DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

JUNE 2021

TECHNICAL STUDY REPORT

HYDROGEOLOGY

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GLOSSARY

Alluvial	Sediments deposited by flowing water.
Alluvium	General term for unconsolidated deposits of inorganic materials (clay, silt, sand, gravel, boulders) deposited by flowing water.
Aquifer	Rock or sediment in a formation, group of formations or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.
Aquitard	Saturated geological unit with a relatively low permeability that can store large volumes of water but does not readily transmit or yield significant quantities of water to bores or springs. An aquitard can sometimes, if completely impermeable, be called an aquiclude.
Australian Height Datum (AHD)	A level datum, uniform throughout Australia, that generally approximates mean sea level.
Bore	Artificially constructed or improved groundwater cavity used for the purpose of accessing or recharging water from an aquifer. Interchangeable with borehole, piezometer.
Borehole	Includes a well, excavation, or other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer. Interchangeable with bores, wells, piezometers, and standpipe.
Clay	Deposit of particles with a diameter less than 0.002 mm, typically contain variable amounts of water within the mineral structure and exhibit high plasticity.
Confined aquifer	An aquifer bounded above and below by impervious (confining) layers. In a confined aquifer, the water is under sufficient pressure so that when wells are drilled into the aquifer, measured water levels rise above the top of the aquifer.
Drawdown	The change in groundwater level in a bore, or the change in water table elevation in an unconfined groundwater system, due to the extraction of groundwater.
Fault	Zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.
Formation	General term used to describe a sequence of rock layers.
Groundwater	Water found in the subsurface in the saturated zone below the water table or piezometric surface i.e. the water table marks the upper surface of groundwater systems.
Groundwater flow	The movement of water through openings and pore spaces in rocks below the water table i.e. in the saturated zone.
Groundwater resource	Groundwater available for beneficial use, including human usage, aquatic ecosystems and the greater environment.
Hydraulic conductivity	Measure of the ease with which water will pass through earth material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (metres per day).
Hydraulic gradient	Change in the hydraulic head over a certain distance.

(Hydraulic) head	Elevation to which water will rise in a borehole connected to a point in an aquifer.
Hydrogeology	The study of the interrelationships of geological materials and processes with water, especially groundwater.
Impact	An event that disrupts ecosystem, community, or population structure and alters the physical environment, directly or indirectly.
Infiltration	The downward movement of water from the atmosphere into the ground; not to be confused with percolation.
Investigation area	The investigation area for the Snowy Mountains SAP, encompassing an area of 72,211 ha including Jindabyne and the Alpine Resorts of Kosciuszko National Park.
Investigation buffer	The area of land encompassed within a 2-km zone adjacent to the Snowy Mountains SAP boundaries.
Lithology	The physical character of rocks.
Modelling	The creation of a computerised model that simulates natural environment, allows simulations to project future outcomes.
Monero Ngarigo	Aboriginal linguistic group who traditionally occupied the eastern side of the Kosciuszko plateau and further north towards the Murrumbidgee River. The traditional custodians of the Snowy Mountains are the Monero Ngarigo people.
Monitoring bore	A bore used to monitor groundwater levels or quality.
Permeability	The ease with which a fluid can pass through a porous medium and is defined as the volume of fluid discharged from a unit area of an aquifer under unit hydraulic gradient in unit time (metres per day).
Piezometric Head (or Surface)	the elevation to which water will rise in a piezometer connected to a point in an aquifer. Differences in piezometric head determine the hydraulic gradient and therefore the direction of groundwater flow. Piezometric surface is a 3D surface connecting point of equal head.
Recharge	Recharge is defined as the process by which water is added from outside to the zone of saturation of an aquifer, either directly into a formation, or indirectly by way of another formation.
Runoff	All surface and subsurface flow from a catchment, but in practice refers to the flow in a river i.e. excludes groundwater not discharged into a river.
Semi-confined aquifer	An aquifer that is partly confined by layers of lower permeability material through which recharge and discharge may occur, also referred to as a leaky aquifer.
Snowy Mountains	The highest mountain range on the continent of mainland Australia, located in southern New South Wales and part of the larger Australian Alps and Great Dividing Range. The mountain range experiences large natural snowfalls every winter.
Special Activation Precinct	A Special Activation Precinct is a dedicated area in a regional location identified by the NSW Government to become a thriving business hub to create jobs, attract business and investors, support local industries and fuel economic development.

Stratigraphy	Branch of geology dealing with the classification, nomenclature, correlation, and interpretation of stratified rocks.
Water table	The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric; it can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch or a tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: — in a natural channel, whether artificially modified or not — in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams.
Yield	The quantity of water removed from a water resource e.g. yield of a borehole.

ABBREVIATIONS

AEM	Airborne electromagnetic survey
AHD	Australian Height Datum
AIP	Aquifer Interference Policy
ANZECC	Australian and New Zealand Environment and Conservation Council
AWD	Available water determination
mBGL	Metres Below ground level
BoM	Bureau of Meteorology
CBD	Central Business District
CDFM	Cumulative departure from mean
DOI-W	Department of Primary Industries – Water
DPIE	Department of Planning, Industry and Environment
DRNSW	Department of Regional New South Wales
EbD	Enquiry by Design
EPA	Environment Protection Authority
ERT	Electrical resistivity tomography
ET	Evapotranspiration
GDE	Groundwater dependent ecosystem
GMA	Groundwater management area
HNSW	Heritage New South Wales
KNP	Kosciuszko National Park
KNP POM	Kosciuszko National Park Plan of Management
LFB	Lachlan Fold Belt
LGA	Local Government Area
LTAAEL	Long-term average annual extraction limit
NPWS	National Parks and Wildlife Service
NSW	New South Wales
RAP	Registered Aboriginal Party
RGDC	Regional Growth NSW Development Corporation
SAP	Special Activation Precinct
SEPP	State Environmental Planning Policy

SMRC	Snowy Monaro Regional Council
TDS	Total dissolved solids
TfNSW	Transport for New South Wales
WAL	Water access licence

EXECUTIVE SUMMARY

INTRODUCTION

The Department of Planning, Industry and Environment (DPIE) is preparing a Master Plan for the Snowy Mountains Special Activation Precinct (SAP) that will be informed by the Structure Plan, community engagement and several technical studies. DPIE has commissioned WSP to prepare a Hydrogeological Assessment as part of the Engineering Package to support the preparation of the Master Plan. This study has reviewed the existing hydrogeological setting, regulatory framework, and water resource availability in the vicinity of the Snowy Mountains SAP.

EXISTING CONDITIONS

Jindabyne, and the surrounding land within the Snowy Mountains SAP, directly overlies the Lachlan Fractured Rock Cost (LFB) Groundwater Source which is comprised largely of Silurian intrusive granodiorites and granite. This groundwater source is a fracture rock aquifer, typically these aquifers have low primary porosity (and therefore storage) with groundwater being transmitted through secondary porosity features such as fractures, joints, and solution voids.

Groundwater yields are reported to be low and, in some instances, drilled groundwater bores have fail to intersect groundwater even at considerable depths. Due to the low yields and geological constraints of the fracture rock aquifer groundwater resources is considered marginal. This is consistent with previous assessments from the former Office of Environment & Heritage study indicating that while groundwater quality was found to be good within the region, groundwater yields were considered unreliable for agricultural and residential purposes (SRSC 2012).

GROUNDWATER AVAILABILITY

The LFB Coast Groundwater Source has unallocated water available and the provision to obtain WAL to extract groundwater as a water supply throughout the Investigation Area. However, as demonstrated through reported groundwater yields, and a Snowy Monaro Regional Council (SMRC) 2014 water supply drilling programme at Dalgety, just having the regulatory ability to obtain a WAL does not guarantee a water supply. The underlying bedrock granite and fractured rock geology results in a relatively poor groundwater resource with high spatial variability, as demonstrated by the numerous number dry bore previously drilled within the Snowy Mountains SAP Investigation Area.

CONCLUSION

Due to the constraints associated with obtaining a suitable groundwater yields, alternative water sources should be considered first. Increasing existing water licence allocations or obtaining water licences for alternative surface water sources may be more appropriate and cost effective for the volumes required for snow making or town supply.

In the event that groundwater is required for the development of the Snowy Mountains SAP, then undertaking additional assessment is recommended to improve the likelihood of identifying drilling targets that may yield groundwater. Additional hydrogeological and geophysical investigation can assist in identifying major structural lineaments (extensive defects zones) within the geology which are more likely to transmit groundwater. Identifying these locations for drilling improve the chances of intersecting groundwater. However, it is important to note that they cannot fully mitigate the risk that drilling fails to yield enough groundwater to satisfy supply requirements.

It is recommended that any proponent intending to progress evaluation and development of groundwater as a water source consider the financial and hydrogeological risks associated therewith, and seek appropriate technical advice to identify and mitigate risks where possible. These recommendations are consistent with previous hydrogeological assessments made by predecessors NSW Government departments.

1 INTRODUCTION

Special Activation Precincts (SAPs) are dedicated areas in regional NSW identified by the NSW Government to become thriving hubs. The SAP program facilitates job creation and economic development in these areas through infrastructure investment, streamlining planning approvals and investor attraction.

The SAP program adopts a collaborative and integrated whole-of-government approach, bringing together the local Council and a range of other relevant State and local agencies.

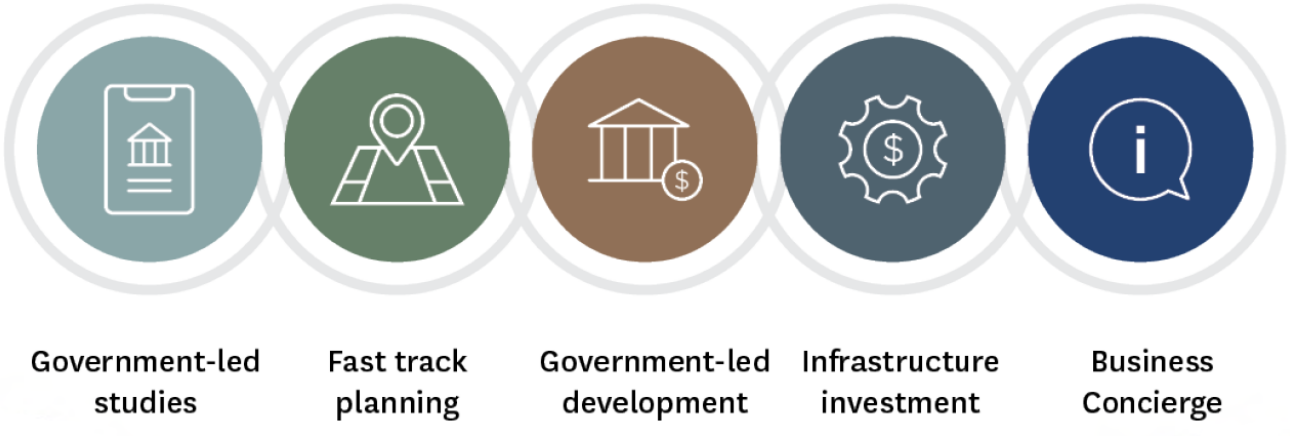
SAPs are unique to regional NSW. By focusing on planning and investment, their goal is to stimulate economic development and create jobs in line with the competitive advantages and economic strengths of a region.

On 15 November 2019, the NSW Government announced its commitment to investigating the Snowy Mountains SAP, to revitalise the Snowy Mountains into a year-round destination and Australia's Alpine Capital, with Jindabyne at its heart. The Snowy Mountains SAP is being delivered through the $4.2-billion Snowy Hydro Legacy Fund.

Different components of each SAP are led by different teams within the NSW Government:

- The **Department of Regional NSW** assesses potential locations for inclusion in the program and considers government investment for essential infrastructure to service the SAPs.
- The **NSW Department of Planning, Industry and Environment** (the Department) is responsible for the planning of SAPs. The Department leads the master planning process, including community and stakeholder engagement, the technical studies required to inform the preparation of a master plan and development of the simplified planning framework for each Precinct.
- The **Regional Growth NSW Development Corporation** (Regional Growth NSW) is responsible for delivering and implementing Special Activation Precincts. This includes attracting investment, providing support to businesses, developing enabling infrastructure, and creating strategic partnerships to foster education, training and collaboration opportunities.

