DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

APRIL 2021

# TECHNICAL STUDY REPORT

## ENGINEERING – GEOTECHNICAL

# TABLE OF CONTENTS

## CONTENTS (Continued)

### LIST OF TABLES

CONTENTS (Continued)

## LIST OF FIGURES



## LIST OF APPENDICES

# ABBREVIATIONS AND GLOSSARY

| | |
|---|---|
| CBD | Central Business District |
| DPIE | Department of Planning, Industry and Environment |
| DRNSW | Department of Regional New South Wales |
| EbD | Enquiry by Design |
| HNSW | Heritage New South Wales |
| 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. |
| KNP | Kosciuszko National Park |
| KNP POM | Kosciuszko National Park Plan of Management |
| LGA | Local Government Area |
| Monero Ngarigo | Aboriginal linguistic group who traditionally occupied the eastern side of the Kosciuszko plateau and further north towards the Murrumbidgee River.<br>The traditional custodians of the Snowy Mountains are the Monero Ngarigo people. |
| 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 |
| 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 |
| SMRC | Snowy Monaro Regional Council |
| 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. |
| STP | Sewage Treatment Plant |
| TfNSW | Transport for New South Wales |
| WTP | Water Treatment Plant |

# EXECUTIVE SUMMARY

This Technical Study will form part of the Engineering Package for the Snowy Mountains Special Activation Precinct (SAP). The recommendations from this report will combine with other technical studies in the disciplines of engineering, planning, environment, economics and legislation to inform the Master Planning for the Snowy Mountains SAP.

## REGIONAL GEOLOGY

The 1:250000 scale detailed surface geology map (1990) from the Bureau of Mineral Resources (Geology of the Kosciuszko National Park; including the Berridale 1:100000 scale geological map) indicated that the surface geology within the site investigation area is mainly comprised of intrusive rock of Palaeozoic age between 435 to 390 Ma. The geology bordering the eastern and south-eastern sides consists of deep marine deposited turbidites comprising sandstone, siltstone and shale of Late Ordovician age, > 435 Ma. The regional geology is highly complex and variable within the site investigation area and Mt Selwyn area and further details including distribution mapping is provided in Section 2.

## SOILS AND LANDSCAPE MAPPING

The Australian soil resource information system (ASRIS) mapping indicated that four predominant soil types are present in the site investigation area and Mount Selwyn area (excluding water bodies and areas not assessed. These soils identified include Alpine Humus Soils, Acid Peat, Brown Earth and Lithosols. A summary of the identified soil types in the site investigation and Mt Selwyn areas are provided in Section 2.

## GROUNDWATER

There is limited available groundwater level information within the site investigation area. No water levels were available from the National Groundwater Information System database for registered bores within the study area.

## SLOPE ANALYSIS

Utilising the available 5 m contour information slope analysis has been undertaken in GIS which is included in the Context Analysis Report. A heat map of the terrain slope indicates where high angle slopes are distributed throughout the site investigation and Mt Selwyn areas.

## ACID SULFATE SOILS

The plans provided in the Context Analysis Report in Appendix A, indicate the site investigation area and Mt Selwyn area are mainly within a broader area of 'no known occurrence' with the exception of proximity to Lake Jindabyne which is indicated to be of high probability. In addition, the presence of deep marine turbidites on the eastern boundary of the site are likely to have been deposited in an environment which promotes the presence of sulfide containing soils. Therefore, this region should also be considered to have potential for acid sulfate soils.

# EXISTING MANAGEMENT STRATEGIES AND PLANS

Several management strategies and plans exist to manage geotechnical risks for infrastructure development which were reviewed and summarised in Section 2. The types of infrastructure likely to be considered are as follows:

- building infrastructure for residential and commercial use
- upgrades and new roads to expand the road network. This may also include bypasses, bridges and tunnels
- earthworks to level areas and may include steep cuts, areas of fill and potentially the need for retaining structures
- new or realignment of utility connections potentially requiring trenching or underboring works.

Of major relevance for geotechnical risk review is the Geotechnical Policy – Kosciuszko Alpine Resorts and the Landslides and Rockfalls Procedures. These have been considered in further detail in the following sections.

# PRELIMINARY ASSESSMENT

A preliminary assessment of the possible geotechnical risks that may impact future development was undertaken based on the available information. A summary of the preliminary findings is as follows:

- Increased population, both permanent and tourists, is likely to increase the exposure to key geotechnical risks.
- Steep sloping ground – in areas where future development transects high angle slopes (i.e. foundation excavations, road alignments, utility alignments) ground may become unstable or be susceptible to erosion during and after construction. This may impact roads, hiking trails, cycleways/trails within these areas.
- Deep and variable weathering – including subsurface corestones may result in slope instability and poor founding conditions for future construction works.
- Faults – where urban expansion follows existing fault lines, highly fractured rock associated along the fault scarp may pose a risk to excavations or long term slope instability.
- Earthquakes – there is a history of minor earthquakes within the site investigation area which with increased population may impact a greater populous. It is unlikely that a significant earthquake would occur in this area.
- Acid Sulfate Soils – in areas identified to have potential for acid sulfate soil a management plan will be required if disturbance of the ground is likely to occur.
- Radon gas – increased population in these areas is likely to expose more people to radon gas particularly during the construction phase of future development.

# RECOMMENDATIONS

The existing Geotechnical Policy controls used to inform proposed developments should be supplemented with the risk susceptibility maps for the respective areas provided in Appendix B. These maps will assist in the identification of potential geotechnical risks at the early planning stage so that proposed developments can be planned with due consideration to the risks. It is noted that the hazards and risks identified in the maps would, in general, not preclude future development, but may have a design and cost implication depending on the particular development.

To further develop the geotechnical risk susceptibility mapping the following is recommended:

- As the areas of development are narrowed down and the type of development known with more certainty, geotechnical risk susceptibility in these areas can be reassessed at a more local discrete scale.
- As additional data becomes available from site walkovers, investigations and additional survey, the analyses in GIS can be updated to reflect the new information and further validate and refine the susceptibility mapping. This would improve the benefit and accuracy of these maps over time.
- For the priority projects listed in Table 4.1 geotechnical risks are generally low.

Geotechnical risk susceptibility is one contributor to overall risk to development and/or population.

# 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.

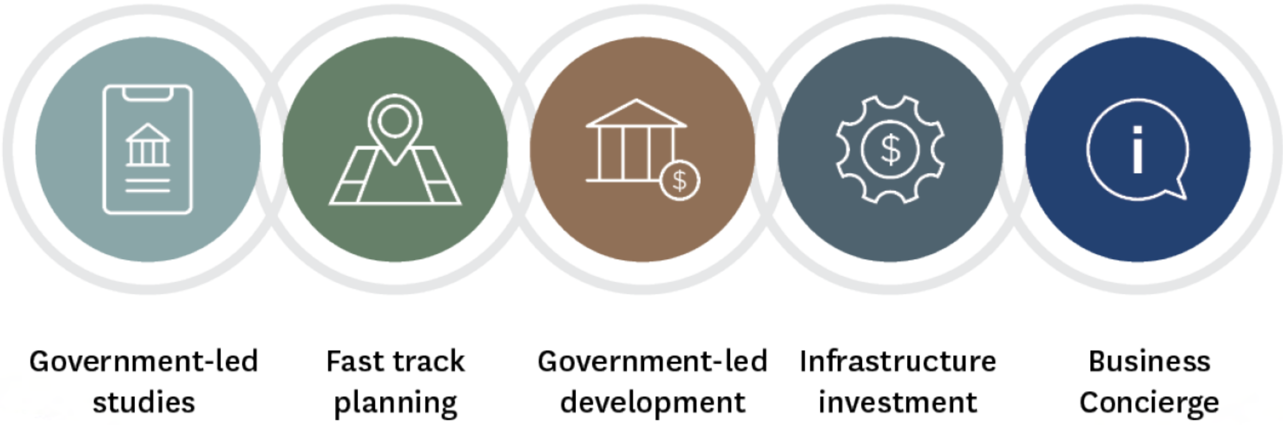
SAPs are unique to regional NSW. By focusing on planning and investment, their goal is to stimulate economic development and create jobs in line with the competitive advantages and economic strengths of a region.

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 masterplan 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.<br>— 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.<br>— Provides zoning and land use controls for each Precinct.<br>— Identifies Exempt and Complying Development pathways for certain development. | — Made by the NSW Department of Planning, Industry and Environment and approved by the Minister.<br>— Identifies the Vision, Aspirations and Principles for the Precinct.<br>— Provides more detailed land use controls where required.<br>— Identifies Performance Criteria at a Precinct-scale for amenity, environmental performance and infrastructure provision.<br>— Identifies the matters to be addressed as part of the Delivery Plan. | — Prepared by Regional Growth NSW and approved by the Planning Secretary.<br>— Identifies site-level development controls.<br>— Provides detailed strategies and plans for:<br>  — Aboriginal cultural heritage<br>  — Environmental protection and management<br>  — Protection of amenity<br>  — Infrastructure and services<br>  — Staging.<br>— 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 & 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 (NSW National Parks & Wildlife Service, 2006). The park contains most of the alpine endemic species found on the Australian mainland (NSW National Parks & 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.

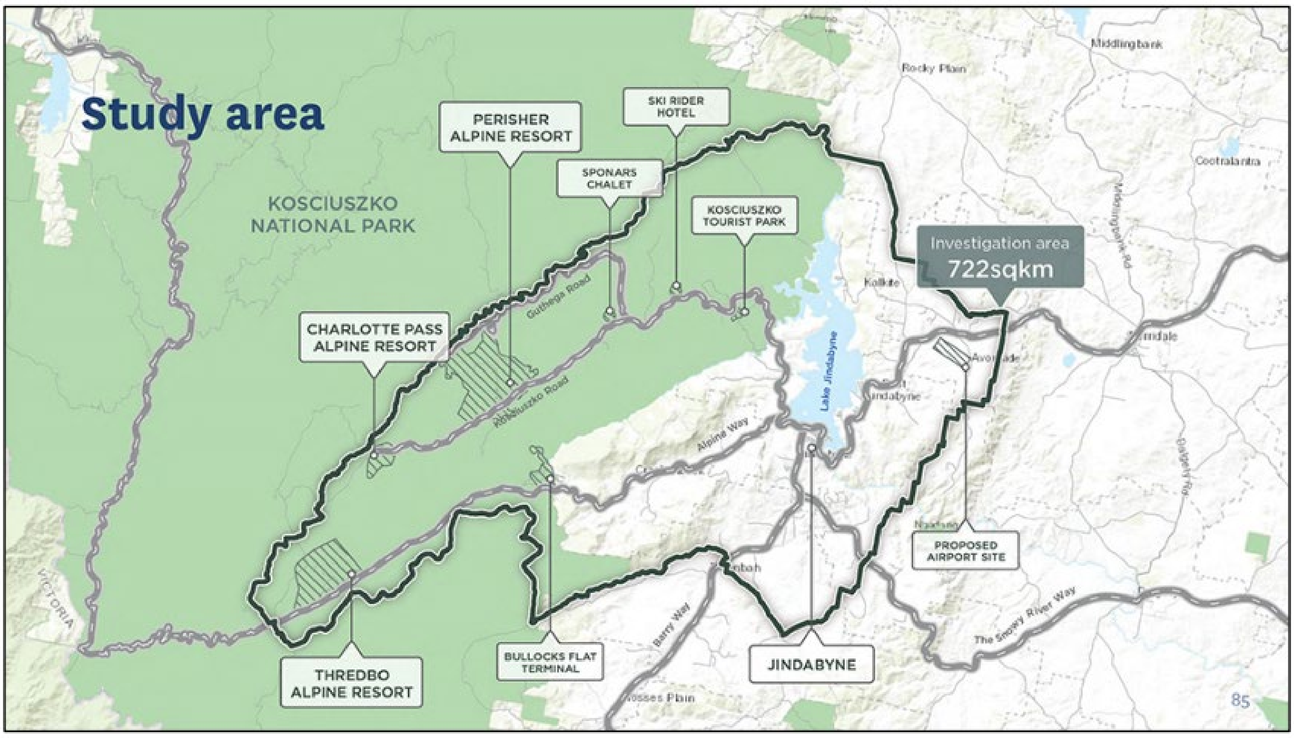



Figure 1.1 Study area

## 1.4 PURPOSE

This Technical Study will form part of the Engineering Package for the Snowy Mountains Special Activation Precinct (SAP). This report builds on the context analysis reporting to provide a holistic view of the geotechnical issues, opportunities and constraints within the SAP study area. It explores stakeholder issues and current and future constraints to investigate strategic projects for the Snowy Mountains area. This Technical Study has been prepared through collaboration with the NSW Government, Snowy Monaro Regional, National Parks and Wildlife Services (NPWS) and other stakeholders including representatives from the Alpine Resorts.

The recommendations from this report will combine with other technical studies in the disciplines of engineering, planning, environment, economics and legislation to inform the Master Planning for the Snowy Mountains SAP.

## 1.5 BACKGROUND INFORMATION

The background information reviewed and summarised in this report:

| | |
|---|---|
| **Policy and Planning Context** | State Environmental Planning Policy (Kosciuszko National Park – Alpine Resorts), 2007 (Alpine SEPP) |
| | Alpine Resorts – Kosciuszko National Park Development Control Plan 2019 |
| | Geotechnical Policy Kosciuszko Alpine Resorts, November 2003 |
| | Kosciuszko National Park Alpine Reports – Geotechnical Policy, 2017 (DRAFT) |
| | Geotechnical maps associated with Geotechnical Policy Kosciuszko Alpine Resorts, https://www.planning.nsw.gov.au/Policy-and-Legislation/Alpine-Resorts#geotechnical_forms |
| | Kosciuszko National Park Geotechnical Policy, Managing geotechnical risks in the alpine resorts, September 2011 |
| | Kosciuszko National Park Plan of Management (KNP POM) – Geotechnical and Water Management amendment, 2010 |
| | Perisher Range Village Masterplan EIS – Groundwater and Geotechnical Study, August 1998 |
| | Snowy Monaro Regional Council, Snowy Monaro Region Planning and Land Use Draft Discussion Paper, January 2019 |
| | Snowy Mountains Special Activation Precinct, Airport Options – Technical and Regulatory Issues Report, February 2020 |
| | Snowy Hydro 2 Feasibility Study, 2017 |
| | Snowy Hydro Exploratory Works Environmental Impact Statement, 2018 |
| **Existing studies** | Report of the inquest into the deaths arising from the Thredbo landslide, June 2020 |
| **Models** | – |
| **Data** | Australian Radiation Protection and Nuclear Safety Agency, Radon map of Australia, 2011 |
| | Geological Survey of NSW Seam less Geology Zone 55 East compilation (2017) NSW Planning and Environment Resources and Energy) |
| | Department of Environment and Heritage, http://www.environment.nsw.gov.au/eSpade2Webapp; |
| | Australian Soil Resource Information System (ASRIS) (http://www.asris.csiro.au/) |
| | Geological Survey of NSW, DIGS Portal, https://search.geoscience.nsw.gov.au/ |
| | Geoscience Australia (previously Bureau of Mineral Resources); National Library of Australia, Trove Portal, http://trove.nla.gov.au/ |
| | The Australian Alps Education Kit – Soils and the Australian Alps factsheet |
| **Standards and guidelines** | Department of Planning, Industry and Environment, NSW National Park & Wildlife Service – Landslides and Rockfalls Procedures, February 2020 |
| | AGS Landslide Risk Management 2000/2007 https://australiangeomechanics.org/downloads/#dlLRM2007 |
| | Australian Building Codes Board (ABCB) Handbook: Landslide Hazards, 2015 |

## 1.6 SCOPE

This Technical Study includes:

- desktop review of the geotechnical constraints of the Snowy Mountains SAP investigation area through detailed review of existing available geotechnical data
- risk assessment and discussion of implications for future growth and development in Kosciuszko National Park, based on existing available geotechnical data.

# 2 SNOWY MOUNTAINS CONTEXT

## 2.1 REGIONAL GEOLOGY

### 2.1.1 OVERVIEW

The 1:250000 scale detailed surface geology map (1990) from the Bureau of Mineral Resources (Geology of the Kosciuszko National Park; including the Berridale 1:100000 scale geological map) indicated that the surface geology within the site investigation area is mainly comprised of intrusive rock of Palaeozoic age, between 435 to 390 Ma. The geology bordering the eastern and south-eastern sides consists of deep marine deposited turbidites comprising sandstone, siltstone and shale of Late Ordovician age, > 435 Ma.

The regional geology is highly complex and variable within the site investigation area and is illustrated in Figure 2.1, refer to Appendix A (Figure 1.1) for a more detailed plan and legend. The main rock units are summarised in Table 2.1.

