winter and spring, water quality was marginally poorer with dissolved oxygen and pH being frequently outside the recommended guideline ranges, and ammonia, NO_x, aluminium and zinc frequently above the recommended guideline limits. There were also occasional exceedances of recommended guideline values for reactive phosphorus, total phosphorus, total chromium and copper.

5.8.1.4 Lick Hole Gully

Lick Hole Gully is a tributary to Yarrangobilly Creek and was monitored at one site (LH_SW_005) (EMM, 2019). In general, water quality at Lick Hole Gully was poor, frequently exceeding ANZG (2018) guideline limits for most physiochemical parameters, nutrients and heavy metals that were monitored including dissolved oxygen, electrical conductivity, turbidity, ammonia, NO_x, total phosphorus, arsenic, copper and zinc. Limited data (one sample) was collected during summer/autumn and infers that the water quality of Lick Hole Gully was poor. Physiochemical parameters of dissolved oxygen and electrical conductivity were outside their respective guideline ranges of 30 – 350 µS/cm and 6.5 – 8.5, and turbidity was also above the upper guideline limit of 25 NTU. Total nitrogen, total phosphorus and copper were additionally above the guideline limits for 99 per cent species protection on this sampling occasion. During winter and spring, water quality appeared to deteriorated with median dissolved oxygen concentrations recorded below the lower limit of 90% saturation, electrical conductivity was above the upper limit of 350 µS/cm, turbidity was also above the upper limit of 25 NTU, and nutrients and heavy metals including total nitrogen, total phosphorus, and copper.

Since the 2019/2020 bushfires, it is expected that Snowy Hydro have continued monitoring the above waterways as part of the Snowy Hydro 2.0 Main Works baseline monitoring program however data from these investigations was not available for review.

5.8.1.5 Tumut River

The Tumut River was monitored at its downstream end where it flows into Talbingo Reservoir (TalS_SW_001) during both the Snowy Hydro 2.0 Exploratory Works and Main Works EIS investigations. Tumut River exhibited similar water quality to the Yarrangobilly River with low turbidity, neutral pH and slightly lower than recommended dissolved oxygen concentrations. Nutrient concentrations were also low, complying with the limit recommend for protection of environmental values. Metal concentrations were generally lower in the Tumut River, with only silver and zinc recorded in concentrations greater than the recommended limit for 99 per cent species protection.

5.9 Sensitive receiving environments

As outlined in **Section 4.1.2.2**, Sensitive receiving environments have been identified based on aquatic habitat as an indicator. Aquatic habitat was assessed against the NSW *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003) and are detailed in the BDAR. The results indicated that the following waterways are sensitive receiving environments as they have been classified as type 1 highly sensitive key fish habitat:

- Tumut River is a permanently flowing major river (greater than fifth order) which drains to Talbingo Reservoir. The waterway contains fish habitat including dense overhanging vegetation, instream riffles and undercut banks. The river is mapped as KFH (DPI 2013) and Murray Crayfish (*Euastacus armatus*) are predicted to occur within this section of the Tumut River (DPI 2018). The Tumut River has been assessed as Type 1, highly sensitive KFH (DPI 2013). With respect to fish passage, it is classified Class 1, major KFH (Fairfull and Witheridge 2003)
- Yarrangobilly River is permanently flowing waterway (greater than a 5th order stream). A variety of aquatic habitat was present including woody snags, gravel beds, riffle pool sequences and overhanging vegetation. Macquarie Perch (*Macquaria australasica*) are predicated to occur within this section of the river (DPI 2018). The waterway is also mapped as KFH (DPI 2013). Vulnerable Murray Crayfish (*Euastacus armatus*) have also been observed in Yarrangobilly River during field assessments (Cardno 2018). Yarrangobilly River has been assessed as Type 1, highly sensitive KFH (DPI 2013). With respect to fish passage, it is identified as Class 1, major KFH (Fairfull and Witheridge 2003)
- Wallaces Creek is a fifth order tributary of the Yarrangobilly River containing a variety of aquatic habitat including; gravel beds, rocks greater than 500 mm, woody snags, instream macrophytes and overhanging vegetation. The waterway has been assessed as Type 1, highly sensitive KFH (DPI 2013) with respect to fish passage, Wallaces Creek has been identified as Class 1, major KFH (Fairfull and Witheridge 2003)
- Sheep Station Creek is an ephemeral third order stream which drains to the Yarrangobilly River (when flowing). The aquatic habitat includes gravel beds and undercut banks and the creek is mapped as KFH (DPI 2013). Threatened fish are likely to occur in the Yarrangobilly River which is located approximately 100 m downstream. Species include Murray Crayfish (*Euastacus armatus*) and Macquarie Perch (*Macquaria australasica*) (DPI 2018). Sheep Station Creek is assessed as Type 1, highly sensitive key fish habitat. With respect to fish passage, the creek has been assessed as Class 2, moderate KFH (Fairfull and Witheridge 2003)
- Cave Gully is an ephemeral third order tributary of the Yarrangobilly River. When the tributary is flowing, aquatic habitat includes gravel beds and undercut banks. The tributary is mapped as KFH (DPI 2013). Threatened fish are not predicted to occur however, Macquarie Perch (*Macquaria australasica*) are predicted to occur approximately 100 m downstream in the Yarrangobilly River (DPI 2018). Cave Gully is assessed as Type 2, moderately sensitive KFH (DPI 2013). With respect to fish passage, the creek is assessed as Class 2, moderately sensitive KFH (Fairfull and Witheridge 2003) due its ephemeral nature.

Additionally, two threatened fish species are predicted to occur within the project area and are assessed in the BDAR. These include Macquarie Perch (*Macquaria australasica*) and Murray Crayfish (*Euastacus armatus*).