The five core pillars of the Special Activation Precincts are:



The planning framework for each Special Activation Precinct includes three key parts:

STATE ENVIRONMENTAL PLANNING POLICY (ACTIVATION PRECINCTS) 2020	SPECIAL ACTIVATION PRECINCT MASTER PLANS	SPECIAL ACTIVATION PRECINCT DELIVERY PLANS

— Identifies each Special Activation Precinct.
— Requires that an Activation Precinct Certificate be sought prior to a development application or complying development certificate being issued, to ensure the development is consistent with the Master Plan and Delivery Plan.
— Provides zoning and land use controls for each Precinct.
— Identifies Exempt and Complying Development pathways for certain development.
	— Made by the NSW Department of Planning, Industry and Environment and approved by the Minister.
	— Identifies the Vision, Aspirations and Principles for the Precinct.
	— Provides more detailed land use controls where required.
	— Identifies Performance Criteria at a Precinct-scale for amenity, environmental performance and infrastructure provision.
	— Identifies the matters to be addressed as part of the Delivery Plan.
		— Prepared by Regional Growth NSW and approved by the Planning Secretary.
		— Identifies site-level development controls.
		— Provides detailed strategies and plans for:
		  — Aboriginal cultural heritage
		  — Environmental protection and management
		  — Protection of amenity
		  — Infrastructure and services
		  — Staging.
		— Provides procedures for ongoing monitoring and reporting.

1.1 MASTER PLANNING

The master planning process for the SAPs adopts an evidenced based approach to determining the best outcome for the precincts. It is designed to ultimately provide a clear pathway for the right types of future development, in the right locations.

The process involves the engagement of a range of technical experts to investigate the study area and prepare technical studies (such as this report) to demonstrate their findings. Each of the technical studies are specifically designed and scoped for each SAP and tailored to the needs of the study area.

Importantly, the master planning process for the Snowy Mountains SAP will build on work already undertaken for portions of the study area as part of the Go Jindabyne master plan.

To achieve integrated and balanced planning outcomes, technical experts and other stakeholders work together at a series of enquiry by design workshops throughout the master planning process. At these workshops, opportunities and constraints are discussed and assessed to inform how the precinct should be shaped. This includes the evaluation of matters such as environmental impacts and benefits, transport opportunities, infrastructure capabilities, stormwater, economic viability and many others. These workshops are designed to give technical experts and decision makers a chance to ensure the identified vision, aspirations and principals for the precinct are guiding the outcomes.

The technical reports will ultimately inform the development of planning controls for the Snowy Mountains SAP to guide the precincts development. These controls will be contained in the master plan, Special Activation Precincts SEPP and delivery plan and will relate to important matters such as amenity, environmental performance and infrastructure provision.

Throughout the planning process, community, stakeholder and industry consultation takes place. Ongoing consultation provides an opportunity for community members and landowners to contribute and help shape the vision for the project.

1.2 SNOWY MOUNTAINS SAP

The Snowy Mountains region is one of Australia's most iconic natural environments. In addition to hosting some of Australia's premier alpine destinations, the Snowy Mountains is home to over 35,000 people and Australia's highest peak, Mount Kosciuszko. The traditional custodians of the Snowy Mountains are the Monero Ngarigo people, in connection with the Walgalu, Ngunnawal and Bidhawal people.

The Snowy Mountains are located in the south east of NSW. This region forms the northern part of the Australian Alps which extends south into Victoria. Predominantly the region is accessed from Canberra which is located approximately 150 kilometres to the north. To the south and west of this region is the sparsely populated high country. The township of Jindabyne situated on Lake Jindabyne provides a hub for the region, with opportunities for tourism and facilities supporting the regional catchment.

Jindabyne is located 175 km south of Canberra and 60 km south-west of Cooma. Jindabyne has evolved into the gateway to the Snowy Mountains and currently services 1.4 million visitors each year who travel to the region to enjoy its unique tourism and recreational offerings (Destination NSW, June 2020 report). There are approximately 35,500 residents of the Snowy Mountains, of which 3,500 residents live in Jindabyne (including Kalkite, East Jindabyne and Tyrolean Village).

Portions of the Snowy Mountains are within Kosciuszko National Park. Kosciuszko National Park is the central segment of the Australian Alps Bioregion containing the highest mountains in Australia and is the largest national park in NSW (NSW National Parks and Wildlife Service, 2006). The park possesses exceptional diversity of alpine plant communities, containing threatened ecological communities (TECs) and providing habitat for a number of rare and threatened species (National Parks and Wildlife Service, 2006). The park contains most of the alpine endemic species found on the Australian mainland (National Parks and Wildlife Service, 2006).

The Snowy Mountains region is home to the Monero Ngarigo people, the tribal homeland stretches from the western slopes of the coastal ranges to the eastern side of the Kosciuszko plateau and further north. Included in the Ngarigo land is the peak of Mount Kosciuszko and the Snowy Ranges. European settlers accessed the region in 1823, and between the late 1830s to 1957 the Monaro highland region was grazing by cattle and sheep. The original town of Jindabyne was settled in the 1840s on the banks of the Snowy River where the main river crossing took place. A bridge was constructed over the river in 1893, contributing to the success of the town. In 1949 the Snowy Mountains Scheme was introduced which consisted of plans to dam and divert water from the Snowy River. By 1964 the dam had created Lake Jindabyne and the township relocated to where it is today. The old town disappeared under Lake Jindabyne in 1967. Although losing much of its built heritage, Jindabyne, as we know it today, was rebuilt and has continued to steadily grow leveraging its tourist and agricultural offerings (Ozark Environment and Heritage, 2020).

Today, the Snowy Mountains region plays a crucial role within the regional and state economy, with its local population swelling with an additional 1.4 million international and domestic visitors each year (Destination NSW, June 2020 report). The region's unique natural environment allows locals and visitors to participate in a diverse array of recreational activities year-round, with many visitors still experiencing the region through the peak winter season.

Priorities for the Snowy Mountains SAP are to capitalise on the unique cultural and environmental attributes which attract 1.4 million visitors annually to the region, revitalise the Snowy Mountains into a year-round destination, and reaffirm Australia's Alpine Capital (Destination NSW, June 2020 report). The revitalisation is to focus on year-round adventure and eco-tourism, improving regional transport connectivity, shifting towards a carbon neutral region, increasing the lifestyle and wellbeing activities on offer, and supporting Jindabyne's growth as Australia's national winter sports training base.

1.3 STUDY AREA

The Snowy Mountains SAP Investigation Area encompasses 72,211 hectare (ha) of land and within this study area are several key areas called “development opportunity areas”:

- Jindabyne growth opportunity areas: parcels of land located primarily to the south and west of the existing Jindabyne township, but also at East Jindabyne
- Jindabyne centre opportunity areas: areas within the existing town of Jindabyne
- Tourism opportunity areas: areas both near the town of Jindabyne and in the Kosciuszko National Park.

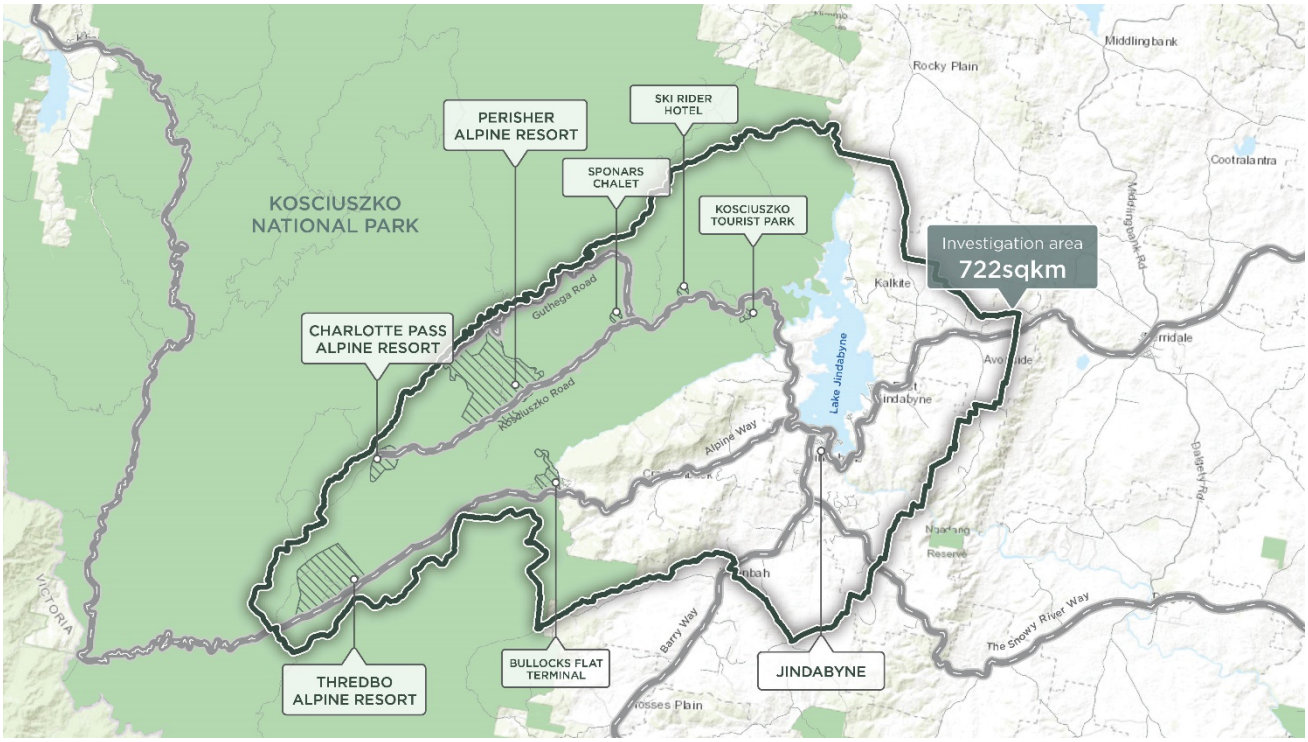


Figure 1.1 Study area

1.4 PURPOSE

This Hydrogeological Study (the report), combined with additional Technical Studies, will form the Engineering Package of the Snowy Mountains SAP. Following the previously issued context analysis, this report describes groundwater availability within the Snowy Mountains SAP Investigation Area in consideration of groundwater being used as a resource for water supply by individuals and industry.

The previously issued context analysis report provided a review of existing studies, data, relevant policies, standards, and guidelines to develop a conceptual understanding of the groundwater environment within the Snowy Mountains SAP Investigation Area. Additional data has since been issued to the project team since finalisation of the context report. This data has further developed and confirmed the conceptual groundwater understanding pertaining to groundwater yield and water access licences within the Snowy Mountains SAP Investigation Area.

1.5 BACKGROUND INFORMATION

Data, made available for review since the issue of the Context report, has been incorporated into the background information table and includes new data sources.

Table 1.1 Background information

Policy and planning context	The Aquifer Interference Policy
	Go Jindabyne 2036 Master Plan – Environment and Heritage
	Water Sharing Plan for the Snowy Genoa Unregulated and Alluvial Water Sources
	Water Sharing Plan for the Snowy Genoa Unregulated and Alluvial Water Sources – Background document
	Water Sharing Plan for the South Coast Groundwater Sources
	Water Sharing Plan for the South Coast Groundwater Sources – Background document
	Water Sharing Rules – Lachlan Fold Belt Coast Groundwater Source
Existing studies	Climate Change Impacts in the NSW Alpine Region – Water availability (NSW OEH 2018)
	Groundwater Monitoring Program, Perisher and Smiggin Holes 1998–1999 – Report on Monitoring Results (SMEC 1999)
	Perisher Range Village Master Plan EIS Groundwater and Geotechnical Study (SMEC 1998)
	SAP Regional Airport Pre-Feasibility Assessment (Arup 2019)
	Snowy Hydro 2.0 EIS and supporting technical documents
	SRSC Integrated Water Cycle Management Evaluation Study (Hydroscience 2012)
	SRSC Integrated Water Cycle Management Plan (Hydroscience 2012)
Data	Bureau of Meteorology, National Groundwater Information System
	Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas
	Geoscience Australia, Australian Stratigraphic Units Database
	Geological Survey of NSW Seam less Geology Zone 55 East compilation (2017) NSW Planning and Environment Resources and Energy)
	SMRC Groundwater drilling data for Dalgety water bores
	WaterNSW Real time data portal
	WaterNSW work summary reports from registered bores within SAP investigation Area

1.6 THIS REPORT

This Hydrogeology Report (this report) builds on the conceptualisation of the groundwater environment established within the Context Analysis Report (June 2020). Several sections have also been included from the previous Context Analysis Report as additional information from RFI's were provided after submission of that report that further evolve the conceptual understanding of the groundwater environment within and surrounding the Snowy Mountains SAP Investigation Area.