Table 2.1 Summary of geological units identified within the site investigation area

| REFERENCE | NAME | DESCRIPTION |
|---|---|---|
| Duki | Island Bend Monzogranite | Biotite monzogranite commonly containing hornblende. |
| Sbue | Etheridge Monzogranite | Biotite monzogranite commonly containing cordierite. |
| Sbuj | Jillamatong Granodiorite | Mafic, evenly fine-grained, cordierite-biotite granodiorite; weakly foliated, biotite sporadically exceeds 25% of rock volume, quartz grains 3-4 mm with random rutile needles, rich in inclusions of metasedimentary origin. |
| Sbuk | Kalkite Monzogranite | Coarse-grained, moderately mafic, sporadically porphyritic biotite monzogranite to granodiorite; biotite as aggregates of small grains (with interleaved muscovite) or large crystals with inclusions of zircon and apatite. |
| Sbul | Leesville Granodiorite | Medium-grained, variably foliated biotite granodiorite to tonalite; tonalite includes quartz, plagioclase, K-feldspar, cordierite, biotite and muscovite; inclusions are of metasedimentary origin. |
| Sbum | Mowambah Granodiorite | Medium-grained mafic biotite-rich granodiorite; strong foliation defined by quartz and biotite crystals plus aligned xenoliths, muscovite flakes accentuate foliation; metasedimentary xenoliths include banded cordierite gneiss. |
| Sbuo | Botheram Granodiorite | Even-textured, fine- to medium-grained quartz-feldspar-biotite-muscovite granodiorite; biotite forms medium- to large grained crystals rather than clusters, muscovite is disseminated. |
| Sbuu | Bullenbalong Granodiorite | Mafic, coarse- to medium-grained, biotite-rich granodiorite; quartz alignment defines a weakly developed foliation, metasedimentary xenoliths (e.g. cordierite-andalusite-biotite) are common. |
| Sjig | Gaden Tonalite | Medium-grained hornblende-rich and hornblende-poor biotite tonalite. |
| Sjij | Jindabyne Tonalite | Medium-grained tonalite with larger hornblende crystals to 20 mm. |
| Sjim | Moonbah Tonalite | Grey, medium-grained, hornblende-biotite tonalite. |
| Sjip | Pendergast Tonalite | Medium-grained, hornblende-free biotite tonalite. |

| REFERENCE | NAME | DESCRIPTION |
|---|---|---|
| Sui__c | Unassigned Silurian intrusions – aplite | Aplite, aplitic granite. |
| Sui__f | Unassigned Silurian intrusions – felsic | Felsic intrusions. |
| Suk | Unassigned Kosciuszko Batholith units | Gneissic to massive granite (common metasedimentary xenoliths), granodiorite and tonalite, sporadic aplite; biotite±muscovite monzogranite, leucogranite; sporadic gabbro, diorite and microgranite porphyry. |
| Oada | Abercrombie Formation | Brown and buff to grey, thin- to thick-bedded, fine- to coarse-grained mica-quartz (+/-feldspar) sandstone, interbedded with laminated siltstone and mudstone. Sporadic chert-rich units. |

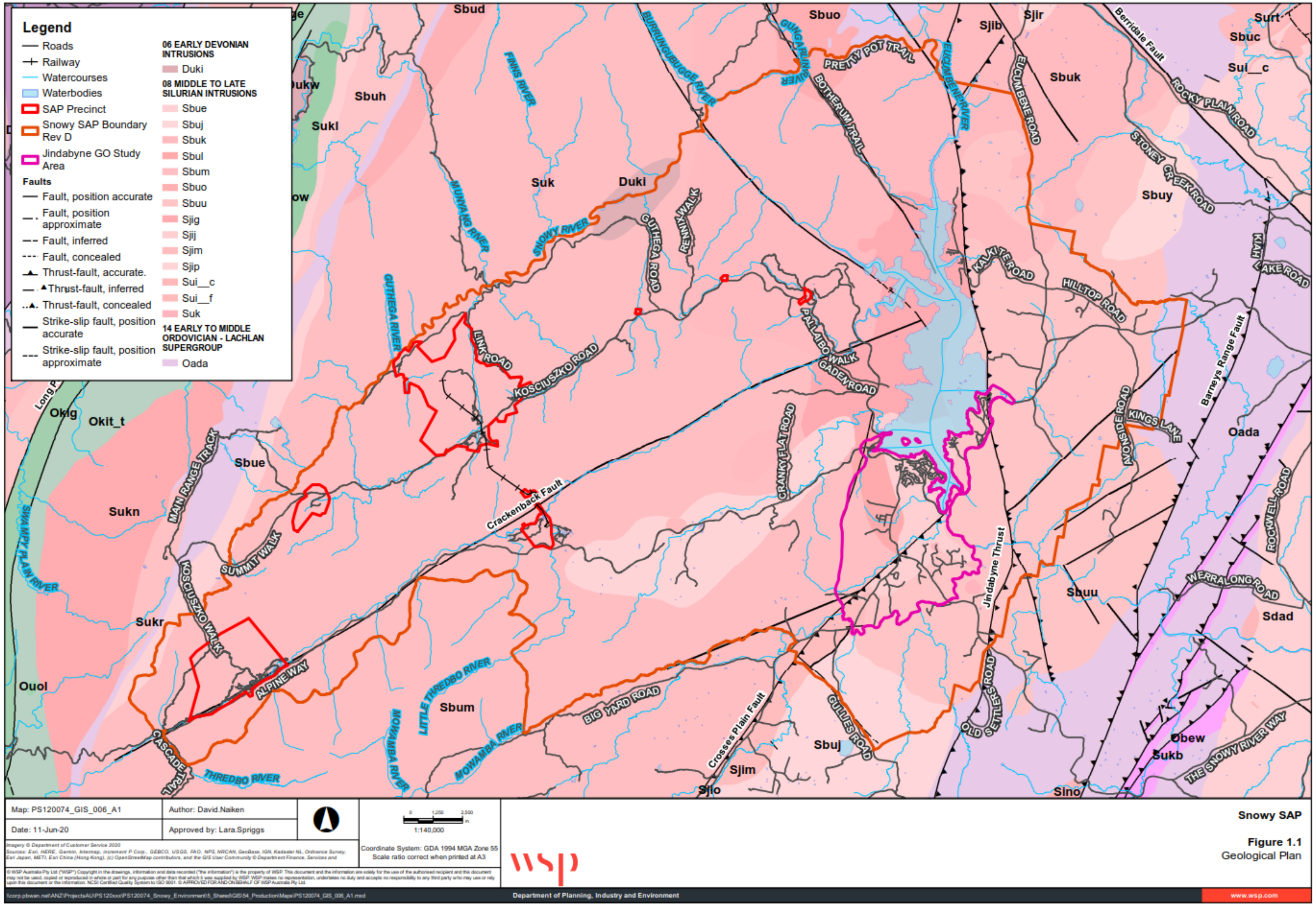



Figure 2.1 Geological map of the site investigation area

The Mount Selwyn area further to the north of the site investigation area, indicated that the surface geology was of volcanic origin of Late Ordovician age, between 458 to 435 Ma. This is illustrated in Figure 2.2, refer to Appendix A (Figure 1.2) for a more detailed plan and legend. The main rock units are summarised in Table 2.2.

Table 2.2 Summary of geological units identified within the site investigation area

| REFERENCE | NAME | DESCRIPTION |
|---|---|---|
| Stu | Tumut Pond Group | Rhythmically bedded grey sandstone (grading to quartzite) and grey slate (grading to phyllite); green, purple and dark grey slates (grading to phyllite). |
| Stuk | Kings Cross Formation | Green, purple and dark grey slate (grading to phyllite). |
| Okig | Gooandra Volcanics | Metabasalt, basalt breccia (emplaced as pillow lavas), amphibolite, chloritic schists, feldspathic sandstone; aphyric and feldspar-phyric basalt, basaltic lava breccia, rhyolite, shale; fine-grained feldspathic siltstone and shale. |
| Okit_t | Temperance Formation – tuff | Interbedded basaltic tuff, chert, and feldspathic arenite, minor agglomerate. |
| Ouog | Geordies Spur Gabbro | Gabbro, diorite, metabasic intrusive rock, pyroxenite. |
| Oada | Abercrombie Formation | Brown and buff to grey, thin- to thick-bedded, fine- to coarse-grained mica-quartz (+/-feldspar) sandstone, interbedded with laminated siltstone and mudstone. Sporadic chert-rich units. |

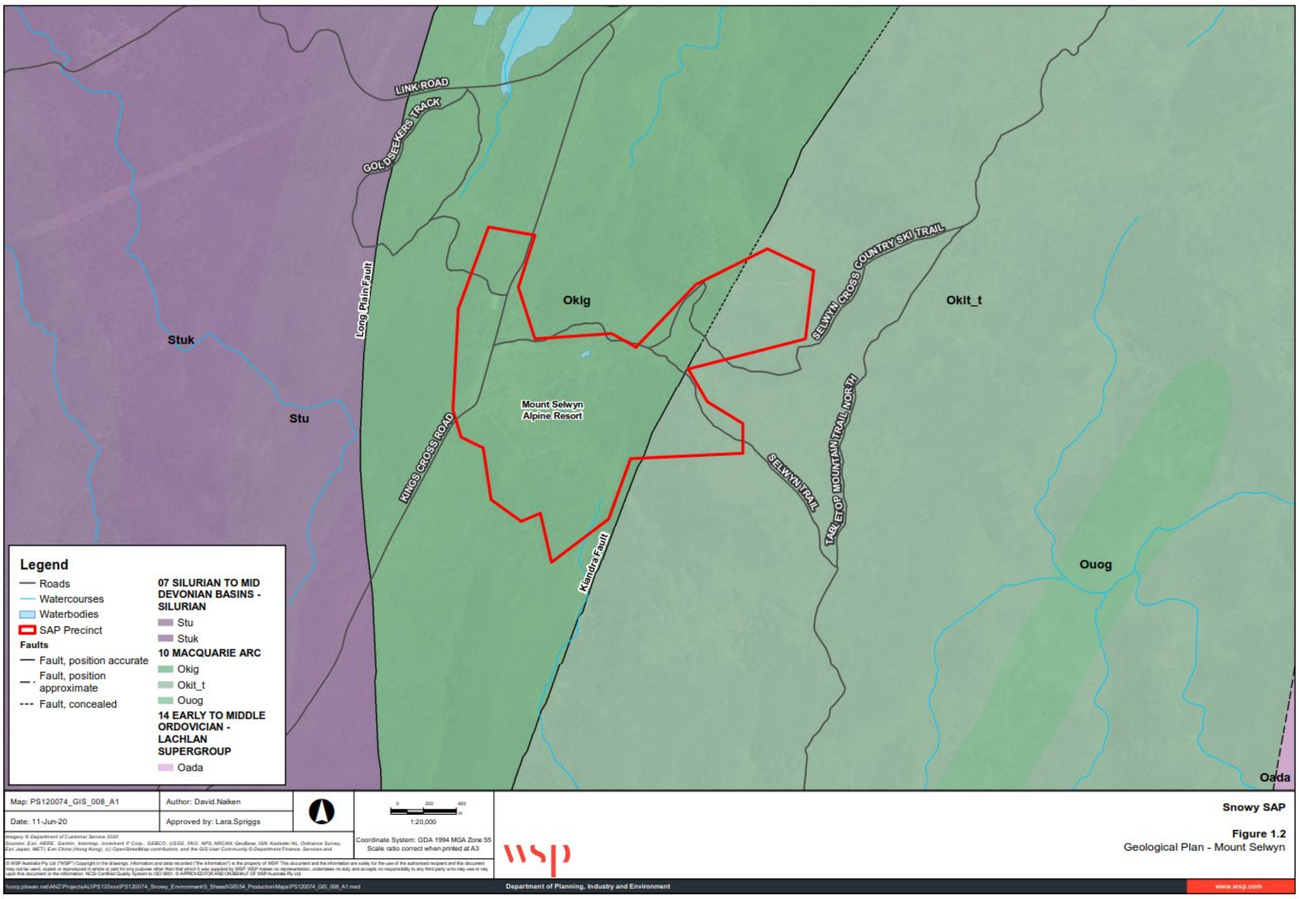



Figure 2.2 Geological map of the Mount Selwyn area

Further details of the surface geology are provided in the following sections.

### 2.1.2 INTRUSIVES

The geological plans indicate that the sub-surface ground conditions for majority of the site investigation area is anticipated to be intrusive rocks. These intrusive rocks are predominantly S-type (sedimentary origin) of the Mowamba Granodiorite and Kalkite Adamellite. However, on the western margin of Lake Jindabyne and extending southwest are anticipated outcrops of I-type (igneous origin) intrusive rocks of the Gaden, Jindabyne, Moonbah, Pendergast and Grosses Plain Tonalites. These rocks will often have preferential weathering along joints resulting in the formation of corestones and variable weathering profiles.

The resort locations of Charlotte Pass, Perisher Range, Sponars Chalet, Thredbo and Bullocks Flat are all situated within the biotite granodiorite and tonalite of the Mowamba Granodiorite.

Ski Rider and Kosciuszko Mountain Retreat resorts are situated in the biotite adamellite of the Kalkite Adamellite.

Jindabyne GO study area is a combination of both the Mowamba Granodiorite and Kalkite Adamellite.

During the breakdown of these granitic rocks it is anticipated that Radon gas may be released. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Radon map of Australia indicates that the Jindabyne--Berridale Region has in home average Radon levels of up to 15 $Bq/m^3$.

### 2.1.3 FAULTS

Several faults traverse across the site investigation area including the major faults; Jindabyne Thrust and Crackenback Fault. The Jindabyne Thrust trends north south along the eastern side of Lake Jindabyne. This is intersected by the Crackenback Fault which trends to the southwest through the southern portion of the site. There are three smaller faults in the north which trend northwest where the Crackenback Fault intersects the Jindabyne Thrust.

Along these fault lines the rock mass can be highly fractured and quite variable which can result in slope instability.

Several earthquakes have been recorded in the last 10 years throughout the site investigation area. These are spread throughout the area with clusters forming to the east of the Jindabyne Thrust. Figure 2.3 illustrates the distribution of these earthquakes.

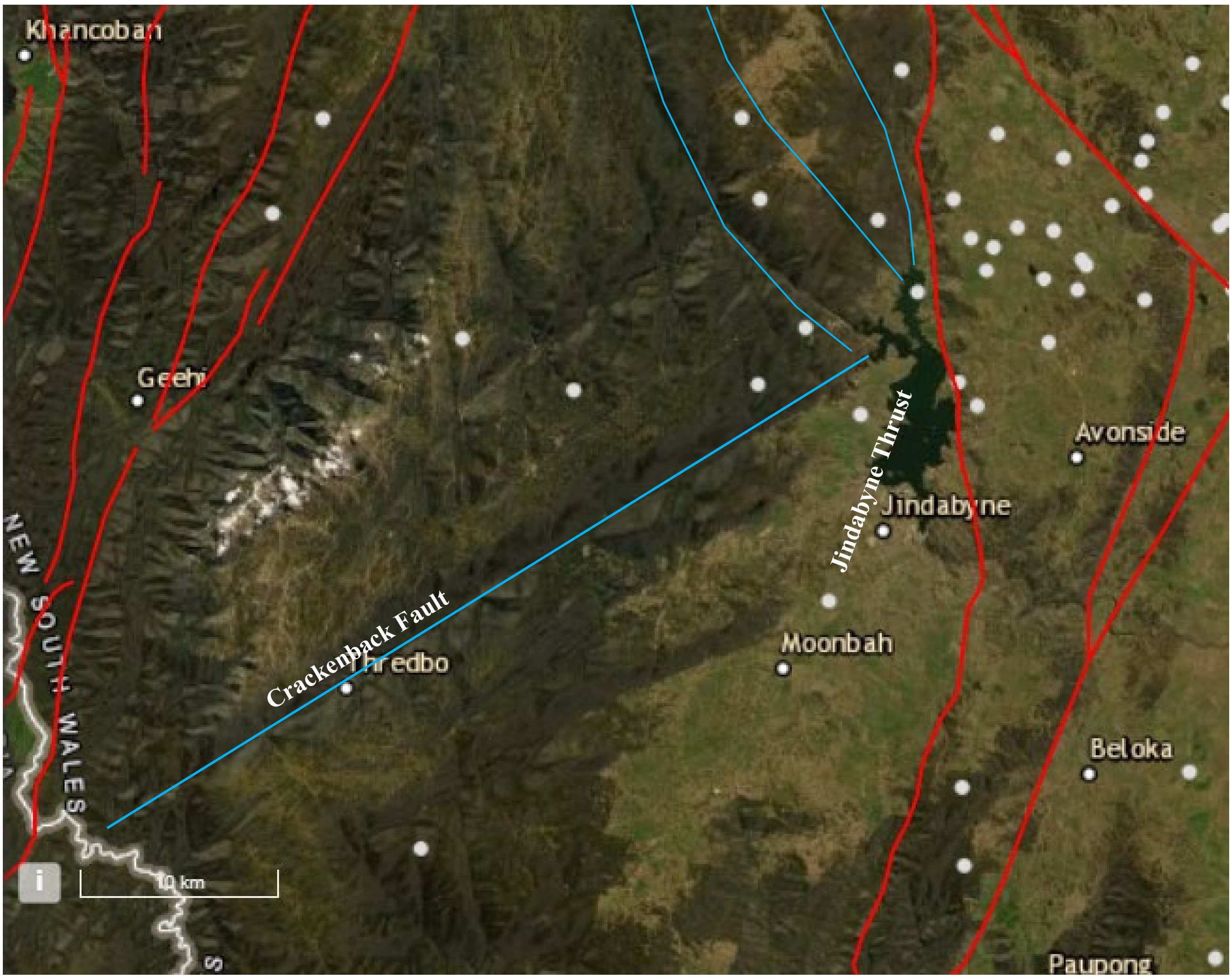



Figure 2.3 Recorded earthquakes in the Lake Jindabyne area over the last 10 years (Geoscience Australia https://earthquakes.ga.gov.au/, accessed on 11 June 2020)

### *2.1.4 MOUNT SELWYN*

The sub surface ground conditions of the area surrounding Mount Selwyn further to the north of the site investigation area is anticipated to be comprised of metabasalt, basalt breccia, pillow lavas, amphibolite, chloritic schists and feldspathic sandstone of the Gooandra Volcanics.

## 2.2 SOILS AND LANDSCAPE MAPPING

The Australian soil resource information system (ASRIS) mapping indicated that four soil types, not including water and not assessed areas, are present in the site investigation area and Mount Selwyn area. A summary of the identified soil types is provided in Table 2.3 for the site investigation area and Mount Selwyn area. The regional scale map is shown in Figure 2.4, refer to Appendix A (Figure 2) for a detailed plan and legend.