5.10 Flooding

Flood modelling of the Yarrangobilly River and its major tributaries was carried out for the Snowy 2.0 Exploratory Works EIS (EMM, 2017). The flood modelling results of flood height and depth for a range of design flood events up to the Probable Maximum Flood (PMF) were provided for establishing existing flooding characteristics. The flood modelling results available covered only a portion of project area east and there are no existing flood modelling results available for remaining areas in project area west.

Figure 5-4 shows the 1% Annual Exceedance Probability (AEP) flood and PMF extents for the project area east. It shows the transmission line structures would be located outside the PMF extent and away from flood prone land.

As described in **Section 5.5.2**, the project area crosses a number of waterways including Wallaces Creek, Tumut River, Yarrangobilly River and Sheep Station Creek. Within the project area:

- The Tumut River water levels are controlled by the Talbingo Reservoir operations
- New Zealand Gully and an unnamed tributary of Yorkers Creek are ephemeral in nature and would experience short duration overland flooding during heavy rainfall events.
- Sheep Station Creek is affected by flooding, with modelling results indicating existing peak flood depths of up to 1.5 m in the 1% AEP event and up to 7 to 8 m in the PMF
- Yarrangobilly, Lickhole Gully, Cave Gully and Wallaces Creek are also subject flooding to in the 1% AEP.

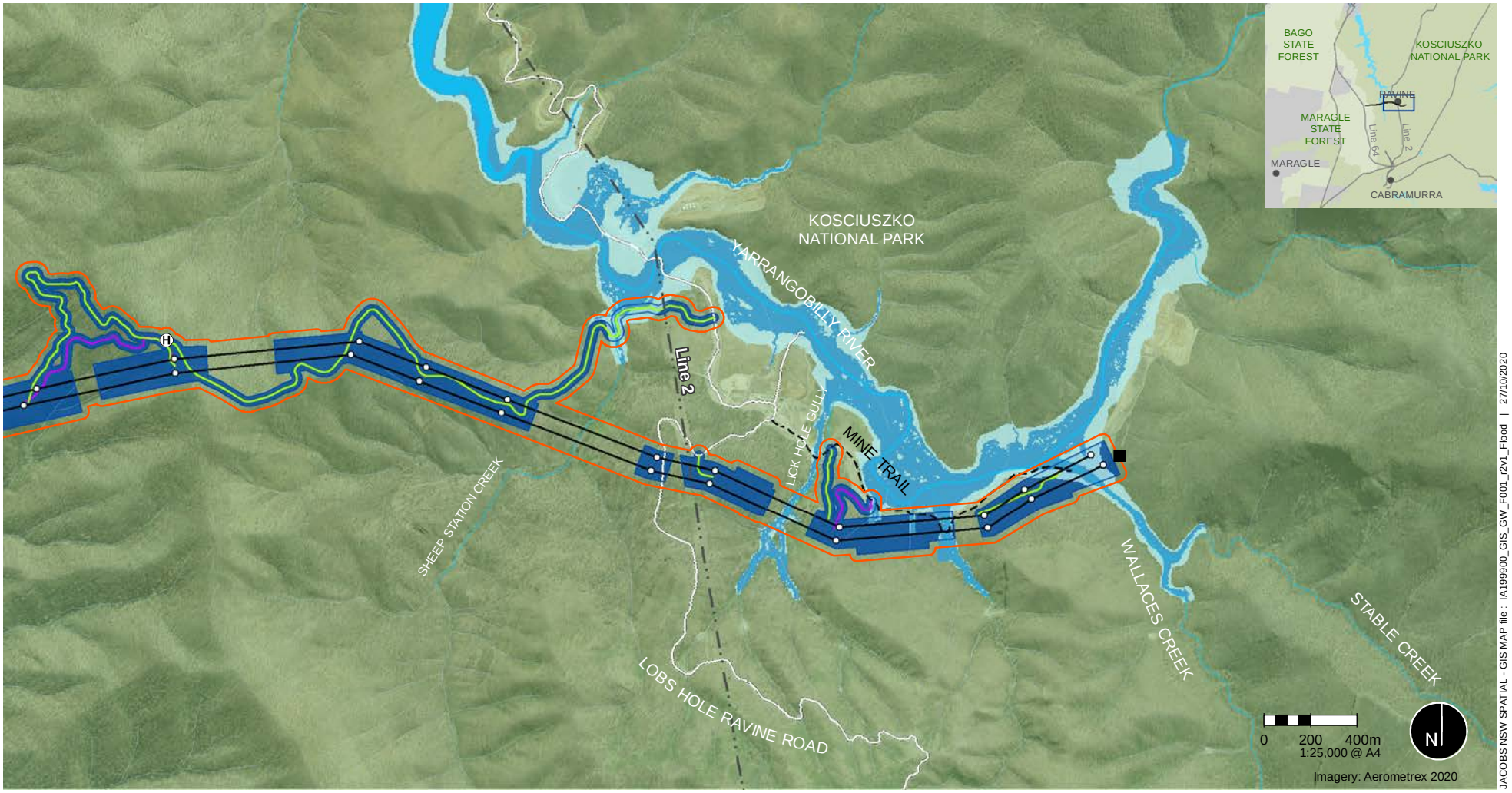


Figure 5-4 | Existing flood extents associated with the Yarrangobilly River

Data source:
Jacobs 2020, TransGrid, EMM 2019,

6. Impact assessment

6.1 Construction impacts – Surface Water

6.1.1 Hydrology and flooding

Two proposed structures shown in **Figure 5-4** located at the far eastern extent of project area east and within the Snowy 2.0 cable yard are subject to flooding in the PMF event, refer to **Figure 5-4**. The depth of flooding in the vicinity of the proposed structures ranges from approximately 7 m to 1.5 m. However, areas in the vicinity of both structures are free from mainstream flooding in the 1% AEP event. The other project components are located away from major drainage lines and flood prone land and would be at low risk of flooding during construction. However, heavy rainfall during the construction period could result in local overland flows entering excavations or stockpiles of construction materials, and spoil being washed away into nearby drainage lines and waterways, overland flows entering excavations or stockpiles.