As such, this report provides details groundwater availability within the Lachlan Fold Belt (LFB) Coast Groundwater Source, and the physical and regulatory considerations in accessing groundwater.

Unlike other technical discipline reports, the same groundwater source underlies the entire Investigation Area, including Selwyn Resort. The same physical aquifer considerations and regulatory environment apply to the whole Investigation Area, therefore this report does not discuss specific groundwater availability within the individual sub areas.

2 REGULATORY CONTEXT

The following section have been distilled from the Context Report and focus on NSW State legislation as it relates to regulating groundwater sources and aquifer interference relevant to the management of groundwater and water resources within the Snowy Mountains SAP investigation area.

2.1 STATE LEGISLATION

2.1.1 *WATER ACT 1912 AND WATER MANAGEMENT ACT 2000*

Water resources are administered under the Water Act 1912 and the Water Management Act 2000 by the NSW Department of Industries – Water (DoI-W). The Water Management Act 2000 governs the issue of water access licences and approvals for those water sources (rivers, lakes, estuaries and groundwater) in New South Wales where Water Sharing Plans have commenced. Water Sharing Plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, as well as, between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. The Water Act 1912 governs the issue of water licences for water sources in other areas. There are Water Sharing Plans for regulated and unregulated river catchments, and groundwater sources in water management areas.

The Water Management Act 2000 requires approvals for activities that impact the aquifer(s) present. The approval is for activities that intersect groundwater other than water supply bores and may be issued for up to ten years.

Part 2 of the Water Management Act 2000 establishes access licences for the take of water within a particular water management area (discussed further in Section 3.3).

Part 3 of the Water Management Act 2000 establishes three types of approvals that a proponent may be required to obtain. These are:

- water use approvals
- water management work approvals (including water supply work approvals)
- activity approvals (including controlled activity approvals and aquifer interference approvals).

Section 66 of the Water Management Act 200 describes the conditions applicable to an access licence. Pertinent of these includes the provision that, at the end of each 5 year interval, the Minister is to vary local water utility licences so as to reflect any variation in population, together with any associated commercial activities, that has occurred during the period in the area which domestic water is supplied under the licence.

2.2 KEY WATER MANAGEMENT POLICIES FOR THE SNOWY MOUNTAINS SAP

2.2.1 *WATER SHARING PLANS*

Water Sharing Plans are established under the *Water Management Act 2000* and are the primary tool for defining water-sharing arrangements in NSW. Water Sharing Plans set the rules for how water is allocated and are intended to remain in force for 10 years thus providing consistency and security over this period for water users and the environment as to how water is allocated and shared. This not only ensures that water is specifically provided for the environment through a legally binding plan, but also allows licence holders, such as irrigators or industrial users of groundwater, who require large volumes of water, to plan their business activities.

Water sharing plans describe the annual surface and groundwater recharge volumes for each identified water source and the volumes of water that are available for sharing. Available water volumes are based on calculated long-term average annual extraction limit (LTAAEL). Provisions are made for environmental water allocation, basic landholder rights, domestic and stock rights and native title rights. Water sharing plans are typically in place for ten years, however they may be suspended in times of severe water shortages.

The key purpose of a water sharing plan is to:

- provide water users with a clear picture of when and how water will be available for extraction
- protect the fundamental environmental health of the water source
- ensure the water source is sustainable in the long-term.

Two Water Sharing Plans are currently operating within the investigation area:

- Water Sharing Plan for the South Coast Groundwater Sources, commenced 1 July 2016
- Water Sharing Plan for the Snowy Genoa Unregulated and Alluvial Water Sources, commenced 1 July 2016.

2.2.1.1 SOUTH COAST GROUNDWATER SOURCES

The Water Sharing Plan for the South Coast Groundwater Sources consisted of three groundwater sources located in Southern NSW as shown in Figure 2.1. These water sources are within the Southern Water Management Area, and the South East Water Management Area are the:

- Lachlan Fold Belt (LFB) Coast Groundwater Source
- South East Coastal Sands Groundwater Source
- Sydney Basin-South Coast Groundwater Source.

Mapped groundwater sources within the South Coast Groundwater Sources extend from Tomerong to the NSW – Victorian border and inland to the Snowy Mountains including Jindabyne. Only the LFB Coast Groundwater Source underlies the investigation. This includes all water contained in all fractured rock below the surface of the ground within the outcropped and buried areas within the sources.

The Water Sharing Plan for the South Coast Groundwater Sources establishes a LTAAEL for each groundwater source that is the allowable limit of extraction for that water source. The LTAAEL is equal to the average annual recharge less the volume set aside for the environment. Each year a provision is made for basic rights to ensure the total extraction from the water source is within the LTAAEL. Applications can be made for local water utilities under an exemption (NSW Department of Infrastructure, Planning and Natural Resources, 2005).

The Project is situated within the LFB Coast Groundwater Source of the Water Sharing Plan that encompasses 20,031 km^2 and carries an LTAAEL limit of 20,000 ML/yr. Town water supply and stock and domestic users have a higher priority for access to groundwater than other groundwater users.

Source: DPIE

Figure 2.1 Water sharing plan for the south coast groundwater sources – plan map

2.2.2 *REGIONAL WATER STRATEGIES*

DPIE is currently preparing 12 new regional water strategies to plan and manage the water needs in each NSW region over the next 20 to 40 years. The strategies are in development and delivery of the final strategies is expected in 2021.

These strategies will set out a long-term "roadmap" of actions to deliver five objectives. Options selected for inclusion in the strategy for each region will need to address at least one of these objectives:

- deliver and manage water for local communities
- enable economic prosperity
- recognise and protect Aboriginal cultural values and rights
- protect and enhance the environment
- affordability – identify least cost policy and infrastructure options.

During extreme events, such as the current drought, the focus is on securing water for basic landholder rights and essential town water supplies. Outside of extreme events, there is greater flexibility to deliver across all the objectives.

2.2.2.1 MURRAY WATER STRATEGY

The Snowy Mountains SAP is located within the Murray Water Strategy region (Figure 2.2). This strategy will consider water supply, reliability and security for towns and businesses in the Snowy region. It will also consider urban water needs, drought security, the reliability of water supply for industries and protection of the region's environmental assets. The draft regional water strategy for Murray is scheduled for release in mid-2021, with the final strategy to be completed in 2022. The strategy will consider all surface water (regulated and unregulated), and groundwater sources in the region.

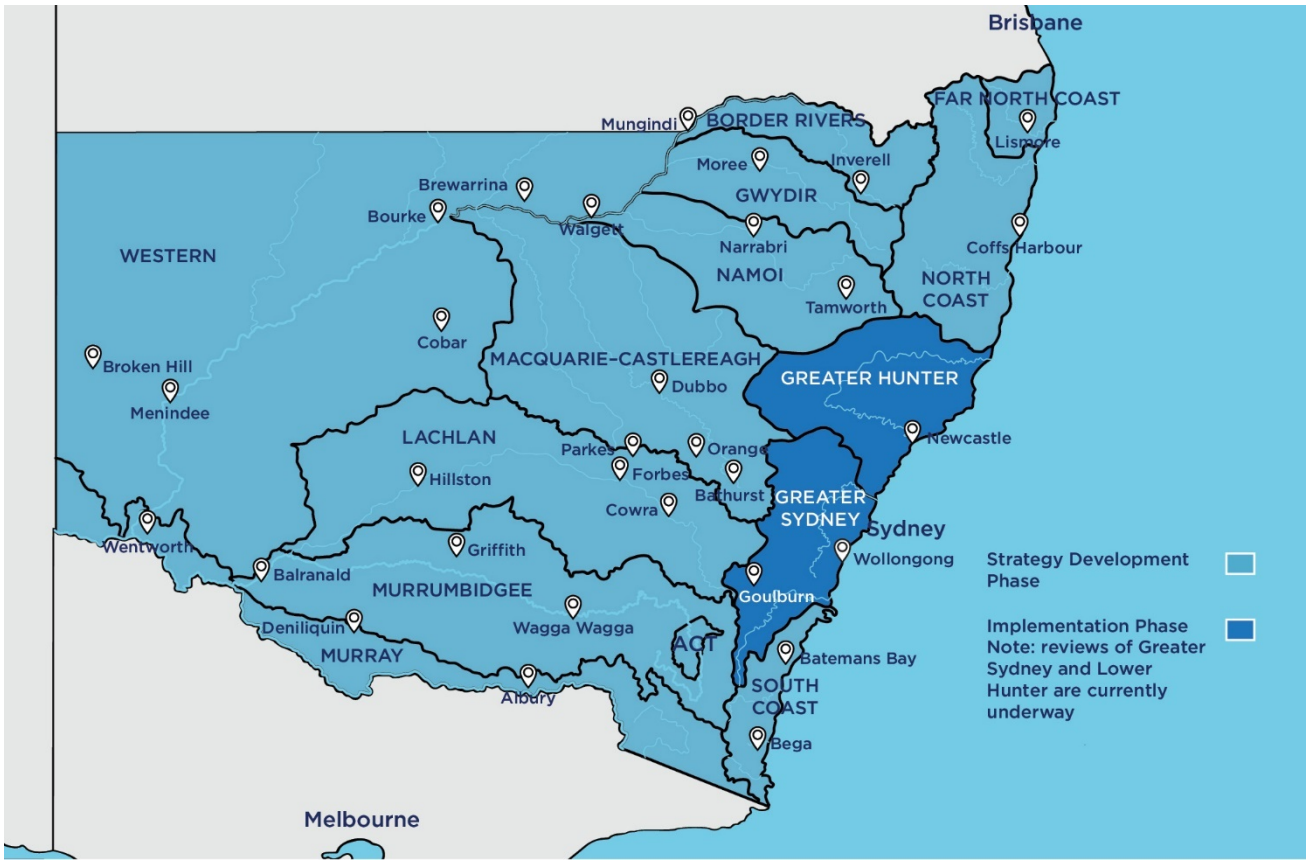


Figure 2.2 NSW Water Strategy Regions (DPIE 2020)

2.2.3 *FACT SHEET ON ASSESSING GROUNDWATER APPLICATIONS, 2018*

The potential impact of groundwater extraction is managed through the assessment of all applications for groundwater dealings and water supply work approvals (bores). Either WaterNSW or the Natural Resource Access Regulator (NRAR) receives applications and then refers them, as required, to the NSW DPIE for hydrogeological assessment.

While noting that the Snowy Mountains SAP is outside the Murray Darling Basin Plan area and therefore does not have a Water Resource Plan, the procedure for assessing applications for water supply works approval is consistent.
The procedure summarised in the flow chart below and the guidance fact sheet includes specific impact criteria for Lachlan Fold Belt (LFB) Coast Groundwater Source.