Table 2.3 Summary of soil types identified within the site investigation area and Mount Selwyn

| REFERENCE | NAME | DESCRIPTION |
|---|---|---|
| AH | Alpine Humus Soils | Shallow, very friable loams. The most extensive soil type found in the subalpine and alpine zones, occurring on relatively sheltered, gentle, well-drained slopes. The surface soil is highly organic with strong plant root development. Highly porous and friable. |
| ACP | Acid Peats | Found in basins and depressions where water collects all year around. They are highly organic and contain undecomposed and partially decomposed plant remains. |
| BRE | Brown Earths | Lower Montane: loams gradually merging into clay with depth. Upper Montane: deep friable loams. Highly porous and friable, these soils are found on the steep slopes of the montane zone. |
| L | Lithosols | Very shallow loams found in pockets on high exposed ridges and elevated stony slopes. They have a lower organic content than alpine humus loams and are highly porous. |
| Water | Water | Lake Jindabyne water body. |
| Not Assessed | Not Assessed | No assessment available in this area. |

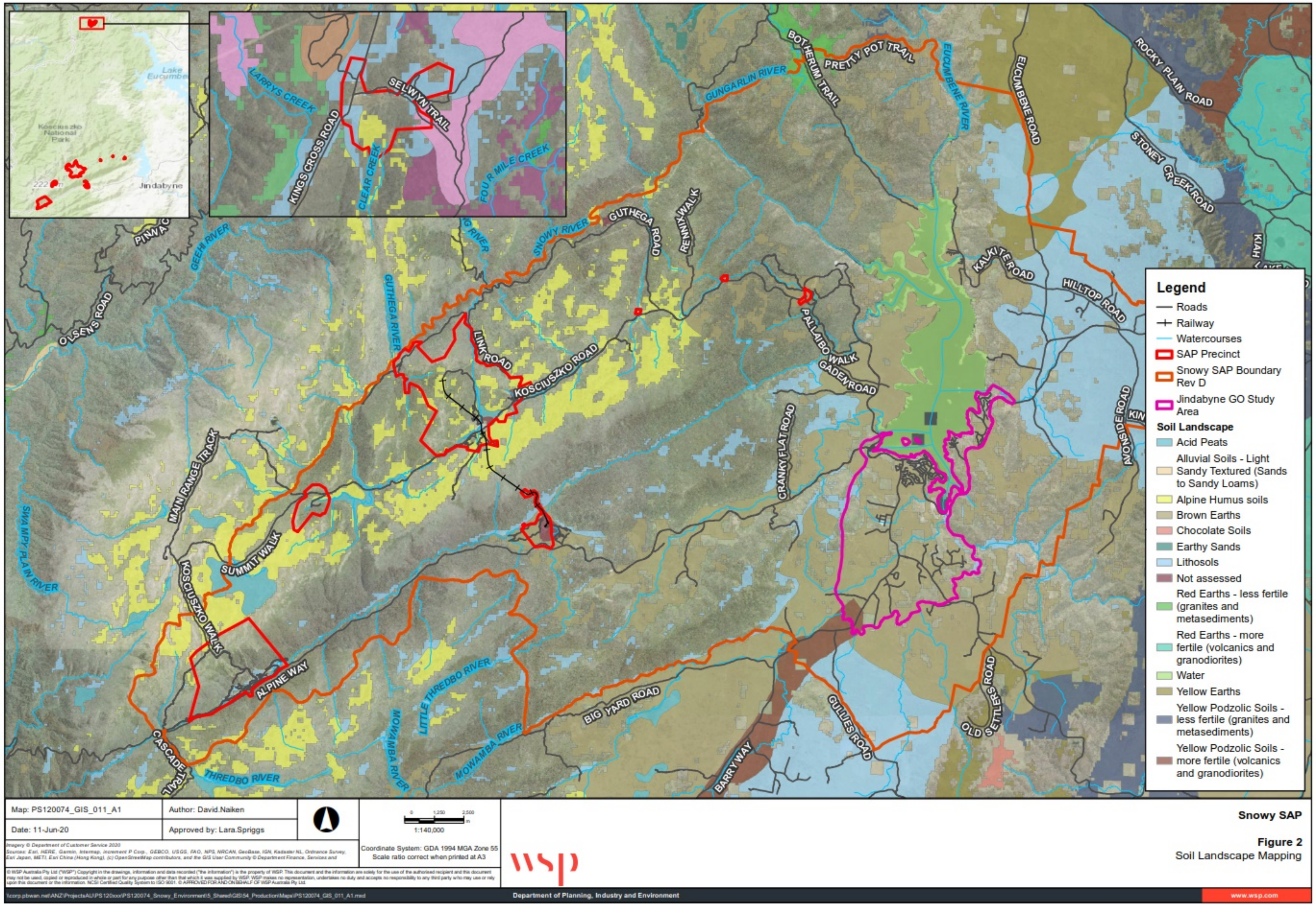



Figure 2.4 Soils map of the site investigation and Mount Selwyn area

## 2.3 SLOPE ANALYSIS

Utilising the available 5 m contour information slope analysis has been undertaken in GIS and a heat map of the terrain slope provided in Figure 2.5, refer to Appendix A (Figure 3) for a more detailed plan and the legend. This analysis indicates where high angle slopes are distributed throughout the site investigation area.

The plan illustrates that majority of the site investigation area has slopes steeper than 30 degrees identified by the yellow and red colouring. This is also the case for the resort locations except for Bullocks Flat and Jindabyne which is indicating only localised steep areas.

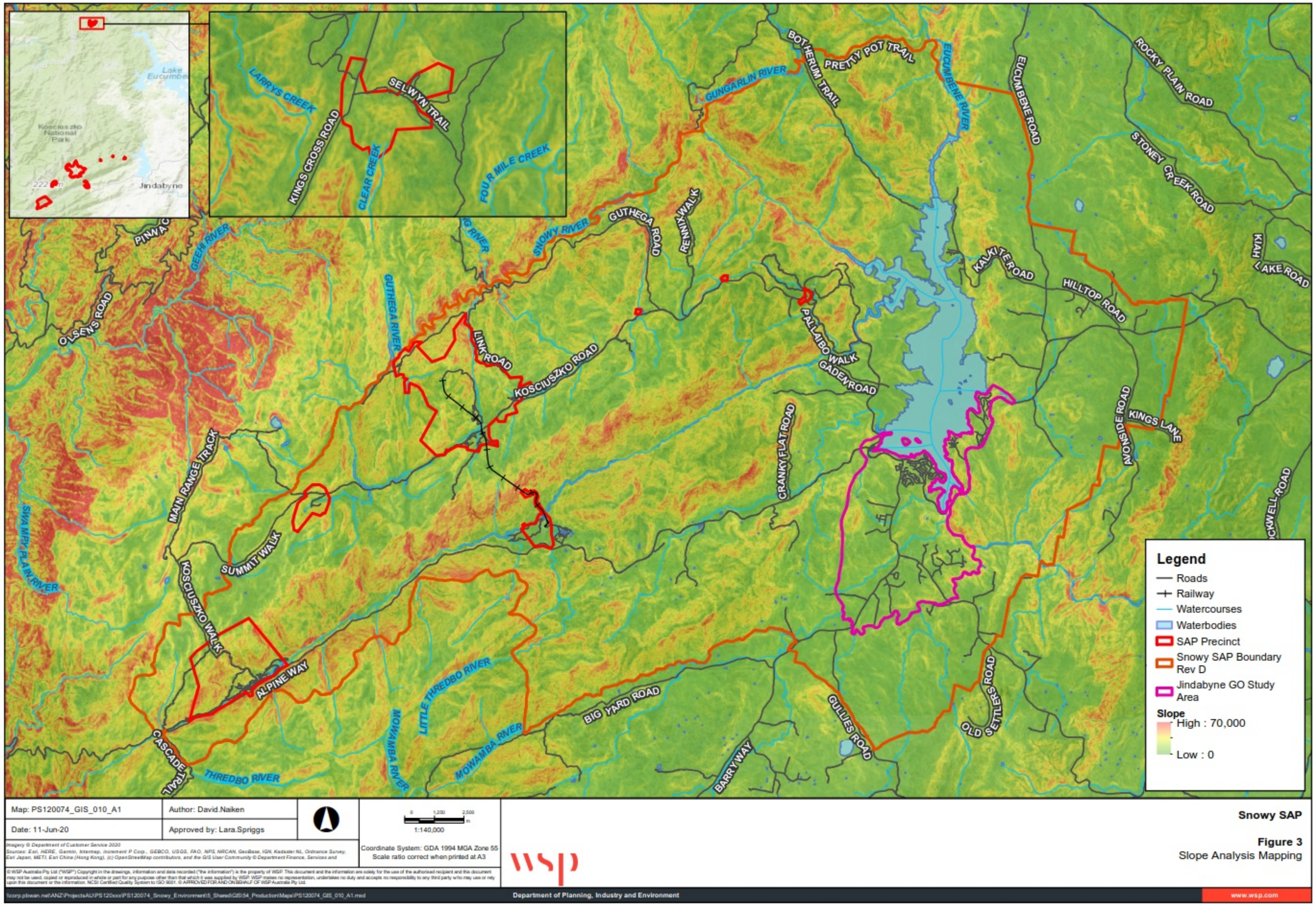



Figure 2.5 Slope analysis heat map

## 2.4 ACID SULFATE SOILS

The acid sulfate soil map presented in Figure 2.6 and included in Appendix A (Figure 4), provide an overview of the acid sulfate soil potential within the site investigation area and Mount Selwyn.

These are based on the Australian Soil Resource Information System – Atlas of Australian Acid Sulfate Soils 1:25000 mapping for NSW. The plans indicate the site investigation area is mainly within an area of 'no known occurrence' with the exception of proximity to Lake Jindabyne which is indicated to be of high probability. In addition, the presence of deep marine turbidites on the eastern boundary of the site are likely to have been deposited in an environment which promotes the presence of sulfide containing soils. Therefore, this region should also be considered to have potential for acid sulfate soils.

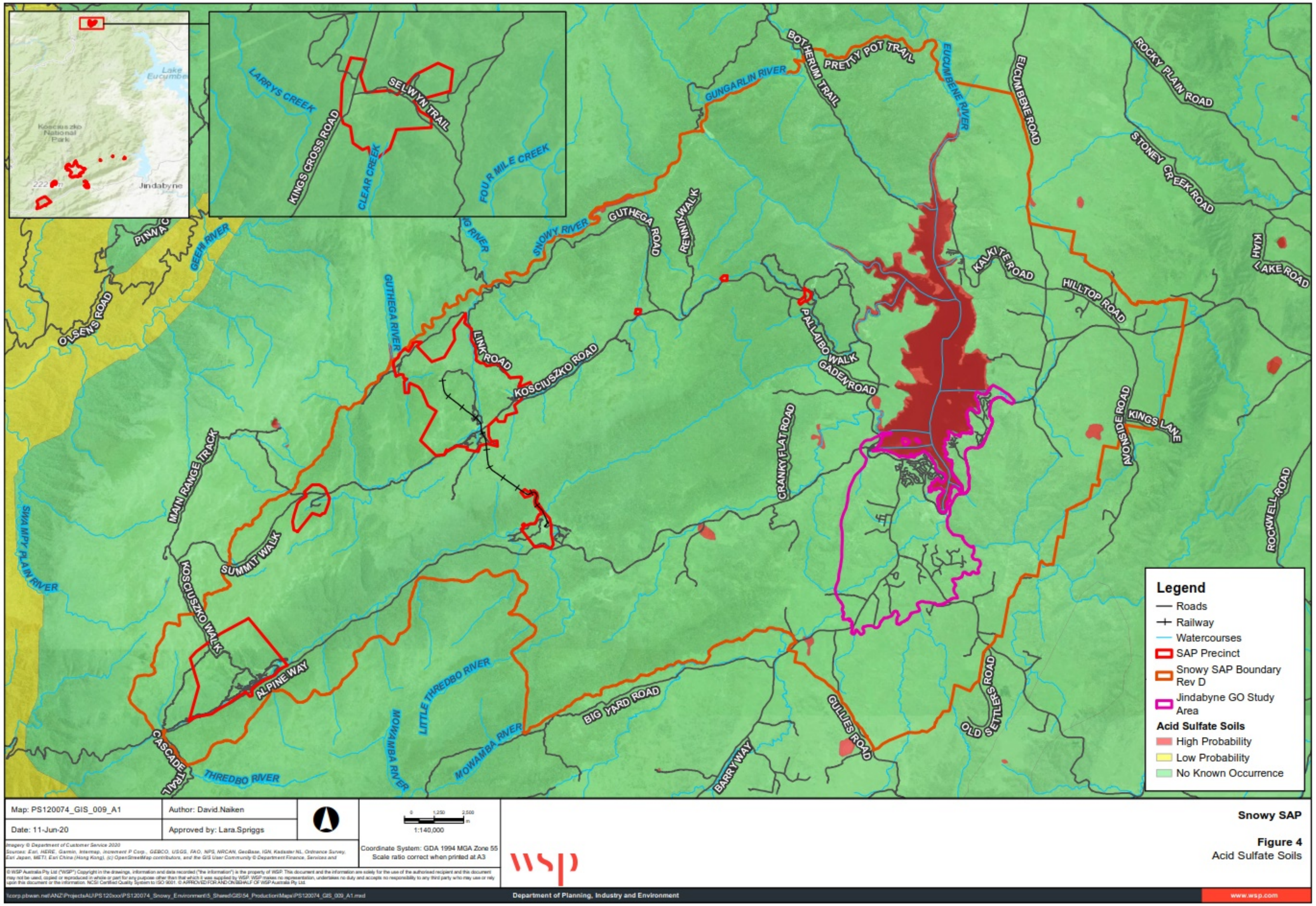



Figure 2.6 Acid sulfate soil mapping

## 2.5 EXISTING MANAGEMENT STRATEGIES AND PLANS

Several management strategies and plans were reviewed as identified in Section 1.1, to understand the proposed development infrastructure. Types of infrastructure likely to be included are as follows:

- building infrastructure for residential and commercial use
- upgrades and new roads to expand the road network including connections. This may also include bypasses, bridges and tunnels
- earthworks to level areas and may include steep cuts and potentially the need for retaining structures
- new or realignment of utility connections potentially requiring trenching or underboring works.

Of major relevance for geotechnical review is the Geotechnical Policy – Kosciuszko Alpine Resorts and the Landslides and Rockfalls Procedures. These have been considered in further detail in the following sections.

### *2.5.1 GEOTECHNICAL POLICY – KOSCIUSZKO ALPINE RESORTS*

The Geotechnical Policy – Kosciuszko Alpine Resorts sets out the structural and geotechnical requirements for development within the Alpine Report Areas. Each resort area has been considered individually and geotechnical risk plans created for each site to identify areas where an upfront geotechnical report is required for development applications. Based on the geotechnical maps (G1, G1-1 to G1-8, G2 to G10) a significant area within each resort development footprint will require a geotechnical report to be completed for future development.

### *2.5.2 LANDSLIDES AND ROCKFALLS PROCEDURES*

Landslides and rockfalls are common in the Alpine Resorts region. The NSW NPWS procedure provides a consistent process for the management of these landslides and rockfalls. This is a proactive approach to managing landslides and rockfalls for early detection. A register of landslides and rockfalls is maintained to enable problem areas to be identified and repair works to be undertaken to mitigate the risk to the public and properties.

## 2.6 GEOTECHNICAL RISK IDENTIFICATION

A preliminary assessment of the possible geotechnical risks that may impact further development was undertaken based on the available information. A summary of the preliminary findings is as follows:

- Increased population, both permanent and tourists, is likely to increase the exposure of key geotechnical risks to a greater populous.
- Steep sloping ground – in areas where future development transects high angle slopes (i.e. foundation excavations, road alignments, utility alignments) ground may become unstable or be susceptible to erosion during and after construction. This may impact roads, hiking trails, cycleways/trails within these areas.
- Deep weathering – variable weathering that include corestones may result in slope instability and founding conditions for future construction works.
- Faults – where urban expansion follows existing fault lines, highly fractured rock associated along the fault scarp may pose a risk of excavation or long term slope instability.
- Earthquakes – there is a history of minor earthquakes within the site investigation area which with increased population may impact a greater populous. It is unlikely for occurrence of a major earthquake.
- Acid Sulfate Soils – in areas identified to have potential for acid sulfate soil a management plan will be required if disturbance of the ground is likely to occur.
- Radon gas – increased population in these areas is likely to expose more people to radon gas particularly during the construction phase of future development.

The above geotechnical risks will be further detailed as the SAP progresses and the areas and type of development are considered.

# 3 TECHNICAL STUDY

This technical study has been carried out to determine the possible geotechnical risks that may impose mitigation strategies for future development. We have given due consideration to the whole of the project area and analysed the available Geographic Information System (GIS) data to determine areas more likely to be susceptible to the identified geotechnical risk, as detailed in Section 2.

To understand the areas susceptible to geotechnical risks for future growth and development, susceptibility zoning has been undertaken. The Snowy Mountains Special Activation Precinct including Mt Selwyn is in highly variable terrain which includes high relief areas, rivers, creeks, fault lines and predominantly is underlain by intrusive rocks. The hazards considered to have the most impact on growth and development considered as part of this assessment include landslide susceptibility, erosion/scour, earthquake (expected up to 4 on the Richter Scale) and radon gas release.

A geotechnical risk susceptibility assessment has been conducted with reference to the guidelines provided by Australian Geotechnical Society (AGS, 2007). Preliminary regional susceptibility zoning maps have been developed as a guide for geotechnical risk and are provided in Appendix B. These maps will need to be validated in future stages of the project as additional information becomes available.

The Snowy Mountaineer (gondola) inputs on the proposed route, length, station locations and operating requirements are still unknown at this stage. Therefore, the Snowy Mountaineer has not been considered as part of this geotechnical risk susceptibility assessment.

## 3.1 PROJECT SPECIFIC APPROACH

For the purpose of this study, susceptibility refers to a qualitative assessment of the potential for a particular hazard to occur in an area. The steps undertaken to develop the regional susceptibility zoning maps are as follows:

1. undertake desktop assessment
2. correlate known geographic features with potential hazard events
3. conduct a check of the known hazard areas to further assess that the correlations with geographic features are reasonable or require reassessment.

Due to limited known hazard data available at the time of this study the final step was not able to be developed fully. This will need to be undertaken in future stages of planning to validate the susceptibility assessment.

### *3.1.1 GEOLOGICAL AND GEOMORPHOLOGICAL FEATURES*

The susceptibility assessment is based on the geological and geomorphological features summarised in Table 3.1.