Construction of the project has the potential to change local flood behaviour due to the alteration or obstruction of existing overland flow paths (for example, due to stockpiling construction materials and spoil, establishment of crane pads, benching of the substation site), the establishment of erosion and sediment control measures, and the introduction of additional impervious surfaces. Any changes to overland flood behaviour would be localised and would not be expected to have any adverse effects on land adjoining the project area or major infrastructure (including Snowy 2.0).

The proposed access track crossing Sheep Station Creek is subject to up to 1.5 m depth of flooding in the 1% AEP event and up to 7 to 8 m depth of flooding in the PMF event. To minimise the track closure during large flood events, the waterway crossing (bridge/culvert) would be designed accordingly during detailed design. It is expected that the waterway crossing would be matched to the natural stream width to minimise adverse increase in flow velocities and to minimise scour at waterway crossing site.

Apart from the crossing of Sheep Station Creek, the other access tracks are predominantly positioned along ridge lines and hill sides and do not cross any existing waterway. These access tracks would be affected by local catchment runoff during heavy rainfall but would not experience any significant flooding. To minimise the effects of overland stormwater runoff, appropriate drainage system and erosion protection works would need to be provided.

6.1.2 Water quality

The potential impacts to water quality associated with construction are presented in **Table 6-1**. As outlined in this table, the construction of the project has the potential to impact the surface water quality of downstream waterways near the project, particularly those within 500 m of the project. Potential impacts to surface water quality include:

- Erosion of soils and sedimentation of waterways
- Tannin leachate from vegetation clearing during the construction and operation
- Accidental leaks or spills of chemical and fuels from construction machinery during construction, or from vehicle accidents using access roads during operation
- Dispersal of residual ash (that is present on the ground surface from bushfires) into waterways.

The potential impacts to surface water quality would be managed through the implementation of adequate mitigation and management measures discussed in **Section 7**.

Table 6-1: Potential construction impacts on surface water quality

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Waterways potentially impacted
Helicopter landing pad at Sheep Station Ridge Helicopters may be used to deliver materials to the high elevations. The area of vegetation clearing required for the helicopter landing pad is about 30 m by 30 m.	Sediments, nutrients, salts, particulate carbon, trace metals and other hazardous chemicals such as sulfate (from oxidation of sulfur in soil organic matter and burnt plant litter leachate)	Erosion and sedimentation during clearing of vegetation and site levelling can: ▪ Alter the geomorphology of waterways ▪ Smother and reduce biological productivity of aquatic ecosystems ▪ Lead to increased nutrients in waterways which can result in algal blooms ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash can also temporarily reduce the dissolved oxygen content in water and may result in fish kills.	Three unnamed waterways within 500 m of the helipad including a tributary of the Tumut River, and two tributaries of the Yarrangobilly River.
Construction compound ▪ Vehicle movements to and from site and accidental spills ▪ Onsite storage of chemicals and fuels ▪ Plant and equipment maintenance and refuelling ▪ Increased soil and pollutants entering waterways via stormwater from runoff from vehicle and plant machinery ▪ Risk of sewage and wastewater spills entering waterways course from toilet/shower facilities.	Sediments, nutrients, hydrocarbons, oil and grease, hydraulic fluids, high pH, zinc, chromium, particulate carbon, salts and other hazardous chemicals including sulfate (from oxidation of sulfur in soil organic matter and burnt plant litter leachate)	▪ Oily films on surface water reducing visual amenity ▪ Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants ▪ Increased alkalinity and pH of downstream waterways which can be harmful to aquatic life. Water contaminated with chromium can accumulate in the gills of fish affecting the health of aquatic animals. ▪ Pollutant runoff from sewage may contain elevated levels of nutrients which can lead to algal blooms and increased turbidity ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash can also temporarily reduce the dissolved oxygen content in water and may result in fish kills.	Waterways within 500 m of the compound including New Zealand Gully, tributary of Yorkers Creek, and tributary of Native Dog Creek. A construction compound and laydown area would also be established within a cleared area at Lobs Hole provided by Snowy Hydro. Whilst the site is already established, the waterways that have the potential to be impacted from construction activities include Yarrangobilly River and its unnamed tributaries in the vicinity of the compound.
Transmission line - Earthworks, excavation and stockpiling ▪ Laydown of materials and equipment and stockpiling of construction materials would occur within the cleared area	▪ Sediment, nutrients, hydrocarbons, metal	▪ Increased sedimentation can alter the geomorphology of waterways and smother and reduce biological productivity of aquatic systems through reduced light	All waterways crossed by the project or located within 500 m of the transmission line corridor have the potential to be impacted by earthworks,