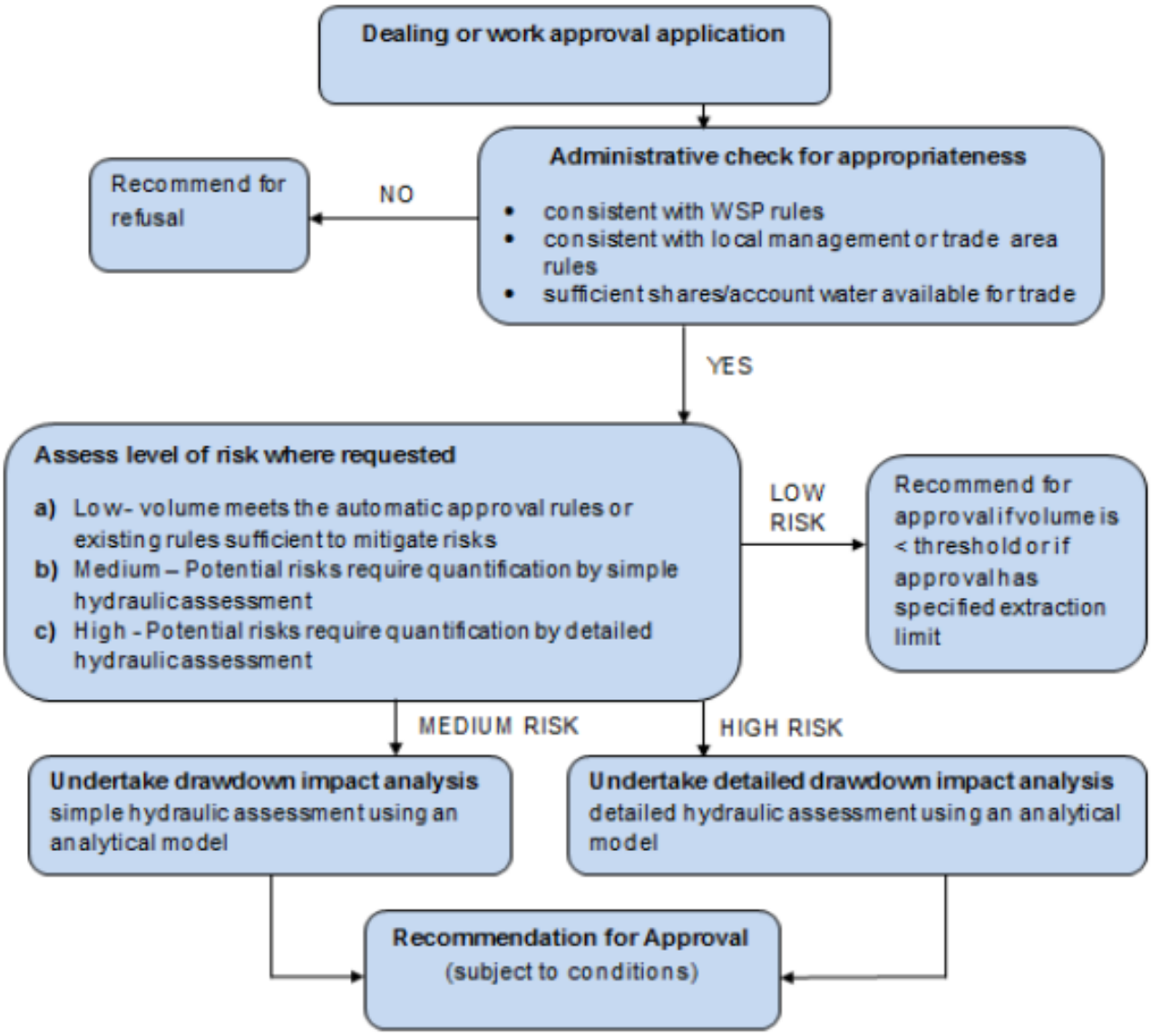


Figure 2.3 Procedure for assessing groundwater applications (Water Resource Plans fact sheet – Assessing Groundwater Applications, 2018

3 HYDROGEOLOGY

3.1 HYDROGEOLOGICAL UNITS

The geological units described previously in the context report are collectively grouped into the Lachlan Fractured Rock Coast Groundwater Source. This groundwater source is a fracture rock aquifer, typically these aquifers have low primary porosity with groundwater being transmitted through secondary porosity features such as fractures, joints, and solution voids.

3.1.1 *LACHLAN FOLD BELT COAST*

Depending on topography, the LFB Coast Groundwater Source is anticipated to contain both a shallow (weathered regolith) and a deep bedrock aquifer. The weathered regolith profile is expected to be thickest along valley floor and flattens on topographic highs, and absent where bedrock outcrops.

It is expected that both the shallow and deep Lachlan Fractured Rock groundwater source are present in the investigation area.

Expected aquifer characteristics are provided in Table 3.1.

Table 3.1 Lachlan fractured rock aquifer characteristics

DESCRIPTION	SHALLOW (WEATHERED REGOLITH)	DEEP (SILURIAN/ORDOVICIAN BEDROCK)
Unit thickness (m)	2 m–60 m	2500 m–4000 m
Aquifer confinement	Unconfined to semi-confined	Semi-confined – confined
Hydraulic conductivity (m/d)	0.01–40	Variable; dependent on connectedness and aperture of fracture and joint systems.
Yield (l/s) [1]	Low	Typically, < 3 l/sec
Hydraulic gradient and flow	Low – moderate gradient Vertical and lateral flow	Variable gradient Flow confined to secondary flow conduits facilitated by fracture and joint systems
Water quality (TDS) mg/L	< 1,500 mg/L (fresh – slightly saline)	< 3,000 mg/L (fresh – slightly saline)

Source: DoI-W, 2017 & GA, 2018

3.2 GROUNDWATER YIELD

Additional groundwater yield data has been provided since the issuing of the Groundwater Context report. This section has been retained and expanded on as it demonstrates the difficulty in obtaining high yielding bores within the Snowy Mountains SAP Investigation Area.

As described in Section 3.1, the underlying geology of the Snowy Mountains SAP Investigation Area is largely comprised of igneous granite type units with low primary porosity. Groundwater flow within this geology is largely dependent on secondary porosity, that is, physical defects (fractures, faults, joints and deformities (folds)) that provide pathways for groundwater to flow. The extent, degree and interconnectedness of the defects also influences groundwater yield. A locally scaled defect zone provides a lower storage volume than a regional scaled defect zone.

Selection of a prospective drilling location, that intersects suitable fractured granite to provide sufficient water volumes, within the Snowy Mountains SAP Investigation Area can be difficult and is reflected by the relatively low density of groundwater bores and low extraction volume within the Water Sharing Plans.

While no groundwater yield data was presented within the exports of both Water NSW Data web portal or BoM's NGIS, a review of WaterNSW works summaries has provided data on groundwater yield from registered bores within the Snowy Mountains SAP area. Data obtained through Work Summary reports include information collected during the drilling of groundwater bores, including water bearing zones and drillers geological logs.

As this data is obtained during drilling, caution is required when reviewing yield rates as they are often obtained during short purging of the bore during the drilling process, or at the end drilling, and as such, are unlikely to be representative of long-term sustainable bore yields. Noting this, the underlying bedrock granites are very competent (largely defect-free) which means that the introduction of drilling muds would generally not been required for drilling stability, which in turn, would result in optimal yields being reflected in estimates during drilling.

The Work Summary reports provided yield data from 77 registered groundwater bores within the Snowy Mountains SAP Investigation Area. The majority of these groundwater bores recording very low yields of <1 L/s with only 14 bores recording yields above 1 L/s and, of these, only 5 bores reported yields above 2 L/s. The two highest yielding bores GW110962 and GW100385 are noted as outliers in the dataset with a recorded yield of 8.1 L/s and 37 L/s, respectively. These two bores are discussed in more detail in the following paragraphs.

Groundwater bore *GW110962* is drilled to a reported total depth of 66 metres below ground level (mBGL) into fresh granite. The water baring zones suggest fracturing between 59 to 63 mBGL with bore construction indicating placement of the bore screen between 54 to 66 mBGL. The presence of a mapped regional structural fault may explain the higher water yields at this location as drilling may have intersected significant fracture zone aquifers associated with this structural feature.

Registered bore *GW100385* is drilled to a reported total depth of 10 mBGL. The bore is located close to the valley floor adjacent Cobbin Creek. The drillers log indicates that the water bearing zone consists of coarse sands and gravels indicating the presence of possible alluvial/colluvial material and, as such, in likely hydraulic connection to the adjacent watercourse. While no alluvial material is mapped at this location, it is not unreasonable to assume its presence due to the topographical setting and it is likely that this groundwater bore is screened within the shallow alluvial aquifer which is hydraulically connected to Cobbin Creek surface water flows.

3.2.1 *SNOWY MONARO REGIONAL COUNCIL GROUNDWATER SUPPLY – DALGETY*

While the SMRC does not use groundwater as a water supply within the Snowy Mountains SAP Investigation Area, they do hold a water licence and extract groundwater at Dalgety just outside the Investigation Area.

In 2014 the SMRC undertook a drilling programme to provide the community of Dalgety with a water supply. Similar to the Snowy Mountains SAP Investigation Area, Dalgety is underlain by granite geology with the same hydrogeological properties (very low permeability and storage).

The drilling programme consisted of the drilling of three boreholes:

- The initial bore was drilled to 120 m and did not intersect groundwater and, was abandoned and backfilled as it was deemed a "dry hole".
- The second borehole, located at a distance of approximately 30 m to the initial borehole, and was drilled to a total depth of 153 m. This bore intersected groundwater at approximately 74 m with a low initial yield. The drilling continued to the final depth with marginal increase in yield. A groundwater production bore was installed within this borehole resulting in a total sustainable yield of 2.5 L/s.
- A third borehole was located approximately 150 m to the north the second borehole and drilled to a depth of 154 m. This borehole failed to intersect groundwater and, like the initial bore, was abandoned.

This drilling programme, undertaken by SMRC, highlights the considerable difficulties and uncertainty in obtaining suitable sustainable groundwater yields from the underlying fractured granitic bedrock.

3.3 WATER ACCESS LICENSES

Water Access Licences (WALs) permit the licence holder to take water from a specified water source in accordance with the licence conditions. Each WAL has an associated water allocation account that, at the beginning of each water year (1 July), may be topped up to a predetermined volume. The predetermined volume for the new water year is based on the licence category and the available water determination (AWD) order announced at the beginning of each water year. Initial Available Water Determinations are made 1 July, then further Available Water Determinations may be made when water becomes available for distribution. For high security water uses such as town water supplies the available volume of water will equal the full licensed volume in all but exceptional circumstances. Lower security licences may have their allocation or share reduced in line with the AWD. In addition to listing the access licence category, a WAL also includes details on the share component, extraction component, nominated works and any conditions for use. Applications for WALs can be processed through the NRAR or WaterNSW, depending on the applicant. WALs typically are accompanied by a water supply work and a water use approval to allow for the holder of the WAL to construct and use a specified water supply at a nominated location.

The NSW Water Register maintained by the NSW Land Registry Services provides detailed information about water access licences (WALs) within NSW. WALs can typically be obtained (subject to restrictions outlined within the relevant Water Sharing Plans) through purchasing or trading of an existing WAL. Table 3.2 lists the total number of WALs per license category within the corresponding Water Sharing Plan.

Of the 65 WALS within the LFB Coast Groundwater Source, eight (8) are within the Snowy Mountains SAP Investigation Area with a total licence allocation volume of 49 ML year which equates to approximately 4% of the licenced available water. No usage for any water year was reported indicating that potentially groundwater allocations are not being used or that licence holders are not reporting usage volumes. A summary of WALs within the Snowy Mountains SAP Investigation Area is presented in Table 3.3.

Table 3.2 Total number of WALs per Water Sharing Plan for the 2019 to 2020 Financial Year (WaterNSW1 2019)

WATER SHARING PLAN	ACCESS LICENCE CATEGORY	NO. WAL(S)	AVAILABLE WATER (ML)	USAGE YTD (ML)
South Coast Groundwater Sources – Lachlan Fold Belt Coast	Aquifer	61	1,210.5	0
	Aquifer (Town Water Supply)	3	21.5	0
	Local Water Utility	1	20	0

Source: WaterNSW1 2019

Table 3.3 Current groundwater WALs within the Snowy Mountains SAP investigation area

WORK APPROVAL	WAL	ENTITLEMENT/ LICENCE ALLOCATION (ML)	REPORTED USAGE 2018–2019	LICENCE PURPOSE	BORE ID
10WA121595	37835	2	–	Domestic, industrial, stock	GW060472
10WA121609	37826	12	–	Recreation (groundwater)	GW100829
10WA121627	37858	4	–	Recreation (groundwater)	GW102952
10WA121633	37859	8	–	Domestic, industrial	GW103159
10CA121659	37836	8	–	Aquaculture, domestic, industrial, irrigation, stock	GW107359
10WA121651	37821	3	–	Industrial	GW108749
10WA121657	37832	5	–	Industrial	GW109210

4 GROUNDWATER AVAILABILITY

To support the development of the Snowy Mountains SAP and, attract industry and development the determination of a secure water supply is required. Groundwater has been identified as a possible source of water to support the growth and development of population and industry.