Table 3.1 Summary of geographic features

| FEATURE | DESCRIPTION | HAZARD |
|---|---|---|
| Geology<br>(Based on 1:250,000 mapping) | Different lithologies from the 1:250,000 scale detailed surface geology mapping were merged into 5 different categories based on their physical properties and geotechnical experience regarding susceptibility to hazard events. | landslide susceptibility, erosion/scour and radon gas release |
| Terrain Slope<br>(gradient in degrees) | With slope gradient increase often the susceptibility of landslide risk also increases. The available contour plans with contours at 10 m increments was used and analysed using GIS software to determine the ground surface gradient. | landslide susceptibility |

| FEATURE | DESCRIPTION | HAZARD |
|---|---|---|
| Terrain Height (mAHD) | With elevation increase often the susceptibility of landslide risk also increases. Contour plans with contours at 10 m increments has been utilised. | landslide susceptibility |
| Fault Proximity (m) | Buffer areas surrounding the fault lines were created to account for the variability of rock structure along these margins and susceptibility of landslide and earthquakes. | landslide susceptibility and earthquake |
| Drainage Proximity (m) | Buffer areas surrounding the drainage channels were created to account for the influence of rivers and creeks on susceptibility of landslide and erosion. | landslide susceptibility and erosion/scour |

### 3.1.2 GIS MULTI-CRITERIA ANALYSIS

The method of GIS multi-criteria analysis adopted for this project considers the geographic features identified in Section 3.1.1 as influence parameters. As the objective for this study is to look at the risk to growth and development the inputs have been divided into classes and subjectively provided a rank and weighting according to their potential to cause hazards impacting development. The regional susceptibility maps were developed by computing and classifying the Potential Index (0-10) into three susceptibility zones; low (<4), medium (5-6) and high (>7) (Refer to Table 3.3).

The Potential Index (PI) is defined as:

$$PI = \Sigma \left( Ri_n * Wi_n \right)$$

Where:

n: the total number of factors, 5 in this study
Ri: Rank for factor i (rank from 1–5, 5 being greatest influence)
Wi: weighting for class of factor i (rank from 0–10, 10 worse case)

The rank and weighting used in the GIS multi-criteria analysis has been provided in Table 3.2 based on technical knowledge of the area.

Table 3.2 Summary of geotechnical assessment rank and weighting

| FACTOR | CLASS | RANK | WEIGHTING |
|---|---|---|---|
| Geological Type (Based on 1:250,000 scale mapping) | Intrusive – I-type | 5 | 10 |
| | Intrusive – S-type | | 7 |
| | Volcanics | | 10 |
| | Sedimentary | | 3 |
| | Water body (lake) | | 0 |
| Terrain slope (gradient in degrees) | <10 | 4 | 0 |
| | 10–20 | | 3 |
| | 20–30 | | 5 |
| | 30–40 | | 7 |
| | >40 | | 10 |

| FACTOR | CLASS | RANK | WEIGHTING |
|---|---|---|---|
| Terrain height<br>(elevation mAHD) | <1000<br>1000–1500<br>1500–2000<br>>2000 | 3 | 1<br>3<br>7<br>10 |
| Fault proximity<br>(m) | <500<br>500–1000<br>>1000 | 2 | 10<br>7<br>3 |
| Drainage proximity<br>(m) | <100<br>100–500<br>>500 | 1 | 10<br>7<br>3 |

## 3.2 SUSCEPTIBILITY MAPS

The final regional susceptibility zoning maps presented in Figure 3.1 to Figure 3.7 and in Appendix B. The maps are classified into three categories: green, yellow and red; defined as: low, medium and high susceptibility, respectively. For each of the susceptibility zones a summary of the potential hazard risk has been provided in Table 3.3.

Table 3.3 Potential regional susceptibility zone implications

| GEOTECHNICAL RISK SUSCEPTIBILITY LEVEL | DESCRIPTION |
|---|---|
| Low | Lower potential for landslides, growth and development will be less influenced by geotechnical hazards. |
| Medium | Moderate potential for landslides, growth and development will need to consider design for earthquake, slope instability and monitoring for radon gas during construction. |
| High | Higher potential for landslides, growth and development will need to consider higher potential for more onerous design requirements for earthquake, slope instability and monitoring for radon gas during construction.<br>**Note high susceptibility of a geotechnical risk does not indicate that the site is not able to be developed. This indicates there may be additional costs for development to mitigate the potential geotechnical risks identified in these areas.** |

Each of the proposed areas are considered in detail in the following sections.

Zoning of the areas at this stage demonstrates the potential level of mitigation strategies that may be required to develop the area. Further validation of the data will be required to develop these maps for use in development planning.

## 3.2.1 ALPINE RESORTS

The geotechnical risk susceptibility zoning for the Alpine Resorts is presented in Figure 3.1.

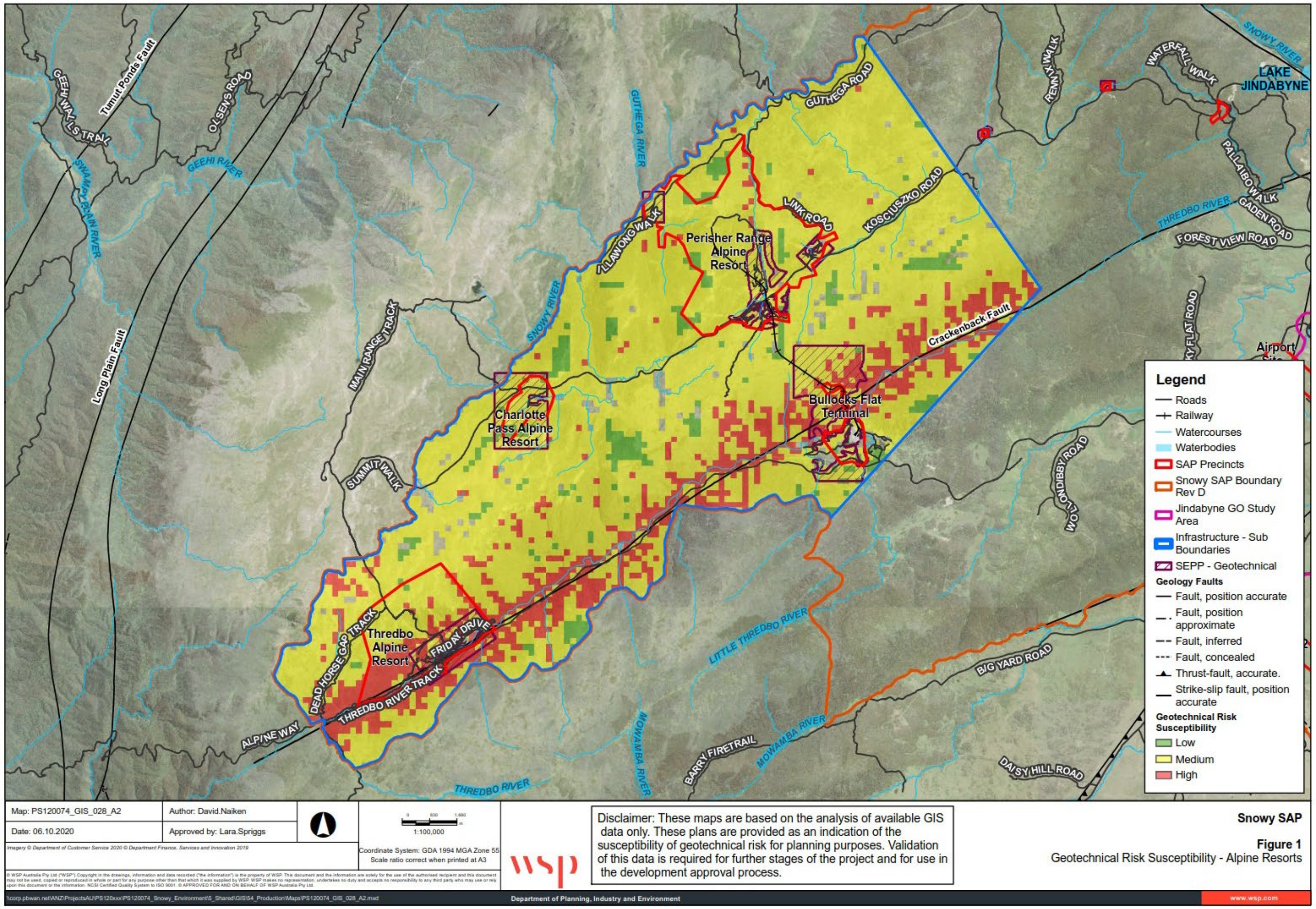



Figure 3.1 Susceptibility plan Alpine Resorts

## 3.2.2 KOSCIUSZKO ROAD AREA

The geotechnical risk susceptibility zoning for the Kosciuszko Road Area is presented in Figure 3.2.

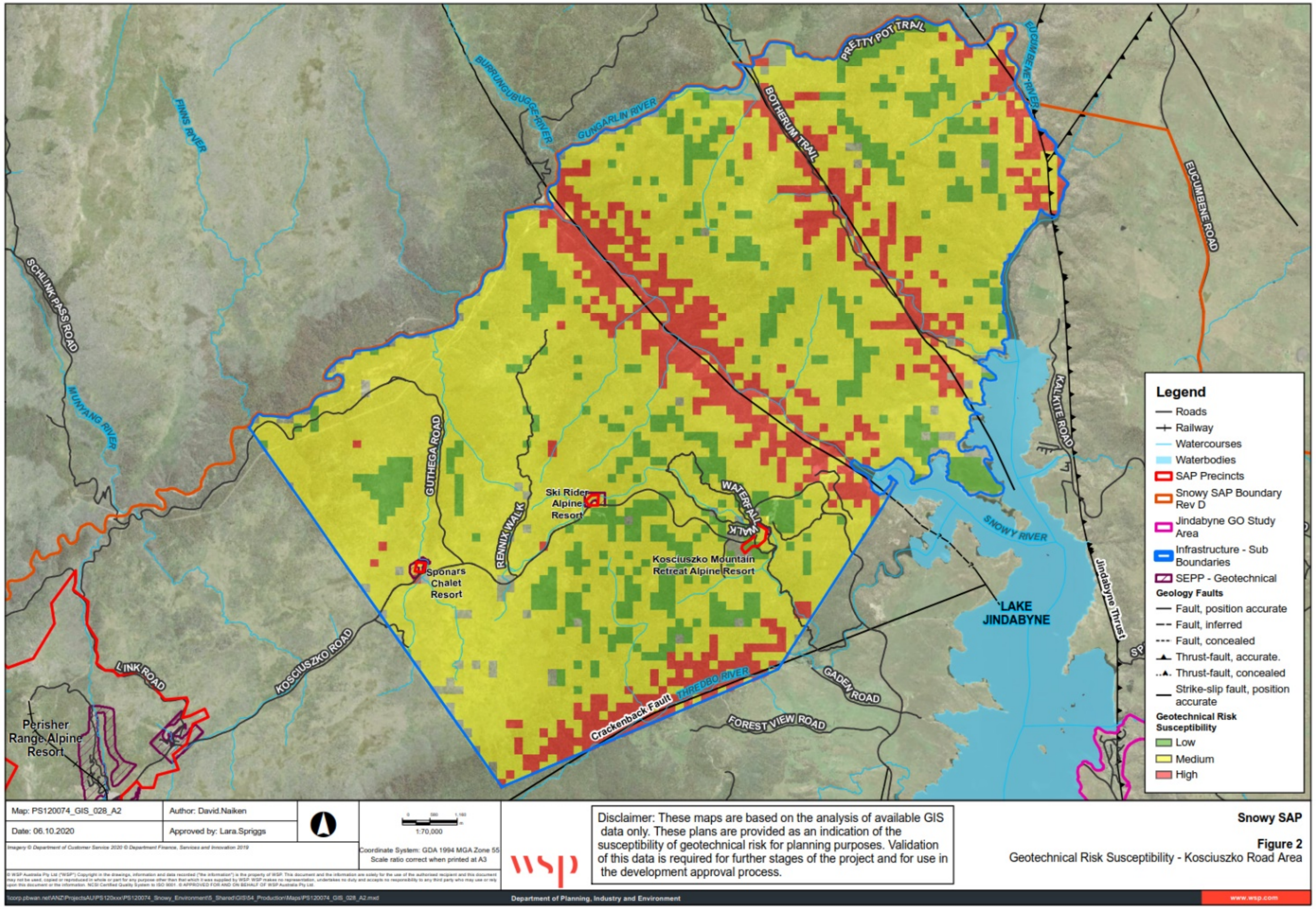



Figure 3.2 Susceptibility plan Kosciuszko Road Area

### 3.2.3 ALPINE WAY AREA

The geotechnical risk susceptibility zoning for the Alpine Way Area is presented in Figure 3.3.

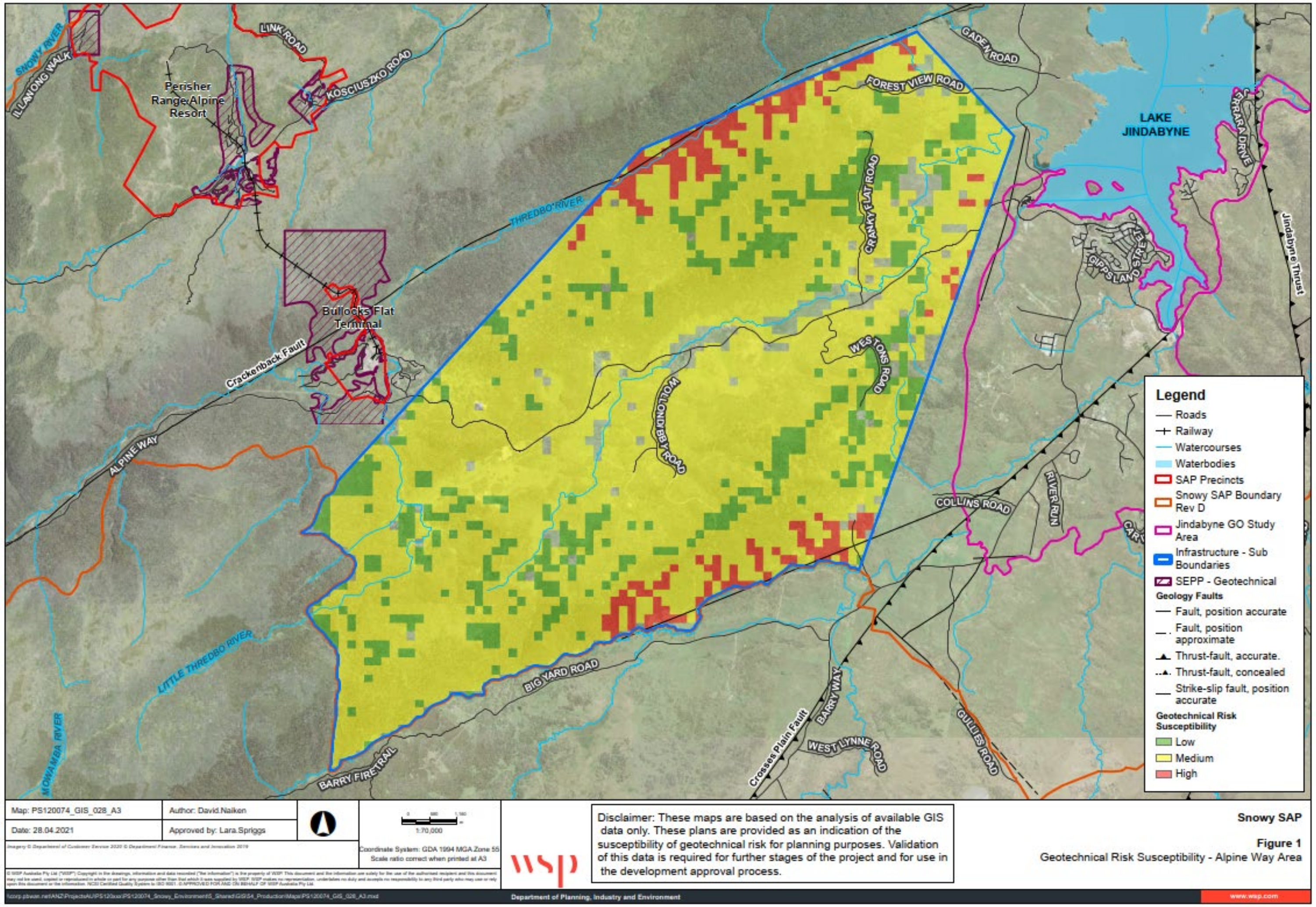



Figure 3.3 Susceptibility plan Alpine Way Area

### 3.2.4 WESTERN LAKE JINDABYNE AREA

The geotechnical risk susceptibility zoning for the Western Lake Jindabyne Area is presented in Figure 3.4.

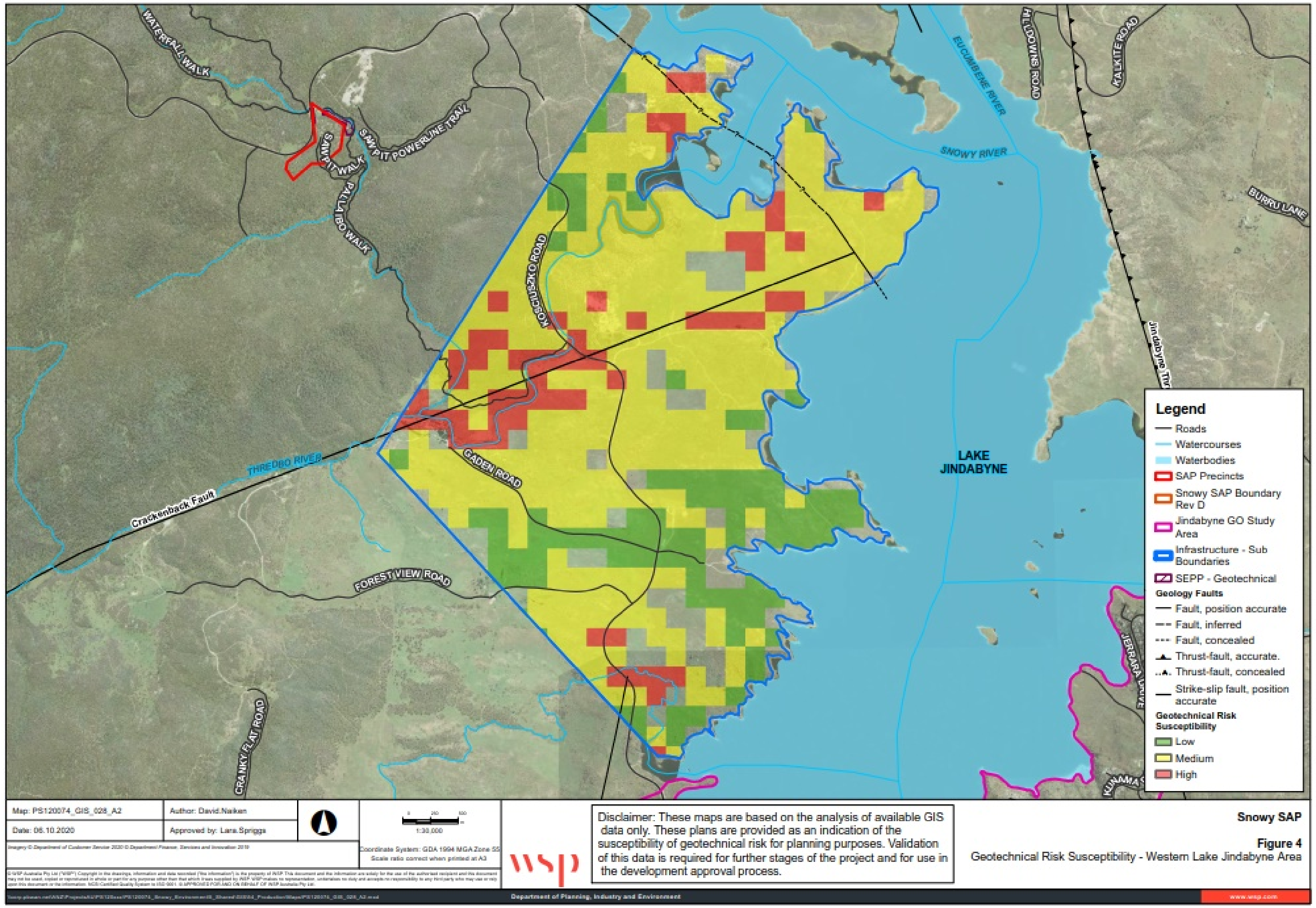



Figure 3.4 Susceptibility plan Western Lake Jindabyne Area

### 3.2.5 JINDABYNE AREA

The geotechnical risk susceptibility zoning for the Jindabyne Area is presented in Figure 3.5.