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Waterways potentially impacted
of the transmission corridor adjacent to each transmission structure during their construction ▪ Erosion and exposure of sediment from spoil stockpiles and materials processing, exposed areas and open cuts due to wind and stormwater runoff leading to sedimentation and contamination of downstream waterways ▪ Following the recent bushfires erosion and overland flow rates will be higher and may contain increased levels of contaminants such as ash, therefore the project area is more susceptible to erosion and contamination presenting a greater risk to downstream water quality, particularly as soils in bushfire affected areas may contain additional contaminants such as trace metals as a result of ash from burnt vegetation.	▪ Contaminants and gross pollutants ▪ Trace metals (manganese, iron, copper and zinc) ▪ Salts, particulate carbon and other hazardous chemicals such as sulfate (from oxidation of sulfur in soil organic matter and burnt plant litter leachate).	penetration decreasing available plant material for fish to feed on ▪ Increased sediments result in increased nutrients in waterways which can lead to algal blooms. This reduces the environmental value of water by limiting its potential uses. ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash can also temporarily reduce the dissolved oxygen content in water and may result in fish kills ▪ Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants.	laydown areas and stockpiles. However, most of these waterways are minor, ephemeral streams with low risk of being impacted. Waterways at greatest risk are sensitive receiving environments crossed by the project including Tumut River, Yarrangobilly River, Wallaces Creek, Sheep Station Creek and Cave Gully.
Substation - Earthworks, excavation and stockpiling ▪ Laydown of materials and equipment and stockpiling of construction materials would occur within the cleared area of the transmission corridor adjacent to each transmission structure during their construction ▪ Erosion soils and exposure of sediment from spoil stockpiles and materials processing, exposed areas and open cuts due to wind and stormwater runoff leading to sedimentation and contamination of downstream waterways ▪ Following the recent bushfires erosion and overland flow rates will be higher, therefore the project area is more susceptible to erosion presenting a greater risk to downstream water quality, particularly as soils in bushfire affected areas may contain additional contaminants such as trace metals as a result of ash from burnt vegetation.	▪ Sediment, ash nutrients, hydrocarbons, metal ▪ Contaminants and gross pollutants ▪ Trace metals (manganese, iron, copper and zinc) ▪ Salts, particulate carbon and other hazardous chemicals such as sulfate (from oxidation of sulfur in soil organic matter and burnt plant litter leachate.	▪ Increased sedimentation can alter the geomorphology of waterways and smother and reduce biological productivity of aquatic systems through reduced light penetration decreasing available plant material for fish to feed on ▪ Increased sediments result in increased nutrients in waterways which can lead to algal blooms. This reduces the environmental value of water by limiting its potential uses. ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash can also temporarily reduce the dissolved oxygen content in water and may result in fish kills. ▪ Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants.	Waterways at greatest risk are New Zealand Gully and tributaries of Yorkers Creek and Native Dog Creek which are located within 500 m of the proposed substation

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Waterways potentially impacted
Pollution – spills from vehicles, construction machinery and plant equipment Transportation of pollutants to downstream waterways from accidental spillages or leaks of petroleum, oils, Ammonium Nitrate Fuel Oil (ANFO) from blasting, and other toxicants from construction machinery, plant equipment, refuelling and vehicles travelling to and from site along access roads and at construction sites.	Hydrocarbons, oil and grease, hydraulic fluids, high pH, zinc, ammonium nitrate and other hazardous chemicals.	Oily films on surface water reducing the visual amenity. Decreased biodiversity, loss of habitat and fish kills from increased concentrations of toxicants.	Waterways located within 500 m of the construction compound and laydown areas, access roads and helicopter pad.
Use of access tracks and roads ▪ New access roads and tracks would be required to allow for vehicles, plant, machinery and equipment to be transported to the work locations, including all transmission structures and the helipad during the construction phase. These tracks would be retained to facilitate ongoing maintenance activities of the transmission lines and provide access during emergency events such as bushfire ▪ Increased sediments to downstream waterways due to soil disturbance from movement across exposed earth and dust from vehicles hauling material throughout the construction site.	▪ Sediments, nutrients ▪ Salts, particulate carbon, trace metals and other hazardous chemicals such as sulfate (from oxidation of sulfur in soil organic matter and burnt plant litter leachate.	▪ Movement of exposed soils can result in elevated turbidity, nutrients, and other contaminants and low dissolved oxygen of downstream waterways ▪ Increased levels of heavy metals (which are bound to sediments) that are toxic to aquatic biota ▪ Stimulate the excessive growth of algae and aquatic plants leading to toxic conditions ▪ Increased sedimentation can smother aquatic life affecting the ecosystems of downstream waterways and sensitive receiving environments ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash can also temporarily reduce the dissolved oxygen content in water and may result in fish kills.	Waterways located within 500 m of new access tracks
New Substation <u>Establishment of the substation</u> ▪ The substation is located on first order tributary of Yorkers Creek and New Zealand Gully ▪ Soil erosion and mobilisation of sediments to waterways due to disturbance of land and clearing of vegetation ▪ Infilling of New Zealand Gully and the tributary of Yorkers Creek	Sediment, nutrients, wastewater/pollutants, high biological oxygen demand (BOD) and tannins. Salts, particulate carbon, trace metals and other hazardous chemicals such as sulfate (from oxidation of sulfur in	▪ Increased sedimentation altering geomorphology of waterway ▪ Increased BOD resulting in decreased available dissolved oxygen which can impact on aquatic ecosystems and lead to fish kills ▪ Ash can contain particulate carbon, salts, nutrients, trace metals which can be toxic to aquatic biota. Ash	Waterways directly impacted are a tributary of Yorkers Creek and New Zealand Gully. Waterways within 500m of the substation have a low risk of being impacted and include a tributary of Native Dog Creek. All waterways within 500 m of diverted water systems have the potential to be impacted by construction of the new substation.