4.1 DETERMINATION OF AVAILABILITY

When assessing the availability of groundwater, several criteria require consideration before it could can be considered a reliable and secure water source. The term groundwater availability can be broken down into the following physical and regulatory criteria:

- the physical presence of groundwater and aquifer properties that support sustained groundwater yields
- the existence of infrastructure, or ability to drill and install groundwater bores, and supporting infrastructure to extract groundwater at a desired location
- the regulatory framework to obtain a water access licence (WAL) for groundwater within the groundwater source
- there the right to extract groundwater from that physical location.

When considering the availability of groundwater for the Snowy Mountains SAP, the following statement summarises the above criteria for a hypothetical proponent wishing to access groundwater for a water source:

> *The proponent has confirmed the presence of groundwater at a location and has the ability and approval to install supporting infrastructure to extract and transfer groundwater at that location. The proponent has obtained a WAL for a defined volume within the LFB Coast Groundwater Sources and confirmed that the proposed extraction satisfies the minimal impact considerations at that location and does not exceed impact criteria upon other groundwater users or the environment.*

If this proponent has undertaken a detailed groundwater assessment that has identified the presence of groundwater at a location, but this location has topographical restrictions, or is located within a sensitive environment that prohibits the installation of a production bore, transfer pipeline and power supply then the availability of that groundwater resource is constrained. Similarly, if the detailed groundwater assessment determined that the groundwater was not physically present at a location then the other criteria become moot.

Continuing with this hypothetical scenario, if the physical presence of groundwater has been confirmed and the location supports the required infrastructure to extract groundwater then the regulatory criteria required consideration. The LFB Coast Groundwater Source has unassigned water and the provision to access this water through a water access licence exists. Therefore, the proponent can obtain a WAL providing that the proponent can demonstrate compliance against the rules for obtaining water supply works approvals.

The physical presence of groundwater within the fractured bedrock granites has previously been described and expanded on within the Context Report, and above, in Section 3.2. The following section describes the regulatory considerations in groundwater availability within the LFB Coast Groundwater Source.

4.2 LIMITS TO THE AVAILABILITY OF WATER

A water allocation informs the licence holder how much water they can extract is known as the available water determination (AWD). AWDs are in effect a statutory water order, issued annually on 1 July and periodically throughout the year. An AWD order for the South Coast Groundwater Sources released 1 July 2020 allocated 100% per megalitre or volume per unit of access licence share component. In affect this allows the licence holder to access the maximum allocation allowable under the WAL.

The WaterNSW water register indicates there is a total of 65 WALs across all access licence categories current within the LFB Coast Groundwater. Through these WALs a total of 1,210.5 ML of water was made available during the 2019–2020 period. This volume has remained largely consistent since the commencement of the water sharing plan in 2016. Due to privacy reasons, the register does not provide spatial or bore details of the WALs, and the outstanding RFI requesting this information means it cannot be confirmed how many of the 65 WALs lie within the investigation area.

The volume of unassigned water within the LFB Coast Groundwater Sources is 16,202 ML/year.

4.3 RULES FOR GRANTING ACCESS LICENCES

Granting of access licences are considered for the following categories:

1. Specific purpose access licences under the Water Management (General) Regulation 2011 including local water utility, major water utility, domestic and stock and town water supply.
2. Aquifer (Aboriginal cultural) access licences, up to 10 ML/year per application.
3. Aquifer (Aboriginal community development) access licences, with a limit of 5% of unassigned water up to a maximum of 500 ML/year.
4. Access licences under a controlled allocation order made in relation to any unassigned water in this water source.

4.4 GROUNDWATER TRADING RULE

Trading within the LFB Coast Groundwater Source is permitted subject to assessment. Trading into the groundwater source is not permitted, nor is the conversion of a water licence to another category of access licence allowable.

There is no current or historic trade data provided on DPIE's Water trade dashboard relevant to the Investigation Area. Due to the availability of additional WALs and unallocated water it is reasonable to assume that there is currently no trading within the LFB Coast Groundwater Source.

4.5 WATER SUPPLY WORKS APPROVALS

The procedure for assessing work approval applications was summarised in Section 2.2.3. Depending on who or what entity is applying for water supply works approvals, applications are made to either WaterNSW or NRAR. Applications are then referred to NSW DPIE for hydrogeological assessment.

Administrative checks are undertaken to assess the appropriateness of the application against the water sharing plan rules, local management or trade rules, and confirms there is sufficient shares/account water available for the application. Providing the application satisfies these criteria the application is assessed against the level of risk of the application. Where required impacts are considered potentially medium or high risk then drawdown impact analysis reflective of the level of risk is required.

5 GROUNDWATER IMPACT CONSIDERATIONS

As requested, consideration has been given to unique activities within the region that may impact on groundwater, such as, snowmaking or the Snowy Hydro power scheme. While the end use of groundwater may be unique to the region, the process of extraction or diversion of groundwater is consistent with most industrial or residential users of groundwater across NSW.

Impacts to groundwater resources can be simplified into two categories: impacts to *groundwater quality* and impacts to groundwater levels (*groundwater quantity*). Impacts to groundwater quality can result from anthropogenic activities such as contamination from point sources, or the secondary result of changing groundwater levels which may result in the oxidisation of sulphides or other minerals which results in the change of chemical quality of groundwater.

Impacts to groundwater quantity is an activity that results in a change to the accessibility of groundwater. The extraction of groundwater through pumping of groundwater bores or intersection through excavation can impact on groundwater levels. This change to groundwater quantity may impact on other groundwater users such as neighbouring groundwater bores or the environment depending on the degree of change on groundwater levels.

The following sections consider the degree of impact of certain regional activities may have on the groundwater environment within the Snowy Mountains SAP Investigation Area.

5.1 SNOWY HYDRO 2.0

Located to the north east and outside the Snowy Mountains SAP Investigation Area, Snowy Hydro 2.0 is the expansion of the existing Snowy Hydro pumped hydroelectricity scheme. The expansion involves linking the existing Tantangara and Talbingo reservoirs through a series of underground tunnels and power station. The project underwent assessment of environmental impacts through the Environmental Impact Statement (EIS) and obtained final Commonwealth approval in June 2020.

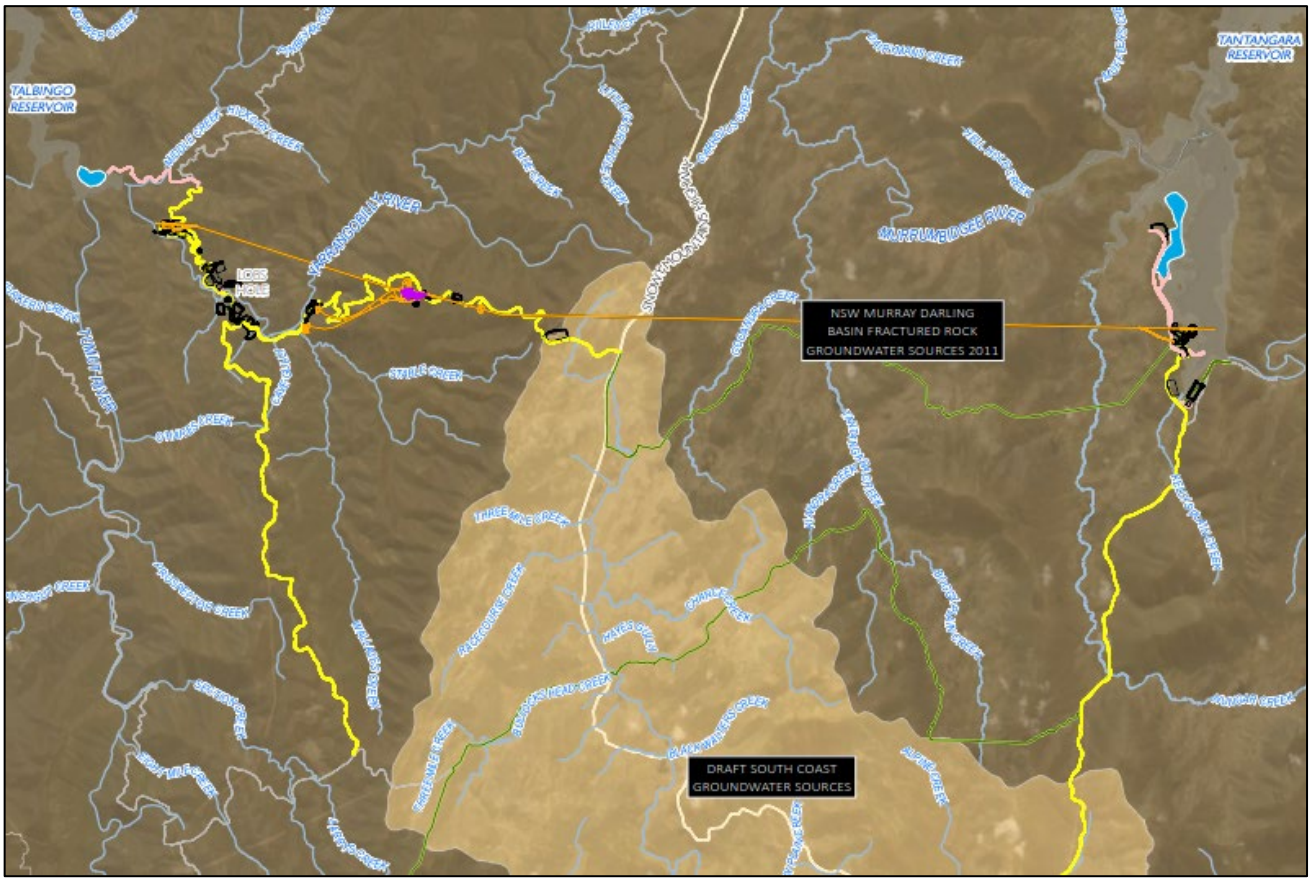
The technical documents supporting the EIS included a comprehensive groundwater assessment that involved the drilling and testing of a large number of dedicated groundwater monitoring and supply bores along with the development and calibration of a numerical groundwater model to predict impacts to the project.

The EIS concluded that the project would take water – through the construction and operation of the project – through the inflow of groundwater into excavated tunnels resulting in a reduction of groundwater levels (drawdown) near the tunnels and reduced contribution to stream baseflow overlying the drawdown impacts.

The EIS also noted that the majority of the project is located within the Water Sharing Plan for the NSW Murray-Darling Basin Fracture Rock Groundwater Source and a minimal portion within the Water Sharing Plan for the South Coast Groundwater Sources as displayed in Figure 5.1.

Numerical modelling predicted the take of groundwater required and, noted the availability of water within each Water Sharing Plan and the licensing requirements for the construction and operation of the project.

Due to the location of the project and predicted impacts of Snowy 2.0 it is highly unlikely that any cumulative impacts from Snowy Hydro 2.0 or extraction within the Snowy Mountains SAP Investigation Area would occur.



Source: EMM Snowy Hydro EIS

Figure 5.1 Snowy Hydro 2.0 groundwater sources

5.2 SNOWY MOUNTAIN SCHEME

As with the proposed Snowy Hydro 2.0 described above the existing Snowy Mountains Scheme consists of a series of storage reservoirs connected through excavated tunnels and pump stations. Constructed between 1949 and 1974 the Snowy Mountain Scheme is the largest engineering project undertaken in Australia.

Snowy Mountain Scheme infrastructure underlying the Snowy Mountains SAP Investigation Area are presented in Table 5.1. As described for Snowy Hydro 2.0, ongoing groundwater inflow into excavated tunnels is expected to continue, as only a small portion of the tunnels are lined.

A recent ten-year review of the Snowy water licence by NSW Department of Industry (2018) does not include a review of groundwater take for the project, neither is groundwater included within the Snowy Water Licence (2002) issued under the *Snowy Hydro Corporations Act 1997*.

It would be reasonable to expect a small volume of groundwater to flow into unlined portions of the tunnels and due to the age of these assets it would be expected that groundwater levels have equalised around the tunnels (reached steady state conditions).

Due to the location of these assets being within Kosciuszko National Park the potential for groundwater extraction impacts from other users is highly unlikely.