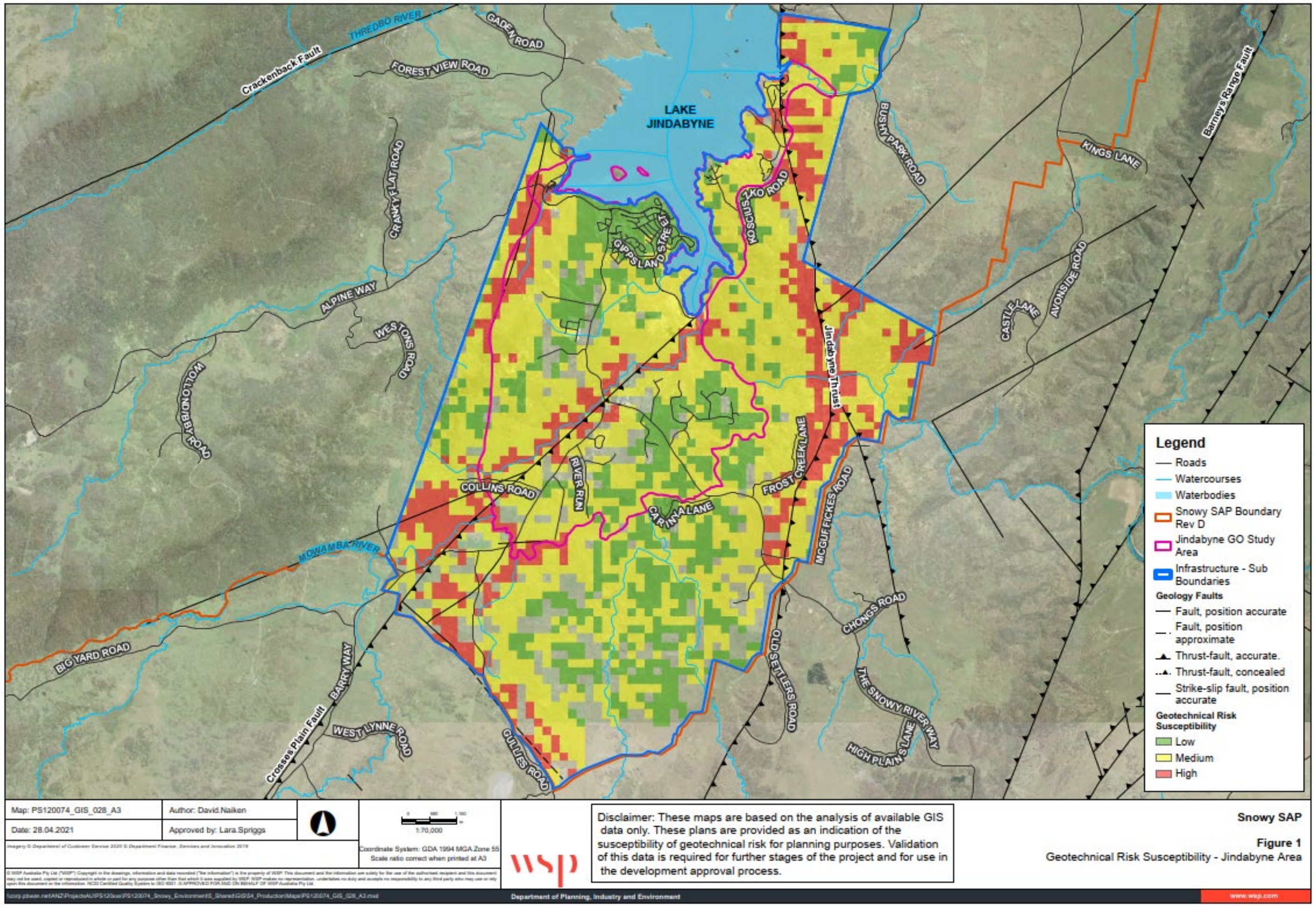



Figure 3.5 Susceptibility plan Jindabyne Area

### 3.2.6 EASTERN LAKE JINDABYNE AREA

The geotechnical risk susceptibility zoning for the Eastern Lake Jindabyne Area is presented in Figure 3.6.

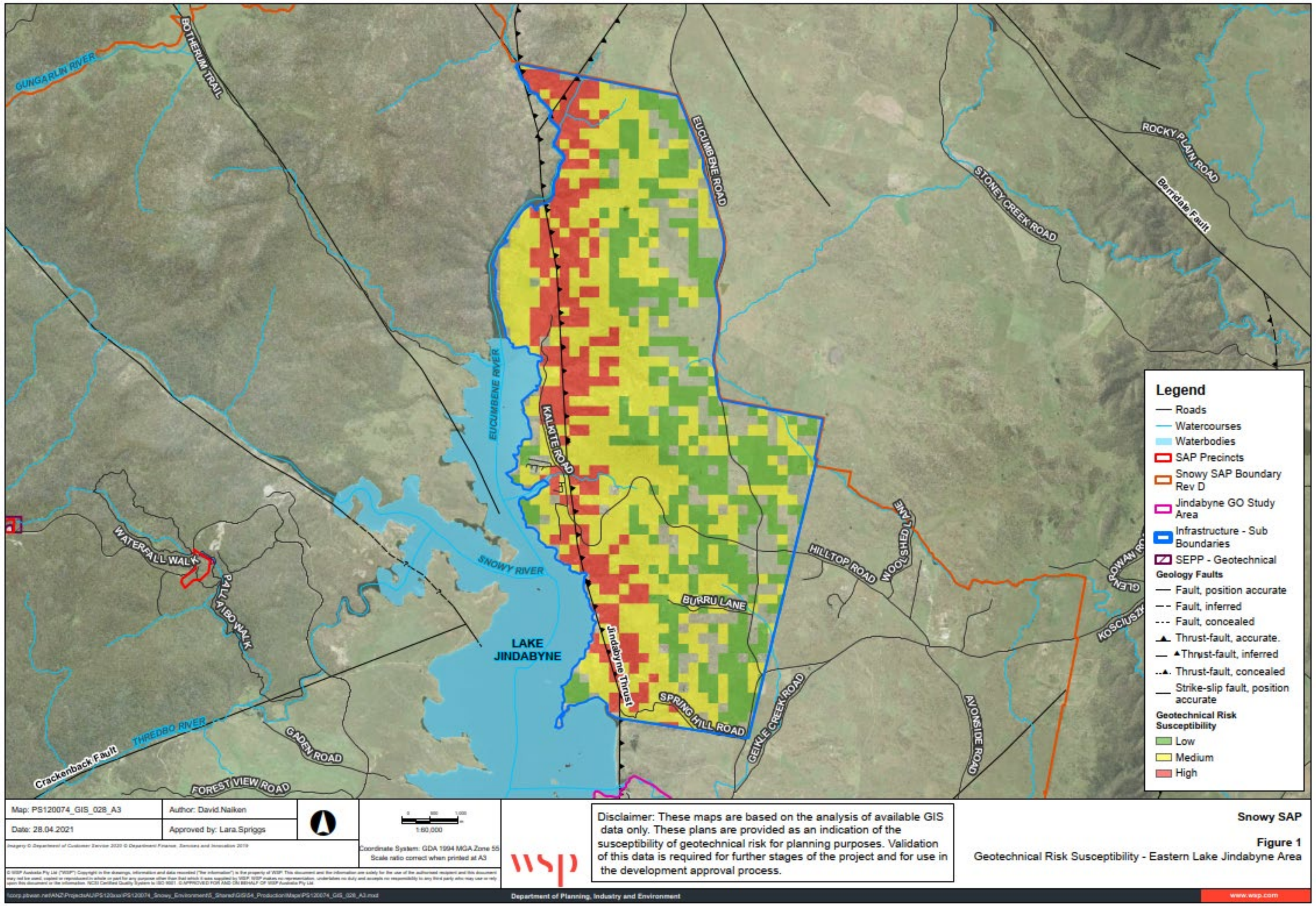



Figure 3.6 Susceptibility plan Eastern Lake Jindabyne Area

## 3.2.7 SELWYN RESORT

The susceptibility zoning for the Selwyn Resort is presented in Figure 3.7.

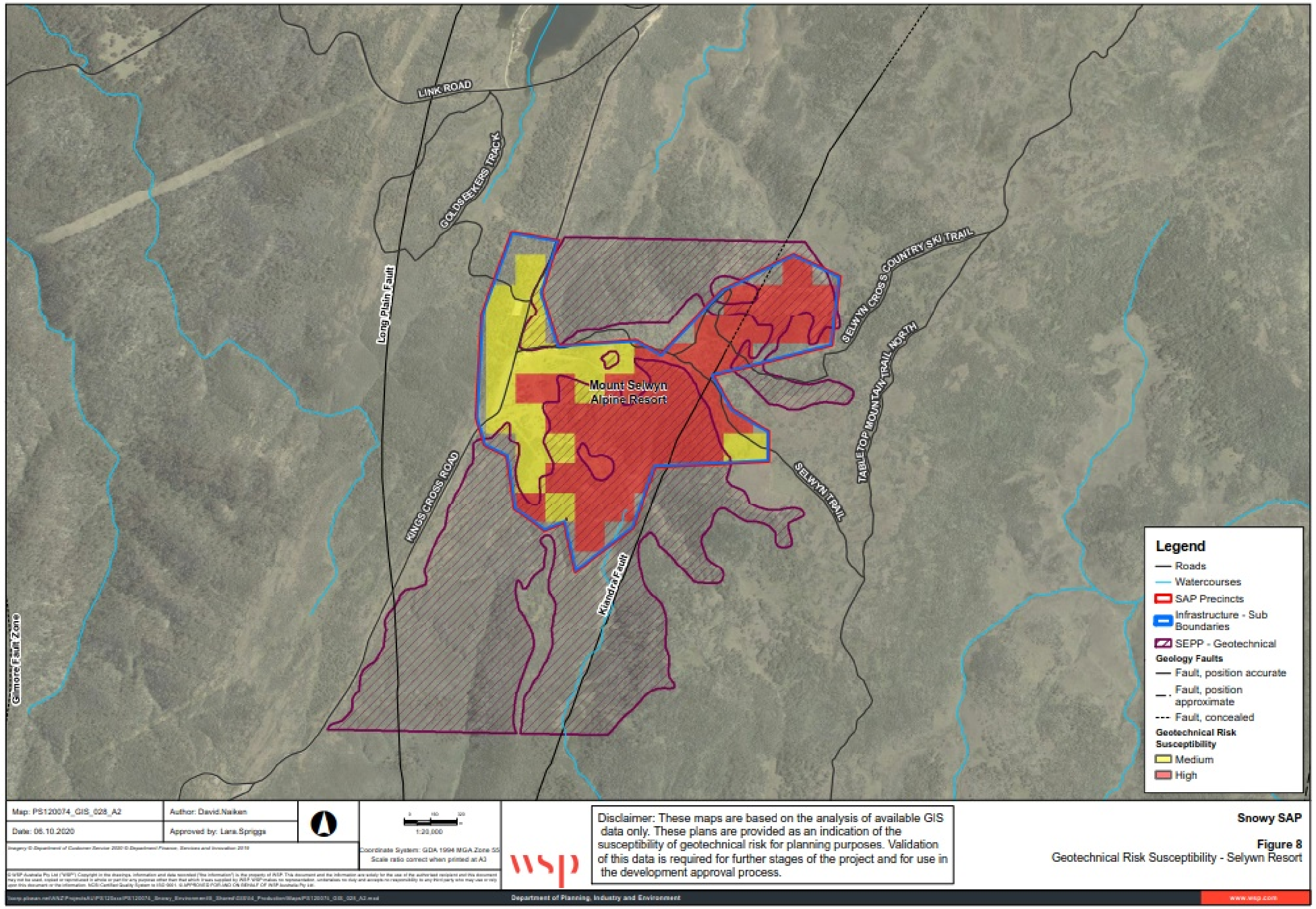



Figure 3.7 Susceptibility plan Selwyn Resort

## 3.3 MITIGATION STRATEGIES

Based on the identified geotechnical features and associated risks, high level mitigation options are identified to reduce the risk to future development. A summary table of the potential mitigation options for the identified geotechnical risk are provided in Table 3.4.

Table 3.4 Summary of potential mitigation options for the identified geotechnical risk

| FEATURE | DESCRIPTION | HAZARD | MITIGATION MEASURES |
|---|---|---|---|
| Geology<br>(1:250,000 mapping) | Different lithologies from the 1:250,000 scale geology mapping were merged into 5 different categories based on their physical properties and geotechnical experience regarding susceptibility to hazard events. | Landslide susceptibility, erosion/ scour and radon gas release | Lithologies with higher rankings are more likely to have potential for shallow rock, variable weathering and presence of radon gas development. This may require more extensive support for excavation and more costly excavation methods. |
| Terrain Slope<br>(gradient in degrees) | With slope gradient increase often the susceptibility of landslide risk also increases. The available contour plans with contours at 10 m increments was used and analysed using GIS software to determine the ground surface gradient. | Landslide susceptibility | Steeper/higher slopes have a higher risk of instability. Excavations in these areas will need to consider stabilisation methods i.e. rock bolts, soil nails and shotcrete, rock fall protection mesh along roads or piled walls for deeper excavations. |
| Terrain Height<br>(mAHD) | With elevation increase often the susceptibility of landslide risk also increases. Contour plans with contours at 10 m increments has been utilised. | Landslide susceptibility | |
| Fault Proximity<br>(m) | Buffer areas surrounding the fault lines were created to account for the variability of rock structure along these margins and susceptibility of landslide and earthquakes. | Landslide susceptibility and earthquake | Consideration may be required in the design phases to accommodate the risk of earthquake in accordance with Australian Standards. Highly fractured rock associated with the fault scarp may require more costly support for excavation or to provide long term slope instability, rock fall mesh may be required, particularly along roads. |
| Drainage Proximity<br>(m) | Buffer areas surrounding the drainage channels were created to account for the influence of overland flow, rivers and creeks on susceptibility of landslide and erosion. | Landslide susceptibility and erosion/scour | More extensive drainage design may be required in these areas to accommodate higher flow capacities. Design of underground elements may require deeper foundations as there may be a deeper weathering profile in these areas. |

# 4 RECOMMENDATIONS

Several projects have been considered as priorities for government led investment as part of the SAP Snowy Project Snowy Mountains SAP based on the Draft Structure Plan. These projects are expected to be delivered in the next 10-15 years. A high-level review of the areas for the proposed project development has been undertaken and the geotechnical risks identified and summarised in Table 4.1.

Table 4.1 Summary of geotechnical risk susceptibility recommendations

| STRUCTURE PLAN | PRIORITY PROJECTS | GEOTECHNICAL SUSCEPTIBILITY | COMMENTS |
|---|---|---|---|
| Jindabyne: South Jindabyne (Growth Area 2 and 3) | Southern Connector Road | Low and medium | Sections of steeper slopes with potential landslide risk and slope stability to consider, excavation in rock, retaining walls and embankments may be required to optimise alignment. |
| Jindabyne: Town Centre (Growth Area 1) | Jindabyne – public realm improvements within town centre | Low | Minimal geotechnical risk to public realm developments. |
| Jindabyne: Town Centre (Growth Area 1) | Library/Innovation Hub and Neighbourhood Centre | Low | Minimal geotechnical risk to development. |
| Jindabyne: Town Centre (Growth Area 1) | Kosciuszko Road – public realm treatments | Low | Localised improvements may require retaining walls. Minimal geotechnical risk to development. |
| Jindabyne: Town Centre (Growth Area 1) | Lake Jindabyne Linear Park – Node 3 – 8 | Low | Minimal geotechnical risk to development. |
| Jindabyne: Town Centre (Growth Area 1) | Extension of Park Road from JJ Connors Oval to Reedys Cutting Road | Low | Upgrade of existing local road. Minimal geotechnical risk. |
| Jindabyne: West Jindabyne (West of Growth Area 3) | MTB and Adventure Park | Low and medium | Located in an area of potential slope instability, however, MTB track and park likely to require minimal excavation works. Embankments built for jumps should consider construction methodology on slopes. Medium geotechnical risk depending on design. |

| STRUCTURE PLAN | PRIORITY PROJECTS | GEOTECHNICAL SUSCEPTIBILITY | COMMENTS |
|---|---|---|---|
| Jindabyne: Sport and Recreation Area | Sport and Education Precinct specifically services and utilities, collector roads, footpaths and bicycle paths, landscaping, street lighting and access on Barry Way.<br>Community facilities (gym, pool, climbing wall, courts) and Sporting Oval and amenities block. | Medium, locally low | Sections of steeper slopes with potential landslide risk and slope stability to consider, excavation in rock may be required. |
| Jindabyne<br>Bullocks Flat<br>Perisher Village<br>Thredbo Resort - East | Park and Ride Facilities at Jindabyne, Bullocks Flat, Perisher and Thredbo | Low and medium | These facilities are largely within existing car park areas. Low geotechnical risk. |
| Jindabyne<br>Jindabyne: East Jindabyne (Growth Area 4)<br>Perisher Village | Services – Water Treatment Plant (WTP) & Sewage Treatment Plant (STP) for Jindabyne, East Jindabyne and Perisher Village | Medium, locally high | Small scale construction related to WTP and STP, low geotechnical risk. Areas of slopes may require retaining walls, potentially excavation in rock to form platforms for infrastructure buildings. |
| Hatchery Bay | Hatchery Bay – services and enabling works | Low | Golf course and residential development. Low geotechnical risk. |
| Thredbo Ranger Station | Thredbo Ranger Station – services and enabling works | Medium | Small scale development, minimal geotechnical risk. |
| Perisher Village | Porcupine Rocks viewing platform | Medium | Minimal construction works, minimal geotechnical risk. |
| Island Bend | Island Bend Camping expansion | Medium | Minimal infrastructure or construction that would have geotechnical risk. |

To further develop the geotechnical risk susceptibility mapping the following is recommended:

- As the areas of development are narrowed down and the type of development known with more certainty, geotechnical risk susceptibility in these areas can be reassessed at a more local discrete scale.
- As additional data becomes available from site walkovers, investigations and additional survey, the analyses in GIS can be updated to reflect the new information and further validate and refine the susceptibility mapping. This would improve the benefit and accuracy of these maps over time
- For the priority projects listed in Table 4.1 geotechnical risks are generally low.