Construction activity / source of pollutants	Pollutants of concern	Potential impact	Waterways potentially impacted
▪ Tannin leachate from clearing and mulching entering downstream waterways. <u>Security fencing at the substation</u> ▪ Palisade/security fencing on all sides of the switchyard. APZ extending up to approximately 45 m from the substation switchyard. ▪ The boundary would be cleared of vegetation and routinely managed to address bushfire risk. <u>Stormwater and drainage</u> ▪ An on-site stormwater drainage system would be established during the construction works, allowing stormwater flows from the site to be diverted appropriately away from the switchyard. The stormwater and drainage system would be developed during detailed design, however is expected to include a series of surface drains which would interconnect with a grid of stormwater pits within the substation site.	soil organic matter and burnt plant litter leachate.	can also temporarily reduce the dissolved oxygen content in water and may result in fish kills ▪ Tannins can also result in dark coloured water being discharged from construction sites into downstream waterways. This affects the visual amenity of the waterway, can alter the pH, reduce visibility and light penetration. ▪ Alteration of geomorphology and diverts flows from existing drainage lines ▪ Inadequate water volumes to sustain aquatic ecosystems. ▪ Increased pollutant or sedimentation from diverted flows.	
Site rehabilitation Primarily the removal/ remediation of the construction compound, removal of any temporary site buildings and environmental controls. This would also involve stabilisation of exposed surfaces across all disturbance areas.	Sediment, gross pollutants.	Increased turbidity and rubbish reducing visual amenity of waterway.	Primarily tributary of Yorkers Creek and New Zealand Gully which are located within 500 m of the proposed substation.
Water extraction Water extraction would be required during construction and would be supplied by Snowy Hydro from their Snowy 2.0 operations at Lobs Hole and would be sourced from Talbingo Reservoir. Runoff or disposal of excess water could enter downstream waterways	Chromium, zinc	Increased concentrations of chromium and zinc could be toxic to biota. This can result in fish kills and decreased habitat and biodiversity.	Waterways downstream of construction works where water sourced from Talbingo Reservoir will be used.

6.2 Construction impacts – Groundwater

Construction related impacts to groundwater are not expected as the local water table is anticipated to be below the depths of open excavations for foundations and footings for the substation and transmission structures.

At the substation, in the boreholes where groundwater was encountered, the water observations were typically associated with weathered granite, with samples logged as plastic silts to sandy silts, with clay (SMEC, 2019). This type of formation would be of low permeability. If groundwater was encountered in any excavations, potential inflows are expected to be minimal and associated impacts to be negligible.

There is potential for shallower groundwater to be encountered within project area east in the vicinity of Yarrangobilly River and it's associated alluvial aquifers where nearby Snowy 2.0 monitoring bores, TMB01A and TMB01B, show the depth to groundwater to be in the order of 5 to 6 mbgl. The transmission structures, however, are located on the elevated flanks of the valley away from shallow alluvial aquifers and the depth to groundwater is likely to be below the base of any excavations. Structure footings in this eastern area are expected to be excavated within the weathered shales of the Ravine Beds or limestone of the Byron Range Group with the formations expected to be of relatively low permeability. The likelihood of encountering groundwater during excavations for the structure footings in these locations is considered low. In the event that groundwater was encountered in any excavations, potential inflows would be expected to be minimal and associated impacts to be negligible.

Boring for pile footings may have potential to encounter groundwater, particularly in the lower lying far east portion of project area east. However, pile footings would typically be driven or bored and are not expected to require dewatering or have any significant impacts on groundwater. Potential for leakage or spills impacting on groundwater are considered to pose the greatest risk to groundwater and are assessed and managed as per potential surface water impacts and management.

The requirement or not for any dewatering during construction would be assessed in detail during detailed design. Any required dewatering, including management and discharge for groundwater, would be managed under the Soil and Water Management Plan (SWMP) of the Construction Environmental Management Plan (CEMP).

6.2.1 Blasting

6.2.1.1 Rock mass damage

Blasting of rock can result in blast induced rock mass damage, which is the propagation of inherent geological discontinuities and/or the formation of new fractures along planes of weakness in the rock mass. The degree of damage or fracturing would be dependent on the rock strength and power of the blast.

Geotechnical investigations for the substation indicate that blasting would not be required. Blasting is only expected to be required for structure footings where high strength rock is present at shallow depths. In most cases it is expected that mechanical excavation and/or rock breakers should be sufficient. It is not anticipated that significant drilling and blasting operations would be required for the project. Where required, blasting would be controlled to minimise air blast and fly rock. Rock mass damage is not expected to extend to any significant depth and would not result in the interconnecting of previously isolated aquifers. Therefore, any required blasting is not expected to result in any groundwater related impacts.

6.2.1.2 Contamination

Leakage or spills of petroleum, oils, or ANFO used for blasting and other toxicants from construction machinery, plant equipment, refuelling and vehicles travelling to and from site has potential to release ammonia, nitrate and hydrocarbons to the environment.

The detonation of ANFO also releases variable amounts of greenhouse and toxic gases. However, most common environmental issues associated with the use of ANFO are related poor fuel ignition and detonation due to the dissolution of ammonium nitrate, in wet holes, and to oil wicking, in dry holes (Brochu 2010). Use of packaged emulsions, and proper loading controls would minimise the potential for incomplete detonation. Detonation efficiency is also increased with smaller ammonium nitrate particles.

With appropriate blast design and management, contamination of groundwater due to blasting is considered unlikely.

6.2.2 NSW Aquifer Interference Policy

An assessment of the project against the minimal impact considerations of the NSW Aquifer Interference Policy is provided on **Table 6-2**. The activities associated with the project are anticipated to have no more than negligible interaction with groundwater and as such the project meets the Level 1 Minimal Impacts Consideration for less productive porous and fractured rock groundwater sources. These means that no further investigation or assessment are required under the NSW Aquifer Interference Policy.