Table 5.1 Snowy Mountain Scheme Infrastructure underlying the Snowy Mountains SAP investigation area

NAME	LENGTH (km)	% LINED	YEAR COMPLETED
Eucumbene-Snowy Tunnel	23.5	19.7	1965
Jindabyne-Island Bend Tunnel	9.8	10.6	1968
Jindabyne Pumping Station	–	–	–
Jindabyne Mine Hydro	–	–	2009
Guthega power station	–	–	1955
Island Bend Pondage	–	–	1965

5.3 EXTRACTIVE INDUSTRY/EXCAVATION

Any extractive industry such as quarrying or excavation that has the potential to intersect groundwater is required to account for the take of groundwater incurred through inflow and evaporation into the pit or excavation. Common examples of where industry or excavation may intersect groundwater include excavated basements, road cuttings through hill slopes and quarrying of sand/rock, road base or building materials.

Any proposed development or excavation with the potential to intersect groundwater would be required to be assessed on a case by case basis to determine minimal impacts and estimate the potential take of water from the aquifer.

Any tunnelling associated with the extension of the Skitube or other infrastructure would likely be required to be assessed under the for groundwater inflow, and where required, obtain WAL licence for the indirect take of groundwater seepage through the excavation.

5.4 SNOWMAKING

Snowmaking technology is employed at several slopes and locations throughout the Snowy Mountains ski fields. Considerable investment has been made at Perisher to improve the efficiency of snowmaking and associated infrastructure that includes, water storages, pump stations, compressors, pipes and snowmaking machines.

For Perisher, water supply for snowmaking is sourced from a Snowy Hydro aqueduct and has been described as “borrowing” water from the catchment as estimates of 93% of the water taken is returned to the catchment in the spring as the snow thaws. Similarly, Thredbo also states that the majority of water used in snowmaking is returned to the catchment through snow melts. Raw water supply for snow making at Perisher is sourced from the Thredbo River under licences.

Any proposed expansion of snowmaking would require additional water supply to increase the volume produced snow. While groundwater is a potential supply option for snowmaking, there are considerable constraints that may result in groundwater not being a viable option for water supply.

As detailed earlier (Section 3.2), the underlying geology has a low primary porosity with groundwater flow being dependent on secondary porosity, that is structural defects and fractures within the rock strata allowing for groundwater flow. Yield data from registered bores within the Snowy Mountains SAP Investigation Area indicated that expected yields would likely be low at <1 L/s (Section 3.2).

While higher yielding bores may be possible, additional detailed hydrogeological investigation would be recommended to increase the potential of identifying suitable drilling locations. Lineament mapping would be required to identify potential lineament features, such as regional faults within the surface geology. As groundwater is frequently associated with these structural features, the identification of these linear features can improve potential of intersecting suitable sustainable groundwater resources.

Confirmatory geophysical surveys, such as airborne electromagnetic survey (AEM) and electrical resistivity tomography (ERT) are useful tools in further identifying and mapping potential groundwater resources and structure lineament networks within the underlying geology. AEM can produce resistivity maps that can reveal zones of low formation resistivity, which indicate water bearing zones. This combined with in-depth understanding of the structures network can map saturated fracture networks. Ground based high resolution ERT may be required to further develop the mapping obtained through AEM. Such surveys provide an appropriate level of confidence in lineament selected groundwater aquifer target/s.

Ultimately the success in obtaining suitable groundwater resources for a water supply is dependent on favourable geological conditions within the Investigation Area. The above mapping and geophysical assessment can improve the potential of identifying promising drilling targets and intersecting fracture zones, but cannot guarantee groundwater supply nor remove the risk that exploratory drilling fails to produce targets with suitable yield potential and hence sustainable groundwater supply outcomes. If suitable groundwater resources were determined, a work approval application and water access licence would be required as outlined in Section 2.2.3.

Due to the considerable constraints listed above, it is recommended that surface water be first considered for additional raw water supply requirement. Groundwater should only be considered if all other water sources/efficiencies savings, are deemed insufficient to meet demand estimates.

5.5 APPLICATION OF ROAD SALT

As described within Section 3.6 of the Flooding and Water Technical Study Report (WSP 2020), Transport for NSW (TfNSW) applies road salt for de-icing of roads during winter periods. The solubility characteristics of sodium-chloride salts mean, runoff from rain and snow melt is the primary transportation method of the road salts. Once mobilised the salt is transported through the catchment to surface water features.

During drier periods where evaporation is in excess of precipitation salt is precipitated out of solution and remains either on, or within the soil matrix. Salts can be remobilised into solution providing there is a sufficient capacity in the hydrological regime to transport the salts to and within the groundwater system.

The granitoid bedrock underlying the Snowy Mountains SAP has very low primary permeability. As detailed in Section 4.3.1 in the Hydrogeology Context Analysis Report, DPIE-Water estimated infiltration rate of 4% prevail across the entire Lachlan Fold Belt Coast Groundwater Source, an area of two million hectares. This equates to over 681,000 ML of recharge into the groundwater source annually.

The limited application of road salts, both spatially and in quantity, to the Lachlan Fold Belt Coast Groundwater Source would have negligible impacts to groundwater quality at the Water Sharing Plan scale. At a local scale the transportation of salt is dominated by snow melt and surface water runoff where salts move in and out of solution depending on the hydrological regime within the catchment. The low infiltration rate of the underlying bedrock aquifer and depth to groundwater, and physical characteristics of the salt reduces the potential impact to groundwater quality.

6 CONCLUSIONS

In building off the previous Groundwater Context Report, this report has described both the physical and regulatory considerations in groundwater availability within the Snowy Mountains SAP Investigation Area.

The LFB Coast Groundwater Source has unallocated water available and the provision to obtain WAL to extract groundwater as a water supply throughout the Investigation Area. Providing a works approval application is consistent with the rules of the water sharing plan and impact assessment is deemed acceptable then water supply works approval would support the granting of a WAL.

However, as demonstrated through reported groundwater yields, and the SMRC 2014 water supply drilling programme at Dalgety, just having the regulatory ability to obtain a WAL does not guarantee a water supply. The underlying bedrock granite and fractured rock geology results in a relatively poor groundwater resource with high spatial variability, as demonstrated by the numerous number dry bore previously drilled within the Snowy Mountains SAP Investigation Area.

Due to the constraints associated with obtaining a suitable groundwater yields, alternative water sources should be considered first. Increasing existing water licence allocations or obtaining water licences for alternative surface water sources may be more appropriate and cost effective for the volumes required for snow making or town supply.

In the event that groundwater is required for the development of the Snowy Mountains SAP, then undertaking additional assessment is recommended to improve the likelihood of identifying drilling targets that may yield groundwater. Additional hydrogeological and geophysical investigation can assist in identifying structural defects within the geology which are more likely to transmit groundwater. Identifying these locations for drilling improve the chances of intersecting groundwater. However, it is important to note that they cannot fully mitigate the risk that drilling fails to yield enough groundwater to satisfy supply requirements.

It is recommended that any proponent intending to progress evaluation and development of groundwater as a water source consider the financial and hydrogeological risks associated therewith, and seek appropriate technical advice to identify and mitigate risks where possible. These recommendations are consistent with previous hydrogeological assessments made by predecessors NSW Government departments.

7 REFERENCES

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8 REPORT LIMITATIONS

8.1 SCOPE OF SERVICES

This hydrogeological technical study (the report) has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client and WSP (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

8.2 RELIANCE ON DATA

In preparing the report, WSP has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, WSP has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. WSP will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

8.3 ENVIRONMENTAL CONCLUSIONS

In accordance with the scope of services, WSP has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Also, it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

8.4 REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the client and no other party. WSP assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of WSP or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

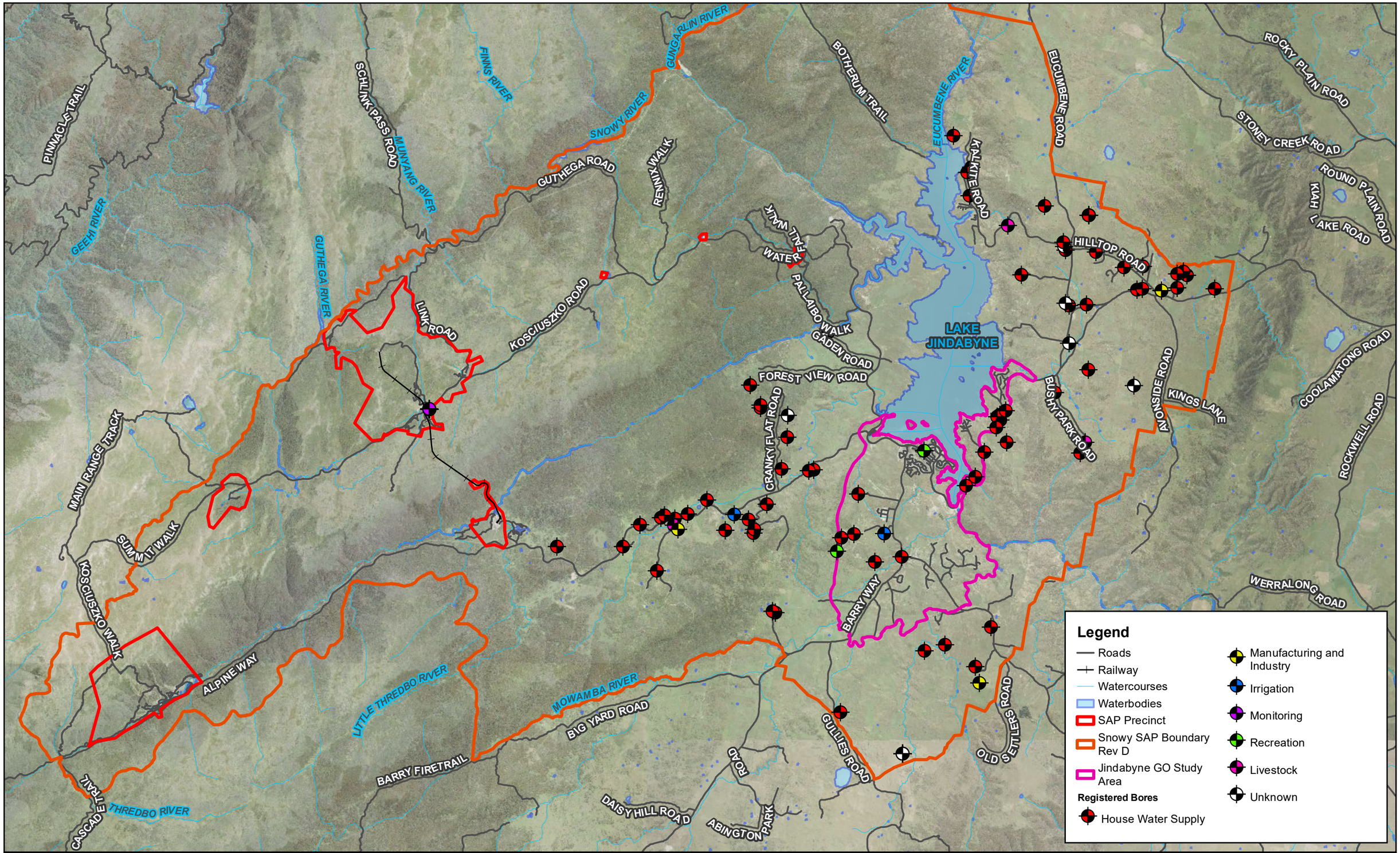
8.5 OTHER LIMITATIONS

WSP will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

APPENDIX A

FIGURES



Legend

- Roads
- Railway
- Watercourses
- Waterbodies
- SAP Precinct
- Snowy SAP Boundary Rev D
- Jindabyne GO Study Area

Registered Bores

- House Water Supply
- Manufacturing and Industry
- Irrigation
- Monitoring
- Recreation
- Livestock
- Unknown

Map: PS120074_GIS_015_A1	Author: David.Naiken
Date: 12-Jun-20	Approved by: Alistair.Stewart