Geotechnical risk susceptibility is one contributor to overall risk to development and/or population.

# 5 LIMITATIONS

## 5.1 SCOPE OF SERVICES

This technical study report (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.

## 5.2 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.

## 5.3 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.

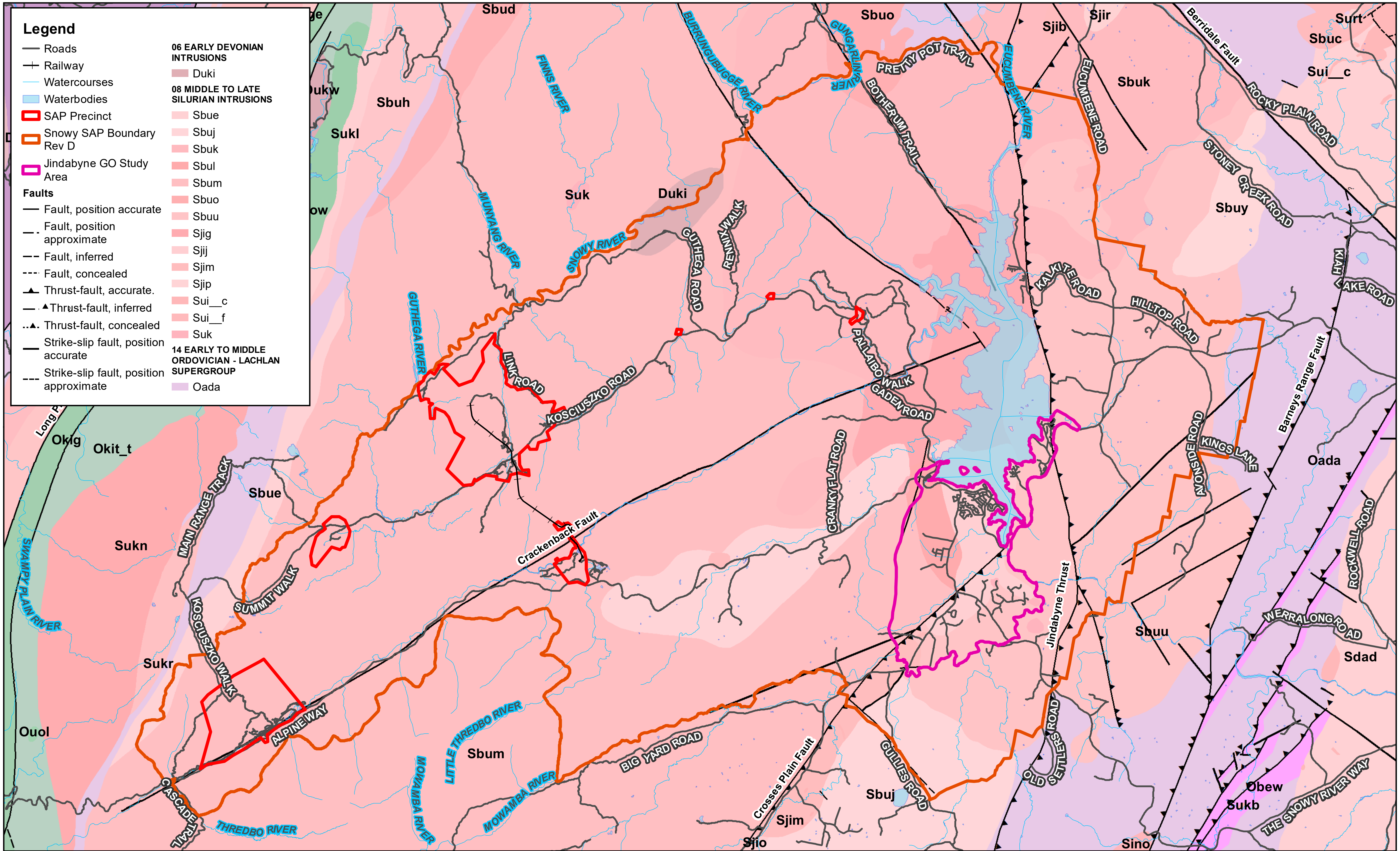
## 5.4 OTHER LIMITATIONS

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

GEOTECHNICAL PLANS

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| Map: PS120074_GIS_006_A1 | Author: David.Naiken |
| Date: 11-Jun-20 | Approved by: Lara.Spriggs |

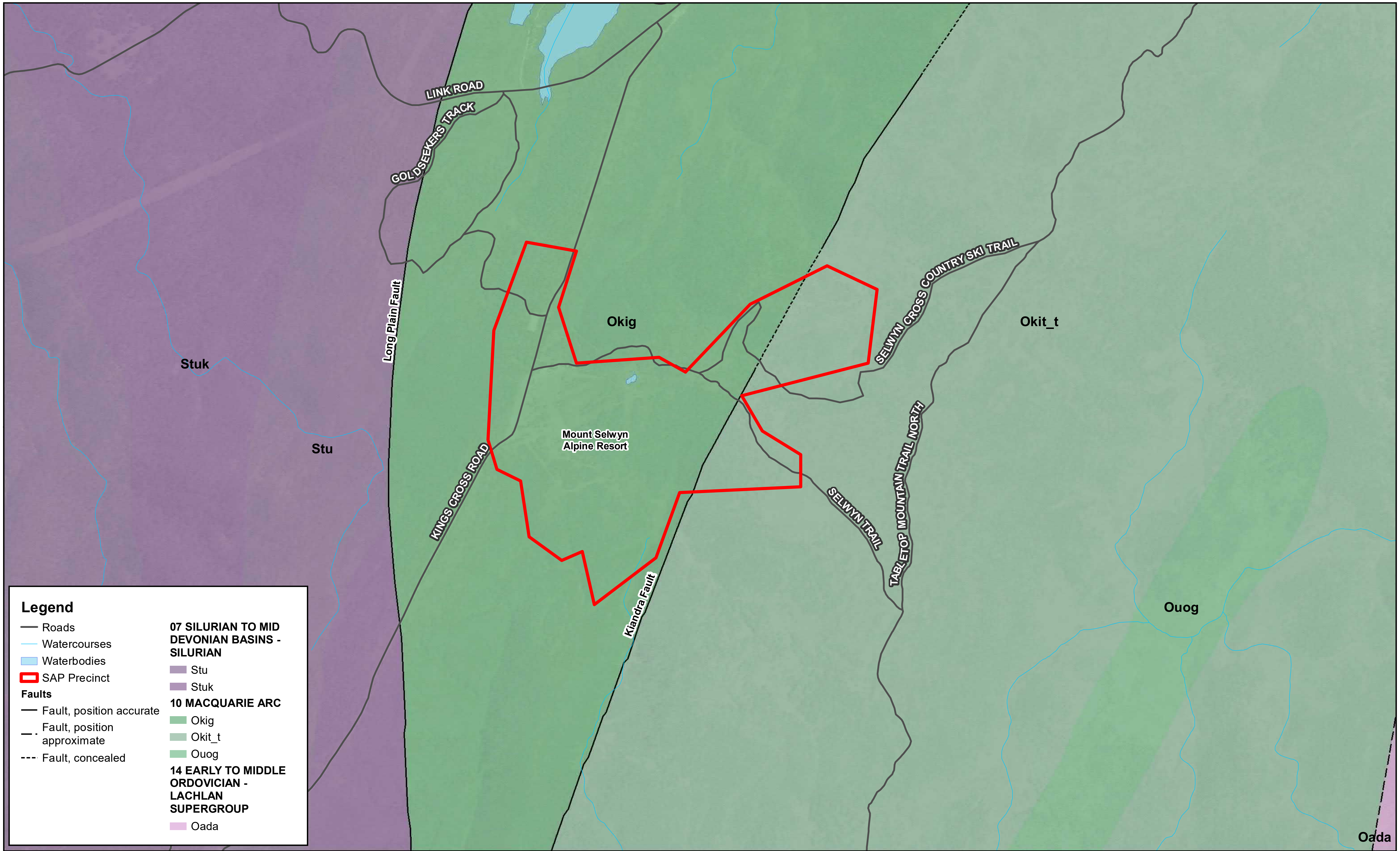
0 1,250 2,500 m
1:140,000

*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*

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

**Snowy SAP**

**Figure 1.1**
Geological Plan




| | |
|---|---|
| Map: PS120074_GIS_008_A1 | Author: David.Naiken |
| Date: 11-Jun-20 | Approved by: Lara.Spriggs |

0 200 400 m
1:20,000

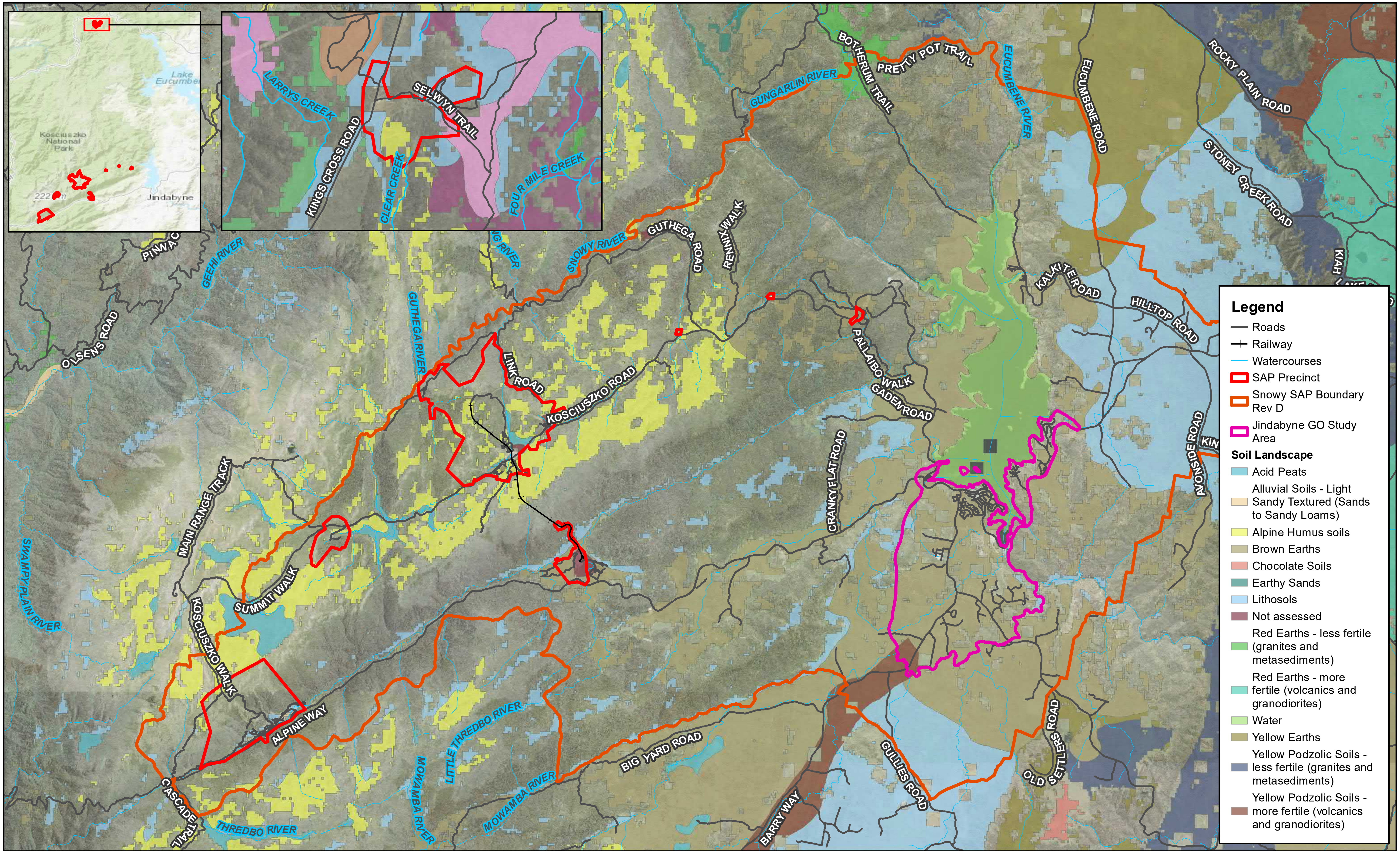
*Imagery © Department of Customer Service 2020*
*Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community © Department Finance,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

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



**Snowy SAP**

**Figure 1.2**
Geological Plan - Mount Selwyn




| Map: PS120074_GIS_011_A1 | Author: David.Naiken |
|---|---|
| Date: 11-Jun-20 | Approved by: Lara.Spriggs |

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

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*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 2**
Soil Landscape Mapping

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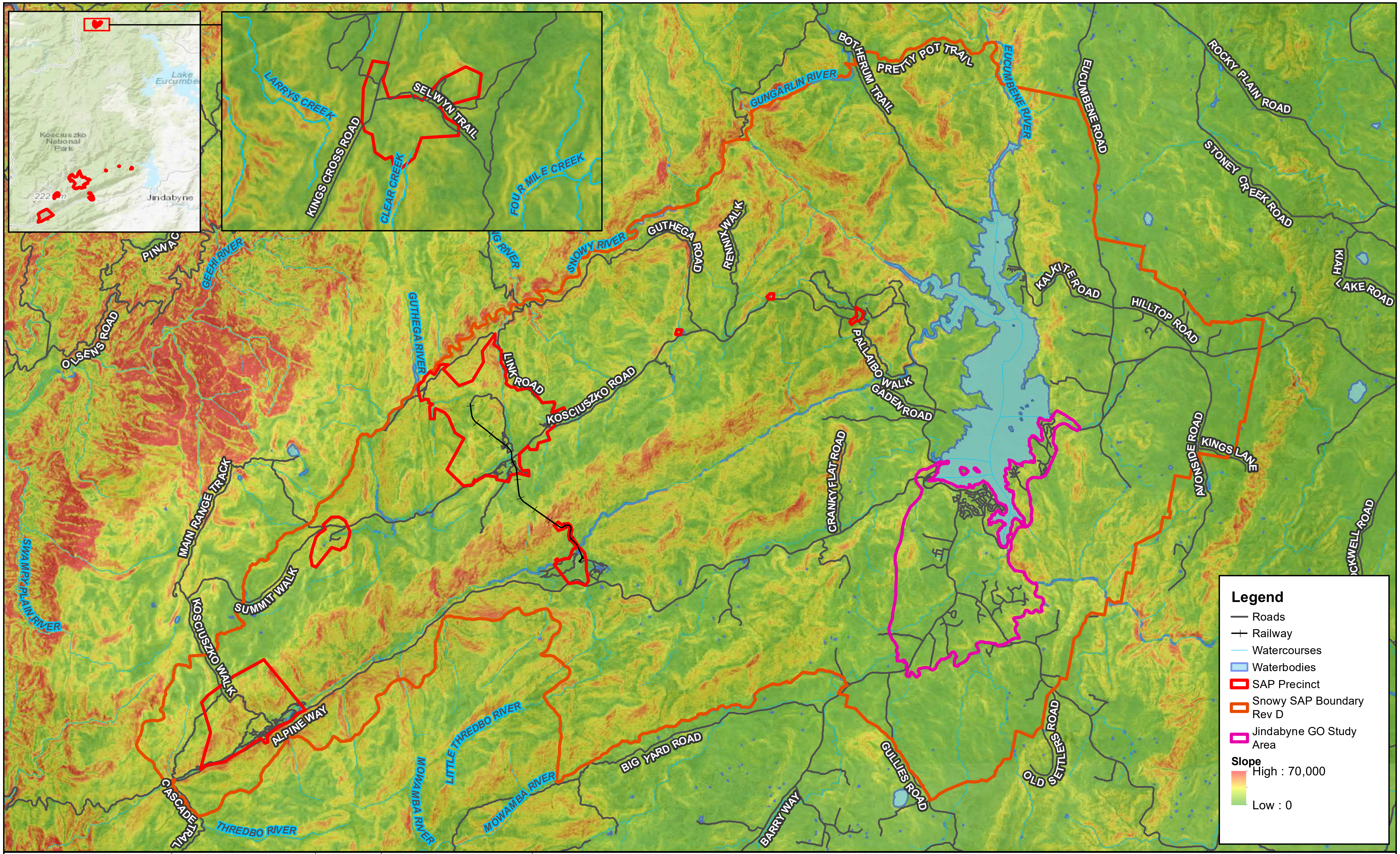


| | |
|---|---|
| Map: PS120074_GIS_010_A1 | Author: David.Naiken |
| Date: 11-Jun-20 | Approved by: Lara.Spriggs |

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*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*