Table 6-2: Aquifer Interference Policy Minimal Impacts Considerations – less productive porous and fractured rock

Consideration	Response
Water Table 1) Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: a) high priority groundwater dependent ecosystem; or b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply.	Level 1 – Acceptable No water level impacts to high priority GDE, high priority culturally significant site, or water supply work are anticipated.
Water Pressure **1)** A cumulative pressure head decline of not more than 40% of the "post-water sharing plan" pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work.	Level 1 – Acceptable No water pressure impacts to water supply works are anticipated.
Water Quality **1)** (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected surface water source that is defined as a "reliable water supply" is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above. (c) No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three dimensional extent of the alluvial material - whichever is the lesser distance) of a highly connected surface water source that is defined as a "reliable water supply".	Level 1 – Acceptable No impacts to groundwater quality or change in beneficial use are anticipated.

6.2.3 Groundwater dependant ecosystems

There is likely to be limited connection with project activities and the GDEs identified within project area east as the components are situated away from the riparian zone of the Yarrangobilly River and Wallaces Creek (and other tributaries) and no activities such as tunnelling are proposed. The project is unlikely to interrupt the hydrological connection between a GDE and the aquifer it depends on. Groundwater quality is unlikely to be reduced. Groundwater recharge is unlikely to be affected. There would however be some direct removal of facultative GDEs a (PCT 302) and this would be the main impact of the project on GDEs. No impacts on GDEs are expected during operation. The impacts on GDEs are discussed further in the BDAR.

6.3 Water access licences

Key water demands for the project include water for dust suppression, concrete batching, testing of the spill oil containment system, access track construction and potable supply for site offices, crib rooms and ablutions. It is expected that the water would be sourced from nearby towns such as Tumbarumba and Tumut for works occurring in project area west. All water to be used during construction project area east would be supplied by Snowy Hydro from their Snowy 2.0 operations at Lobs Hole and would be sourced from Talbingo Reservoir. Any produced grey water or black water would be exported off-site for appropriate disposal.

The project is not anticipated to have any surface water or groundwater take, either directly or indirectly. As such water access licences would not be required.

The requirement, or not, for any temporary construction dewatering would be confirmed during detailed design. It is noted, however, that an exemption for the requirement to hold a water access licence applies for excavations required for the construction of a building, road or infrastructure of up to a maximum of 3 ML in any one water year, where the water year runs from 1 July to 30 June.

6.4 Operational impacts

6.4.1 Hydrology and flooding

During operation, the project would not be expected to cause any significant adverse impacts to flooding of any nearby properties or infrastructure (including Snowy 2.0). The new access tracks and associated drainage channels and the waterway crossing (culvert/bridge) at Sheep Station Creek would cause minor interception and diversion of catchment runoff. This would not be expected to cause any significant changes in existing flow patterns or flooding conditions.

As described in **Section 5.10**, Tumut River water levels are controlled by the Talbingo Reservoir operation and the majority of structures nearest to the Tumut River would be located approximately 280 m above the Talbingo Reservoir. Therefore, the majority of the structures would not be affected by elevated reservoir levels caused by flooding. However, the first pair of structures within the Snowy 2.0 cable yard would be located within the PMF flood extent. As such, the structures would be designed with appropriate footings to ensure stability. The structures and footings would not represent a significant barrier which would concentrate surface water flow.

As the substation site is located on two waterways (New Zealand Gully and an unnamed tributary of Yorkers Creek) which experience short duration overland flooding during heavy rainfall events, it would be expected that the substation site would potentially be subject to overland flooding. The substation would include new drainage infrastructure to manage overland flow and runoff through the substation site and discharge it into downstream waterways. The new impervious surfaces of the substation site may cause an increase in the peak flow rate and volume of runoff discharged from the substation site area. There is an existing access track on the downstream side of the substation (about 120 m to the north) where there is a potential for a minor increase in flood risk and erosion at two waterways crossings. This access track would be upgraded to provide access to the substation. Overland flooding impacts at the substation site and flood risk at the access road to the substation would be considered during detailed design, to ensure that the substation's drainage and stormwater system is adequate.

6.4.2 Water quality

The potential impacts to surface water quality associated with the operation of the project are presented in **Table 6-3**. No operational impacts are anticipated for groundwater.

Table 6-3: Summary of potential operational impacts on surface water quality

Operational element/ source of pollutants	Pollutants of concern	Potential impact	Receiving waterway
Runoff from access tracks New access tracks would be established to facilitate construction and would remain in place throughout operation.	Sediments, nutrients, chemicals, heavy metal, oil and grease and petroleum hydrocarbon	▪ Movement of exposed soils can result in elevated turbidity, nutrients, and other contaminants and low dissolved oxygen of downstream waterways ▪ Increased levels of heavy metals (including aluminium and iron) which are toxic to aquatic biota stimulate the excessive growth of algae and aquatic plants leading to toxic conditions ▪ Increased sedimentation can smother aquatic life affecting the ecosystems of downstream waterways and sensitive receiving environments.	All drainage lines within 500 m of new access tracks and roads may be impacted.
Spill events Discharge of spill via runoff into nearby waterways from vehicles travelling to and from site during maintenance and accidental chemical and oil spills during routine maintenance of the transmission connection and substation.	Oil and grease, fuel and various hazardous chemicals transported by vehicles at the substation. Accidental spills during routine maintenance.	▪ Increased toxicant concentrations may be toxic to aquatic biota and fish ▪ Oily surface films reduce the visual amenity of the waterway.	All drainage lines within 500 m of access tracks and maintenance works.
Regular maintenance including vegetation removal ▪ Vegetation removal required to maintain appropriate clearances between ground vegetation and transmission lines and around the substation APZ ▪ Soil erosion and mobilisation of sediments to waterways due to disturbance of land and clearing of vegetation ▪ Tannin leachate from clearing and mulching entering downstream waterways.	Sediment, nutrients, high biological oxygen demand (BOD) and tannins.	▪ Increased sedimentation altering geomorphology of waterway ▪ Increased BOD resulting in decreased available dissolved oxygen which can impact on aquatic ecosystems and lead to fish kills ▪ Tannins can also result in dark coloured water being discharged from vegetation removal into downstream waterways. This affects the visual amenity of the waterway, can alter the pH, reduce visibility and light penetration.	All drainage lines within 500 m of areas cleared under routine maintenance.