0 1,000 2,000 m

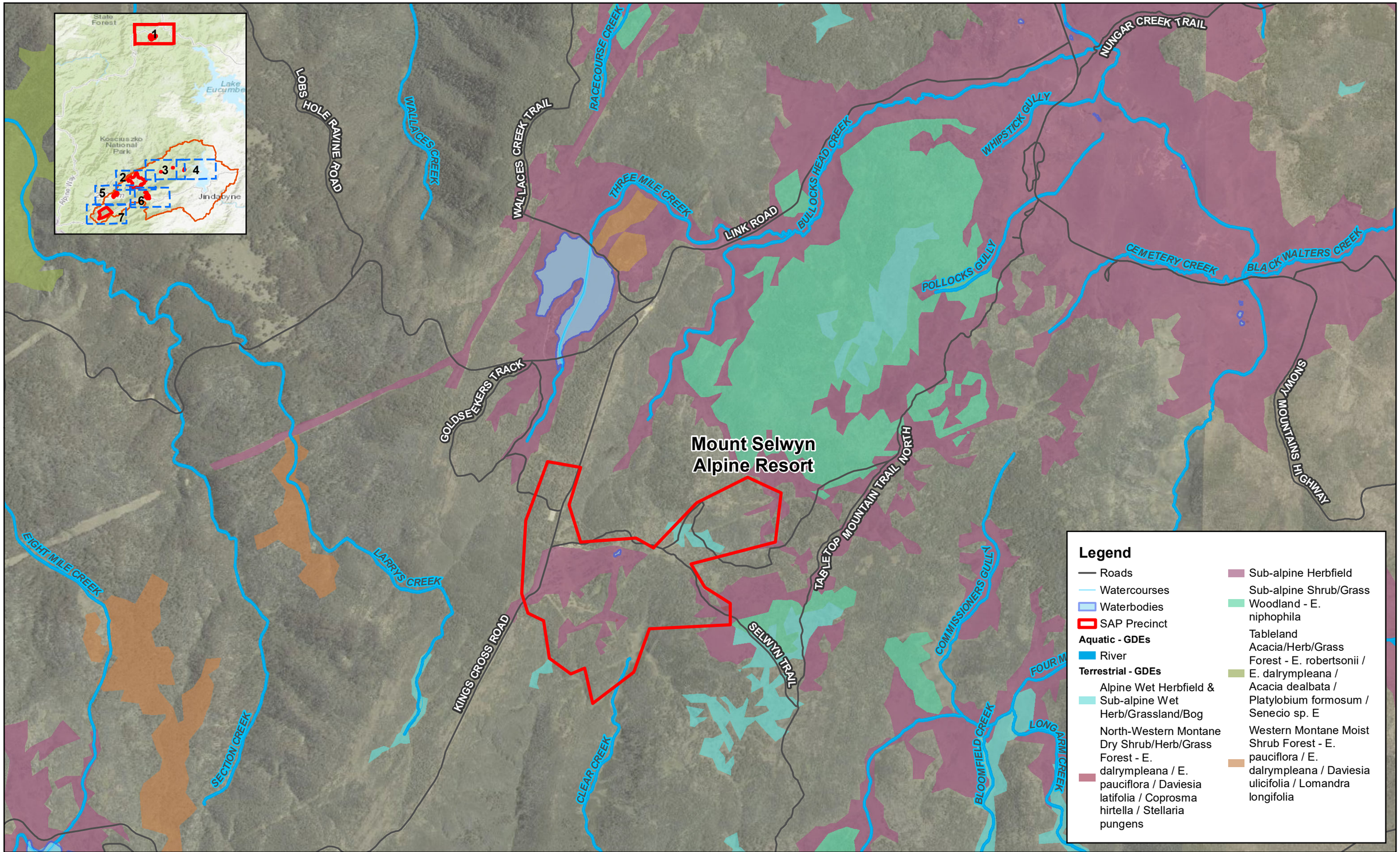
1:130,000

Coordinate System: GDA 1994 MGA Zone 55
Scale ratio correct when printed at A3

Imagery © Department of Customer Service 2020
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community © Department Finance, Services and

Snowy SAP

Figure A.1: Registered Bores



Map: PS120074_GIS_016_A1	Author: David.Naiken		0 250 500 m 1:30,000
Date: 12-Jun-20	Approved by: Alistair.Stewart		Coordinate System: GDA 1994 MGA Zone 55 Scale ratio correct when printed at A3

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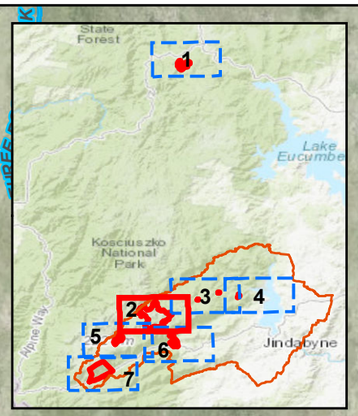
Groundwater Dependent Ecosytems
Figure A.2: Mount Selwyn Alpine Resort



Perisher Range Alpine Resort

GUTHEGA RIVER
FALLS CREEK
SNOWY RIVER
GUTHEGA ROAD
PERISHER CREEK
LINK ROAD
POUNDS CREEK
ILLAWONG WALK
MOUNT TATE ROAD
BLUE COW CREEK
DAINERS CREEK
KOSCIUSZKO ROAD
WRAGGES CREEK
PIPERS CREEK
SMIGGIN CREEK
PRUSSIAN CREEK
TWYNAM CREEK
FARM CREEK
PERISHER CREEK ROAD
BURRAMYS ROAD
HEATLEY ROAD
SPENCERS CREEK
GUTHRIE CREEK
ROCK CREEK

Legend

- Roads
- Railway
- Watercourses
- Waterbodies
- SAP Precinct
- Snowy SAP Boundary Rev D

Aquatic - GDEs

- River

Terrestrial - GDEs

- Alpine Wet Herbfield & Sub-alpine Wet Herb/Grassland/Bog
- Montane / Sub-Alpine Dry Rocky Shrubland
- Sub-alpine Shrub/Grass Woodland - E. niphophila
- Tableland Acacia Moist Herb Forest - E. pauciflora / E. dalrympleana / Acacia dealbata / Helichrysum scorpioides

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0 250 500 m
1:30,000

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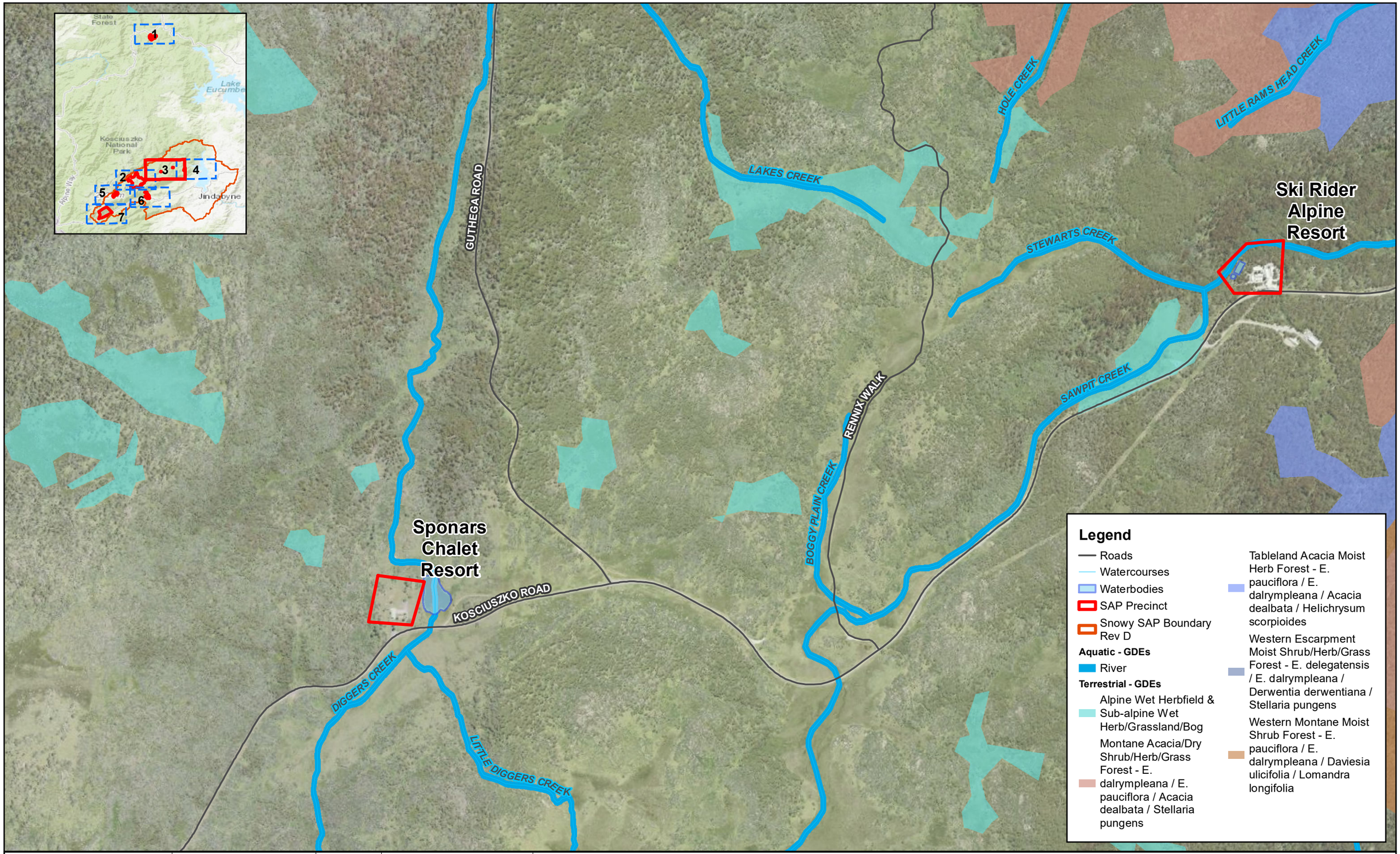
Groundwater Dependent Ecosytems
Figure 5.2: Perisher Range Alpine Resort



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Date: 12-Jun-20	Approved by: Alistair.Stewart		Coordinate System: GDA 1994 MGA Zone 55 Scale ratio correct when printed at A3

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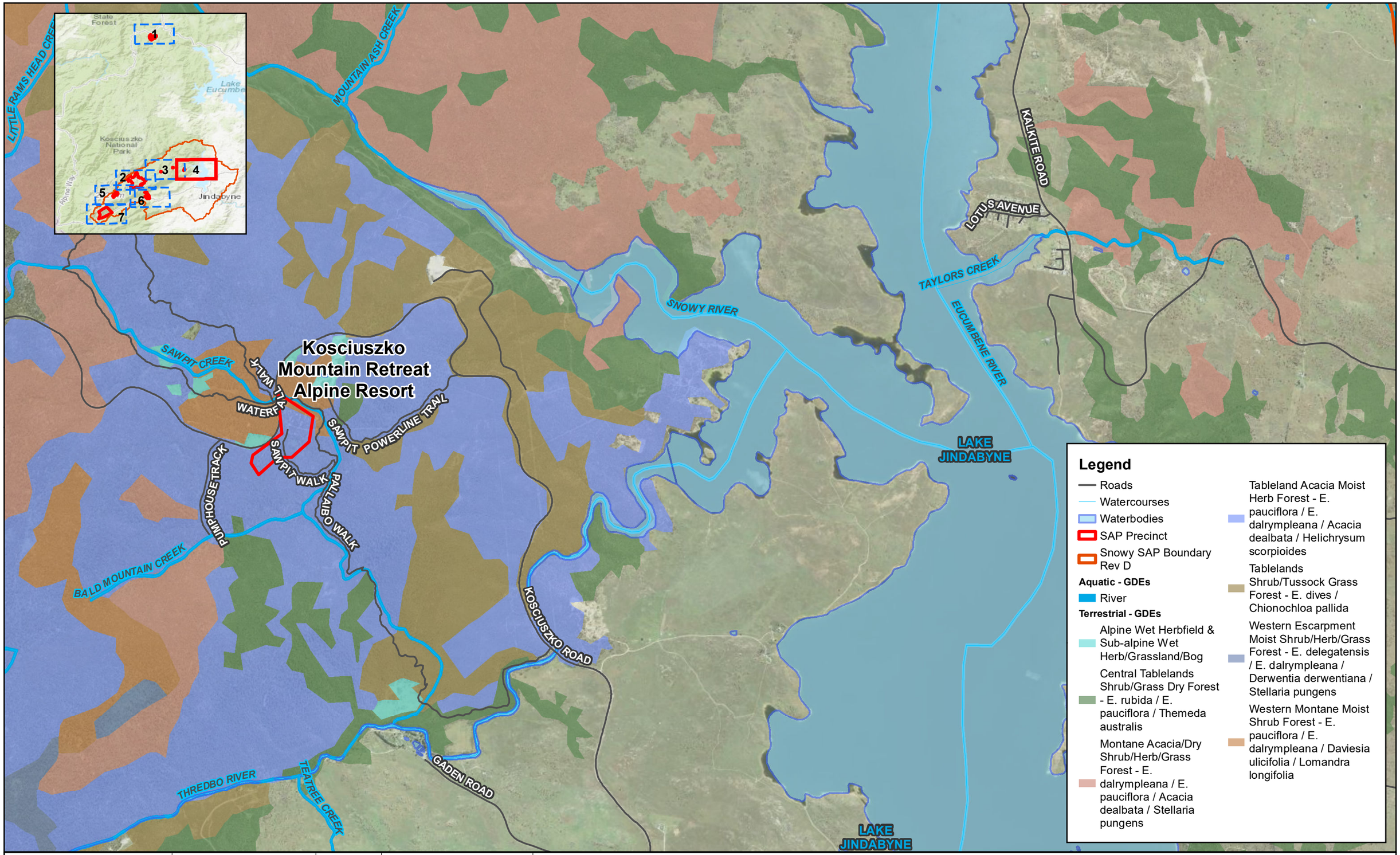
Groundwater Dependent Ecosytems
Figure 5.2: Sponars Chalet Resort and Ski Rider Alpine Resort