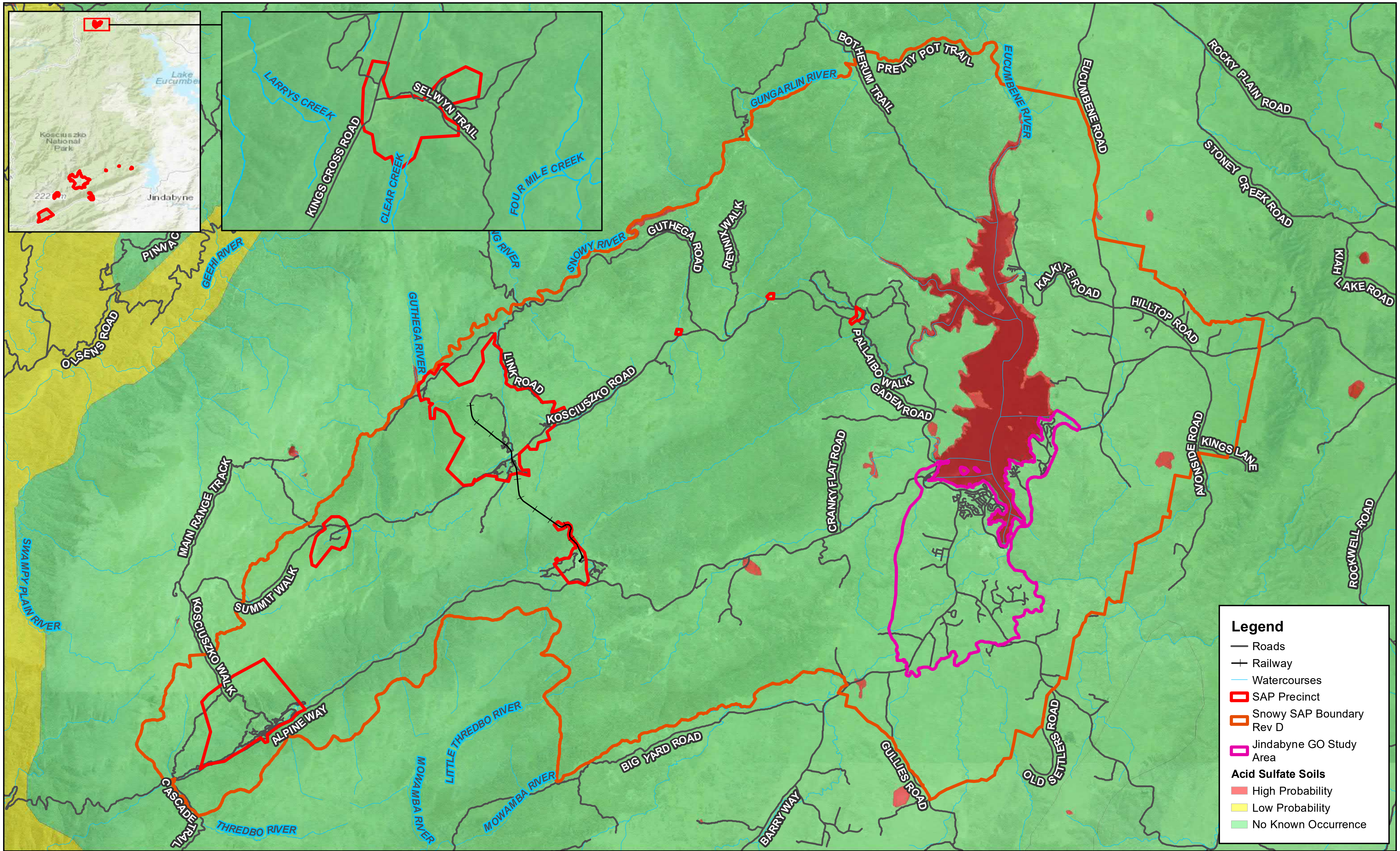
0 1,250 2,500 m
1:140,000

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

**Snowy SAP**

**Figure 3**
Slope Analysis Mapping

wsp




Map: PS120074_GIS_009_A1

Author: David.Naiken

Date: 11-Jun-20

Approved by: Lara.Spriggs

1:140,000

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*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*

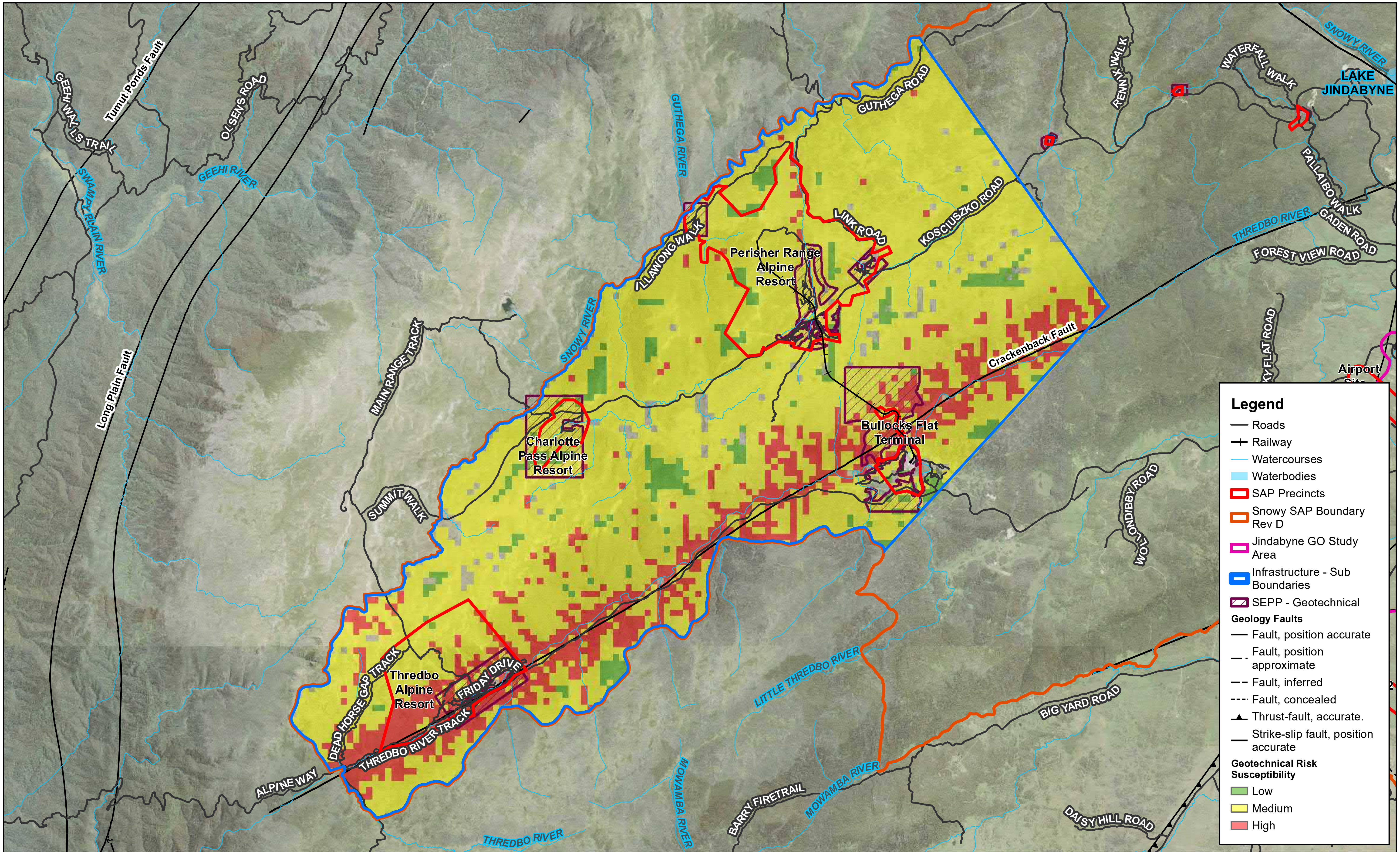
Coordinate System: GDA 1994 MGA Zone 55
Scale ratio correct when printed at A3

**Snowy SAP**

**Figure 4**
Acid Sulfate Soils

# APPENDIX B

REGIONAL SUSCEPTIBILITY ZONING




| | |
|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken |
| Date: 06.10.2020 | Approved by: Lara.Spriggs |

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0 830 1,660 m
1:100,000

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

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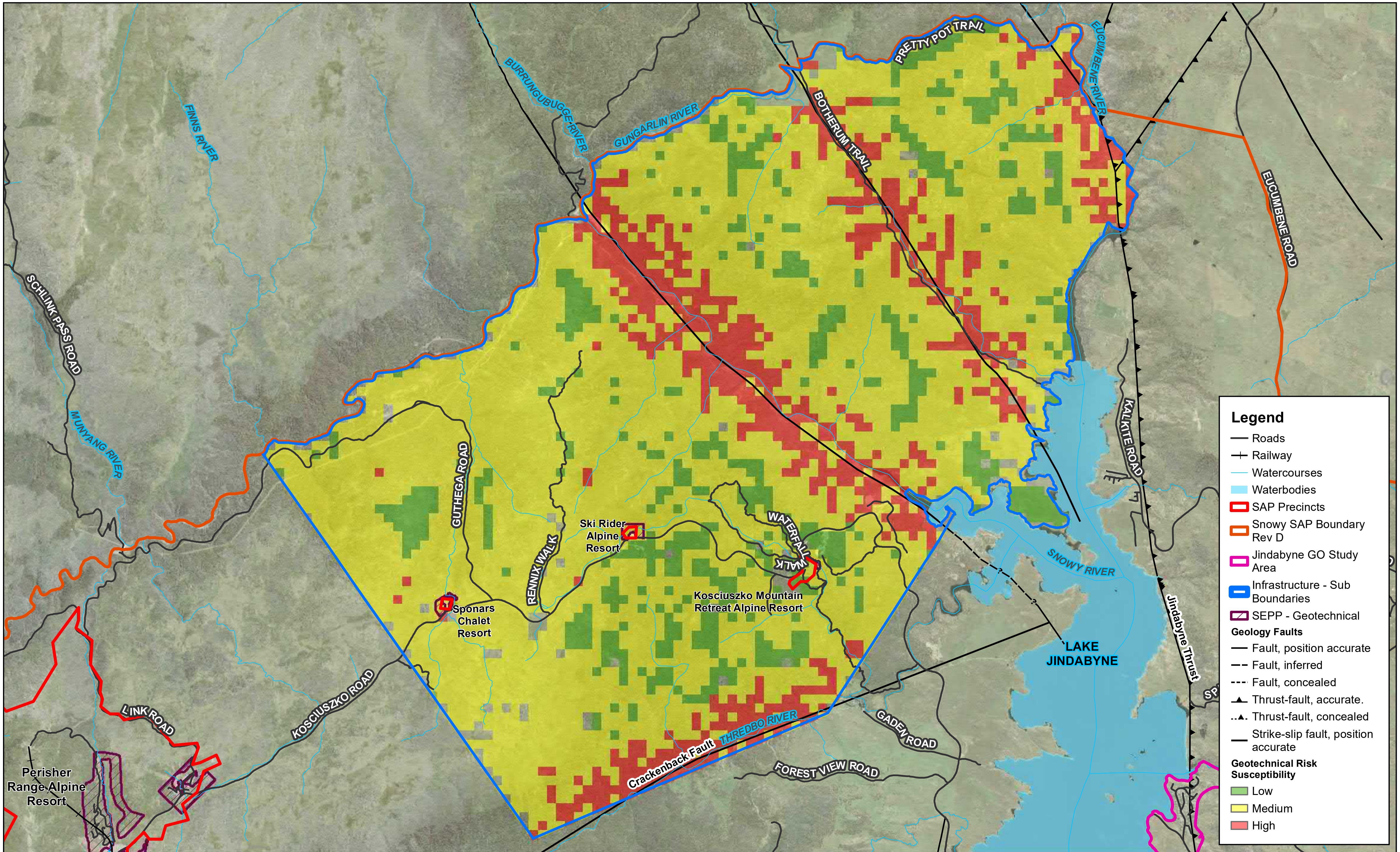
**Snowy SAP**

**Figure 1**
Geotechnical Risk Susceptibility - Alpine Resorts




| | |
|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken |
| Date: 06.10.2020 | Approved by: Lara.Spriggs |

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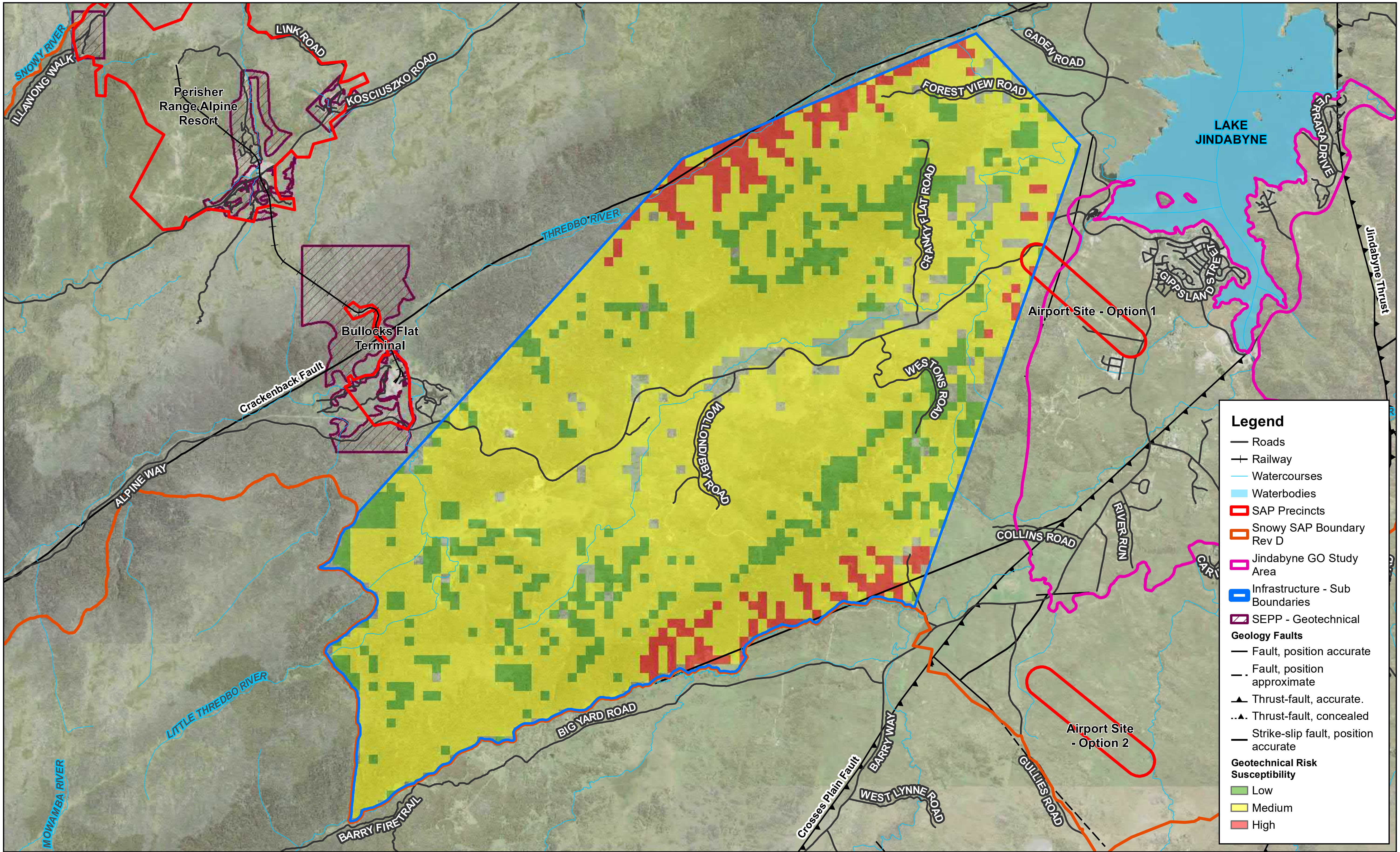
**Snowy SAP**

**Figure 2**
Geotechnical Risk Susceptibility - Kosciuszko Road Area




Map: PS120074_GIS_028_A2

Author: David.Naiken

Date: 06.10.2020

Approved by: Lara.Spriggs

0 580 1,160 m

1:70,000

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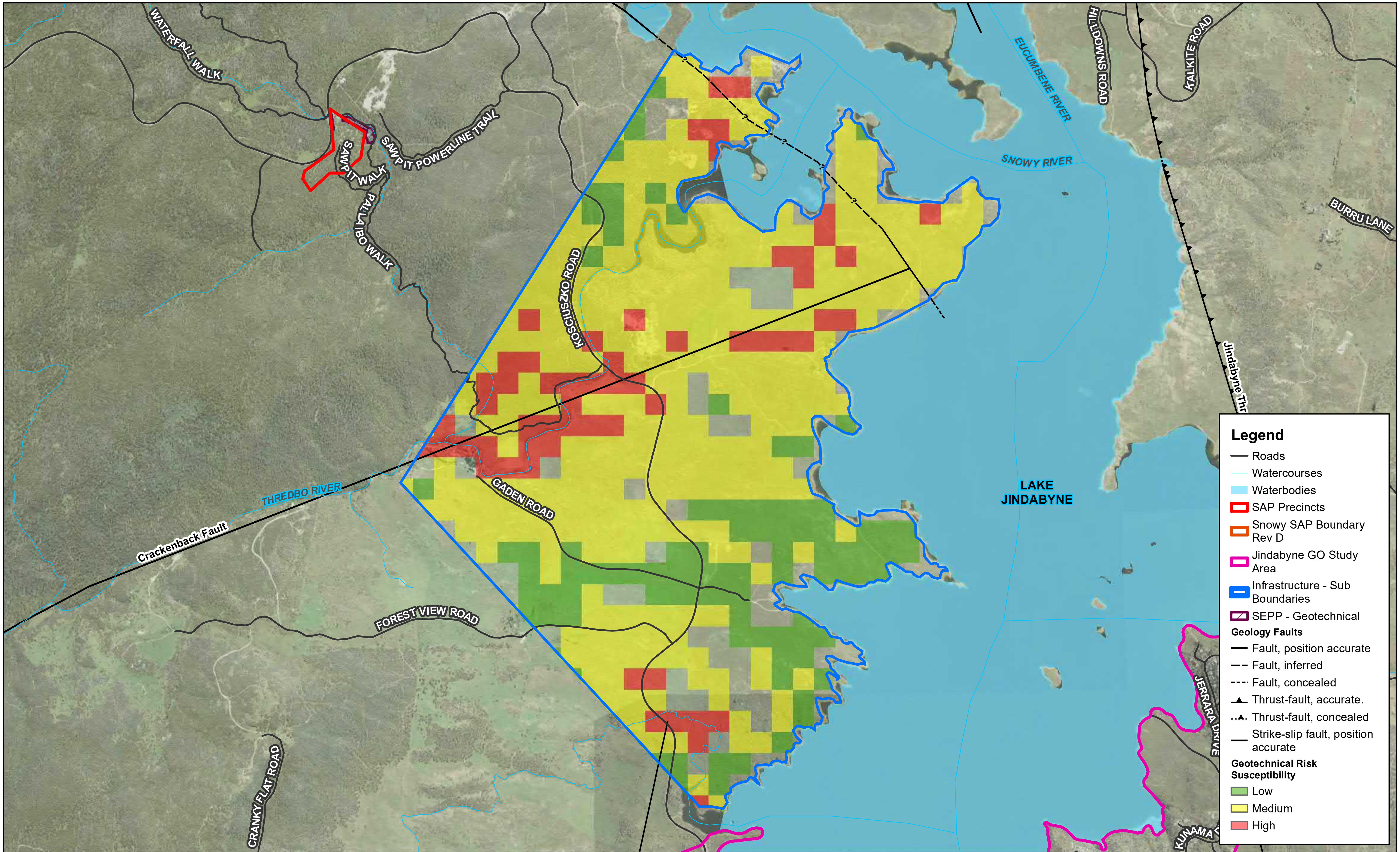
**Snowy SAP**