As outlined in **Section 2.6.1**, the substation would have a stormwater and drainage system as well as an oil containment system. Potential impacts to surface water quality would be managed through the implementation of adequate mitigation and management measures discussed in **Section 7**. An assessment of residual risk to surface water quality associated with the operation of the project is provided in **Section 8**.

6.5 Water balance

The project is not anticipated to have any significant take of surface or groundwater resulting from either construction or operation. The project would not have any discharge to the environment other than water applied for dust suppression, and diverted surface water runoff around the substation site, which would be appropriately managed with adequate drainage and stormwater design as required to manage potential impacts on receiving waters.

Approximately 60,000 kilolitres of water is expected to be required over the duration of construction works. It is expected that water would be required for:

- Amenities at the substation site
- Dust suppression during excavation works and for stockpiles
- Concrete production (it is expected that concrete would be sourced from offsite suppliers and from the Snowy 2.0 concrete batching facilities associated with the Snowy 2.0 Main Works)
- Access track construction
- Testing of the spill oil containment system following construction of the substation.

It is expected that the water would be sourced, via tanker, from nearby towns such as Tumbarumba and Tumut for works occurring in project area west. It is expected that water to be used during construction in project area east would be supplied by Snowy 2.0 Main Works operations at Lobs Hole and would be sourced from Talbingo Reservoir. The approval for all water supply infrastructure at Lobs Hole would be sought separately by Snowy Hydro.

Stormwater and water used for the testing of the spill oil containment system at the substation site would be captured and treated on site. Wastewater from the amenities would be collected and disposed of off-site.

Construction and operation of the project would have negligible impact on quantity of the region's surface and ground water resources, including Yarrangobilly River, Wallaces Creek, Talbingo Reservoir and the Tumut River.

7. Management and mitigation measures

This section provides an overview of the measures to manage the potential impacts of the project on surface water and groundwater during construction and operation. It provides an overview of the broad objectives for management of flooding and water quality impacts, measures to consider during the detailed design process to avoid and minimise impacts, as well as key strategies for minimising flooding and water quality risks related to construction and operation of the project.

7.1 Overview

Management measures are proposed with the objective of minimising any short-term impacts that may be encountered on downstream waterways, groundwater resources, and sensitive receiving environments. The implementation of these measures would aim to manage potential degradation of the nominated environmental values and that any changes in water quality would have a neutral or beneficial effect.

7.2 Mitigation measures

Recommended safeguards and mitigation measures to manage potential impacts of the project's construction and operation are summarised in **Table 7-1**.

Table 7-1: Summary of environmental management measures

Aspect	Environmental management measures	Responsibility	Timing
Waterway crossings	The waterway crossing over flood impacted waterways such as Sheep Station Creek will be designed and constructed in a way that minimises flood risk and minimise upstream and downstream impacts. Detailed flood modelling will be undertaken to define flood behaviour for the existing conditions and construction and operation of the project. The waterway crossing will be designed to ensure flow and drainage is maintained in waterways where construction works are taking place or where the permeant waterway crossing will be. The waterway crossing culverts would be constructed in accordance with minimum design criteria for waterway crossings outlined in *Why do fish need to cross the road? Fish passage requirements for waterways crossings* (Fairfull and Witheridge, 2003).	TransGrid / Construction contractor	Detailed design
Flooding	▪ Overland flooding impacts would be considered during detailed design, to ensure that the substation's drainage and storm water system is adequate, and the substation's platforms are above the required flood immunity. ▪ Structures within the flood extent will be designed with appropriate footings to ensure stability against hydrostatic pressure and debris load.	TransGrid	Detailed design
Construction earthworks	A SWMP will be prepared and implemented as part of the CEMP. The SWMP will include: ▪ Erosion and sediment control plans for all stages of construction ▪ Details on the construction and management of sediment basin if determined to be required ▪ Protection of waterways such as scour protection, stabilisation and revegetation ▪ Any imported fill will be certified at source locations as pathogen and weed free Excavated Natural Material or Virgin Excavated Natural Material) ▪ Management of stockpiles and spoil ▪ Tannin leachate management controls ▪ Management of accidental spills, response and reporting ▪ An induction protocol ▪ Responsibilities for all management measures.	Construction contractor / TransGrid	Construction