Map: PS120074_GIS_016_A1	Author: David.Naiken		0 250 500 m 1:30,000
Date: 12-Jun-20	Approved by: Alistair.Stewart		Coordinate System: GDA 1994 MGA Zone 55 Scale ratio correct when printed at A3

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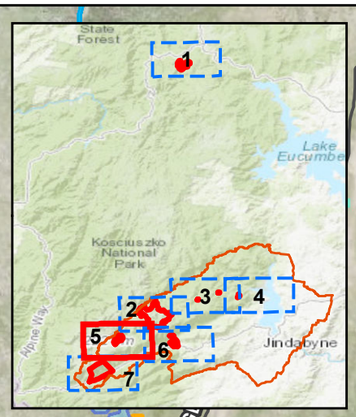
Groundwater Dependent Ecosytems
Figure 5.2: Kosciuszko Mountain Retreat Alpine Resort



BLUE LAKE WALK

CARRUTHERS CREEK

BLUE LAKE CREEK

Perisher Range Alpine Resort

KOSCIUSZKO ROAD

GUTHRIE CREEK

BETTS CREEK

MAIN RANGE

CLUB LAKE CREEK

Charlotte Pass Alpine Resort

SPENCERS CREEK

CHARLOTTE PASS ACCESS

WRIGHTS CREEK

TRAPYARD CREEK

SUMMIT WALK

KOSCIUSZKO WALK

MERRITTS CREEK

SNOWY RIVER

Legend

- Roads
- Watercourses
- Waterbodies
- SAP Precinct
- Snowy SAP Boundary Rev D

Aquatic - GDEs

- River
- Wetland

Terrestrial - GDEs

- Alpine Wet Herbfield & Sub-alpine Wet Herb/Grassland/Bog
- Montane / Sub-Alpine Dry Rocky Shrubland
- Sub-alpine Shrub/Grass Woodland - E. niphophila

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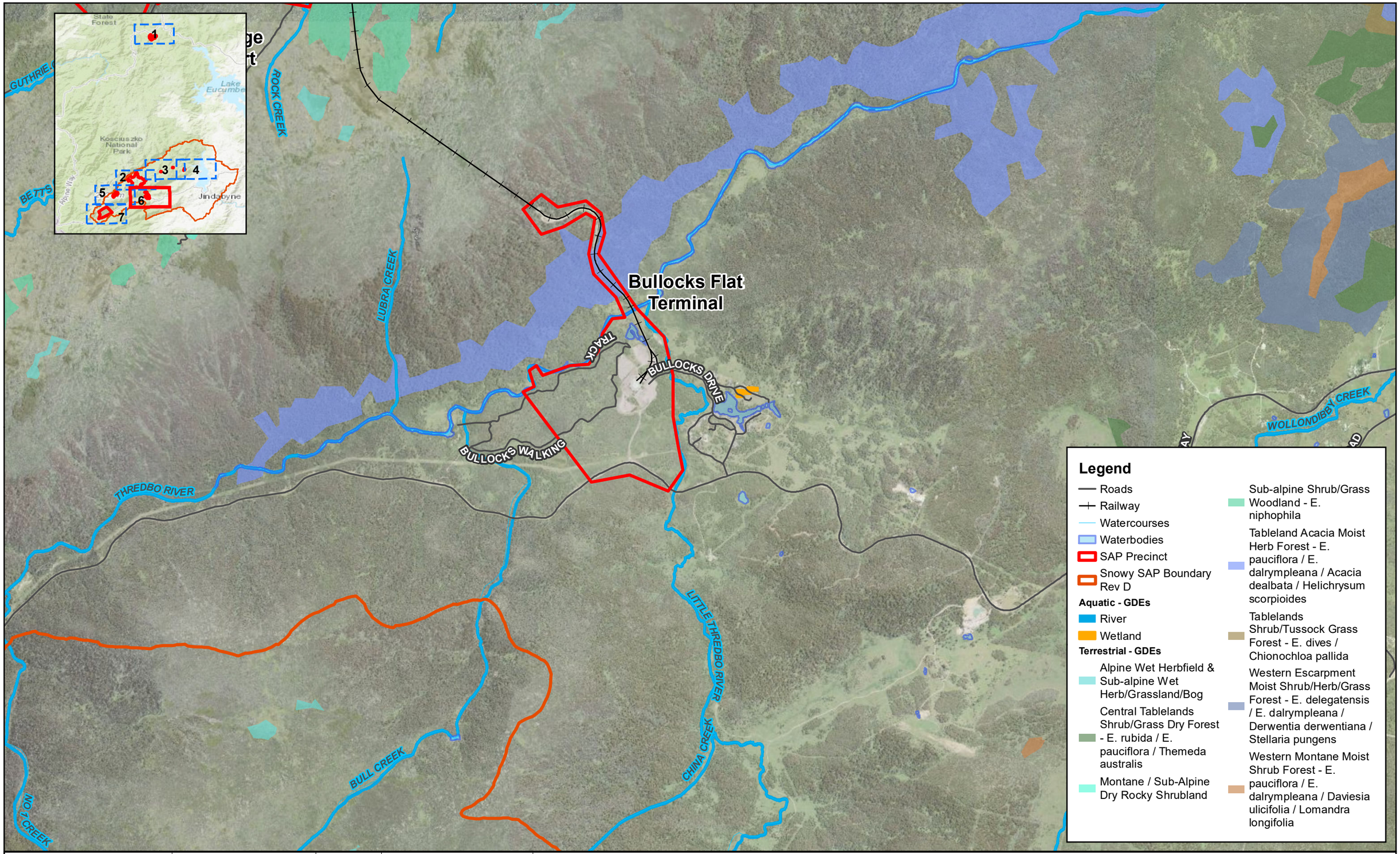
Groundwater Dependent Ecosytems
Figure 5.2: Charlotte Pass Alpine Resort



Map: PS120074_GIS_016_A1	Author: David.Naiken		0 250 500 m 1:30,000
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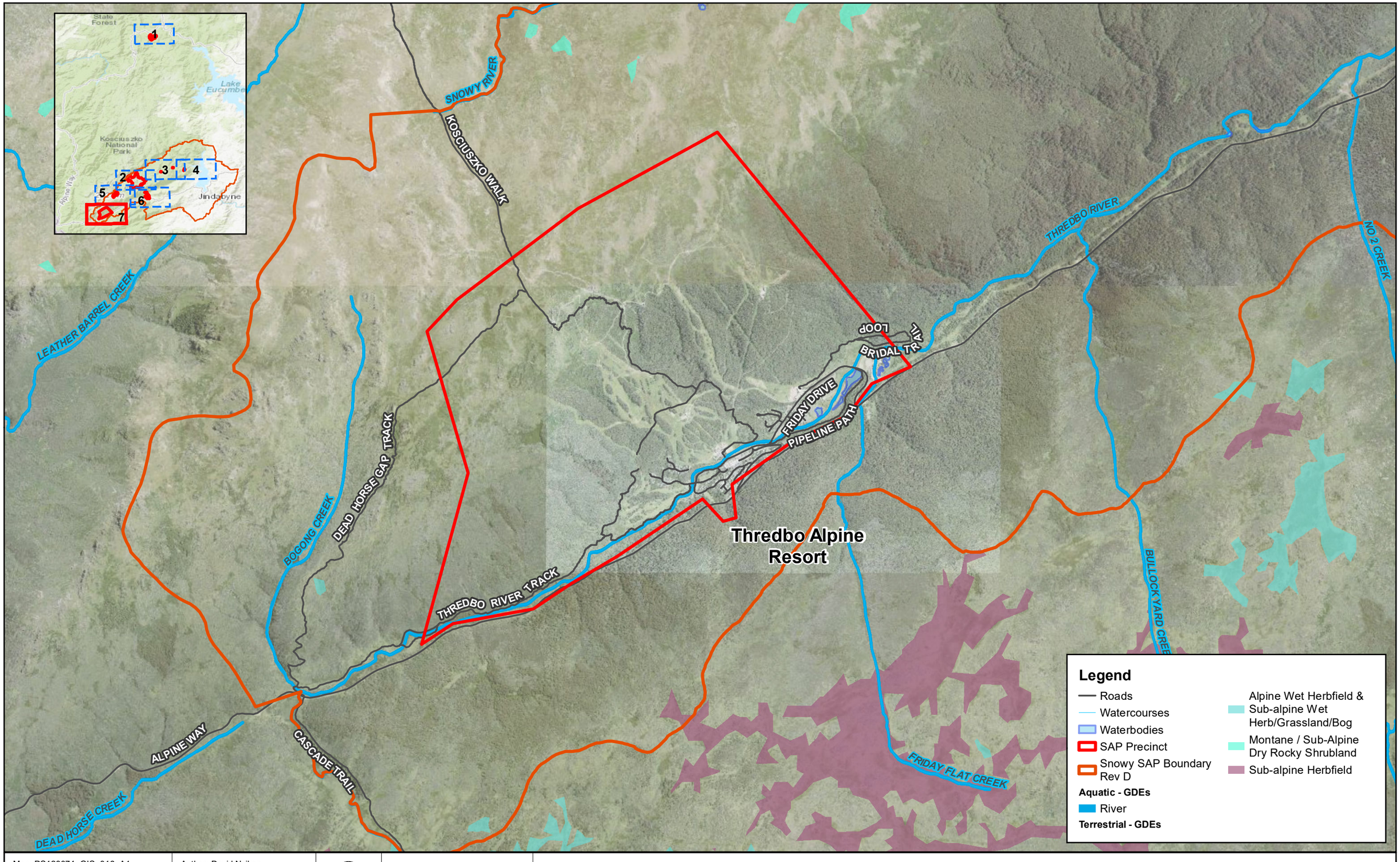
Groundwater Dependent Ecosytems
Figure 5.2: Bullocks Flat Terminal



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Groundwater Dependent Ecosytems
Figure 5.2: Thredbo Alpine Resort

ABOUT US

WSP is one of the world's leading engineering professional services consulting firms. We are dedicated to our local communities and propelled by international brainpower. We are technical experts and strategic advisors including engineers, technicians, scientists, planners, surveyors, environmental specialists, as well as other design, program and construction management professionals. We design lasting Property & Buildings, Transportation & Infrastructure, Resources (including Mining and Industry), Water, Power and Environmental solutions, as well as provide project delivery and strategic consulting services. With approximately 48,000 talented people globally, we engineer projects that will help societies grow for lifetimes to come.

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