**Figure 3**
Geotechnical Risk Susceptibility - Alpine Way Area




| | | | |
|---|---|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken | | 0 250 500 m<br>1:30,000 |
| Date: 06.10.2020 | Approved by: Lara.Spriggs | | |

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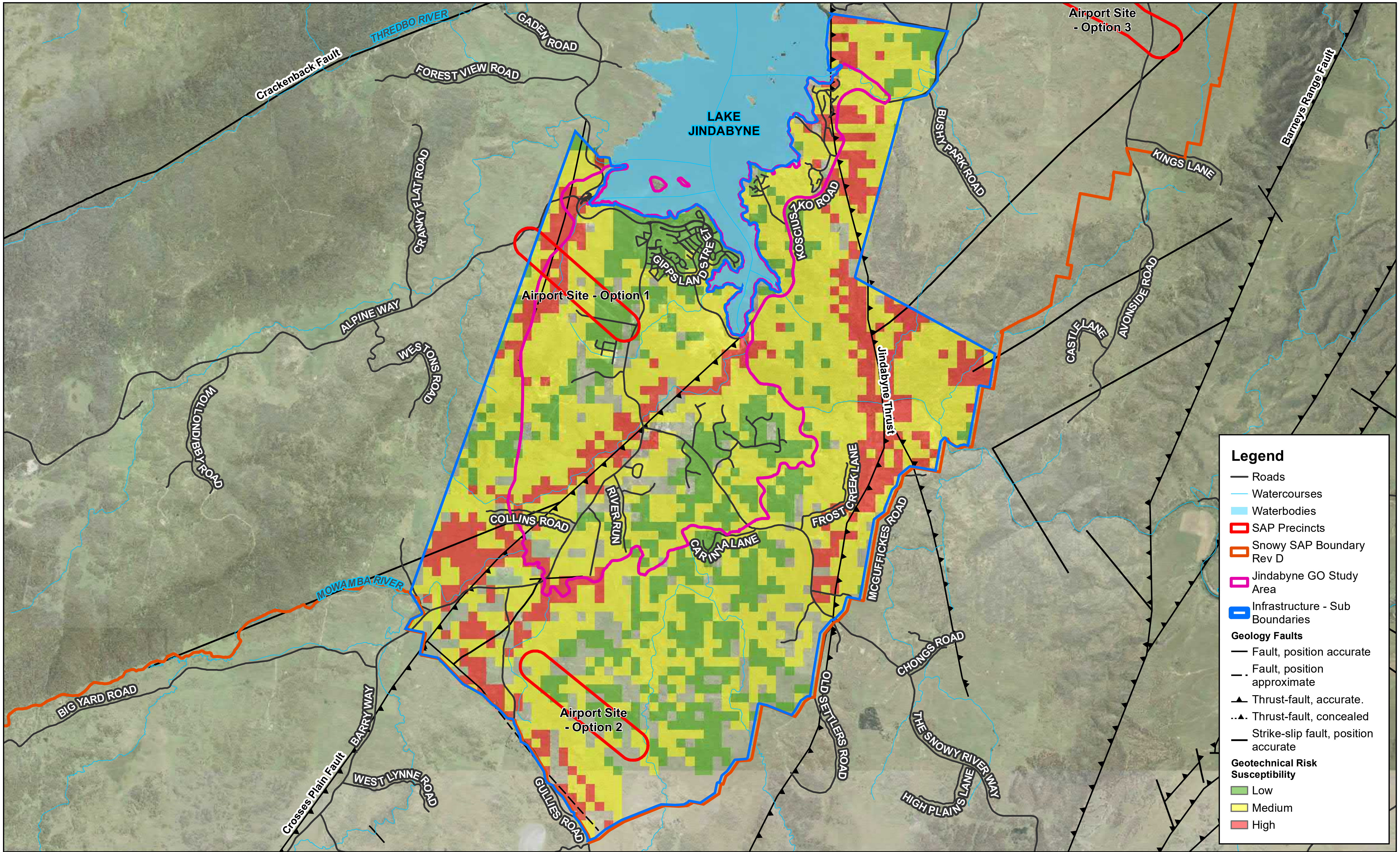
**Figure 4**
Geotechnical Risk Susceptibility - Western Lake Jindabyne Area




Map: PS120074_GIS_028_A2 | Author: David.Naiken
Date: 06.10.2020 | Approved by: Lara.Spriggs

Coordinate System: GDA 1994 MGA Zone 55
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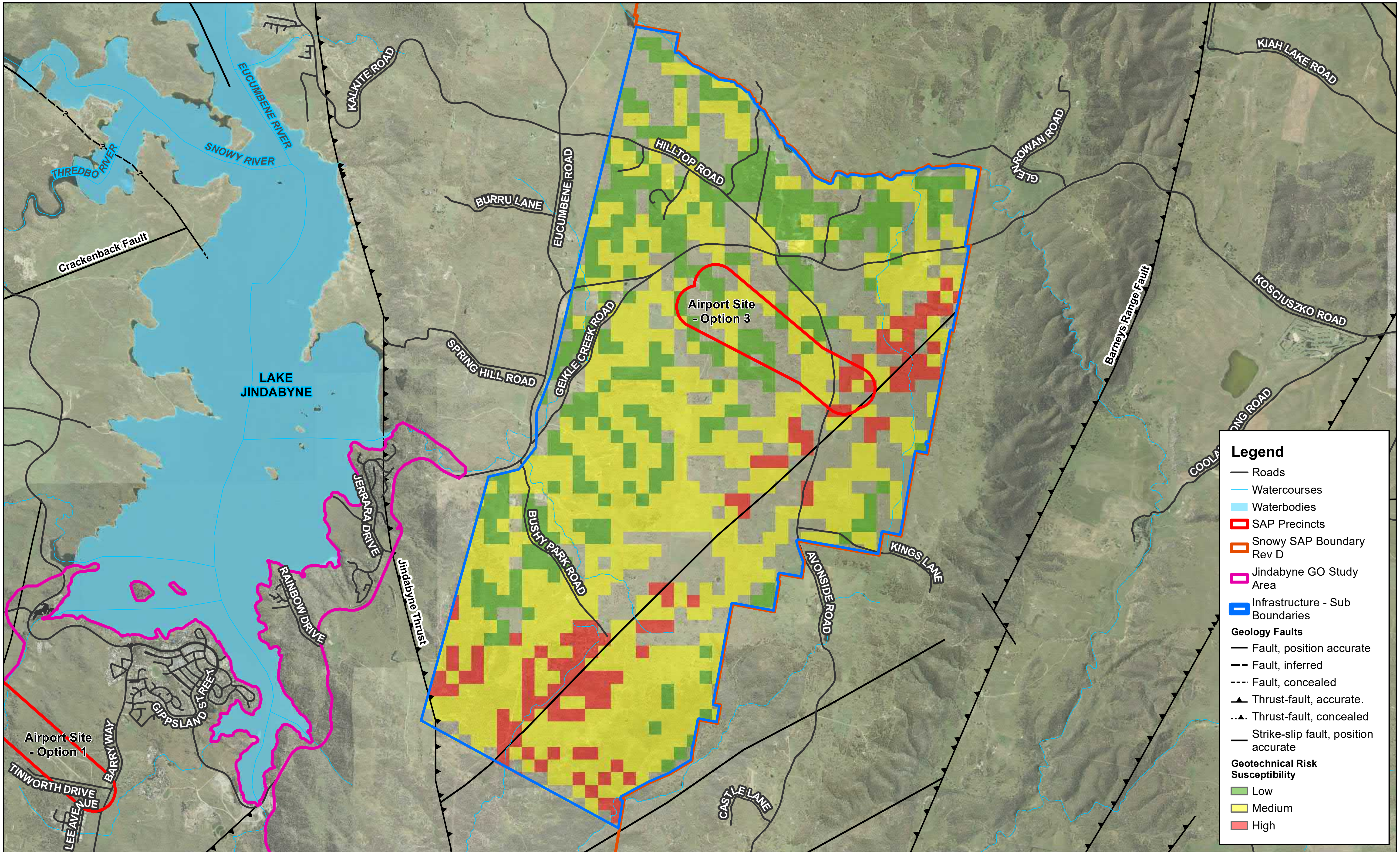
**Figure 5**
Geotechnical Risk Susceptibility - Jindabyne Area

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|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken |
| Date: 06.10.2020 | Approved by: Lara.Spriggs |

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0 420 840 m
1:50,000

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



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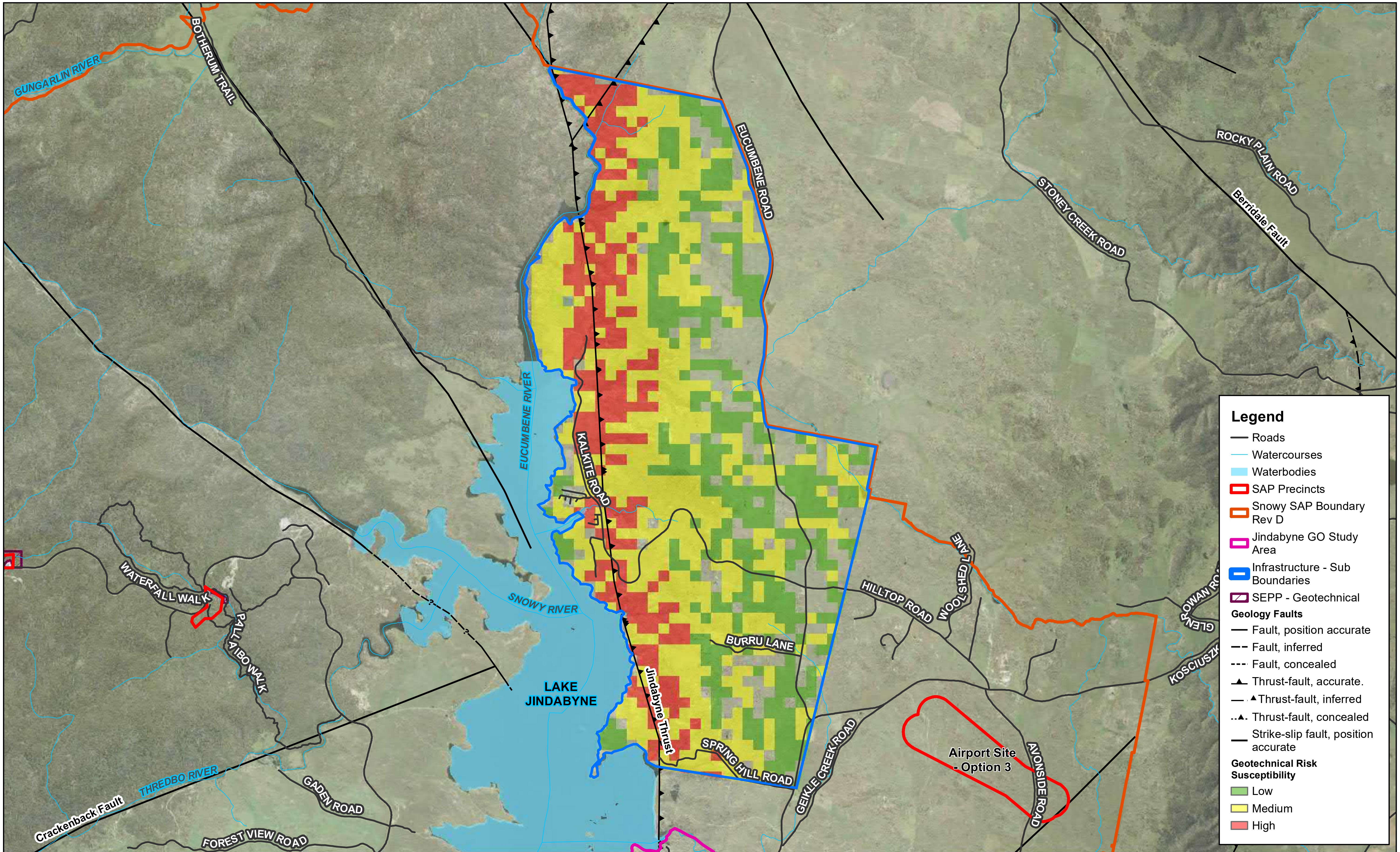
**Figure 6**
Geotechnical Risk Susceptibility - Proposed Airport Area




| | |
|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken |
| Date: 06.10.2020 | Approved by: Lara.Spriggs |

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0 500 1,000 m
1:60,000

Coordinate System: GDA 1994 MGA Zone 55
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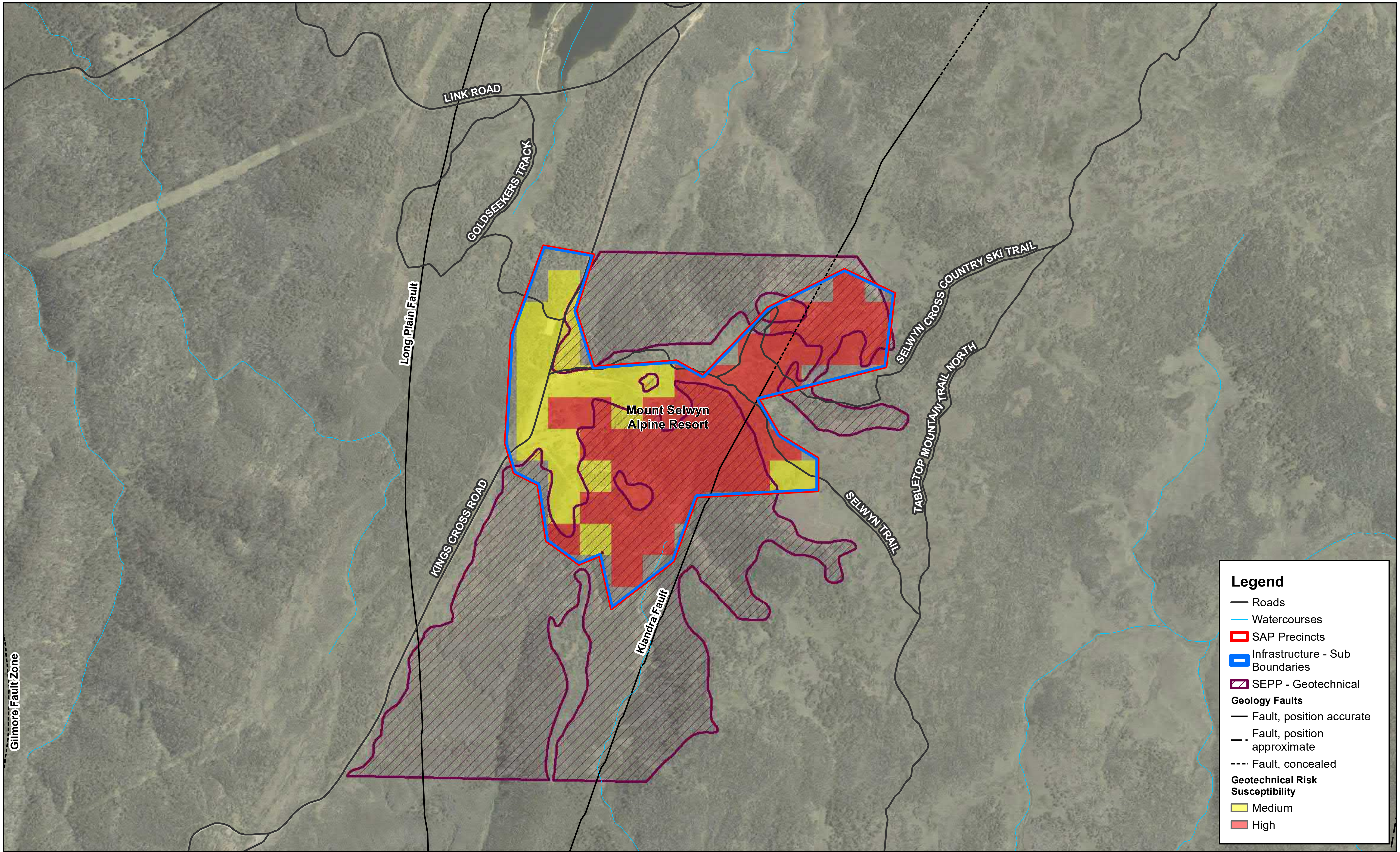
**Figure 7**
Geotechnical Risk Susceptibility - Eastern Lake Jindabyne Area




| | | |
|---|---|---|
| Map: PS120074_GIS_028_A2 | Author: David.Naiken | |
| Date: 06.10.2020 | Approved by: Lara.Spriggs | |

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0 160 320 m
1:20,000

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

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**Figure 8**
Geotechnical Risk Susceptibility - Selywn 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 50,000 talented people globally, we engineer projects that will help societies grow for lifetimes to come.