Aspect	Environmental management measures	Responsibility	Timing
Spoil management	Any spoil will be stockpiled in a manner so as to avoid the possibility of sediments entering waterways (including stormwater drains) or migrating off-site.	Construction contractor	Construction
Leakage or spills impacting soils, surface water or groundwater	▪ All chemicals or other hazardous substances will be stored in a bunded area and away from any drainage lines/pits. The capacity of the bunded area will be at least 130% of the largest chemical volume contained within the bunded area. ▪ No refuelling or bulk herbicide preparation will occur within 40 m of natural drainage lines. ▪ Environmental spill kits containing spill response materials suitable for the works being undertaken will be kept on site at all times and be used in the event of a spill. ▪ Any spills will be contained, cleaned up promptly and immediately reported to the relevant site representative.	Construction contractor TransGrid	Construction
Water quality impacts from stormwater runoff	▪ All erosion and sediment control measures will be designed, implemented, progressive rehabilitated and maintained in accordance with relevant sections of "Managing Urban Stormwater: Soil and Construction Volume 1" (Landcom, 2004) ('the Blue Book) (particularly Section 2.2) and "Managing Urban Stormwater: Soil and Construction Volume 2A – Installation of Services" (DECC, 2008)". ▪ The SWMP will include arrangements for managing wet weather events, including monitoring of potential high risk events (such as storms) and specific controls and follow-up measures to be applied in the event of wet weather. ▪ Where required, adequate sediment controls (including the consideration of sediment basins) would be included in the access track design to manage erosion and sedimentation and associated impacts on receiving waters.	Construction contractor	Construction
Dewatering	In the event that dewatering is required then the following management measures will apply: ▪ Confirmation of whether or not a licence under the WM Act as defined under the Aquifer Interference Policy is required prior to any dewatering activity commencing. ▪ If dewatering is required, the management of discharge water will be documented in the CEMP. ▪ Discharge water will be limited to vegetated, grassed areas, away from waterways, and within the project area. If the discharge water is highly turbid, dewatering through a filter sock (or similar), or via transportable sedimentation tanks will be considered, where appropriate, to minimise sedimentation ▪ If dewater is expected to exceed three megalitres in any one water year, where the water year runs from 1 July to 30 June a licence maybe required.	Construction contractor / TransGrid	Construction
Flood risk management	A flood management plan (FMP) will be prepared as part of the CEMP for the project and will detail the processes for flood preparedness, materials management, weather monitoring, site management and flood incident management. The FMP will also address procedures and responsibilities for flood response (preparation of site upon receipt of flood warning, evacuation of site personnel) during and recovery following a flood event.	Contractor	Prior to construction
Waterway crossings	▪ The waterway crossing and access tracks would be inspected as part of the maintenance inspections to ensure all crossings remain in good condition.	TransGrid	Operation

8. Residual impacts

It is considered unlikely that minor changes to surface water or groundwater quality in the project area would result in a deterioration of water quality that would prevent the use of the waterways or groundwater resources for their nominated environmental values. With the implementation and management of mitigation measures the potential residual impact on surface water and groundwater quality from key risks including erosion and sedimentation, accidental spills and vegetation clearing is considered low.

9. Conclusion

The eastern extent of the project is defined by the location of the proposed Snowy 2.0 cable yard in KNP. From the Snowy 2.0 cable yard, the transmission connection extends west through KNP, through a landscape characterised by steep, mountainous terrain before traversing Talbingo Reservoir. The transmission connection then continues west, passing Elliott Way before entering Bago State Forest to the proposed substation site and the connection with existing transmission lines. The project falls within the Murrumbidgee catchment within the Snowy Mountains alpine region.

The assessment of existing water quality data of Lobs Hole (Talbingo Reservoir), Yarrangobilly River and Tumut River found that water quality is generally good and meets required limits for protection of nominated environmental values (refer to **Table 4-1** and **Table 4-2**). Nutrient levels and turbidity were consistently low and pH levels neutral. Dissolved oxygen levels were slightly below the lower recommended limit, and some metals exceeded the recommended limit for 99 per cent species protection.

Groundwater quality in the region has been found to be typically neutral to alkaline and fresh. Depth to groundwater is likely to range in depth between three and 50 mbgl, depending on location and topography. No groundwater users have been identified within 5 km of the project.

The construction and the operation of the project has the potential to impact nearby waterways near, particularly those within 500 m of the project. Potential impacts to surface water quality include:

- Erosion of soils and sedimentation of waterways
- Tannin leachate from vegetation clearing during the construction and operation
- Accidental leaks or spills of chemical and fuels from construction machinery during construction, or from vehicle accidents using access roads during operation
- Dispersal of residual ash (that is present on the ground surface from bushfires) into waterways.

To minimise impacts to surface water quality, a range of measures would be implemented during the construction and operation of the project including:

- Development and implementation of a SWMP as part of the CEMP
- Spoil and spill management
- Water quality monitoring
- Stormwater management controls.

Earthworks or excavations during construction are not anticipated to encounter groundwater or require dewatering. In the event that groundwater was encountered in any excavations, potential inflows would be expected to be minimal and associated impacts to be negligible. More detailed assessment for the potential to encounter shallow groundwater would be undertaken during detailed design and geotechnical investigations. In the event that groundwater is shallower than anticipated and dewatering is required, dewatering would be managed under the SWMP as part of the CEMP.

Assessment of the project against the minimal impact considerations of NSW Aquifer Interference Policy demonstrate that project is expected to have no more than negligible impacts on groundwater users, groundwater dependent ecosystems or groundwater quality.

The project is also not anticipated to have any significant take of surface or groundwater resulting from either construction or operation. The project would not have any discharge to the environment other than water applied for dust suppression, dewater (if required), and diverted surface water runoff around the substation site, which would be appropriately managed with adequate drainage and storm water design.

Most project components are located away from major waterways, drainage lines and flood prone land, as such it would be at low risk of flooding during construction. However, heavy rainfall during the construction period could result in local overland flows entering excavations or stockpiles of construction materials, and spoil being washed away into nearby drainage lines and waterways, unless appropriate management measures are implemented.

The first pair of structures within the Snowy 2.0 cable yard and the waterway crossing at Sheep Station Creek would be located within the PMF flood extent. In addition, the new substation would potentially be subject to overland flooding. As such these components would be designed accordingly during detailed design to ensure appropriate flood immunity.

During operation, the project is not be expected to cause any significant adverse impacts to flooding of any nearby properties or infrastructure (including Snowy 2.0) nor cause any significant changes in existing flow patterns or flooding conditions.

Overall with the implementation of the proposed mitigation measures, the project is expected to have minimal impacts on existing groundwater, flooding, surface water resources and environmental values during the construction and operational phases.

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